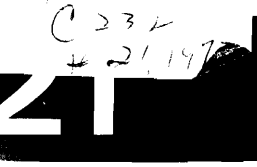

Science Council of Canada

September 1973
Report No. 21

Strategies of Development for the Canadian Computer Industry

September 1973

Strategies of Development for the Canadian Computer Industry

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150 Kent Street,
Ottawa, Ontario.
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The Hon. Jeanne Sauvé, P.C., M.P.,
Minister of State for Science and Technology,
House of Commons,
Ottawa, Ontario.

Dear Minister:
In accordance with sections eleven and thirteen of the Science Council of Canada Act, I take pleasure in forwarding to you the views and recommendations of the Council as they concern the requirements for the development of a Canadian computer industry, in the form of Science Council of Canada Report No. 21, entitled *Strategies of Development for the Canadian Computer Industry.*

This Report represents another of the Council's views on computers in Canada. The first was published in August 1971 as Science Council Report No. 13, *A Trans-Canada Computer Communications Network* and contained recommendations for the creation and operation of a national network of computers.

Yours sincerely,

Roger Gaudry,
Chairman,
Science Council of Canada.

*This is the date on which this Report went to the printer.

Summary of Principal Conclusions

This Report surveys the present state and future prospects of the Canadian Computer Industry, and suggests certain areas for policy and development for both Government and the industry. The basis of the Science Council's argument rests on its belief that computer technology is a "transformative technology" – one that is having and will continue to have far-reaching effects upon man, his economy and his society, and one that no nation can leave entirely to others to develop.

Among the many specific conclusions scattered throughout the present Science Council Report the following ten have been selected since, in our opinion, the actions which they imply together constitute the salient elements of an industrial strategy for this industry.

Government Procurement Policies (pp. 69–71)
All Governments can exercise considerable leverage on the development of an industry by appropriate use of their purchasing power. The procurement policy for computer hardware and services should strongly favour the contracting out principle already accepted by the federal government; decisions on purchase of specific goods or services should be based upon a wide assessment of contributions to Canadian industrial development which can be stimulated by buying within Canada as opposed to importing from abroad.

At the federal level, the EDP Policy Report prepared for Treasury Board provides useful guidelines for the implementation of the necessary purchasing policy.

Development of a Hardware Industry (1) Support of Specialization (pp. 53–54)
In the long-term, Canada's best hope for developing an indigenous computer hardware industry lies in specialization. The Science Council recommends that preferential support be given to those companies in Canada specializing in the manufacture of minicomputers or of communications-related peripheral equipment.

Development of a Hardware Industry (2) Canadian Participation in Ownership (p. 53)
Government grants which lead to an entry into Canada of foreign computer corporations, or which expand the activities of existing foreign controlled firms within Canada, should wherever possible be tied to equity participation in those companies by individual Canadians, by Crown corporations or by other government sponsored agencies.

In most cases, foreign takeovers of Canadian-controlled computer companies are unlikely to be in the best long-term interests of the country; where this is the case, takeovers should not be permitted.

Development of a Hardware Industry (3) Canadian Tariff Policy (p. 66)
Tariff Policy has been a traditional tool used to assist domestic industrial development. Computer tariffs should be formulated in such a way as to

provide a climate of opportunity to the Canadian computer industry to improve its performance in areas such as R & D and manufacturing at a higher level of sophistication or complexity.

Development of a Software Industry (1) Ownership Policy for Service Bureaux (pp. 58–59)

We envisaged a further development of *service bureaux*, accompanied by more intense interaction with the communications industry, to form major *computer utilities* for the operation of data banks to service the needs of many segments of our national life. To ensure that such comprehensive service systems are developed in a manner calculated to best serve Canadian needs, and to make possible their regulation, as necessary, in the interests of security and privacy of information, *we argue that it is necessary that these service bureaux be Canadian-controlled.*

In advocating such a course of action we are following the well established Canadian precedent of ensuring Canadian control over specified areas of our economy (e.g., communications, air transportation, banking) where such areas are deemed to be of particular significance to Canada. The administrative arrangements used in any of the past cases to create the desired level of Canadian control or equity participation could be adapted to fit the circumstances of the case of the service bureaux.

Development of a Software Industry (2) International Transmission of Data for Processing (pp. 40, 59, 66)

Steps should be taken to subject to regulation (possibly by imposition of a tariff) the electronic transmission of data for processing by U.S.-based service bureaux and subsequent retransmission to Canada. The objectives of such action should be to equalize the competitive bases of service bureaux operating in the two countries in a fashion analogous to traditional treatment (by tariff or quota regulations) of manufactured goods.

There are already examples of U.S. companies using pricing policies which constitute *de facto* dumping of excess computer capacity on the Canadian market; more generally, because of differences in tax structures, equipment costs and so forth, the operating costs of U.S.-based service bureaux are often lower than those of bureaux operating in Canada – in such cases the absence of any form of regulation of electronically transmitted data offers an unfair competitive advantage to the foreign bureaux.

Financial Support for the Industry (1) Incentive Programs (pp. 67–69)

As a supplement to the vigorous pursuit of the government purchasing policy which we have recommended, we would further propose that existing government incentive programs be used: a) to encourage the development of a minicomputer and communications-related peripheral equipment manufacturing industries and; b) to support the service sector of Canada's computer industry by providing substantial support for software development and marketing.

Financial Support for the Industry (2) Venture Capital (pp. 48–51)
A definitive study is needed of the venture capital market in Canada to ascertain which steps are required to improve the flow of such risk money into Canada's high technology industries.

Manpower Development (p. 52, p. 72)
A strong and healthy computer industry can provide a variety of challenging careers for Canadians of different levels of education and training. Our educational institutions are currently producing the well-trained people the industry needs – they should be encouraged to continue to do so.

In addition, efforts should be made to establish professional requirements and standards in the computer industry, together with an effective system of self regulations in a manner similar to that prevailing in the traditional professions. Such an initiative by the profession would enhance the confidence with which governments could embark on programs of support for the development of the industry.

Industry-University Relations (p. 60)
It is important to Canada that the industry and the universities be partners, not competitors, in this high-technology business. As a contribution to improving relationships, unfair competition by publicly-funded university computer facilities in the private business sector should be discouraged.

A Note on "Branching Out"
The Science Council's proposals for a meaningful strategy for the Canadian computer industry were developed in parallel with the preparation and publication of the report of the Federal Computer/Communications Task Force entitled *Branching Out.** The report of the Task Force is more comprehensive than this Science Council report, covering as it does some subjects previously dealt with by the Council in Science Council Report No. 13, *A Trans-Canada Computer Communications Network*. A reading of the two Science Council reports is of value in order to fully comprehend the differences in approach taken by the two bodies. The two reports of the Task Force and of the Science Council are similar in some respects but in certain areas there are considerable differences. There are fundamental differences in the underlying philosophies adopted in the two reports which lead to substantial divergences in the recommended actions to be taken by government. In some cases when faced with an identical set of facts the two reports contain mutually-opposing recommendations, as, for example, in the case of ownership policy for service bureaux. The differences reflect the different weights accorded to the various factors involved in assessing policy options.

**Branching Out*, Report of the Canadian Computer/Communications Task Force, Information Canada, Ottawa, 1972. Catalogue No. Co21-1/1972, 2.

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Introduction

In a period of less than a quarter century, the computer has emerged as one of the significant phenomena of modern economic and social life. Internationally, the "computer industry" (or, more precisely, the group of closely linked manufacturing and service industries focussing on the computer and its applications) has evolved from modest beginnings to become a major economic force, with current revenues in excess of $15 billion annually. In Canada, the current rate of expansion of the industry is about 16 per cent a year; many economists predict that this rate of expansion will be maintained for many years to come.

If only on the grounds of its economic significance, its growth, and such questions as whether the Canadian computer industry can make a rôle for itself in the present intense competition for international markets, there would be ample reason for the Science Council to look closely at the computer industry. But beyond this, and perhaps even more significant, there are questions that bear on the impact of the computer on society – on the preservation of national capabilities for self-government and social development, and on the impact of the computer on such traditional concerns of the democratic system as the privacy and security of individuals. For adequate and understandable reasons, society has viewed the development of the computer with mixed feelings. It is clear that we need a comprehensive national policy for the development and application of the computer in all its ramifications; a policy based on adequate consideration of the technical, economic, social, political and cultural phenomena and values that are in play in our society. To do this means that we consider many aspects of the computer in relation to society, rather than focus on any single aspect of this relationship: it means that, for a body such as the Science Council, we will have to come back at frequent intervals to a review of developments in this field, rather than attempting a "once for all time" assessment.

While the Science Council, almost from its beginnings, has attempted to keep in touch with developments in this field, its formal consideration of computer technology and applications goes back to the formation of an appropriate Science Council committee some three years ago. As the committee and the Council evolved in their appreciation of the multidimensional nature of the "computer revolution", it was decided that a number of reports should be issued, each dealing with a specific area of interest, rather than delaying publication until the field could be comprehensively studied and reported upon. (A goal which, in the light of rapid development in this field, might in fact be unattainable.) In September 1971, our first Report on Computer Applications and Technology[1] was published; this recommended the development, at the earliest possible date, of a Canadian-owned trans-continental network for computer communications – a present day equivalent to the earlier successes in developing trans-Canada transportation and communications systems.

This second Report examines the Canadian computer industry, both

[1]Science Council of Canada Report No. 13, *A Trans-Canada Computer Communications Network*, Information Canada, Ottawa, 1971.

as a producer of equipment and as a provider of a variety of services involving the storage and processing of information. In view of the rate of development of the industry, the question of foreign ownership, and its significance in terms of potential employment and of spillover into other areas of economic and social life, the Science Council can only conclude that a high priority should be assigned to the development of a national policy, and appropriate industrial strategies, for the production of computer hardware and software, the training and certification of men and women capable of working with the new technology, and the provision of adequate standards and safeguards for ensuring that this industry serves our national interests. Ultimately, we are dealing with a potentially significant national resource, one which constitutes a quasi-public utility overlapping the traditional boundaries between the public and the private sectors.

As noted previously, the developments in this field are characterized by such rapid change that it is virtually impossible to deal "once for all time" with appropriate guidelines for policy. This report, and its predecessor, are offered as a suggested basis for policy in key priority areas. Much more remains to be done. One can note, for example, the need to deal with the question of privacy of information and with a host of other "social-impact" aspects of the computer revolution.[2] The Science Council is currently assessing its agenda for further policy reviews in this area. We would welcome comments and suggestions from those who share our concern that Canadian computer policy develop to meet the challenges which this evolving technology and its continuously expanding range of application pose for the future of our country.

[2]See for example: *Privacy and Computers*, Report of the Department of Communications and Department of Justice, Information Canada, Ottawa, 1972. Catalogue No. Co21-3/1972.

Perspectives on the Significance of a Computer Industry

To many, particularly those engaged in the computer industry today, it is "obvious" that the computer industry is "important": to others, such statements would be subjected to intense scrutiny. For those who do have doubts about the validity of a discussion on industrial strategy for this particular facet of man's activity, we will attempt to make some answer to the question.

"Why bother with a Canadian computer industry in the first place?" A few years ago, it would have been easy to give an answer based on *a priori* assumptions about the virtues of new and exciting technologies, and the conventional wisdom of conventional economics. Now – particularly if we look to the future, that is to a span of decades over which a computer industry would go through its major developmental period – conventional answers seem to be inadequate. We are less comfortable than we were with notions of technological gigantism; we have seen, too often, that well-motivated technological advances entrain with them unforeseen and serious consequences. Accepted economics has come under fire; a new, ecologically and socially oriented economics, aiming less at exploitation of nature than at achieving some sort of dynamic equilibrium with nature, seems to be emerging. Embarrassing questions are asked. Why strive to create yet another new, massive industry when we are having difficulty sustaining the massive industries we have inherited from the past? Why strive to define an industrial strategy for Canadian computer development when more basic issues are upon us? Is this not a trivial exercise in an age where basic values, social forms, whole nations, industries, and cultures seem to be in the process of being cast back into the historical melting-pot?

These major questions about the direction of social change, and the nature of changing values, have been raised time and again in the last few years – not least in some of the more general discussions and analyses that have taken place under the auspices of the Science Council of Canada. Yet, the discussion has seemed to trail off once one attempted to come to grips with specific activities where there is a clear interface between technology and society. There is always a certain haziness in our forecasts about the future. If predictions were clear-cut and easy to make, there would be no need to regard "futuristics" as anything other than a logical extension of the short-term planning process. This haziness accounts, to some extent, for the difficulties we face in relating the general discussion of change to the specifics of change and development in a particular area. Yet a start must be made somewhere. Given the centrality of ongoing developments in the computer field compared with the processes of development and change in contemporary society, it seems appropriate that some such effort be made with regard to this particular field.

Consideration of the economic and technological aspects of the "computer revolution", as they impinge on the development of our society, remains as an appropriate area of concern when setting objectives and criteria for the development of the Canadian computer industry. But while such considerations are necessary elements of any attempt to establish objectives and criteria, they are not, in themselves, sufficient to such an effort. The framework that we establish for the definition of policy options must bring together the shorter-range economic and tech-

nological considerations and the longer-range elements of political, social and cultural transition.

To do this, we begin by attempting to suggest just how significant the "computer revolution" really might be, particularly when we place it in historical perspective. Oddly enough, much of the boosterism about computers, over the last decade or so, has erred by *underestimating* the industry. A "growth industry" has been identified; the "transformative" aspects of this industry and this technology have only begun to be explored.

Historically, the most significant of man's cultural revolutions have come to pass when man's consciousness of his place in the world and his ability to do something about his place in the scheme of things, have advanced together. The harnessing of steam for power, and with it the emergence to significance of the modern industrial capitalist and the professional engineer, was not just important only in so far as it magnified man's capacities with regard to material production. Its greater significance was in the realm of man's consciousness of himself and of his relationship to nature. The steam engine powered an intellectual revolution. Western man became preoccupied with growth and change, and his efforts to understand nature were harnessed to newly-awakened aspirations to "master" nature. We are only now beginning to revise the value system that developed during the "Age of Energy": an age to which the harnessing of steam gave an initial impetus.

In the period into which we are entering, the computer and related technologies are likely to perform a similar function in relation to man's aspirations as did that of the steam engine during the first few generations of the period 1750 – 1950. We confront a *transformative technology*, a technology which gives impetus to fundamental change in human thought and action. Such technologies are to be distinguished from *extrapolative technologies*, those technologies which (however significant) represent: (a) extensions from an existing technological base (as the railway engine was from the earlier stationary steam-engine) and; (b) relate to already perceived societal functions which are to be carried out in improved and more efficient fashion. The railway engine moved goods and people conveniently over long distances – but the industrial steam engine helped to create a society with an increased need for such movement. The computer is already beginning to work changes in our society, and to create needs (barely discerned, as of the present time) which will have to be met in new, as yet unforeseen, ways.

We are already beginning to perceive some signs of the impact of the computer on social consciousness and action. Surely it is significant that some of those most intimately related to the development of the computer have been among the most concerned and innovative prophets of major social change. We may also note the speed with which technical concepts (feedback, input-output, systems) associated with computer technology have passed into general usage, and have become organizing concepts for the way in which we think about ourselves (in certain of the psychological orientations) and about society. The move away from linear to non-linear reasoning has surely been given impetus by our interplay

with a multi-levelled, random-access technology for organizing, retrieving and utilizing information. The ability to aggregate information and to play with it – to use simulation and other techniques – opens vistas of intellectual power (and even the promise of social wisdom, which is something rather different from social knowledge) more challenging than the vistas of material power opened up by the harnessing of steam. In ways that are still rather crude, we are even now beginning to reap some benefits from the first stages of this revolution: the first tentative steps toward the creation of a physiological-psychological "brain science" that uses the computer to make new connections among disparate sets of data, and that is partly based an analogues between computer processes and brain processes; and – to cite another example – in our growing awareness of the cumulative evidence pointing to the need to revise the socio-economic imperatives inherited from the age of industrialization. If we look a little bit into the future, it appears a reasonable hypothesis to suggest that development of computer technology, and the associated "software" spillover into our concepts and knowledge technologies, together with developments in the sciences and technologies associated with the production and utilization of energy, constitute the cutting edge of major and comprehensive technologically-based socio-cultural change.

Ultimately, then, the reasons for development of objectives, criteria and strategy in the computer field, relate, not only, or even primarily, to our economic and technological concerns, but more fundamentally to concerns about human creativity and development. Transformative technologies like the computer are important in so far as they enhance our ability to continue the primal human activity of exploring the world around us. Willy-nilly, we are already sufficiently into the development of computers that our interaction with them is going to change the way in which we perceive and act in the world around us. We need to bring some part of this adventure under reasonable strategic guidance: we need to establish some appropriate objectives and criteria for computer development (and thus also for *our* development in relation to computers) even while we recognize that no complete and comprehensive strategy can be set in advance.

Objectives and Criteria for Development of a Canadian Computer Industry

A strategy for development of a computer industry in Canada is one part, albeit only a small one, of the effort to retain for Canadians some possibility of their making decisions about their rôle in this transformative process. Our earlier Report, on computer-communications networks has argued the case for a priority approach to the development of new and innovative communications networks: another vital thread in the skein of policy for the future. In the present Report, we shall attempt to balance considerations of the transformative potential latent in computers, with the practical and immediate considerations of an economic and technical nature which serve as constraints on Canadian endeavours in this field. We shall try, in other words, to identify some priority areas for development of the Canadian computer industry that are reasonable in terms of attainability, and that at the same time might retain for Canada the ability to interact directly in the shaping of a most significant emerging technology. To do so means that, at the outset, we must establish the relationship between development of a computer industry and major national objectives. We must also delineate some criteria or yardsticks for the performance of the industry and for public policy relating to it.

A general sketch of some possible objectives and criteria is presented in the remaining pages of this chapter. Instrumental objectives having to do with strategy and how strategy might be implemented are left for the appropriate portions of the chapters that follow, where we discuss specific aspects of the computer industry in Canada. Before turning to even the general objectives and criteria, however, we will anticipate our analysis somewhat by presenting, for the benefit of the general reader, a capsule outline of the computer industry.

Elements and Structure of the Computer Industry: A Preliminary Outline

When we speak of a computer "industry", three general considerations must be kept in mind, by way of preliminary orientation:

1) The computer "industry" is really *a closely-linked network* of industries and commercial activities encompassing both manufacturing and service activities, centering on the production, distribution, and utilization of goods and services based on computer and related technologies, in both their hardware and software aspects. It is *not* a single, tightly defineable industry on the model of those which emerged during the industrial revolution *per se*. Indeed, the term "industry" may be somewhat obsolescent (except in terms of corporate organization) in describing these economic activities. An analogy may be useful: we conventionally think of the "automobile industry" as that industry which manufactures automobiles, assembling them from components, and then distributing them to consumers. We would come closer to conceiving the automobile industry in terms that are perhaps analogous to the computer industry if we included not only the production and distribution of cars, but also the petroleum industry, the highway construction business, much of modern advertising, driver-training programs, etc.

2) Even when we attempt comprehensively to define the computer

industry (or industries), its boundaries are somewhat fuzzy; they overlap into other areas. Our first report on computer applications and technology focussed on the emerging linkages between computer development and modern telecommunications. In the present Report, when we discuss the development of large-scale integrated circuits (LSI's) which serve as a basis particularly for new minicomputer developments, we are overlapping into the general area of electronics, where such devices have multiple potential applications. The existing computer industry, commercially, is closely linked to the distribution of conventional business equipment; card-punch and card-sort equipment, which has been used as a major part of the input-technology for computers, and existed prior to the development of the computer, was (and is) used independently in a variety of business and research applications. On the service side of the computer industry, it is often difficult to draw a line between advisory services offered concerning computer utilization by business, and a variety of advisory services offered to management.

3) The content of the industry is equally comprehensive and diffused on a "hard-soft" (tangible-intangible) continuum. At one end of the continuum, what are produced and offered for sale or lease are machines: complex machines which, to the casual observer, present themselves as aggregates of metal, plastic, complex wiring, buttons, arrays of electric-light bulbs, visual displays, and/or sheets of paper unreeling through a device that looks like a glorified teleprinter – something very tangible indeed. At the other end of the industry are men and women dealing in ideas, and charts, doodling on scratch-pads, and conferring over what (to the uninitiated) seems to be mysterious hieroglyphics – a somewhat abstract activity which, as some cynics have suggested, seems most appropriate to a new technocratic priesthood, not to an industry.

At the heart of all this activity, which for the reasons cited is hard to delimit and define, is the *computer*, or rather the *computers*, for they very considerably in scale and in power. While it may be appropriate in another context to deal with special-purpose machines (e.g., analog and hybrid computers, fluidic computers, and wired-logic computers), in this Report we are concerned primarily with *general-purpose computers*: information processing machines whose design and functioning incorporates an internally-stored program and digital electronic technology. Such general purpose machines are the ones that are likely to have the greatest economic and socio-cultural impact.

A computer consists of a **mainframe** (a central information-processing unit and the immediate means of access thereto) and a variety of **peripherals.** The central processing unit (CPU) is the "core" of the computer. It is here that basic memory, arithmetic, logical, and internal control functions are performed. Whatever the size of the computer, a super-computer costing more than $2 million for the mainframe, and housed in a specially-designed environment, or a minicomputer costing somewhat less than $20 000, and sitting on a desk in a laboratory or an office, or the machines ranging between the two extremes, a central processing unit is at work.

Peripherals are devices attached to the computer mainframe so that, in fact, information may be processed by, and through, the CPU. For pur-

poses of this Report, peripherals are divided into two main types:

High-speed devices for storage and rapid input and retrieval of data (e.g., disc files, drums, magnetic tapes, line printers, card readers, various types of scanners, etc.) which are usually wired directly to the mainframe, and;

Lower-speed devices which are "terminals" (both teleprinter-like machines and various graphic displays) which allow for convenient man-machine interaction, both as regards communication by the operative to the machine, and as regards the operative's ability to "read" or "view" processed data in a form usable by him. Terminals of this sort may be quite remote from the mainframe, connected to it by various existing communications technologies. (Hence the importance of the computer-communications questions which we discussed in our Report No. 13.)

So far we have been discussing, whether in terms of mainframes or peripherals, the more tangible physical equipment which we can see around us when we visit a data processing center. In the accepted jargon of the industry, what we have been discussing is **computer hardware.** For the hardware to be used in any meaningful fashion, we need to couple it with appropriate **computer software.** It is the software which "makes the computer go", which guides its functioning in a fashion responsive to the information needs of the human beings who are utilizing the computer. In the most general sense of the term, "computer software" refers to the *programs* (sequence of instructions) that are written (encoded) by computer programmers to specify the operations that a computer is to perform and the interrelations among these operations. For purposes of this report, we classify software as either "systems software" or "application software":

Systems software is the software used to monitor and guide the general operations of the computer hardware so as to enhance its efficiency and simplify such programming as may be required for specific jobs (i.e., certain operations are already covered by the systems software, and do not have to be rewritten when programs for applications are developed). Because systems software has to do with the general functioning of the machine, it has generally been developed and provided by the supplier of the computer mainframe.

Application software are programs written to perform a specific job or application (e.g., to prepare pay cheques, or to control certain machinery in a steel mill). Because of the wide variety of activities for which a general-purpose computer might be used by individual enterprises, application software is usually supplied or developed in response to the needs of a particular user.

Bearing in mind this outline of the main elements that come together to constitute a usable computer (an outline which is necessarily superficial, from the point of view of some of the readers of this report), we can now make a preliminary classification of the various groups that come together to constitute the "computer industry". Pending a more detailed breakdown that will be delineated in the body of this report, we can identify three segments of the industry:

1) *Hardware suppliers* are involved in the design, manufacture and distribution of computer hardware, whether mainframes and/or peri-

pherals. (In addition, suppliers of hardware usually find it economically worthwhile to design and market systems software that complements their particular brand of hardware.)

2) *Service suppliers* are the owners and operators of service bureaux, software houses, consulting firms concerned with advising on data processing, facilities management companies, and systems houses. In short, they are in the business of supplying computing services, either on the client's premises or in the various ways whereby the client transmits his data to the service house. They provide information and expertise in aid of the client's efforts to use computers effectively and efficiently in relation to his (the client's) own needs.[1]

3) *Miscellaneous suppliers* provide facilities for data communications, market facility equipment, or operating supplies (e.g., computer punch cards).[2]

These are the major segments of the industry. Of course, we have to consider others as well: the various kinds of clients, and their needs; the facilities for educating and certifying those who work in the industry. But, in the main, this report will be concerned primarily with the suppliers of goods and services in the computer field, and with public policy relevant both to their needs and to their responsibilities in our society and economy. We have already dealt, in Science Council Report No. 13, *A Trans-Canada Computer Communications Network* with the most important of the miscellaneous suppliers, i.e., those involved in the data communications field. Accordingly, the present Report focusses primarily on suppliers of hardware and of services.

Some Relevant National Objectives

We can now indicate what our objectives might, in general, be in this area of national socio-technological policy and we can begin, in rudimentary form, to suggest some of the ways that certain values in our society impinge upon the development of a Canadian computer industry. The following general statements are elaborated upon and further assessed in other appropriate parts of the report.

Our objectives may be classified according to two general questions, the first having to do with *national objectives* that impinge on the development of the computer industry, while the second relates to the *criteria* we establish for industry performance.

How do salient national objectives, and significant realities of national life, define the scope and limits of a program for developing a Canadian computer industry? Some elements of an answer might be as follows:

1) The general purpose of public policy should be to enhance the ability of Canadians to make and/or affect collective decisions bearing on their collective activity, while enhancing (to the greatest extent possible consistent with the necessary collective element in social development) the

[1]The various subdivisions of this segment of the industry are defined and discussed in "The Canadian Computer Industry – Opportunities and Constraints."

[2]Of course, major firms – most notably, most of the large multinational computer companies active in Canada – will engage in activities in more than one of these three segments.

range of options available to them in small social groups and as individuals. Given the existing significance of the computer, and its likely significance in the future, this general purpose of public policy would be weakened in the absence of a comprehensive policy for the development and utilization of computers. Given the importance of the supply and distribution of computer hardware and software for the development and utilization of computers in society, now and in the future, we would argue that no effective computer policy is possible without some decisions being taken about the mode of supply (including manufacture, if appropriate) and distribution of computer-related goods and services in Canadian society.

2) Because of the economic and technical realities of the computer industry (capital intensity; high, and rapidly changing, technological content; intense international competitiveness centering on the central rôle in the industry of a single multinational corporation), some degree of concentration of effort is required in any Canadian effort to establish a rôle for this country in the future development of the computer. This will be especially important in the strategies we develop for policy in the 1970s and 1980s. At some point, however, concentration of effort must be balanced against two realities of Canadian life: the multiregional character of Canadian economic activity and Canada's society and culture; and the need to safeguard against the over-concentration of economic power that is an inherent danger when we are dealing with such a significant transformative technology.

3) An effective national strategy must seek to do more than replicate what has already been achieved elsewhere. Where an indigenous base for a significant, specialized, and innovative approach to computer development seems to exist, or be capable of development (e.g., as regards the potential for using large scale integrated circuits (LSI) capabilities not just to produce exportable components, but to produce Canadian minicomputers), such possibilities must be carefully looked into, and – if at all possible – their development must be stimulated. The goal here is, in part, to make real the possibilities of Canadians sharing in at least part of the creative-cum-practical potential inherent in the computer as a transformative technology.

4) In more immediate terms, computer development must be closely monitored, with a view to linking it to national and regional employment and education programs. More sophisticated information must be generated concerning the types and quantities of employment possibilities (and demands on education) associated with various levels, and "mixes", of computer development and utilization in this country. (This latter task has not been undertaken in this Report but it is our hope that we have identified the need for such an activity.)

5) It must be recognized that the way in which the service side of the industry develops (its configuration, ownership, composition and span of activities) will, in many respects, be vital to the way in which this country, as a modern, information-based and "data-rich" society, can develop in the future, including the very near future. As this Report will argue, one very urgent series of decisions, linking developments in the service sector of the industry to national objectives, and, indeed, to the national *ethos*, has to do with whether effective public policy decisions can and will be made, in

timely fashion, as regards the transmission of computer-storable data to "data banks" in the United States, where it will be more difficult to regulate the use of such data according to such legislation as the Parliament of Canada and the various Provincial Legislatures may, from time to time, see fit to pass.

Other points might well be made with regard to national objectives of a comprehensive kind and the computer industry. However, the above five points should serve to indicate at least some of the general considerations that bear keeping in mind.

Criteria for the Canadian Computer Industry

The points that we have just made relate, primarily, to the kind of public policy questions that would have to be answered if we want to develop a Canadian computer industry and try to fit it into the general set of values and objectives that are relevant to the future development of Canadian society. Another set of points – "criteria", more than "objectives" – has to do with the computer industry, its performance and its responsibilities. What can and should we reasonably expect of an industry which is so potentially significant? Some of the major points that we should consider are the following:

1) The need for sufficient Canadian participation in, and control over, the industry and its various segments in order to ensure a primary responsiveness to the perceived economic and social needs of this country (including an appropriate consideration of the profitability of the industry) rather than a primary responsiveness to decisions made elsewhere with little specific attention to Canadian conditions or Canadians needs;

2) The maintenance within the industry of standards of professional, technical and business responsibility appropriate to an industry which is going to have, in increasing measure, a major *public* impact and which will involve major public expenditures each year (irrespective of the particular form of ownership system *within* the industry and its segments);

3) Sufficient specialization of endeavour to enable Canada to meet some of its own needs for hardware from its own capabilities, and to develop markets abroad in selective areas of computer hardware and software; conversely, some degree of intelligent planning by the industry, in cooperation with government, so as not to jump into ventures involving international competition where the records suggest that the odds are weighted far too heavily against any kind of venture that Canada could engage in;

4) A degree of corporate and governmental responsibility such that the thrust of industry development shift toward the build-up of ventures sustainable over the long-haul, even in the face of the short-term attractiveness of ventures involving less-sustainable activities (governments should be especially careful as regards the effects of incentive policies);

5) The development of appropriate linkages, and of well-thought-out and implemented division of functional responsibility, among government laboratories, the universities, and industry, so that each plays a rôle in the development of computers without crowding out the effective possibilities

for growth and innovativeness in one or other of the associated sectors;

6) The provision of employment possibilities for Canadians in as many aspects of the industry as is possible over any given period of time;

7) A conscious effort to "demystify" computers and computer-associated activity, and provide information to the public about the development of the industry, so that citizens will be better informed and able to exert an influence in an area of socially-relevant technology that is going to be vital to their lives and to the future of the economy and of the society in which they live;

8) A concerted effort to work out an appropriate balance between two competing social needs and values: on the one hand, the provision of legitimate access to computer-stored information required for more rational and efficient public and private decision-making; on the other hand, protection of the individual's right to an appropriate degree of privacy and, at a minimum, his or her right to be safeguarded against capricious and illegitimate use of computer-stored personal information, and what must frankly be called sloppiness (already an irritant to many customers who deal with firms that make use of computers) in the handling of data.

Not all of these criteria will be discussed in detail in a report of this type but these are some of the points we have had in mind in carrying out our study of the industry.

The development and use of computers, which means, in part, the making of decisions with regard to this somewhat unique "industry", involves not only the harnessing of the skills of the technicians and the making of decisions by the technocrats. At the most basic level, this industry and its development requires us to make some very real choices as to value, and as to how we adhere to our values in practice. Here, indeed, may be a key area where we test whether our social values can, in fact, be articulated and applied to the moulding of a new society. Appropriately, we may close this segment of our Report with a quotation from Norbert Wiener, the mathematician who was so close to the research out of which computers evolved, and who became so concerned with the significance of the computer revolution as measured not in technical, nor solely in economic, but primarily in human terms:

"[The] new industrial revolution is a two-edged sword. It may be used for the benefit of humanity, but only if humanity survives long enough to enter a period in which such a benefit is possible. It may also be used to destroy humanity, and if not used intelligently it can go very far in that direction. There are, however, hopeful signs on the horizon.... I have been delighted to see awareness on the part of a great many [business people] ... of the social obligations of those responsible for management to see that the new modalities are used for the benefit of man, for increasing his leisure and enriching his spiritual life, rather than merely for profits and the worship of the machine as a new brazen calf. There are many dangers still ahead, but the roots of goodwill are there, ..."[3]

[3]Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society*, Doubleday Anchor Books, Garden City, New York, 1954. Revised edition, p. 162.

The Canadian Computer Industry in Ecological Perspective

In recent years, we have become increasingly aware of the need to look at living systems in ecological perspective; that is, in terms of a system of interdependent linkages among various forms and levels of life. We look at a particular sub-system by locating it, first, in its environmental life-space; we seek to map its relationship to other sub-systems, in terms both of its impact on these and the impact that they, in turn, have on it. By analogy, we may speak of the ecological setting of an industry: how that industry (perhaps in one country, such as Canada) is located within, and related to, a wider network of industrial systems. For purposes of this chapter, we shall deal with three kinds of structural relationships that are significant for an understanding of the Canadian computer industry, as it presently exists:

- The relationship of the computer industry in Canada to the international computer industry;
- The main structural relationships that exist among the major subdivisions of the computer industry within Canada;
- Some of the linkages between the computer industry itself and actual and potential users of computers and computer services (i.e., the relation of the industry to its markets).

International Industry

In the two decades since the sale of the first production-line computer, the computer industry has become a major international industry. A recent speech by an official of the International Labour Organization notes that, of the upwards of 150 independent political entities in the world (many of them "mini-states" by any reckoning), only two have not yet installed some sort of computer facility as an aid to the conduct of public business. Following the governments, which have generally pioneered in the use of computers, businesses and educational institutions throughout the world have either acquired computers of their own or made arrangements to have their needs for electronic data processing serviced by outside firms. In the arena of business and government, use of the computer has evolved from a luxury to, in many cases, a necessity. (Though we must note that there have been many cases of "overselling" by aggresive representatives of manufacturers or service firms.) The growth of perceived needs has interacted with the growing technical sophistication and reduction of unit-costs (i.e., costs of handling "bits" of information) to give impetus to the mushrooming of this industry on a worldwide scale.

The present magnitude of the computer industry, and some suggestion of its future prospects may be briefly indicated at this point.

The early lead taken by the United States in the development of computers, the relationship of this development to governmental support for the technology (as a spin-off from defence and space programs), and the cumulative build-up of technology and invested capital in this area has contributed to American dominance in this area. According to Mr. Isaac L. Auerbach, president of the Auerbach Corporation of Philadelphia, speaking at a recent computer symposium in Toronto, the installed base of computers at present (with projections to 1976) may be broken down, by country and area, as is shown in Table I. About 90 per cent of the world

market, according to the same source, is supplied by American companies. Among the American companies, International Business Machines (IBM) has a dominant position. It accounts, internationally, for the supply of almost two-thirds by value (about $30 billion) of installed equipment.

Table I–Distribution of Installed Computers, Present and Projected

Installations	Present Value $ billion	percentage	1976 Value $ billion	percentage
U.S.A.	30	60	47	53
Japan	3	6	10	11
U.K.	3	6	5	5.5
Other Europe	9	18	18	19.5
Other non-communist countries	5	10	10	11
Total	**50**	**100**	**90**	**100**

Source: Mr. Issac L. Auerbach, President of Auerbach Corporation of Philadelphia, Speaking at a Recent Computer Symposium in Toronto.

The trend is also discernible if we look at individual markets (other than those in the "socialist" countries – though even here, leading Western firms have begun to penetrate). We may take, as an example, computer sales in the Republic of South Africa. From the late 1950s to the beginning of the 1970s, about 400 electronic data-processing systems were sold in South Africa. The rate of growth of this market was about 25 per cent a year, and the value of installed equipment, by the beginning of the 1970s, was around $140 million. Almost two-thirds of current business was generated by American firms; IBM claimed a 45 per cent share of the market, while National Cash Register, Burroughs, and Control Data Corporation divided a further 20 per cent among themselves: most of the remaining business was handled by the British company, International Computers, Ltd. As of 1970 the Univac division of the Sperry Rand Corporation was launching an effort to penetrate this market (aiming at a 7 per cent share of the market by the mid-1970s, while another American company, Honeywell, was setting up a joint venture with a South African company. Univac's venture illustrates some of the complexities and linkages in the international computer field. Its first big delivery, of a Univac 1108, was to a Johannesburg service bureau jointly owned by the Anglo American Corporation of South Africa, Ltd., and Computer Sciences Corporation of Los Angeles. Three other South African cities were to be serviced, via data communications linkages, from this center.[1]

Internationally, the computer business, particularly as it relates to the supply and distribution of large mainframe computers, is one that is characterized by competition among giant corporations, each zealously safeguarding and trying to extend its share of the market. To penetrate the market requires major and sustained commitment of capital and of organizational capabilities. Outside of the United States, various devices have had to be resorted to in order to build sufficient power to engage in competition with the multinational giants: the aggregation of British computer com-

[1]"Numbers Game in Africa", *U.S. News and World Report*, Washington D.C., May 4, 1970. p. 85.

panies into a major, government-encouraged, computer company, International Computers (Holdings), Ltd.; the recent Japanese move, at government initiative, to form three stronger computer companies out of six manufacturers that already showed some signs of economic and technological strength; the various moves at trans-national mergers and marketing arrangements. In this field, the race may not necessarily be to the swift – as the ruins of so many ventures, launched with high hopes, seem to demonstrate – but rather to those who are powerful enough to last the distance and to bear the costs of competing with the giants of the industry, particularly IBM. It is hard to mount major challenges to the existing market configuration, due to the difficulties of mobilizing capital and organizational capabilities on a scale, and at a level, required to sustain any meaningful challenge.

At the present time, the large multinational corporation seems to have inherent advantages when engaging in across-the-board ventures in the computer manufacturing field. Given the scale of effort that is required to develop, manufacture and market this equipment, centrally-directed strategies aimed at taking advantage of savings in cost in particular phases of the work in one or another country can lead to significant total savings for the manufacturing company. For example: a large international company headquartered in the United States, may, in the manufacture of its line of computers, pick up on research conducted in its Montreal research laboratories, carry out development, design and testing near Cambridge, Massachusetts, ship blueprints and specifications translated into Chinese to a subsidiary in Taiwan where electronic components are to be manufactured, and re-import components into the United States for assembly at a factory near Chicago. At each step of this process (and our example is loosely modelled upon an actual case) marginal savings may be effected; these savings follow from the working, in practice, of various instances of comparative advantage and international division of labour; they can be brought together and orchestrated by central management to give an edge to that company in competing against other companies who must carry out all, or most, of the process in a single country.

The multinational corporation may also be favoured by its ability to gear itself to international variations in the market. A case in point is the IBM 3000 series, which was marketed widely in Europe throughout the 1960s:

"A splendid example of the kind of business machine that IBM sold in volume throughout Europe in the nineteen-sixties was a compact accounting system designated as the 3000 Series. It was a case of a promising demand being satisfied by a beautiful product, explicitly put together to meet continental needs and kept off the market in the United States. Contrary to usual IBM practices under which domestic (U.S.) operations take care of design and development, the 3000 sprang from the World Trade Corporation....

"The laboratories of Herr (Hans) Borsdorf's IBM Deutschland designed the 3000 originally, but sales and technical people from a dozen different countries studied it in a collective collaboration that made it wonderfully

applicable to a large number of unrelated operations. It was a real all-purpose product based on punch card usage, non-electronic, relatively inexpensive, capable of performing basic accounting functions; and it wasn't very heavy or very big. It was intended to captivate the small business man, the little company, and it was a bargain. It could be bought outright for $16,500 and installed in a space occupied by two or three small desks, or it could be rented for $340 a month. Volkswagen, no small business operation, took thirty of them for automobile agencies around the continent at a cost of nearly half a million dollars. In six of seven months, sales of more than $13 million were reported. As fast as they could be produced, they were installed, and in a couple of years there were thousands in operation all over Europe. They were exported, too, to Latin America, Africa, and the Far East. But because the 3000 could not be produced at a competitive price in America, it was never marketed in the United States or Canada. Cost-conscious buyers there had to settle for more sophisticated electronic equipment that was more efficient, operated at higher speed, and cost a great deal more than $340 a month."[2]

The IBM 3000's were not, of course, computers; but this is precisely the point – given its far-flung operations, both as regards manufacturing and sales, the company could gear itself to what would best sell in particular markets. In this case, it developed a product line in Europe that it could not, or would not, market in its domestic market area. Given the barrier erected in this case between the North American and overseas markets, it was possible to gain maximum benefit both from the "non-computer" and from the more sophisticated electronic equipment that was used, more expensively, to perform the same function in North America (perhaps in excess of customers' needs). An optimum trade-off was approximated, rather than allowing a situation to develop whereby one machine would cut into sales of the more sophisticated machine in the home market.

In general, the propositions about rationalized operations on a multinational basis, engaged in by corporations that are rich in capital, technology, management, and marketing skills, as put forward in the recent Study of multinational corporations[3], carried out for the Science Council, hold *a fortiori* as regards the manufacture of mainframe computers for international markets. The realities of international competition in a field so dominated by major multinational corporations must be borne in mind when assessing Canadian strategies with regard to the international computer market. There are significant constraints that limit Canada's ability to compete for exports in this field. As will be discussed in some detail later in this Report, the lesson seems to be that, if export markets are to be developed, the optimum strategy would be to seek and to exploit special situations, that is, exploitable "gaps" that may exist or may emerge internationally.

[2]William Rodgers, *Think: A Biography of the Watsons and* IBM, Stein and Day, Signet Books, New York, 1969. pp. 258-9.

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

We have already touched upon the rôle of IBM in the international computers field. Any survey of the international situation would lack a key element were we not to attempt some generalizations about the development of IBM as the dominant company producing and marketing computers and ancillary goods and services. To begin with, it should be noted that the present concern for IBM's dominance, the tendency to treat it as a sort of corporate "bogeyman", is not entirely justifiable. It can be argued that the rapid development of the computer industry, its evolution to a high degree of sophistication with regard to its technology, and the emergence of the computer as a pervasive phenomenon in all of the industrialized societies, might not have occurred (to this degree, and with this rapidity) had it not been for the lead given by IBM's aggressive development and diffusion of its product line. On the other hand, the association of commercial dominance in a technologically transformative field with any single company (even if that company were to act in a most benign fashion) must give pause to anyone who reflects upon how significant computers are, and are likely to become, in the present phase of development of society. Whatever IBM has contributed to the development and diffusion of this technology, it is understandable that its position and rôle is now increasingly being questioned and that various efforts are being made, in the United States and elsewhere, to find ways to reduce or dilute IBM's hegemony in the computer field.

The bases of IBM's hegemony are two-fold: technological, and even more significantly, organizational. On the technical side, IBM inherited, from the pre-computer era, the patents and processes associated with Herman Hollerith's method for handling data via the medium of punched cards. These had originated as far back as 1890, when he developed a "piano roll" system for the U.S. Census bureau, so that data could be handled by punching holes in sheets of paper. Hollerith's later development of this process was undertaken under the auspices of the Tabulating Machine Company, which later became one of the components of IBM. In the interwar period, IBM was already marketing fairly sophisticated pre-computer card-punch and card-sort equipment based on the Hollerith patents. A major boost was given to the production and sale of this equipment (as well as other, mainline, IBM office equipment) by the Depression. At a time when other large corporations were in difficulties, IBM substantially increased its business, having found a major customer in the U.S. Federal Government, whose New Deal agencies were developing a new type of public policy dependent on the ability to monitor and effectively process large quantities of socio-economic data. Thus, in the pre-computer period, a basis was laid, deriving from well-established IBM patents and expertise, for the company's close association with the U.S. Federal Government's mounting needs for effective data processing. This association was to be extended and strengthened under the impetus of World War II and the Cold War. When World War II came, it was natural to turn to IBM to develop, in conjunction with leading American universities large-scale sequence controlled calculators which were employed in a variety of war-related research applications (e.g., production of nautical almanac tables, time-tide tables for Pacific islands landings, fire-

control system calculations for the B-29 bomber). Ultimately, this work, as well as contracts between the company and electronics researchers at major university research centres, were to lead IBM to a position in the vanguard of the developments that were to result in the early generation of computers, the prototypes of those that we now know.

But the technological factor was not the dominant one in IBM's strides toward hegemony in this field. Other companies, some of them with much greater expertise in electronics and in the relevant areas of engineering, were also pioneering in this field in the late 1940s and early 1950s. While IBM was not a laggard as far as the technology was concerned, it was somewhat conservative (compared to other companies) in the speed with which it moved from a technological advance to the actual marketing of machines. Time and again, in the development of computers, it was other companies who first moved to market an advance – only to fall by the wayside while IBM forged steadily ahead.

A number of factors combined to produce the organizational and marketing strength of IBM in both the United States and international markets:

– An aggressive approach to marketing at all levels, from the development of strategy at the top to the training and motivation of the individual IBM salesman. This is a long-standing and carefully maintained tradition at IBM, going back to the early days of intense competition in the sale of cash registers and office equipment.

– The pre-computer links that were established with customers for conventional business and office equipment. IBM, as an established business equipment firm, had a beachhead in the market and could eventually exploit this in the sale or lease of computers. Other companies which developed their computers from a base in the electronic and engineering fields had to create new markets among users of business equipment.

– IBM's history has been one of steady growth (even in the Depression, as already noted). It entered the computer field as an already strong company from the point of view of capitalization, research and development, and corporate organization and management.

– The close contacts with the U.S. Government, established by IBM from the 1930s on, were a major asset, both as regards research and development, and with respect to acute awareness of emerging needs of government for more and more sophisticated data processing equipment. Developments pioneered to meet government needs yielded spillovers into the regular commercial market.

– The established product lines to meet diversified business equipment needs provided a cushion against the hazards of marketing in the newly-emergent computer field.

– As early as the 1920s and 1930s, IBM was actively engaged in the development of major export markets, and even before World War II it had established a significant overseas basis for operations in Europe.

The battles with competitors which IBM won on the basis of these long-established strengths are part of the lore of the computer industry, and need not be discussed here in any detail. In terms of the international market, one case may be illustrative, since it involves a major effort by a

government to support an indigenous company in its efforts to compete with IBM in the home market:

"... IBM's comparatively mediocre computer line in the late 1950's had caused the confident [French Company] Machines Bull to invest heavily in the advanced but costly Gamma series. Manufacture in 1960 of the highly regarded machines, the first to appear with germanium diodes, shook up IBM considerably.

"... Radio Corporation of American and Machines Bull came to an understanding under which the latter received patent rights and U.S. training for its engineers; in return RCA machines were allowed in France ... [In] preserving its virtue on paternal orders from the righteous de Gaulle, Bull lost something else not quite so irreplaceable: money. Even with sales up 21 per cent in 1962, profits fell steeply. Bull had to give as much as 35 per cent discount to compete with IBM machines.... With much of its equipment on lease, Bull could not wait out the period of return on rentals. A new company, half French and half American, was formed to take mortgages on leased equipment and get working money back into the Bull bank accounts.

" 'It was not a normal deal', said a Bull man in reviewing the matter. 'Passion was involved, reason was not....'

"In the two-year period during which Bull tried to make its superior Gamma computer the sought-after princess, if not the queen, of the European market, software, programming, and service problems compounded by capital shortcomings made it necessary to become less discriminating [about foreign participation], regardless of de Gaulle and national pride. Having grown from annual sales of $1,500,000 to nearly $100,000,000 in thirteen years, a record not achieved by IBM itself, the fall of Bull was all the more humiliating because it was visible to much of the world. A loss of $25 million in 1963 came at a time of record high sales, when the Gamma Computer was indeed making inroads on the market, when Bull had service centers all over Europe and Latin America, and was selling equipment for Remington Rand's UNIVAC in the United States. Bull simply couldn't keep it up, and in the faltering interim, IBM drove forward with such force that the French company reeled.

"... [In 1964] control [of Bull] passed into the hands of the Banque de Paris et des Pays Bas, and a few weeks later [Bull's president, Joseph] Callies was succeeded by the bank's nominee, Roger Schultz. The government promised $63 million in capital and contracts, and it was disclosed that an agreement had been reached which accommodated de Gaulle's requirement for the preservation of national honour and General Electric's insistence upon capital control commensurate with about $50 million. The big power in jet aircraft engines and the developing nuclear industries of the United States had bought its way into the European computer market....

"Reduced to trapping size by IBM, Machines Bull would now be taken over by General Electric, said Joseph Callies; full control was "inevitable" in view of the fact that the annual sales of Olivetti (with which Bull had a financial and producing agreement), Britain's ICT, Germany's Telefunken and Bull did not, combined, equal the cash flow of IBM.

"... GE wound up with two-thirds of the company

"... IBM recovered the bit of the market it had lost for a time when Bull was going well, and things settled down in Europe to the old operational balance of power in which IBM took the bulk of the computer market, with all other producers sharing between 20 and 25 per cent."[4]

Based on the continuing significance of many of the factors already cited as reasons for the rapid development of IBM as the major power in the computer field, and buttressed by the very magnitude of the company and the momentum that is built into its international operations, the dominance of IBM is likely to continue, both in the United States and on the international scene. However, in the coming decades, the *degree* of IBM dominance may diminish somewhat, thus contributing to a greater pluralism in the computer field and to some enhanced possibilities for competing companies which carefully appraise the market in search of special competitive opportunities.

Some of these factors are the following:

– "Unbundling": this refers to the changing behaviour of IBM as regards the conditions surrounding the use of hardware. In the past, IBM leased a single package of hardware and software. Now a customer can mix IBM hardware with software of his own choosing. This has opened the software market and has allowed for the entry and growth of many more software firms. It appears that unbundling is now in the process of being expanded to include the use of non-IBM peripherals with IBM mainframes. Just how far this latter practice will go remains unclear since it appears that IBM's current liberal policy may be a reaction to a pending United States Justice Department antitrust suit.[5]

– Innovation in the computer field has led to a wide diversification of product lines and of ranges of computers; even IBM cannot establish dominance across the board and must be selective in the lines which it develops and markets.

– Now that computers are pervasive in the advanced societies, the early advantages conferred upon IBM by its existing, pre-computer, penetration of the business machine market are less salient than they once were.

– Competitors have learned something from the battles of the past and the ruins of the competitive wars that have marked the evolution of the computer industry. Firms like Burroughs, for example, are applying much more sophisticated strategies of product development and marketing than was the case in the past. They are increasingly able to exploit weaknesses in the IBM position.

– The international scene is now characterized by the emergence of new and potentially powerful competitors, e.g., the Japanese companies, and also by the coming together, in Europe and elsewhere, of developmental and marketing consortia, often backed by a number of governments.

The erosion of IBM dominance is not, however, to be looked for in the near future. IBM is an extremely competent, well-managed company, which

[4]William Rodgers, *Think: A Biography of the Watsons and* IBM, *op. cit.* pp. 254-256.

[5]See "The Landmark IBM Case Gets Down to Issues", *Business Week*, New Jersey, October 21, 1972. Number 2251, p. 46.

has arrived at its present position as a result of a demonstrated ability to recognize shifts in the market and in its socio-economic environment and which has responded to these shifts in ways which have promoted corporate growth. Its resources are immense. Even if it is faced by antitrust action, past experience (e.g., with respect to the classic cases of antitrust action against Standard Oil and against Du Pont) indicates that it takes decades to implement such policies with regard to major corporations and that, by then, they have grown so much more that their position may be only marginally affected. Finally, in international terms, IBM may follow the practice (for example, in its efforts to establish some sort of participatory foothold in Japan) of joining, or co-opting those from whom a significant threat to its position might arise. All in all it is safe to conclude that any Canadian strategy for developing a computer industry in the 1970s and 1980s will simply have to recognize IBM dominance (to whatever degree) as a fact of life in the computer industry.

The Computer Industry in Canada

Data for this section have been derived from surveys conducted by various government agencies and by groups in the private sector, supplemented by interviews conducted with personnel from a number of computer companies.

In general we found that there was a lack of reliable and standardized data relating to the computer industry in this country. There are three regular sources for Canadian computer statistics: the Department of Industry, Trade and Commerce; Statistics Canada; and the Canadian Information Processing Society. However, statistics compiled by the Department of Industry, Trade and Commerce are sample data only, for selected three-month intervals. Statistics Canada data are obscured by the inclusion of computers in a general classification that includes everything from postage meters through sorting and tabulating machines to computers as defined in this report.

The Task Force on Computer Communications in its publication *Branching Out* has compiled a great deal of useful data relating to the size and structure of the Canadian computer industry. Unfortunately, these data have been compiled for purposes of that particular study and there is no guarantee that they will continue to be collected on an ongoing basis and made generally available. We urge that, in order to facilitate planning by the Federal and provincial governments, as well as by private industry, steps be taken to continue to collect such detailed data and make them available, on a regular basis, as soon as possible after they have been collected.

It should be noted that statistics relating to the computer industry need to be assessed with some care. As stated above, the computer "industry" is really a complex of interrelated manufacturing and service industries. The boundaries separating component suppliers, computer manufacturers, service firms, and users are often difficult to determine. This problem is compounded by the fact that companies that engage in both computer and non-computer activities often do not break out their data.

The growth of the computer industry in Canada reflects the fact that internationally, in recent years, this industry's growth rate has led all others. In Canada, the rate of growth of the computer industry as a whole has been about 16 per cent per year. It is anticipated that this rate of growth will be maintained or exceeded through the 1970s. Accordingly, it is expected that by 1980, computer industry revenue in Canada should be approximately $2.4 billion (1.7 per cent of the Gross National Product) compared to a 1970-71 level of about $592 million.[6] These figures may be compared with the new passenger-car sales revenues of the Canadian automobile industry which, in 1970, amounted to $2.5 billion.

If we compare data for various countries (see Table II which gives 1971 year-end estimates of the number and value of all installed computers, together with other derived data, for the leading twenty countries), Canada ranks seventh, in absolute terms, in the number and value of installed computers. Canada also ranks seventh according to the total value of computers taken as a percentage of GNP.

If we look at the number of installed computers per million people, Canada ranks second in the global comparisons. Only the United States has a higher ratio of computers to population: 417 per million of population, compared to Canada's 177 per million (note also the data for their major competitors – 137 per million in the United Kingdom, 83 per million in Japan, and the rather low ratio of 23 per million in the Soviet Union). The fact that Canada, despite its high ranking in per capita terms, has a computers per capita ratio well under 50 per cent of that of the United States, may be subject to a number of interpretations. One is that defence and space activities, together with spin-offs from other high-technology endeavours, account for much of United States computer use; this interpretation would seem to be weakened, somewhat, by the very low comparable ratio for the U.S.S.R. Another possible interpretation derives from the fact that, on an individual basis, a typical Canadian computer user makes use of computers only to about half the extent of a comparable American user. This may suggest the continuation, in future, of some lags in productivity and sophistication of computer use in this country, deriving not so much from the capabilities of the Canadian computer industry *per se*, but rather from the general sociology of business and government in this country and the way in which accustomed ways of decision-making and administration affect receptivity to evolving computer applications.

International comparisons of data on computers are useful as a means of putting the Canadian industry into perspective. However, it would be dangerous to put too much emphasis on such statistical comparisons as a motivation for policy. A "catching up" psychology might, in fact, impede the search for a viable policy of development and utilization of computers in the service of Canada's national objectives. While developments in this field in other countries have to be carefully monitored and assessed, the basis for making computer policy in this country should be rooted in a careful analysis of the disparate needs of a variegated Canadian society, and

[6]This does not include salaries and wages of users of computers. See *Branching Out*, Report of the Canadian Computer/Communications Task Force, Information Canada, Ottawa, 1972.

Table II–Estimated Worldwide Installations of Computers at Year-End 1971

Country	No. of Computers	% of Total	Value of installed Computers $ millions	% of Total	1969 GNP $ billions	Computer value as % of GNP	GNP per Capita $ thousands	1969 Population millions	Number of computers per million people
U.S.A.	84 600	59.4	28 900	60.8	932	3.08	4.61	202	417
W. Germany	7 800	5.5	2 890	6.1	165	1.75	2.69	61.2	128
Japan	8 680	6.1	2 860	6.0	174	1.64	1.66	105	83
U.K.	7 600	5.3	2 475	5.2	93	2.63	1.68	55.5	137
France	6 700	4.7	2 150	4.5	130	1.65	2.55	51.0	131
U.S.S.R.	5 500	3.9	1 460	3.1	260	0.56	1.08	241	23
Canada	3 800	2.7	1 295	2.7	79	1.65	3.65	21.5	177
Italy	3 300	2.3	1 040	2.2	82	1.26	1.55	53.1	62
Netherlands	1 680	1.2	530	1.1	29	1.85	2.21	12.9	130
Australia	1 340	0.9	415	0.9	30	1.40	2.37	12.5	107
Sweden	800	0.6	405	0.9	28	1.43	3.53	8.0	100
Belgium	1 050	0.7	355	0.7	23	1.56	2.36	9.7	108
Switzerland	755	0.5	345	0.7	19	1.83	3.03	6.2	125
Spain	720	0.5	255	0.5	29	0.87	0.85	34.1	21
Brazil	730	0.5	250	0.5	23	1.07	0.25	92.3	8
Denmark	390	0.3	175	0.4	14	1.22	2.94	4.9	80
S. Africa	480	0.4	145	0.3	7	2.06	0.36	19.6	24
Mexico	360	0.3	130	0.3	8	1.44	0.18	48.9	7
Finland	255	0.2	105	0.2	9	1.12	1.95	4.7	54
Norway	270	0.2	100	0.2	11	0.93	2.77	3.9	69
Subtotal	*136 830*		*46 280*		*2 145*	*2.15*	*2.05*	*1 048*	*130*
Others	5 570	3.8	1 220	2.7	438	34	0.17	2 492	2
Total	**142 400**		**47 500**		**2 583**	**1.85**	**0.73**	**3 540**	**40**

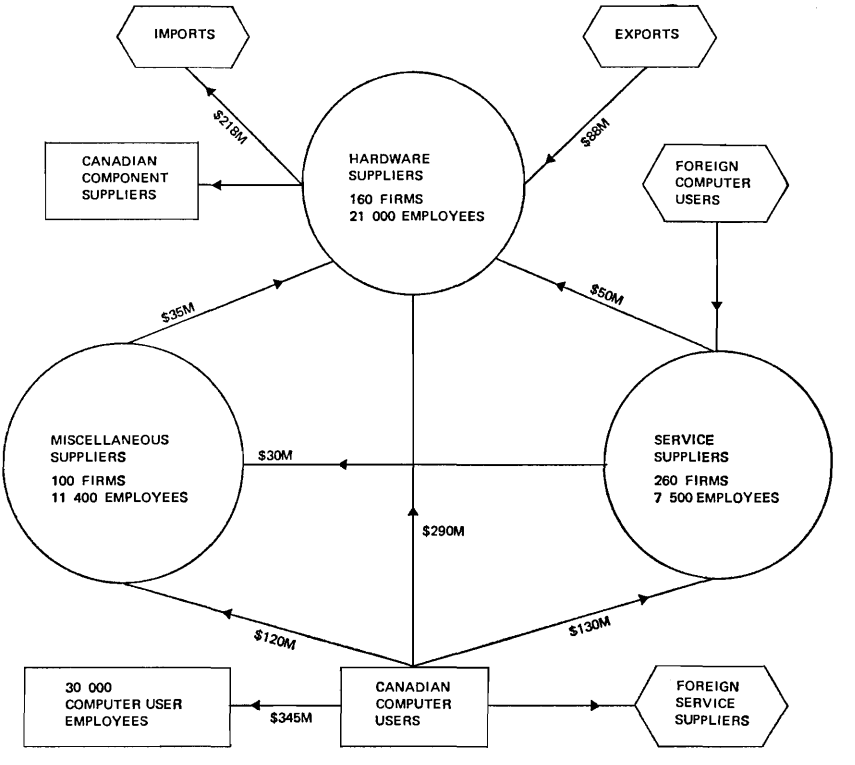
Source: Copyright 1971 by International Data Corporation. Reprinted by Permission.

a sophisticated socio-technological assessment of the way in which computer development and applications might serve various of these needs. Merely to strive (even implicitly) to raise Canada's level on the international indices might lead to situations where judgement was suspended in the rush to try out economically unviable applications. Rather, within the framework of general policy, applications of computers in Canada should be judged in terms of whether they have merit in terms of technical feasibility, economic and/or social practicality and socio-economic desirability.

An approximation of the structure of the computer industry in Canada, and its relation to its suppliers and customers, is provided in Figure 1. In the accounting year 1970–71, Canadian computer users spent a total of approximately $592 million on computer goods and services purchased within Canada. This total may be subdivided as follows:[7]

Computer hardware	$375 million
Computer services	$133 million
Miscellaneous computer supplies	$ 84 million

Figure 1–Canadian Computer Industry Revenue and Structure 1970–71



Note: M = million
Source: Branching Out, Report of the Canadian Computer/Communications Task Force, Information Canada, Ottawa, 1972.
Miscellaneous other sources.

[7]See *Branching Out*, Report of the Canadian Computer/Communications Task Force, Information Canada, Ottawa, 1972.

In addition to goods and services which were purchased, about $345 million was expended in Canada, in the same period, on payroll for in-house computer-related employees. If we add together purchase of goods and services *and* payroll, expenditure in Canada on computers and on direct costs of utilizing them amounted, in 1970–71, to $937 million (about one per cent of GNP) – over fifty per cent higher than the revenues of the computer industry *per se*.

Hardware Suppliers

As already noted, the main products of hardware suppliers are mainframes, peripherals, and some types of communications hardware used to link mainframes to peripherals. The hardware suppliers also supply some software (usually systems software).

Any discussion of supply of computer hardware in Canada immediately raises two issues: the negative imbalance between import and export of computer hardware; and the rôle of foreign-owned multinational companies in the production and distribution of computer hardware in this country. For 1970–71, a deficit of $130 million (equivalent to about 40 per cent of total purchases of computer hardware in Canada in that year) existed between computer hardware imports and exports (see Figure 1). Little manufacturing of computer hardware actually takes place in Canada. A breakdown by countries of our imports of computer hardware ($217.8 million) and our exports ($88 million) is given in Table III; as might have been expected, this shows that the trade imbalance is due primarily to a deficit in the computer hardware trade with the United States – a deficit of $143 million in the designated year. However, the import-export table does not tell the whole story. The best estimates from informed industry sources are that the bulk of our exports consisted of card-punch and card-sort equipment, together with some exports of minicomputers, while the bulk of imports consisted of central processing units. In sum: while our production for export consists largely of relatively unsophisticated equipment, our imports of computer hardware are heavily concentrated in the areas of greater sophistication and more advanced technology.

At present, there are in excess of 3 500 installed computers in Canada; Table IV gives a breakdown of the number and value of computer mainframes installed by various suppliers, together with other relevant data about the suppliers. All of the companies listed in this table are subsidiaries of foreign corporations; with the exception of Philips (an international firm with headquarters in the Netherlands), all are American-owned. The market is dominated by IBM, with 1 303 installed computer systems (63 per cent of the value of installed systems in Canada).

Most of the listed suppliers are engaged in the business of marketing and servicing mainframes and peripherals imported from the United States. Such manufacturing as does occur in Canada tends to involve products with a high electro-mechanical content, rather than advanced electronic product lines. Manufacturing of these somewhat less sophisticated product lines has tended to be rationalized so that much of the actual production is for export markets (the assembly of minicomputers by Datagen of Canada is an exception). The bulk of exports accounted for by

Table III–Canada's 1970 Imports and Exports of card punching, sorting and tabulating machines, computers and parts over $1 million.

Imports

Trading Nation	$ millions	% of Total
U.S.	202.9	93.2
U.K.	8.1	3.7
West Germany	2.8	1.3
Japan	1.6	0.7
Netherlands	1.1	0.5
Other	1.3	0.6
Total	**217.8**	**100.0**

Exports

Trading Nation	$ millions	% of Total
U.S.	55.3	62.8
U.K.	9.1	10.3
France	5.6	6.4
West Germany	5.2	5.9
Japan	1.6	1.8
Netherlands	1.5	1.7
Australia	1.4	1.6
Brazil	1.3	1.5
Sweden	1.1	1.3
Italy	1.0	1.1
Other	4.9	5.6
Total	**88.0**	**100.0**

Source: Dominion Bureau of Statistics, *Trade of Canada, Exports by Commodities*, Ottawa, 1971. Cat. No. 65-004.
Dominion Bureau of Statistics. *Trade of Canada, Imports by Commodities*, Ottawa, 1971. Cat. No. 65-007.

Table II are produced by the subsidiaries of American firms.[8]

In 1969, the Canadian government awarded grants amounting to about $23 million, to Control Data Company (via Control Data of Canada) to assist in the setting up of development and manufacturing facilities in this country.[9] This will constitute the largest computer research and development effort to date in Canada. At the present time about 500 employees, including many engineers and programmers, are active in CDC's development program which is underway near Toronto (included in these employment figures are approximately ninety professionals which CDC has brought in from its American facilities to assist in the early phases of the work). At

[8]It should be stressed that the mere fact that a company is engaged in the export of a particular type of industrial product should not be overemphasized, from the point of view of attaining national economic objectives. At least two other factors have to be considered: the degree of technological sophistication of the product line, and the extent to which the export item was designed and developed in Canada and afforded an opportunity for high-level employment of Canadian skills. Cf. Arthur J. Cordell, *The Multinational Firm, Foreign Direct Investment and Canadian Science Policy*, Science Council of Canada Special Study No. 22, Information Canada, Ottawa, 1972. pp. 56-65.

[9]Grants of $19 million were made under the Program for Advancement of Industrial Technology (PAIT) and $4.1 million under the Regional Development Incentives Act; these were for development facilities near Toronto and manufacturing facilities near Quebec City. Some CDC's research and development may also qualify for grants under the Industrial Research and Development Incentive Act (IRDIA).

Table IV–Mainframes in Canada and their Suppliers

Company		Mainframes Currently Installed	% of Total Number	% of Total Value	Computer Manufacture in Canada	R & D in Canada	Canadian Head Office
Burroughs Business Machines	BUR	439	12.3	3.8			Toronto
Control Data Canada Ltd.	CDC	67	1.9	3.9	Will manufacture mainframes	Mainframe R & D	Toronto
Collins Radio Co. of Canada Ltd.	COL	10		0.7			Toronto
Digital Equipment Ltd.	DEC	641	18	3.6	Back-plane wiring		Carleton Place
Datagen of Canada	DGC	89	2.5		Minicomputer assembly		Hull
Honeywell Ltd.	HON	353	9.9	10	Key-tape manufacture		Toronto
Hewlett-Packard Ltd.	HP	82	2.3				Toronto
International Business Machines Company Ltd.	IBM	1 303	37.7	63.3	Mainly keypunch manufacture	Misc. hardware and software R & D	Toronto
National Cash Register Co.	NCR	71	2.0	1.5			Toronto
Philips Electronics Industries	PHL	64	1.8				Toronto
Univac Division of Sperry Rand Canada Ltd.	UNI	244	6.9	6.3	Power Supplies		Toronto
Xerox of Canada	XDS	27	0.7	1.5			Toronto
Others		158	4.4	5.4			
Total		**3 548**					

Source: Number and value data from May 1971 Canadian Computer Census by the Canadian Information Processing Society.

present, it is still unclear whether the Canadian effort at CDC will be integrated with the global activities of the firm or whether it will consist of a distinctive product line with an international product mandate.

IBM Canada also is engaged in research and development activities in this country. This R & D is not mainframe oriented, but is focussed on a variety of projects that dovetail with IBM's worldwide product lines: the nearly 300 R & D personnel involved are engaged in work on key-entry devices similar to keypunches, small systems, software development, etc.

In addition to the mainframe suppliers, there are about a hundred other companies in Canada that are suppliers of computer peripherals. While most peripherals used in Canada are imported from the United States, a few Canadian-owned companies have entered the market. Only a few examples of peripheral-manufacturing activity can be cited, but these may serve to give some general idea of the range of activities, and the possibilities, in this area.

Consolidated Computer Ltd. (Toronto) is a Canadian company that has designed, and is manufacturing and marketing, terminal stations (under the name "Key-Edit") for entering data into a computer. Its Key-Edit systems use off-the-shelf minicomputers and peripherals, but the interface design and the software is Canadian. CCL has actively penetrated world markets and after an initial period of financial difficulties the company now appears to be headed toward a successful comeback.[10]

Leigh Instruments Ltd. produces and markets the Leigh Alphagraphic printer, a device of its own design, which takes data generated by a computer and prints it in alphanumeric or graphic form on special paper. These devices are marketed in Canada, the United States, and the United Kingdom.

T-Scan Ltd. markets a transaction terminal with such applications as stock quotations, mail order catalogue purchasing, and off-track betting. The terminal is unique, it has a high Canadian content as regards both design and manufacture, and it is believed to have excellent market potential.

Service Suppliers

There are about 260 companies that provide computer services. The greatest number of these (approximately 140) are service bureaux; the remainder consist of firms of various kinds, offering or based on computer services – software houses, consulting firms, facilities management companies, and systems houses.

Service Bureaux are firms that, on a contractual basis, supply data processing and other computer services for their clients. Such arrangements are particularly attractive to small companies which may not want to engage in the complexities and costs of establishing and maintaining their own computer facilities. Service bureaux are also used by larger companies which, for various reasons, may decide to contract out all computer-related activities, rather than develop in-house facilities. Even firms that have their own computer facilities may at times make use of a service

[10] *Financial Post*, Toronto, September 23, 1972.

bureau; for example, when in-house facilities are temporarily overloaded.

Many service bureaux provide both an over-the-counter service and a remote job entry service involving data communications. A few also provide time-sharing services for scientific applications. The technological and economic viability of remote and time-sharing service operations depends greatly upon the availability of economical data communications (cf. our earlier report, *A Trans-Canada Computer Communications Network*).

Scores of service bureaux have opened up in Canada in the last few years. But the competition for this business has been very keen, both among domestic operators and on the part of American firms that have offered data-handling services in Canada utilizing data-communications links to American centers. While data comparable to the import-export figures for computer hardware are not available, it is widely assumed that a considerable deficit in across-the-border trade already exists in the computer service sector, including the services offered by service bureaux. In the absence of countervailing policies, this trend is likely to increase as a consequence of further development of data-transmission technologies and the competitive base afforded by the already large American market. (As is the case in the manufacturing areas, once costs are largely covered by a large domestic market, any business acquired from a neighboring market is a bonus and can be solicited by various means, including a differential rate system – hence the phenomenon, already suggested by some analysts, of "dumping" surplus data-processing capacities across national boundaries).

Approximately two-thirds of the service bureaux operating in Canada are Canadian-owned; however, these Canadian firms enjoy less than one-sixth of the revenues accruing to service bureaux. Foreign-controlled companies are able to practice economies of scale and generate higher revenues, and most of them are realizing profits; in contrast, many of the Canadian-owned companies have struggled to survive economically while operating at a net loss.

IBM operates the largest network of service bureaux in Canada. Its twenty-three "Data Centres" account for about 20 per cent of the combined revenues of all service bureaux currently operating in Canada (i.e., in excess of $20 million of a total service bureau revenue of about $115 million). There are, however, several Canadian-owned service bureaux with annual gross sales ranging between $3 million and $6 million. As the volume of business increases, and if (as could be expected) this results in a diminution of excess computing capacity held by some of these firms, the profitability of many service bureaux could significantly improve.

Most of the other types of service firms – consulting firms, software houses, facilities management companies, and systems houses – are, in Canada, comparatively small.[11] Their activities are varied, and the boundaries between the various types of function are blurred. Consulting firms, software firms, and systems houses also engage in such specialized functions as process control and operations research. For their part, service bureaux are often also engaged in general consulting and/or the development of software. Both the newness of the industry, and the competitive conditions

[11]The distinction among these firms is discussed in the chapter "The Canadian Computer Industry – Opportunities and Constraints".

and uncertainties that prevail, tend to force firms into seeking opportunities for survival and growth wherever these opportunities may arise, rather than along lines of functional specialization that may be more appropriate to a well-established and stable market.

Distribution and Growth: Some Patterns and Trends

It is hazardous to estimate growth patterns for a rapidly developing and diversified high-technology industry. Unforeseen developments may jeopardize the validity of even the most carefully constructed projections. However, some projections have been made and are offered by way of indicating, in general fashion, just what the prospects for the industry appear to be at the present time.

The Trans-Canada Telephone System has completed a detailed study which attempts to predict future computer/communications requirements. This study concludes that the total number of computers in Canada will increase dramatically during the remainder of this decade; it is estimated that from the 3 800 currently installed the installations will rise to about 20 000 by 1980 (see graph, Figure 2).[12] Significant developments will occur at the two opposite ends of the continuum of computer size and function. Thus, there will be much more use of minicomputers: in terms of number of units, these will account for 42 per cent of all installed computers in 1980. On the other hand, if we look at the value of equipment, a somewhat different perspective is provided: the large, highly sophisticated supercomputers will, by 1980, account for 30 per cent of installed value, while minicomputers will account for 3 per cent of value.

In the course of the decade, the total installed value of computers in Canada is expected to increase exponentially. In 1971, the installed value of computers in this country was $1.3 billion: the 1980 value is expected to reach $12 billion. All ranges of computer will play their part in this growth:

Minicomputers will be used extensively for industrial control, in small business applications, and as terminals for accessing larger computers;

Mid-range systems will be used by many businesses and public agencies;

Large computers will be operated mainly by large businesses and other institutions on a similar scale, and by service bureaux serving numerous clients;

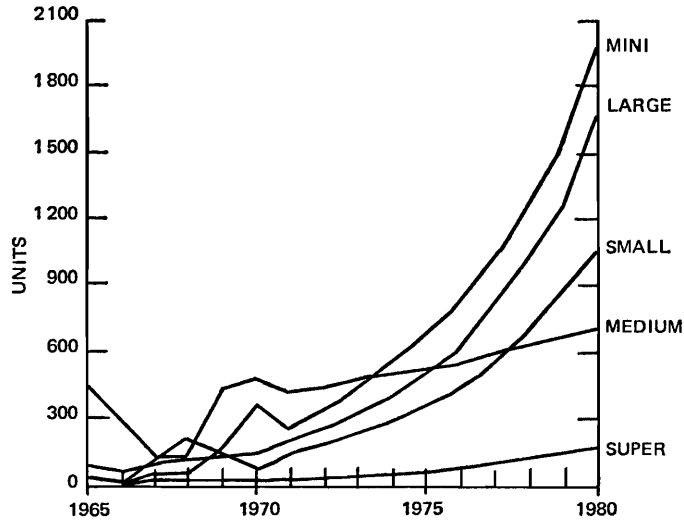
Very-large computers ("supercomputers") will be used in a number of evolving applications – for example: databank applications and network configurations with many remote users (such as the Air Canada reservation system, the Bank of Montreal computer system, and the Department of National Defence management information system).

A major trend is toward large computer systems, with networks of geo-spatially dispersed users, linked to central facilities by communications systems. As a consequence, peripherals will account for a growing share of the cost of computer hardware, rising from a present 50 per cent to about 70 per cent of the cost of a total system by about 1980.

A key device is the on-line terminal, the availability of which dramati-

[12]See also *Branching Out*, Report of the Canadian Computer/Communications Task Force, Information Canada, Ottawa, 1972. Vol. 1, pp. 53 and 56.

Figure 2–Estimated Annual Unit Sales of Computers by Size in Canada



Source: Trans-Canada Telephone Study "Communications Computers and Canada, 1971".

cally increases availability of access to centrally-located data-processing facilities. These will proliferate greatly in the future – the telephone system's estimates on the increase in installations of these devices are as follows:

1970 (in service)	55 000 units
1975	(approx.) 200 000 units
1980	(approx.) 575 000 units

In the course of the decade, growth in the service sector of the computer industry is expected to be at least as great as growth in the hardware sector. The increased availability of diversified hardware, ranging from minicomputers in offices (the acquisition and deployment of which will call for expert consultations) to integrated networks (offering customers access to computers more powerful than those they could afford to install and operate on their own) will profoundly affect both the growth prospects and the configuration of the computer service industry in Canada. There will be a shifting balance in response to both the new technologies and to changing economic conditions on the part of direct users of computers and those who offer services on contract. At the same time, a trend to increasing specialization and centralization is likely to occur within the service sector; one result may be that programming by the ultimate user may be seen to be less desirable, and more responsibility for programming will be "contracted out" to specialists.

Computer Applications and Computer Users

It is important, periodically, to remind ourselves that computers are basically tools which, like other tools – from the primitive stone axe through the steam-engine to the automobile and the airplane – are used by

human beings in the effort to satisfy, more effectively and efficiently, perceived human wants and needs. But both technologically and in their organizational implications computers are generally more complex, and have wider-ranging implications, than any other tool that we use.

The computer is the human tool which pre-eminently relates to man's central function as a data-acquiring, data-ordering, data-transforming, and data-deploying creature whether he does this on an individual basis, or collectively, through the organizations he has created. All other human activities are dependent, explicitly or implicitly, on man's ability to deal with data. The tools which man has evolved or created in order to extend his data-handling talents and propensities (whether they be "soft" tools like the various informal or formal educational systems he has created, or "hard" tools such as modern electronic communications media) are, because of their closeness to his central function, the key technologies created and used by man. At the present stage of human development, even if only temporarily, the computer represents man's highest achievement in creating a tool that, properly used, can aid him in extending his ability to assimilate and order data and in using his relationship to these data to satisfy a multitude of wants and needs.

All this may seem far removed from the hard-nosed economic questions of computer markets. Yet these "philosophical" questions inherent in the concept of the computer as a central, "transformative" technology, as argued in the "Introduction" of this report, mean that, even on the purely economic and market-oriented level of analysis, it cannot be treated as just another product of our industrial civilization. Because the computer is an adjunct to a central thread of human activity that pervades all ancillary human and organizational activities, the scope of computer applications and the repercussions of these applications, are virtually unlimited, at least as compared to most other technologies. In market terms, the market is not just related to one or another type of human activity, but utimately covers virtually the whole span of human activities. Today's markets for computer applications may be related to a relatively narrow span of business, research, and governmental activities: tomorrow's markets may range as far afield as computer-based information and entertainment systems or computer-stored banks of genetic information. A two-fold process of extension of applications may be foreseen: increasing applications of computers to areas already included in the span of human activity, but not presently utilizing computer technology; and new applications arising from new discoveries and technologies in a variety of fields, some of them new fields of endeavour that will have been made possible largely because of our extended, computer-based data-handling capabilities.

Even in the limited historical time period between the emergence of the first production-line computer and the present, the extension of computer applications has been remarkable. New and exciting applications are emerging almost every day. In health care, computers monitor various aspects of patient care; they analyze the results of such diagnostic procedures as electrocardiograms; we have a capability to store and "instantaneously" recalled the medical file of every Canadian or selected data

from such files. In the legal area, computer systems are being developed for the indexing and retrieval, according to a set of selected "key word" references, of the entire body of our statute law and precedent. In the field of communications, computers are being used, and are under further development, for the routing of telephone calls and of digital data between computer systems and terminals. Banks are already using computers to supervise self-serve banking and to carry out on-line banking transactions; significant further development will occur in this field in the 1970s. In the interest of airline efficiency and air-traffic safety, air-traffic control systems are being developed that use computers to process and display radar signals and other relevant data. These are but a few examples of worthwhile development of computer applications.

At the present time, however, the bulk of computer applications in Canada has to do with "routine" business and governmental operations. (It should be noted, however, that in many instances, because of the advent of the computer, operations that are now considered "routine" would have been thought of as beyond ordinary information-processing capabilities in the pre-computer age.) About half the computers in Canada are being used by three user groups: manufacturers, educational institutions, and government (see Table V). Manufacturers use computers extensively for payroll, billing, inventory, and many other information retrieval functions. In addition, some manufacturers use process-control computers to automate certain routine manufacturing operations, and to improve the quality and through-put of their processes. In terms of geographical distribution throughout the country, Canadian computer installations tend to follow the existing patterns of distribution of population and economic activity – though there appears to be some "loading" that favours even more the more populous and prosperous regions (see Table VI).

Considerable optimism is warranted when we consider the range of actual applications of computer technology at the present time, and as we become aware of the even greater potential for applications in the future.

Table V–Distribution of Installed Computers in Canada by User Group

User Group	Number of Installed Computers	% of Total
Manufacturing	846	23.6
Education	508	14.4
Governments	453	12.8
Distribution	301	8.5
Service Bureaux	285	8.0
Financial	268	7.6
Utility	147	4.1
Transportation	131	3.7
Primary/Resource	122	3.4
Communication	89	2.5
Petroleum	82	2.3
Construction	48	1.3
Others	268	7.8
Total	**3 548**	**100.0**

Source: May 1971 Canadian Computer Census by the Canadian Information Processing Society.

Table VI–Distribution of Computers in Canada by Province

Province	Number of Installed Computers	% of Total
Ontario	1 814	51.1
Quebec	764	21.5
British Columbia	290	8.3
Alberta	283	8.0
Manitoba	145	4.1
Nova Scotia	92	2.6
Saskatchewan	73	2.1
New Brunswick	51	1.4
Newfoundland	31	.9
Prince Edward Island	4	–
Northwest Territories	1	–
Yukon	–	–
Total	**3 548**	**100.0**

Source: May 1971 Canadian Computer Census by the Canadian Information Processing Society.

However, it would be erroneous to base policy solely, or even mainly, on the *potential* range of applications. There is a demonstrated "gap" between potential application and our actual experience to date in computer usage; this gap relates, in part, to the newness of this technology and our relative inexperience in acquiring it and properly putting it to use. Though many successes have been registered – particularly when new and useful functions have emerged that can only be performed by computers – many users have had experiences with computers that have been disappointing and, in some instances, disastrous. (One can cite from American experience the disaster that occurred when the Pennsylvania and New York Central railways were merged and railway boxcars were "lost" because of the computer program's inability to meld effectively the two component lines' systems for computerized monitoring of boxcar location.) All too often, among first generation computer users, the new electronic data processing technology was poorly understood; inefficiencies in its use were compounded by the tendency to acquire and perceive computers as a sort of corporate status symbol.

The current generation of computer users are adopting a more hard-nosed, results-oriented, approach to the use of computers. This attitude is reflected in a statement by the Honourable C.M. Drury, President of the Treasury Board:

"There are a number of practical and urgent questions which we should be asking ourselves. For example, is the Government getting a proper return on its investment (in electronic data processing-EDP)? We are now spending something like $100 million per annum on computer activities, with a growth rate between 25 and 30 per cent. Cumulatively, the Government has spent over $700 million on EDP, and this figure will likely be doubled by 1975. These figures are staggering. The government feels that the taxpayer has a right to know more about these expenditures than merely the type of services which the computers provide. For example, he is entitled to know where and how his money is being spent; if the perfor-

mance of EDP is adequate, and by what standards; and the future rôle which the Government envisages for EDP. In anticipation of these questions, the Government should be asking itself whether its current and forecast expenditures on EDP are in proportion to the public's needs. Are they too much? Or are they not enough?"[13]

The results users strive to obtain by means of computers include, but are not limited to, the following:
- accurate and fast processing of routine paperwork;
- precise control of inventory, and other aspects of a business;
- up-to-date access to stored information;
- increased through-put;
- high quality of information, and sophisticated ability to break out various categories of information from aggregate data;
- rapidity and convenience of access to stored information.

The application of computers is fundamentally different from the application of most other tools that organizations use. Other tools or machines are usable as delivered. A newly-delivered computer, however, is simply the hardware component of a potentially useful tool. The vital ingredient is the applications software which specifies in minute detail the precise operations which the computer is to perform. In many cases, the entire operating procedure of a company must be analysed and possibly even amended before preparation of the applications software can even begin.

[13]The Hon. C.M. Drury, Speech to the Data Processing Institute of the Federal Institute of Management, Fourth Annual Convention, Ottawa, February 22, 1971. Chapter V.

The Canadian Computer Industry – Opportunities and Constraints

The growth in the number and range of applications of computer technology, and increasing awareness of needs, both domestic and international, that can be served by such applications, constitutes the main dynamic for expansion of opportunities for a Canadian computer industry. The main benefits from the development of such an industry in Canada are those that accrue in terms of better servicing of the needs and wants of Canadian computer users. Other benefits would include employment opportunities (at various levels of skills), development of some export markets, and perhaps such "intangibles" as enhanced self-esteem or international prestige related to Canada's demonstrating an ability to maintain a viable position in this field.

At the same time, there are a number of impediments or constraints that are operative and that, unless they can be surmounted, will collectively hinder Canada's ability to maintain and extend its activities in the computer field. Among these are questions relating to the "state of the art", to the financing of the industry, to markets at home and abroad, and to the impact of the multinational corporations.

Any effort to deal with the complexities of the opportunities and constraints facing the computer industry must, necessarily, be somewhat arbitrary in the selection and organization of the material to be considered. In this chapter, we shall attempt to deal with these problems and prospects in the following order:

1) General questions having to do with the capital requirements of the industry;

2) An analysis of the hardware sector of the industry, together with some discussion of problems of keeping abreast of technology and of technological innovativeness;

3) Problems and prospects of the market for computers, both domestic and international;

4) The impact of the multinational corporation on the Canadian computer industry;

5) Problems and prospects of the software and service sectors of the Canadian computer industry.

Capital Requirements and Financial Impediments

On the hardware side, the computer industry is capital intensive. Heavy burdens are placed on financing because of extensive research and development requirements, the system of leasing equipment and thus deferring payback over the course of several years, and the nature of technological and organizational competition in the industry (the need to be able to outlast temporary, but severe, competitive setbacks resulting, for example, from the introduction of advanced product lines by competitors). The computer service industry, on the other hand, is somewhat less capital intensive; hence it is not susceptible to financial impediments to the same degree.

The relative differentiation between the financial requirements of the hardware and the service industries is one of the reasons why the Canadian industry, as a whole, is characterized by a small number of Canadian-

owned hardware companies compared with a much larger number of service companies of various kinds.

The availability – or, rather, the restrictions on the availability – of venture capital[1] is one of the most severe impediments facing Canadian-owned hardware suppliers. In part, this reflects the general climate of the Canadian economy, together with the generally conservative investment tradition of Canadian financial institutions and of individual Canadians. (They usually tend to prefer to put their money into bank accounts, savings bonds, and insurance policies, except for a traditional and somewhat aberrant love for penny-stock gambling in moose pastures!) But there are also some features intrinsic to the computer industry which tend to discourage ordinary individual or institutional investors, at least in the early phases of the development of a company, i.e., when venture capital is most needed.

The first is the massive nature of the capital requirements on the manufacturing side of the computer industry. A second is that computer manufacture is subject to unusually high risks arising from recurrent phases of technological obsolescence, intensive competition, and the high unit value of systems and products (which generally require that the products be leased, rather than sold. As seen in the case of Bull's "Gemini" computer, even a company with a very successful product can be strangled by the need to tie up capital for the periods of time it takes for return on leases to build up momentum). While a successful investment can yield substantial returns, particularly in the appreciation of the value of a "growth stock", the past experience of many investors in both Canada and the United States who have suffered severe losses as a result of investment in the computer industry has led others to become apprehensive about further ventures into this field.

A third, more general problem is that the general demand for venture capital in Canada is potentially much greater than the funds that are available. This is because Canada is a relatively young country with still undiscovered and undeveloped natural resources, a rapidly expanding labour force, an increasingly well-educated population, and an appetite for manufactured goods and services which, on a per capita basis, is comparable to that of the United States. At the same time, because we are so close to the United States, investors in this country are aware, at a relatively early stage, of developments among technologically-sophisticated companies in that country, and can assess these developments against the background of the significantly larger markets for new and improved products which exist in the United States.

It is estimated that there are only about $100 million of net new Canadian venture capital available each year, to be competed for intensely by all types of companies. Under the best of circumstances, therefore, a developing Canadian company will likely require some form of government assistance and/or the support of a well-established, prosperous parent company (e.g., the support given to T-Scan Ltd. by Consumer's Gas Co.).

[1] *Venture* or risk capital may be thought of as an investment involving (a) deferment of payback over a long period and (b) the potential for above average payback, accompanied by above average risk that the return will be minimal, or even zero.

To put the venture capital requirements of potential Canadian computer manufacturers in perspective, it is worth looking at one key area: research and development. If one were tempted to think of across-the-board competition in international markets, one would have to remember that here it is the absolute strength of a nation's computer industry, rather than its relative strength (per capita or as a percentage of GNP) that is important; to say that we might invest more per capita, or as a share of GNP, would not help us compete against the more powerful American companies. Currently, major computer companies in the United States spend in excess of $1 billion a year on research and development (related support industries spend additional millions of dollars). This figure, $1 billion a year, is equivalent to one-half of the net total of new Canadian corporate security issues; *it is roughly three times the total expenditures for research and development in all industrial sectors in Canada.* Any effort to meet such massively-financed competition head-on is obviously beyond Canadian capabilities. Rather, competitive efforts will require at least three things: identification of "gaps" in the market and the development of products uniquely able to fill these gaps; some degree of collaboration, in product development and marketing, with companies in other countries (at least in some cases); judicious and innovative use of such venture capital as may be obtainable, so as to squeeze as much mileage as possible from the dollars available.

An investigation of the difficulties involved in trying to make a financial success of a Canadian computer company, and in relating the search for investment to the development of the new technology, can be instructive. The following comments come from a case history compiled for the Science Council by a firm of management consultants:

"An entrepreneur is inspired by an idea. He promotes the idea but his optimism overrides sound, conservative business judgment. The financial commitments obtained to meet the early start-up requirements are insufficient. The entrepreneurial skills needed to initiate the venture are continued instead of being replaced by professional management. Optimism continues that solutions will appear imminently despite [a] steadily declining condition. Two or three efforts are made to finance the concern but, finally, it goes to the wall.

"Frequently at this point, the necessary management changes are made, a realistic appraisal of financial requirements is undertaken and help appears. This was the case with Company X.

"The Company still has problems to solve, however; first, its reorganized *pro forma* statement shows negative equity and a total dependence on debt financing. It still has unprofitable activities and businesses to dispose of, but these at least have been written down to estimated market value. Most significantly, however, it has yet to obtain the necessary type of marketing assistance available in the U.S.

"Over the longer term there are further imponderables. The company must ultimately obtain further financing and, at some point, it must shift its emphasis from its present restricted product line which is bringing it into direct confrontation with a multinational giant. This will require careful

expenditure of funds for research and development, a good perception of market requirements, and ability to build a reputation for customer satisfaction and confidence in the company's ability to survive. Failing the attainment of these conditions, survival will depend on the sale of the company to a larger entity in the computer manufacturing industry."

The Hardware Sector

The development of a viable computer hardware industry in Canada, one that can most effectively serve Canadian domestic needs and that can identify and penetrate export markets (at least on a selective basis), requires that four conditions be satisfied:

1) The development and/or acquisition of up-to-date device technology;

2) The retention and effective deployment of highly-skilled designers, engineers and technicians, operating as a team;

3) Efficiency in the manufacturing process; and

4) Aggressive marketing.

An assessment of whether these conditions are, or can be, satisfied in the manufacture of computer hardware in Canada leads to somewhat mixed conclusions. While the Canadian industry is at or near the forefront of technological developments in certain areas (e.g., in the development of large-scale integrated electronic circuits (LSI's)), the general problem of keeping up with rapidly-changing technology is rendered more difficult by the constraints on capitalization and by the dominance of multinational firms in the Canadian computer hardware field.

Computer technology is characterized by extreme rapidity of change in component technology. Over a period of about fifteen years, the fundamental electronics of device technology has shifted from using vacuum tubes through discrete transistors to small-, medium-, and large-scale integrated circuits. At the present time, the advance in device technology is occurring so rapidly that if a subsystem or system requires more than a year for design and manufacture, it will be based, at least in part, on obsolete technology before it can be marketed.

Ready access to the best available state-of-the-art in device technology is a prerequisite for continued development of the Canadian computer industry. At least two Canadian firms are in the forefront in some areas of digital computer component technology. However, it is generally agreed that in order for Canadian computer designers to have access to new devices at least as soon as they are available to their counterparts in other countries, a combination of intensive domestic R & D and agreements with leading device manufacturers around the world is required. The existing technology base of the industry (with certain exceptions noted below) is inadequate to meet emerging needs, unless a concerted effort is mounted on both these fronts.

The major technologies required for a healthy Canadian computer industry are:

1) component and design technology;

2) software technology; and

3) applications technology.

At present, much of our technology in the computer field is dependent on technology transfer from the United States, either through in-house transfer from multinational corporations to their subsidiaries in Canada, or through direct acquisition by Canadian-owned peripheral manufacturers. In principle, there is nothing wrong with technology transfer of this sort; no one would argue that, in a field as complex and as capital-intensive as computers, any country could afford to base itself on complete autarky. In practice, however, certain difficulties emerge.

In the case of the straightforward acquisition of technology from American device suppliers, the very scale of the U.S. market, where the greatest proportion of customers is to be found, may diminish the service that can be provided to Canadian firms. A new and desirable device may be in short supply for some period of time; the larger American domestic customers may be serviced on a priority basis while the supply to Canada is temporarily restricted. Contractual arrangements and intrafirm understandings in the U.S. may also have an impact on the availability of advanced technology to the independent Canadian manufacturers. In general, the extremely high degree of dependence on American suppliers of device technology that has prevailed up to this time is a weakness that should be corrected.

The specific problems created by the *modus operandi* of multinational corporations are discussed separately, in a later section of this Chapter.

Experience in recent years suggests that, at the engineering and highly-skilled-technician level, Canada is in a relatively fortunate position. A high level of supply of such people is essential since, at most levels of activity, ranging from design and prototype construction through actual manufacturing and testing of computer hardware, the industry is characterized by its dependence on highly-skilled personnel (though the introduction of LSI's may reduce somewhat such dependency in various phases of manufacture).

The fact that Canada has been able to design and produce such innovative systems as the Ferranti-Packard 6000 computer and the Northern Electric SP-1 computer-controlled switching system is an indication of the design competence, technical skills and accumulated experience of the people that work in the Canadian computer industry. Engineering faculties and technical colleges are turning out graduates whose skills and knowledge compare favourably to those of their counterparts in other countries, including the United States. However, at the present time, the supply of engineering graduates is in excess of Canadian demand; some of our best graduates are looking abroad in order to find challenging employment. It is clear that our educational system would be fully capable of supplying the manpower requirements even for a computer industry that was vastly expanded from the current base.

But before we conclude our discussion of the manufacture of computer hardware, it is necessary to look at the opportunities and constraints that exist in each of the three specific sub-divisions of the hardware field: medium-sized and large mainframes; minicomputers; and peripherals.

Mainframes

The leading American mainframe companies all market and service their computer systems in Canada. But, with the exception of the Northern Electric special-purpose switching computer and the efforts of Control Data Canada Ltd., mainframe research, development and manufacture is practically non-existent in Canada. At the present time, any attempt by an independent Canadian firm to design, produce and market mainframes for general-purpose computers would mean direct competition with IBM, whose enormous capital and organizational resources virtually guarantee its continued eminence in the field. The many previous efforts that have been made to launch major competition in the area of general-purpose computers underline the high risks involved in this field; the losers in these competitive battles have included several state-supported firms in various countries which, despite the full support of their national governments and major commitments of public funds, have failed, to date, to penetrate world markets in a significant way.

To the extent that participation in this key area of computer development is considered desirable, the Science Council feels that the best chance for Canada to hedge against the inherent risks and maximize opportunities lies through concluding suitable alliances with established multinational firms. Agreements with such firms should, however, be carefully drawn up and monitored to ensure that Canada gains significant short-term and long-term benefits in those areas of the computer industry where independent domestic companies have little chance of establishing and sustaining themselves.

The use of various grants to induce Control Data to establish facilities in Canada will, for the lifetime of the arrangement at least and, one would hope, beyond it, assure Canada of some of the advantages associated with a domestically-based mainframe industry. Among these anticipated benefits are improved support for computer users, jobs for technical and managerial personnel, increased business for domestic component suppliers, and an improved position as regards possible exports. However, in the long run, there are some implicit dangers in relying purely on grants to attract this kind of activity by foreign-owned companies: we should attempt to move toward equity participation in such firms in order to safeguard and extend our interests. International competition among various countries eager to attract such industry is such that, while grants may initially attract a firm, other sustained policies (including policies aimed at securing for one's nationals a voice in that company's decisions) may be required to keep such a firm in Canada and to ensure that it develops its Canadian operations to their maximum potential. Otherwise, one might find that after grant money had been extensively committed to such endeavours– perhaps at the expense of low support, or complete lack of support, for other worthwhile projects – Canada could end up in a worse position than if an agreement had never been concluded.

Minicomputers

Development of minicomputers over the last decade has constituted one of the most significant trends in the computer manufacturing industry, and

this trend is likely to continue worldwide, and be strengthened, into the 1980s. As a result of advances in the state-of-the-art and the lowering of prices, these devices are now finding wider and wider application. Among the present applications are use of minicomputers as "intelligent" terminals, applications in process control, and direct use of minicomputers in "stand-alone applications", i.e., for various kinds of regular data-processing. The "minis" have begun to challenge conventional, larger and more expensive general-purpose computers in many areas. They offer one of the most promising fields for development of manufacturing, if care is taken in selecting objectives for industrial strategy in this field. In addition to their direct applicability, they are also of great significance as the key device in various types of small, highly marketable, systems which can command a much higher price than can the "mini" *per se.*

The estimated trend in minicomputer sales in Canada was shown in Figure 2. There is very keen competition for the Canadian domestic market in minicomputers. Most U.S. manufacturers of these devices are working through subsidiaries or distributors to gain a share of the Canadian market, and at least two subsidiaries are engaged in the assembly of minicomputers in Canada. However, there are two major shortcomings in the situation that presently prevails in the minicomputer field in Canada: there is little value added in the assembly operations; and there is no significant commitment, in practice, to design or product improvement activities.

The Science Council believes that, despite the fragmentation that currently prevails in the market, a Canadian minicomputer manufacturer offering a good product whose service was supported by Canadian-based hardware and software design teams, would be able to capture much of the domestic market and to establish a viable base for penetrating some foreign markets as well. A number of important benefits would accrue to Canada from the establishment of a Canadian foothold in the minicomputer field encompassing design, manufacture and marketing; among these are the following:

- greater responsiveness to the requirements of Canadian users of computers, minicomputers, and minicomputer-based systems;
- increased markets for Canadian-produced components;
- improved original-equipment manufacture and end-user capability;
- export potential.

As a catalyst to an early start of such activity, **the government should make the provision of appropriate stimuli to minicomputer manufacturing a vital part of its current consideration of overall industrial and technological strategies.**

When and if a significant manufacturing capability for minicomputers is established in Canada, there should be an effort to discourage companies that merely market their minicomputers in Canada without engaging in other activities. We might look at Japan's policy of not allowing minicomputers to be imported from abroad.

The manufacture and marketing of peripherals constitutes a promising area of development for the Canadian computer hardware industry. Peripheral devices require much less development input, and much lower financial backing, than is the case with general-purpose systems and main-

frames. Already, in the case of terminals, Canadian firms have established a significant foothold in the peripheral manufacturing field. One Canadian company is now marketing plug-to-plug compatible equipment for high-speed input and output of data.

Canada has a well established expertise in communications technology. In view of this fact, and our geographically-conditioned requirement for first-rate communications facilities, **Canadian industry should pay particular attention to the design and production of peripherals required for computer communications.** Development of improved overland and satellite communications, expansion in the use of remote terminals, and the evolution of computer utilities should lead, as a consequence, to an expansion of domestic and international markets for modems[2], multiplexors[3], and other communications-oriented peripherals.

Market Fragmentation

We believe that the Canadian market, in aggregate, is large enough to serve as a base for a viable computer industry. Unfortunately, the significance of the total size of the Canadian market is diminished as a result of excessive market fragmentation. The market that already exists is crowded not only by numerous small Canadian companies but by hundreds of subsidiaries and distributors that, in many cases, engage only in the distribution of products manufactured outside the country.

It is clear that the competitiveness of Canadian computer producers in both domestic and foreign markets could be significantly improved if it were possible to realize economies of scale in R & D, in manufacturing, and in marketing. Economies of scale could be linked to a discernible need for Canadian-controlled companies to specialize in their activities. A merger of smaller companies would help to promote such economies of scale, as well as contributing to an upgrading in the quality of management. At present, managers of Canadian-controlled computer companies are often quite capable from the point of view of their technical skills, but too often lack managerial skills and experience, a point demonstrated by the case study on pp. 50-51.

The government and the Canadian computer industry must work diligently to promote every effort to penetrate, on a selective basis, the international computer market. Major obstacles to market penetration are imposed by some foreign countries through protectionist policies (part of

[2]*Modem* (acronym for modulator/demodulator): a device which enables data to be transmitted over long distances without significant signal error; it is used for conversion of signals between digital and analog modes when digital computers are connected to analog communication channels.

[3]*Multiplexor*: "A communications control device which enables a central processor to be connected to a large number of different communications channels, any or all of which may be transferring data to or from the processor. The multiplexor operates at high speed to service each channel character by character, and interrupts the process to place each character into memory. Control data is transferred to and from the central processor to identify each character, and this allows input messages to be assembled in memory for processing or retransmission."

Anthony Chandor, (ed.) with John Graham and Robin Williamson, *A Dictionary of Computers*, Penguin Books, 1970. p. 261.

their own strategies of development for domestic computer industries) and via preferential government purchasing of domestically-produced computers. Despite the fact that many technologically advanced Canadian products (particularly communications-oriented hardware, various items of software, and special-purpose systems based on minicomputers) are technically superior to what is available from other sources, the Canadian industry has had only a limited opportunity to supply large and expanding international markets. There is every reason to believe that such products would do well in international competition if existing barriers to competition abroad were lowered.

The Impact of the Multinationals

In the early phases of development of a computer industry in Canada, the multinational corporations played a useful rôle as vehicles for the transfer of technology. However, at the present time, the impediments attendant upon the dominance of foreign-owned subsidiaries in the manufacturing sector are somewhat more evident than any continuing advantages. We have already noted, for example, that imports by these companies tend to consist of relatively sophisticated systems or sub-systems, while exports from their subsidiary manufacturing facilities tend to consist largely of relatively unsophisticated electro-mechanical devices. The net effect seems to be a retardation of the technological and managerial sophistication of the computer manufacturing industry in Canada. While arrangements with the multinationals will continue to be required, the general problem remains: how to counter the adverse impact of multinational firms operating in Canada insofar as it may constitute a burden on the type of development appropriate to the Canadian computer industry in the secondary and tertiary phases of its development.

The impact of the multinationals is felt in all areas that are significant to the development of the computer industry: in its technology, its management, and its marketing.

The subsidiaries of multinational computer firms in this country have relatively free access, often in prepackaged form, to the technology of their parent companies. This easy access to the technology (though in some cases, the less advanced parts of the parent company's technological "mix") tends to inhibit the degree to which subsidiaries engage in research and development associated with innovation while it maintains their competitive advantage over Canadian-owned companies. The latter are forced, by their very independence, to maintain some sort of research and technology base, but they operate (in most cases) at such a comparative disadvantage in their routine functions that they seldom reach that critical size where innovation on a broad scale is worthwhile. Experience in other areas of high-technology industry (e.g., the case of Northern Electric[4])

[4]Cf. A.J. Cordell, *The Multinational Firm, Foreign Direct Investment and Canadian Science Policy*, Science Council of Canada Special Study No. 22, Information Canada, Ottawa, 1971. pp. 49-52. Also for a larger discussion of the effects of the importation of "predigested technology", see P.L. Bourgault, *Innovation and the Structure of Canadian Industry*, Science Council of Canada Special Study No. 23, Information Canada, Ottawa, 1972.

suggests that, when Canadian firms do reach a critical size and at the same time have managed to maintain their own technology base, their economic performance is often markedly better than that of companies that have unimpeded access to technology and product information generated abroad. Whether this would hold in the case of the computer industry is difficult to predict; the fact is that at the present time we do not have independent computer manufacturers operating on a scale where this proposition would be testable.

Marketing is also affected by the multinational dominance of the Canadian computer industry. Many foreign-controlled subsidiaries in Canada are barred from exporting, or limited in what they can export, by parent-company policy or by the government policies that prevail in their parent-company's headquarters country. At a more basic level, the foreign ownership dimension acts as a constraint on the kinds of mergers that may be desirable for more efficient operations in the domestic or international markets. There are, however, numerous problems which militate against the possibility of subsidiaries of different multinational firms merging to improve their position and address themselves to unique Canadian potentialities and problems. A merger of subsidiaries of multinationals A and B would, in effect, create a new type of Canadian-based firm which might be in conflict with the interests of either parent firm and/or the general policies of either or both of the headquarters countries.

In the past, a number of small Canadian companies have been taken over by foreign-controlled firms and integrated to create a co-ordinated company. It is hoped that if and when legislation governing foreign-takeovers is passed, it is complemented by policies aimed at ensuring that Canadian-owned companies are able to acquire, and encouraged to acquire, promising smaller companies. In no industry might such policies be more significant than in computers.

Where established multinational firms operating in Canada are concerned, it is recognized that the trend is now toward rationalization and full integration of activities on a global or North American basis. Rationalization may mean, in many cases, that such research and development that does occur under the auspices of the subsidiary in Canada leads, not to manufacturing in this country, but rather, to production located elsewhere within the global firm. In such cases, a total systems capability is less likely to develop within the Canadian operation; nor are spin-off companies likely to be formed in this country. In whatever way possible, we should attempt to influence corporate policies so that, where rationalization does occur, R & D undertaken in Canada is linked to manufacturing that takes place in this country. International product mandates should be sought – that is, the Canadian subsidiary should, for certain products, be assigned autonomous responsibility for all aspects of development of certain products, from design through marketing, on an international basis.

Finally, it is clear that the multinational firm also has a considerable impact on the quality of management available to the Canadian industry and on the scope within which management skills can be applied. The branch-plant structure tends to inhibit the development of effective senior

management. The most promising juniors managers may be siphoned off to corporate headquarters, or to other parts of the global operation, once they have acquired some experience and demonstrated their ability. Alternatively, the price of staying in Canada may be the acceptance of limitations on ultimate advancement.

In summary, then, our two principal points concerning the hardware industry are:

1) It would be prudent to limit Canadian involvement in large mainframe development and production to alliances with existing multinational corporations, such as the one Canada now has with Control Data Corporation. We are of the firm opinion, however, that as CDC's operations develop, and if any other major agreements are made with foreign computer firms, there should be provision made for sufficient Canadian equity participation to assure the long-range protection of Canadian national interests.

2) The thrust of Canadian support for a computer hardware industry should be aimed at the development of a Canadian-controlled minicomputer industry, and at the support of a specialized peripheral-manufacturing industry which would concentrate, initially at least, on communication-related equipment.

Software and the Service Sector

We have already noted that the service side of the computer industry is growing at a somewhat higher rate than the industry as a whole. This sector of the industry, which provides assorted services and expertise to computer users, has already had a considerable impact on the functioning of the Canadian economy; over the next decade, its evolution will have a major impact on the kind of computer applications that are adopted in Canada.

Much of the manufacturing activity in the Canadian computer industry will continue to be linked to the activities of multinational companies. However, the Science Council believes that the computer service industries can, and should, be predominantly Canadian-owned and -controlled. This is both desirable and feasible. Service functions relate primarily to applications and, hence, to user requirements: the import of high technology and the ability to penetrate export markets are not as significant as on the manufacturing side. Canadian ownership and control is *desirable* because the computer service industry will, in future, permeate nearly all business and governmental functions, particularly as the government increasingly engages in the "contracting out" of various activities. Moreover, the computer service industry will be closely linked to the communications industry in providing a variety of business and personal informational services to individuals.

Canada has historically had a policy of maintaining majority Canadian ownership, or even exclusive Canadian ownership (whether by private or public means) in those sectors of the economy that are vital to the functioning of the country and to the furthering of national identity: e.g., banking and major financial institutions; transportation and com-

munications; the electric power industry and similar public utilities, etc. In future, the computer service industry (a vital emerging part of the national network for the dissemination and use of information) will be recognized as playing a similar, important, rôle in national life. Canadian ownership of this part of the computer industry is a natural, and necessary, objective.

Within the computer industry, the service bureaux play a particularly important rôle. At the present time, hundreds of business and governmental activities are dependent upon access to competent service bureaux. We can envisage a further development of such bureaux, accompanied by more intense interaction with the communications industry, to form major *computer utilities* for the operation of data banks that serve the needs of a clientele embracing the legal, health care, and commercial and consumer credit fields, as well as a wide range of individual and institutional customers. The impact of such developments on the Canadian way of life will be considerable. The analogy with banking, communications, transportation and other fields, where steps have been taken to protect the national interest should be clear to any discerning observer. To ensure that such comprehensive service systems are developed in a manner calculated to best serve Canadian needs, and to make possible the application of such regulations as the Parliament of Canada and the several provincial legislatures may see fit to impose, from time to time, in the interests of security and privacy of information, **it is necessary that, right from the start, these business institutions be Canadian-controlled.**

The main requirements for a viable computer service industry are available at the present time. While the industry makes significant use of computer hardware and communications facilities, its most necessary prerequisite is the availability of highly-skilled people. At the present time, high-calibre personnel with training in computer science, engineering, and a variety of technical skills are available, in this country, to meet the needs of the computer service industry; these should continue to be available in sufficient numbers to satisfy growing requirements in these fields.

There already exists a two-way flow of computer services across the Canada-U.S. border, with the balance generally favouring the U.S. During our study we have come across examples of what can only be termed "dumping" of surplus computer capacity by U.S. organizations whose facilities are already paid for by their American clienteles. Such dumping represents unfair competition with Canadian service companies and measures should be taken to stop it.

Service Bureaux

Service bureaux, varying greatly in size, offer the computer user an alternative to purchasing and operating his own system. In many cases, significant economies and considerable improvement in service are being realized as both small and large computer users turn to the service bureaux in order to gain the benefits of innovations in hardware and increased sophistication in software.

At the present time, negative aspects of the service bureaux pheno-

menon are easily discernible, for example, overcrowding of the market, with resultant fragmentation and hence an overcapacity (as indicated by excessive idle capacity for service bureau computers). However, with the trend toward increased use of service bureaux, the prospects are excellent for most of the well-established firms. Improvements in communications networks (both those that are presently being implemented and those envisaged in the future) should enable the large bureaux to provide unique services via computer networks and remote terminals. Some of these services will not be feasible for independent users or small bureaux and, after a period of transitional shake-ups, the situation of the service bureaux should be characterized by a greater degree of economic and organizational rationalization.

Computer applications of interest to government, business and universities will be significantly enhanced by the emergence of shared hardware, software, and data facilities. In particular, data banks for the monitoring of consumer and business credit, and in health care, legal, and governmental applications, are expected to make use of the facilities of larger service bureaux. (While we see the efficiency of such operations being enhanced, we are aware of the disquieting opportunities for invasion of privacy which this very efficiency affords.)

While the main trend in the service bureau field will be the emergence of larger, rationalized firms, small bureaux can serve a unique need by providing specialized services for selected categories of customers. For example: a wide range of computer services could be provided for private medical practitioners by smaller bureaux operating in various cities in Canada.

We must note one thorny problem relating to unfair competition faced by commercial service bureaux. Universities are often acting irresponsibly in using publicly-subsidized equipment, acquired in support of their non-profit research and teaching activities, to compete unfairly with private Canadian service bureaux. Academic entrepreneurship of this sort does not reflect well upon the universities, and where it exists should be terminated at the initiative of the appropriate university decision-making bodies.

Software Houses

The software houses generate specialized software to perform various functions on the customer's own computer; the degree to which specialized information about the customer's needs is required will vary with the size and complexity of the particular operation.

At the present time, much of the existing software in use by Canadian firms falls short of optimal quality standards. Given the low sophistication and relative inexperience that was inevitable during the early phases of development of computer applications, it is understandable that much of the software still in use today was designed by inexperienced programmers or has been extensively modified and patched together over time. Presumably, much of this existing software will be replaced as users become more demanding about the payoff from applications.

Canada has already produced some high-quality software packages

that are widely used[5]; we are in an excellent position to engage in further development in this field. Unfortunately, major barriers exist to the effective marketing of software packages. Many users find it difficult to understand the basic concept of software as a means of upgrading the performance of hardware. Others are wary, because they have had experiences of purchasing software in the past that did not live up to expectations. In addition, there are uncertainties about the patentability of software; there is some degree of fear in industry that, under existing conditions, one company may gain access to proprietary software developed for another company competing in the same field. Despite these difficulties, there is rapid growth in the marketing of software packages.

It is important that the Canadian government give recognition to software as an industrial product, which can be treated, commercially, like other industrial products. Software houses, which develop these products, should be seen as an important segment of a potentially viable Canadian industry.

Facilities Management Firms

The facilities management firms, which offer computer services connected with the operation of on-site computer facilities owned by a client (often accepting, in partial payment, the right to use surplus capacity to service other clients), are emerging as a new form of service house. By simultaneously serving many customers, and acting as a link in the pooling of their resources, a facilities management firm can help its clients to achieve impressive economies in hardware, software, and total systems productivity. Pooled use of hardware reduces the burden of capital investment and can enable Canadian firms to make more efficient use of their financial resources; moreover, it is possible to write single programs to service several customers' needs. Canadian firms with computer operations expertise, particularly service bureaux, should be encouraged to expand into the facilities management type of activity. A wide range of current users of computer facilities, including government departments, should consider engaging facilities management firms to manage their computer operations.

Systems Houses

Development and marketing of special-purpose systems, combining appropriate hardware and software, requires that the systems house have expertise in both the hardware and the software fields, and, perhaps even more important, that it have a detailed knowledge of the kind of application for which the system is to be developed. In many cases, the major hardware for a special-purpose system consists of an off-the-shelf minicomputer. Peripheral devices are connected to the minicomputer by interface hardware that is designed and manufactured by the systems

[5]The Watfor and Watfiv compilers developed at the University of Waterloo are being used by more than 400 computing centres throughout the world. I.P. Sharpe Ltd., of Toronto has developed and is marketing a software package called APL Plus. CDP Computer Data Processors Ltd., of Calgary has also developed and is selling application programs and service for geophysical exploration.

house, which also provides appropriate system and application software.

There are many promising opportunities in this field, and a substantial Canadian capability already exists. Opportunities for the development and marketing of specially-tailored systems are expanding as a result of the decline in price and increase in sophistication and capacity of minicomputers, as well as the increased recognition of the wide range of special applications for which such systems are appropriate.

Unlike the market for minicomputers themselves (where, in any event, Canada has a potential base for development), the market for systems built around minicomputers is not yet characterized by the existence of strong, potentially dominant, competitive forces. The amount of capital required to establish a systems house is variable; some flexibility exists, depending on the complexity of the special system to be manufactured. In many cases, a relatively small investment can serve to launch the development, manufacture and marketing of such a device. The viability of existing Canadian firms would have been enhanced had contracts for special systems required by the Department of National Defence, the Department of Transport (for air traffic control), and the banks, been awarded to Canadian companies. In general, in view of the existing demonstrated capability of Canadian firms to excel in design of interfaced hardware/software systems, it would seem likely that production of special-purpose systems based on minicomputers can provide another area of strong support for development of the Canadian computer industry.

Government Policy and the Canadian Computer Industry

Governmental policy for the computer industry in Canada may be viewed in terms of a three-fold interaction. At one and the same time, it is necessary to promote the **development** of the industry (according to such yardsticks as industry size, composition, level and mix of employment, i.e., criteria for economic development); to enhance the **performance** of the industry (standards for hardware and software, education and professional standards for personnel, high standards of service to computer users, i.e., quality criteria for the industry in relation to its clientele); and to guide the development of the industry's **relationship to broader national objectives** (e.g., its impact on the balance between foreign ownership and Canadian ownership, its contribution to balance of payments, its spillover into other sectors of the economy and society, its regional distribution, etc.). The requirements for effective public policy in this area are, of necessity, exceedingly complex and to achieve the proper "mix" among policy objectives requires a delicate and constantly reviewed effort to achieve some balance among interlocking developmental strategies. In sum: no *single* policy will achieve, for Canadians, the type of healthy and responsible computer industry that is needed in this country; rather, the pursuit of this overall objective requires that a number of policies be pursued simultaneously and in harmony with each other.

Classical assumptions about the market economy are singularly inappropriate in this field. In an earlier era, characterized by a much simpler and technologically less-sophisticated industrial economy, it was possible to postulate that national objectives could be reached if each businessman or each firm were left free to operate according to their own best interests (or, at least, these interests as perceived by the decision-maker within each business). But, as attested to by the increasing amount of government subsidization of industry, government regulation, etc. – as well as by taxation to achieve objectives that are beyond those that the industrial system itself promotes – it is clear that we are beyond such simple views of the workings of an economy and a society. While we do not, as a body, subscribe to the view that complete governmental intervention is required in the operations of industry, the Science Council concurs in the opinion that

"where individual profit maximizing decisions do not lead to a socially desirable outcome, one should not rely on the social consciences of companies to meet social objectives. If a social goal is important, and the market place does not achieve it, it is the rôle of government to change the market environment so that corporations doing what they do best – earning profits – also achieve the social purpose. In fact, in our eyes, it is an abdication of the rôle of government to leave national decisions to the goodwill of management."[1]

In general, in a mixed economy, government interacts with indus-

[1]D.D. Cowan and L. Waverman, *The Good Corporate Citizen in the Computer Industry*, Science Council of Canada unpublished report, May 1971.

tries (including the computer industry) in a number of ways. Some of these are:

1) As the architect of the legal and regulatory framework within which the industry operates;

2) As the architect of incentive programs which modify the industry's behaviour;

3) As customer for the goods and services produced by the industry;

4) As negotiator of trade agreements, multilateral tariff and non-tariff concessions, etc., which broaden opportunities for sales in foreign markets;

5) As a source of commercial information and assistance about penetration of foreign markets, as well as a gatherer and disseminator of information and technical intelligence about industry developments abroad.

(Where appropriate in the above listing, the term "government" is used generically, to include both the federal and the various provincial governments.)

These, and other miscellaneous governmental activities, are important not only to the development of an industry, but also so that the industry may best find its place in the total fabric of national life. For government-industry interaction to be effective, public policy must be well articulated and well co-ordinated so as to strike a balance among such immediate and sometimes conflicting objectives as maximization of tax revenues, enhanced employment opportunities, achievement of a favourable balance of payments, and the building up of an indigenous industrial capability in areas where such capability is deemed desirable.

Given the rapid development of the computer industry, and the complexities which confront it as it enters into a new phase of its evolution in this country (and internationally), it is understandable that we may have fallen short of the ideal in the articulation and co-ordination of policy. At the present time, the Canadian computer industry complains that it has not been made aware of the Federal government's intentions in this field, and there has been doubt expressed that the Federal government has, in fact, arrived at a policy.

Throughout the earlier chapters of this report we have made suggestions on specific direct actions which governments might undertake to stimulate the computer industry. In this chapter we draw attention to the indirect adverse effects on the computer industry which result from the applications of public policies which were not designed with the computer industry specifically in mind.

Corporation Taxes

The computer industry, like most other industries, is likely to receive a considerable stimulus from the reduction of the corporate tax rate[2] (down to 41 per cent from 49 per cent). Moreover, the two-year accelerated depreciation that is now possible on production machinery is likely to increase the

[2]The tax changes referred to are those announced when the Federal budget was introduced on May 8, 1972.

use, by various industries, of process control computers. The impact of this is likely to be felt in the industry as a whole, particularly among manufacturers of minicomputers and by the systems houses.

Suppliers and users of computers would benefit significantly if more generous capital cost allowances were allowed on all computers. In particular, this would have a positive impact on the Canadian service bureaux, which must compete with U.S. service bureaux that enjoy a relatively more favoured tax and economic position. The Canadian allowance of 20 per cent per year on a declining balance is considerably lower than what is allowed in most other countries (which give greater weight to rapid obsolescence in this field), and contributes, to some degree, to the higher computing costs that prevail in Canada.[3]

Tariffs

At the present time Canadian tariff regulations and the Excise Tax Act do not make specific provision for computer hardware and software,[4] and the current application of these inappropriately formulated regulations is detrimental to the interests of computer manufacturers, the component suppliers, the computer user and, perhaps, ultimately to the public as a whole.

Existing classification and systems of valuation for computers, under the tariff regulations, are distinguished by anomalies and, indeed, by outright absurdities. Central processing units have, in some cases, been brought into Canada as calculators or as refrigeration units. Whether or not a rather trivial item is added or deleted (e.g. a panel meter) may change the duty considerably within the 7.5 per cent to 20 per cent range applicable to most-favoured nations. Software and data tariffs are even less consistent than for hardware. A complex computer program, a compiler worth $10 000, can enter Canada, but in view of the intangibles involved, the only tariff that is levied may be the tariff on its recording medium – a reel of magnetic tape, worth, perhaps, $30.00. If the compiler is simply made available to the user via a telecommunications link that crosses the international boundary, no tariff whatsoever is levied.

These instances of anomalies in the existing tariff framework would be amusing, were it not for their real impact on the development of the industry. The Science Council believes that tariffs can be formulated for computer hardware on the basis of proper classification and valuation.

It is impossible, however, to implement adequate tariff protection for software, or for electronically-transmitted data. Like any concepts and ideas relevant to the evolution of a given technology, these can be transmitted in many forms. If protection is required for software and data transmission, primary reliance should not be placed on tariffs – rather, such protection should take the form of domestic incentives, or of exemptions for the use of Canadian facilities.

[3]At least one dissenting opinion should be noted. It has been argued that, without appropriate countervailing mechanisms, fundamental tax concessions favouring the rapid development of the computer industry could force the pace of innovation at a more rapid rate than is needed, and hence exacerbate instability in some sectors of the industry.

[4]The Tariff Board is currently reviewing tariffs on computers and on telecommunications equipment.

Federal Sales Tax

A federal sales tax of 12 per cent is levied on all computer hardware sold in Canada, whether domestically manufactured or imported. On hardware manufactured in Canada, the excise tax is levied on the price at point of sale; for imported hardware, however, the tax is on the duty-paid value, which is often below the selling price for comparable Canadian-made hardware. Such an arrangement, whatever its original intent, has the practical effect of discriminating against Canadian computer manufacturers: it should be changed.

A further requirement is that the federal sales tax on leased equipment be paid in full at the time that the leasing arrangement enters into effect. Again, from the point of view of closing loopholes in the collection of government revenues, the intent of this provision may have seemed reasonable at the time it was enacted. However, as applied to the computer industry and its customers, such a provision ignores the prevalance of leasing arrangements as a legitimate means of safeguarding against obsolescence in a rapidly-changing field, where equipment may have to be replaced or substantially modified at frequent intervals. If we wish to further develop the Canadian computer industry, and enhance the use of computers as a means of raising the efficiency of industry and commerce in this country, some alternate provisions for payment of this tax should be considered: e.g., spreading out payments over the duration of the initial lease.

The excise tax on computer hardware appears to be particularly detrimental to Canadian service bureaux. The excise tax of 12 per cent contributes greatly to the higher cost that Canadian computer service bureaux must pay for their computer hardware: it is an added burden on their efforts to be competitive with American-based companies which do business in Canada. Cost differentials can be significantly affected by the excise provisions. The competitive margins are such that whether or not the excise is levied may mean the difference between getting certain types of business or not getting it. (It has been suggested that the oil companies, with a high volume of geophysical exploration data to be processed, are induced by such differentials to process their data in the United States, rather than in Canada.)

Incentive Programs

A multitude of Federal and provincial industrial incentive programs now exist. These are designed to achieve a wide range of objectives – especially the generation of employment, the stimulation of expanded industrial capability, and the minimization of regional economic disparities. While there have been problems in reconciling the disparate objectives of such programs, nevertheless some such incentives seem to be required to compensate for geographic and other disincentives to development that would have an excessive impact on the Canadian economy if governments did not intervene.

The most promising programs whereby the Federal government can encourage the development of a Canadian computer industry are those that

are administered by the Department of Industry, Trade and Commerce: PAIT (Program for the Advancement of Industrial Technology), IRDIA (programs under the Industrial Research and Development Incentives Act), and DIP (Defence Industry Productivity programs).

PAIT is the major discretionary program for stimulating development within the industry on a project by project basis. Over a five-year period ending in March 1971, it had already paid out some $9.8 million toward the support of 34 computer projects. Considerably more than this figure has been committed for ongoing expenditure over the next few years: commitments include $19 million to Control Data Canada for mainframe development; $8.3 million to National Cash Register for development of a banking terminal system; and a major grant to Canadian Aviation Electric Ltd. for its flight simulator program.

Under the government's program directed at regional development, the largest grant received by a computer company in Canada was $6 million to IBM for its Bromont, Quebec, components plant. Initially, this grant will generate about 200 jobs associated with the operation of equipment to fuse metal to a ceramic substrate component. One question that arises in connection with this type of grant (related, as it is, to the subsidization of in-house manufacture of primary components, rather than to integrated development of a product line) is whether it contributes adequately to the overall development of the Canadian computer industry.

Although PAIT has been effective (as measured by the number of new computer products stimulated, and by the fostering of increased activity within the industry), it could, no doubt, be improved. Some discernible shortcomings are the following:

1) There are complaints that *small companies* are often discouraged by government officials who seem to feel that the amounts being sought by these companies do not justify the administrative expenses entailed in the establishment of a program.

2) Innovative proposals involving, at least on first consideration, a high degree of *risk* may be rejected too frequently. It is legitimate that government officials seek to minimize risk and to reflect the government's overall concern to extract maximum utility from its investment; however, such concerns, which are instilled in officials in the course of their regular career development, have negative consequences if they are over-emphasized when applied to a program like PAIT.

3) The PAIT program, as presently conceived, gives insufficient recognition to *marketing* as an essential component of any innovative type of industrial activity. Admittedly, in mid-1971, PAIT was extended to provide assistance to those market assessment activities that were aimed at establishing the commercial feasibility of a product. However, even the amended PAIT program fails to take into account the realities that prevail in the computer industry: it is not uncommon for the cost of launching a new computer product to include as high as a 70 per cent cost component for marketing.

4) As implemented, PAIT has not given adequate recognition to *software* as a product which should be supported in the same manner as hardware.

5) As a general operating principle, it would be beneficial if the PAIT *definition of innovation* were widened to include *any* innovation that will likely lead to a marketable product. Under the present ground rules, *technical* innovation is required by PAIT. But in the computer industry, many valuable products (both in the hardware and the software fields) simply consist of a collection of relatively standard modules directed toward a particular application: the "innovation" is not in the technology, but rather in seeing the application and in bringing together the available components in such a way as to effectively meet the requirements of the application.

Governments as Customers

The federal and provincial governments have purchased more than 25 per cent of the computers used in Canada, and have enormous continuing requirements for computer service and expertise. Unfortunately, the potential to use the leverage conferred by their purchasing power in order to bolster and influence the Canadian computer industry has, to date, largely been wasted. The "push" generated by numerous governmental incentives has not, in other words, been complemented by strategic use of the "pull" inherent in the public sector of the market for computer goods and services.

Provincial governments, particularly in view of their jurisdiction in such fields as health care, direct welfare, and education are very large actual and potential computer users. But it is the Federal government which is by far the greatest computer user in Canada. The Federal government operates over 250 installed computers, has an annual EDP budget of $81 million (expected to grow to $174 million by 1975), and has direct responsibilities in fields requiring large and sophisticated computer applications: national defence, communications, air traffic control, etc. A Federal government policy in the computer field that made effective use of its leverage as purchaser of equipment and services could have a major positive impact on the development of the Canadian computer industry.

It is possible that some progress at the Federal level may result from the "Policy on Electronic Data Processing in the Federal Government" that was announced by the Treasury Board in February 1972. The statement announced general objectives of the new policy, and left details of implementation to be unveiled at a later date. Insofar as the objectives for governmental purchasing and operation are concerned, the Science Council finds itself in general agreement with the Treasury Board statement:

"The objectives of this policy are to provide an environment for equipment, personnel and supporting services that will optimize the contributions of EDP to government in total, while recognizing the respective roles of departments and Central Agencies; to allow the acquisition of equipment and services of an optimum quality with timely delivery and least cost, and consistent with any national industrial strategy established for Canada; and to provide for evaluation of EDP programs before, during and after implementation."

In assessing this statement, it is necessary to pay particular attention to the question of what might constitute an appropriate balance between the "least cost" criterion and the requirements of a "national industrial strategy".

When we consider governmental purchases, cost should not be so narrowly construed as to encompass only the *direct cost* of equipment or of services. A wider concept of *real cost* must be developed and kept in mind: this would involve consideration of revenues to government arising from corporate and other taxes, consideration of whether profits leave Canada as a result of particular purchases (including purchases from foreign-owned companies) or are retained for further investment in this country, etc. Purchase of equipment or services consistent with a national industrial strategy must place some definite value on the relative performance of competing companies in R & D and manufacturing activity, employment opportunities, and potentiality for development of an export base resulting, over time, in additional revenue.

It will be difficult to work out criteria for ultimate, "real" costs of government purchasing policies in the computer goods and services areas. However, attempting to establish such cost criteria is indispensable both to an effective procurement policy and to any comprehensive industrial strategy for the development of the computer industry (or other industries, for that matter). In the interim, as such a policy is being evolved, *directed purchases rather than competitive bidding* may have to be countenanced, at least in some strategically-significant cases.

The February 1972, EDP policy also commits the Government to favouring "contracting out"[5] over in-house activity, wherever this is appropriate: "The Government will meet its needs for EDP equipment and services from the private sector, except when it is in the public interest or [where] it would be more economical to provide them internally." This is also a statement that the Science Council can endorse, if "more economical" is understood as being subject to the general interpretation (i.e., according to balanced criteria of public interest), rather than referring narrowly to "least direct costs" in each and every case.

A great proportion of new government requirements for data processing should be contracted out to the private service sector. Canadian service bureaux, software houses, and system houses should benefit considerably. The payoff, from the point of view of individual government departments and agencies (and, ultimately, the taxpayer) will be that outside expertise will be brought in as required, and there will be an ultimate reduction of long-term commitments for personnel and facilities (i.e., greater flexibility, over time, in meeting government's EDP needs). To implement these policies most effectively will require some changes in the administrative process: "red tape", that has previously impeded contracting out, will have to be substantially reduced.

[5]A general increase in contracting out has long been recommended by the Science Council, and is now a definite policy of the government. The implementation of the policy has been outlined in many of the recent speeches of the Minister of State for Science and Technology. It should also be noted that both the British and American governments are now strongly committed to the principle of contracts to outside industry for the development of major governmental computer systems.

To complement the "contracting out" policy, we would further recommend the adoption of a "multiple sourcing" policy – i.e., a policy of purchasing the major components of a large system from a variety of suppliers rather than from a single source. Multiple sourcing has a variety of advantages from the point of view of industrial strategy:

– It will allow smaller Canadian companies to bid on parts of projects when they might well be unable to bid on the full project. Too often federal agencies, like Air Canada, have purchased very large systems from foreign suppliers, arguing – lamely in our view – that no Canadian company big enough to fill the order existed. Multiple sourcing is an effective answer to such a criticism.

– Support can be given to the systems houses in the computer service sector, who should be involved in putting together the total system from the component parts.

– On more technical grounds, it is seldom the case that a single supplier is the best source of supply for all parts of a large and complex system.

A Software Clearing House

The Department of Industry, Trade and Commerce, Statistics Canada, and the National Research Council currently provide technical and marketing information utilized by the Canadian computer industry.

An additional service that should be provided is a software clearing house. This would probably fit most appropriately within the National Research Council's range of industry-related activities. Such a service would make available to Canadian computer users a description of the full range of computer software that is available in Canada. Such a facility would significantly reduce duplication of effort in the software field. A start toward creation of a software clearing house might be made by cataloguing all non-proprietary government software, disseminating this information, and establishing procedures whereby such software could be acquired by interested users.

The United States has fully recognized the significance of providing wider and easier access to available software technology. It has created a Government-sponsored clearinghouse called COSMIC (Computer Software Management and Information Center) which provides to interested users, at reasonable cost, computer programs developed over the years by U.S. Government agencies and by firms contracting to supply such programs to government. Originally, these programs may have cost millions of dollars from public revenues for development. Available on tapes and cards, many of these programs can be integrated into research, commercial or industrial applications with little or no modification. Properly applied, these programs save organizations both money and developmental time. COSMIC is viewed, quite properly, as a valuable national resource in the computer age; **its use has been limited to clients in the United States.**

Training and Professional Standards

The computer industry depends ultimately on the quality, disciplined imagination and high level of skills of its personnel. At the present time, Canadian educational facilities are able to provide the industry with the required input of new, well-trained men and women. Indeed, much of the immediate impetus to a policy aimed at development of this industry is to assure that not only will jobs be made available to utilize this trained manpower, but that the mix of jobs (from those requiring basic skills to those requiring sophisticated creative ability) will be sufficient to afford these young people adequate and rewarding challenges in their own country.

Activities of private educational enterprises offering training in the computer field should be closely monitored by the Department of Consumer and Corporate Affairs and by the appropriate provincial agencies. While many of these schools offer legitimate training, there are some indications that some of them, at least, combine over-inflated claims about the career potential in the computer field with insufficiently rigorous screening of applicants for training.

The general efforts of the industry and the associations of professional and technical personnel to raise professional requirements and standards should, where appropriate, be accorded full support by governments. Where necessary, and when codes of proficiency and professional conduct are drawn up that warrant such support, consideration should be given to providing the associations with a legal base for quasi-regulation of their own members, analogous to that enjoyed by other, historically established, professional groups in our society.

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Publications of the Science Council of Canada

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First Annual Report, *1966-67* (SS1-1967)
Second Annual Report, *1967-68* (SS1-1968)
Third Annual Report, *1968-69* (SS1-1969)
Fourth Annual Report, *1969-70* (SS1-1970)
Fifth Annual Report, *1970-71* (SS1-1971)
Sixth Annual Report, *1971-72* (SS1-1972)

Reports

Report No. 1, **A Space Program for Canada** (SS22-1967/1, $0.75)
Report No. 2, **The Proposal for an Intense Neutron Generator: Initial Assessment and Recommendations** (SS22-1967/2, $0.25)
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