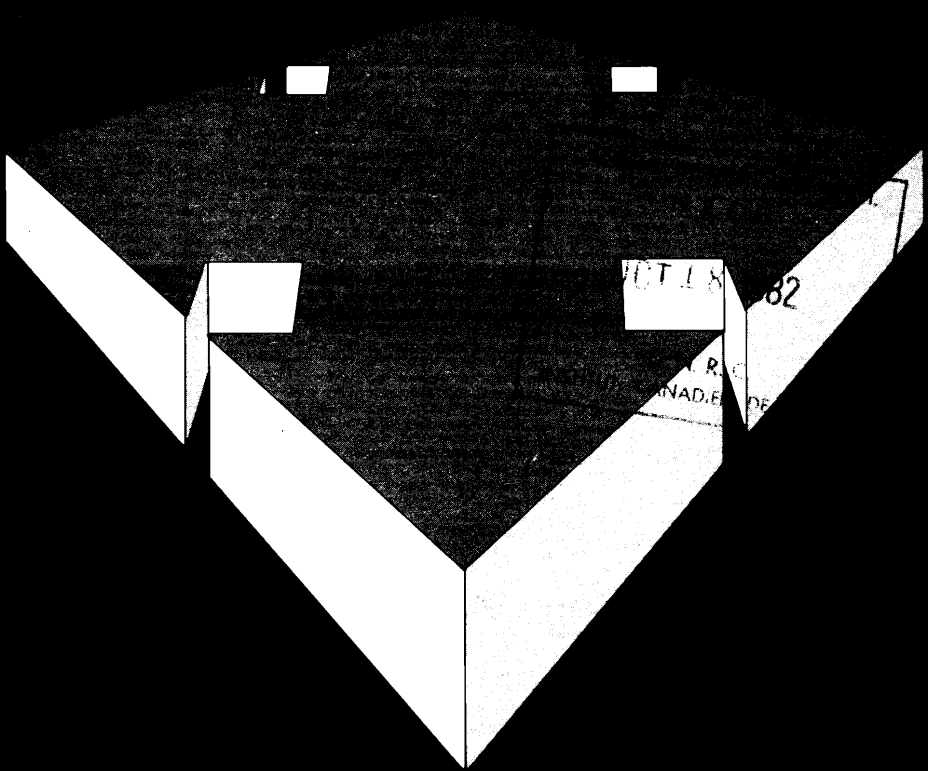
Threshold Firms

Science Council of Canada

Background Study 48

Backing Canada's Winners

Guy P.F. Steed



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July 1982

Science Council of Canada
100 Metcalfe Street
17th Floor
Ottawa, Ontario
K1P 5M1

Available in Canada through

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and other bookstores

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Hull, Québec, Canada K1A 0S9

Vous pouvez également
vous procurer la version française,
à l'adresse ci-dessus

Catalogue No. SS21-1/48E
ISBN 0-660-11185-3

Price: Canada: $6.95
Other countries: $8.35

Price subject to change without notice.

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Backing Canada's Winners

by Guy P.F. Steed

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Guy Steed is currently a science adviser with the Science Council of Canada, on secondment from the University of Ottawa, where he is a professor of geography. He was born in Singapore, attended school at Charterhouse in England, then studied geography, economics and political science at McGill University, obtaining a BA (Hons.) in 1961. He gained his PhD at the University of Washington in Seattle in 1966.

Dr. Steed is a specialist in the fields of industrial geography and regional development. He has taught at the Queen's University of Belfast (1964-65), Simon Fraser University (1966-75), and the University of Ottawa (since 1975). He is the author of over 35 articles in professional journals, reports and chapters in books and has contributed to several Science Council publications. His research in the past decade has focused upon Canadian metropolitan industrial development; the spatial organization of multinational corporations; international trade, location and adjustment mechanisms of the soft sectors; and the geographic consequences of technological change.

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Foreword

In 1979 the Science Council published *Forging the Links: A Technology Policy for Canada*, a report containing policy initiatives designed to revitalize Canadian industry. The report proved timely in its focus on Canada's increasing vulnerability in a rapidly changing world, its emphasis on the need for innovative industry in Canada (a theme promoted by the Science Council for more than a decade now), and its recommendations for a technology policy.

In view of our continuing concern about defects in the structure of Canadian industry, Council has supported further research on the problems of domestic industrial adjustment and the roles and contributions of science and technology. For instance, it has commissioned studies to examine the performance of foreign subsidiaries and paths of adjustment by domestically owned enterprises. Thus, recently it published *Multinationals and Industrial Strategy: The Role of World Product Mandates*, a study by its ad hoc Industrial Policies Group, which examines and promotes the acquisition of world product mandates by some foreign-owned subsidiaries manufacturing in Canada.

In *Threshold Firms: Backing Canada's Winners*, Dr. Guy Steed addresses and develops a positive response to the adjustment potentials and problems of some of Canada's domestically owned firms, those medium-sized and operating in more technology-intensive sectors. His background study provides detailed insights into the distribution and operation of threshold firms, their technology strategies and performance. This knowledge then leads to recommendations that are sensitive and responsive to the particular conditions and roles of those threshold firms.

The study represents the author's views and not necessarily those of Council. It is a significant contribution to our understanding of Canadian industry and Council is pleased to make it available to the public.

Maurice L'Abbé
Executive Director
Science Council of Canada

Acknowledgements

Several colleagues have kindly and significantly contributed to the preparation of this study, by providing encouragement, information and critical comment. Special thanks in this regard are due to James Gilmour, Director of Research of the Science Council of Canada, and to Michael Jenkin, Dirk de Vos, Shawn Brennan and Bill Forward, project staff of Council's Industrial Policies Committee. I would also like to thank Tom Clarke of Stargate Consultants, Christopher Maule, Department of Economics, Carleton University, and Pat Johnston, Vice-President, Legislative Affairs, Canadian Federation of Independent Business, for their informed comments on an earlier draft; John McVey, Chief of the Multinational Enterprises Section of Statistics Canada, for his able help in the preparation and interpretation of the data base for Chapter III; Brenton Barr, Department of Geography, University of Calgary, for his ready cooperation in the interviewing of firms in the Prairie provinces; Frances Bonney, Faye Borden and Francine Benoit for their willing, prompt and expert assistance in the library of the Science Council of Canada; Flo Ling, Marian Mayer and Laurette Beauchamp for their cheerful typing of several drafts; Susan Burns for her editorial assistance; and, in particular, the many businessmen who contributed so generously with their time and thoughts. Recognition of their contribution does not, of course, imply their endorsement of this study.

Finally, thanks are due to Diana, Timothy, Nancy and Robin, for their inspiration, encouragement and patience during preparation of the manuscript.

Preface

Intense pressures prevail among developed countries to reach the front or keep ahead in technology-intensive competition. This study focuses on some Canadian participants in the competition, our threshold firms, many of which have emerged as world-class competitors. These threshold firms are defined as Canadian-owned, medium-sized and operating in one or more of our five most technology-intensive industries. The study outlines the geographical and industrial distribution, behaviour and performance of such firms and indicates why they are expected to play an important role in Canada's industrial revitalization. It suggests that their performance may be positively influenced by innovation policy, which has become the point of convergence between industrial policy and science and technology policy.

The study puts forward an urgent case for a national commitment to nurture and promote threshold firms. It argues that Canada's current policies and support mechanisms do not serve them as well as they might. It recommends measures to help strengthen their international competitive position and speed Canada's adjustment to new global realities. The recommendations are designed not merely to aid existing firms, but also to encourage the emergence of additional strong, indigenous, core companies. It is through threshold firms in particular that government innovation assistance (and other forms of government-industry cooperation) can do the most towards creating regional and national self-fulfillment.

G.S.

I. Towards Backing Winners

New Directions

Canadians have yet to agree on desirable industrial priorities to compete successfully in an increasingly tough international environment. We confront several major challenges in choosing priorities and subsequently trying to influence the direction of industrial adjustment and moderate its pace. Our relatively small economy has great potential, due particularly to the range and extent of our energy resources.[1] Yet it is currently rather fragile, being both very open to such practices as dumping and "unfair" competition and spread so thinly across an enormous geographic expanse.[2] In addition, industrial adjustment is heavily constrained by a variety of factors, including the lack of accessibility for our manufacturers, at least through exports, to as large markets as are open to their competitors in other advanced industrial countries (AICs). The challenge of setting industrial priorities is significantly complicated by the existing regional distribution of industry[3] and is probably increased by the degree, as well as the focus, of foreign ownership.[4] The challenge is magnified further by the abundance of centralized and decentralized institutions able to influence public policy with respect to industry, by interregional tensions and the virulence of regional grievances (at least as expressed through our political institutions), and by a disturbing, possibly increasing, depth of distrust and lack of collaboration among government, business and labour.[5]

Such distrust does not augur well when forms of "corporatism"[6] appear to have gained vogue in international competition. Industrial democracies, some despite their rhetoric, have shown growing inclination to provide massive funding to their leading firms for R&D, export development and other purposes, because they view

high-technology firms as key instruments of national sovereignty. This inclination follows upon their sobering experience with both the failure of their macroeconomic policies and the problems arising from the interaction of their earlier industrial and regional policies, including various forms of reactive intervention and protectionism. The latter interaction has proven especially disruptive. As Thurow,[7] an American economist, points out:

> "Within the category of options called industrial policies there are two broad choices. Policies can be built to help losers or winners. The correct solution is to have a social safety net for helping individuals who are hurt when losers fail and an industrial policy for insuring that America has sunrise industries into which individuals can move when their old jobs disappear. An industrial policy designed to prop up dying industries is a route to disaster. We need only look at the countries that have tried – Britain and Italy. No one can make it work."

However "correct" such an economic solution, it runs headlong into political, social and geographic realities, especially if the expected winners and losers are concentrated in different regions. A weak central government in a federal system enhances the sensitivities and potential for conflict between development, efficiency and regional equity objectives in science, technology and industrial policies.

The developed countries have become partners in a world system of dynamic interdependence, driven by continual innovation and technology flow. National technological capacity has become a vital asset. Strengthening technological innovative capacities is an absolute necessity for Canada, just as it has become for other Organization for Economic Cooperation and Development (OECD) countries.[8] From that necessity must spring a new approach to innovation and industrial policy in Canada. The questions then arise – could and should an important part of the new direction for policy be to cultivate and capitalize upon the prevailing or potential expertise and international competitiveness of our threshold firms in "sunrise" industries.[9] It is an initial premise of this study that these threshold firms, which are in a stage of transition, will be technologically oriented in their competitive strategies and will be the firms most likely to see, and be suitably flexible to grasp quickly, the opportunities for technological innovation, as well as derive benefits from R&D support. They will be the main source of Canada's new core companies.

After a period of largely neglecting R&D and following mainly passive approaches to industrial policy – depending mainly on financial support programs, particularly last resort financing, to help firms meet the new trading environment – in the early 1980s the federal government appeared ready to shift its focus. It opted for a

more active and nationalistic tone in its approach to industry, seeking to stimulate industrial R&D, promoting the Canadianization of the energy sector and expressing its intent to introduce measures that will develop and strengthen Canadian-controlled manufacturing firms.[10] Several advisers have recommended such a path. They have concluded that Canada, whose industrial economy has long been primed and dominated by foreign-controlled firms, too many of whose branch plants have no mandate to export or to innovate, must now look largely to indigenous firms (defined as Canadian-owned), with their own R&D, design and engineering capability, to outperform rival firms abroad.[11] Some have also advocated development of an industrial strategy focused on "chosen instruments," "national champions," or "core" companies, in a manner now so frequently followed by other countries.[12]

Canada already has some experience with such chosen instruments, at both federal and provincial levels. But their number is relatively small and most are not primarily involved in manufacturing. Moreover, in view of the past failure of the private sector to fill a particularly debilitating vacuum or to grasp a major opportunity emerging in the Canadian industrial system, the instrument chosen has usually been a "commercial" Crown corporation. Thus Canadian governments have taken the route of state ownership often more on the perceived basis of pragmatism or necessity than of ideology or principle. Only rarely have they nurtured favourites in the private sector, such as Bombardier in transport equipment, CAE in flight simulators or Spar in satellites at the federal level, and at the provincial level, SED Systems, Saskatchewan's favoured electronics, aerospace and communications firm. Canada has been slow to emulate the apparent successes of some AICs in such "corporatism," combining the resources of the state with the energies of a preferred private enterprise. Our options may be limited in this regard, notably by the degree of foreign ownership, but also perhaps by the current lack of agreement on industrial priorities generally and the divergence of views between government and business. These factors make it difficult to identify more than a very few industries, such as aerospace, from which instruments could be chosen.

The prospects of building an industrial strategy focused on private-sector core companies depend in part on the existence of suitable companies from which to choose. According to Britton and Gilmour, the core companies should deploy offensive and, at the least, defensive technology-development strategies, and be competitive, or have the potential to become so, in foreign markets.[13] Such companies will be found, they argue, among the 40 Canadian-controlled companies that spend more than $1 million per year on R&D, and in the future, core companies will emerge from the greater number of small firms that are aggressive and possess patents.

Shepherd has emphasized that a policy of sponsoring core companies in specific sectors, as proposed by the Science Council in 1979, should focus on indigenous firms.[14] A main feature of his argument is that, in several sectors, domestically owned companies perform more R&D per dollar of sales than do foreign-owned companies, and that, given the nature of the truncation of foreign-subsidiaries, our central thrust must be to build Canadian-controlled, technology-intensive corporations in sectors where we have decided to specialize. He suggests the selection of such core Canadian companies should not be regarded as necessarily a central Canada policy, if some medium-sized companies are included. However, "since much of our industry is foreign-owned, this core-company concept will not be easy to implement; it will meet the vigorous but fatuous criticism that the concept implies a hostility to foreign investment." He adds:

> ". . .innovation policies must increasingly recognize the important role played in Canada by small and medium enterprises, as generators of technology, as risk takers, and as employers. . .. It is from this group that our 'core' companies will develop. It is this group that the successful core companies will nourish."

A policy of sponsoring core companies requires active government intervention of a sort that may currently lack broad national consensus. Yet would this be a surprising policy for a small and open economy in light of modern international developments? Is it the case that larger, more spatially compact and industrially diversified economies than Canada's may enjoy the luxury of less intervention, insofar as their greater resilience allows governments to be more indifferent to petitions to promote winners, preserve jobs, bail out losers, or generally protect threatened interests?[15] Is it not more appropriate to devote greater efforts to coordinate and shift the relative emphasis of government programs away from reinforcing failure and towards supporting positive adjustment policies designed to speed industrial restructuring? Such policies should promote present and potential winners, offer more generous adjustment assistance to the soft sectors, and build on regional strengths in a way that minimizes interregional conflict and reinforces regional interdependencies. Such an industrial restructuring would enable us to withstand foreign competition.

To maintain a thriving market economy in modern conditions requires sensitive and intelligent government support. It presupposes acceptance of the interdependence of public and private endeavour and of intervention based more on pragmatism than simplistic ideology, a route already followed in most AICs.

For Canada, interventionist policies appear "palpably inescapable" to some experts. By strengthening market forces and entrepreneurship, positive adjustment policies would provide a broad foundation for a new approach to industry-government relations.[16] This might involve some government influence on a broad range of

management decisions, and require much greater business-government interaction than has previously been acceptable in Canada, particularly in Ontario. It would sustain a mildly active form of economic nationalism.

Some movement in this activist direction, including specific support for locally based high-technology firms, was already apparent during the 1970s in several provinces, especially Saskatchewan and Québec. Some movement is also belatedly visible at the federal level, though strong supportive measures are still lacking. It is even evident in Ontario, the pivot of Canadian manufacturing. Thus the Ontario treasurer, previously one of the freer enterprisers in the cabinet, has noted he is moving away from the philosophy that government's role is simply to create the environment for growth. It is his perception now that "North Americans have been naive fools compared with our major trading partners."[17] Ontario's Conservative government has also introduced legislation to support the objective of helping Canadians to exercise increased control over their economic affairs, by acquiring and owning a greater share of the manufacturing sector. In promoting the provinces' Business Buy-Back Program, the previous Ontario Minister of Industry and Tourism argued "this initiative is key to increasing Canadian participation in the economy, and to maintaining viable manufacturing operations in Ontario."[18] In a subsequent document, a strong plea for interprovincial economic cooperation, he also noted:

> "During the past few years it has become clear that international markets are increasingly being dominated by foreign companies that are government supported, government directed, and sometimes protected by the security of closed domestic markets. For most of our international competitors, trade – and all aspects of trade, including heavy subsidization of R&D – has become an extension of government economic and industrial strategy. We would be naive to ignore what is happening."[19]

Moreover, in redefining his government's role he argued:

> "Our government does not have the resources. . . to sustain weak companies at the expense of the strong. . . we must stop watering down our resources by backing losers simply on the grounds that they need help. Instead, we must do everything we can to pick – and back – the winners."[20]

Purpose and Approach

It is time we started feeling good about things we do well, or so a popular TV advertisement admonishes us. And rightly so. Too common a trait of Canadians, it seems, is to show little aptitude for rejoicing in our manufacturing successes as opposed to brooding over if not bemoaning our failures. However, redressing the imbalance requires detailed knowledge about successful firms.[21] And it is

hardly surprising in a country of vast distances that we know so little about our small and medium-sized winners, or those with potential to become so.

This background study seeks to raise public awareness about performance, potentials and problems of technology-intensive industries, hence to contribute to discussion on the development of interrelated science, technology and industrial policies for Canada. Such policies must be rooted in a concrete and practical grasp of the workings of industry. The study's focus is on the condition and situation of threshold firms, which are medium-sized, Canadian-owned firms in the electrical, chemical, machinery, transport equipment, and petroleum and coal products industries. Its general purpose is to outline the technology strategies and innovative focus of these firms, indicate their patterns of survival and paths towards success and examine the efficacy of government policies and programs designed to influence them.

These threshold firms are potentially or actually in transition between the state of a small-medium enterprise (SME) and a large enterprise. How many are there on which to build? What are their characteristics? How vital and vibrant are they? Are these Canada's unsung heroes, its generally less visible current and potential winners? Are any at the forefront of global industrial innovation? Should they be targets for specific Canadian policies for science, technology and industry? And if so, what sorts of measures might be appropriate?

Threshold firms are the main source of potential core companies. This study has the following purposes:

1. to establish and document the scale and distribution, both industrial and geographic of threshold firms;
2. to indicate the extent and form of turnover in their population;
3. to analyze their behaviour and performance, with particular regard to their technology strategies and forms of innovation;
4. to assess their use of, and satisfaction with, the available government schemes supporting R&D and innovation activities;
5. to promote awareness of their achievements and the importance of their R&D, design and engineering;
6. to consider some situations in which they benefit from and contribute to Canada's technical advance;
7. to point out the varied roles they play in different industries; and
8. to contrast their various ties to their regional industrial environments and reveal the pressures towards, and direction of, geographic expansion.

My approach to the study is to combine a synthesis of several recent studies, some of them not widely distributed, with an analysis

of data obtained from both Statistics Canada special runs and a series of interviews with senior executives, and then to provide a number of case histories of threshold firms. The interviews and case histories provide a reasonable cross section of experience, from varied industrial and regional environments. Examples include successes and failures as well as some walking wounded. The case histories illustrate what threshold firms are like, what they do and how some come into being; they present the views of the firms' leading executives on strategies and problems; and they identify some similarities and differences between firms. If the study can dispel some of the ignorance, which seems to exist even at high levels, concerning the nature and performance of these types of firms, it will have made a useful contribution.[22] Perhaps the study may also help to dispel the usual image held by foreigners of Canada: that of simply an exporter of raw materials, a country badly lacking in manufacturing and technological capabilities.

Why Threshold Firms?

To understand the importance of threshold firms we must look at them in the context of the emerging objectives of Canadian governments, and trends in the international and domestic industrial systems. Many factors contribute to the potential special role of small and medium indigenous manufacturing enterprises in general and threshold firms in particular in the Canadian economy. The following appear most pertinent.

1. *A notable structural problem in Canada's external trade.* This emphasizes the need to strengthen Canada's trade position by introducing measures to generate a more viable and prosperous manufacturing sector, particularly to encourage firms with inhouse product design and engineering capability to develop unique products for export.[23]

2. *The small likelihood of being able to strengthen significantly and build on the "soft" manufacturing sectors.* The competitive advantages of some East European "state trading" countries and newly industrializing countries (NICs) are increasing, not only in the case of standardized products made with mature technologies by low-skilled workers, but increasingly in less standardized products and components requiring newer technology in some sectors of medium technology intensity.[24] The more rapid transfer of technology, usually through multinational corporations (MNCs), has contributed to short-circuiting the product cycle in favour of NICs.[25]

3. *The poverty of reliance on currency depreciation to improve competitiveness of Canadian manufacturing, particularly end-products manufacturing.* This is a poor approach given the structure and

ownership characteristics of this sector and the fact that much of the international competitiveness in medium- and high-technology sectors is on a nonprice basis, is heavily dependent on technological innovation and product performance, and is frequently conducted intrafirm.[26]

4. The shifting emphasis of AICs away from largely defensive and reactive industrial and commercial policies towards more anticipatory and positive adjustment policies. The latter policies aim to build on the strengths of individual firms which have revealed their capability to perform. They support promising industries, particularly through the promotion of R&D and technological innovation, in conjunction with a range of other measures.[27] They attempt to deal with those many market imperfections which undermine the effectiveness of macroeconomic policy.

5. The dominance of Canadian manufacturing, particularly the medium- and high-technology sectors, by foreign-owned corporations. Only a few foreign-owned corporations have an inhouse Canadian R&D and design capability that enables them to export and to earn a world product mandate or significant specialized mission.[28]

6. The growing rate of withdrawal and closure of foreign-owned branches, plus the suspicion that American policy makers have stepped up a subtle campaign against foreign branches. The campaign includes measures such as the rapid growth of duty-free manufacturing zones along US borders, and a reduced preference for Canadian manufacturing projects by experienced US firms, at least with respect to the transfer of significant new products.[29]

7. The considerable difficulties expected for foreign subsidiaries bargaining to obtain specialized missions and world product mandates. It may take a long time, according to some leading Chief Executive Officers (CEOs), before new mandates are acquired and have significant impact;[30] yet domestic origin and control of technology and design plus export market access are fundamental to export performance.

8. The lack of large Canadian-controlled firms in more technology-intensive sectors and the fact that government influence is already extensive on many of those firms. Several of them are fully government owned, such as de Havilland and Canadair, and some partly government owned, such as AES, Polysar and Connaught, three subsidiaries of the Canada Development Corporation, whose major shareholder is the federal government. Among these government-owned firms several are relatively recent acquisitions and some have been nurtured to become winners. Among those in the private sector several have become world leaders in their fields, including

Bombardier in snowmobiles and other transport equipment and Northern Telecom with its digital-based communications equipment.

9. The growing emphasis among many AICs on regional policies designed to mobilize the potential of a region's indigenous establishments and nurture, in particular, small and medium-sized indigenous enterprises, which many consider likely to be the main sources of future employment and income opportunities.[31] In Canada this trend has received additional impetus given the strong powers of the provinces, largely in the form of province-building strategies aimed at reducing dependence on external decision making. Many provincial strategies include measures to support innovative and technologically advanced firms, particularly those headquartered in the province, whose development decisions they have a greater potential to influence than those of externally controlled firms.[32]

10. The trend to look upon SMEs not only as powerful tools of regional policy but also as significant sources of innovation.[33] This contrasts with prior academic and central government preoccupations with large companies, and a social ethos which has long underplayed the role of SMEs and lacked appreciation of their risk taking and initiative.[34]

Outline

Chapter II reviews literature on the nature of technological innovation, the technology strategies of firms, the role of SMEs in technological innovation, government support for technological innovation, and some ideas about the size distribution and technology strategies of Canadian firms, particularly the problems confronting indigenous firms in establishing and maintaining innovative capabilities. The review provides the basis for a series of questions regarding R&D and innovation by threshold firms.

To help identify threshold firms, Chapter III makes use of a special tabulation from Statistics Canada. It also draws upon several recently published reports that provide useful insight into the behaviour and performance of some threshold firms. Chapters IV and V then analyze data obtained through interviews with leading executives in over one-third of these threshold firms. They focus on the recent growth, technology strategy, R&D orientation, profitability, types of innovation and export orientation of two subgroups: those electrical products, transport equipment and chemical threshold firms undertaking R&D; and the machinery firms, which comprise the main sectoral group. The report identifies their use of government schemes for R&D and innovation assistance. It indicates their attitudes towards these schemes and some recommendations for changes. Chapter V also notes the anticipated expansion of some

threshold firms in the medium term and details the firms' views of the key constraints to their expansion. Chapter VI traces the regional ties of several groups of threshold firms and their propensities to extend their operations outside Canada. It provides some comparisons and contrasts between three main regional groupings: the auto parts threshold firms in southwest Ontario; the Prairie farm machinery, transport-equipment and electronics threshold firms; and the electronics and telecommunications threshold firms of the Ottawa Valley in eastern Ontario. It also contains case histories of about one-tenth of the threshold firms. Chapter VII then draws some conclusions and makes some recommendations.

II. Innovation, Intervention and Indigenous Firms

Technological Innovation

Technological innovation, as the proliferating literature about it during the 1970s reveals, is a very complex and protracted process. It may involve a few "climactic decisions," but more frequently consists of a series of small decisions, usually made in the context of serious constraints arising from previous decisions and necessitated by continual changes in external information, all as seen against some projected but uncertain future horizon.[1] The process tends to vary widely among sectors and according to whether it is a product or process innovation, and whether it is radical or largely incremental. Similarly innovations may come from a variety of sources, including suppliers, users and a firm's own work force.[2] Radical innovation, requiring both market and technological breakthroughs, is particularly risky. Its success probably involves a variable blending of judgement, grit and sheer luck.[3]

Some of the factors associated with success and failure in industrial innovation and the characteristics of technically progressive firms have been identified.[4] However, researchers have tended to overemphasize factors internal to the firm and radical or major innovations, and until very recently, tended to ignore the role of government policy or legislation, competition or the effect of the general economic environment.[5] The literature has given insufficient attention to the cumulative effect of numerous small technological innovations, such as improvements in materials handling, more convenient production techniques, reduced maintenance and repair costs, and all the other small but cost-reducing or technology- and quality-improving innovations.

It is difficult to analyze the process of technological innovation because it is influenced by such a wide range of factors. New technology may spring from many sources, including the inhouse R&D of corporations, research associations, private inventors, universities, research councils and government research establishments. Its development and use may be influenced by at least seven major factors: (1) general economic conditions; (2) market demand and competition; (3) access to finance; (4) taxation policies; (5) government R&D expenditures; (6) patents and licensing; and (7) a complex variety of behavioural and cultural factors.[6] Many of the factors are not readily quantifiable and attempts to isolate the role of any one have rarely proved fruitful. Yet there have been limited recent methodological advances identifying interactive groups of factors linking firm and management characteristics to results and revealing contrasts between sectors.[7]

There is also a growing conviction concerning the primary place of entrepreneurial individuals in successful technological innovation. That place tends to vary, however, depending upon the stage of a firm's development, particularly if it diversifies into largely unrelated areas.[8] Hence, as a firm grows, successful radical innovation requires a changing combination of entrepreneurial, managerial and technological talents, and different people are likely to be effective in different ways depending on the stage of the firm's development. Using this focus on the dynamic evolution of the firm, Utterback and Abernathy have proposed a model of the innovation process that is seemingly plausible for many industries, other than perhaps the chemical industries in the North American context.[9] The model draws upon product-cycle concepts. It suggests that as a product matures the innovation mode shifts from radical product innovation, which is performance maximizing, to incremental innovation focusing on cost minimizing. Similarly, process innovation gradually increases in importance outweighing product innovation once the product has moved from its initial fluid state through to a transition state in which a dominant design emerges. The product may ultimately reach the specific state if it becomes standardized and stable and the process of production becomes more rigid, efficient and based on economies of scale. The base for competition tends to shift over the product's life cycle from functional product performance to product variation and then to cost reduction. One implication of this model is that in the fluid state at the beginning of the product's life cycle the SMEs in AICs will tend to have a comparative advantage. That advantage may also be enhanced if life cycles are shortening.[10]

Developing this model, Utterback indicates how the conditions necessary for rapid innovation are different from those required for high levels of output and efficiency in production.[11] Regarding the earlier fluid stage, he argues:

"Innovation is at first stimulated by information on users' needs and even by users' technical inputs. As the product line and process develop, opportunities created by expanding internal technical capability increasingly provide the stimulus for innovation. Later, pressures to reduce cost and improve quality are expected to be the major stimuli for change. The initial product line is diverse, often being mainly custom designs. Innovative emphasis will begin to shift when it includes at least one product design stable enough to have significant production volume. The line of business will consist mostly of undifferentiated, standard products when it is fully developed."

The innovative process for a typical new product is often seen as linear in form, frequently characterized by six stages: (1) basic research, which is rarely undertaken by business firms; (2) applied research; (3) exploratory development, which may involve considerable design work; (4) scheduled development, with prototypes and pilot plants; (5) commercial manufacturing; and (6) marketing. From this linear perspective has derived the emphasis of much government policy towards industrial innovation on the earliest parts of the process, especially stage 2, although in Canada the federal government has given particular emphasis until recently to stage 1.

The process is by no means linear, however. Indeed, it may more frequently be reverse-linear. R&D may rarely be the beginning of the innovative process. Many successful innovations have been initiated by astute market appraisal and recognition of the technological feasibility of an innovation, followed by the formulation of the idea into a design concept, which leads to problem-solving R&D activity or sometimes leads directly to design of a suitable technical response. Good communications between these functions are generally crucial to success.[12] Moreover, the success of those organizations able to sustain their innovative capabilities appears to lie not only in their ability to attract or retain high-quality personnel, particularly engineers and other technologists, but also to avoid excessive compartmentalization of R&D as a function apart from, and often geographically distant from, marketing and manufacturing functions, rather than being integrated with them.[13]

Innovation has been called "a 'coupling' process, which first takes place in the minds of imaginative people somewhere."[14] At an interorganizational level the process involves at least three clearly different patterns in which the dominant locus of innovation is either (1) the product user, who may develop the idea through to building and proving the value of a prototype, an approach often found in scientific, medical and dental instruments or chemical process innovations; (2) the product manufacturer, as in textile machinery; or (3) the materials supplier, as in the case of developers of new synthetic materials such as poromerics, substitutes for natural leather.

Technological Innovation Process and Government Intervention

Whether the principal determinant of technological innovation is the pull of market demand or the push of science or technology has been a subject of policy significance and some controversy. The proponents of demand-pull seemed ascendant in the 1960s, their arguments fostered by the detailed empirical work on patent statistics by Schmookler[15] and the interpretations of some major British[16] and American[17] studies. More recent research has argued, convincingly, that "the primacy of market demand forces within the innovation process is simply not demonstrated," that there has been an unfortunate confounding of "need" and "market demand"; that the process is probably characteristically iterative, responding to both demand and supply forces; that it is quite possible to subscribe, at least partially, to both theories, with a counter-Schmookler pattern of development evident in certain phases, for instance in the evolution of the plastics and drug industries; that in many respects large R&D-intensive firms anticipate more than respond to market demand; and that, chance plays a greater role in competitive survival and growth than it is comfortable to admit.[18]

Governments of the AICs commonly try to justify public intervention in technological innovation, through such mechanisms as funding R&D, by reference to several notional types of market failure, including the disparity between private and social costs and benefits, industrial concentration and capital market imperfections. However, economic theory offers little guidance to how specifically governments should intervene in the innovation process. Indeed, the interactions and feedback mechanisms involved are so extraordinarily complex that the process is not well understood. As an Australian report comments: "It is easy to advocate increased spending on industrial innovation, but it is very difficult to compare the benefits of different support mechanisms and to determine the best way to invest the funds that are available."[19] Nevertheless, economic theory can more easily be used to justify government support for innovative SMEs than for larger enterprises because SMEs are inherently more risky and confront greater difficulty in gaining access to capital markets.

Government approaches to stimulating innovation have varied. Most approach the challenge with the same principal tools: R&D support within private firms; procurement policies; programs to meet capital needs, both for venture capital and start-up funding, measures to assist industrial restructuring; creation of innovation centres; and manpower policies.[20] However, the differences in emphasis have been substantial, whether with respect to the degree of intervention, the linking of technology policy and economic growth policies, the stress on commercialization of technology in contrast to

its creation, the focus on mergers and strengthening the technological base of particular sectors and specific firms, the reliance on industry-government-university cooperation, or the priorities for "big science" and "key technology" programs.

The role of government measures in influencing technological innovation and project success has also been subject to much debate. The debate cannot be resolved because the effects of government measures are still not satisfactorily addressed by the prevailing means and procedures of evaluation. Nevertheless, a few points warrant mention. Perhaps the major finding of empirical research in the 1960s and early 1970s was the important, if not key, role of government procurement policies in influencing technological innovation.[21] Despite such findings, however, most government measures have focused on supply-side targets, leading Rothwell and Zegveld to conclude:

> "It would appear that, once again, government policies are rooted more in the theories of a previous intellectual generation (one that stressed the importance of supply factors in stimulating technological change and industrial innovation) than in contemporary economic thought."[22]

Two other studies provide different perspectives on the roles of governments. A recent major report on 164 innovation projects initiated since 1968 and spread among five industries in five countries, identified 12 broad mechanisms through which governments may influence the process of technological innovation. It found government involvement in nearly one-half the projects and concluded that its most significant result was the failure to detect any effect on project performance of government attempts to stimulate innovation, insofar as variations in project success or failure can be taken as a measure of effectiveness of the government actions.[23] Only in the Netherlands was government activity perceived to have had any positive influence on project success. The results reinforce the conclusions of another major recent study which attempted to discern management perceptions of government incentives to stimulate technological innovation in England, France, West Germany and Japan. The study found support for arguments that there are differences among industrial managers in different countries with regard to their knowledge and their attitudes towards government support for the R&D and innovation process, and that they perceive the effect of these actions differently. It noted that government action to stimulate innovation is perceived as comparatively irrelevant and as tending to delay the process, being too slow and complex to meet industry needs.[24] The report also provides a succinct statement of a paradox arising from government incentive programs (IPs) for technological innovation:

"It is inevitable that the most direct government IPs seem to be, in general, designed to minimize failure, even though failure is functional in this instance, and to temper success, even though it is the possibility of untempered success which is necessary given the risks involved. This combination of circumstances makes it likely that no direct IP would last long if it were, indeed, successful at stimulating the innovation process, because the combination of high profits when successes do occur combined with the apparent waste due to the high overall failure rate would be prime material for untoward political consequences."[25]

Despite such private sector perceptions and attitudes, and the paradox arising from incentive programs, the strategic importance of technology in international competition has led to a continued proliferation of government policies and programs that attempt to support and stimulate technological innovation. The risks multiply that measures taken in one country will affect the interests of others. This is most pronounced in the AICs aiming to support "future technologies."

Technological Innovation and SMEs

The innovation potential of SMEs has become a focus of widespread recent attention. Even though there are well-known advantages of large firms in the innovation process, the importance of firm size has varied considerably both between industries and between types of innovation within an industry.[26] Many SMEs have succeeded by achieving technical competence in producing small batches or custom products and have developed capabilities as manufacturers of producers' goods, frequently operating as contractors to large enterprises. They have played a significant part as generators of technological innovations both for radical new technology and improvements. For instance, one report on 352 major innovations made in five countries between 1953 and 1973 indicated SMEs (defined as having sales less than $50 million) accounted for nearly one-half.[27] They are the most cost-efficient performers of R&D; their share in innovations tends to be much higher than for R&D; and their significance for technological innovation is generally most concentrated in machinery, instruments and electronics.[28] As might be expected, they tend to make a strong contribution to innovation in those industries with low capital intensity but requiring sophisticated and specialized technological capabilities and relatively small production and marketing resources.[29]

In a period of environmental turbulence and high unemployment, a notable feature of SMEs, particularly new small firms, has been their major contribution to maintaining and generating employment, as seen in the United States[30] and the United Kingdom.[31] However, the success of America's small technology-based firms may

not be readily replicated because it has been based on a combination of unusual factors.[32] There have been few equivalents within Western Europe. Some contrasts between the United Kingdom and West Germany are instructive.[33] In the former, poor economic conditions have had a generally adverse effect on the formation and growth of such firms at least until the late 1970s, a situation reinforced by unfavourable cultural and attitudinal factors regarding technological entrepreneurship. Yet recently several new high-technology firms have emerged, perversely spurred perhaps by recession and the threat of unemployment and university finance shortages.[34] In West Germany, however, where the economic climate has been much more favourable, it has still not, by itself, been sufficient to generate many such firms. There appears to have been a latent hostility there to entrepreneurship. And existing entrepreneurs appear to be averse to depending on external finance, are very suspicious of the banks, yet lack the possibility of going public.

Until 1975 few countries had special aid programs for SMEs. Governments in OECD countries have recently introduced or expanded special measures to generate such technology-based firms and support technological innovation by existing SMEs.[35]

SMEs in the high technology sector usually specialize and often do custom work. Their flexibility offers scope for innovation and the development of new products. For highly specialized products they frequently have a national or even global monopoly, at least at the outset. However, SMEs also have inherent disadvantages, mainly related to shortages of specialized skills, lack of adequate cash flow and inability to obtain economies of scale in production and distribution. SMEs are often not able to make the transition to the large production that their successful new products require and tend then to be acquired by larger firms. Governments have tried a variety of measures to overcome these disadvantages; the emphases, such as on cost reduction and risk reduction schemes, of their policies, vary considerably between countries.[36]

Innovation and Technology Strategies of Firms

Research into the nature of company strategies and R&D, particularly for SMEs, appears to have received rather scant attention despite the indications that R&D by more technology-intensive firms is often of primary importance to their long-term success. A decade ago, in his examination of the concept of corporate strategy, Andrews[37] noted the key role of technological change and argued: "Technological developments are not only the fastest unfolding but the most far reaching in extending or contracting opportunity for an established company." It is surprising, therefore, to find that company strategies for R&D and the incorporation of technological issues within strategic decision making have until recently been ac-

corded little interest in business literature on strategic decision making and long-range planning.[38]

Discussion of technological issues at a microlevel during the 1970s was heavily devoted to describing the characteristics of innovations by firms and their association with success or failure, or to delimiting the sources of their technology. Initially there was little concern for whether it was realistic to conceive of a technology strategy for the firm. However, analysts subsequently learned how corporate strategies may respond to different techno-economic environments and recognized that managers need guidance in the formulation of such strategies.[39] Two recent reports, based on generalized and aggregate notions, offer broad insight on the topic, although they pertain more to larger corporations. Thus Rosenbloom[40] shows how technology strategy brings together significant aspects of the organizational and environmental contexts of innovation. For instance, he indicates how the concept of strategy formulation involves matching "capability" (including technological capability) as an aspect of organizational context, with "opportunity," which is an aspect of environmental context. More recently, Ford and Ryan[41] have outlined the changing decisions companies face in choosing when, how and whether to sell their technologies, according to different phases in the life cycles of such technologies. They visualize that in the new global environment companies must improve their rate of return on technology investments by marketing their technologies and not depend simply on using technology solely in product sales.

The need to establish a strong competitive position through in-house technological superiority, to keep a business vigorous, is emphasized by Hayes and Abernathy.[42] They chide the use of modern management principles in the United States as possibly causing sluggish economic performance, and indicate that market success through technological superiority is the strategy of the seasoned European and Japanese managers with whom they had talked. One management principle they consider has been carried too far is emphasizing the need for a market-driven strategy:

> "A market-driven strategy requires new product ideas to flow from detailed market analysis or, at least, to be extensively tested for consumer reaction before actual introduction. It is no secret that these requirements add significant delays and costs to the introduction of new products. It is less well known that they also predispose managers toward developing products for existing markets and toward product designs of an imitative rather than innovative nature. There is increasing evidence that market-driven strategies tend, over time, to dampen the general level of innovation in new product decisions."

Roberts[43] earlier developed this line of thinking. He also contributes an argument concerning corporate strategic alternatives for medium-sized firms. He identifies three general strategic approaches available to a firm: market-dominated, capital-dominated and technology-dominated. For the medium-sized firm, he argues, the capital-dominated strategy is usually incompatible with the firm's resource base. The market-dominated strategy offers little advantage either, because the medium-sized firm is wise to avoid the great growth markets of the future, which he deems the natural "cataclysmic market battleground of the behemoths," and because searching for market niches too small to be of interest to the very large firm may be too self-limiting. Roberts considers that small to medium-sized firms have a comparative advantage in pursuing a technology-dominated strategy. His argument draws heavily on the evidence of the Myers-Marquis[44] study, which evaluated 567 successful commercial innovations in five industries. It showed that 65 per cent of the innovations cost less than $100 000 from concept to market implementation. In promoting a technology-exploitative strategy that is not dependent on the availability of significant capital, the medium-sized firm, Roberts recommends, should be concerned that its ideas be related to market needs, but not necessarily subservient to extensive market research.

> "My own studies of 250 new high-technology companies showed that company growth tended to accompany rapid movement of advanced technological ideas into the market-place (Roberts, 1968). The emphasis of this finding is on the quickness of market exploitation of a technology. As somewhat further support, my data showed that extensive market research correlated with failures. Entrepreneurs observed that if you can market research the innovation, you're already too late!"[45]

A technology-dominated strategy requires inhouse technological capacity. Such capacity may offer five kinds of primary benefits, according to Gold:[46]

1. Attaining competitive advantages through new or better products or processes;
2. Obtaining knowledge that can be sold advantageously;
3. Keeping up with, or avoiding injurious lags behind, competitors;
4. Minimizing prospective differential disadvantages involving inputs, transport, and so on; and
5. Providing the image of highly progressive management.

Gold argues that most enthusiastic supporters of expanding R&D efforts expect the outcomes to be concentrated in categories 1 and 2, but such expectations are not realistic and can only lead to underestimates of the gains from R&D programs. In his estimation, the largest and most consistent yields from technological develop-

ment efforts are likely to be defensive gains in categories 3 and 4. Such contributions appear to be underappreciated, or even ignored. Gold also identifies four alternative strategies for advancing technology: evolutionary (or incremental) improvements; licensing; scale increases (in search of production economies from larger operations); and major advances. He provides a crude but useful comparison of these technology strategies, measuring each against five characteristics: relative costs of development; relative likelihood of commercial success; relative time to achieve such success; relative magnitudes of resulting market rewards; and the extent of attendant costly disruptions in organizational arrangements, capital allocations, materials requirements, labour relations and marketing patterns.

Freeman[47] has usefully categorized six alternative strategies of firms towards technological innovation, emphasizing that these strategies are not purely definable forms. Firms may shift between strategies as well as follow different strategies in their different product lines. The strategies, which range from those adopted by firms with extensive inhouse scientific and technical capabilities to those of firms that lack virtually all such functions, are categorized as offensive, defensive, imitative, dependent, traditional and opportunist. The first two strategies require firms to be knowledge-intensive. They are differentiated on the basis that an offensive strategy involves seeking technical and market leadership by being ahead of competitors in the introduction of new products, whereas the defensive innovator does not wish to be first, but still wishes not to be left too far behind. By contrast, the imitative innovator is content not to keep up with the leaders, but rather follow well behind, often heavily dependent on licensing the appropriate technology where the firm has a decisive cost advantage or a captive market. The dependent firm is like the imitator in that both lack many inhouse scientific and technical functions. However, the dependent firm essentially plays a satellite or subordinate role, drawing usually upon either its parent or a large customer for its technology. It frequently operates as a subcontractor. And the traditional firm is like this dependent firm with respect to its lack of most inhouse technology functions, but differs in that the dependent firm is often requested to change the nature of its product, whereas the traditional firm operates in a market where there is no such need. Finally there is the opportunist strategy, which involves the sharp entrepreneur taking advantage of new opportunities without any inhouse scientific and technical capabilities.

Our understanding of technology strategies of firms has been only modestly furthered by studies of technological innovation. Most studies have been directed towards analyzing such innovation as a discrete event rather than continuing effort. They have viewed var-

ious technological and other features of new products in a product-specific rather than company-related perspective, so Nystrom[48] argues, with emphasis on differences between products rather than companies. Nystrom's concern has been with company development, including how companies choose new markets and areas of technology, and how they organize and focus their R&D efforts, points which require further attention in studies of product innovation. In two empirical analyses he has distinguished between company R&D policy and realized R&D strategies. He has also tackled the problem of measuring the success of such strategies. Nystrom identifies three main R&D policy dimensions. He distinguishes between concentrated and diversified R&D, according to whether or not the firm intends to branch into new product areas and technology; between technological and market orientation in seeking ideas for new products; and between defensive and offensive R&D. An offensive approach involves attempts to be ahead of competitors in new product development; a defensive one to protect an established market and technological position by developing and introducing new products of a "me-too" or imitative type. Nystrom also identifies three distinguishing characteristics of R&D strategies: orientation – external orientation involves greater dependence on external consultants to carry out the whole range of R&D activities than does internal orientation; use – use can be isolated or synergistic, meaning that different technologies are combined; and organization, which can be fixed or responsive. Attempts to differentiate firms on the basis of these distinctions appear to be useful, but inevitably depend on a good deal of intuitive appraisal. Nevertheless, the concepts offer some insight into contrasts in R&D strategies. Of course, the usefulness of such distinctions also depends on whether the choice of strategy determines the success of R&D, a sparsely plumbed area of research.

A major problem in this area is how to measure R&D success. Each measure, such as number of new products, sales of new products, market position for a new product or degree of patent protection, has distinctive limitations. Nystrom,[49] in one study drawing upon detailed personal interviews of executives of a few Swedish companies, opts for an outcome measure based on the level of technological innovation, which he interprets to refer to the extent to which the basic product design utilizes advanced technology not previously applied to the problem area. A high level of technological innovation may not, however, be combined with strong patent protection. The presumption is that the combination of a high level of technological innovation and strong patent protection will strengthen competitive advantage. In another study of a larger number of companies in the Swedish farm machinery industry, Nystrom and Edvardsson[50] use two measures, the number of new products and

the number of new products for which companies have gained patent protection. Such measures, by emphasizing the contribution of R&D to development of new products, of course underestimate the other contributions, including the role of upgrading existing products and processes.

Indigenous Enterprises and Technology Strategies

In characterizing Canada's manufacturing firms, Britton and Gilmour[51] suggest:

> "There is a unique size-ownership dichotomy producing a sort of technological dualism, with a plethora of small, often inefficient technologically-isolated Canadian firms on one side, and larger, but still inefficent, technologically-dependent foreign firms on the other."

Safarian[52] disagrees with this view. He argues that "once one moves beyond the tail in the distribution, one is likely in a number of industries to see some medium-sized and larger domestically-owned firms competing with the medium-sized and larger foreign-owned firms." This report does not resolve the issue but it will indicate that in most of the more technology-intensive sectors the number of indigenous, medium-sized firms would seem to be strikingly small.

Safarian also raises the question why Canadian-owned firms are not entering more quickly at the mature technology stage of the product cycle, or even earlier, if it is the case that multinational firms are becoming vulnerable to oligopolistic reaction effects far more quickly on both products and processes. The answer lies in the problems they have establishing and maintaining strong inhouse R&D and technical capabilities, cracking multinational business procurement practices and obtaining the capital to exploit opportunities.

Over a decade ago Crookell[53] evaluated the competitive problem of the Canadian-owned firm and argued that it stemmed from its inability to operate in conditions of high uncertainty, a thesis he supported with evidence from the household appliance sector. Killing[54] extended the argument, suggesting it applies primarily to those industries in which there is a short lag between world introduction and Canadian introduction of new products. His research on the 50 largest public Canadian-owned secondary manufacturing firms that are acquiring product-related technology under licence agreements also indicates that for those firms with a low inhouse R&D competence, which rely on the licensor for a continuing transfer of technology, licensing is not a viable growth strategy. In subsequent work exploring which type of licence agreement or joint venture is most appropriate for a given situation, he argues that, no matter which type of agreement is chosen, the firm acquiring the

technology should strengthen its own technical capabilities, the better to understand the supplier and judge the appropriateness of the technology.[55]

It seems likely, moreover, that licensing is more appropriate for process innovations, which can probably be more easily transmitted at arm's length between firms, than for product innovations. However, firms may hesitate to send their process technology abroad for fear of losing control over it, particularly if circumstances encourage hard-to-detect illegal imitation. From the viewpoint of indigenous firms it is also not encouraging to discover, on the basis of results from a relatively small sample of US multinationals, that "firms are more likely to license innovations that are only marginally profitable than ones that are very profitable, and that they are more likely to transfer very profitable innovations via subsidiaries than by licensing."[56] To obtain access to more profitable technology it may be necessary to have worthwhile technology, or the prospect thereof, to offer in exchange. Telesio for instance, on the basis of a survey of 66 large multinationals, concluded:

> "Licensees might find that they cannot obtain access to state-of-the-art technology in the pharmaceutical, chemical, and electrical industries if they offer no technology in return or if their R&D program does not promise important innovations. A licensee wanting to purchase such technology should be prepared to do research at the same advanced level and to license competitors with some of the fruits of this research."[57]

Licensing may also be fruitful for indigenous medium-sized firms with existing technical capabilities in two situations. First, to obtain government-originated technology. As Miedzinski[58] has argued, such firms are the most likely clients for government technology in Canada, where most large firms tend to acquire their technology either internally or from their parents abroad, and small firms lack the capability to accept sophisticated technology. The second situation is revealed through the example of an industrial chemical specialty business, whose versatile equipment enables it to make numerous products for which production scale is not very important. This indigenous chemical firm has built a successful technology strategy on licensing by negotiating the best agreement it can, then, having established itself in the market, developing other products based on similar or closely related technology which it sells to the same or similar markets. However, such a strategy may be less feasible now than it used to be. As the firm's chief executive officer laments:

> "It has become increasingly difficult to find foreign companies willing to undertake licence agreements with Canadian companies. A few years ago, many companies were keen to conclude them but now they want to enter joint ventures with Canadian

firms, to export into Canada, or to find Canadian companies who will manufacture their products on a toll basis."[59]

Moreover, for indigenous firms lacking technological capability, joint ventures are not likely to be a fruitful mechanism either. Such ventures are only appropriate in unique circumstances, and are most common when each partner contributes something unobtainable through the market place. SMEs involved in successful joint ventures are usually the suppliers of technology, not the acquirers.[60] And if they lack good marketing skills and distribution channels they have little to offer in exchange for needed technology.

An alternative route for those lacking technological capabilities is diversification. Yet diversification, especially through a strategy of technology acquisition in areas outside the prevailing core skills of the firm, would not seem a profitable path for indigenous firms, few of which have had, at least until recently, core skills in technology-intensive areas. Canadian manufacturing firms, most of them with core skills in resource-oriented and low-technology sectors, have generally lacked success in their diversification strategies, particularly in their attempts to achieve reasonable size within related product groups. This has left them at a considerable disadvantage in their ability to undertake R&D and to innovate.[61] Many enterprises that have achieved larger size have done so through diversification into product areas unrelated to their core skills, whereas it is the size of the related product units that is crucial to achieving economies of scale and continuous process and product innovation.

Insofar as diversification involves the learning of new skills it is a risky process. Analyses by Killing of 40 companies manufacturing more than 70 products under licence in Canada and the United Kingdom indicate that:

"Licensing can help, if the skills which need to be learned are related to those existing in the firm. If they are not, licensing can become a trap, enticing a firm to produce a product which it does not have and cannot develop the skills to produce. Firms which license products requiring the development of unrelated skills invariably use current and future technology agreements which restrict them to old products, and their lack of confidence limits them to products requiring a low initial investment."[62]

For Canadian SMEs lacking inhouse R&D and technological capability, the strategy of making licensing agreements with foreign sources of technology would not seem a fruitful path to diversification. However, although creating an inhouse R&D capability may first be easier, maintaining it has been a major problem. Crookell,Wrigley and Killing have concluded that:

"Canadian firms lack the scale and the local market size to generate continuous R&D profitably. This is not to say that small firms cannot generate new products, but simply that small firms

usually cannot do so on the continuous basis necessary to remain competitive internationally in the long run."[63]

The implication is that they must achieve a larger scale and extend their sights to foreign markets, in order to maintain continuous R&D profitably.

Questions Arising

This review of literature on technological innovation and discussion of the Canadian context provide both background perspective as well as a basis for the following questions. These questions are explored in more detail in subsequent chapters.

1. Do threshold firms undertake R&D and, if so, how critical has their R&D been to their survival?
2. Have they managed to maintain continuous R&D profitably over recent years?
3. To what extent are their strategies technology-dominated?
4. Are their technology strategies primarily offensive, defensive, imitative or dependent?
5. Are their technological innovations radical or largely incremental?
6. Have their designs progressed from an early fluid state – with orientation to customized or small batch production – to become dominant designs with longer production runs?
7. Is their base for competition in functional product performance, product variation or cost reduction?
8. Is their R&D outcome reasonably measured by the number of new products and patents achieved?
9. What has been the source of government support, if any, for their efforts in technological innovation?
10. What has been the efficacy of such government support?
11. Do they differ in their knowledge of and attitudes towards government action regarding R&D and innovation?

III. A Vital and Innovative Core?

Small Indigenous Enterprises

Threshold firms develop out of the pool of small firms. The plight of small manufacturing firms in Canada has been the subject of widespread attention in the past decade. Among the advocates of the role of small business in building a more balanced economy is Peterson.[1] He has demonstrated how small manufacturing firms are disadvantaged, and how the greater capital-intensiveness of large firms and their continued growth has been fostered by the Canadian income tax system.

Small firms in Canada's technology-intensive sectors have been the specific focus of several reports, following widespread recriminations over the lack of a supportive environment to stimulate more of them. Usually founded by scientists or engineers, a high proportion of whom are not Canadian born, they tend to lead a very precarious existence. With creativity in technical areas often at a premium, they have been characterized in reports made mainly in the early 1970s as having a narrow product line and limited local market and financial resources; as being weak in management skills, especially in marketing and financial areas; and on the whole as not being highly innovative, tending to adapt ideas and modify products from outside the firm.[2] Litvak and Maule[3] found there was little tax incentive in the 1960s and early 1970s for entrepreneurs in these small firms to invest their time and capital in the pursuit of a product concept or marketing opportunity. Financial problems are particularly prominent among these firms at an early age and the scarcity and cost of venture and development capital to start and expand such firms have been widely noted and deplored.[4]

The problems are complex and involve widely contrasting viewpoints. For instance, one venture capitalist recently indicated that for each 500 deals he reviews, he will fund only 10-15, and out of these only two will be phenomenally successful. Hence, "investing in small firms requires a stout heart and staying power. Losses appear quickly; winners take time to mature."[5] A contrasting viewpoint, on the trials and tribulations of Canada's technological entrepreneurs searching for financial support in the earlier 1970s and their intense frustrations with private risk taking, for which Canada has had an excessively weak tradition, is vividly portrayed by Ross.[6] Canada's banking system is not well suited for domestic high-risk situations.[7] The chartered banks are not venture-capital lenders. Although they could play a key role for SMEs in their early years by providing loans against initial orders, in practice the banks currently provide capital based upon three times the firm's asset coverage, including personal cross guarantees on borrowers' assets.

The opportunities, incentives and range of start-up and development assistance for small firms significantly improved, however, in the past decade, at least until the economic slump and the 1981 federal budget. Venture capital has become more readily available, as through Ontario's Small Business Development Corporations, and management, technical and information assistance has been improved. Ingenious little firms have arisen in a wide range of communities across the country, many of them producing electronic products or scientific equipment, others manufacturing machinery or transport equipment.[8] The scale and geographic pattern of their emergence is not readily documented at this stage, but the regional propensity for innovation is probably far more widespread than generally expected and is not restricted to the major industrial centres. Indeed, although the constraints to technological innovation may still increase with remoteness from the industrial heartland, as some suggest,[9] those constraints are being more successfully overcome now in many peripheral centres, particularly across western Canada. Moreover, even within the industrial heartland the propensity to spawn small high-technology firms in the 1970s has probably been greater in little industrialized Ottawa-Hull than in the much larger industrial centres of Montréal and Toronto. The scale and geographic dispersion of this emergence augurs well for the development in the near future of several potential "core" companies. The most viable members of this wave of new firms have already reached the category of threshold firms.

The creation of a Ministry of State for Small Business at the federal level in the mid-1970s and the introduction in recent years of several federal and provincial business programs and incentive schemes tailored to small business needs and potentials are indicative of a greater, though not concerted or clearly focused, attempt to

alter the previously excessive orientation of government support towards big business. Québec has been notably ahead of the other provinces in the extent of its programs focusing on building successful SMEs, organizing much of its economic machinery around them.[10] No doubt more could be done, perhaps by improved financing and public sector procurement policies, by training assistance and by aiding small firms to serve foreign markets, through export incentives and promotion. Canada's banks might well be more innovative and aggressive in adapting their trade, finance and related services to the needs of small exporters.

However, the proliferation of federal and provincial programs bears the aura of a shotgun approach. Some programs, such as Ontario's recently introduced Small Business Development Corporation and the various new provincial organizations that aid SMEs to solve technical problems and support promotion of innovative products, certainly show initial signs of success. They strengthen the prospects for small indigenous firms in the technology-intensive sectors. But the flurry of government programs needs more careful focusing and intermeshing. Moreover, it seems likely that much of the assistance may simply go to prop up weak firms leaving less funds available to back the strong. Demands for government assistance are increasing, but government resources are not expected to grow commensurately. Currently most programs are not very selective, and they usually involve both a last-resort approach and a significant burden criterion, which may lead to inefficient allocation of government resources. A number of suggestions have been made to deepen the incentives and improve the programs. One warranting attention is for more private sector participation in decisions about allocation of funds and that the federal government, ". . .in taking a higher degree of risk than the private sector under similar conditions, might be subject to less criticisms if it picked the winners both in terms of firms it supports and sectors where there is a perceived need for government intervention."[11]

Threshold Firms

Do threshold firms constitute a vital and innovative core from which Canada's future winners will most likely emerge? They are already successful survivors in that they have managed to overcome (1) the pitfalls of the start-up crisis, which lead to high failure rate within the first few years of most new firms; and (2) the delegation crisis, in which the initial entrepreneur or owner-manager confronts the need to delegate key tasks, as the firm's growth renders him or her unable to exercise total managerial control any longer and internal and external forces necessitate the development of a more rational and bureaucratic structure.[12] They have moved beyond the more frenzied and fragile existence of the mass of smaller companies. It

is on such medium-sized indigenous firms in the more technology-intensive sectors that we shall now focus. It is their capacity to innovate and seek out new opportunities that makes them fundamental to the further development of Canada's economy. Among them are Canada's largely invisible stars, positioned on the threshold of leadership and providing the strong foundation on which, some argue, Canada must rapidly seek to build. But how many firms are there of this type? And where are they? What niches have they created to survive and succeed?

There has been almost no discussion of the growth and problems of this type of SME among management scientists, organization theorists and economists until very recently.[13] Theory construction has been limited and subject to harsh criticism.[14] The dominant theme has been one of "stage" models of growth, whereby firms are viewed as passing through stages, involving both external pressures for growth and internal driving forces. Other main insights include how the limitations of the entrepreneur's expertise limit growth of the firm; how the desire for growth and the capacity to grow varies between entrepreneurs and is affected by the social identity of the entrepreneur, distinctions being made between the "artisan," the "classical entrepreneur" and the "manager"; and how the greatest opportunities for SMEs lie in the interstices left open by large firms, or comprise functions in which the SME operates as a dependent "satellite" or "specialist servant" producing mainly to the specifications of large firms.

Significant differences have also been noted between countries in the climate they offer to nourish the founding and growth of these firms.[15] Research on technological innovations by SMEs reveals a useful distinction between entrepreneurial and other firms. It indicates that entrepreneurial firms, which are capable of making their own innovations and often have a high level of scientific and technological skills, tend to be found only in certain industries, which generally have relatively low barriers to entry. The main industries appear to be scientific instruments, electronics and machinery, which are industries with low physical capital intensity.[16]

Canadian Reports

Several recent reports provide useful insights into Canada's indigenous medium-sized firms, particularly those more technology-based. For instance, Simmonds et al.,[17] who have analyzed the use of technology and science in Canadian industry, surveyed 226 firms known to be engaged in R&D. Among the firms, 74 were, by their definition, medium-sized (100-999 employees), and 39 out of the 74 were Canadian-owned. In their ranking of the relative importance of components of technical effort, the medium-sized Canadian-owned firms differed from their US-subsidiary counterparts. Indigenous

firms gave greater emphasis to R&D and design and engineering; whereas the US subsidiaries ranked production support first. The rankings by small and medium Canadian-owned firms were similar, indicating perhaps that growth from small to medium size did not lead to a shift in technical priority from R&D to production support, a shift which was common to US-owned subsidiaries. Simmons et al. note the significance of hiring or promoting the right staff when the medium firm undergoes its management transition. They suggest how the firm, as it moves into areas it knows less well, confronts a significant change in the nature of its competition, no longer necessarily being ignored by the larger firms, with which it enters competition despite lacking their resources. They quote Shepherd on the emergence of the transition company, "characterized by increasing numbers of products and markets, far flung efforts, highly leveraged financial structures, widely fluctuating earnings and weakness in management control." They argue that, from the subsequent shakedown and winnowing the company frequently emerges with aims better defined and management more assured. Often the original entrepreneur moves on, perhaps to establish another company, a feature noted in several other recent reports.

Knight and Lemon placed a similar emphasis on the importance of finding or developing good management.[18] They surveyed 53 small and medium-sized Canadian technology-based companies, 26 of which had over 100 employees. They found few of these firms were large enough to have a formal R&D or marketing group, but the larger the firm the more likely it was to have a well-rounded management team, and the more successful it was in the commercial phase of innovation. They also found that few firms considered themselves technologically innovative, or had more than one innovation. Most of the firms made use of government assistance, mainly technical assistance, and managers felt assistance should be more oriented to commercialization than R&D efforts. Managements were usually more oriented to the technology of the product rather than the market need for the product. Expansion by the survey firms, they found, was occurring chiefly in the United States.

A report by Litvak and Maule[19] focused specifically on this phenomenon of direct foreign investment in the US by Canadian-owned technology-based SMEs. Of the 25 firms they surveyed, 18 were essentially medium-sized, having a sales volume of between $5 million and $50 million. Most of the firms had established affiliate operations in the US in the 1970s, usually after exporting for a few years first. The affiliates were nearly all wholly owned, operated with high-debt ratios, with much of the debt capital raised in the US. The firms had mostly built a dominant market position in Canada and were not in competition with large firms. Their US sub-

sidiary, rarely established on the basis of a production cost comparison, had as a major objective to project to their American customers the image of a US-oriented company. The combination of the tendency to replicate their operations and to borrow heavily in the US means that expansion there will not generate much in the way of earnings for repatriation for some time.

A different insight into SMEs is provided in another recent article by Litvak and Maule.[20] In an initial study[21] in 1970-71 they had surveyed 47 small companies, relatively newly established and founded by technologically oriented entrepreneurs, all of whom had received government assistance. At that time they had judged 15 per cent of the firms to be successful and 30 per cent to have some chance of success. A decade later, they found 18 had become failures, and 29 (62 per cent) were still in operation. They considered 9 of the 29 survivors to be marginal, most of them having remained small, focused on narrow product lines and earning minimal or no profits. Twenty (43 per cent) of the initial 47 firms remained financially viable. Marketing myopia, pronounced among the failures, appeared less of a problem among the successful survivors. Eight of the 20 companies had publicly traded shares. Two of the eight had become subsidiaries of larger firms, suggesting their viability might be attributed to their parents. The act of "going public," to raise small amounts of capital, had not been assisted by prevailing rules and practices, and Litvak and Maule noted "the disappointing financing performance of the new issue, and the loss of some control that accompanied it, made the 'going public' experience less than a satisfactory one for most of the firms, regardless of their subsequent commercial performance."

Among the 29 survivors 13 had sales in excess of $5 million, and 10 of these Litvak and Maule defined to be threshold firms. Many of the firms, they found, had chosen to expand operations outside Canada. Most of the successful survivors had followed strategies of geographic rather than product diversification, establishing foreign subsidiaries generally in the United States. This suggests that the firms' competitiveness and possibly their survival in Canada hinged on achieving market success in the US. Rather than confront the bigger companies, in the manner suggested by Simmonds et al.,[22] these firms had avoided direct competition. With few exceptions they had concentrated on specialized rather than mass markets, served mainly industrial users, and competed largely on a basis other than price.

A fifth report, produced for the Toronto Stock Exchange, attempts to portray the financial environment as it faces Canada's "potential winners," the high-technology "stage three" companies – those which have survived start-up (stage 1) and early development (stage 2), and are still growing, hence are typical candidates

for listing on the stock exchange.[23] The report examines the growth and development of 10 private Canadian-owned high-technology companies founded in the 1970s. Each had survived five years and their size ranged from 47 to 280 employees. The sample was skewed to the upper end; most were medium-sized firms. None was still solely dependent on its founding entrepreneur. Their growth rates, even though volatile and sometimes involving violent contractions, were nevertheless furious, averaging almost 60 per cent compounded average annual growth in sales and requiring annually almost 40 per cent more employees. Their debt/equity was twice the average of Canadian manufacturing, a high level of leverage which heavily increased risk. Each had been approached by potential acquirers. Despite their average need for 75 per cent more equity to maintain adequate working capital and more comfortable debt-to-equity ratios, there was little reason for them to contemplate a public issue. The report revealed how transaction costs and undervaluation of shares made it prohibitively expensive. "As a consequence, the country doesn't get the growth of employment it requires; some companies are acquired and their growth rates probably slow; some may be acquired by foreign-based companies and their technologies are lost. Everyone loses." The solutions visualized involve transaction cost reduction, increased market visibility, and improving the main marketplace by encouraging extensive individual participation in stock ownership. The report identifies an equity gap for firms in the 100-200 employee range, a size too small to warrant listing on the Toronto Stock Exchange, yet, at least for those in Ontario, too large to have access to funds from small business development corporations. Investors in SBDCs must divest when the firm achieves the 200 employee level, which is far too low to facilitate the normal venture capital payback period.

Financial problems for the medium-sized firms are not eased by Canada's income-tax system, insofar as corporations with assets of $1 million to $25 million pay the highest effective tax rate. As Peterson[24] has revealed, these corporations are too large to benefit significantly from the small business deduction and not capital-intensive enough to benefit from the capital cost allowance (CCA), a key factor in keeping down the effective tax-rate of larger corporations. The CCA encourages the growth of the larger firms through the deferral of a significant portion of income taxes each year. The effective tax rate is highest for medium-sized manufacturing corporations. In 1974 it was about 36 per cent, compared to an average of about 30 per cent for all manufacturing corporations.

Identifying Threshold Firms

To identify the category of firms that we have called threshold firms requires definitions specifying size, industry sector and ownership.

No single definition can satisfactorily describe a diverse and changing universe of firms. The definition must also be adapted to the data available. The source of our data is a special tabulation provided by the Multinational Enterprises (MNE) section of Statistics Canada. The basic unit of the tabulation is the individual plant or establishment, each of which since 1970 has been assigned a unique serial number (which therefore enables us to trace a plant when its ownership, industry classification, or country of control changes), a number to indicate its company or legal entity membership, and a number indicating the country of control. In those instances in which several legal entities are under common control, the companies making up the enterprise receive a common enterprise number as well.

Regarding the size criterion, there is no single, simple and widely agreed upon definition to indicate the upper limit of a small firm or the lower limit of a large one. Definitions abound.[25] They tend to vary according to purpose, form of ownership, stage of a country's development and type of decision behaviour. Size is most frequently defined by number of employees, and often by total assets or capital invested by owners. For this study the type of threshold firm to be analyzed is defined as a Canadian-owned enterprise with 100 to 2499 employees in Canada, that provides 100 or more jobs at one or several establishments classified according to its (their) main product as belonging to one of the more technology-intensive sectors. The definition effectively includes what some may consider to be still relatively small firms as well as others which have achieved quite large size. Several countries, for instance, define the absolute upper limit of a small firm as 500 employees. Nor does our definition attempt to differentiate small from medium-sized firms on the basis that the former are independently owned and managed or that their decision-making behaviour is different. Moreover, with this definition an enterprise may be included as a threshold firm even though its main product focus is outside the technology-intensive sectors, as long as it fulfills the other criteria and has a plant, or plants, with a total of 100 or more employees assigned to the sectors included.

The definition of technology-intensive sectors is also subject to widely varying opinions, particularly as the usual procedure of equating technology-intensive with amount of R&D performed tends to ignore the extent of technology-input through licensing and other transfers, which often involve little or no domestic inhouse R&D. However, the distinction between R&D intensity and technology-intensity in Canadian conditions, although relevant for a few indigenous concerns heavily dependent on licensing agreements, is generally far more pertinent for foreign subsidiaries of the branch plant or rationalized type, which may be technology-intensive but dependent on their parents' R&D. For the purposes of this study the technology-intensive sectors are given a broad definition, using the

2-digit SIC (Standard Industrial Classification) category, to include industries that ranked in the top four either in research-intensity or in percentage of current intramural R&D expenditures in 1975.[26] The four highest research-intensity industries, measured in terms of R&D as a percentage of value added, are electrical products (5.1), petroleum and coal products (4.6), machinery (3.2) and chemical products (2.5). The fifth industry included is transportation equipment (1.5), which ranked fourth in percentage of current intramural R&D expenditures, but was of medium research-intensity. These five accounted for three-quarters of the 1975 current intramural R&D expenditures. The number of firms in these five industries that reported undertaking R&D in 1975 was 410, or about 56 per cent of the total 727 manufacturing firms reported as performing R&D.[27] The other main industries that performed R&D but are excluded by the definition used here are primary metals, and pulp and paper, both of which were of medium research-intensity.

The definition of ownership and its relation to control is also subject to some dispute, mainly with regard to a few large Canadian enterprises not held through some form of majority ownership.[28] Within Canada few corporations control others by holding minority shares.[29] Among SMEs maintenance of control generally requires over 50 per cent ownership. The smaller the enterprise, the easier it will be, if the enterprise is public, for outside groups to obtain funds sufficient to buy a large block of shares and acquire control.

This analysis identified threshold firms through the special tabulation provided by Statistics Canada. Firms in the tabulation were assigned to enterprises according to ownership of majority voting rights. Where information on ownership of voting rights is unavailable (for smaller firms) to assign control, Statistics Canada undertakes research on ownership patterns and assigns control to what they consider the most likely enterprise. With regard to foreign control the Statistics Canada procedure is as follows: "In the absence of conclusive evidence to the contrary, a corporation is considered to be foreign controlled if 50 per cent or more of its voting rights are known to be held outside Canada or are held by one or more Canadian corporations that are themselves foreign controlled." Of course control is not only attained through means of ownership. Some firms may, for instance, be subject to a degree of foreign control to the extent they are dependent on, or tied to, restrictive licensing agreements or management contracts.

The Scale and Distribution of Threshold Firms, 1976

In 1976, the latest year for which the Statistics Canada special tabulation was available, there were 165 threshold firms. Between them, they employed about 71 000 people. Among these firms, 93 (56 per cent) were at the smaller end, with 100 to 200 employees,

whereas only 10 firms (6 per cent) employed 1000 to 2499 people (Table III.1). Notably, threshold firms were virtually absent (just one firm) in the petroleum and coal products industry, and were only sparsely represented (18 firms) among the eight subcategories in the chemical industry. Twenty-nine (nearly 18 per cent) were in the electrical industries, including five of the ten that employed over 1000 people. Threshold firms were mainly concentrated in the machinery and transportation equipment industries, each with just over one-third of the firms. The rather narrow industrial distribution of the firms is more apparent when analyzed at the 3-digit SIC level, which breaks the five industries down to 30 subindustries. Fifty-five per cent of the firms were based in one of four subindustries: "other" machinery (40 firms); motor vehicle parts and accessories (20); truck and trailer bodies (19); and agricultural implements (12).

On a regional basis, and assigning the few multiple-region enterprises to the region having the enterprise's major technology-intensive employment, about half the threshold firms in 1976 were in Ontario (86 firms), 21 per cent in Québec (35), 18 per cent in the Prairies (30), and the remaining 8 per cent in BC (8) or the Atlantic Provinces (6) (Table III.2). The threshold firms tended to cluster into five regional groupings of subindustries: "other" machinery in Ontario (22 firms); motor vehicle parts and accessories in Ontario (18); "other" machinery in Québec (10); agricultural implements in the Prairies (10); and truck and trailer bodies in the Prairies (10). These five regional clusters accounted for 70 firms (45 per cent).

The Entry and Exit of Threshold Firms, 1970-76

Consider now the turnover of threshold firms. In a dynamic economy the population of firms and their activities will inevitably fluctuate. There is a continual process of reorganization, often including mergers, acquisitions and high rates of entry and exit among SMEs, as they adapt to changing circumstances. The more dynamic and rapidly growing smaller public companies, in particular, soon attract acquirers' attentions and if not closely held find it difficult to resist take-over pressure. A Canadian banker[30] portrays the crisis confronting the ambitious:

> "In the world of small business, the moment of crisis arises at that point when they are about to break through 'from small to big.' The major problems are financial and these are compounded if the new success is largely dependent on off-shore sales. For many a small firm with a potentiality for greatness this is the end of the line. Lacking sufficient capital and unaware of the alternatives of bridging the gap, the original owners feel compelled, if not to sell out, then at least to grossly water down and so be reduced to managing that which they once owned."

Table III.1 - Canada's Threshold Firms,* by Size and Industry, 1976

SIC		Enterprise Size — by Employment					
		100-199	200-499	500-999	1000-1499	1500-2499	Total
Machinery							
311	Agricultural implement	9	2	1			12
315	Other machinery, equipment	23	13	2	1	1	40
316	Com. refrigeration, air conditioning	2		1			3
318	Office, other machinery	1	1				2
Transport Equipment							
321	Aircraft and parts	4	2	3			9
323	Motor vehicle		1				1
324	Truck and trailer	7	7	3		2	19
325	Auto parts, accessories	12	6	1		1	20
326	Railroad rolling stock						0
327	Shipbuilding, repair	7		1			8
328	Boatbuilding, repair	1	1				2
329	Misc. vehicle	1					1
Electrical Products							
331	Small electrical appliances	1	2				3
332	Major appliances		2	2		1	5
333	Lighting fixtures	2					2
334	Household radio and TV					1	1
335	Communications equipment	6	1		1	1	9
336	Electrical industrial equipment	3		1	1		5
338	Electric wire and cable	1					1
339	Misc. electric products	1	1	1			3

Petroleum and Coal Products							
365	Petroleum refining						0
369	Misc. petroleum, coal products	1					1
Chemicals and Products							
372	Mixed fertilizers						0
373	Plastics, synthetic resins	2					2
374	Pharmaceuticals, medicines	2	1				3
375	Paint and varnish	1	3				4
376	Soap and cleaning compounds	1					1
377	Toilet preparations						0
378	Industrial chemicals	1		1			2
379	Misc. chemicals	4	2				6
Total		93	45	17	3	7	165

* See p. 47.
Source: Statistics Canada, special tabulation by MNE Section.

Table III.2 - Canada's Threshold Firms, by Industry and Region, 1976

SIC	BC	Prairies	Ontario	Québec	Atlantic
311		10	1	1	
315	4	3	22	10	1
316		1	2		
318			2		
321		1	4	2	2
323				1	
324	1	10	5	3	
325		2	18		
326					
327	3		3		2
328			2		
329		1			
331			3		
332			3	1	1
333				2	
334			1		
335			5	4	
336			5		
338				1	
339			2	1	
365					
369				1	
372					
373			1	1	
374			2	1	
375			2	2	
376				1	
377					
378		2			
379			3	3	
Total	8	30	86	35	6

Source: Statistics Canada, special tabulation.

Canadians perceive the reorganization process for technology-intensive firms as involving probable foreign takeover. To those who support domestic ownership, the vision of their compatriots nurturing the birth and growth of small firms, only to see the more successful taken over by foreigners, may have limited appeal. However, the initiative for mergers and acquisitions usually comes not from any predatory behaviour on the part of foreign enterprise but rather from those wishing to sell control of their business. The desire to sell may arise from several motives, including the wish of an owner-manager to make a significant capital gain, to retire, to overcome personal deficiencies or difficulties in managing rapid growth, or perhaps to cut losses in a failing enterprise or to get needed capital for

expansion. The motives for acquisition are also complex. The Royal Commission on Corporate Concentration[31] identified more than a dozen such motives, one of which was that of acquiring control of independent and relatively small but promising companies in order to provide financing and management that they could not otherwise obtain. Very fast growing firms in particular may seek a takeover, to help finance their growth in order to seize an opportunity or prospect that may not remain open for long. Acquisitions by nonresident owners have raised questions as to why the indigenous firms are worth more to nonresidents than to Canadians, and whether it is more appropriate to provide incentives and to adjust income-tax legislation in order to encourage domestic acquirers, rather than to restrict foreign acquirers through the Foreign Investment Review Agency (FIRA), and thus to motivate and assist the growth of Canadian ownership at a rate faster than the growth of foreign ownership.[32] Of course, the impact of FIRA is still open to wide conjecture, but one general contention is that the FIRA procedure "amounts to a process by which the acquisition activities of large domestic firms are subsidized at the expense of smaller domestic companies."[33] To the extent that FIRA restricts the number of potential buyers of Canadian-owned firms it may also reduce the prospective capital gain for owners of a threshold firm who desire to sell out to the highest bidder and, theoretically, reduce the incentive for establishment of such firms.

This report does not attempt to examine the complexities of mergers, acquisitions and FIRA's impact on threshold firms. It does, however, provide some insight into changes in the population of threshold firms in the early 1970s, a period in which FIRA's impact was minimal in that FIRA was only formed in 1973. Special tabulations from Statistics Canada can be used to reveal some dynamics of the population of threshold firms during 1970-76, including changes between domestic and foreign ownership. I matched the 1970 and 1976 files on individual plants, noting changes, if any, in their controlling enterprise. Those few plants and enterprises that were founded after 1970 and that closed before 1976 were excluded. The analysis covers three plant categories: those in continuous existence between 1970 and 1976; those founded after 1970 but still operating in 1976; and closures by 1976 of those existing in 1970. By far the majority of enterprises had just one plant within Canada.

Between 1970 and 1976, 92 firms achieved threshold status, a rate of about 15 per year, or 9 per cent per year, if measured against the base of 165 threshold firms in 1976 (Table III.3). However, these entries were not entirely new enterprises. They comprised two basic categories. One was those plants and enterprises in the 1976 file not matched in the 1970 file, hence apparently new. There were only 19

Table III.3 - Canada's Threshold Firms Entries, by Industry, 1970-76

	Entry Category and Subcategory						
SIC	U	M	M1	M2	M3	M4	Total (U+M)
311		9	8			1	9
315	5	12	8	1	3		17
316	1	2	2				3
318							0
321		3	1	2			3
323							0
324	5	10	8		2		15
325	4	9	4	4	1		13
326							0
327		6	4		2		6
328							0
329		1	1				1
331		1	1				1
332							0
333							0
334							0
335		3	3				3
336		4	2		2		4
338							0
339	1	2	1	1			3
365							0
369	1	1	1				2
372							0
373		2	1		1		2
374		3	2		1		3
375		2	1		1		2
376		1	1				1
377							0
378	1	1			1		2
379	1	1			1		2
Total	19	73	49	8	15	1	92

*U = unmatched in 1970 file: apparently new between 1970 and 1976;
M = match in 1970 and 1976 files, but in 1976 meets criteria;
M1 = same enterprise, ownership and SIC category, but below 100 employees in 1970;
M2 = same enterprise, ownership and within size criterion, but changed SIC category since 1970;
M3 = same enterprise, SIC category and within size criterion, but repatriated since 1970;
M4 = same enterprise and ownership, but below 100 employees and changed SIC category since 1970.
Source: Statistics Canada, special tabulation.

of them, including five each in "other" machinery and truck and trailer bodies, and four in motor vehicle parts. The second category, with 73 firms, comprises those enterprises matched in both files,

meaning the firms were not new. This category is made up of four subgroups. The main one, with 49 firms, includes those firms that otherwise fulfilled the criteria for threshold status in 1970 except they were too small. By 1976 they had reached 100 or more employees. A second subgroup, with eight firms, joined the threshold population because of a shift in their SIC status. For instance, four left the ranks of metal fabricating firms when their product focus became relatively more weighted, by share of shipments, to motor vehicle parts. Another 15 represented the phenomenon of repatriation, a result some observers may find unexpectedly large. They entered the threshold category not because of any change in SIC or employment size group, but because they changed ownership from foreign-owned to Canadian-owned. This subgroup was spread relatively evenly among the industry categories. The final subgroup comprises only one firm, which increased in size to 100 employees by 1976 and shifted its product focus, leading to a change in SIC status.

There were also 45 exits from the category of threshold firms in 1970-76 (Table III.4). Exits should not, of course, be construed to mean failure or bankruptcies. Among the 45 exits, 17 comprised firms that, according to the criteria specified, would have been identified as threshold firms from the 1970 file, but that were not matched in the 1976 file. Thus these apparent closures occurred at a rate of about three per year. The larger category of exits, with 28 firms, included those firms still in existence in 1976, but no longer qualifying for threshold status. For 16 of those 28 firms, the reason was that they were no longer Canadian-owned. Several were acquired by European concerns, but most were taken over by American enterprises. Thus the net loss to foreign ownership in threshold firms for 1970-76 was just one firm. There were no cases identified of exit through takeover by larger domestic concerns. There were two smaller subgroups of exits, with nine and three firms respectively. In the first, firms retained Canadian-ownership and stayed in the same SIC category, but dropped to less than 100 employees. In the second, they retained Canadian-ownership and were still of suitable size; but shifted product focus sufficiently to be reclassified in an SIC category not included here.

These figures do not seem to indicate a supportive environment stimulating a thriving entrepreneurial spirit. With 92 entries and 45 exits during 1970-76, the net increase in threshold firms was 47. Eight additions per year hardly constitutes a dynamic pace of change. At this rate new threshold firms will not have a suitably wide impact on the economy. The Canadian environment appeared more supportive for some sectors than others, insofar as the additions were not evenly distributed among the five industries (Table III.5). Most net additions were in transportation equipment and other machinery. There was a small net loss recorded in electrical products.

Table III.4 - Canada's Threshold Firms Exits, by Industry, 1970-76

SIC	Exit Category and Subcategory*					
	U	M	M1	M2	M3	Total (U+M)
311	1	1	1			2
315	3	6	3	1	2	9
316						0
318		1			1	1
321	1					1
323						0
324	1	1			1	2
325	2	3			3	5
326						0
327		2	1	1		2
328		1		1		1
329						0
331	1	1			1	2
332	1	1			1	2
333	1					1
334						0
335	3	3	2		1	6
336	1	3			3	4
338						0
339		1			1	1
365						0
369						0
372						0
373	1					1
374		2	1		1	2
375						0
376		1			1	1
377	1	1	1			2
378						0
379						0
Total	17	28	9	3	16	45

*U = unmatched in 1977 file: apparent closure;
M = match in 1970 and 1976 files, but does not meet criteria in 1976;
M1 = same enterprise, ownership and SIC, but size reduced to below 100 employees;
M2 = same enterprise, ownership and within size criterion, but changed SIC;
M3 = same enterprise, SIC and within size criterion, but became foreign-owned.
Source: Statistics Canada, special tabulation.

R&D and Patents of Threshold Firms

Threshold firms do not necessarily deploy an offensive, or even defensive, technology-development strategy. Nor are they all likely to be technologically innovative. Some firms may well be largely dependent, lacking initiative in product design and having no R&D;

Table III.5 - Percentage Distribution of Canada's Threshold Firm Turnover, by Industry, 1970-76

Industry	1976 Population (%)	1970-76 Entries (%)	1970-76 Exits (%)	1970-76 Net Change in Number of Firms
Other machinery	35	32	27	17
Transport equipment	36	41	24	27
Electrical products	18	12	36	−5
Petroleum and coal products	1	2	—	2
Chemicals	11	13	13	6

Source: Statistics Canada, special tabulation.

some are imitative, following the leaders in established technologies and maintaining some adaptive R&D functions.

An initial simplistic indication of the technological innovativeness of threshold firms may be obtained through the use of two science and technology indicators, R&D and patents. Neither measure is particularly satisfactory. R&D, a widely used surrogate for technological innovation, is only one of many phases contributing to such innovation. It is, however, one of the most costly phases, particularly it seems for Canadian innovations.[34] Moreover, R&D is simply a measure of input and not necessarily a good indicator of innovative output.

The number of threshold firms undertaking R&D and the extent of their R&D employment is given by the *Directory of Scientific and Technological Capabilities in Canadian Industry, 1977*.[35] The directory may not be accurate because it was based on voluntary replies, hence the following numbers are probably underestimates. It indicates that there were only 43 threshold firms undertaking R&D, about one in four (Table III.6). Their total R&D employment came to more than 1000 scientists, engineers and technicians, in a ratio of about 1:6.5:5 respectively. This R&D effort was heavily concentrated in two industries, "aircraft and parts," and "communications equipment," which between them accounted for over half the threshold firms' total R&D employment. Notable for their proportionately low level of R&D contribution were firms in the "truck and trailer" and "auto parts" industries. Only 10 of the threshold firms had more than 15 employees in R&D, and three of these had over 150 so employed, a rough indication of the extent to which R&D was concentrated in relatively few of the threshold firms.

Patent data provide another surrogate for technological innovation, in this case a measure of the inventive output of the firm.

Table III.6 - Canada's Threshold Firms, R&D 1977 and Patents 1972–77, by Industry

SIC	Total firms	R&D		New Patents	
		No. firms	Employ-ment	No. firms	Total patents
311	12	6	29	2	3
315	40	6	76	15	70
316	3	1	29	1	2
318	2	2	23	1	1
321	9	4	384	2	7
323	1	0	0	0	0
324	19	1	2	5	13
325	20	1	3	8	26
326	0	0	0	0	0
327	8	1	3	0	0
328	2	0	0	1	2
329	1	0	0	1	5
331	3	1	3	3	5
332	5	2	17	1	4
333	2	0	0	1	1
334	1	1	26	1	31
335	9	6	346	3	12
336	5	3	18	0	0
338	1	0	0	0	0
339	3	1	14	1	4
365	0	0	0	0	0
369	1	0	0	0	0
372	0	0	0	0	0
373	2	0	0	0	0
374	3	1	13	0	0
375	4	2	20	0	0
376	1	0	0	0	0
377	0	0	0	0	0
378	2	0	0	0	0
379	6	4	65	1	2
Total	165	43	1071	47	188

Source: Ministry of State for Science and Technology, *Directory of Scientific and Technological Capabilities in Canadian Industry, 1977;* and *Patent Office Records*, 1972–77.

The measure is, unfortunately, a highly imperfect one, to be used with considerable caution. Not all innovations, for instance, are eligible for patent protection and in some industries there is a much lower propensity to patent than in others. For example, many electronics firms have avoided or stopped patenting many of their inventions, to maintain secrecy and help retain their competitive edge.[36] In other instances, a firm may seek to protect itself by surrounding a single invention with a number of defensive patents,

hence the patent data may overstate the number of inventions. Moreover, the patented invention may not necessarily become a commercially successful technological innovation.

The threshold firms between them received 188 new patents in 1972-77 (Table III.6). The "other machinery" industry was by far the leading source of patents, followed by "household radio and TV," and "auto parts."[37] Interestingly, then, the distribution of these patents by industry is not significantly correlated with the industry distribution of R&D. The patent measure identifies a different set of sectors as innovative. Although there are discrepancies between the time periods of the two data sets, and we might expect current patenting activity to be a function of past R&D activity, nevertheless, the juxtaposition of these two surrogate measures seems to indicate that R&D input does not necessarily lead to successful innovative output, at least in the form of patents. Nor, perhaps, is R&D necessary to achieve patents. In fact, among the 47 threshold firms that obtained new patents, there were 29 firms (62 per cent) that between them had 101 new patents, yet reportedly were without R&D. The remaining 18 that did have R&D obtained 87 new patents.

In order to provide further insight into the type of technological innovativeness and the particular niches created by threshold firms, the next chapters consider in more depth both the nature of R&D and its role in the competitive strategy of some R&D performers, and the situation of the machinery firms, which constitute the main subgroup of threshold firms.

IV. Defensive Technology Strategies and Incremental Innovation

Canadian R&D and Innovation

Future core companies may well emerge from Canada's group of R&D-performing threshold firms, but there is no simple way to identify the sectors or firms most likely to continue to be innovative and successful. Nevertheless, we can describe the recent track record of many of the firms, the nature of their technology strategies and the role of government programs in supporting or stimulating their R&D and technological innovativeness. We look, first, at the relatively few Canadian studies concerning firm size, ownership or control, and innovative activity. The studies have largely focused on aspects of R&D, such as the determinants of R&D expenditures, rather than the broad concept of technological innovation. They indicate, among other points, the following:

1. Although there is evidence from other countries suggesting that, among firms engaged in R&D, the R&D effort tends to be highest relative to size in middle-sized firms, in Canada the small R&D-performing firms devote a larger proportion of their sales to R&D activities than other firms, and medium-sized R&D-performing firms (sales $10-50 million) have a higher R&D intensity than their larger counterparts, a situation partly reflective of conditions of extensive foreign ownership.[1]

2. R&D-intensity levels are generally greater in the Canadian-controlled segments of industries than in the foreign-controlled segments, with the differences between the two intensities likely to be greater, the greater the R&D intensity of industry.[2]

3. Government incentive grants in particular, and current sales and cash flow are the principal determinants of R&D expenditures.[3]

4. Government-subsidized R&D increases the total amount of R&D spending, rather than causing company-funded R&D to fall proportionally.[4]

5. The probability of receiving a government subsidy for R&D is determined principally by the industry in which a firm is operating and, to a lesser extent, by the size of the firm, its ownership, and its location.[5]

6. Larger firms in some industries seem to be able to make better use of a given R&D budget than smaller firms, but innovative activity does not seem to rise more than proportionally with firm size.[6]

7. There is a link between government subsidies for R&D and patenting activity, with the larger a firm's reported R&D expenditures, the greater the number of patents subsequently obtained.[7]

8. A company's own commitment of funds to R&D increases with size as measured by sales and employment, though in electrical and some chemical products the R&D increases more than proportionally with size after a very high sales threshold is reached.[8]

9. Based on an analysis of 283 major innovations in five industries, Canadian-controlled SMEs tend to come up with product rather than process innovations, to finance their innovations from a large number of external sources, to develop innovations designed to fill market niches, and to rely heavily upon customers as sources of ideas for their product innovations and upon suppliers for their process innovations. For medium-sized firms the government tends to play a less important role in funding innovations than it does for small and large firms.[9]

Survey of R&D-Performing Firms

The widespread tendency to equate R&D with innovation and innovation with competitive advantage leads to the expectation that core companies are most likely to emerge from the one-quarter of threshold firms performing R&D. For this group of firms, we argue, inhouse technological capacity is critical to their development and combines with capital limitations and uncertainty about the potential success of their R&D efforts to dominate their management and innovation strategies. To attain some understanding of company strategies we report on selected elements of the firms' recent or current environment, behaviour, and performance. We gathered the data by a survey of R&D-performing firms.

These threshold firms are based in the electrical products, transport equipment and chemicals sectors. We indicate the employment growth and competitive environment of the firms; their R&D scale, trends and focus; their R&D contact system; the role and use of government support for R&D; and some features of the success of their R&D.

Outside the machinery group there were, as previously indicated, 28 firms categorized as both threshold firms in 1976 and performing R&D in 1977 (see Table III.6). This survey is based on interviews with 24 of those firms. Excluded from the survey are the three largest R&D performers, whose scale of R&D was substantially greater than the firms surveyed, and one smaller firm, whose CEO was new and not suitably informed to respond to several of the survey questions. The survey data were collected by telephone or face-to-face interviews with the CEO or occasionally another senior executive of each firm. The interviews were based on an interview guide (Appendix A) designed to focus the questions in the main areas for all firms; multiple-choice answers were provided for several questions. The interviews sought to foster discussion to permit more precise understanding of the questions by the firms and more accurate interpretation of their responses.

Growth, Profitability and Competitive Environment

The 24 threshold firms surveyed employed nearly 5000 people in Canada in 1980. Several also had significant employment in plants and offices abroad. Nine firms employed less than 200 people each in Canada, eight from 200 to 400, whereas seven had over 400 employees. Performing R&D provides no assurance of capability for growth or survival, but many of these firms did grow impressively during the difficult years from 1975 to 1980. Only four firms actually declined in employment, including one that dropped to 95 employees, below the threshold status, and another whose employment reduction was weighted by the sale of one of its small subsidiaries. Five firms made relatively marginal changes in their total employment, growing at a rate of 1 to 35 per cent over the five years. Six firms grew 36 to 70 per cent, and another five 71 to 115 per cent. The final four surged ahead by more than 116 per cent. In a few cases growth was bolstered by acquisitions, but for most their growth was through internal expansion. Each of the survey firms was still Canadian-owned in 1980 despite the fact that several of the privately-owned ones had received overtures for foreign and domestic takeover. They reported they were not interested. One CEO, whose firm had quadrupled in size since 1973, indicated he received offers about once a week for a foreign takeover. Among the public firms, one that had only one shareholder with a significant stake kept a wary eye on the market and expressed concern over the potential for a takeover, foreign or otherwise. One firm was state-owned, with a federal and provincial stake in its ownership.

The firms achieving very rapid growth did not necessarily attain high profitability. The CEOs were asked to rate their firms' recent profit performance (1977-79) in relation to both the Canadian manufacturing average and that of their main competitors in Canada

Table IV.1 - Employment Growth and Profitability of 24 Threshold Firms

Employment Growth, 1975-80 (by percentage)	Profitability in Relation to Canadian Manufacturing Average, 1977-79			Profitability in Relation to Main Domestic Competitors, 1977-79			
	Below	Average	Above	Below	Average	Above	Unknown
Negative	2	1	1	1	1	1	1
0-35	0	3	2	0	2	3	0
36-70	0	2	4	0	0	6	0
71-115	0	3	2	0	1	2	2
116+	0	3	1	0	3	1	0

Source: 1980 survey.

(Table IV.1). Discussion concerning the best measure of profit for these types of firm proved inconclusive; CEOs of private firms rarely will provide such measures. Hence the rating used here is a subjective one, albeit reasonably accurate in that only three categories are used. The rating is based on the CEO's personal interpretation of which is the most appropriate measure or combination of measures of profit. Only two of the CEOs considered their profit performance in recent years below the national average for manufacturing. Twelve (50 per cent) rated their level as average and 10 (42 per cent) above average. Among CEOs of the nine fastest growing firms only three assessed their profit performance to be above average, whereas CEOs of four of the six firms with an intermediate growth rate (36-70 per cent) rated their level as above average. The two firms with below average profit performance were among the four firms whose employment level declined.

When compared with their competitors in Canada, only one of the CEOs rated his company's profitability as below average. Three CEOs indicated they were unable to compare their profitability with their competitors in Canada as their main domestic competitors were either large firms whose profit levels covered a wide range of items or smaller private firms who did not report their profits. Among the remaining 20 CEOs, 7 considered their profitability to be similar to their competitors, whereas 13 (54 per cent) reported above average profitability. Notably, all six CEOs in firms with intermediate growth rates considered their profits to be above those of their domestic competitors.

How intense is the competition in the niches occupied by these threshold firms and is this related to their profitability and employment growth? The CEOs were asked to rate the strength of the competition confronting them, using a scale ranging from 1 (very intense) to 7 (insignificant). The majority of the CEOs (54 per cent) rated their competitive environment in categories 1 or 2. Only two

Table IV.2 - Profitability, Growth and Intensity of Competition of 24 Threshold Firms

		Strength of Competition, 1980							
		Very intense						Insignificant	Varied
		1	2	3	4	5	6	7	
Profitability relative to Canadian manufacturing, 1977-79	below	1	1	0	0	0	0	0	0
	average	4	2	1	1	0	0	1	3
	above	4	1	0	0	0	1	0	4
Employment growth, 1975-80 (by percentage)	negative	3	1	0	0	0	0	0	0
	0-35	2	2	0	0	0	0	0	1
	36-70	1	0	0	0	0	1	0	4
	71-115	2	0	1	0	0	0	1	1
	116+	1	1	0	1	0	0	0	1

Source: 1980 survey.

CEOs (8 per cent) viewed their competition to be relatively insignificant. However, seven CEOs (29 per cent), each managing several product lines, noted the extent of competition varied widely across their product range, some lines having a virtual monopoly, others facing strong competition. There was no simple relationship between the reported degree of competition and level of profits (Table IV.2). Among the 10 CEOs reporting above average profitability, five confronted intense competition and four were in the "varied" category. Similarly, a lack of strong competition did not necessarily signify high rates of employment growth, and CEOs in four of the nine fastest growing firms assessed their competition as intense.

The pertinent role of the firms' technology strategies is suggested by the fact that with few exceptions, the CEOs of the surveyed threshold firms perceived they had attained their competitive edge most importantly through inhouse technological developments. Fourteen CEOs (58 per cent) rated such inhouse developments as the single most important factor. One CEO gave equal weight to inhouse technological developments, licenses purchased from other firms and lower prices. The CEOs gave a singular lack of emphasis to the direct role of price competition. Only one CEO, with a firm in the chemical sector, perceived his competitive edge was obtained most importantly through lower prices. The remaining eight CEOs (33 per cent) gave equal weight to inhouse technological developments and the development of production and/or marketing and service capabilities.

R&D Importance, Scale and Focus

Inhouse technological developments may be achieved, of course, without R&D. To ascertain the role of R&D, the CEOs were asked to indicate, on a scale of 1 (critical) to 5 (unimportant), how significant

they considered their R&D efforts to have been in the survival and success of their firm in the past decade. Two-thirds of them rated such efforts to be critical, and less than one-tenth suggested they were relatively unimportant. R&D was defined, as in Statistics Canada surveys of industrial R&D, to be investigative work carried out (1) to acquire new scientific and technological knowledge, (2) to devise and develop new products or processes, or (3) to apply newly acquired knowledge in making technically significant improvements to existing products or processes.

Most of the 24 threshold firms maintain only a small R&D effort, without formal organization. To discern the changing scale of their effort, the CEOs were asked to indicate, to the nearest half person-year, how many scientists, engineers and technicians they employed for inhouse R&D in 1975 and 1980. Several emphasized the difficulty of responding accurately because various people do several jobs in addition to R&D, particularly engineers in the small threshold firms. Most firms sustained at least a small R&D team. In 1975, nine firms had less than three person-years in R&D, 11 between four and nine person-years, and only four over 10 person-years. The trend, however, was towards significantly increased R&D effort. Only one firm cut back on its R&D person-years between 1975 and 1980, six maintained the same effort, two increased it up to 20 per cent, five between 20 and 49 per cent, and 10 over 100 per cent. Indeed, nine of the latter 10 firms more than doubled their R&D person-years (and six of those nine also reported above average profitability).

The focus of R&D by these 24 threshold firms was predominantly on the development component, leading to the design, construction and testing of prototypes or models. Seventeen CEOs (71 per cent) indicated 100 per cent of their R&D was devoted to the development component. Most of the remaining firms allocated 5-25 per cent of R&D person-years to research, all of which was applied research rather than basic, as we might expect. The focus of the development work was quite varied. About 17 per cent of the firms devoted the whole of their development effort to the improvement or adaptation of existing products. Another 17 per cent of the firms spent 25-50 per cent of such effort on developing new products; 21 per cent spent 51-75 per cent on new products; and another 17 per cent spent 76-100 per cent on new products. However, several CEOs emphasized the difficulty of meaningfully defining "new" products and indicated also that their allocation of development effort between new products and the improvement or adaptation of existing products tended to fluctuate quite widely. Among those undertaking the development of new products, one-quarter emphasized the new products on which they were working were not essentially imitative ("me-too") products. Seventeen per cent specifically noted that their new product R&D comprised largely custom design work. Thus most

of the firms surveyed seem to be taking a defensive approach to R&D. Much of their emphasis is on incremental improvements, often minor adaptations.

The infrequency of an offensive approach is not surprising. Thus, as Hogan and Chirichiello[10] argue, in their review of R&D by American small firms, which they defined to be firms employing less than 1000 people:

> "In addition to capital limitations, a second major problem facing the small firm is the one of uncertainty of success in its R&D effort. A small company with only limited available capital cannot afford to finance very many unsuccessful projects. They do not have the financial capacity to sustain long-term losses in their R&D efforts. To do so could force the company out of business. Therefore, most small manufacturing companies must, of necessity, forego long-range R&D work that does not have a high probability of success and concentrate their R&D efforts against short-term work with a low risk factor. Since the small firm generally does not have the resources necessary to conduct extensive systematic marketing studies and to forecast marketing demands, they will generally concentrate their R&D efforts in areas in which they have already gained a marketing expertise."

Confronted typically with limited working capital, and given that R&D is a current expense, SMEs generally must attempt to keep R&D payback time to a minimum. Thus their focus tends to be on urgent projects in areas closely related to their current market and technological expertise.

These points suitably characterize the behaviour of the threshold firms in the survey. Among the 15 CEOs who discussed the points in some detail, 78 per cent noted that 90 per cent or more of their R&D person-years are allotted to urgent or high priority projects. Over 85 per cent of these CEOs also mentioned that virtually 100 per cent of their R&D effort focuses on areas in which they have existing market expertise. Similarly, nearly all judged that 80 per cent or more of their R&D efforts focus on areas of technology with which they are familiar. With regard to the risks of not succeeding in their projects, six out of 15 CEOs (40 per cent) assessed 90 per cent or more of their projects to be operating at low risk. As one commented, such projects are ones for which you are reasonably assured of success, even if the process is likely to be painful. Several argued the risks for their firms were less in terms of finding a clearly identified market than in choosing which technology would be most appropriate. There were, however, a few survey firms attempting more risky projects. Three CEOs (20 per cent) rated as much as one-half of their R&D projects to be medium or higher risk. Of course, successful commercial development, particularly of new projects, depends on strong performance in all areas of the firm, and perception of the risks of not succeeding in R&D projects must be seen in this context.

Table IV.3 - R&D Contact System of 24 Threshold Firms, by Type and Firm Scale

Environmental Contact	Total Employment			R&D Person-Years		
	100–199	200–399	400+	1–3	4–9	10+
Little or none	3	1	0	1	3	0
Spontaneous but temporary	5	4	2	5	4	2
Systematic and organized	1	3	5	1	3	5

Source: 1980 survey.

R&D Contact System, Funding and Government Support

In the development of new products and processes or the improvement of existing ones, a major determinant of success is the extent of cooperation in R&D among firms and between firms and agencies.[11] Such contacts are particularly significant for threshold firms as a source of ideas and development assistance; they reduce otherwise excessive reliance on limited internal R&D competence. Thus the CEOs of the 24 threshold firms were asked to indicate what sort of cooperation existed between their inhouse R&D and that of other firms or agencies: whether there was (1) little or none, (2) spontaneous but temporary cooperation, or (3) systematic organized cooperation. The responses indicate most firms make some effort to cooperate. Only four CEOs (17 per cent) responded they had little or no cooperation. Eleven (46 per cent) reported their cooperation was spontaneous but temporary, generally depending on the requirements of particular projects. The remaining nine (38 per cent) maintained systematic and organized cooperation. The general tendency was that the larger the firm and the more person-years alloted to R&D, the greater the likelihood of maintaining systematic and organized cooperation (Table IV.3).

The CEOs identified the extent to which they maintained, in the two previous years, R&D contacts with provincial government research establishments (such as CRIQ in Québec), universities, the National Research Council (NRC), other federal establishments (such as the Department of Communications) and contracting engineers or consultants. The main R&D contacts of these threshold firms, outside those with their immediate suppliers or purchasers, are with contracting engineers or consultants (42 per cent of firms) and with universities (33 per cent) (Table IV.4). Although two CEOs noted their university contacts involved searches for practical applications of academic research, the dominant university contact is with Waterloo University through its student co-op program. Some CEOs reported satisfaction with this linkage, others were less keen about

Table IV.4 - R&D Contacts of 24 Threshold Firms, by Institution and Type

Institution	Contact Type (by no. of firms)	
	Spontaneous but temporary	Systematic and organized
Provincial government establishments	2	3
Universities	3	5
National Research Council	1	2
Other federal government establishments	2	2
Contracting engineers and consultants	5	5

Source: 1980 survey.

the results to date. Surprising, perhaps, is the small use of the federal and provincial establishments. Although only three CEOs (13 per cent) noted they had R&D contacts with the NRC, several expressed a desire to find ways to make better use of this federal agency. Among those maintaining contact with provincial research establishments (25 per cent), there are also mixed reactions. Several were very pleased with their results, whereas one CEO simply dismissed his experience as a disaster.

The tendency noted by Hogan and Chirichiello[12] for SMEs with small R&D operations to contract out some of their specialized R&D work was not apparent among these threshold firms. Two-thirds of the firms do no contracting out of their R&D and only 17 per cent of the firms contract out more than 15 per cent of their R&D effort. Some CEOs commented on the difficulty of finding suitable contractors for specialized work in Canada. Some kept the work inhouse for fear of leaking out ideas.

The 24 threshold firms are relatively R&D-intensive in that about 80 per cent of them have a level of R&D spending that is 1 per cent or more of their total sales. Indeed, over a third of them have a level of 3 per cent or more. Government support appears to have provided only small stimulus to this level of R&D effort. Funding for R&D has come almost entirely from company sources. More than 80 per cent of the firms funded 1980 R&D from retained earnings; others supplemented this with grants from the federal government. Another source of government support for R&D is through tax incentives. In several recent budgets the federal government has introduced tax incentives for increased R&D. Although these tax incentive initiatives may help boost retained earnings and indirectly therefore support R&D, in practice they have not been very helpful. Even though just over 40 per cent of the CEOs indicated the tax incentive measures for R&D in the federal budgets of 1977-80 had been

helpful, several mentioned that the impact was very marginal. Moreover, despite the fact that nearly all the threshold firms in the survey were making a profit, several had not made use of the tax incentives. Firms found the R&D tax incentives very complex to compute, and virtually impossible to forecast accurately. Some firms, particularly those with small R&D efforts and without a formal R&D budget, noted their difficulty in specifying which costs were eligible for remission of taxes.

R&D grants have been more fruitful. Their impact has been greater than is apparent from the simple measure of contribution towards R&D funding. Whereas few of the 24 threshold firms in 1980 had any type of federal grant in support of their R&D, several had at one time or another during the previous decade obtained such a grant. And although one-quarter of the firms had not received any R&D grants, another quarter had obtained two or more. Four types of grants available to support R&D during the 1970s were used by the survey firms: IRAP, PAIT, IRDIA and EDP grants.

IRAP (the Industrial Research Assistance Program), administered by the NRC, was initiated in 1962 to provide financial assistance for the establishment of new industrial research teams or the expansion of existing ones. NRC pays the salaries of the company research staff working on approved research projects, with the company paying for all other R&D equipment and overhead costs. In recent years about 65 per cent of IRAP funds have been allocated to SMEs (less than 1000 employees).

PAIT (the Program for Advancement of Industrial Technology), administered by the Department of Industry, Trade and Commerce, was in operation from 1965 to 1977. When initiated it was intended to be a loan program with emphasis on product development. However, by 1970 it had not generated sufficient interest and the repayment provisions were dropped. The program was changed to a shared-cost grant, oriented to the development or improvement of a product or process. Analysis of the program indicates that medium-sized firms, with sales of $10 million to $50 million, had the greatest chance of successfully undertaking a PAIT project.[13]

IRDIA (Industrial Research and Development Incentives Act), introduced in 1967, was a more ambitious attempt to influence R&D. It offered a nontaxable cash grant of 25 per cent of the capital costs for R&D and 25 per cent of the increase in current R&D expenditures in Canada over the average of such expenditures in the preceding five years.

The final program, EDP (Enterprise Development Program) administered by the Department of Industry, Trade and Commerce, was introduced in 1977 and designed to consolidate seven of that department's industry-related assistance programs, including PAIT and IRDIA.[14] EDP gives preference to promising SMEs and its philos-

ophy is to operate at the margin, to supplement rather than to compete with or supplant private-sector resources. Its criteria provide for a last-resort test for loan insurance and a means test, called the "significant burden" criterion, for contributions. This latter criterion has reputedly successfully redirected innovation funds to SMEs undertaking relatively major development projects.[15] Of the four programs, EDP is the most oriented to the whole innovation process, rather than just the earliest R&D stages.

Among the firms surveyed, 3 (13 per cent) had received an IRAP grant, 10 (41 per cent) a PAIT grant, 6 (25 per cent) an IRDIA grant, and another 6 (25 per cent) an EDP grant. Although there were occasional dissident notes, especially concerning EDP which several CEOs considered thoroughly clumsy and complicated, generally there was consensus among the CEOs of the recipient firms concerning the effectiveness of the grants. Comments such as "it put us on the map" or "was crucial in the firm's development" were common. Many CEOs were not enamoured with the paperwork required, particularly for the EDP grants. Focusing on EDP, they generally agreed with the need to provide detailed information to protect the public interest and avoid excessive government grants but several felt the program should be prepared to support more high-risk projects, especially with firms having a reasonable track record. Of those few applying, none had been turned down for an EDP grant on account of the "significant burden" criterion, but some had been refused for other reasons. However, a number of CEOs stated they had not attempted to obtain an EDP grant for a new product on the grounds the approval cycle was too slow for the program to be of assistance, or they felt that the hassle simply wasn't worth it. Some CEOs with small threshold firms simply confessed their ignorance concerning what programs were available.

R&D Success

The combination of the critical role assigned to R&D efforts in the survival of the survey firms plus their average or above average profitability provides a general measure of the success of their R&D. To further evaluate R&D success, we requested information on three additional measures:

1. the number of new products (from both a technical and marketing point of view) that their R&D contributed during the 1970s;
2. the percentage of total sales in 1979 that those new products accounted for; and
3. the number of those new products for which they had obtained patent protection.

Taken at face value the responses suggest there was a great deal of technological innovativeness and renewal of product ranges by the

survey firms. Only one CEO indicated his firm's R&D contributed no new products. Four (17 per cent) reported from one to three new products; six (25 per cent) reported from four to six new products; and five (21 per cent) reported seven or more new products. The remaining eight CEOs (33 per cent) noted they had many new products, some reporting between 30 and 40, but many of them were actually produced as single items or perhaps in small batches. Insofar as one new product produced in volume may have greater overall impact than a large number of custom-manufactured new products, little emphasis should be given to this simple quantitative measure alone. Moreover, several CEOs indicated they were not comfortable with definitions of new products, finding it difficult in particular to decide whether a substantially improved model with a slightly different market was really new or not. Conceptual difficulties abound in this area.

The estimated contribution of the new products of the 1970s to total sales in 1979 varied widely. This measure revealed that many of the survey firms depended heavily on what they identified as their new items. Out of the 22 CEOs providing information, eight (36 per cent), not all of whose firms were basically custom designers or fabricators, revealed that over half their total sales came from such new items (Table IV.5). Those with greatest dependence on the new prod-

Table IV.5 - New Products and Profitability of 22 Threshold Firms

Sales of Products New in the 1970s as a % of Total 1979 Sales	Profitability Relative to Canadian Manufacturing, 1977-79		
	Below average	Average	Above average
0-10	0	3	4
11-25	1	2	2
26-50	0	1	5
51-75	1	1	2
76+	0	4	0

Source: 1980 survey.

ucts were not necessarily the most profitable, however. Indeed the majority of the survey firms that reported above average profitability compared to all Canadian manufacturing were at an intermediate level in their dependence on those new products, in the range of 26-50 per cent. Neither were those with the greatest dependence on the new products the fastest growing in employment during 1975-80 (Table IV.6).

Regarding the final measure, the CEOs generally considered patent protection to be a poor surrogate measure of technological innovativeness, for the type of reasons noted earlier. Several of the firms did hold patents, but a frequent response, particularly in the

Table IV.6 - New Products and Employment Growth of 22 Threshold Firms

Sales of Products New in the 1970s as a % of Total Sales in 1979	Employment Growth, 1975–80 (%)				
	Negative	0–35	36–70	71–115	116+
0–10	0	1	0	1	1
11–25	1	2	0	2	0
26–50	1	1	2	1	1
51–75	1	1	2	0	0
76+	1	0	0	1	2

Source: 1980 survey.

electrical products sector, was that technology was moving too fast to warrant filing for patents. Besides, for many firms a major concern was not to divulge their technology. Moreover, although some did take out patents they wondered whether it made sense as it would be extremely expensive to fight to protect their patents from infringement, a concern which others noted had deterred them from bothering to file. One CEO in a transport equipment firm mentioned that he took out patents to protect himself because he worried someone might copy his product and subsequently turn around to sue his firm. Thus the pertinence of this measure seems to vary from sector to sector, indeed between particular lines within sectors, for some CEOs referred to specific product lines in which they considered the patent they held was important to their competitive ability and to others in which their patent was really insignificant. As Hogan and Chirichiello[16] note, smaller firms do not consider patents as valuable as do larger firms. Patenting is important, however, when the small firm is interested in licensing its R&D results to other firms. Whereas such an interest was not mentioned by the CEOs interviewed here, it was pertinent to some of the case study firms discussed in Chapter VI.

In view of prevailing conditions, most firms in this survey have shown a remarkable propensity for adaptation and renewal. Inhouse development of technology, considered critical to their continued success in very competitive conditions, has received important support in many cases from government R&D grants. The R&D tax incentives have proved less helpful in supporting and stimulating R&D spending, according to the CEOs. Most firms have boosted their R&D input, much of which focuses on urgent, short-term work with a low risk factor and high potential profitability. They have largely defensive technology strategies and are seeking mainly incremental improvements or development of imitative new products predominantly within their existing areas of marketing and technological competence. One-third of the firms have maintained and developed

their inhouse technology capabilities largely to serve unique custom demands or small orders, and serve market niches which in some cases are less prone to intense competition.

V. Thrusters and Sleepers Among the Threshold Machinery Firms

A Bleak Environment

The largest group of threshold firms is in the machinery industry, producing primarily resource-based and industrial machinery. Among developed countries this industry, which is often broadly termed "the mechanical engineering industry," contains businesses ranging from those whose competitive success is built largely on their production skills and capability to produce long runs of standard mechanical components such as bearings, valves or springs, to some that are little more than simple local assembly and service operations. Others are highly specialized in complex machine assembly and their competitive success lies less in scale of production than in R&D and/or design capability. Each of these types of business has its own innovative focus.

The machinery industry has been heavily buffeted during the past decade by technical change, particularly by the race to incorporate new technologies such as microelectronics, ultrasonics and lasers into machinery design. Internationally the industry typically has a high skill-intensity of manufacturing and contains many SMEs, sometimes operating in oligopolistic conditions, sometimes achieving virtual monopoly powers, usually of short duration, through the development of new or improved products. Some firms are regionally sheltered, specializing in servicing local needs; this work frequently involves short lead times. Some SMEs have achieved success through specialization in producing long runs of one or two products, and others have found their niche in custom production, or as subcontractors with production capabilities closely geared to the requirements and specifications of large firms.

Price is not the major determinant of commercial success in the nonelectrical machinery industries. Although large changes in exchange rates and relative prices in recent years have had some impact on export volumes internationally, the competitive advantages due to lower prices have not been large and have been felt slowly.[1] Buyers are often prepared to pay premiums for machinery or components that are more sophisticated or technologically advanced, that have a better reputation for quality and reliability or where speed of delivery is advantageous.[2] Buyers tend also to support firms with a reputation for meeting delivery dates and providing speedy and reliable spares service and good after-sales service.

In export competitiveness for engineering products generally, and for mechanical engineering products in particular, technical quality or sophistication appears to be a prime determinant. Moreover, during periods of rapidly changing technology there tends to be continual pressure for technical improvements. Yet, as Rothwell[3] notes, following his appraisal of British and West German exports of 41 engineering products in 1975, "Technical change, in engineering goods at least, is not a sufficient condition for ensuring trading success; it is, however, most certainly a *necessary* condition." Although the importance of technological innovation to the trading success of a country may seem apparent, such innovation is difficult to identify in the machinery and components industry. R&D is particularly deficient as a proxy measure of innovative effort for this industry, as a substantial part of the innovative effort is in design engineering, which is not incorporated within the usual definition of R&D. One major attempt to relate innovative effort (using R&D as a proxy) to changes in trade shares for 10 developed countries indicated, among other points, a positive correlation for four R&D-intensive industries (aircraft, chemicals, drugs and instruments) but a poor correlation for mechanical machinery.[4]

Canada offers an unusually bleak environment for machinery production. Comparing the industrial structures of the United States and Western Europe with Canada reveals Canada is about 60 per cent underrepresented in the machinery industries.[5] Indeed the major portion of Canada's deficit in manufactured end products is accounted for by machinery, in which import penetration rose from 67 to 70 per cent over the past decade. The machinery deficit reached $6.1 billion in 1980. Despite a massive growth in domestic demand for machinery in the past two years, domestic producers have managed to compete successfully for a very small part of that growth, and Canada now only produces about 30 per cent of the machinery it buys. This situation, which represents an enormous and growing drain on our foreign exchange account, will not be readily reversed without a significant change in policy towards the industry. Yet attempts to stimulate import substitution and export promotion may

well be constrained by the size, structure and ownership features of the domestic industry. The protection provided for the industry by tariffs is generally very limited.

The prevailing viewpoint of Canadian governments has been that to protect or encourage the machinery sector could prove counterproductive to supporting the resource and other manufacturing sectors. Prior to the Kennedy Round of GATT (General Agreement on Trade and Tariffs) negotiations there was a 22.5 per cent duty on machinery and equipment of a make or kind produced in Canada, but only a 7.5 per cent duty on other kinds. In 1968, following the Kennedy Round, the duty was lowered to a uniform 15 per cent rate, but a Machinery Program (MACH) was also introduced allowing on two main categories virtual duty-free importation of machinery and equipment considered not available in Canada. MACH was introduced as a new approach to industrial development based on individual technical and commercial assessments of the capability of the Canadian machinery industry to supply products to meet the needs of domestic users. There is little or no tariff protection on a wide range of resource machinery that is imported under "end use" tariff items, as a special support for the resource industries, as well as virtual duty-free entry on agricultural equipment. Canadian machinery producers have also only received mild protection from the various types of nontariff barriers.[6] They have, however, received some assistance through the MACH program, which the federal Department of Industry, Trade and Commerce[7] argues has been an important industrial development tool. It has provided a continuing interchange between the department and machinery manufacturers regarding their capacity to meet users' requirements; it has brought their capabilities to the attention of potential customers; and it has identified the demand for specific types of machines that might profitably be manufactured domestically. The department claims, in this regard, that:

> "Many machinery manufacturers have been assisted through the provisions of the program to either increase the range of products manufactured in Canada, expand production facilities, carry out rationalization arrangements, increase Canadian content and/or improve their international competitiveness (through special remissions of duty for production components not available in Canada on an economic basis)."

Although the machinery industry has had difficulty in capturing a significant portion of its domestic market, its strength, deriving partly from growing concentration on specialized types and sizes of machines, has enabled it to boost its exports from $0.6 billion in 1969 to $3.4 billion in 1979. The latter represents about 35 per cent of sales. Yet, despite the export surge, the machinery deficit has worsened and fears have been expressed that there is little the govern-

ment can do, given the prevailing ownership structure of the industry, other than try to persuade foreign-owned subsidiaries to expand in Canada. Robinson[8] has also recommended Canadian-made machinery and equipment should be allowed more rapid depreciation than that imported. In view of the enormous potential market for machinery for the major new resource projects expected during the next decade, it has been suggested the federal government pursue a strategy to encourage new product development by approaching Canadian machinery and equipment producers and offering them grants to develop product lines not currently produced in Canada.[9] Provincial government officials in Alberta and Québec have recently advocated coordination of their large provincial projects to assist the emergence of a much stronger Canadian mining-equipment industry, and the Ontario government has decided to establish a resource-machinery centre in Sudbury. Mining purchasers have expressed further interest in obtaining domestic supplies – for the practical reason of security of supply.[10] However, these initiatives confront, among other things, a structural problem. The smaller machinery firms are largely custom producers and lack the size or capability to respond, and the larger firms are predominantly foreign-owned and, with rare and notable exceptions, have limited product responsibilities assigned to them and weak domestic R&D and design capabilities. Moreover, the introduction a decade ago of the American DISC program (Domestic International Sales Corporation) which cuts manufacturers' corporate taxes by 50 per cent on production exported from the United States, plus the further lowering of tariffs following the Tokyo Round, has prompted some American subsidiaries to relocate production to the United States. The Canadian industry has sought, with little avail, to obtain better export assistance and measures to counteract DISC.

Many of Canada's machinery firms are oriented to serving the special needs of one or two industries in a given region. Ondrack, from his evaluation of 22 small and medium-sized industrial machinery firms in 1975,[11] and subsequent follow-up analysis in 1980 of 19 of those firms (11 of them Canadian-owned), argues:

> "Rarely can a firm hope to expand from one region of Canada to another by staying within the market and technological knowledge of its original market. Instead, it appears that many regional firms prefer to seek out foreign markets before trying to expand operations very much in other regions of Canada. . .. This situation forces small firms to prematurely try to enter foreign markets when the firm lacks sufficient depth in capital and personnel resources."[12]

Also, in his estimation, the foreign-owned firms are less sensitive to Canada's market conditions, often having the option, for instance, to use slack facilities in Canada to produce inventory for other lo-

cations, a form of "passive" exports that has arisen to take advantage of the lower value of the Canadian dollar.

> "Thus in order to compete, the Canadian-owned firms must take more risks in establishing R&D operations and pursuing export sales than foreign-owned competitors in Canada. By taking these risks, the Canadian-owned firm has a far greater danger of becoming overextended and thus must be much more sensitive to variations in Canadian business conditions."[13]

Although Canada has about 2000 machinery firms, the 10 per cent that employ more than 100 people account for nearly 70 per cent of total employment and value of production. Most larger companies are American-owned, and foreign-owned subsidiaries account for close to 70 per cent of the value of assets in this industry. However, nearly a quarter of the 200 or so larger machinery firms are threshold firms, and it is to consideration of their circumstances and performance we now turn.

Survey of Threshold Machinery Firms

There were 52 firms identified as threshold machinery firms in 1976. They accounted for more than a quarter of the total number of threshold firms. Thirty-nine of those firms (75 per cent) were surveyed in 1980. The survey includes more than half of those that employed over 200 people in 1976. Three of those whose CEOs were interviewed were subsequently excluded from the survey, one because it became foreign-owned in 1979, another because its newly appointed CEO was in the process of trying to stave off a bankruptcy, and the third because it had just gone into receivership and bankruptcy. The second of these three firms was among those that had been repatriated from foreign-ownership in the early 1970s. It had had a large R&D and engineering team, now virtually disbanded, had moved into a new computerized product area, became overextended and ran into cash-flow problems on some large government contracts. Among the remaining 36 firms in the survey, all were still Canadian-owned at the time of the survey in 1980, but one was awaiting approval, subsequently granted, from FIRA to be taken over by a foreign-owned subsidiary firm. Its CEO claimed his company was a world leader in some of its market segments. Even though he had plants operating in several countries, he was finding that shifting exchange rates were making the Canadian plant, which was already exporting more than 75 per cent of its output, increasingly export competitive. He was particularly frustrated at the loss of much business – contracts approaching $20 million in recent years – through inability to finance the expansion of his plant and the installation of up-to-date machinery. The CEO was embittered by his experience with Canadian banks, which he argued were nowhere near as generous as the banks in the US. His company had written off several

million dollars on R&D and his application for a PAIT grant had been turned down. The CEO had reviewed Canada's system of R&D and innovation grants and could not see how they could be used by a medium-sized firm that required continuous improvements to its products, did not have a large R&D team, and was not operating in areas considered high technology. In this regard his experience resembles that of another medium-sized mechanical equipment manufacturer recently quoted in *The Financial Post*:[14]

> "All R&D is carried out under our own funding. With the present government systems it is possible to obtain help if your company is a small or large business. Government also favors high technology areas such as electronics. For a business with $14 million sales and 300 employees (and not doing high technology) there is little value in any government program."

The survey data for the remaining 36 machinery threshold firms were collected by telephone or face-to-face interviews in spring and summer 1980. The interviewers used an interview guide (Appendix B) similar to that used for the survey of R&D-performing firms.

Nearly all the survey firms (83 per cent) were not controlled by another firm and were privately owned. One firm was a cooperative. Among the remaining firms most were owned by holding companies and reportedly operated in a highly autonomous manner. Many of the CEOs indicated they received frequent offers for foreign takeover, but, so far at least, were not interested. One CEO, who held 51 per cent of the shares in his firm, indicated that if he were to sell he would rather have a large Canadian-owned firm to assist him and provide overseas marketing clout. Another CEO, his firm publicly owned, reported, "We've been worried about our backside, but can pretty well control our stock, and at least we have FIRA to go to bat for us." Among the more profitable firms several CEOs agreed their firms might appear ripe for takeover but argued not only were they not for sale but they were in search of acquisitions themselves.

Employment, Profitability and Competitive Environment

The 36 machinery firms employed about 8300 people in Canada in 1975 and 10 200 in 1980, an increase of 23 per cent. Four of the firms had yet to reach threshold status in 1975, employing less than 100 people each. Twenty firms had 100-199 employees in Canada, eight had 200-399 employees and four had over 399 employees. The pace, as indeed the direction, of employment change from 1975 to 1980 was far from even among the firms (Table V.1). Eleven firms (31 per cent) grew by over 70 per cent; eight of them, nearly all smaller ones, more than doubling their size. Nine firms (25 per cent) dropped in size, a few by over 30 per cent, and another nine remained stable or grew by less than 35 per cent over the five years. Thus in both the R&D and machinery surveys, about one-third of the firms (37.5 and

Table V.1 - Employment Size and Growth, 1975–80, 36 Threshold Machinery Firms

Employees in 1975	Employment Growth, 1975–80 (by percentage)					
	Negative	0–35	36–70	71–115	116+	Total
less than 100	0	0	1	2	1	4
100–199	4	6	3	4	3	20
200–399	4	2	1	0	1	8
400+	1	1	2	0	0	4
Total	9	9	7	6	5	36

Source: 1980 survey.

Table V.2 - Employment Growth and Profitability of 36 Threshold Machinery Firms

Employment Growth, 1975–80 (by percentage)	Profitability in Relation to Canadian Manufacturing, 1977–79			Profitability in Relation to Main Domestic Competitors, 1977–79			
	Below	Average	Above	Below	Average	Above	Unknown
Negative	6	3	0	5	3	1	0
0–35	1	4	4	1	2	4	2
36–70	1	3	3	1	2	3	1
71–115	0	5	1	0	5	1	0
116+	0	4	1	0	2	2	1
Total	8	19	9	7	14	11	4

Source: 1980 survey.

31 per cent, respectively) achieved an employment growth of more than 70 per cent during the turbulent years 1975-80. A higher percentage of the machinery firms than R&D-performing firms declined in employment (25 versus 17 per cent respectively).

The threshold machinery firms proved relatively profitable. Indeed, 28 CEOs (78 per cent) viewed their profitability in 1977-79 to be average or better in relation to all Canadian manufacturing. As in the case of the R&D survey, the machinery firms that achieved very rapid growth did not necessarily attain higher profitability (Table V.2). Among the nine firms (25 per cent) whose CEOs considered their profitability to be above average (this compares with 46 per cent in the R&D survey), most made employment gains at a slow or intermediate pace. However, the CEOs of the 11 fastest growing firms all claimed average or better profitability. The CEOs of six of the nine firms whose employment levels had declined viewed their profitability to be below the national average. In comparing their profitability with that of their main domestic competitors, rather than against the national average, the picture shifts only slightly, with two additional CEOs claiming above average performance. Four

CEOs felt unable to respond satisfactorily on this point. Table V.3 relates firm employment size in 1980 to the level of profitability with regard to the national average for 1977-79. There is a higher propensity for above average profitability, the larger the machinery threshold firm. Sixty-seven per cent of those employing over 400 people in 1980 achieved above average profitability, according to their CEOs, compared with 25 per cent of those employing 200-399, and 11 per cent of those employing less than 200.

The nature of the competitive environment confronting the threshold machinery firms may be ascertained in part by identifying their key sources of competition and the number of their main competitors. Only one CEO, his firm a custom producer, highly specialized and with nearly all of its output exported, claimed a virtual monopoly. Among the remaining 35 firms, 25 (71 per cent) of the CEOs identified imports as a key source of competition, though often in conjunction with competition against domestic foreign subsidiaries (23 per cent) or Canadian-owned firms (14 per cent) or both (9 per cent) (Table V.4). Nine CEOs (26 per cent) identified imports alone as their key source of competition. The main source of import competition was the United States, as mentioned by 24 CEOs (69 per cent). Eight (23 per cent) referred to European competition, and three (9 per cent) to Japanese. For 10 firms (29 per cent) their key competitors were within Canada alone and only one was predominantly competing against another Canadian-owned firm. Among the nine most successful machinery threshold firms, defined here to be those claiming above average profits and hereafter called the "thrusters," only two competed primarily with domestic foreign subsidiaries. Seven were confronted by significant import competition. Just one of the thrusters had another Canadian-owned firm as one of its key competitors. The "sleepers," those eight machinery threshold firms whose CEOs claimed below average profitability, were more varied in their range of competition.

Table V.3 - Employment Size and Profitability of 36 Threshold Machinery Firms

Employees in 1980	Profitability in Relation to Canadian Manufacturing, 1977-79			Total
	Below	Average	Above	
Less than 100	1	0	0	1
100-199	4	11	2	17
200-399	2	7	3	12
400+	1	1	4	6
Total	8	19	9	36

Source: 1980 survey.

Table V.4 - Key Sources of Competition for 35 Threshold Machinery Firms

	Source of Competition						
Firm Type	I*	I+DFS†	I+DCO‡	I+DFS+DCO	DFS	DCO	DFS+DCO
All 35 firms	9	8	5	3	6	1	3
Thrusters§	2	4	1	0	2	2	0
Sleepers**	2	1	1	2	2	0	0

* I = Imports.
† DFS = Domestic foreign subsidiary.
‡ DCO = Domestic Canadian-owned.
§ CEO claims above average profits.
** CEO claims below average profits.
Source: Survey 1980.

Table V.5 - Number of Firms Constituting Key Competition in Main Product Lines of 34 Threshold Machinery Firms

	Number of Key Competitors			
Firm Type	1-2	3-5	6-10	11+
All 34 firms	11	6	5	12
Thrusters	5	0	1	3
Sleepers	1	2	2	2

Source: Survey 1980.

Several firms compete in markets marked by a high degree of economic concentration. Among the 34 firms whose CEO reported the number of the firm's main competitors, 11 (32 per cent) considered that only one or two firms constituted their key competition in their main product lines, and five of the 11 were thrusters (Table V.5). By contrast, among the 12 firms in the least economically concentrated markets, just three were thrusters. The number of key competitors may not necessarily be indicative, however, of the intensity of the competition, at least as perceived by those confronting it. In practice, just under one-half of the CEOs viewed their competitive environment to be very intense, but there was a greater propensity for sleepers to assess their competitive environment to be very intense than for thrusters to do so (Table V.6).

Twenty-five (69 per cent) of the CEOs perceived that their firm's competitive edge arose from product performance (innovative technology), ranking this factor as the single most important or first equal, usually equal with distribution and service to their customers (Table V.7). Eleven CEOs (31 per cent) emphasized the role of timing and service, and their capacity for flexibility, as significant in maintaining their competitive edge. By contrast, only two CEOs viewed their firm's edge to lie most importantly in price competition alone, and five others ranked such competition equal first with other factors. Relatively less emphasis was given also to marketing, which was ranked first or first equal by only one-fifth of the CEOs, none of them, notably, being among the sleepers. The thrusters predominantly emphasized the crucial role of innovative technology in their

Table V.6 - Intensity of Competition of 36 Threshold Machinery Firms

	Competition Intensity			
Firm type	Very Intense	Intermediate	Insignificant	Varied
All	16	15	1	4
Thrusters	3	5	0	1
Sleepers	5	2	0	1

Source: Survey 1980.

Table V.7 – Basis of Competitive Edge for 36 Threshold Machinery Firms

Factor	All Firms		Thrusters		Sleepers*	
	Most imp. factor	1 of 2 most imp. factors	Most imp. factor	1 of 2 most imp. factors	Most imp. factor	1 of 2 most imp. factors
Product performance	12	13	4	4	2	4
Marketing skills	1	6	0	3	2	0
Price	2	5	0	1	1	1
Production capability	0	4	0	2	0	0
Distribution and service	1	10	0	2	0	3

* The CEO of one sleeper bewailed his firm's current lack of any competitive edge.
Source: Survey 1980.

competitive edge, but not to the exclusion of other factors. This focus, and the lack of emphasis on price, is not too surprising for firms in this sector. As the chairman of a large machine tool firm notes:[15] "When you spread the cost of the machine the price doesn't really matter. The technical side of the machine and its ability to do the job are more important than price."

Technology Strategies

Although innovative technology was given less emphasis by the threshold machinery firms surveyed than by the R&D performers, nevertheless it was a prominent feature of their competitive edge. Did the firms obtain that innovative technology by licence, inhouse development, or some other means? The means by which it is obtained is of considerable consequence, as Bourgault and Crookell[16] have so astutely argued. Continual product renewal is imperative to sustain a modern manufacturing firm; this requires a design and engineering capability to produce engineering drawings, product and equipment specifications, materials and parts specifications, production procedures and quality control procedures. Bourgault and Crookell suggest that between the completion of R&D and the finalization of the design of the new product, the product must be tuned to market needs and engineered to be suitably cost competitive. Once it is in production it requires continuous updating, to take advantage of new materials, techniques and production machines. However,

> "the capability for autonomy in technology is not necessarily absent if a firm does not engage in R&D. The absence of the R&D function can be compensated to a large degree through the purchase of licences and know-how. A far more serious defi-

ciency in a firm is the lack of design and engineering capability. Without this function, or access to it from a parent or affiliate, a manufacturing company cannot survive except in the most static types of industry."[17]

Indeed, without such a function it becomes technologically dependent and is most unlikely to be able to compete against its own technology source.

Consider the state of R&D and design and engineering capabilities in the threshold machinery firms. In 1980 the total number of scientists, engineers and technologists employed in R&D, as reported by each CEO (according to the nearest half person-year for each firm), was 197. That represented a 55 per cent increase over the 127 so employed five years earlier, some indication of a growing focus on increasing R&D capabilities. Nearly a third of those employed in R&D in 1980 were in the thrusters, which sustained a 167 per cent rate of increase in R&D employment between 1975 and 1980. By contrast the sleepers, which between them had employed virtually the same number in R&D as the thrusters in 1975, increased their total by 53 per cent. However, the bigger R&D performers were not the fastest growing. Indeed, four of the nine firms which grew most rapidly in employment in 1975-80 had no R&D in 1975 and three still had none five years later.

In 1980, only eight (22 per cent) of the machinery thresholds did not undertake R&D. Thus most firms did maintain at least a small R&D effort, with more than half employing four or more people in R&D on a person-year basis and nine employing 10 or more (Table V.8). Virtually all the R&D was development work. Only one

Table V.8 - R&D Employment by Threshold Machinery Firms, 1980

	Person-Years Employed in R&D			
	0	1–3	4–9	10+
All 36 firms	8	9	10	9
Thrusters	1	2	4	2
Sleepers	1	3	3	1

Source: 1980 survey.

CEO, in a firm with one of the larger R&D efforts, indicated more than 5 per cent of that effort was on applied research. The development emphasis was relatively evenly split between that on new products as opposed to incremental adjustments to existing product lines, although some CEOs indicated all their development was towards new products and others focused entirely on incremental developments. Seven CEOs (19 per cent) indicated some of their R&D effort was towards development of new rather than imitative products.

The machinery threshold firms are of a size that is most likely to benefit from outside RD²E (research, development, design and engineering) assistance. Indeed Rothwell[18] argues the signs are that few mechanical engineering companies can survive without the use of external technical assistance to supplement inhouse resources. For instance, competitive pressures for innovation in the farm implements industry are forcing SMEs to look outside for specialist skills in electronics, metallurgy, soil mechanics and agrochemistry. It is not surprising, therefore, to find the threshold firms have a relatively diverse RD²E contact system. Yet eight CEOs (22 per cent) indicated they had made no use of RD²E facilities at provincial government establishments, universities, the NRC, other federal establishments or contracting engineers and consultants. The most frequent contacts were with provincial government establishments and the universities (44 per cent of the firms and 33 per cent respectively) (Table V.9). Firms in the Prairies made relatively frequent use of

Table V.9 – Use of External R&D and Design and Engineering Facilities by 36 Threshold Machinery Firms, 1977–79

	All 36 Firms	Thrusters	Sleepers	Largest*	Smallest†
Provincial government establishments	16	3	4	4	3
Universities	12	3	3	3	2
National Research Council	3	0	0	0	1
Other federal establishments	1	1	0	1	0
Contracting engineers and consultants	9	1	2	2	6
None of above	8	2	0	3	1

* Ten largest firms, each employing 300 or more people in 1980.
† Ten smallest firms, each employing less than 140 people in 1980.
Source: 1980 survey.

their provincial research councils, and several of the Ontario firms had turned to the Ontario Research Foundation for assistance. Use of the universities tended to be on an infrequent basis, as well as being less common. One CEO was in the process of looking to see what the universities had to offer. Another had had troubles communicating. Most surprising, perhaps, was the limited use of the NRC by only three firms (8 per cent). One CEO indicated he had tried without much success, whereas another had had discussions with NRC staff but felt NRC was not able to perform the sort of research he needed. Nine firms (25 per cent) made use of contracting engineers and con-

sultants, whose services were in particular demand by the smallest firms. Thrusters did not use external RD^2E facilities more extensively than sleepers, and the largest firms showed less dependence than the smallest on such facilities.

Thirty-one (86 per cent) of the machinery threshold firms had the full range of design and engineering functions, the capability to produce engineering drawings, product and equipment specifications, materials and parts specifications, production procedures and quality control procedures. One firm lacked capability in the last two functions, and three firms lacked one of the last three functions. The one firm which lacked all five design and engineering functions drew upon design consultants. Its CEO indicated he had obtained an IDAP grant (Industrial Design Assistance Program) "but the project bombed." Ninety-five per cent of his sales were products designed by others. He assessed his profits as average in 1977-79, but feared they were rapidly declining and he anticipated substantial layoffs.

Among the eight threshold machinery firms that undertook no R&D, all but one maintained the full range of design and engineering functions. One was a thruster, designed all the products it sold and exported a third of its production. The other seven had average profits. They either manufactured under licence (up to 30 per cent of their sales volume being accounted for by the licensed products), or acted largely as distributors of other firms' products, or, in the case of two firms, made products to customers' designs, such products accounting for all the sales of one firm and 40 per cent of the other. One, whose CEO candidly commented he copied his competitors' products and did some redesigning, had no exports. Among the other six, two did virtually no exporting, whereas four had exports accounting for 20-50 per cent of their total sales. Evidently the lack of R&D capability, although it may deter capacity to innovate and develop products suitable for export competitiveness, may be countered in part, in the machinery sector at least, by maintenance of the range of design and engineering functions. However, CEOs of two of the four firms achieving over 20 per cent exports emphasized price as the single most important factor in their competitive edge, and the third CEO gave marketing skills and the firm's distribution network equal weight. Only the fourth, the CEO of one of the most rapidly growing threshold machinery firms, with 50 per cent of its total sales accounted for by products of its own design, gave primary emphasis to the firm's innovative technology.

The threshold machinery firms tend to design most of the products they sell (Table V:10). Only seven (19 per cent) sold products of other firms' design that accounted for over 60 per cent of their total sales. Products designed by the firm made up a larger proportion of the sales of the thrusters and largest 10 firms than of the sleepers and smallest 10 firms.

Table V.10 - Sales of Products of their Own Design by 36 Threshold Machinery Firms, 1980

Firm Type	% Total Sales Accounted for by Products of their Own Design					
	0–19	20–39	40–59	60–74	75–89	90–100
All 36 firms	3	3	1	3	8	18
Thrusters				2	2	5
Sleepers		2			2	4
Largest		1	1		3	5
Smallest	2	1			3	4

Source: 1980 survey.

Production Method and Product Innovation

Firms generally compete according to their methods of production. Those with custom and small batch production tend to compete on the basis of their technical performance, whereas those geared to long production runs are most frequently concerned with minimizing costs. The nature and function of innovation differs between these modes.[19]

Twenty of the threshold firms (56 per cent) were custom or job shops, and small batch producers or some combination thereof (Table V.11). Among those 20 only two were thrusters, and one of these was among the largest firms. The smallest firms had a high propensity to produce only in small batches, whereas the largest machinery thresholds, and seven of the nine thrusters compared to three of the eight sleepers, achieved much of their production in large batches or by continuous or mass production methods. However, custom work did not necessarily lead to slow growth. Of the eight firms wholly oriented to custom work, two were "speedsters," that is among the nine firms (25 per cent) that grew by more than 90 per cent in employment in 1975-80, whereas four were "laggards," that is among the nine firms whose employment levels declined. However, the laggards did tend to have a high proportion of custom work, whereas the speedsters were more likely to achieve large batch production. Some CEOs noted their firms made their money on the custom work and took on work with larger batches primarily as fillers, whereas others made their money on the larger batches, competing on a price basis with little, or even a "ruinous," margin for the custom work.

This focus on the firms' production methods provides some insight into the firms' types of product innovation, in the form of new product innovation in the 1970s both from a marketing and technical point of view. The CEOs of only five firms (14 per cent) indicated they had no such new products, and three of the five were among the smallest firms (Table V.12). One of the five was also a thruster. It was lacking in R&D but had the full range of design and engineering

Table V.11 - Production Methods of 36 Threshold Machinery Firms

Production Method	All 36 Firms	Type of Firm					
		Thruster	Sleeper	Largest	Smallest	Speedster*	Laggard†
Custom/job shop 80–100%	8	0	3	2	1	2	4
Small batch and custom/ job	3	2	0	1	0	0	1
Small batch 80–100%	9	0	3	0	6	2	1
Small batch and large batch	10	3	2	3	2	4	2
Large batch and/or continuous process or mass production	6	4	1	4	1	1	1

* Speedsters are the nine firms (25 per cent) with fastest growth (over 90 per cent) in employment, 1975–80.
† Laggards are the nine firms (25 per cent) whose employment declined, 1975–80.
Source: 1980 survey.

Table V.12 - New Product Innovation by 36 Threshold Machinery Firms

No. of New Products in 1970s	All 36 Firms	Type of Firm					
		Thruster	Sleeper	Largest	Smallest	Speedster	Laggard
0	5	1	0	0	3	0	1
1	9	4	1	4	2	1	0
2	1	4	1	0	1	0	1
3	4	2	2	3	0	4	2
4+	17	2	5	3	4	5	6

Source: 1980 survey.

functions, provided parts for the agricultural machinery industry and exported a third of its output. Its CEO emphasized, however, that the firm's competitive edge lay in price and production capability as much as product performance. Nearly half the CEOs claimed their firms had introduced four or more new products in the 1970s. This seemingly high level of innovation is predominantly related, however, to the production of new machinery or equipment on a custom basis or in small batches, an approach rarely leading to better than average profitability for the firm as a whole. Thus only two thrusters produced four or more new products in the 1970s, whereas four thrusters produced only one each. The threshold machinery firms that had

achieved larger size and/or above average profitability were generally those with relatively few new products, but they were new products for which they had found markets enabling them to produce in large batches, continuous processes or mass production. By contrast, the sleepers and laggards, although apparently quite innovative on the basis of introduction of new products did not achieve such high profits and increases in employment. Moreover, the introduction of many new products was characteristic not only of the speedsters, accounting for the major portion of total sales in most of them and revealing a high degree of product turnover, but also of the laggards, whose innovative efforts had a stronger custom focus.

Not all the laggards had a custom focus, and the experience of one that was particularly innovative warrants brief discussion. The CEO of this firm, which devoted 12 person-years to R&D in 1980, was a highly imaginative engineer and appeared more interested in innovation than simply making money. The firm had introduced, through inhouse developments, 16 new products in the 1970s, virtually all of them profitable, but some more marginally so than others. The firm had grown rapidly until recently when it had to make a substantial cutback in employment. The main basis for its decline in employment, as explained by the research director and paraphrased here, provides some insight into the difficulties for a threshold firm in producing a new product, particularly an imitative item, as a direct challenge to a large multinational. A significant part of this threshold's sales between 1967 and 1977 arose from its distribution of a product for an American corporation we shall call "C." Cancellation of the distributorship in Canada by "C" had been mooted at least as early as 1976 and this caused the CEO to consider very seriously developing a rival product for the Canadian market to preserve the $2-million business associated with the distributorship. The CEO obtained outside research assistance to review the patents on the product of "C" and come up with a rival concept that would not infringe on the American patents, and that could be patented by the threshold to protect its new line. This involved studying some 15-20 patents with as many as 13-15 clauses in each patent. The study after about five months led to several concepts calculated not to infringe the patents held by "C." Three months later the threshold had ready a prototype whose performance was considered acceptable. It proceeded to produce 50 preproduction units in late 1977 and early 1978. It sold most in Canada and some in the United States. The product was such a success in the United States, a decision was made to enter the United States market and plans were made to build up to 350-500 production units per month. Many of the components were subcontracted, but much fabrication and the final assembly work were done inhouse, with units being produced

at an average of 300 per month. Subsequently, it was decided to increase the power output both to adjust for the Canadian climate and in response to a similar move by "C." Six prototypes were built and tested, a new power unit evolved, and by February 1979 ten preproduction units were sent for field evaluation. "C," which held 85 per cent of the American market and was the threshold's only significant competitor for this product, had fixed its price sufficiently low that the threshold was unable to obtain a margin of more than about 12 per cent gross profit for the sale of its units in the United States, where it had a limited set of distributors. The profitability in Canada was considerably better, with a gross profit of 25-28 per cent. Nevertheless, because of the high volume of production going to the United States, about 300 per month, the CEO saw that without the cost reduction activities, which had been planned but largely side-tracked when development efforts went towards the new power unit, a loss of sufficient magnitude would be incurred that it was necessary to sell off the product. Another major American corporation, "D," expressed interest in early 1979 and negotiations for the product's sale were completed in five months. To complete the negotiations the firm had to obtain permission from the federal Department of Industry, Trade and Commerce to sell off the technology for the product since it had been developed under an EDP grant. The grant funding had to be paid back. In the meantime "D" committed to produce the products in Canada and obtained approval from FIRA.

The firm had also managed to develop sales in Japan and Australia. "C" reacted in both those export markets as well as the United States with legal harassment reflected in lawsuits for alleged patent infringement. In its arrangements with the threshold firm, "D" agreed to pick up these costs of litigation. It was subsequently resolved that the patent on which "C" was hanging its case was not valid because the technology had been disclosed prior to issue of the patent. In consequence, according to the research director, an antitrust suit by the US government will be added to the antitrust counter suit issued by the threshold, and it is expected the matter will be settled much in favour of the threshold firm and "D." Nevertheless, in the meantime the firm had dissipated part of its marketing organization, cut back on production lines and employees and expected its sales to drop to about half the prior level of $12 million. "D," by contrast, a $3-billion corporation with a wide distribution system in place, is expected within three years to move the new product from the approximate 7 per cent share achieved in the US market by the threshold firm in the first year, to nearer 50 per cent.

Evidently this apparent laggard has been very innovative, developing and producing a product which looms as a considerable success. According to the research director, "the whole situation proves that we can concept, design and manufacture competitive products

in respect to performance and market acceptance. We fall very short, however, in being competitive on price and profitability." Tackling a giant corporation head-on with an imitative product that must compete on a price basis with very high-volume production would not seem a suitable strategy for a threshold lacking substantial resources and without considerable marketing clout. Threshold firms usually stand their best chance of success by focusing on areas in which they currently have a strong business position that they can sustain or expand through a relatively low level of RD^2E investment.

Government Support for R&D and Innovation

The machinery threshold firms tend to vary widely in their inclination and ability to obtain federal grants to support their efforts in technological innovation. Although several firms were well tuned to the grant mechanisms and had received three or more grants in the past decade, a few CEOs expressed bewilderment at the changing array of programs available and felt it was time to assign someone in their firm to explore the possibilities. One CEO noted his predecessors had shied away from government "interference." Some CEOs felt "handouts" should be available only to the smallest firms, and there was the occasional CEO antagonistic to any grants, devout in the belief there was no good reason for the government to interfere in the marketplace. In any event, relatively few threshold machinery firms were heavily dependent on government innovation grants. One recently appointed CEO was uncertain whether his firm had received a grant in the 1970s. Among the remaining 35, 16 (46 per cent) had not received any federal grant directly oriented to the support of their R&D and product innovation efforts (Table V.13). The

Table V.13 - R&D Innovation Grants Awarded to 35 Threshold Machinery Firms

Type of Grant Awarded	All 35 Firms	Type of Firm					
		Thruster	Sleeper	Largest	Smallest	Speedster	Laggard
None	16	4	4	2	4	3	4
PAIT	8	3	1	2	3	1	2
IRAP	2	0	1	1	1	0	2
DIP*	2	0	0	0	1	1	0
IRDIA	7	2	0	3	1	4	1
EDP	2	0	1	0	2	0	1
Mini-IRAP†	1	0	1	0	1	0	1

* A program designed to sustain and develop the technological capability of Canadian firms for defence export sales or associated civil export sales.
† Initiated in 1978–79 and assists firms not large enough to maintain their own separate research facility by paying salaries of those working in research organizations on the client's project.
Source: 1980 survey.

smallest thresholds, with probably the greatest needs for assistance, nevertheless had a greater propensity than the largest not to have received such grants, and more than half those at an intermediate size, with 140-300 employees, had not received grants. The most frequently obtained grants were from PAIT, received by eight firms, and IRDIA, received by seven. Five of the thrusters, compared to only one sleeper, had received either a PAIT or an IRDIA grant. EDP had been used by only two of the machinery thresholds, although three firms were waiting to hear if their EDP grant applications were accepted.

Among the comments and complaints expressed concerning the programs were the following:

1. Several CEOs were frustrated by what they perceived to be unnecessary and overwhelming paperwork, a burden particularly for smaller firms lacking experience in these matters.

2. Two CEOs referred to the fact that costs that are covered by an EDP grant are those incurred after the date of grant approval. However, to achieve a competitive posture it may be necessary to move faster than the grant approval time allows, so some key costs may have to be incurred earlier and are not recoverable.

3. The CEO of one larger thruster noted that technology developed partly with PAIT assistance must be employed within Canada, a seemingly wise regulation to obtain national reward from grant expenditures, yet a constraint for firms that wish to establish similar facilities abroad. These firms need to export substantial domestic parts and components to their foreign assembly plants; their foreign subsidiaries may in this way benefit Canada. The regulation is also an irritant, as it must be interpreted in cases where the firm subsequently develops the technology further without the benefit of a grant, then must obtain, no doubt after some delay, government permission to allow overseas direct investment.

4. The CEO of one sleeper found his PAIT grant very helpful, despite the paperwork and "the staggering amount of things we had to do we didn't want to. But the end was worth it. Maybe it was good for us because it forced us to use outside help – design consultants."

5. A CEO of a thruster, who at the time had had plenty of frustrations with his PAIT grant, felt it looked good now and wished to return to a PAIT-type system. A medium-sized firm, he argued, tends to have a reasonable asset base so has problems in obtaining an EDP grant because of the "means test."

6. Another CEO, with a firm attempting to expand its R&D effort and break out from what he visualized had become a dead end (the firm was excessively tied to technology licensing agreements), was worried that, with EDP money short in 1980, and despite his ability to meet other requirements and covering criteria, his project would have to be very competitive in its estimated return on investment for his grant application to be accepted. Moreover, an EDP grant al-

lows claims for costs of prototypes, some special R&D equipment and R&D person-hours but not the cost of capital equipment. Yet to exploit fully the results of his R&D, his project was going to require a great deal of capital expenditure.

7. The CEO of a larger firm undertaking no R&D and with a substantial part of his firm's output produced under licence from an American company, had sought grants several times, including from EDP, but had found the firm did not qualify. Its efforts, subsequently very successful, were basically in design engineering and development. In this CEO's view, the grant programs needed to be "much more practical and bloody-minded, not something put together by a bunch of academics, otherwise we'll be conned out of our socks by other countries."

8. The CEO of a speedster, and one of the largest firms, which did not do much R&D, commented that a firm his size had difficulty in getting into "the government grant action" and that from the little he knew of design programs the standards were so tough it was difficult for a medium-sized firm to make use of the program.

9. The CEO of another speedster, basically a job shop, in whose early development a PAIT grant had played a vital part, currently was unable to cope with all the business available, but desired to get into R&D and needed outright cash grants as the firm was unable to generate sufficient cash flow. The CEO was starting to explore the grant programs and had also just received FIRA approval for a joint venture in Canada with a European firm, a prospect which the CEO hoped would help lead the firm away from excessive emphasis on custom work and contribute towards the development of R&D.

10. Among those firms receiving innovation grants, the CEOs had varying reactions as to how effective and vital the grants were in their firm's development, but the majority considered them to have been both effective and very important.

Tax incentives for R&D are another source of support for innovation, at least for those 28 of the 36 firms which reported undertaking R&D. These incentives are, of course, designed to reward those making profits, and in practice only 13 CEOs among those 28 firms reported they had taken advantage of the tax incentives for R&D (Table V.14). As we might expect, those most likely to use the incentives were the thrusters, speedsters and largest firms. However, not all those eligible actually took advantage of the incentives. CEOs with firms having smaller R&D efforts noted their difficulties in separating out eligible costs, some finding the system very confusing. Some with large RD²E teams indicated they found it a horrendous and tedious process trying to separate out the R&D from the design and engineering as their accounting records were simply not designed to identify such distinctions. Those taking advantage of the incentives found them generally "quite useful," but several CEOs

Table V.14 - Threshold Machinery Firms Taking Advantage of R&D Tax Incentives, 1977-79

Firm Type	Total No. of Firms	No. of R&D Performers	No. Taking Advantage of R&D Tax Incentives
All 36 firms	36	28	13
Thruster	9	8	6
Sleeper	8	8	0
Largest	10	8	5
Smallest	10	10	2
Speedster	9	7	6
Laggard	9	9	1

Source: 1980 survey.

noted they would prefer a definite cash settlement for R&D expenses and some recommended that, because current incentives for firms with small R&D efforts are hardly worth the effort required to claim the reward, the incentives should be significantly increased for SMEs, perhaps to the point of an 150 per cent write-off of costs against taxes, and possibly even escalating the reward according to level of exports. However, the latter is not acceptable within the terms of GATT.

The federal government's measures to provide R&D and innovation support through grants and tax incentives would appear, therefore, to have had relatively small impact on the 36 threshold machinery firms. Nearly half the firms had not obtained a grant and two-thirds had not taken advantage of the tax incentives. And of those that had, not all had found them useful or of significant benefit. However, nine firms (25 per cent), with only one among the smallest and one laggard, proved highly exploitive, being able to make use of both sets of measures.

Export Competitiveness and Technology Strategy

In view of the growing focus on improving the export competitiveness of Canadian secondary manufacturing, consider now the export performance of the threshold machinery firms and the role of their technology strategies in contributing to this performance. To the extent such firms are regionally sheltered, or do custom work and subcontract to larger domestic enterprises, we might expect their export contribution to be limited. In fact, these firms are by no means restricted solely to small domestic market niches. Among the 36 firms, export performance is substantial. It also generally improved from 1975 to 1979, as measured by each firm's change in exports as a percentage of its total sales. Whereas for 21 firms (58 per cent) the percentage of exports in total sales held steady, for 12 (33 per cent) it increased by over 6 per cent. And for only three did it decrease by over 6 per cent (Table V.15). Two of the largest firms that were also sleepers and laggards both had their exports decline by over

Table V.15 - Change in Export Performance by 36 Threshold Machinery Firms, 1975-79

Change in Exports as % of Total Sales, 1975-79	All 36 Firms	Type of Firm					
		Thruster	Sleeper	Largest	Smallest	Speedster	Laggard
Decline by over 10%	2	0	2	2	0	0	2
Decline by 6-10%	1	1	0	0	0	0	0
Steady within + or −5%	21	6	5	3	7	4	6
Increase by 6-25%	4	1	1	3	1	2	1
Increase by 16-25%	3	0	0	1	0	1	0
Increase by over 25%	5	1	0	1	2	2	0

Source: 1980 survey.

10 per cent in relation to total sales. The speedsters and smallest firms generally showed the highest propensity for exports to grow as a percentage of total sales.

The extent to which the firms were export-oriented in 1979 varied widely. Three firms had no exports and eight did virtually no exporting, whereas 12 exported over 70 per cent of the value of their shipments. The thrusters, in particular, but also the largest firms and speedsters, were generally much more export-oriented than the sleepers, the smallest firms and the laggards, but there were some in each of the latter categories with a high level of exports, just as the former categories contained firms doing very little exporting (Table V.16). The survival and success of many of these threshold machinery firms thus appears to hinge on their market success abroad, primarily in the United States.

Table V.16 - Export Performance by 36 Threshold Machinery Firms

Exports as % of Total Sales	All 36 Firms	Type of Firm					
		Thruster	Sleeper	Largest	Smallest	Speedster	Laggard
0-9	11	1	5	3	5	1	6
10-24	2	0	0	1	0	1	0
25-39	6	1	1	1	2	4	1
40-54	3	1	0	1	0	1	0
55-69	2	1	0	1	0	0	1
70-84	5	3	0	1	1	2	0
85-100	7	2	2	2	2	0	1

Source: 1980 survey.

The lack of R&D has not deterred some firms from achieving export competitiveness, as noted earlier, but only four of the eight without R&D managed to achieve over 25 per cent exports (Table V.17). Export competitiveness, at least when measured by

Table V.17 - Exports, R&D and Design in 36 Threshold Machinery Firms

Exports as % of Total Sales, 1979	R&D Person-Years, 1980				% Total Sales Accounted for by Products of Own Design		
	0	1-3	4-9	10+	0-39	40-74	75+
0-9	3	5	2	0	4	2	4
10-24	1	0	1	0	1	0	1
25-39	2	0	2	2	0	0	6
40-54	2	1	1	0	0	2	2
55-69	0	0	1	1	0	0	2
70-84	0	0	1	4	0	0	5
85-100	0	3	2	2	1	0	6

Source: 1980 survey.

exports as a percentage of total sales, evidently increases, for this group of thresholds, with the number of person-years of R&D. Thus none of those without R&D achieved 55 per cent or more exports, compared with 33 per cent of those with one to three R&D person-years, 40 per cent of those with four to nine, and 78 per cent of those with 10 or more. Similarly, the greater the percentage of total sales accounted for by products of own design, the more likely that total sales would include a high proportion of exports. No doubt the line of causation is not a simple one-way process, but the lack of sales of products of own design appears to significantly limit export capability. Among the 14 firms exporting 55 per cent or more of their shipments, only one sold products predominantly not of its own design. The anomalous situation of this one firm with a limited percentage of sales accounted for by products of its own design, yet able to achieve a very high percentage of exports, warrants note. This threshold, which is among the smallest, but neither thruster nor sleeper, nor speedster or laggard, is one of those repatriated in the last decade from American ownership. The Canadian owners bought the product line from the previous large American parent, which had chosen to drop out of competition when it found the North American market too small for its interest. The threshold, which received assistance from the Ontario Development Corporation, now has a small R&D effort and the full range of design and engineering capability. It is in the process of developing and redesigning some of the components and parts of its product line, but is still dependent on its previous parent's design. Its CEO gives equal weight in the firm's competitive edge to its product's performance and price. With the previous parent out of the market the CEO feels the threshold

now has plenty of room within which to manoeuvre in North America. Its main competition comes from a European firm.

Future Plans

From the viewpoints of profitability, employment growth, product innovation and export performance, therefore, Canada clearly has a small but vital and innovative group of threshold machinery firms. They constitute a significant resource Canada should nurture with sensitivity. Among these firms are several that, through their technology strategies and other capabilities, have managed to become world leaders, with successful export markets in specialized areas that can be dominated by firms with limited financial resources. For a number of these firms, the Canadian market accounts for a relatively small component of their total sales.

Fourteen of the 26 firms whose CEOs discussed their future plans talked with optimism about their intentions and prospects and were preparing for substantial growth, usually with emphasis on continued specialization, further R&D, and export expansion to Europe, Australia and the Third World. Several CEOs visualized foreign acquisitions, joint ventures and/or licensing agreements to obtain further reward from their investments in technology. Several considered they had achieved a size and profitability such that they were beyond the need for capital and most of these felt the major constraints to their growth were in the paucity of suitably skilled labour and inability to arrange for immigration of those with the requisite skills. Others were convinced they had major prospects in export markets, which they were aggressively developing, if only they could obtain better export financing. One of the largest firms, with substantial export aims, found the Ontario government supportive for export loans up to $1 million only, whereas it needed $10 million, a level at which the federal government also balked. Several CEOs were frustrated by the level of assistance available, including from the Export Development Corporation, in view of their understanding of what foreign governments made available to their competitors. Another area several CEOs wished to see developed was export consortiums to tackle large foreign projects, with better risk insurance to help them minimize the necessary contingency fees in bid prices.

Contrast, finally, the problems of expansion and survival of two types of threshold machinery firms, one oriented to volume production, the other to custom work. An executive with a thruster, and one of the largest thresholds, who had considerable foreign experience, outlined his views on his firm's constraints to growth arising from the nature of Canadian financial assistance as follows:

> "We are in a very capital-intensive industry. To be competitive we require high volume production to justify automation, but to get this high volume we must begin with low prices, therefore

we are continually having to invest dollars up front and wait one to two years to see the payback, and even longer on new product development. It is especially difficult for small private companies to finance this type of business. In the US this can be achieved through Municipal Bond Finance at roughly one-half of the market interest rate. Our recent expansion into (an American State) was able to take advantage of this type of debt financing. In (a European country), where service is one of the important criterion for obtaining business with European distributors, we had to erect a warehouse for holding our goods in transit from Canada. . . .we were able to arrange 100 per cent mortgage financing through the (European country) government with deferred principal and interest payments. I can point to other examples of this type of creative financial assistance which allows capital-intensive export companies to survive and expand. By contrast the type of assistance available from the Canadian Federal Government is both limited and negative. We are able to borrow funds through the Federal Business Development Bank at higher than going market interest rates and only as a last resort. Assistance is available from the Department of Regional Economic Expansion, only if we are willing to locate in uneconomic manufacturing areas which would guarantee increased costs of production. Research and development money is available through the Enterprise Development Program, but the company must show financial need. That is, they must be either very small or in very poor financial condition. . . We are not looking for hand-outs, only recognition that exports are a valuable service to the country and justify special treatment to help us remain competitive."[20]

For the custom producer, job-shop-type threshold firm the problem of expansion tends to be of a different order. The CEO of one such threshold, a thruster still relatively small, with five person-years of R&D, 85 per cent exports in 1979, and an entrepreneur with a record of successfully introducing from inhouse skills a significant product innovation in the 1970s, outlined his technology strategy designed to achieve 50 per cent growth by 1985. His firm has generated some momentum, as the impact of R&D investment in its new high-technology products over the past five years begins to catch up. Capital is no longer perceived as a major problem, for this threshold has managed to build a reputation and obtain access to financing from commercial banks at acceptable terms. The firm's production is in the order of 60-70 per cent custom and 30-40 per cent small batch. The CEO feels he cannot abandon the custom work because he needs the dollars to generate turnover in a year, but he has to compete on a price basis with limited margins for this work. Staying in custom work, however, means he cannot break out from dependence

on someone else's ideas. His goal is to achieve 60 per cent output in small batch, by developing products with fewer differences in design, to enable higher product volume. The necessary approach, so he ascertains, is to obtain dominance in a certain product area and modularize and standardize it. Thus the design time and sales effort required to meet individual customer needs can be reduced. By this strategy he hopes to inch his way out of dependence on custom work. The only alternative to this incremental expansion would require making a quantum leap, which would involve having to go public or arrange a takeover, both of which he seeks to avoid.

VI. Three Regional Clusters

Regional Industrial Environments

There are several distinctive regional clusters of threshold firms in Canada as might be expected in a country with widely varied regional industrial environments. The focus of the technology strategies and function of innovation tends to vary significantly between these clusters, moulded in part by the nature of the particular regional industrial environment, as well as by the type of industry.

The size of a firm is one of many determinants affecting the sort of environment to which the firm will respond. In general, the larger a firm the more geographically extensive is the environment it can scan, respond to, and influence. The smaller a firm the more likely it is to lack a permanent scanning capacity and well-developed marketing functions to identify opportunities. Hence the smallest firms tend to be most dependent on their local environment; indeed they "may sometimes exist simply as an expression of a particular regional industrial environment."[1] Yet, by clustering together in a region, SMEs may also achieve the scale and influence of larger firms, particularly if they develop strong associations and constitute a significant element of the regional economy.

The nature of the technology strategy and the type of product innovation of many threshold firms will reflect, possibly strongly so in the smaller ones, their particular regional industrial environment. The regional context affects the ease with which a firm may discover and grasp opportunities. Distance factors are significant constraints to knowledge of opportunities and affect the capacity to respond. How a firm responds, for instance, will depend on the costs, availability, orientation and vitality of regional and local resources,

including business services and the support of universities and government institutions.

The significance of regional conditions in helping to nurture and sustain threshold firms varies not only according to alternative opportunities for the use of scarce resources but also according to the nature of the firm's competitive orientation. Thus some threshold firms, as with most small and medium enterprises, and contrary to some of the expectations noted in Chapter III, tend to complement large firms. Those lacking a distinct technological advantage and the ability to garner substantial resources will rarely be able to survive by competing directly with large firms. Their strengths lie in two types of markets. The first is a market characterized by fragmented and variable demand, in which production may be exposed to frequent and rapid changes, which enable the firm to capitalize on its greater flexibility, perhaps even its greater efficiency, when based on the technology of custom and small batch production. And second is a market that is relatively small or geographically fragmented (sheltered by high transport or communication costs). They may be "allowed" to operate in these two types of markets, insofar as they are of limited interest to the large firm. In such markets the firm operates basically as a subcontractor to other firms in the region, frequently to the large ones.

In several countries, SMEs oriented towards supplying other manufacturing companies with parts, components or machinery generally maintain a stable relationship with their purchasers; as subcontractors they frequently sell the largest parts of their output locally or within their regional environment. Indeed, the less standard the supplies, the greater the sensitivity to distance effects, and the more important is communication about specifications and other features of the products. For instance, Fredriksson and Lindmark[2] in their investigations of purchasing behaviour in local and interregional production systems in Sweden suggest, in an argument reminiscent of the product-cycle model, that the determinants of such systems are to be found more in this interplay between flows of information and material than in the usual emphasis given to transport costs. They argue:

> ". . .the more standardized a product is, the less information may generally be said to be associated with the supply in question. Conversely, the supplies that are customer-specific in one or more respects are often characterized by extensive technical co-operation between the buying and selling firms. This co-operation requires reliable and rapid communication of information, which is at present usually conveyed through personal contacts. These distance-sensitive contacts limit the geographical area in which possible contractors should be located, if placing production with them is to be considered profitable.

"It may therefore be assumed that the production of non-standardized articles is largely placed with subcontractors located in the same geographical area as the buying firm. In the case of even more specific purchases there may be only a few suppliers available so the buyer is forced to look further afield despite this need for close co-operation.

A major actor affecting a firm's national environment is the federal government, and firms will be sensitive to federal government actions such as tax measures, grant schemes, tariff regulations and a whole host of other measures and regulations. The impact of these actions sometimes varies by region, in some cases by intent. Innovation in some firms is particularly attuned to federal actions in areas such as space contracts or defence procurement, where there may be advantages in geographic proximity, although federal evaluation procedures in allocating contracts incorporate the factor of regional industrial benefits. The survival of other firms is wholly dependent on these actions. Smaller firms, unable to afford the costs of maintaining an Ottawa office, may benefit most from locating their production facilities there if they are dependent on certain types of federal government contract work.

A knowledge of the contrasts between groups of threshold firms and their particular contexts may assist, then, in any attempt to deal with the challenge of constructing an industrial policy that is regionally sensitive, contains a specific SME orientation, and seeks to stimulate technological innovation. Consider the situations of three main regional groupings of threshold firms: the auto parts and accessories producers in southwestern Ontario; the Prairie threshold firms, mainly in the machinery and transport equipment sectors; and the electronics and telecommunications threshold firms in the Ottawa Valley.

Threshold Auto Parts Firms in Southwestern Ontario

There were 18 threshold auto parts firms in southwestern Ontario in 1976, nearly all employing between 100 and 500 people, and providing about 6500 jobs, which was nearly 10 per cent of the total for all Canadian threshold firms. Between them they comprised just over one-fifth of Ontario's threshold firms. They constitute a significant though relatively small number of Canada's independent auto parts producers and until recently have competed primarily against US independents for that share of business that the major North American manufacturers are prepared to buy from outside suppliers.

The technology strategies of these thresholds are distinctive. Only one of them reportedly undertook R&D in 1976, and by far the majority still have none. Their innovation lies not in the design of new products so much as their solutions to fulfilling the product requirements specified by other firms, an approach generally leaving

them with no control over their products. They are primarily engaged in relatively short-term product and process development work oriented to putting existing designs into production more cost effectively than their competitors, often drawing upon their own skilled and entrepreneurial tool makers. Most of the firms are not of a size usually able to perform R&D, do not need to perform R&D to fill their existing niches, are not organized in a way to allow the efficient execution of R&D even were they to receive government R&D funding, and are oriented to responding efficiently to a well-defined product need. This means existing government programs for encouraging R&D, which do not provide funds for process and tooling development unless it is related to a unique new product, are of little relevance to them.[3]

Most of these threshold firms capitalize on their proximity to the major Canadian assemblers by adapting quickly to the changing needs of their customers, a short-term preoccupation that often affects their capacity to become price competitive in broader markets as they must spread their tooling costs over lower volumes in the domestic market. Despite this proximity the smaller firms face significant costs if they go after advance knowledge of key decisions being made by their major customers. These decisions on product intentions are traditionally kept close to the vest by the big firms and are centralized usually in Detroit or elsewhere in Michigan. Without the capacity to maintain representation in Detroit to liaise continually with the engineering divisions and purchasing departments of the leading vehicle producers, these firms have difficulty anticipating broader opportunities and influencing the purchasing officers of the major firms. Planning intelligently is very difficult in such circumstances. Another problem confronts the Canadian-owned independent parts producers as a whole but particularly the SMEs. It concerns grievances over being, in their perception, at the mercy of the large firms, receiving unfair treatment and confronting undue prejudice.[4] The majors counter such grievances by referring to any weaknesses of the firms involved, or by providing examples, albeit rare, that despite any problems of visibility and access to purchasing decision makers, firms with good products and reputations can succeed in breaking previous strong ties. Such ties are sustained often by long-term friendships between US independents and the major vehicle firms. In the opinion of some firms, the Canadian product must be better than the competition, not just equally good, to get the business. This tough atmosphere has kept many manufacturers away from Detroit[5]; hence most of these threshold firms follow dependent strategies, building to other's blueprints. They operate predominantly within the confines of their immediate regional environment, constrained by an inability to muster sufficient resources to create products suitable for broader markets.

With the growth of pressures on the vehicle firms arising from new environmental and safety regulations and fuel efficiency needs, the amount that the majors are prepared to purchase from suppliers rather than make inhouse has been increasing. However, the prospects for expansion by most Canadian independent parts producers appear limited; this group is already carrying much of the Canadian value-added requirements set up by the Auto Pact, established in 1965 to integrate the North American automobile industry. Moreover, the North American vehicle firms, to take the pressure off price competition with the Japanese, must seek to out-innovate them. With this task, they have also placed a greater reliance on suppliers to do their own costly development work. So the new opportunities for suppliers have the appearance of being very risky. The majors have chosen in common "to distribute some of their risk (e.g., product development) to their suppliers, by encouraging development of ideas that have unproven market potential."[6] Smaller suppliers do not usually command suitable resources to take on such high-risk development work. Those lacking new technology or unable to upgrade their technological sophistication will face diminished opportunities.

The independent parts producers in Canada and the United States have also come into increasing competition with parts made in other countries, especially from the Third World, a trend which has received stimulus from the pressure on the vehicle producers to switch their plants to smaller vehicles and particularly to the so-called "world cars." The expected trend for world cars is that they will allow for standardized and interchangeable parts, to maximize economies of scale globally, and for assembly in fewer locations in selected industrial countries, leaving much of the component and subassembly work to be farmed out to countries offering cheaper labour costs. Such trends, enabling the large firms to spread investment costs on a more global basis, do not augur well for the survival of those Canadian firms unable to adapt. The Canadian Automotive Parts Manufacturers Association (APMA), concerned about the problems of adapting, alleged recently, in a presentation to the Minister of Economic Development, that:

> "Automotive parts manufacturers in these developing countries have been able to increase their share of the US market as a result of their government's wide range of domestic export incentives and export support programs. The governments of many other producing countries have also implemented a number of export programs aimed at supporting growth in their automotive parts industries. Meanwhile, the potential of the Canadian independent automotive parts industry, with the exception of limited cases, has largely been ignored by the Federal Government. At the same time Canada's traditional parts

market in the United States has been eroded, and within Canada the production-to-consumption gap is growing."[7]

The Canadian auto parts industry, as also the assembly industry, has struggled to survive a number of strains and setbacks and is no longer expected to be a major job creator. However, it will almost certainly continue to be a key sector of employment in southwestern Ontario, provided it can obtain access to the capital and skilled labour needed to maintain and upgrade required product development and production capacity. To revive the auto parts industry in Canada the APMA in 1980 pressed the federal government for an assistance package with three elements: expansion of existing programs for research, design and development in Canada; an interest grant on loans for capital expenditures on new machinery and equipment and new construction; and grants for Canadian automotive parts manufacturers who increase their export sales.

There is a widespread feeling that Canada has not received a fair deal from the 1965 Auto Pact and that the country should take a firmer stand with the major vehicle firms, to influence their purchasing patterns. The Ontario Minister of Industry, for instance, recently argued that:

> "Some decisions affecting the structure and operations of the (auto) industry are not made in a way which benefits Canada. For example, many of the purchasing policies and practices of the major auto makers are – advertently or inadvertently – detrimental to Canadian parts suppliers. Those companies, albeit for valid business reasons, seek large and experienced suppliers – prerequisites that far too often exclude sound, capable but smaller Canadian manufacturers."[8]

In 1980 the Americans agreed to the federal government's request for formal talks to consider Canada supplying a "fair share" of auto production, investment and parts. However, the talks contributed little beyond the airing of grievances and the US still will not accept our notion of "fair share." The safeguards incorporated under the Auto Pact had brought the value of so-called Canadian content to a peak equal to 90 per cent of the value of production in 1972, but the ratio has reverted to between 60 and 70 per cent since then. This has led the Canadian APMA, not surprisingly, to continue pressing for a fairer share of the North American parts market. It has suggested a variety of methods, including elimination of duty-free imports of parts and vehicles from third countries; expansion of third country remission programs, in which overseas manufacturers can reduce the duty they have to pay on vehicles exported to Canada by purchasing Canadian-made parts; and provision of a 10 per cent bonus to vehicle manufacturers on the value-added acquired by purchasing from Canadian auto parts producers, the bonus to be gradually eliminated.

Without renegotiation of the Auto Pact, which is not a strong prospect, the only directions in which the independent auto parts producers in Canada can expand are through exports overseas, and by shifting focus to incorporate an R&D effort. As MacDonald has argued:

> "The Auto Pact asked for vehicle assembly and we got vehicle assembly as the dominant fact of the vehicle manufacturing industry. It encouraged the vehicle manufacturers to secure parts from independent parts manufacturers rather than manufacturing them themselves. . . . It is difficult to perceive what independent parts manufacturers in Canada can do within Canada to improve their position relative to that of the vehicle manufacturers. They have developed an industry which proportionally employs more Canadians than in the United States. . . . Legitimate problems with regard to their capacity to expand in Canada remain because of shortage of financial resources, the availability of lower cost money in the United States, and the cost penalties imposed on production in Canada by government taxes on building materials and non-production equipment."[9]

MacDonald believes the independent auto parts producer wishing to expand must do so in offshore markets, which have been made accessible because of Duty Remission Orders to offshore manufacturers. By his estimate:

> "In the duel between the North American vehicles and off-shore imports, the independent parts manufacturers hold a trump card which the government will wish them to play. If they are successful in their use of the Remission Orders to gain access to Germany, Italy and Japan, there will be some Canadian value added in the imported vehicles which would otherwise be completely absent."[10]

It seems possible, however, that acquiring overseas business may require the parts supplier to establish plants near its overseas clients. Incorporating a suitable R&D effort may prove even more challenging. In its recent report[11] on opportunities for Canadian research and development directed towards the needs of the North American auto market, Arthur D. Little (Ltd) recommended the minimum number of scientific and technical personnel engaged in R&D for effective use of funding is 10, that companies with existing R&D capability are considerably more attractive for funding than those with only product and process development capabilities, and that the recommended minimum number of employees for effective use of R&D funding is roughly 350-400. Few threshold auto parts firms begin to approach such criteria.

One which does, however, warrants mention. It provides an interesting example of how one threshold has broken from the confines of its regional environment. Its technology strategy, sustained de-

velopment effort and overseas exports have contributed to its becoming an outstanding success, to the point indeed that the firm may be close to graduating beyond threshold status. It also provides an unusual example of how a Canadian threshold firm has slowly but successfully tackled the giants head-on, drawing on the technical assistance of another giant and significant government support. The firm is Tridon Limited of Burlington, Ontario, a producer of windshield wipers, turn-signal-flasher units, hose clamps and insert fittings. The firm now has about 600 employees in Canada and as many or more abroad, spread among manufacturing plants in France and the United States (Nashville, Tennessee), and sales-warehouses in Singapore, Australia, Britain, West Germany and Denmark. It is still a private company and its CEO is the single dominant shareholder. It has managed, with the deft use of government assistance, to break out of the stifling confines of its regional context and domestic orientation through the development of its own patented product, an item low in bulk and high in value, which it has succeeded in selling in large volume to domestic and export markets.

The firm, founded in Hamilton in 1923, had for many years specialized in manufacturing metal parts, mainly hose clamps, in large volume for the domestic market. In the mid-1960s, when it was still a small specialist producer, lacking exports and with only one engineer, its CEO decided the domestic market was too small to continue to support the firm with its existing product lines. His choice was whether to diversify by taking on more products or to continue as a specialist and compete in the export market. He chose the latter, and after several tough years of painstakingly building contacts, participating frequently in federally and provincially sponsored trade missions and making slow gains, he finally took the major step in 1973 of purchasing a French hose-clamp producer, which was of similar size to Tridon at that time and had a reputation in Europe for a quality product. He resolved the problem of his banker's balking at the amount he required to borrow to make the French acquisition by astutely switching banks.[12] He then added other company lines for distribution in France, which provided Tridon with the strong base to penetrate more readily the European market. In the late 1960s the CEO had also decided that to achieve long-term growth would require the development and patenting of unique products.[13] The product on which he chose to specialize the firm's efforts was windshield wipers. At that time the production of windshield wipers was dominated by two US manufacturing giants holding a battery of patents which covered the use of metal parts. Tridon's technology strategy involved establishing a major R&D program, built with the strong support of PAIT grants. It sought to avoid infringing the patents held by the two US giants by designing and producing an all-plastic wiper arm and synthetic rubber blade. Its first new wiper

blade was ready in 1970 and was sold in the auto after-market. It took another three years to approach the large vehicle firms to have its product used as original equipment, and two more years, with some successful sales in Europe, before Ford decided to support a test of the plastic wiper blade in its supplier research program. The test results led to considerable changes in physical and material construction, with rigid polyester replacing polycarbonate plastic and the design shifting from a single to a three-piece superstructure, but all of the advantages of the original plastic blade were retained.[14] With further federal assistance, Tridon then managed to capture 50 per cent of Ford's windshield wiper requirements in its second year of becoming a supplier of original equipment to Ford.

Tridon now has about 40 engineers involved in development work and sells three-quarters of its Canadian output to markets around the world. In 1979 it opened a plant in Nashville, Tennessee, which provides a second source of supply, as required from original equipment suppliers to the major vehicle firms, and also offers access to the American market from a location with wage rates about 20 per cent less than in Ontario. The rapid growth in demand for its products recently posed the dilemma of whether to expand with another plant in Tennessee, where the capital costs would also be significantly less for a new plant, in part because the state was prepared to offer financing at rates more attractive than those available in Canada, or to seek a cash grant from Ontario's newly introduced Employment Development Fund to support expansion in Ontario. Tridon took the latter path and with significant provincial funding has recently opened a plant at Oakville.

Access to capital would not appear, however, to be a problem for Tridon. The firm has grown largely through the retention of profits and limitation of dividends. Its profit record has enabled it to attract good financial support in recent years from banks and other lenders. So far it has not needed or chosen to go public to obtain the capital to sustain its appetite for further acquisitions which in 1979 included another French firm, with sales equivalent to about $10-million Canadian, a producer of specialized metal clamps oriented to the aerospace sector. In support of its aim for continuing technical leadership the firm has received PAIT, IRDIA, EDP and IRAP grants, which have enabled it to compete effectively with larger corporations. Regarding the efficacy of the grants, a senior company official comments (letter, 21 January 1982): "the grant programs have been well administered by government officers who, once the company's track record was proven, gave great assistance and encouragement."

The Prairie Threshold Firms

A distinct contrast with the auto parts firms is provided by the nearly one-fifth of Canada's threshold firms based in the Prairie Provinces.

The 30 threshold firms identified there in 1976 were dispersed widely among the five main metropolitan areas as well as a number of smaller towns. The two main groupings of firms, accounting for one-third each, were in the agricultural implement and the truck and trailer body industries (Table VI.1). All but two of the Prairie

Table VI.1 - Prairie Threshold Firms, by Industry and Resource Market Ties, 1976

SIC	Industry	No. of Firms	Firms with Strong Ties to Resource Markets*		Firms Surveyed
			Direct	Indirect	
311	agricultural implements	10	10		7
315	"other" machinery	3	1	2	3
324	truck and trailer	10	1	9	2
325	auto parts, accessories	2		2	1
Other industries		5	3		1
Total		30	15	13	15

* Estimated by author from combination of survey, company reports, trade literature.
Sources: Statistics Canada, and survey by author.

threshold firms appeared to have strong direct and/or indirect ties with the regions' resource base. The direct ties, mainly through markets, are relatively obvious in the cases of the 10 agricultural machinery firms; two fertilizer producers, which not only sell to regional farmers but also depend on regional resource inputs; a firm producing machinery parts for oil and gas drilling; a truck and trailer firm with product lines for the agricultural and energy sectors; and another firm specializing mainly in trucks for rugged off-road areas and sold primarily to the petroleum industry. The indirect ties may be less apparent from the general industrial classifications, but include two so-called auto parts firms whose output goes primarily to agricultural machinery firms; two "other" machinery firms which supply many of the resource industries with customized equipment, parts or machinery; one truck and trailer firm with a wide variety of bulk-handling equipment; and eight producers of trailers and mobile homes, much of whose output is destined for the region's resource-based communities.

A survey of one-half of these Prairie threshold firms provides some further indication of their regional focus and the success with which they fill their particular niches. The survey covers 15 of the threshold firms with strong ties to the regional resource markets.[15] It excludes the fertilizer producers and most trailer and mobile home

manufacturers. Nine of the 15 firms had not achieved minimum threshold size of 100 employees in 1970, and one which started the 1970 decade beyond that minimum was below it in 1980. Two firms had 100-199 employees in 1980, seven had 200-399 employees, and five had over 400. Only one had declined in employment over the decade. Between these firms their total employment, at nearly 4500 in 1980, had more than doubled. The survey reveals that most of these Prairie threshold firms (73 per cent) have carved out moderately or very profitable niches for themselves (Table VI.2). Many (60 per cent) were established on the Prairies more than 2 decades ago (Table VI.3); neither of the two thresholds founded in the past decade was entirely new. Both resulted from the purchase of older firms, one of which was bankrupt and the other close to it. There was a notable tendency for the older firms to be the least comfortable within their niche, in that one-half of the eight firms established prior to 1950 reported they were either unprofitable or in one case only marginally profitable on average over the years 1977-79, whereas all those founded since 1950 considered themselves moderately or very profitable (Table VI.4).

Table VI.2 - Profitability of 15 Prairie Threshold Firms

Average Profitability, 1977-79	No. Firms
Very	2
Moderately	9
Marginally	1
Not	3

Source: Author's survey.

Table VI.3 - Age of 15 Prairie Threshold Firms

Decade Founded	No. Firms
1920-29	3
1930-39	2
1940-49	3
1950-59	1
1960-69	4
1970-79	2

Source: Author's survey.

The extent to which the survey firms have expanded beyond the confines of their regional market is quite varied, with four groups of situations generally discernible. The first group contains two firms without any exports in 1979 and one with virtually no exports. None has foreign branch plants and each is oriented to serving the regional market (Table VI.5). In the second group are four firms

Table VI.4 - Age and Profitability of 15 Prairie Threshold Firms

Date Founded	Profitability on Average, 1977–79	
	Moderately or Very Profitable	Unprofitable or Marginally Profitable
1920–49	4	4
1950–79	7	0

Source: Author's survey.

Table VI.5 - Exports of 15 Prairie Threshold Firms, 1979

% of Total 1979 Sales to Export Markets	Agricultural Machinery	Other Industries
0–5	1	2
6–15	1	3
16–25	0	0
26–49	2	2
50+	3	1

Source: Author's survey.

whose market focus extends beyond the region in a limited way, with exports between 6 and 15 per cent of their total sales. Most have expanded their sales into the neighbouring states of the American northwest, where they have invested in service depots and in several cases in manufacturing branches; some have acquired similar small American firms, rather than spread their focus elsewhere in Canada. However, one of the transport equipment firms has successfully spread across Canada with service outlets and small manufacturing plants and has started building a market in neighbouring American states. The third group, with four firms, has achieved greater and more geographically extensive export penetration. Exports account for one-quarter to one-half of their total sales and, though they are still focused mainly on the American northwest, also extend in several cases to Australia, Europe and sometimes Third World countries, including Mexico and the Middle East. The fourth group, another four firms, has the least ties to the regional market, with exports accounting for more than one-half their total sales. Each of these firms has more than doubled its size in the 1970s and built its export success on narrow product lines, with frequent replacement or upgrading of products within the line and drawing on substantial investment in R&D. Each reported nine or more person-years in R&D in 1980. None of this group has an American branch plant.[16]

To protect and/or expand their niche most of these Prairie threshold firms have significantly increased their R&D investment since 1975. At that time eight firms (53 per cent) invested less than

three person-years in R&D and only one had nine or more person-years (Table VI.6). By 1980 eight firms had nine or more, and the

Table VI.6 - R&D by 15 Prairie Threshold Firms, 1975 and 1980

R&D Employment (Person-Years)	1975	1980
less than 3.0	8	4
3.0–5.5	4	1
6.0–8.5	2	2
9.0+	1	8

Source: 1980 survey.

total person-years of R&D among the firms had increased by over 130 per cent. Those firms with the greatest R&D intensity, measured in terms of R&D person-years per 100 employees, tended also to be the most export-oriented (Table VI.7). Furthermore, the few firms

Table VI.7 - R&D Intensity and Export Orientation of 15 Prairie Threshold Firms

R&D Intensity* 1980	% Total Sales to Export Markets, 1979				
	0–5	6–15	16–25	26–50	51+
less than 1.0	2	1	0	1	0
1.0–1.9	1	1	0	1	0
2.0–3.9	0	1	0	1	1
4.0+	0	1	0	1	3

* Measured in R&D person-years per 100 employees.
Source: 1980 survey.

reporting marginal or no profits were among the least export-oriented. The three reporting they were unprofitable are notable for the emphasis they have each placed recently on a strategy of rapidly building an R&D team.

Canadian Co-operative Implements Ltd, incorporated in 1940 and based in Winnipeg, is one of these laggard firms in search of renewal through a significant shift in technology strategy. It is one of the largest Prairie threshold firms. With increased factory efficiency, it was in 1980 only about three-quarters of its maximum employment size in the 1970s. Owned by close to 100 000 Prairie farmers, and with nine major coops now holding preferred shares, this producer of a diverse range of mainly heavy agricultural equipment ran into major difficulties in the late 1970s. Nearly bankrupt after major losses, it was bailed out by a 1978 $35-million financial package put together by the three Prairie provincial governments, the federal government and the nine coops. The firm has sadly lacked a significant innovative capability and has been focused en-

tirely on serving its regional market. It is now in the process of major restructuring to improve its productivity and tarnished image. It has recently launched a major new technology strategy emphasizing inhouse R&D, with the intent of introducing many new or redesigned products.[17] In the three years after 1978 it introduced 14 new products. It has also expanded its engineering department from six people in late 1978 to 51 in early 1982. With improved productivity and new products, the firm visualizes it will be in a position to enlarge its geographical marketing base, particularly into the neighbouring American Great Plains areas, where the equipment and conditions are most compatible, and also overseas. The new strategy should then enable the firm to benefit from the substantial and coordinated support which the three provincial governments are preparing to offer to Prairie agricultural implement manufacturers to promote export sales.

Since 1978 the firm has made a number of submissions to federal agencies to obtain technological assistance, but to little avail. Invited to assess the efficacy of those federal programs the firm's CEO responded (by letter, 19 January 1982):

> ". . . we could only suggest to you that the major benefit which has allowed us to introduce fourteen new products in three years has been that we have been turned down by the Federal Government in most instances. This has allowed us to proceed ahead with the projects on our own at a more rapid pace and in talking to other industry members who have tried to work with the Federal programs and become completely tangled in red tape, we now feel that the Federal Government has in fact done us a favour by turning down many of our requests."

The growing size of Prairie farm implement firms, including several of the thresholds, has enabled a more sustained export effort in areas beyond the United States, particularly in Australia and in some Third World countries such as Mexico, that are most likely to be receptive to the innovative dry-land farming technology and techniques developed in the Prairies. Enthusiasm for the prospects of serving large Third World markets with this technology, although aroused by the lowering of tariffs by several countries desiring to import superior equipment to that provided by local producers, is tempered by the domestic parts content regulations and transfer of technology requirements prevailing in many such countries. The smaller firms with specialized product lines have greater difficulty in offering a product range of interest to foreign dealers and could benefit from a coordinated provincial and federal effort to support several firms prepared to work together as a consortium to offer such dealers a broader product line to sell.

Two potential benefits of the thrust towards developing a more geographically diversified export market, from the viewpoint of

some agricultural machinery threshold firms, are that it will help level out the inevitable and disruptive hills and valleys of Prairie sales, and reward them more fully for their investment in existing product development. However, export expansion may be limited in geographical extent by the technology of existing products. Further expansion may require additional R&D. Illustrating the point is the situation of another threshold firm, Morris Rod-Weeder Co. Ltd., hereafter referred to as MR-W. This firm, privately owned and employing over 600 people, is based in Yorkton, Saskatchewan. It has one manufacturing plant in North Dakota, another in Minnesota, and is considered the world's largest producer of rod weeders. Its main lines are rod weeders and chisel plows, but it also produces other types of farm implements and, unlike many other farm implement manufacturers, many of its component requirements, including hydraulic control systems. Producing its own components provides it with the dual advantages of incorporating better design and maintaining closer control of component quality.

MR-W has a history of innovation going back to an important 1929 patent and the development of machinery systems supportive of the principals of minimum tillage, the progressive concept which gradually emerged with the growing recognition that traditional farming techniques were not suitable for application in the Prairies and the American Great Plains. Much of MR-W's innovative contribution and substantial R&D investment is focused on the design of equipment that is in accordance with minimum tillage and compatible with the changing capabilities of tractors.

MR-W's founder and CEO, often asked how his privately owned company can compete with the large multinational farm implement corporations, responds: "I always have to ask, how can they keep up with us? We've identified a specific area and we specialize in that area. They're so busy competing with each other trying to cover every market, there's no way they can bother to concentrate on these specific situations."[18] In fact, MR-W benefited during the 1970s when the major manufacturers found they could not profitably compete in all farm implement areas, and their competition diminished as they began to drop their tillage lines to specialize in tractors and other powered equipment.

During the 1970s MR-W, which had already obtained a significant market in the United States, began a more concerted effort to expand its sales to offshore areas, intending to sell at least 25 per cent of production offshore, primarily to countries that have ties to CIDA (the Canadian International Development Agency).[19] However, the firm's main offshore success has so far proved to be in Australia, many of whose farmers have been switching over to the minimum tillage system. Other markets show prospects and the firm's equipment is being tried in experiments in a wide variety of

countries. The expansion into Australia required little or no technical change to the firm's implements, but "as we expand into other areas of the world," the CEO notes, "we have to develop new and different machines. That's what we're doing right now, but it is a slow process."[20] The process requires a careful blending of technology and export marketing strategies in order not to overextend the firm's resources.

Another Prairie threshold firm attempting to overcome disruptive fluctuations in its sales is Canadian Foremost Ltd (CFL) a firm that in 1980 employed nearly 200 people at its three Calgary plants. Although the firm entered business in 1965, its roots go back to a general contracting firm, which in 1952 formed a subsidiary company to develop off-road track vehicles. That company subsequently merged in 1958 with another company producing farm equipment which was then known as Robin-Nodwell Limited.[21] Robin-Nodwell continued to develop additional machines during its early phase, and in 1968 was sold to Canadair Ltd of Montréal. Ultimately, in 1976, Canadian Foremost Ltd acquired all the business assets of the Canadair firm (Canadair-Flextrack Ltd) that related to the vehicle business. CFL, then Foremost Developments Ltd, was established in 1965 when the originator of the tracked vehicles, and his son, the CEO, started a new business in competition with Robin-Nodwell.

CFL now designs and produces off-road vehicles and hydraulically operated oil-field pumps. It went public in 1971 through a reverse takeover, but was not listed on the Toronto Stock Exchange until 1978. It received a substantial infusion of capital from four venture-capital firms in 1973, then avoided a feared takeover in 1978 when its CEO purchased most of the shares held by the venture-capital firms.[22] CFL is now controlled by its management, the CEO being the majority shareholder through a holding company.

In its early years CFL focused on contracts for specialized vehicles to develop the oil fields of northern Alberta. When that market slowed in the late 1960s it looked seriously at the international market and achieved considerable success with its innovative technology. Indeed, it became heavily reliant on export contracts, especially with the Soviet Union, and in the second half of the 1970s about three-quarters of its sales were for export outside North America.

Within its highly specialized niche CFL is a world leader and confronts little global competition. However, it has found its market to be disruptively and unpredictably cyclical. As its contracts are often relatively large and involve unduly long negotiation times, it faces a climate of considerable uncertainty. Spells of boom and bust in sales are reflected in highly variable profitability. As the CEO notes:[23] "Early on, this up and down activity was really very hard on us and we would get ourselves into financial crunches where we would need a major sale to get us out of trouble." Their strategy to

overcome this problem has involved developing a core of key people and subcontracting a major part of their requirements, to provide more flexibility; strengthening their financial position so they have no long-term debt to service; and diversifying, both by extending their line of off-track vehicles and by developing new product lines.[24] Between 1975, its peak in sales, and 1980, CFL spent nearly $2.5 million in R&D, an enormous outlay for a company with about $10 million in assets. It has developed a new line of technologically superior hydraulic oil-field pumping units, designed particularly for heavy-oil operations. The initial units, though much superior technologically to the conventional mechanically driven pumping units, also proved to be much more expensive, particularly because they were not mass produced. CFL has now developed a cheaper version, that will, it hopes, generate a substantial leap in sales in the early 1980s, as well as contribute to greater stability in the balance sheet.

CFL has not sought EDP or other government funds supportive of technological innovation in recent years. Its philosophy has been that the cost of each R&D project should be carried by the company. However, in earlier years it did make use of the federal PAIT and IRDIA programs. Its CEO indicates (letter, 2 February 1982):

> "The PAIT program was undertaken for the development of a tracked log skidder. The unit was developed, but we subsequently made the decision to drop the product because the market was too scattered and too unpredictable, however, the component technology that we gained during this development has been very useful in further improving our other tracked and wheeled vehicles. An IRDIA grant was taken out in conjunction with a provincial grant (from Alberta) for the development of a military high-performance tow truck and recovery vehicle. Two prototypes were developed. At the time, these were considered technically ahead of any world wide competition; however, once again, the markets were too scattered and the Canadian Department of Defence was unable to purchase more than one unit, so this product has not developed an on-going market."

Since 1976 at least three more firms based in the Prairies have achieved threshold status, each growing very rapidly. Friggstad Manufacturing Ltd in the small town of Frontier, Saskatchewan, has quickly followed the path of many other agricultural implement manufacturers; noting the advantage of an American presence, they established a branch plant in neighbouring Montana. The firm's growth at Frontier has been constrained by its ability to attract a labour force from the sparse population in its vicinity. The firm emerged from the winter tinkering of a farmer and his sons in 1969 to produce a longer and stronger cultivator than was available from the major producers.[25] The results proved so suitable for the large grain farms of the region that the firm has been pressed continually

to expand. Its employment has risen steadily to about 130 people in 1980 and 180 in 1981. With the exception of 1977, the firm has managed to achieve average or better profitability, and it exports not only to the United States but also to Australia. It has recently diversified its product line with the introduction of an air seeder, produced to its own design. In the past year it has established a six-person R&D team, to design and develop future products.

The firm has sought little federal innovation assistance, obtaining only a small grant to determine the feasibility of some proposed equipment. It has, however, drawn upon two provincial programs. The first, a grant from the Design Awareness Program involving outside engineering assistance in the design of a new implement, proved unsatisfactory. The second, from which beneficial results are expected, involves aid from the Saskatchewan Research Council using computer-aided design to develop a light duty cultivator.

A second initial success, with faster and greater growth and a similar expansion path into the United States, is that of Dreco Energy Services Ltd, based in Edmonton. Founded in 1972, Dreco had grown to about 250 employees and $19-million sales by 1978. By 1981 its employment had reached 2300, it had nearly 150 people in its design and engineering departments in Edmonton and Houston, and its 1981 sales were over $290 million. The firm has very rapidly achieved the lead in oil-drilling technology in the United States and, with 25 per cent of the global market, held the position of largest manufacturer of drilling-rig masts and structures in the world.[26] The firm's young CEO, a mechanical engineer, pioneered the use of computer-aided design programs to redesign and make engineering improvements to drilling rigs. The results by 1977 were so successful the firm had developed two-thirds of its business overseas. It has quickly captured most of the Canadian market, but concluded that to remain healthy in Canada it would have to sell competitively in the US. It then broke into the tough US market by establishing many small branch plants in Louisiana and Texas, a move designed to ease access, secure cheaper financing through US industrial development revenue bonds on which no income taxes are paid, and obtain the necessary economies of scale to compete in a market considered to be in the order of 10 times the size of the Canadian market.[27] In 1980 Dreco went public with a share offering on the American Stock Exchange. Its directors, who hold over three-quarters of the shares, also moved financial headquarters to the US. There has been speculation of a similar move of corporate headquarters.[28] However, with the sudden downturn of the US market and continuing high interest rates, Dreco's debt burden has proved excessive. Canadian operations are now in receivership, though not liquidation.

The third new Prairie threshold firm, SED Systems, Inc has emerged under more unusual circumstances and with a rather dif-

ferent set of ties to the region. A fast-growing electronics firm, based in Saskatoon and with 1980 sales near $15 million, SED traces its 1965 origins to the space engineering division of the physics department at the University of Saskatchewan. In support of Canada's space program at that time, it received NRC contracts to produce scientific payloads for rockets and balloons. By the late 1960s, when NRC was changing its approach to university financing, its work had developed to the point it was infringing on the private sector; yet it required further expansion to employ fully its inhouse expertise and could no longer depend on federal government contracts to sustain itself.[29] Thus in 1972, when it had 50 employees, SED was incorporated as a private business, owned by the University of Saskatchewan, its founders' intent being to facilitate the flow of technology from university and government to industry, under the constraint of having to make a profit and no longer with the unfair support of the tax-free status accorded to universities.

It has proved sufficiently successful that by 1980 SED had expanded to nearly 300 employees. Unlike many of the other Prairie threshold firms, it has grown through substantial product diversification. It has produced a number of technologically innovative and commercially successful products and has reduced its dependence on government contracts to about one-third of its total sales.[30] In support of its product innovation, it has had small involvement with PAIT and IDAP grants. Its largest government assistance for product innovation has been from the federal Department of Communications (DOC). SED has achieved international prominence for its high technology products in aerospace, communications and specialized electronic instrumentation.

A small part of its business also involves operating as a licensee for federal-government-developed technology. In 1975, SED obtained a contract from the DOC to establish itself as a supplier of microwave components for earth stations used in satellite communication systems. It made use of certain amplifiers developed by DOC engineers, a technology transfer which necessitated some interchange of personnel between the firm and DOC. It is now well poised to take advantage of the fact it is the only commercial producer in the world of earth receiving stations for information transmitted through communication satellites, and its situation has been greatly enhanced by American decisions to deregulate ground stations.[31] The firm's market orientation, although it includes instrument and control products suitable for regional agricultural, petroleum and mining interests, has until recently been predominantly national in scope. The CEO now intends to increase exports.[32] An important step was the 1978 award of a contract from Hughes Aircraft of Los Angeles for design and manufacture of test equipment for communication

satellites. SED has also recently licensed a New York firm to manufacture products using technology developed and patented by SED. By 1981 40 per cent of its total sales were exports.

SED's location is unusual for an electronics and communications firm. It now has several plants and offices scattered around Saskatoon, and maintains an office for marketing liaison in Ottawa. In 1979 the University of Saskatchewan sold part of its interest in the firm, but still maintains 50 per cent of the voting shares. The rest is evenly split between the provincial Crown Investments Corporation and SED's employees. A university spokesperson reveals the sensitivities, concerning the firm's location, of a province desiring to diversify its industrial base and build on high technology. He points out: "We'd have sold it all but we were afraid it would have been moved away from Saskatoon."[33] The firm's regional ties are evidently of a somewhat different order to most other Prairie threshold firms.

The Ottawa Valley Threshold Firms

The threshold firms which have emerged in the Ottawa Valley provide a distinct contrast with most auto parts threshold firms of southwestern Ontario and Prairie threshold firms. They tend to differ with respect to the nature of their regional ties, the scale of innovative effort and path of geographic expansion. They are generally much younger, are more R&D intensive and show a greater propensity for developing European as well as American ties. Some have grown very rapidly. They form an important part of the extraordinary surge of high-technology firms in the region during the past decade. Thus, Ottawa-Carleton, which is the area containing by far the majority of the Ottawa Valley firms, in 1981 had 255 high-technology companies. Most were sales outlets or computer service firms, but there were also 64 firms whose main activity was manufacturing. A survey of 45 of these 64 high-technology manufacturers (70 per cent), covering nearly all the major employers and excluding Crown corporations such as Atomic Energy of Canada, revealed 39 are Canadian-owned and most are small, with single plants.[34] Eight Canadian-owned high-technology firms had 50-99 employees, another nine had 25-49 employees, and 13 had less than 25 employees. Among these 30 smaller Canadian-owned firms 21 were formed after 1970. The growing confidence and air of optimism associated with these firms is reflected in the past and expected pace of growth of many of them. The CEOs of 11 of the 30 smaller, privately-owned local firms, five of them already employing over 50 people, expect to reach threshold status at least by 1985. Seven of the 11 project they will reach 200 or more employees by then.

Of the eight threshold firms based in the Ottawa Valley in 1980, only three were of threshold status in 1976; the other five were too

small at that time. Between the eight they employed about 2500 people in the region in 1980. Several also had branches or associated companies elsewhere in Canada and/or other countries. As with most of the new high-technology manufacturers established in the region since 1970, several of the threshold firms have some roots in either Computing Devices of Canada, an Ottawa firm founded in 1948 and heavily oriented to military projects, which became an American subsidiary in 1969 and which employed about 750 people in Ottawa in 1980; or in the R&D labs of the National Research Council or the Communication Research Centre; or in the Bell Canada, Bell-Northern Research, Northern Telecom group. The 1975 failure of an associate of the latter group, Microsystems International Ltd, which had about 500 employees, also provided a major core of talent to the existing firms. Some of its employees also created new firms in the region.

The Ottawa Valley has provided many advantages to the firms, particularly a supply (now severely limited) of appropriately skilled labour and proximity to a variety of federal government departments, which often are key customers, a stable client enabling some to become more innovative, and/or provide advice and program assistance and/or contribute technical help in product development. Whereas the seeds of this complex of firms were sown during the Second World War expansion of NRC, their flowering has occurred in the past decade. The network of skills, resources and information has now achieved a notable degree of self-reinforcement, attracting other firms to the area and stimulating ambitious and disaffected employees in existing firms to set up a firm themselves. Knowledge is the key to their survival and success. And with a base in the new, mainly electronic, technologies they can usually start up with relatively small capital requirements, drawing upon a newly alert local investment community. The strength of the region has come to lie largely in its extensive knowledge of electronic technologies. And contributing to this strength is the fact that many of those with high skills desire to live in the region, finding it offers an attractive lifestyle.[35]

High-technology firms producing high value and low bulk products are sometimes visualized to be relatively footloose, and many regions desire to attract this type of firm. Although an unusual combination of circumstances has spawned the emergence of many such firms in the Ottawa Valley, once the firms have achieved threshold size we might expect their locational requirements to be quite different. How strong, then, are their ties to the region? Consider the attitudes of senior executives in five of Ottawa's threshold firms towards the ability of various Canadian cities to fulfill their requirements.[36] The executives were asked, "given the current (1981) locational requirements of your firm, how satisfactory would you

expect a location for your company to be in the following major Canadian cities?" They were invited not to interpret this in terms of a branch expansion and were provided with a scale ranging from 1 (very satisfactory), 3 (acceptable), to 5 (unsatisfactory). Four of the five executives ranked Ottawa as very satisfactory. Two also considered Toronto would be very satisfactory, and one of those two executives suggested his firm would be equally well situated in any of six cities among the 11 noted. The executive who rated Ottawa as only satisfactory did not rank any other city higher. These executives evidently felt Ottawa most satisfactorily fulfilled their current requirements, followed usually by Toronto among the cities considered. On the whole most did not view their type of firm to be relatively footloose. In fact, two or more of them rated six of the 11 cities to be less than acceptable for a firm with their locational requirements (Table VI.8). However, attitudes are not immutable and are

Table VI.8 - Ratings of 11 Canadian Cities Regarding Locational Requirements by CEOs of Five Ottawa Threshold Firms, 1981

	Attitude				
	Very Satisfactory		Acceptable		Unsatisfactory
City	1	2	3	4	5
Halifax	0	1	0	1	3
Montréal	0	1	1	2	1
Ottawa	4	1	0	0	0
Toronto	2	2	1	0	0
Hamilton	1	0	3	0	1
Kitchener–Waterloo	1	1	2	1	0
London	0	1	2	1	1
Winnipeg	0	1	1	2	1
Edmonton	0	1	1	2	1
Calgary	0	0	2	1	1
Vancouver	1	1	2	1	0

Source: Derived from questionnaire responses (DeGenova, forthcoming).

not necessarily a significant determinant of ultimate behaviour, and these firms in several cases have branches or subsidiaries already established elsewhere in Canada. Moreover most Ottawa threshold firms have achieved considerable export success and have followed foreign expansion paths. This expansion has taken the route of acquisitions or branch plants both in the United States, often in close proximity to the region in a fashion somewhat similar to the Prairie threshold firms, and in Western Europe.

Although there is a general aura of success associated with the growth of high-technology firms in the Ottawa Valley region, not all the firms, some thresholds among them, are apparent winners. The region has its living dead and walking wounded. One of the larger

thresholds, for instance, had a particularly hard struggle to survive and to find its niche; another has had to trim its sails significantly and shift direction in search of renewed profitability. Consolidated Computer Inc (CCI), founded in 1968 by a Queen's University professor, and originally headquartered in Toronto is one of those firms. CCI, which until recently had over 200 of its 400 or so employees based at its manufacturing facilities in Ottawa, spent much of the 1970s in the red. In the mid-1970s it was subject to an aborted attempt at merger with a Montréal firm. Frequently bailed out with government assistance and in one case saved at the last minute from bankruptcy by a large contract from a British computer firm, CCI became 50 per cent owned by the federal government, 15 per cent by the provincial government (through the Ontario Development Corporation), and 24 per cent by a Japanese firm, Fujitsu Ltd, which in the early 1970s was importing and marketing CCI's key-to-disk systems in Japan. The company's original pioneering work on keyboards and video-display terminals for feeding data to computers was generally very successful, but heavy orders led to cash problems because CCI had decided to lease rather than sell its equipment, had opened more marketing fronts in Canada, the US and Western Europe than it could support, its stock offering had proved unfavourable and the Canadian banks were not prepared to risk further support. The company went into receivership in 1972.[37] The two governments, viewing the firm to be too critical to abandon, then bailed it out. CCI's subsequent efforts, incorporating a very large R&D investment and a narrowing of the scope of interests, did not manage to provide it with more than an occasionally profitable year.

In recent years CCI re-oriented its technology strategy to incorporate greater joint effort. For instance, the company made a technological agreement with Fujitsu, which is the largest Japanese computer firm, to develop small computer systems, designed by Fujitsu, for the North American market. Holdings in CCI represented an opportunity for Fujitsu to expand its small North American base from which to compete with IBM, in its strategy of erecting a circle of consortia around IBM.[38] Fujitsu had acquired shares in CCI in 1976 in exchange for its technological assistance for the development of the key-to-disk data entry systems, which required further engineering work. The federal and provincial governments, which had acquired interests in the firm in 1972 expecting eventually to sell their holdings depending on the company's viability,[39] felt the arrangement with the aggressive and ambitious Fujitsu was a fortunate move in helping keep Canada's largest manufacturer of minicomputer systems afloat and assuring Canada a stake in the computer industry. The move was expected to give CCI access to state-of-the-art hardware technology, and provide Fujitsu with software development for new products.

CCI achieved export competitiveness, but without profitability. About two-thirds of CCI's production was for export by the late 1970s.[40] The company, whose lottery terminals provided the one bright prospect among a series of products many considered outdated, struggled to create a small niche in the highly segmented international computer business. It was the largest of a group of smaller firms competing in that business and specialized in a segment that complements the area dominated by the giant firms.[41] Despite optimistic predictions, it failed to find a suitable niche, even with enormous reliance on government support, as indicated by its $10 million loss on sales of only $22.7 million in 1979, and $13.5 million loss in 1980. It appears now that the firm was never financially viable. The federal government has been challenged for the secret appropriations by civil servants and lack of accountability in propping-up this heavily debt-ridden firm.[42] After accumulating losses of $91 million and further liabilities of $34 million, it has finally found a private-sector buyer for CCI. Thus this case represents a sobering reminder of the inherent difficulties of identifying at the time whether or not performance predictions are wildly optimistic. It reveals rather starkly the "untoward political consequences" arising from the failure of government incentive programs, as noted in Chapter II. Terminating support for a firm may be an even tougher decision for a government than terminating support for a project is for a private sector manager.

Another large Ottawa threshold firm which has had some difficult spells in the 1970s is Leigh Instruments Ltd. Like CCI, Leigh invests heavily in R&D, to the order of 5-7 per cent of sales. Founded in Ottawa in 1961, Leigh had over 400 employees in the Ottawa Valley in 1980 and over 1000 more elsewhere in Canada, the US, Ireland and Britain. Leigh, which went public in 1965, built its reputation by successfully fulfilling a contract, with the support of Defence Industry Productivity Program (DIP) funding, to produce Crash Position Indicators, which are used to locate downed aircraft. Subsequently it substantially diversified its product lines, through in-house developments and a major program of acquisitions, both domestic and in the United States and United Kingdom. It became internationally known for its design, development and manufacture of electronic and electromechanical systems for aircraft, postal automation equipment, traffic control, inspection, packaging, security and communications equipment, and until recently audio components and systems for the home and automobile.

Leigh has successfully penetrated US markets with the assistance in some cases of defence-related programs and through the US-Canada defence-production-sharing arrangement. Although the contract work on which Leigh depended was generally profitable, a series of acquisitions created management problems. The firm rap-

idly achieved product and geographic diversification. However, in the mid-1970s Leigh experienced heavy losses. Its product lines had become too diverse. After 1975 it again briefly achieved profitability, but maintained its reliance on large contracts, many from federal or provincial government departments or Crown corporations as well as from foreign government departments and large multinational firms. Then in 1979, despite a substantial increase in sales, the company again reported a significant net loss. Its problems were primarily related to large Middle Eastern contracts, and in its large industrial products division in Waterloo, Ontario, where the low-technology, high-volume production of audio power products was unprofitable and vulnerable to lower cost imports. Following a revolt by dissident shareholders, Leigh recently acquired new management. It has now discontinued the audio lines, closing plants and leading to a substantial contraction in its employment in Waterloo; the plant there is no longer the largest producer of vehicle audio speakers in North America. Its Waterloo Industrial Products Division is now the main supplier of teleprinters to CNCP. Leigh had also assembled the teleprinters at Syracuse in New York state, supplying that plant with subassemblies from Waterloo. The Syracuse plant is now largely a marketing outlet. Leigh had originally obtained the right to manufacture teleprinters from Northern Electric, which held the licence from Western Electric in the US.

Leigh is reducing the autonomy of its divisions in an attempt to provide a stronger, centralized operation, strengthening its marketing and narrowing its product focus towards emphasizing its profitable high-technology products, aiming at technical superiority in its chosen areas of unique electronic systems. The company has obtained a $10-million loan from a consortium of trust companies to help retire some long-term debt and provide financial stability. It has also broadened its technology strategy, incorporating a joint venture with an Italian company to develop and manufacture radar systems and establishing a 50-50 partnership with Petro-Canada to market electronic systems for oil and gas operations. In addition, the prospect of significant contracts from the new F-18 fighter aircraft program, the acquisition of a contract to design, build and install an air traffic control system at several Canadian defence department locations, and strong potential in several other areas such as vessel-traffic management has led the new management to predict a successful turnaround. The firm managed to achieve a profit in 1981. The CEO hopes soon to raise exports to 70 per cent, 10 per cent higher than the 1980 level, primarily by penetrating Third World markets.[43]

Four of the youngest Ottawa threshold firms, each founded since 1968 and none having reached threshold size by 1976, illustrate elements of the spinoff phenomenon and the varied form and role of early links with government, the heavy emphasis on R&D, the role

of speed in moving from concept and design to manufacture and sale, and the tendency for growth to require exports and lead to early foreign investment. Epitek Electronics Ltd, is the oldest of the four and the one until recently with the least dynamic growth path. Founded in 1969 and employing 150 people in 1981, the company produces thick film microelectronic circuits, miniature components for microcircuits, audio amplifiers and other products. The company has three founders, two of whom are still with the firm. All three were with Bell-Northern Research's thick film hybrid research lab in the mid-1960s. Although their research was successful its future development was uncertain because some fears arose that it would conflict with the development potentials of thin film technology, on which BNR's joint parent, Northern Telecom, was working. Seeing an opportunity, they established Epitek. The early years were rough and the firm proved initially unable to obtain government assistance. However, with the eventual assistance in the early 1970s of Ontario Development Corporation loans to aid expansion, and with NRC grants in support of R&D, Epitek made steady if unspectacular growth through the 1970s. The firm remained almost exclusively a custom service. It focused mainly on small and medium orders, in which it can be more competitive on the basis of personnel ability, rather than the large volumes, where competition is greatest and more dependent on equipment capability.[44] The firm's heavy R&D commitment and design capability has led to the development of a number of new products. It currently has mini-IRAP and DIP grants supporting its efforts at further product innovation.

By 1980 the firm had about 60 per cent of its output destined for export markets in Europe and the United States, and had established a sales office in neighbouring New York State. A joint venture involving a manufacturing plant in Ireland lasted only from 1976 to 1977. Epitek now ranks among the top five or six thick-film hybrid microcircuit and networks manufacturers in North America. Currently it is moving into thin-film hybrids, built to military specifications. With a backlog of orders and the potential to take advantage of increased military applications in the US, Epitek is poised for substantial growth and it has considerably expanded its production facilities. Its management is aiming for a sales increase from $3.2 million in 1980 and $4.8 million in 1981 to $22 million in 1985. The firm, which was privately owned until 1981, has recently negotiated controlling interest in an inactive public holding company based in Toronto, a friendly reverse takeover. To help pay for major expansion it will make a private share offering. It also plans to open a branch plant in 1982 at Ogdensburg in nearby New York State.

With about the same number of employees in 1980 as Epitek, but two years younger and with more than double its total sales at $7.4 million, is Lumonics Inc, an Ottawa threshold firm which de-

signs and produces lasers for industrial and general-purpose markets. In industry its lasers are mainly used to imprint code numbers on packages and products, the chief market being the electronics sector. Its general-purpose markets include government, university and corporate research laboratories. Lumonics is the fifth largest laser manufacturer in the world. It is a world leader in pulsed types of laser, lacks direct competition in its basic product lines, and exports over 90 per cent of its output. Over half its sales are to the US, and nearly a third to Europe and Japan.

The firm's laser technology evolved from military R&D on gas lasers developed by the Defense Research Establishment at Valcartier, Québec. Its three founders, one of them a former vice-president of Computing Devices who heard about the new technology, obtained a manufacturing and sales licence in 1970. With the backing of less than 100 small shareholders the company commenced operations and obtained R&D grants from a variety of NRC and Industry, Trade and Commerce Department programs. They proceeded to develop the technology for commercial uses.

Their major advance came in 1976 with the introduction of a laser system for fine marking of materials and products, a specialized niche defined by their high-energy pulsed dioxide laser. Sales reached $9 million in 1981, maintaining about a 30 per cent annual growth achieved over recent years. Lumonics remained a private company, under the control of the original partners, until 1980, though in the interim it obtained additional working capital by selling a one-third interest to Maclaren Power and Paper Company, which is owned by Noranda Mines Ltd. To help cover debts arising from the firm's 1980 doubling of plant floor area and to help finance development of new products and potential acquisitions, Lumonics went public in 1980. It has been investing in R&D at the rate of 25-50 per cent of annual sales, supplementing the investment of its own revenues in R&D with substantial but progressively smaller federal government grants. Although Lumonics already sells over half its output to the United States and lacks direct competition, it nevertheless feels potentially vulnerable there to "Buy America" laws when domestic companies do emerge, as they inevitably will. Hence its management feels there is no way it can avoid eventually having to manufacture there, although its federal government licence does not currently allow manufacture outside Canada. It has been searching for a way to establish its presence.[45] Interested in joint ventures and acquisitions, it is still in the process of searching for an appropriate choice. As one step it has now arranged to construct a plant in Phoenix, Arizona. An earlier attempt at a "friendly" acquisition of a California firm nearly its own size and with laser technology oriented to science and medical markets complementary to its own was not fulfilled. In 1982 it diversified into solid state lasers by ac-

quiring a 10-year-old British company about half its size. This move will provide Lumonics with access to the largest-selling type of lasers and help introduce its own products into European markets.

Whereas Lumonics was started on the basis of government-developed technology, the next threshold firm was founded as a supplier of technology to government. Gandalf Data Communications Ltd is a year older than Lumonics; it was founded as a two-man partnership in 1970, before incorporation in 1971. The firm's products, the first of which arose from a contract from the Communication Research Centre of the federal Department of Communications, consist of three major lines: limited distance data "modems" (LDS), which enable computers to talk to each other over telephone lines, and for which Bell Canada is a major domestic customer; computer port selection and contention systems, a form of private automatic computer exchange (PACX), the initial one being constructed for McGill University; and, a more recent addition, mobile computer terminals, which have found significant use in computer taxi-dispatching systems. Gandalf has consistently reinvested about 7 per cent of its sales revenues each year. It has used only tax credit programs to support its product development not having been successful in any application for federal product development grants. Its CEO has expressed frustration with the "grant bureaucracy" and exhibited little patience for the time-consuming task of rehashing and regenerating proposals.[46] It has strongly emphasized identifying and responding to customer needs, by creating products that are truly innovative, rather than imitative, in order to stay well ahead of imitators and price competition, and by producing to international standards of reliability and compatibility. From its initial designs, made under contract usually for specific domestic customers, Gandalf has then refined and standardized the products and offered additional features to expand their applications.[47]

Gandalf has proved remarkably successful. By 1981 it had sales of $40 million and employed about 728 people, 420 of whom were in the Ottawa Valley area. Finding it difficult to obtain sufficient skilled workers in Ottawa and with the added impetus of a grant from the Department of Regional Economic Expansion, it recently opened a new plant in neighbouring Hull. It has also taken an aggressive international stance. Gandalf delayed its successful export drive in the United States until 1975, to enable suitable provision of back-up maintenance service and access to spare parts. It chose initially to serve the American market primarily through establishing an associate company in Illinois, licensed to manufacture as well as sell its larger volume items in the US. Subsequently this associate company became a wholly owned subsidiary of Gandalf Technologies Inc, prior to that company selling its stock publicly in December 1981. Gandalf took the same approach in the British market by form-

ing an affiliate licensed to manufacture there in 1977. This company has also subsequently become a wholly owned subsidiary of the public company.[48] This approach, involving the self-financing of the affiliates, has helped to establish credible export marketing and technical support organizations and to reduce the pressure on the Canadian parent's resources which were needed to fund domestic expansion and R&D. Gandalf has retained its R&D functions in Ottawa. It became a public company in 1981 partly to raise the substantial financial resources needed to support major expansion. About 15 per cent of the company is now held by the public, following a $20-million share offering. The two founders retain control, each holding one-third interest.

Gandalf sells about 70 per cent of its products outside Canada and about half its Canadian output is exported. Although the domestic market is barely 3-5 per cent of the combined North American/Western Europe potential total market for such Canadian high-technology products, it nevertheless plays the necessary role of "a nursery from which maturing products emerge onto the international stage." This point is strongly emphasized by Gandalf's chairman, to highlight the critical need for "continuing commitment by private industry and Crown corporations, as well as governments, to buying Canadian technology."[49] Success in the Canadian market alone cannot be expected to generate sufficient revenues to finance the investment needed to bring forward a continuing stream of new high-technology products. And, as Gandalf discovered, for recently founded firms that are relatively small, even becoming a successful exporter may not bring in sufficient revenues at the right time, insofar as the investment for R&D may be needed prior to the receipt of initial revenues, which are frequently tied up in export receivables. Moreover, taxes are based on year of sale, not on receipt of revenues. Smaller Canadian high-technology firms thus have a tougher task in overcoming this problem of funding R&D from internal resources than do equivalent firms based in much larger markets. Gandalf's experience reveals the problem and helps point towards some creative solutions.

The last of these four young Ottawa thresholds, Mitel Corporation, is both the youngest and largest. It is a bright star that many have desired to acquire. In less than a decade, its remarkable performance has not only led it to threshold size but to the strong likelihood of reaching much beyond. Its superb record has rightly led to international acclaim. Mitel has risen from two employees in 1973 to 640 in 1979 and nearly 2500 in 1981, a pace that has also involved a high amount of subcontract work. Its management expects to reach well beyond 2500 employees very shortly, a confidence that does not seem ill-placed. The firm, after small initial teething problems in 1973, has been consistently profitable, its profits being about 13-15

per cent of sales in recent years. It has also managed to double its revenues every year since 1973. Its total sales rose from $43.4 million in 1979-80 to $111.2 million in 1980-81. The firm retains strong ties to its region of origin, but has expanded its sights across the world in various ways and with astonishing rapidity.

Mitel's founders, two British immigrants, left Ottawa's ill-fated Microsystems International Ltd, a producer of general-purpose silicon chips built on purchased technology and owned by Northern Electric Ltd, two years before that firm's demise. Both were disaffected by the direction management was taking. They then boldly proceeded to overcome one challenge after another; beginning with their own $4000, an initial contract from a Canadian subsidiary of a giant British electronics firm, and the subsequent offer of 25 per cent interest to obtain capital from a small group of Ottawa lawyers, (a move enabling them to avoid being at the mercy of bank loan officers).[50] Following a path of careful identification of markets and the special needs of potential clients, the task largely of its engineering and technically oriented sales force, Mitel has generated many innovative products and registered a large number of patents to protect its inventions. And in the process of compiling this remarkable record of growth and innovation it has competed successfully against some of the largest high-technology companies in the world. The two founders credit much of their success to their team approach, a management style involving frequent brainstorming sessions, and their emphasis on speed. They argue that "given enough talent, any engineering team can eventually reach an objective. The trick is to get there first. We know we can run the giants like Northern Telecom Ltd and Western Electric Ltd ragged. They've been brought up in a monopolistic environment, and they've got slack because of lack of competition."[51] Of course, following "Carterphone," the US Supreme Court ruling in 1968 that customers using the telephone system have the right to purchase their own equipment and attach it to the telephone network, a number of small firms have, like Mitel, seized on the opportunity to capture business in the US from the major telephone company suppliers. Mitel stands to make significant gains also from any cracks occurring in the British and Canadian telephone monopolies.

Mitel has produced a steady stream of innovative products, from its early tone generator and tone receiver, to dialed digit displays, tone-to-pulse converters, intercoms, large-scale integrated circuits (LSIs or "chips") and very large-scale integrated circuits (VLSIs); then in 1978, its analog private branch exchange (PBX) switchboards, which come in a variety of lines. The company is now expanding into digital-switching PBXs. In its choice of products it has consciously avoided consumer markets until recently (when the SX-2, or home PBX system was introduced) and has only attempted to enter areas

in which it feels it can do well, filling (until the PBX) perceived gaps in other manufacturers' lines. It has chosen so well it has managed to gain a dominant market share with each product it has introduced.[52]

A key component in Mitel's technology strategy has involved its choice of chips and semiconductor technologies. Early in its development Mitel had decided the best source of custom semiconductor devices would be one where it could control the design.[53] Its subsequent innovative chip design and proprietary semiconductor technology has allowed it to produce special integrated circuits with greater processing speed and lower power consumption. Tying its chip technology development with that of its systems products saved development time, which was an important part of its rationale for entering the highly competitive semiconductor field. It has designed these devices for its particular telecommunications needs and has been able to retain its innovative advantage in part because it has virtually no staff turnover, unlike the situation in the Silicon Valley of California where the major geographic concentration of competitors contributes to constant reshuffling of technical staffs, leading to rapid transfer of key ideas. Mitel also markets about half of its chips to other original equipment manufacturers, the longer production volumes helping to reduce the cost of the chips it needs. However, in 1980 it expanded its semiconductor production capacity, introducing the first of a new range of components, which will help broaden its horizons. And these components, unlike the earlier ones, are not designed primarily to satisfy its inhouse requirements. Its strategy has been to introduce the components singly, to enable high-volume production and obtain learning advantages, to smooth the path for new additions.[54] In its effort to stay ahead in chip technology, Mitel also established a small think-tank group at Lake Tahoe near the California-Nevada border, seeking to draw readily on the expertise in the Silicon Valley area. The experiment did not prove satisfactory and was terminated in 1980.

Mitel's technology strategy involves a highly intensive R&D effort, with some of its R&D expenditures, including about one-third in 1979, funded by the federal government. It spends about 12 per cent of sales on R&D. Recently it has also agreed to the transfer of some of its technology, obtaining additional revenue by entering into licensing agreements. It has made two agreements with a Czechoslovak firm, which will manufacture certain of Mitel's products and have the right to market them outside North America. And in an astute move, subsequently successful, to obtain an important contract with British Telecom in 1980, Mitel signed two licensing agreements to transfer certain of its technology to some British firms.

Mitel's exports have risen dramatically since 1976 when they were less than half a million dollars. They now far exceed domestic

sales. In 1980 the firm made about 20 per cent of its sales in Canada, 70 per cent in the United States and 10 per cent in Europe. It expects major expansion in most of these markets, particularly in Europe where the telephone networks are notably outdated. Competition will be stiff in countries where domestic telecommunications firms are closely allied to state-run post offices.[55]

Nevertheless, Mitel made yet another significant coup in 1981 when, in a most unusual move, the French government gave it permission to set up a wholly owned subsidiary. Previous French policy had insisted on technology transfer via sale or licence to indigenous firms or the setting up of joint ventures. Mitel has also negotiated rights to license some of its technology to a French firm and agreed to establish a large R&D centre in France.

Mitel's foreign markets are increasingly served from its growing network of foreign plants, but in 1980 more than half its manufacturing capacity was still in Canada. Mitel, which owns most of its facilities both at home and abroad, ships kits for automated assembly and testing in many of its foreign plants. About 55 per cent of its work force is still based, however, in Canada. Its headquarters, all of its current R&D and its main manufacturing facilities are in the Ottawa area. Chip production it undertakes at its wholly owned subsidiary, Mitel Semiconductor Inc, in Bromont, Québec. The plant at Bromont was acquired in 1976 from Siltek International, another producer of chips, which had gone bankrupt. Mitel received an IMDE grant from the federal Department of Supply and Services to upgrade the capital equipment at the plant. Also in 1976 it opened manufacturing branches in Shannon, Ireland and Ogdensburg, New York, both offering advantages in lower costs and elimination of duties on products shipped from Canada. By 1980 it was greatly expanding those plants and had added facilities in England, Puerto Rico and Florida and offices in Japan and Hong Kong. In the US it had quickly set up a wide network of sales offices. The firm's geographic strategy has been to secure its markets and satisfy local politics by establishing a strong local manufacturing presence. In 1980 it also showed interest in expanding into the US through acquisition, but reconsidered its attempt to acquire a producer of computer terminals when the New York firm's management became hostile to the offer. Mitel's move was part of a strategy to enter the "office of the future" market, which will involve linking word processors, teletype machines and computers.

To help finance its hectic pace of expansion Mitel went public in 1979. It made a second share offering in 1980 and also arranged for its shares to trade on the London Stock Exchange, a move expected to assist in raising capital in the future. A US listing was made in 1981. Mitel's two founders still control the firm; between them they own just under one-half the shares. Investors in earlier

private stock placements include the Maclaren Power and Paper Co. and a large number of the firm's own employees.

The firm's needs for substantial amounts of capital have also led, reluctantly perhaps, to government sources. Although Mitel's two founders are strong proponents of tax measures to assist the development of Canadian firms, and one of them is on record with a strong antipathy towards grants,[56] the firm has nevertheless become a major recipient of grants and incentives from several federal government programs. Recently it has announced it will open three large plants in economically depressed parts of Canada, one in eastern Ontario and two in New Brunswick, and thereby obtain about $20 million in grants from the federal Department of Regional Economic Expansion. Such investment provides an interesting example of what may be achieved by linking the promotion of high-technology winners with the resolution of employment problems in distressed regions, a strategy of positive adjustment assistance.

In support of its technological advances the firm has benefited from IRAP and EDP grants, and from assistance through several unsolicited proposals to the federal Department of Communications. Mitel was also a major recipient of grants by the federal government to the Canadian electronics industry in 1980, being awarded $21 million from the $50-million program. In return, Mitel has given the government the right of first refusal on its shares, should the firm's founders eventually choose to sell.

Interestingly, the general reaction to the 1980 program by the electronics firms involved has been that the amounts available are pitiful, token gestures, in comparison to the massive investments being made by the governments of other industrial countries. Moreover, few can obtain access to the government funds because they lack the capital necessary to match the government grant. However, among senior executives in the Ottawa threshold firms, views regarding the merits and roles of government involvement remain surprisingly diverse. They range from the abhorrence of intervention expressed by the president of Gandalf, who does not expect handouts from anybody so he may retain his independence, to the satisfaction of several others with the extensive government assistance they have received.[57] Nevertheless, the milieu which has contributed so importantly to spawning and nurturing these firms continues rife with various forms of federal government cooperation and intervention.

VII. Conclusions and Recommendations

Context

Does the threshold group constitute a promising core of innovative firms warranting better assistance by government to accelerate structural adjustment, advance industrial growth and grasp emerging opportunities in the face of intense international competition? In my judgement the answer is a cautious yes on all counts, particularly in light of the apparent inadequacy of macroeconomic policies to achieve a satisfactory climate for development;[1] the need to cultivate skilled entrepreneurship, which is the creative centre of modern capitalism;[2] and the concern that other countries are, covertly if not overtly, strongly sponsoring their promising sectors and firms.[3] Such selectivity is increasingly viewed positively elsewhere, at a time of increasing restraints on government expenditure. It need not be market-distorting or injurious, particularly in a medium-sized country characterized by a series of weakly connected small regional economies. However, the instruments chosen must be judiciously used.

Indeed, selective promotion is warranted when the market fails to support risky innovation and export efforts by technology-intensive SMEs. These SMEs need better access to capital markets. By assisting them governments can look forward in the aggregate to high social rates of return.[4] Moreover, in conjunction with attempts by government to promote firms in cases where private markets have failed (a failure which has to some degree arisen through government actions hostile to risk taking) it may also prove fruitful if they introduce other measures to encourage private delivery systems.

So far, it is primarily via weak support for promising sectors or activities through existing, often ponderous, industrial assistance

programs that Canada has followed any sort of "chosen instrument" or core company policy. Most assistance measures and programs are available to all sectors. Some of the main programs specifically exclude the stronger firms. The rare exceptions have mainly arisen where a private manufacturing firm has become shaped largely by the dictates of government purchasing policy, with the government bearing a high proportion of the risks inherent in the firm's technological development. Emerging international conditions warrant experimenting with different forms of industry-government cooperation, giving greater emphasis to particular industries and giving the private sector more of a say in government programs. Conditions also warrant an industrial-policy framework that provides promising firms with greater flexibility to respond to the constraints and opportunities confronting them.

With the emergence of Japan's wide-ranging capabilities and with NICs, state-trading countries from Eastern Europe and the newly industrializing countries now offering serious price competition in an increasing variety of manufactured goods, Canada, as with other AICs, must resort increasingly to technological excellence to maintain or enhance its competitive position. Canada's technological capacity has become a vital asset whose inhouse development requires substantial promotion to sustain and strengthen our international competitiveness. Fortunately, following a decade in which they rated low priority on the political scene, technological issues, particularly the promotion of R&D, are belatedly receiving more widespread attention.

In response to rapid international developments, the federal and provincial governments are now showing growing recognition of the validity of arguments emphasizing the need for selective and positive adjustment policies. Past industrial policy has been too reactive and excessively preoccupied with depressed industries, just as current economic strategy is too enamoured with natural resource developments. Future industrial policy should do two tasks. First, it should ease the decline of weaker firms in those soft sectors no longer able to withstand international competition. The political choice of propping up such firms over the past two decades has involved substantial budgetary and economic costs, but led to limited revitalizing of the declining sectors. It has also helped ossify the industrial structure and contributed to diverting resources away from those sectors able to compete in the new international environment. The recent establishment of the Canadian Board for Industrial Renewal suggests that politicians may now be resolved to overcome this problem. The board offers the soft sectors a chance to achieve faster internal structural adjustment. The board's members, private-sector dominated, have responsibility for picking winners.

The second task is to build on strengths, particularly to nurture and support those sectors and firms currently or potentially com-

petitive internationally. However, simply supporting promising sectors may not be fruitful in Canadian circumstances, in view of the extent of foreign ownership and the prevailing import/export behaviour of most foreign subsidiaries. Hence the second task primarily involves two elements, enticing the establishment of world product mandates or significant specialized missions by foreign subsidiaries on the one hand, and enhancing the innovative capabilities of indigenous firms in the more technology-intensive sectors on the other. More widespread product mandating by foreign subsidiaries, to the extent it may be induced, may also become associated with, if not deliberately tied to, the development of indigenous firms, including threshold firms. Such development appears to have been stifled until recently by both the crowding out of particular sectors by foreign entrants and the lack of domestic procurement by the traditional branch plant foreign subsidiaries. However, there may be a large zero-sum element involved in measures aimed at supporting world mandating, particularly at a time when capital and skilled labour are in short supply. The more resources required as inducements to foreign-subsidiaries, the less resources are likely to be available to strengthen indigenous enterprises. Some balance between the two must be sought. Of course, the more sanguine one's assessment of the prospects of establishing more world product mandating, or the greater one's concern for the higher risks arising from the associated increased specialization, presumably the more supportive one may be towards focusing efforts on strengthening indigenous firms.

Despite the trend towards repatriating firms, which has been spurred on by various recent government incentives and actions, the stock of indigenous firms is currently all too limited. It seems likely the best and most immediate prospects for increasing Canadian ownership will be through promoting the growth and innovative capabilities of existing indigenous firms, although there may be occasional opportunities to purchase the Canadian subsidiaries of multinationals, as indicated earlier.[5] It is not easy, however, to discern which of these firms are potential winners (except for a few with currently outstanding track records) particularly given the risks inherent in the R&D work on which their future competitiveness is likely heavily, though by no means solely, to depend.

Much attention has been devoted to the very small and large indigenous firms. Several among the small number of large firms have been propped up in recent years or purchased from foreign owners by governments. Some of the state enterprises have achieved outstanding success and others seem poised for it. However, whereas governments have nurtured or assisted in the promotion of a few large winners, including some in the private sector, they have also been castigated for the paucity of their assistance to others, particularly towards the development of the technological and export ca-

pabilities of these firms. Canadian government assistance does not compare well with direct and indirect government assistance available to their competitors abroad. Developing more large Canadian-controlled firms may also be the key to expanding the market potential for small indigenous firms.

Similarly, the lack of a suitable environment to spawn the emergence of many more small, technology-intensive firms has been the focus of much soul searching and widespread discussion this past decade. Although the Canadian record for new technology-based firms may stand well in comparison to the British and West German, it probably still does not bear comparison with the earlier American record. Recently, a number of initiatives have been taken and programs introduced by Canadian governments, the investment community and others. It is still debatable, particularly after the 1981 federal budget and in the general conditions of economic slump, whether prospects and incentives for the creation of new firms and the means to assist their survival through the early stages of development have improved. However, a small wave of exciting new threshold firms is emerging, particularly in the Ottawa area.

Threshold Firms

Less attention has been given to the middle category of firms, the threshold firms. As the successful survivors of the early phases of a firm's development, they comprise a crucial seedbed of innovation with prospects of becoming core indigenous companies. This report shows there is a strikingly small number of threshold firms, probably still fewer than 200. They tend to be found mainly in the machinery and transportation equipment industries, and to a lesser extent in the electrical industries, including electronics, avionics and telecommunications. About one-half of them are in Ontario, a quarter in the West and a fifth in Québec. Their total number did not increase very rapidly in the early and mid-1970s. Among those achieving threshold status more recently, several arose as spin-offs from other threshold or larger domestic manufacturers, which provide an important incubator function.

The surveys and case studies indicate most consider they have recently achieved average or better profitability. And these firms generally constitute a vital and innovative core, a key element contributing to renewal of the country's industrial fabric. Many now have management and inhouse technological capabilities that have placed them among the world's best. In developing those capabilities and as part of their strategies for innovation, over a quarter of them in the mid-1970s, and perhaps most now, maintain an R&D effort. Such effort is often limited by the scale of their resources to lower risk projects intended for direct application. It generally involves some cooperation with other firms and agencies. Surprisingly, few

draw upon the facilities of the NRC, an institution which otherwise has a fine reputation for its industrial assistance programs.

The threshold firms tend to operate within very competitive environments and, according to their CEOs, attain their competitive edge most importantly through inhouse technological developments. Few attempt to compete primarily on the basis of price. Their main competition, at least among the machinery thresholds, is from imports and foreign subsidiaries in Canada. Most are not oriented to competing with the world's giant corporations, but some are. A few of these Davids have shown remarkable ingenuity by not only surviving but coming out winners against the Goliaths. And they have contributed, in the process, to tempering the monopolistic powers of the largest corporations. Others, despite developing suitable products, have lacked the marketing capability and resources to survive a frontal challenge of the giants. It is only rarely they have sown the seeds of their own destruction, insofar as few have achieved growth and profitability only to be taken over by larger and often foreign firms. It is not for the lack of overtures. Frequently the more successful have themselves contributed to their own growth through acquisitions, often of foreign firms. Most remain private. A few are closely held public corporations.

Among the threshold firms surveyed for this study, the majority are oriented to serving industrial markets. They fill, even dominate, specialized niches, some of which are predominantly regionally sheltered. Others are mainly oriented as customized producers or specialist suppliers, sometimes to larger firms within their region. A few customized producers have managed to maintain a high level of exports, usually to the US. However, many threshold firms have captured markets of much wider geographic scope, often based on dominant designs with longer production runs. Indeed the common path to success would seem to require an inhouse RD^2E capability to enable the firm to introduce new or improved products, to compete on the basis of its products' performance and, to reap the rewards of its R&D investment by focusing on exports, in order to reach the scale of production at which it may attain better profitability. However it may cost more to sustain an effective foreign marketing effort than to develop a suitable product. Significant amounts of capital are needed to exploit export opportunities, and younger and faster growing firms frequently are unable to generate sufficient cash flow.

The study establishes and explores links between R&D and exports at the level of the firm. It also shows that when a threshold firm becomes heavily dependent on its export market, or in some cases simply in order to penetrate a major foreign market, it frequently establishes a presence abroad. It usually feels the necessity to secure its foreign market by local production there, whether through acquisition, joint venture, or more commonly by establish-

ing a branch plant. A number of Canada's threshold firms have taken this risky path of international geographic diversification, rather than domestic or product diversification. Often they are driven into doing so at an early stage in the firm's development. Achieving success in the American market appears, in particular, to be a *sine qua non* for survival of many threshold firms at home. Indeed, it seems, as suggested by Niehans' comments with regard to the case of Swiss firms that:

> "Multinationalism helps to equalize the economic opportunities between firms of small and large countries. It is not, as is sometimes argued, a new offensive weapon of large, developed countries to gain economic dominance. It is the traditional defense of small developed countries to preserve economic equality."[6]

Fortunately, the federal government has come to appreciate the pressures for such direct foreign investment, recently changing its directive to the Trade Commissioner Service which had previously discouraged firms from servicing foreign markets through direct investment when promoting exports from Canada.

The performance of many threshold firms should contribute to casting aside any mythology that a Canadian manufacturing firm can only be developed if it can be supported on a domestic base.[7] The high level of exports of some of the more successful threshold firms does not necessarily diminish the significance, however, of working closely with domestic customers. Indeed, for some firms home orders provide a necessary springboard. They are the crucial testing ground for establishing new products, taking them through the initial fluid state and bringing their design to standards that will enable the subsequent capture of export markets. In a number of cases the springboard has been government procurement through key technology development contracts. The path of "homespun growth" may prove a crucial prerequisite to export success. For others, the penetration of foreign markets requires precise market identification, with additional RD^2E work not to stabilize the design but rather to adjust their product lines to suit specific foreign conditions, particularly those in the Third World.

In the propagation of technology, as reflected in industrial R&D, the threshold firms make a relatively modest contribution to the national total. Some firms, particularly the dependent ones playing a satellite role, have maintained their niche so far without performing R&D, though how securely they may continue to do so is open to reasonable doubt. However, a more general trend among the threshold firms surveyed is the substantial intensification of R&D effort. Their technology development and R&D is sometimes offensive, in several cases leading to outstanding success. They usually generate several new products. But most have an important defensive emphasis: they undertake largely incremental innovation and intro-

duce imitative types of new products. A few firms, despite their R&D, still rank among the walking wounded or living dead.

There has been limited success with the government programs aimed at stimulating technological innovation, according to the CEOs. The existing programs are but slightly responsive to the capital needs of many threshold firms, particularly those outside the electronics and telecommunications areas. Notably few threshold firms have made use of the grant and tax mechanisms designed to provide assistance for R&D and technological innovation. A few are simply unaware of what is available, and some indicate they have no desire to obtain "hand-outs." A greater number express frustration with the existing mechanisms. They do not appreciate the complexity of tax incentives, which few even among those eligible have used. And more particularly they dislike both the excessive focus of the EDP program on the financially weak, through its criterion of "significant burden," and its cumbersome operation in conditions where quick reaction is imperative if government funding is to be useful. Several threshold firms have, however, benefited from government procurement contracts and innovation grants, emphasizing their major role in the firm's development of technological and other capabilities.

Backing Threshold Firms

Backing threshold winners involves acceptance of the sort of selectivity now practised in many AICs. It will require new attitudes among senior bureaucrats. The private sector also must take more initiative in identifying where its medium- and long-term interests lie and stress its acceptance of monitoring to ensure its accountability in return for public expenditures towards achievement of such interests. New measures may be necessary, or certainly improvements in delivery of existing ones. This study does not attempt, however, to evaluate the detailed impact on threshold firms of a variety of potential measures. Its primary intent has been to contribute to public awareness and the making of more informed judgements and decisions.

Although the emphasis has been largely on R&D and technology strategies, the promotion of a strong innovative core of firms involves much more than aid for R&D. In a growing company the capital requirements for R&D are usually a small component of the firm's working capital requirements, hence R&D aid at best generally represents only a tiny proportion of the firm's overall capital needs. It is difficult to specify which policy measures should receive priority to strengthen particular types of firms. There are complex interactions and feedbacks between all a firm's functions from research to marketing, and innovation theory is unable to identify a few key global determinants of technological innovation. Freeman,[8] reflect-

ing on the limitations of policy research for the stimulation of industrial innovation, offers the wise, if sobering, reminder that "although we must not expect too much of policy research in the sense of providing unequivocal answers, we should expect it to reduce our ignorance and at least slightly to increase the probability of being able to make good decisions." Others have been struck by the inability of innovation theory to lend credence to specific policy, and by the weak generalizations deriving from conceptually abstract and highly aggregative work on innovation by scholars.[9] The detailed analyses made in this study suggest, however, that policy approaches will need flexibility, to be responsive to differences in circumstances of the various types of threshold firms, including their regional and international dimensions; and speed, to be timely in the provision of assistance *when* it is needed to sustain cash flow and grasp opportunities *while* their windows are still open. Provision of flexibility and speed will require a greater willingness on the part of governments to take risks and to accept some failures as the price of some major successes.

If Canadian governments show resolve to expand our advanced industrial base, they may find the greatest leverage in targeting policies and programs suited to the particular conditions of threshold firms. They may obtain an early reward from a concerted thrust to build on the strengths of this core of innovative Canadian-controlled firms, for such firms have the corporate infrastructure and personnel most suited to take initiatives quickly, given the right circumstances. They will find, however, that the appropriate measures and priorities will differ significantly between the various groups of threshold firms, according to the specific sector and stage of firm development and opportunity, and even to the particular regional situation of a firm. Nevertheless, there may be agreement between threshold firms concerning some key measures to help sustain their development and contribute to their international competitiveness.

It is necessary to anticipate foreign reactions and the international impact of potential measures. Thus one difficulty in designing measures to assist in the innovation and commercialization stages of technological developments is to avoid triggering foreign countervailing measures in response to subsidizing domestic production. Sensitive to this, some governments have created programs whose level of support is far from apparent, and most governments emphasize policies offering support for the earlier stages of innovation, where their efforts, justified on economic grounds, may play a catalytic role, particularly in enticing the investment of private risk capital. The range of practical measures is substantial, however, and governments have certainly not limited their support to those earlier stages. Some, such as training and export incentives, which have received growing attention recently, may have greater impact ulti-

mately on technology development. The priority of government measures may also vary between sectors.

Greater R&D grants, for instance, are likely to have a higher priority and to be of much more assistance to the telecommunications threshold firms than to auto parts threshold firms. The latter will benefit from more competitive loans, assistance through research centres and grants for process and tooling development, domestic content rules for imported vehicles, help towards establishing joint ventures to build on the advanced technology of small foreign firms and towards marketing their products in Detroit or abroad, and aid towards technology surveillance – keeping abreast of product design and material changes by the automobile firms. Similarly, more nationalist procurement policies by governments and Crown corporations, involving sympathetic first customers prepared to pay a premium to develop and sustain indigenous capability in certain higher technology goods, will be of substantial importance to the electronics and avionics thresholds, but have little impact on the agricultural machinery firms. The latter's innovative capacities and overall performance may be sustained by emphasis on increased assistance for overseas market appraisals, foreign testing of equipment, financial backing through CIDA, high-level political promotion, better export financing and creation of consortia for export promotion.

Policies claiming key opportunities from promising major resource projects for Canadian-owned firms, as recommended by the Major Projects Task Force, will benefit some transport equipment and machinery threshold firms. The machinery firms would also benefit from measures strengthening their domestic market potential by allowing more rapid depreciation and a higher tax credit for machinery and equipment made in Canada than for imported machinery, as well as from improved antidumping surveillance and protection. Measures against predatory importing should ensure foreign competitors do not obtain the traditional "one free bite" in large "one-time" machinery projects.

There is a diversity of interests between the threshold firms, yet a strong commonality to their circumstances. Many CEOs noted during interviews that their interests are not well represented and do not necessarily coincide with those espoused by their own sectoral or other business lobbies. Thus the concept of a threshold firm may have some utility, in Canadian circumstances, for science, technology and industrial policy. Mending the rupture in government-business relations will require a concerted effort on both sides. If CEOs of threshold firms can pinpoint how their priorities differ from those of small and large businesses, and why they warrant national promotion, then they may be in a better position to influence public policy decisions, involving whether they succeed or fail. The firms must become better organized and more skillful at employing the

political process.[10] The successful example of CATA (Canadian Advanced Technology Association) provides an indication of what may be achieved.[11] It would be appropriate, therefore, to convene a conference of CEOs of threshold firms, inviting them to explain their perception of emerging domestic and export opportunities and needs, identify their interests, evaluate their priorities for private and public sector action, and consider the costs and benefits of various measures.

I recommend several specific public sector measures for further discussion.

1. Revenue Canada, for tax purposes, and those federal institutions operating industry assistance programs should reconsider their interpretation of what constitutes R&D. The current definition is heavily oriented to scientific research. Its interpretation leaves much room for bureaucratic discretion. According to Revenue Canada, interpretation problems can only be resolved by reference to the facts of each case. However, past interpretation has not readily incorporated the type of exploratory development work, trial production and engineering follow-through (including field and software experiments and shop-floor trial and error that is often undertaken by engineers and technicians, particularly in machinery and transport-equipment firms) that should, legitimately be considered R&D. A broader interpretation would more accurately reflect the spirit of current policy, which aims at increasing R&D in order to strengthen our international competitiveness.

2. The National Research Council should explore ways in which its programs, personnel and facilities may be made more accessible and useful to medium-sized firms, particularly those in the machinery and transport-equipment sectors.

3. The federal government should establish a new position, Foreign Technology Officer (FTO). FTOs might be drawn from NRC's industrial research assistance program and be seconded to the Department of External Affairs. They should be posted in several leading countries and complement the work of the Science Counsellors in existing postings. Their responsibility should be to provide a technology surveillance function, exploring the 99 per cent of newly developed technology (including that from government and university labs) originating outside Canada and identifying those technologies posing opportunities or threats to Canada. They should also respond to specific requests for technological information required by Canadian firms. This may be viewed as both a defensive measure, to assist Canadian firms to keep abreast of foreign initiatives, and an offensive measure, to identify appropriate technology and specify R&D priorities on the basis of prospects for domestic commercial exploitation.

4. The federal government should introduce personal tax measures designed to ease the raising of equity capital by threshold firms. These initiatives should contribute to overcoming the capital problems of threshold firms with prospects of growing very rapidly. Helping to reduce their debt/equity ratio would assist their stability and likelihood of success. It may also help circumvent the problem of new companies which may not have a revenue base sufficient to take advantage of current government incentive programs.

5. In formulating the new Industrial Opportunities Programs, the federal government should relax, if not remove, the "significant burden" criterion present in EDP, at least with respect to technology-intensive SMEs with medium- or long-term innovation projects. This would make the financially stronger thresholds eligible for innovation assistance. Canada could build on firms that already have a strong capacity for innovation and the corporate infrastructure most suited for innovation. The federal government should make a concerted effort to increase the speed and flexibility of delivery, and the preparedness to take risks, and carefully monitor expenditures.

6. The federal government should provide, perhaps through the Industrial Opportunities Program, special funds for technology-intensive SMEs to foster, where suitable, domestic rather than foreign expansion. Such funds should, in effect, counter the incentives to foreign expansion provided by offshore availability of such financial vehicles as special industrial development bonds, which are a form of tax-free financing. The fund's primary aim would be to support expansion in Canada rather than abroad. Almost inevitably a threshold firm will establish a foreign branch plant early in its development to make its presence felt in a major foreign market. This initiative should be aimed primarily at influencing the firm's *subsequent* expansion decisions, to encourage the firm to locate the bulk of new production jobs in Canada.

7. Some provincial governments in the late 1970s detected, and have recently attempted to fill, a void in federal programs responsive to the aspirations and opportunities of technology-intensive SMEs. The federal government should consider the advisability of reasserting its presence and visibility. It should provide an *integrated package of assistance* for such firms, on the premise the whole is greater than the sum of its parts. This will involve bargaining both with firms, in a fashion common in Europe, and provincial governments. There is need to harmonize, and where appropriate rationalize, the provision of financial assistance to technology-intensive SMEs across the country, to avoid undue competition between the provinces in their funding programs, and remove or reduce undesirable inequities in treatment.

8. The federal government should offer to first-time applicants cash and management assistance in the preparation of grant proposals by technology-intensive SMEs.

9. The federal government should consider the rapid introduction of measures to overcome or significantly reduce tax disincentives to exports. In particular, they should review problems associated with the premature recognition for tax purposes of foreign income, and the tax treatment of Canadians employed overseas on marketing and contracts.

10. The federal government should give highest priority to examining the export measures of other AICs. It should ensure export assistance is at least equivalent to that available to SMEs in other leading AICs. In view of Canada's limited industrial export marketing expertise, it may be appropriate to support the development of export diagnosis and export manager for hire programs similar to those available in some European countries.

11. To help overcome problems of small size and high specialization of domestic technology-intensive SMEs, the federal government should offer nonrepayable contributions of up to 75 per cent of consulting, legal and financial costs associated with: a) mergers, acquisitions or joint ventures between two or more domestic technology-intensive SMEs contributing to their greater viability and export capability, and b) acquisitions of, or domestically controlled joint ventures with, foreign SMEs by domestic technology-intensive SMEs, providing such actions may be expected to contribute significantly to strengthening the firm's domestic performance.

12. The federal government should ensure that technology-intensive SMEs are sufficiently aware of government instruments and support mechanisms that could assist their innovation and related activities.

13. The federal department of Supply and Services, in cooperation with its provincial counterparts, should establish an annual competition award scheme which provides recognition, prestige and possibly financial reward, to employees of federal, provincial and municipal governments or crown agencies, for imaginative public procurement ideas that potentially strengthen the innovative capabilities of domestic technology-intensive SMEs.

14. The federal government should facilitate, with suitable urgency, the entrance to Canada of highly skilled persons or those in rare occupational groups when requested for employment by technology-intensive SMEs.

An additional measure that warrants consideration involves our national media. To help raise our sorely needed public awareness of,

and self esteem for, Canadian industrial successes, national media, TV in particular, should provide better coverage, perhaps regular brief reports, on the successes of technology-intensive SMEs.

Probably the best investment Canadians can make in their industrial future is to nurture new threshold firms and to back existing ones. Raising our consciousness of the population and performance of threshold firms will increase our sensitivities to their problems and needs, and enhance the collective will to build on their strengths and potentials. Measures such as these should prove a step in the right direction towards greater regional and national self-fulfillment. They fit well within the principles of positive adjustment. They support the market economy and the open trading system.

Appendices

Appendix A – Questionnaire completed during Telephone Interviews of Threshold Firms that perform R&D

Firm Name _____
Location _____
Respondent _____
Telephone _____

A. *R&D Scale and Focus*

1. How many scientists, engineers and technicians do you currently employ for inhouse R&D, measured in terms of man-years?
   s _____ e _____ t _____
2. How many man-years did you devote to R&D in 1975?
3. How is your R&D expenditure allocated between:
   research _____ % development _____ %
   a) for the research component what % is
      basic _____ % applied _____ %
   b) for the development component what % is for
      1. new products _____ %
      2. improvements/adaptation of existing products _____ %
      3. related activities _____ %
4. Regarding the *new* products, what % are essentially "me too" products? _____
5. Do you prepare a formal R&D budget?
6. What % of your R&D man-years is focused on areas in which you have existing market expertise? _____ %
7. What % of your R&D man-years comprises urgent or high

priority projects?_____ %
medium priority_____%
low priority_____%

8. What are the main sources of the ideas for your R&D projects?
9. What % of your R&D man-years is focused on areas of technology with which you are very familiar _____ %
10. How would you allocate your R&D projects in terms of the risks of not succeeding commercially?
_____ % high _____ % medium
_____ % low
11. What is the level of your R&D spending as a % of your total sales? _____ %

B. *R&D Contact System*

1. Regarding your inhouse R&D, what sort of cooperation do you have with other firms or agencies?
   a) little or none
   b) spontaneous but temporary
   c) systematic and organized
2. Do you make use of external R&D facilities at:

	No	Yes	Frequency in last 2 years
a) provincial government establishments			
b) universities (which?)			
c) NRC			
d) other federal establishments (which?)			
e) contracting engineers, consultants			
f) others (specify)			

3. What % of your R&D do you contract out? _____ %
4. What is the purpose or focus of this external R&D?
_____
5. Have you had difficulties in finding suitable contractors?

C. *R&D Funding and Government Support*

1. What is the source of your R&D funding?
   retained earnings _____
   external private (contract) _____
   provincial government _____
   federal government _____
   other (specify) _____
2. Have the tax incentive measures for R&D in the budgets of the past three years proved of assistance to you?
   No _____ Yes (in what ways?) _____
   How crucial? _____

3. Have you made use of any federal or provincial programs to support your R&D efforts?
   Which ones? _____
   How effective? _____

D. *R&D Evaluation*

1. Did your R&D efforts contribute to the development of any new products during the 1970s? ("new" from a technical and a marketing point of view)
   If so, how many? _____
   For how many of these were you interested and able to achieve patent protection? _____
   And how many proved commercially successful? _____
   What % of your total 1979 sales came from these new products? _____ %
2. How significant do you consider your R&D efforts have been to the survival and success of your firm in the past decade?
   critical 1 2 3 4 5 unimportant
3. Over the next 3 years how do you expect your R&D employment will change?
   _____ % increase/decrease
4. Do you foresee a significant change in role or focus for this R&D? If so, what?
5. Have you found it difficult to attract and to keep R&D personnel?
6. Do you feel the government should introduce additional measures or change existing ones to support your R&D efforts?
   If so, what changes do you recommend?

E. *General Information*

1. What is your total number of employees?
   domestic _____ foreign based _____
2. What was your total in 1975?
3. What employment change do you expect in the next 5 years?
   _____ %
   What is the basis for this expectation?
4. How would you rate the strength of the competition confronting you?
   v. intense 1 2 3 4 5 6 7 insignificant
5. How have you obtained your competitive edge? Most importantly through:
   inhouse technical developments
   your marketing skills
   by licences obtained from outsiders
   other (specify)

6. How would you rate your profit performance 1977-79 in relation to:
   a) your main competitors in Canada:
      above average below
   b) all Canadian manufacturing:
      above average below
      (using your judgement as to what is the most appropriate measure of profit for your type of firm).

Appendix B–Questionnaire completed during Telephone Interviews of Threshold Machinery Firms

Firm Name _____
Location _____
Respondent _____
Telephone _____

A. *R&D, Design and Engineering*

1. Do you undertake inhouse R&D?
   a) If so, how many man-years (scientists, engineers, technicians) do you *currently* devote to this R&D?
   b) How many man-years did you devote to R&D in 1975?
   c) How is your R&D expenditure allocated between:
      Research _____ % and
      Development _____ %
      i) for the research component what % is
         Basic _____ % Applied _____ %
      ii) for the development component what % is for:
         1) new products? _____ %
         2) improvements/adaptations of existing products? _____ %
         3) related activities? _____ %
   d) Regarding the *new products*, what % are essentially "me too" products _____ %
   e) What are the main sources of the ideas for your R&D projects?
   f) Have you taken advantage of tax incentives for R&D investment? _____. If not, why not? _____
      How would you like to see the tax incentives for R&D improved?
2. Do you have inhouse design and engineering capability to produce:

	Yes	No
engineering drawings		
product and equipment specifications		
materials and parts specifications		
production procedures		
quality control procedures		

3. What % of your total sales are accounted for by products of:
   your own design _____ %
   designs mainly specified by customers _____ %
   other sources, e.g. licensors _____ %

4. Do you make use of external R&D or design facilities at:

	No	Yes	Frequency in Past 2 Years
a) provincial government establishments			
b) universities (which?)			
c) NRC			
d) other federal establishments (which?)			
e) contracting engineers, consultants			
f) others			

If so, what is the purpose of this external R&D?

B. *Innovation and New Products*

5. Have you made use in the 1970s of any federal or provincial programs to support your efforts in product innovation?
   a) Which ones? When?
   b) How vital were they to the development of your firm?
   c) How could the programs be improved to suit your specific needs?
6. During the 1970s, did you produce any new products (new both from a marketing and technical point of view)?
   a) If so, how many? _____
   b) For how many of these were you interested and able to achieve patent protection? _____
   c) How many have proved commercially successful? _____
   d) What per % of your total sales are now accounted for by such new products? _____ %
      What % are exported? _____ %
   e) Would you please name and briefly describe your *main* new product innovation: _____
   f) What is unique or different about this innovation?
   g) When did *you* first commercially launch this product? _____

C. *Markets and Competition*

7. What % of your total sales are to export markets? _____ %
   a) How has this changed in the past 5 years? _____ %
   b) Are you actively seeking export market opportunities?
      In the US? _____
      Where else? _____

8. Regarding your domestic sales, do you sell across the country?

   _____

   Are more than 50 per cent domestic sales local? _____
   Which domestic sector comprises your main home market?

   _____

   Is government purchasing currently/potentially vital to you?

   _____

9. What are your key sources of competition?
   a) i) imports: _____ US _____ Europe
   _____ Japan _____ Other
   ii) domestic firms: _____ Canadian-owned
   _____ Foreign subsidiaries
   b) How many firms constitute your key competition?
   c) How would you rate the intensity of the competition?
10. Regarding your competitive edge, which is the most important:
    product performance (technology), marketing, price, production capability, or some other factor?
    a) why is this?
    b) which rates second in importance?

D. *General Information*

11. Regarding your number of employees
    a) what is your current total?
    _____ domestic _____ foreign based
    b) what was your 1975 total?
    c) what is the growth you aim for by 1985?
    d) what are the main *constraints* to the growth of your firm?
12. Do you have some general long-term corporate goals?
    If so, would you describe them briefly? (sales, exports, specialization/diversification, R&D, plant expansion).
    How do you intend/expect to achieve them?
13. Is your firm controlled by another firm?
    If so, what is the name and country of origin of the controlling firm? _____

    _____

    Do you operate as a separate profit centre?
14. What % of your production
    is custom/job _____ %
    small batch _____ % large batch _____ %
    mass production _____ %
15. How would you rate your profit performance for 1977-79 in relation to:
    a) your main domestic competitors:
    above average below
    b) all Canadian manufacturing
    above average below
    (using your judgement as to what is the most appropriate measure of profit for your type of firm).

Notes

I. Towards Backing Winners

1. Seizing the major industrial benefits within Canada from the mega-energy and transport projects of the next two decades is perhaps too widely considered to offer the most significant prospect for revitalizing the Canadian economy.

2. See the Minutes of Proceedings and Evidence of the Sub-Committee on *Import Policy*, Standing Committee on Finance, Trade and Economic Affairs, Issue No. 19, House of Commons, Ottawa, 2 November 1981.

3. Canada, Department of Regional Economic Expansion, *Single-Industry Communities*, DREE, Occasional Paper, Ottawa, n.d.; J.V. Marshall, "Industrial Diversification in the Canadian Urban System," *The Canadian Geographer*, 1981, vol. 25, no. 4, pp. 316-32.

4. Foreign ownership, its role still subject to widespread debate, has diminished in the 1970s. Growing federal and provincial intervention has strengthened the indigenous "bourgeoisie," according to J. Niosi, *Canadian Capitalism: A Study of Power in the Canadian Business Establishment*, James Lorimer, Toronto, 1981.

5. See M. Jenkin, "The Prospects for a New National Policy," *Journal of Canadian Studies*, 1979, vol. 14, no. 3, pp. 126-41; D. Brown and J. Eastman, *The Limits of Consultation*, Science Council of Canada, Discussion Paper D81/1, Supply and Services Canada, Ottawa, 1981; and J. Gillies, *Where Business Fails*, The Institute for Research on Public Policy, Montréal, 1981.

6. The concept of "corporatism" has become fashionable. It has gained a wide variety of meanings – see J.T. Winkler, "Corporatism," *European Journal of Sociology*, 1976, vol. 17, no. 1, p. 101. It is used here to refer to the increase in direction, though not necessarily control, by the modern state, including through microeconomic intervention, and the tendency of the modern state to share its own traditional sector of decision making with private interest groups, operating as a bargaining agent rather than through coercion – see A.W.J. Thomson, "Trade Unions and the Corporate State in Britain," *Industrial and Labour Relations Review*, 1979, vol. 33, no. 1, pp. 36-54. In Europe corporatism has led in some cases to forms of tripartite economic consultation. In Canada, by contrast, the strength of geographic forces has become such that, some argue, we have developed a kind of "territorial corporatism" conducted through relations between governments rather than the familiar European corporatism – see D.J. Elkins and R. Simeon, *Small Worlds*, Methuen, Toronto, 1980, pp. 297-98. Moreover, the term has evoked unpleasant connotations and initial attempts at tripartism were stillborn. They were hindered by attitudinal and institutional barriers, including the structural fragmentation of Canadian institutions and particularly the structural disjunction of the Canadian labour movement – see Ed Finn, "Tripartite consultation at the national level," *The Labour Gazette*, February/March 1978, pp. 65-70. However, there are some signs of further attempts at the federal level to overcome such barriers, to establish some form of tripartite consultation and collaboration in the shaping of industrial policy; and at the provincial level Québec, with its mini-summits, has led the way. For a recent critique of "corporatism," including arguments that advanced capitalism requires corporatism as its defensive shell, see A. Cox, "Corporatism as Reductionism: the Analytic Limits of the

Corporatist Thesis," *Government and Opposition*, 1981, vol. 16, no. 1, pp. 78-95. For some discussion of the complexities and problems of business-government relations in Canada, and particularly of the internal divisions and conflicts of interest that haunt business at the general, sector and industry levels, see D.H. Thain and M. Baetz, "Increasing Trouble Ahead for Business-Government Relations in Canada?" *The Business Quarterly*, 1979, vol. 44, no. 2, pp. 56-65.

7. L.C. Thurow, "The Productivity Problem," in *Policies for Stagflation*, vol. 2, Ontario Economic Council, Toronto, 1981, pp. 11-34.

8. See Emile van Lennep, "Breaking Out of a Vicious Circle," OECD, May 1981, vol. 100, pp. 15-17.

9. A more detailed definition of threshold firms is provided in Chapter III.

10. See H. Gray, "Economic Nationalism and Industrial Strategies," notes for an address at the École des Hautes Études Commerciales, 3 June 1980. The federal government appears to have chosen to delay introducing new measures, perhaps in response to threats by the Americans of countervailing measures in response to the program of Canadianization of the energy sector.

11. See P. Bourgault and H. Crookell, "Commercial Innovation in Secondary Industry," *Business Quarterly*, 1979, vol. 44, no. 3, pp. 56-65; and F. Lazar, *The New Protectionism,* Canadian Institute for Economic Policy, Ottawa, 1981.

12. For some examples from Japan, France and West Germany, see Fred Harrison, "Chosen Instruments of Public Policy," *The Financial Post*, Toronto, 18 July 1981, pp. 1-2. In 1981 a commitee of Dutch industrialists, led by the chairman of Royal Dutch/Shell and backed by the labour unions, submitted an influential report favouring a philosophy of "picking winners." See *The Economist*, 30 January 1982, p. 13 (Holland Survey).

13. J.N.H. Britton and J.G. Gilmour, *The Weakest Link: A Technological Perspective on Canadian Industrial Underdeveloment*, Science Council of Canada, Background Study 43, Supply and Services Canada, Ottawa, 1978. These strategies are discussed in Chapter III of this study. There are somewhere from 45 to 70 indigenous firms with sales over $250 million, which should enable them to maintain an effective innovative performance.

14. J.J. Shepherd, *The Transition to Reality,* Canadian Institute for Economic Policy, Ottawa, 1980, pp. 23-24; and Science Council of Canada, *Forging the Links: A Technology Policy for Canada*, Report 29, Supply and Services Canada, Ottawa, 1979.

15. See S. Ostry, "Government Intervention: Canada and the United States Compared," *Policy Options*, 1980, vol. 1, no. 1, pp. 26-31, for some thoughtful observations on contrasting national bases for intervention. There is a growing chorus even in the United States towards support for an interventionist industrial policy as that nation begins to lose its economic innocence – see R.B. Reich, "Why the US needs an industrial policy," *Harvard Business Review*, 1982, vol. 60, no. 1, pp. 74-81; and R.E. Müller and D.H. Moore, "America's Blind Spot: Industrial Policy," *Challenge*, 1982, vol. 24, no. 6, pp. 5-13.

16. Shepherd, *op. cit.* Also see Gillies, *op. cit.*, regarding private sector responsibilities; and R.E. Ross and P.M. Banting, "Improving Canada's global competitiveness," *Business Quarterly*, 1981, vol. 46, no. 3, p. 44.

17. Quoted in *The Financial Post*, Toronto, 27 December 1980.

18. L. Grossman, Minister of Industry and Tourism, Ontario, "Statement to the Legislature on the Ontario Business Buy-Back Program," 17 June 1980, Release from the Ministry of Industry and Tourism, Toronto.

19. L. Grossman, *Interprovincial Economic Cooperation*, Ontario Ministry of Industry and Tourism, Toronto, 1981.

20. L. Grossman, "Redefining Government's Role in Our Economic Future," *Business Quarterly*, 1979, vol. 44, no. 2, p. 83.

21. For one attempt to redress the imbalance, this time looking at four winners among our foreign subsidiaries, see Science Council of Canada, *Multinationals and Industrial Strategy: The Role of World Product Mandates*, Working Group on Industrial Policies, Supply and Services Canada, Ottawa, 1980.

22. See Pat Johnston, "Invisible stars: Canadian high technology companies," *In Search*, 1980, vol. 7, no. 4, pp. 12, 14, 16, for comments on the apparent ignorance. The newly appointed president of A.D. Little Canada Ltd also notes there are all kinds of success stories people know nothing about. See *The Financial Post*, Toronto, 7 November 1981.

23. See Canada, Export Promotion Review Committee, R. Hatch, *Strengthening Canada Abroad*, Department of Industry, Trade and Commerce, Ottawa, 1979; B.W. Wilkinson, *Canada's Trade Options*, The Ryerson Lecture in Economics, Ryerson, Toronto, 1978; H.L. Robinson, *Canada's Crippled Dollar*, James Lorimer, Toronto, 1980; and Science Council of Canada *Hard Times, Hard Choices*, Industrial Policies Committee, Supply and Services Canada, Ottawa, 1981. This thrust runs counter to the current federal priority to strengthen our trade position and develop an economic strategy based very heavily on building megaresource projects.

24. See P. Caldwell, "U.S. Becoming Economic Colony for Failing to Meet World Challenges," *The Financier*, February 1979, p. 21; S. Lall, "Offshore Assembly in Developing Countries," *National Westminster Bank Quarterly Review*, August 1980, pp. 14-23; R.A. Matthews, *Canadian Industry and the Challenge of Low Cost Imports*, Economic Council of Canada, Discussion Paper No. 172, Ottawa, 1980; and L. Kim, "Stages of Development of Industrial Technology in a Developing Country," *Research Policy*, 1980, vol. 9, no. 3, pp. 254-277.

25. See OECD, *The Impact of the Newly Industrializing Countries on Production and Trade in Manufacturers*, OECD, Paris, 1979.

26. See J.H. Dunning and P.J. Buckley, "International Production and Alternative Models of Trade," *The Manchester School*, December 1977, vol. 45, no. 4, pp. 392-403; W. Walker, *Industrial Innovation and International Trading Performance*, JAI Press, Greenwhich, Connecticut, 1979; K. Pavitt, "Technical Innovation and Industrial Development," *Futures*, December 1979, vol. 11, no. 6, pp. 458-470; and Statistics Canada, *Canadian Imports by Domestic and Foreign-Controlled Enterprises, 1979*, cat. no. 67-509, Ottawa, 1981.

27. See OECD, *Policies for the Stimulation of Industrial Innovation*, OECD, Paris, 1978; and J.J. Shepherd, *op. cit.* The Swedish approach is outlined in A. Elzinga, "Science Policy in Sweden – Sectorization and Adjustment to Crisis," *Research Policy*, 1980, vol. 9, pp. 116-146.

28. See H. Crookell and I. Graham, "International Marketing and Canadian Industrial Strategy," *Business Quarterly*, 1979, vol. 44, pp. 28-34; H. Crookell and J. Caliendo, "International Competitiveness and the Structure of Secondary Industry in Canada," *Business Quarterly*, 1980, vol. 45, pp. 58-64; Science Council of Canada, *Multinationals and Industrial Strategy: The Role of World Product Mandates*, Working Group on Industrial Policies, Supply and Services Canada, Ottawa, 1980; and N.W. McGuiness and B. Little, "The Impact of R&D Spending on the Foreign Sales of New Canadian Industrial Products," *Research Policy*, 1981, vol. 10, no. 1, pp. 78-98.

29. R. Vernon and W.H. Davidson, "Foreign Production of Technology-Intensive Products by U.S.-based Multinational Enterprises," Report to the

National Science Foundation, Boston, 1979; R.L. Perry, "Galt Revisited," *The Financial Post*, Toronto, 18 and 25 August, and 1, 8, 15 and 22 September 1979; and W.H. Davidson, "Trends in the Transfer of US Technology to Canada," *The Adoption of Foreign Technology by Canadian Industry*, Proceedings P81/2, Science Council of Canada, Ottawa, 1981, pp. 9-38.

30. See D.P. De Melto, K.E. McMullen and R.M. Mills, *Innovation and Technological Change in Five Canadian Industries: Preliminary Report*, Economic Council of Canada, Discussion Paper No. 176, Ottawa, 1980; and L.K. Lodge (chairman), *The Report of the Advisory Committee on Global Product Mandating*, prepared for the Ontario Ministry of Industry and Tourism, Toronto, 1980. For a rationale, based on internalization theory, as to why we should expect little R&D in Canada by foreign subsidiaries, see A.M. Rugman, "Research and Development by Multinational and Domestic Firms in Canada," *Canadian Public Policy*, 1981, vol. 7, no. 4, pp. 604-616.

31. See H.-J. Ewers and R.W. Wettmann, "Innovation-oriented Regional Policy," *Regional Studies*, 1980, vol. 14, pp. 161-179; and R.P. Oakey, "Technological Change and Regional Development," *Area*, 1979, vol. 11, pp. 340-344. National regional policies tend to be least effective in a period of economic recession, thereby placing greater responsibility for regional growth on firms already in the distressed regions.

32. See J. Maxwell and C. Pestieau, *Economic Realities of Contemporary Confederation*, C.D. Howe Research Institute, Montréal, 1980.

33. R. Rothwell and W. Zegveld, *Industrial Innovation and Public Policy*, Francis Pinter, London, 1981.

34. Perhaps the major reversal has occurred in France. In the years immediately prior to a 1979 restructuring, two-thirds of innovation aid went to 10 large groups of firms. In 1980 two-thirds was distributed to 1500 SMEs. See T. Gaudin, "The Development of the French Innovation Policy," in G.F. Stuart and V. Kuntze, eds., *National Innovation Policies – The Challenges in Loooking Ahead*, Karlsruhe, The Six Countries Programme on Aspects of Government Policies Towards Technological Innovation in Industry, February 1982, pp. 67-68.

II. Innovation, Intervention and Indigenous Firms

1. See M. Gibbons and K. Littler, "The Development of an Innovation: The Case of Porvair," *Research Policy*, 1979, vol. 8, pp. 2-25. For indication of the wide range of literature available on the topic, see T.E. Clarke, *R&D Management Bibliography – 1981*, Stargate Consultants Ltd, Ottawa, 1981.

2. See, for instance, K. Pavitt, ed., *Technical Innovation and British Economic Performance*, Macmillan, London, 1980. In Canada there are indications that whereas foreign-owned firms tend to rely on their parent firms for innovative ideas, Canadian-owned firms tend to rely on their customers and suppliers. See D. De Melto, K.E. McMullen and R.M. Mills, *Innovation and Technological Change in Five Canadian Industries: Preliminary Report*, Economic Council of Canada, Discussion Paper No. 176, Ottawa, 1980.

3. *The Economist*, London, 10 November 1979.

4. See R. Rothwell et al., "SAPPHO updated – project SAPPHO phase II," *Research Policy*, 1974, vol. 3, pp. 258-291; R. Rothwell, "The Characteristics of Successful Innovators and Technically Progressive Firms," *R and D Management*, 1977, vol. 7, pp. 191-206; and R.G. Cooper, "The myth of the better mousetrap: what makes a new product a success?" *Business Quarterly*, vol. 46, no. 1, 1981 pp. 69-81.

5. N. Rosenberg, *An Assessment of Approaches to the Study of Factors Affecting Economic Payoffs from Technological Innovation: A State of the*

Art Study, vol. 1, report prepared for the National Science Foundation, US Department of Commerce, National Technical Information Service, Washington, D.C., 1975, PB 245-905; and R. Rothwell et al., "Some Methodological Aspects of Innovation Research," *Omega*, 1977, vol. 5, pp. 415-424. The role of incremental improvements is well outlined by S. Hollander, *The Sources of Increased Efficiency: A Study of Dupont's Rayon Plants*, MIT Press, Cambridge, Mass., 1965.

6. S. Dollond, "Factors Affecting Industrial Innovation in the United Kingdom," *Planned Innovation*, 1979, vol. 2, pp. 351-354.

7. Rothwell et al., "Some Methodological Aspects of Innovation Research," *Omega*, 1977, vol. 5, pp. 415-425.

8. M.A. Maidique, "Entrepreneurs, Champions and Technological Innovation," *Sloan Management Review*, 1980, vol. 21, pp. 59-76.

9. J.M. Utterback and W.J. Abernathy, "A Dynamic Model of Product and Process Innovation," *Omega*, 1975, vol. 3, pp. 639-656.

10. Rothwell and Zegveld, *Industrial Innovation and Public Policy*, Francis Pinter, London, 1981.

11. J.M. Utterback, "The Dynamics of Production and Process Innovation in Industry," in *Technological Innovation for a Dynamic Economy*, eds. G. T. Hill and J. M. Utterback, Pergamon Press, New York, 1979, pp. 40-68.

12. R. Rothwell and A.B. Robertson, "The Role of Communications in Technological Innovation," *Research Policy*, 1973, vol. 2, pp. 204-225.

13. This point is made in Sir Montague Finniston (chairman), *Engineering Our Future*, report of the Committee of Inquiry into the Engineering Profession, Cmnd 7794, Her Majesty's Stationery Office, London, 1980. See also W.E. Souder, "Promoting an Effective R&D/Marketing Interface," *Research Management*, 1980, vol. 23, no. 4, pp. 10-15.

14. C. Freeman, "The Determinants of Innovation," *Futures*, 1979, vol. 11, pp. 206-215.

15. Jacob Schmookler, *Invention and Economic Growth*, Harvard University Press, Cambridge, Mass., 1966.

16. L. Langrish, M. Gibbons and W.C. Evans, *Wealth from Knowledge*, Macmillan, London, 1972.

17. S. Myers and D.G. Marquis, *Successful Industrial Innovations*, National Science Foundation, Washington, 1969, NSF 69-71.

18. See D. Mowery and N. Rosenberg, "The Influence of Market Demand Upon Innovation: A Critical Review of Some Recent Empirical Studies," *Research Policy*, 1979, vol. 8, pp. 102-153; and K. Pavitt, ed., *Technical Innovation and British Economic Performance*, Macmillan, London, 1980.

19. ASTEC (Australian Science and Technology Council), *Industrial Innovation*, Australian Government Publishing Service, Canberra, 1979.

20. J.H. Hollomon et al., "Government and the Innovation Process," *Technology Review*, 1979, vol. 81, no. 6, pp. 30-41.

21. SPRU-TNO, "The Current International Economic Climate and Policies for Technical Innovation," Report to the Six Countries Programme of Innovation, TNO, Delft, Netherlands, 1977.

22. Rothwell and Zegveld, *op. cit.*, p. 81.

23. T.J. Allen et al., "Government Influence on the Process of Innovation in Europe and Japan," *Research Policy*, 1978, vol. 7, pp. 124-149.

24. A.H. Rubinstein et al., "Management Perceptions of Government Incentives to Technological Innovation in England, France, West Germany and Japan," *Research Policy*, 1977, vol. 6, pp. 324-357.

25. *Ibid.*, p. 36.

26. See F.M. Scherer, *Industrial Structure and Market Performance*, Rand McNally, Chicago, 1971; E. Mansfield, "Size of Firm, Market Structure

and Innovation," *Journal of Political Economy*, 1973, vol. 71; and C. Freeman, *The Economics of Industrial Innovation*, Penguin, Middlesex, 1974.

27. National Science Foundation, *Indicators of International Trends in Technological Innovation*, NSF-C889, Washington, DC, 1976.

28. See K. Pavitt and W. Walker, "Government Policies Towards Industrial Innovation: A Review," *Research Policy*, 1976, vol. 5, pp. 11-97; R. Rothwell, "Small and Medium Sized Manufacturing Firms and Technological Innovation," *Management Decision*, 1978, vol. 16, no. 6, pp. 362-370; and Office of Federal Procurement Policy, *Small Firms and Federal Research and Development*, Office of Management and Budget, Washington, DC, 1977.

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

30. D.K. Birch, *The Job Generation Process*, MIT, Cambridge, Mass., 1979.

31. S. Fothergill and G. Gudgin, *The Job Generation Process in Britain*, Centre for Environmental Studies, Research Series 32, London, 1979.

32. See A. Osborne, *Running Wild*, McGraw Hill, Berkeley, 1979. Among these factors have been the size of the American market, the attitudes of scientists and the public at large in supporting entrepreneurship, the ease of mobility between universities and industry and the supportive government procurement programs.

33. Arthur D. Little, Ltd, *New Technology-Based Firms in the United Kingdom and the Federal Republic of Germany*, Anglo-German Foundation for the Study of Industrial Society, London, 1977.

34. See *The Economist*, London, 11 July 1981.

35. See R. Rothwell and W. Zegveld, "Government Schemes to Assist Innovation in Small- and Medium-Sized Manufacturing Enterprises," *Management Decision*, 1980, vol. 16.

36. R. Rothwell and W. Zegveld, *Industrial Innovation and Public Policy*, Pinter, London, 1981.

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38. An exception, the classic article on the relationship between strategy and technology, is H.I. Ansoff and J.M. Stewart, "Strategies for a Technology-based Business," *Harvard Business Review*, 1967, vol. 45, no. 6, pp. 71-83. See the arguments in H. Nystrom, *Creativity and Innovation*, Wiley, Chichester, 1979; and A.M. Kantrow, "The Strategy-Technology Connection," *Harvard Business Review,* 1980, vol. 58, no. 4, pp. 6-8, 12, 13, 18, 21. A recent report on the semiconductor industry found that companies which pursued "major innovation" strategies returned the best performance results – see R.W. Wilson, P.K. Ashton and T.P. Egan, *Innovation, Competition and Government Policy in the Semiconductor Industry*, Lexington Books, Lexington, Mass., 1980.

39. See P.N. Khandwalla, "The Techno-Economic Ecology of Corporate Strategy," *Journal of Management Studies,* 1976, vol. 13, no. 1, pp. 62-75; and T.E. Clarke, "Decision-Making in Technologically Based Organizations," *IEEE Transactions on Engineering Management*, 1974, vol. EM-21, no. 1, pp. 9-23.

40. R.S. Rosenbloom, "Technological Innovation in Firms and Industries: An Assessment of the State of the Art," in *Technological Innovation*, eds. P. Kelly and M. Kranzberg, San Francisco Press, San Francisco, 1978.

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44. S. Myers and D.G. Marquis, *Successful Industrial Innovations*, National Science Foundation, NSF 69-71, Washington, 1969.

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47. C. Freeman, *The Economics of Industrial Innovation*, Penguin, Middlesex, 1974.

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49. *Ibid.*

50. H. Nystrom and B. Edvardsson, "Research and Development Strategies for Swedish Companies in the Farm Machinery Industry," Report 139, Department of Economics and Statistics, Swedish University of Agricultural Sciences, Uppsala, 1978.

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53. H. Crookell, "The Role of Product Innovation in Trade Flows of Household Appliances Between Canada and the U.S.A.," University of Western Ontario, London, 1970.

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58. J. Miedzinski, "Technology Transfer in Canada," in *Technology Transfer in Industrialized Countries*, ed. S. Gee, Sijthoff and Noordhoff, Alphen ann den Rijn, The Netherlands, 1979, pp. 37-50. See also B. Bhaneja et al., *Technology Transfer by Department of Communications*, Background Paper No. 12, Ministry of State for Science and Technology, Ottawa, 1980.

59. J. Blachford, "Technology Transfer Through Licensing: The Experience of a Small Canadian-Owned Chemical Company," *The Adoption of Foreign Technology by Canadian Industry*, Proceedings P81/2, Science Council of Canada, Ottawa, 1981, pp. 123-130.

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12. D.H. Thain, "Stages of Corporate Development," *The Business Quarterly*, 1969, vol. 34, no. 4, pp. 32-45.

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17. W.H.C. Simmonds et al., *The Use of Technology and Science in Canadian Industry*, National Research Council, Ottawa, 1975.

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22. Simmonds et al., *op cit.*

23. P. Johnston, *Nothing Ventured. . . Investing in Canada's Winners*, The Toronto Stock Exchange, Toronto, 1980; M. Binks, "Expansion in the Small Firm," *Planned Innovation*, vol. 3, no. 1, pp. 27-31, defines the financial constraint to expansion as follows: the smaller the firm, the larger the proportional increase in capital base required to respond to an increase in demand, but the lower its ability to command loan and equity finance.

24. R. Peterson, *Small Business*, Porcépic, Toronto, 1977.

25. *Ibid.*

26. The rankings are outlined in Canada, Ministry of State for Science and Technology, *R and D in Canadian and Foreign-Controlled Manufacturing Firms*, Background Paper No. 9, Supply and Services Canada, Ottawa, 1979.

27. See V.K.R. Chand, *Characteristics of Research and Development Performing Firms in Canadian Manufacturing*, Ministry of State for Science and Technology, Background Paper, Ottawa, 1980.

28. See the discussion in S.D. Berkowitz et al., "The Determination of Enterprise Groupings Though Combined Ownership and Directorship Ties," *Social Networks*, 1978-79, vol. 1, pp. 391-423.

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3. J.D. Howe and D.G. McFetridge, "The Determinants of R&D Expenditures," *Canadian Journal of Economics*, 1976, vol. 9, no. 1, pp. 57-71; and S. Globerman, "Market Structure and R&D in Canadian Manufacturing Industries," *Quarterly Review of Economics and Business*, vol. 13, no. 2, pp. 59-67. But reports by large Canadian-owned R&D performers suggest

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4. R.E. Caves, M.E. Porter and M. Spence, *Competition in the Open Economy: a model applied to Canada*, Harvard University Press, Cambridge, Mass., 1980.

5. D.G. McFetridge, *Government Support of Scientific Research and Development: An Economic Analysis*, University of Toronto Press, Toronto, 1977.

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15. This is the argument made in Canada, Department of Industry, Trade and Commerce, *The Enterprise Development Program*, First Annual Review, for the period 1 April 1977 to 31 March 1979, Department of Industry, Trade and Commerce, Ottawa, June 1979.

16. Hogan and Chirichiello, *op. cit.*

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2. See I.B. Kravis and R.E. Lipsey, *Price Competitiveness in World Trade*, National Bureau of Economic Research, New York, 1971.

3. R. Rothwell, "Where Britain Lags Behind," *Management Today*, November 1978, pp. 82-85.

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10. See *The Financial Post*, Toronto, 30 May 1981. The major resource companies tend to emphasize reliability and service and are reluctant to buy from small firms without track records.

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14. *The Financial Post*, Toronto, 25 October 1980.

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5. See A.D. Little Ltd, *op. cit.*

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See also "Why the auto parts companies are reeling," *Business Week*, 15 June 1981, no. 2692, pp. 114C and ff.

7. Automotive Parts Manufacturers Association, brief to the Minister of Economic Development, Ottawa, 1979, p. 19.
8. As quoted in *The Citizen*, Ottawa, 2 May 1980.
9. MacDonald, *op. cit.*, pp. 49 and 55.
10. *Ibid.*, p. 55.
11. A.D. Little, Ltd, *op. cit.*
12. *The Toronto Star*, Toronto, 10 March 1979.
13. *The Globe and Mail*, Toronto, 3 June 1978.
14. *Canadian Plastics*, May/June 1978, p. 29.
15. The survey is based in part on interviews conducted for this report by Dr. Brenton Barr of the University of Calgary.
16. One of these firms has most recently been purchased by a larger Canadian-owned firm.
17. See J. Hunter, "C.I. Aims to Expand Research and Markets," *The Manitoba Co-operator*, 21 February 1980. To finance its expansion plans CI required $30 million in 1981. There has been considerable tension generated between the federal government and Prairie politicians regarding the initial federal offer of contribution towards the refinancing package.
18. Quoted in *Western Construction and Industry*, February 1979, p. 29.
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25. See *The Financial Times*, Toronto, 19 May 1980.
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27. See *The Financial Post*, Toronto, 5 July 1980.
28. See Allentuck, *op. cit.*, and "Dreco goes from strength to strength," *The Financial Post*, Toronto, 10 October 1980.
29. See *Canadian Business*, 1977, vol. 50, no. 11, p. 22.
30. See *Western Construction and Industry*, October 1978, p. 94.
31. See *Canadian Electronics Engineering*, June 1980.
32. As noted in *The Globe and Mail*, Toronto, 26 March 1979.
33. Quoted in *The Financial Times*, Toronto, 23 June 1980.
34. Reported in D. De Genova, "Manufacturing in Ottawa-Carleton," MA thesis, Department of Geography, University of Ottawa, forthcoming.
35. See De Genova, *op. cit.*
36. The survey results reported here are drawn from the original questionnaire survey by De Genova, *op. cit.*
37. See *Computer World*, 5 December 1977, p. 62.
38. See *The Financial Post*, Toronto, 18 September 1976.
39. As reported in *Electronic News*, 10 January 1977, p. 38.
40. See *Canadian Datasystems*, June 1979.
41. See *Computer Data*, August 1979, p. 15.
42. See J. Chevreau, "Ottawa's computer loser is on the block," *The Globe and Mail*, Toronto, 13 July 1981; and L. Whittington, "MPs urge probe of $125 million loss," *The Citizen*, Ottawa, 3 December 1981.

43. See P. O'Connor, "Leigh Instruments; a turnaround may be lurking in the wings," *Canadian Business*, 1981, vol. 34, no. 2, pp. 16, 19.

44. See *Canadian Electronics Engineering*, February 1974, p. 25.

45. See *The Citizen*, Ottawa, 2 August 1980.

46. For comments by its CEO see D. Cunningham, "Achievements Don't Often come Easy," *CIPS Review*, 1980, vol. 4, no. 5, pp. 6-8.

47. See *Canadian Datasystems*, November 1976, p. 51.

48. For details see *Canadian Electronics Engineering*, March 1979, pp. 14-16.

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50. See H. Traynor, "If You Can't Beat the Telecommunications Giants – Supply Them," *Canada Commerce,* Summer 1977, pp. 25-32.

51. Quoted in A. Weiner, "How Creative Companies Work," *Canadian Business,* 1981, vol. 54, no. 5, p. 80.

52. As reported in *The Financial Times*, Toronto, 23 June 1980.

53. See *Canadian Electronics Engineering,* May 1979, p. 30.

54. See J. Hewer, "Mitel Travels the Octal Bus Line," *Canadian Electronics Engineering,* 1980, vol. 24, no. 5, pp. 20-22.

55. See G. Davies, "$1 billion in sales by 1985," *Executive,* January 1981, pp. 48-51.

56. As reported by R. Steklasa, "Mitel Glowing in Electronics Gloom," *The Financial Post*, 26 November 1977.

57. See M. Mittelstaedt, "Ottawa: the New High-Tech Haven," *Canadian Business,* 1980, vol. 53, no. 6, pp. 43-46.

VII. Conclusions and Recommendations

1. What constitutes a favourable climate? For arguments on the validity of studies on the so-called business climate see the various articles in *Inc.*, vol. 3, no. 10, 1981. The inadequacy of macroeconomic policies is outlined in OECD, *Technical Change and Economic Policy*, OECD, Paris, 1980.

2. For an eloquent argument on this need in an American context, but also unabashed promotion of the role of a supply-side policy focus, see G. Gilder,*Wealth and Poverty*, Toronto, Bantam Books, 1981.

3. See OECD, *Science and Technology Policy for the 1980s*, OECD, Paris, 1981; and D. de Vos, "Governments and Microelectronics," Science Council of Canada, Background Study (forthcoming). For small countries picking promising sectors is virtually equivalent to picking firms.

4. Indication of the higher social rates of return compared to private rates from innovation are provided by E. Mansfield, "How Economists see R&D," *Harvard Business Review*, 1981, vol. 59, no. 6, pp. 99-106.

5. For an argument why the purchasing route is not a feasible means of increasing Canadian ownership in the particular case of one industry, see M.J. Gordon and D.J. Fowler, *The Drug Industry*, James Lorimer, Toronto, 1981.

6. See T. Agmon and C.P. Kindleberger, eds., *Multinationals From Small Countries*, MIT Press, Cambridge, Mass., 1977, pp. 37-38.

7. Also see R.W. Wright and V. Kobel, "Turnkey Projects: Canada's Route to Third World Markets," *Business Quarterly*, 1981, vol. 46, no. 1, pp. 46-55.

8. OECD, *Policies for the Stimulation of Industrial Innovation*, OECD, Paris, 1978, p. 8.

9. For instance, see R. Nelson and S. Winter, "In Search of a Useful Theory of Innovation," *Research Policy*, 1977, vol. 6, no. 1, pp. 36-76; R.M. Green and J. Ronayne, "Innovation Policy and the Balance of R&D in

Australia," *Search*, 1980, vol. 11, no. 12, pp. 403-406; and B. Gold, "Productivity, Technological Change and International Competitiveness," *Technovation*, 1982, vol. 1, no. 3, pp. 203-13. Relatively little is known even about the effects of various tax measures on innovation, according to E. Mansfield, "Tax Policy and Innovation," *Science*, 12 March 1982, vol. 215, pp. 1365-75.

10. For elaboration on this theme, but with respect to larger Canadian firms, see I.A. Litvak, "Government Intervention and Corporate Government Relations," *Business Quarterly*, 1981, vol. 46, no. 3, pp. 47-54.

11. CATA has about 50 members. It seeks to promote the interests and conserve the rights of technology-based, Canadian-controlled companies. Membership ranges from very small to large firms and includes a few threshold firms. Most members are in the electronics, telecommunications or instruments industries.

Publications of the Science Council of Canada

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