Public Policy and the Quebec Aerospace Sector

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Abstract

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For over 150 years, governments around the world have adopted various types of policy measures to influence not only the level but also the nature of economic activity within their jurisdictions. These measures have commonly been referred to as "industrial policy". Since the end of WW II, governments in most developed and some developing countries have oriented their industrial policy programs to promote the growth of high technology industries within their borders. Such industries are seen to offer benefits which spread throughout the national economy.

Using the Quebec aerospace sector as a case study, and drawing on both secondary research and interviews with firms and government officials active in the sector, the research addresses several questions. First, why do some areas develop successful and ongoing clusters of innovative, high technology industries? Second, what has been the role of public policy, if any, in the inception and ongoing success of these clusters? Third, how has public policy in this area evolved over time, and why?

The research will describe and explain the evolution of industrial policy initiatives as they have been implemented in Quebec towards the aerospace sector. In order to provide a baseline to evaluate the degree of public sector involvement, the research will also examine the province's successful pharmaceutical sector

Drawing on the concept of the multi-firm production network characterized by extensive inter-firm learning, the research will describe the types of industrial clusters which can exist, and the benefits which accrue to participating firms. It will then show that the Quebec aerospace sector is indeed a successful and self-sustaining agglomeration of firms. Further, this research will suggest that public policy initiatives have had a degree of impact, if only indirect, on both the inception of and the ongoing development of the sector. Finally, the research will identify several factors, notably the ascendancy of conservative fiscal policy and the increasing importance of multilateral trade

agreements, which have led to the changes in the way the public sector supports and encourages the sector.

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CHAPTER ONE

Introduction

Industrial policy is a generic term used to encompass a wide variety of policy initiatives which are focused on the structure and nature of economic activity in a given jurisdiction. Among the possible objectives of industrial policies are: Improvement in the competitive position of a nation's industries; redirection of industrial activity toward those fields which provide higher real wages; retraining and relocation of workers who have been adversely affected by restructuring; promotion of high-technology industries through financial support of Research & Development (R&D), high risk investments and new market development; industrial restructuring, including mergers and joint ventures, which enhances the competitive position of a nation's industries; export assistance for firms within the jurisdiction; and, the establishment of mechanisms which permit management, labor, financial institutions and the general public to arrive at consensus on critical issues of economic development (Magaziner & Reich, 1982).

Writing about industrial policy in Canada, Atkinson and Coleman (1989) distinguish between two alternatives: Anticipatory industrial policy, with its emphasis on an integrated program of intrusive policy instruments aimed at structural transformation of an economy; and, reactive industrial policy, which is based upon the immediate needs of specific firms (often for distress financing) and is aimed at creating a climate attractive to investment.

Science and technology policy (S&T) has been defined as "a practical activity concerned with developing, managing, and supporting the capabilities of countries to advance and apply knowledge" (De La Mothe & Dufour, 1995, p. 219). Through most of the post-war period, S&T in the United States and, to a lesser extent, in Canada, was oriented towards basic research in pursuit of various national missions, notably defense, space and health (Ostry & Nelson, 1995). However, in the last ten years, the nature of the connection between science and policy has changed, particularly in the United States and Canada. As noted by the Organization for Economic Cooperation and Development (OECD) in its 1993 survey of science and technology policies in member countries, there has been a shift in policy emphasis regarding support for technology, "...with governments allocating funding to innovation in order to maintain economic competitiveness and stimulate growth" (p. 13). This policy shift has meant that while governments still devote considerable resources to supporting basic research and the creation of knowledge in pursuit of broad societal goals, S&T policy has come to overlap with industrial policy in several key areas.

Trade in high technology products has represented an increasing share of world trade. This trade has several unique characteristics, including the predominance of intra-industry trade, primarily of intermediate products, among countries with similar factor endowments, under conditions of imperfect competition and increasing returns to scale (Krugman, 1990; Scherer, 1992; Tyson, 1992; Noponen, Graham & Markusen, 1993). The unique conditions of high technology trade strike at the key policy prescription arising from Ricardian theory: That free trade will maximize national welfare. In contrast, high technology trade raises the possibility that certain policy measures could shift the composition of international economic specialization in a country's favor by creating comparative advantage (Krugman, 1980). As Skolnikoff (1992) emphasizes:

> Success in technology-intensive trade is determined not by a state's endowment in natural resources or productive land, but rather by the skills of its people, the quality of its science and technology, its capacity for technological innovation, and the effectiveness of policy and management. In short, comparative advantage in technological goods is 'created' by a society through its policies and human abilities (p. 227).

This type of comparative advantage is qualitatively different from traditional notions of comparative advantage. The latter are based on price-based competition, where "competitiveness" is essentially a problem of increasing productivity through cost-cutting. Industries where price competition is the dominant strategic imperative tend to be characterized by widely available technologies and relatively low entry barriers. Advocates of the traditional notion of competitiveness believe that "correct" macro-economic policies, in terms of monetary growth, fiscal policy and exchange rate determination, are the keys to assuring long-term competitiveness for a nation's industries. However, industries characterized by the need for constant innovations in product and processes can escape the imperative of price-based competition, generating quasi-rents from imperfect competition (Best, 1990; Storper, 1995). In these industries, according to Storper (1995), competitiveness "...is to seek greater differentiation of products at any given moment, while constantly adapting the configuration of products and processes in order to anticipate, and outrun, attempts at imitation by competitors" (p. 291). Storper then posits that those firms, sectors, regions or countries that can learn more rapidly or more efficiently than their competitors become competitive because their knowledge constitutes an asset that cannot be immediately copied.

Lundvall (1992) notes that technical progress is not regarded as a goal in itself, but that national governments engage in policies which promote innovations based on the assumption that innovations promote economic growth. This assumption is built upon the idea, first articulated by Schumpeter (1942), that the only kind of competition which really counts is competition "...from the new commodity, the new technology.... This kind of competition is much more effective than the other [i.e., price-based competition] as a bombardment is in comparison with forcing a door" (p. 84, cited in Nelson, 1996, p. 89). Innovation is defined as "a new use of pre-existing possibilities and components.... Almost all innovations reflect already existing knowledge, combined in new ways" (Lundvall, 1992, p. 8). Nelson (1993) posits that "successful innovation in high technology industries often is not so much a matter of invention, as it is a matter of design, in the sense of trying to devise a product or process that will achieve a desirable cluster of performance characteristics, subject to certain cost constraints" (p. 8).

To state that innovation represents an act of building upon that which already exists is to recognize that innovation is a process rather than a single event (Lundvall, 1992). This process requires two key elements: interactive learning and collective entrepreneurship (Lundvall, 1992). Johnson (1992) posits that certain institutional arrangements can promote learning and thus innovation. The capabilities of firms in a country to transform employees' expertise into new products are not entirely endogenous to each firm, but rather are also dependent on the strength of firms' institutional relationships with customers, suppliers, and research institutions (Kogut, 1991). Kogut concludes that "the capabilities of a firm are nested in wider institutional capabilities of a country" (p. 40).

A substantial body of literature has been developed around the concept of the industrial district. Alfred Marshall (1923) studied turn-of-the-century groupings of producers in Britain and Germany, such as Lancashire (textiles), Sheffield and Solingen (cutlery). The industrial structures of the districts he studied were composed of small, locally-owned firms. The Marshalian districts were fairly self-contained units, with limited connections to external firms and a high degree of intra-district trade based on long-term contracts and commitments between buyers and sellers found within the district. Marshall posited that firms within the district benefited in three key ways: Concentrating on firms in the same industry allows for the creation of a pooled labor market, particularly for workers with the specialized skills needed by the industry in question; encouraging the formation and provision of various specialized supporting services needed for the ongoing operation and success of the industry, including maintenance and repair expertise, and "patient capital" offered by institutions within the district; and, facilitating rapid flows of information and ideas between firms in the district, even in the absence of formal cooperation between member firms.

An extension of the Marshallian industrial districts has been the numerous case studies done on clusterings of firms in Italy [the so-called "Italianate" districts, to use the terminology of Markusen (1996)] (Piore & Sabel, 1984; Sabel, 1989; Best, 1990). These districts are groupings of small, highly innovative firms organized along craft-like rather than mass-production principles who have been able to compete in the global marketplace in several industries, including knitwear, ceramics and construction machinery. Members of these districts compete, but also collaborate, in the development of new technologies and methods, and find themselves in rotating roles as suppliers, customers and partners. Contributing to a high level of inter-firm cooperation are extensive networks of institutions that bind otherwise-competing firms together in a variety of activities, such as trade associations, guilds, unions and cooperatives for purchasing materials, marketing regional products, securing credit, and supplying semi-finished inputs.

An essential element of the Italianate district is the competitive focus of firms in the district. As described by Best (1990), firms in these districts are not organized according to traditional mass-production/price-competition principles, but rather are "entrepreneurial", defined as competing on the basis of innovations in products, production process and/or organization. In this context, the district develops a series of consultative and cooperative links between mutually dependent firms. The balance between cooperation and competition is ensured by a network of inter-firm institutions which not only manage the common programs member firms agree to but also ensures that competition among members does not degenerate into price-oriented competition which inhibits future investments in innovations.

The question of why some regions develop into successful industrial clusters and others do not is complex. Lured by the prospect of creating the next Silicon Valley, governments at various levels throughout the world have used a variety of incentives in attempting to attract and retain firms in a wide range of industries. All too often, these efforts fail to achieve their ambitious goals. To understand what is required to form an ongoing industrial district, it is necessary to understand the internal dynamics of such groupings, and to focus on how these dynamics produce benefits for firms found within them.

As noted above, the growing importance of trade in high technology products has had profound implications for the theoretical basis of trade theory and for the location of particular economic activities. Classical trade theory was predicated on Ricardian comparative advantage theory, refined by Heckscher-Olin and Samuelson, which states that countries specialize in certain goods based on factor endowments, and then trade under conditions of perfect competition and constant returns to scale with other countries who have specialized in other goods and who have complementary needs. However, trade in high technology products frequently consists of intra-industry trade, whereby countries with similar factor endowments exchange goods that are basically similar, under conditions of imperfect competition and increasing returns to scale. An important feature of intra-industry trade is that the goods exchanged are mainly intermediate goods, sold by producing firms to other producers.

Given the homogeneity of national factor endowments for these types of goods, the determination of which country produces what goods for intra-industry trade is primarily driven by attempts by firms to exploit increasing returns to scale (Krugman, 1990; Tyson, 1992; Noponwn, Graham and Markusen, 1993). In fact, the presence of increasing returns to scale is in turn an important explicator of geographical clusterings of firms engaged in the provision of intermediate goods (Krugman 1991).

Storper (1992) builds on these notions of the firm to posit that "technological advantage exists when the actors in a given place possess products, processes, and attendant knowledge that permit them to produce better things than other places, or simply permit them to produce goods and services not elsewhere available" (p. 65). The process of continuous innovation which creates an endless stream of new and improved products through a dynamic re-deployment of specialized production skills and equipment is referred to by Storper as "product-based technological learning" (PBTL).

Storper then suggests that the linkage between PBTL and the development of industrial districts is built upon the reality that competition on the basis of skill and knowledge increasingly depends on resources that lie outside the boundaries of major firms, and thus are not entirely appropriable by them. However, the obvious solution to this solution—vertical integration, with acquired assets made increasingly specific to proprietary processes in order to minimize costs—is not readily available to firms in industries characterized by rapid technological evolution. Rather, these firms must retain a certain degree of flexibility to avoid "lock-in" and be able to switch to new products and processes as the competition and market dictates.

The solution to this dilemma is the production network, characterized by a significant degree of vertical (and probably, horizontal) disintegration of the production system, whether inter-organizationally (independent firms) or intra-organizationally (between units of production within a firm). Storper (1992) describes a production network as being "...neither a firm (hierarchy) nor a system of market transactions...it is, instead, a set of units joined in relatively durable relationships through an 'organized market' involving some degree of cooperation or, at least, symmetry of power relations" (p. 79). Members of the production network, according to Storper, may not have general purpose assets that permit them to sell their outputs on the open market, yet they may also lack specific assets that are amenable to vertical integration. Rather, he states, "they are specialized to a given range of activities, involving particular competencies on the parts of firms and units" (p. 79). By including some units with high internal scale economies for certain functions or by aggregating several producers in the same sector and thus creating the benefits of external scale economies in lieu of internal economies, the production network achieves a compromise between the conflicting needs of cost minimization and avoidance of lock-in outlined above.

Storper (1992) states that "...where rapid learning is taking place, the transactional structure is likely to involve constant negotiation, re-negotiation, and dependence on achieved understandings as the basis of achieving common re-interpretations of new evidence and opportunities" (p. 84). The existence of this ongoing process of learning/negotiation between network members dictates, according to Storper, that the PBTL production network be based on agglomeration, since this is the most effective way to manage these exchanges.

What factors do promote the give-and-take of ideas and information so crucial to the success of a PBTL network? Sabel (1989) points to the existence of trust between network members, which is established "...through common education and professional experiences, reinforced at times by ethnic allegiances or—cause or consequence of economic success?—local pride" (p. 47). Storper (1992) identifies a body of conventions in a given network as being the essential element for ensuring that PBTL occurs among network members. He describes the conventions of a given production network as the "principles of mutual engagement" that are accepted by network participants. These conventions may be explicit or implicit, and constitute the rules and practices that help network participants reconcile differing notions of product quality, innovation, and standards of value. In other words, network members must subscribe to its conventions to feel sufficient confidence to enter into relationships based on learning with other network members.

Inspired by the success of some of the better-known industrial districts, policymakers around the world have tried to find the secret for creating "sticky" industrial districts, defined by Markusen (1996) as the ability of a district to both attract and retain firms. However, as Storper (1995) notes, reliance on improvement of factor supplies, coupled with conservative macro-economic policies as a putative replacement for more activist policy measures, has had a fairly disappointing record in changing the composition of economic activity in several countries.

Several researchers (including Jorgenson (1984); Duffy (1988); Bishop (1989); Reich (1990), and Puri & Suchon (1997)) have attempted to identify the necessary attributes which a region must offer to attract and retain knowledge-intensive industries. However, if the vision offered by Storper is indeed accurate, then the key question for policymakers in terms of how to form and nurture successful geographic agglomerations of knowledge intensive firms is not what discrete factors have to be built or bought for a given region, but what type of policy measures can be devised which will encourage the "dense" relationships and exchanges among firms in a given area. If such relationships can be encouraged, then the firms in the region can be expected to engage in the kind of continuous innovation which is the essence of establishing and maintaining competitive advantage in knowledge-intensive industries. In other words, policy measures that promote linkages and collaboration among firms in a given area can be expected to promote greater learning and hence skill development by these firms. This in turn can be expected to result in greater innovation by area firms. The types of public policy measures which promote these linkages are varied, and range from programs which aim to bring company representatives together to discuss issues pertaining to the industry, to programs which encourage firms to collaborate in developing and/or operating common training or marketing institutions.

These types of public policy initiatives require varying levels of funding. A significant constraint on the implementation of public policy measures aimed at industry has been the ascendancy over the past ten years of the "sound finance" school of thought among policymakers in North America. This school of thought mirrors the shift to the right that occurred in American society in the 1980's, and which has occurred in Canada since the mid-1990's. The "sound finance" school is based upon a number of misconceptions about government deficits. These include:

1) A government must manage its finances the same way individuals and businesses do: excessive debt represents a claim by others on the government and so should be avoided.
2) Government deficits will "crowd out" domestic private investment by causing inflation and increasing interest rates.
3) High deficits lead to inflation, since the central bank will tend to monetize the deficit.
4) Deficits represent a burden on future generations: Ultimately, the debt will have to be repaid through increased taxes imposed on future generations.

Each of the above notions is highly questionable yet they have gained a surprising level of public acceptance. However, despite the shaky theoretical foundations of the sound finance school, it has come to dominate the public policy discourse in both Canada and the United States over the past few years, with major consequences for S&T policy.

The Canadian Aerospace Industry

The aerospace sector is one of the most dynamic sectors of the Canadian economy today. Canada's aerospace sector is the world's sixth largest, with total industry sales of almost $11 billion in 1996. Between 1985 and 1995 the sector grew by over 150%, and anticipated sales are expected to exceed $15 billion by 1999 (Aerospace Industries Association of Canada (AIAC), 1996). Currently, over 70% of industry sales are exported with the proportion of exports to total sales forecast to increase to 76% by 1999 (AIAC, 1995). It employs over 54,000 people across the country, making it one of the top ten manufacturing sectors in terms of employment. The sector is one of the largest sources of R&D in Canada, with firms investing over $1 billion per year in new technologies (AIAC, 1996).

The Canadian aerospace industry has a high degree of geographic concentration, with almost 45% of total sector employment in Quebec and 37% in Ontario (Industry Canada, 1995). In terms of shipments, almost 49% and 36% come from Quebec and Ontario, respectively (Industry Canada, 1995). The Quebec aerospace sector, consisting of approximately 215 firms, has been extremely successful over the past two decades. Between 1984 and 1994, the sector increased total employment from approximately 8,100 to about 26,400 (Industry Canada, 1996a). Quebec aerospace firms have increased their share of total Canadian aerospace sales from 46% in 1984 to 55% in 1994, while increasing their share of total Canadian aerospace employment from 41% to 49% over the same period (Industry Canada, 1996a).

The aerospace sector shares certain characteristics of all high technology sectors. The industry is characterized by significant barriers to entry in the form of capital requirements stemming from the massive R&D investments typically required, coupled with the long pay-back period which producers must confront. New products generally require three to five years of significant R&D investment before they are ready for market. Annual cash from operations typically only turns positive seven to nine years into the life of a new aerospace product, while cumulative net cash flow generally only becomes positive after fifteen years (AIAC, 1996, Industry Canada, 1995). The industry is also characterized by significant "first mover advantages" derived from product and process innovations. This makes for a high risk environment for both existing players and potential new entrants. The risks in the sector are magnified by the long development cycle, with new products and programs frequently having to sustain negative cash flows for up to seven years before revenues exceed sunk and ongoing expenditures (AIAC, 1996). As noted previously, high technology sectors are frequently characterized by increasing returns to scale, and the aerospace sector is no exception, with learning curves in the industry being quite steep. This means that decisions taken by firms regarding where to site certain activities will have long-term impacts, as firms will attempt to capitalize on increasing returns to scale rather than disperse activities in search of lower factor costs.

Another important characteristic of the aerospace sector, which follows from the above-noted set of circumstances, is that it has been and continues to be profoundly influenced by various public policy initiatives. In other words, governments around the world have rejected traditional free trade theory and have attempted to "create" comparative advantage for their respective home-based aerospace firms. Government involvement in the aerospace sector has, since the end of World War II, taken various forms, including procurement for military and some civil applications, direct ownership, various subsidies and tax expenditures to help home-based aerospace firms undertake R&D, financing for export sales, and investment in specialized training facilities.

The long history of government involvement in the sector makes it an ideal case study of the impacts of S&T policy on corporate decision making. The ongoing success of Quebec's aerospace sector can be traced to many factors, but it is my contention that appropriately timed and targeted public policy initiatives have been an important dominant driver of this success. Specifically, I intend to use the sector as a case study to show that notwithstanding the current ascendancy of the "sound finance" school, there is a place for public policy, specifically active S&T policy, in promoting development in high-technology sectors.

The data will consist of a review of various secondary sources, supplemented with interviews including a range of company, industry group and government officials. From the data I hope to produce an inventory of what public policy initiatives have been directed at the sector. I will attempt to describe what level of resource commitment has been made to support the sector's development and ongoing growth. I will also develop a full description of what formal and informal mechanisms have been developed to encourage learning ("PBTL" in the Storperian sense) among sector participants, as well as an analysis of the role of public policy, if any, in the introduction and ongoing operation of these mechanisms.

The thesis will draw on several fields. My major field is Public Policy analysis, which will provide the means for analyzing the various attempts by governments in the past to influence the nature and development of the two clusters. Strategic Management approaches will address questions dealing with how firms in the industry compete, how they evaluate opportunities, and how they can be structured to gain competitive advantage through continuous product and/or process innovations. I will also draw on insights from Macro Economics in order to provide an understanding of the overall fiscal regime in which successful S&T initiatives can occur.

The thesis will have both a historical and a future orientation. The historical perspective will review the history of the sector, highlighting the key policy initiatives and company decisions which contributed to its development and growth. Both the historical perspective and future orientation will rely on various secondary sources supplemented by interviews with various firms in the sector and with selected government officials.

Hypotheses

I will examine the following three hypotheses:

> 1) The Quebec aerospace sector is a physical agglomeration of firms that has evolved as a result primarily of market forces, including the international division of labor, competitive advantages of particular firms, and various profit-maximizing strategies adopted by various firms. Relationships among firms in the sector are driven purely by traditional models of inter-firm relations whereby firms deal with other firms to achieve cost minimization. There is little if any learning between firms in the sector. Public policy's role in creating and nurturing the cluster has been mainly in the form of various reactive industrial policy measures and has had a marginal role in its evolution.
>
> 2) The Quebec aerospace sector is indeed a production network in the Storperian sense, characterized by a high degree of trust between members and an ongoing process of product-based technological learning. The sector owes its success to its ability to be continually innovative due to an ongoing re-deployment of specialized learning skills and resources among its members. However, this situation has materialized solely as a result of private sector activities, with public policy being largely irrelevant in nurturing or strengthening these trends.
>
> 3) The Quebec aerospace sector is indeed a production network in the Storperian sense, characterized by a high degree of trust between members and an ongoing process of product-based technological learning. The sector owes its success to its ability to continually innovate due to an

> ongoing re-deployment of specialized learning skills and resources among its members. Public policy, undertaken under the aegis of an "anticipatory" industrial policy outlook, has played a meaningful role in promoting both the trust that exists between members of the Quebec aerospace sector and the actual PBTL that goes on within it. Public policy has therefore contributed to the sustainability of the Quebec aerospace sector by contributing to its ability to engage in continuous innovation.

It is my contention that the data will support the third hypothesis. In other words, I expect to find that there is an extensive network of connections among firms in the Quebec aerospace sector, that these connections involve a high level of inter-firm learning, that firms in the sector have a high level of trust such that they can engage in the kinds of data exchange necessary to practice product-based technological learning (PBTL), and finally, that public policy has played a significant role both in creating the climate of trust necessary for PBTL to occur, and in fostering the ongoing exchanges among firms.

CHAPTER TWO

Methodology

To supplement the review of secondary sources, I conducted a series of interviews during the fall of 1997 and the spring and summer of 1998 with a number of firms and institutions active in the Quebec aerospace sector. This group included two separate Quebec government agencies, three specialized training institutions, and six Quebec-based aerospace firms. I held one interview with each of the Quebec government agencies and the specialized training institutions. Out of the six aerospace firms included in the group, I met once each with four of them, and twice with two of the larger firms.

The two Quebec government agencies included in the group were the Ministry of Industry, Trade, Science and Technology (MICST), and the Caisse de dépot et placement du Québec. At the former, I spoke to Mr. Gilles Brabant, Industrial Development Advisor, and at the Caisse, the author met with Mr. Jean Claude Cyr, Vice-President, Development and Planning and Coordinator, Quebec Economic Affairs. These meetings were conducted at the respective Montreal offices of the two organizations.

The group also included several specialized educational institutions in the Montreal area, including the Centre d'adaptation de la main-d'oeuvre (CAMAQ); the Ecoles des Métiers de l'aérospatiale de Montréal (ENAM); and the Ecole de technologie supérieure (ETS). I conducted telephone interviews with the executive directors of each of these three institutions: Mr. Serge Tremblay of CAMAQ, Ms. Marie Anne Desjardins of ENAM, and Mr. Jacques Fortin of ETS.

Finally, the group included six Quebec-based aerospace firms, with two firms drawn from each of the three tiers of the industry. [The aerospace industry is characterized by a three-tiered hierarchy, with manufacturers of complete aircraft at the summit ("primes"); producers of complex sub-systems such as propulsion and navigational systems on the next level ("second-tier"); and small, specialized machine shops focusing on specific components on the last level ("third-tier"). Chapter 6 provides a more detailed description of the industry's structure]. Both first-tier and one of the second-tier firms were selected by the author based on their willingness to participate in the research. The other second-tier firm, as well as the two third-tier firms, were referred to the author by a first- or second-tier firm who had ongoing dealings with them. In the case of the first- and second-tier firms, I met with senior representatives in charge of either public affairs or procurement. In the case of third-tier firms, I met with one owner-manager and one general manager. With one exception, all of the firm interviews were conducted at the respective firms' facilities.

Given the overall composition of the group and the way I selected its members, it could best be described as a targeted, judgement sample of key informants. This methodology can be considered as being useful when the total sample size is extremely small (Boyd, Westfall and Stasch, 1989). An important question that arises when using a judgement sample is that of validity and potential bias in responses. This could be of particular concern given that some of the group members were referred to me by firms who were their customers. This could have led to a situation where some respondents may have been uncomfortable in expressing certain opinions in order to protect existing commercial relationships. To alleviate this concern, I began each interview by stressing the confidential nature of the data collection process. In order to protect the confidentiality of the private sector respondents, no attribution is done by firm or individual name. Rather, when specific quotes are used, they are attributed to firms in a general way (e.g., p = prime; s = second-tier; t= third-tier). I explained this procedure to each firm's representative prior to the start of every interview, and all of the firms indicated that they were comfortable with this arrangement.

In order to gauge whether public policy towards the Quebec aerospace sector has been "anticipatory" or "reactive", I will use the level of public policy involvement in the Quebec pharmaceutical industry as a benchmark measure. The pharmaceutical industry was chosen for several reasons. It is a high-technology industry, characterized by many of the issues regarding R&D intensity and entry barriers which confront the aerospace industry. It has a significant presence in Canada, with total industry shipments of about $6 billion per year (Industry Canada, 1996b). Moreover, the industry has a major presence in Quebec, with several multinational manufacturers basing their production facilities in the province. Finally, the pharmaceutical industry is greatly influenced by public policy, in terms of support for R&D via tax expenditures or direct programs, and in terms of broader issues such as intellectual property protection and the training of qualified workers.

CHAPTER THREE

Industrial Policy

Industrial policy is a generic term used to encompass a wide variety of policy initiatives which are focused on the structure and nature of economic activity in a given jurisdiction. Among the possible objectives of industrial policies are: Improvement in the competitive position of a nation's industries; redirection of industrial activity toward those fields which provide higher real wages; retraining and relocation of workers that have been adversely affected by restructuring; promotion of high-technology industries through financial support of R&D, high risk investments and new market development; industrial restructuring, including mergers and joint ventures, which enhances the competitive position of a nation's industries; export assistance for firms within the jurisdiction; and, the establishment of mechanisms which permit management, labor, financial institutions and the general public to arrive at consensus on critical issues of economic development.

Writing about industrial policy in Canada, Atkinson and Coleman (1989) distinguish between two alternatives: Anticipatory industrial policy, with its emphasis on an integrated program of intrusive policy instruments aimed at structural transformation of an economy; and reactive industrial policy, which is based upon the immediate needs of specific firms (often for distress financing) and is aimed at creating a climate attractive to investment.

Johnson (1982) points out that industrial policy is not merely a question of state intervention in the economy, since all states intervene in their economies for a wide range of reasons. Rather, he states that the key questions are what form such intervention takes and what purposes it is pursuing. Contrasting the evolution of public policy in the United States with that of Japan, he refers to the former as representing the "regulatory orientation" while the latter typified the "development orientation." According to Johnson, the regulatory, or market-rational state, concerns itself "... with the forms and procedures—the rules, if you will—of economic competition, but does not concern itself with what industries ought to exist and what industries are no longer needed" (p. 19). In contrast, the developmental, or plan-rational state, is characterized by the existence of an industrial policy in pursuit of various social and economic goals, in particular the attainment of a structure of domestic industry that enhances the nation's international competitiveness.

The Organization for Economic Co-operation and Development (OECD) presents three different approaches to industrial policies. The OECD taxonomy is based upon the degree to which resource allocations within an economy are made on the basis of short-term market signals versus government involvement. The first approach identified by the OECD is one in which resources are primarily directed by short-term market signals, and public policy is primarily aimed at maintaining a competitive environment. In the second approach, resource allocation is done by market transactions based on long-term relationships between economic agents, with public policy more actively involved in industrial development either through explicit targeting or through implicit agreement on common goals with private sector economic agents. The third approach to industrial policy is characterized by resource allocation in response to a mix of short-term market signals, long-term relationships among economic agents and government directives in pursuit of a range of objectives. Public policy under this approach may include active support of certain industries, sectoral initiatives and programs aimed at preserving employment.

The OECD notes that the choice of which approach to adopt is ultimately a political decision, going to the heart of differences in the political economies of nations. However, the OECD states that in recent years, there has been a convergence among member governments towards industrial policies that minimize interference with market mechanisms and which aim to improve the functioning free markets (a reflection of the ascendancy of the "sound finance" school of thought, discussed in Chapter 5). This "market-oriented" industrial policy is in direct contrast with previous industrial policy orientations, which, according to the OECD, consisted of measures to support declining industries or to pick winners.

The new type of "market-oriented" industrial policies fall into two broad categories. The first aims at correcting particular market flaws or at indirectly improving the market's functioning. Included in this category of "market-correcting" or "market-enhancing" activities will be measures to remove disincentives to R&D, to help firms cope with the costs of training or environmental protection, to improve the flow of information in the economy, and to prevent monopoly or protect property rights, particularly with respect to intellectual property such as patents and copyrights.

The second category of "market-oriented" industrial policies are focused on aiding industry without targeting specific ones. The main emphasis of these types of measures are to enhance the quality of inputs available to industry. This category includes various investment tax credits, general subsidies for R&D expenditures, measures to improve the skills of the labor force, investments to upgrade infrastructure, and the provision of consulting services to economic agents.

Science & Technology Policy

Science and technology policy (S&T) has been defined as "a practical activity concerned with developing, managing, and supporting the capabilities of countries to advance and apply knowledge" (De La Mothe & Dufour, 1995, p. 219). The linkage between science and the state was strengthened during the post-World War II period to the point where a nation's science system came to be seen as a source of national prestige and confirmation of cultural achievement (De La Mothe & Dufour, 1995). Through most of the post-war period, S&T in the United States and, to a lesser extent in Canada, was oriented towards basic research in pursuit of various national missions, notably defense, space and health (Ostry & Nelson, 1995). S&T in both countries was also predicated on what has been called the "pipeline" model. Under this model, according to Branscomb (1993):

> Innovations arise in the research laboratory or inventor's shop, and after a sequence of discrete steps through applied research, development and design, are produced and marketed. It is further assumed that this process is more or less automatic and invisible (p. 14).

Another key assumption of the "pipeline" model is the concept of "spinoff": the idea the "the technology created in pursuit of government missions will automatically flow to industry and thus contribute to prosperity" (Branscomb, 1993, p. 14). These assumptions explain the appeal of the pipeline/spinoff model to fiscal conservatives and others ideologically opposed to government involvement in the economy. As Branscomb (1993) notes, if spinoff is indeed automatic and cost-free:

> ...the government does not have to select or subsidize the firms or industries that will benefit from commercializing government R&D...government can claim that its policies achieve the goals of economic growth without interfering with the autonomy of private firms (p. 14).

However, in the last ten years, the nature of the connection between science and policy has changed, particularly in the United States and Canada. As noted by the OECD in its annual survey of science and technology policies in member countries, there has been a shift in policy emphasis regarding support for technology, "...with governments allocating funding to innovation in order to maintain economic competitiveness and stimulate growth" (p. 13). The OECD notes that this shift has been particularly pronounced among the Anglo Saxon countries who have attempted to capitalize on their scientific bases which were built up during the Cold War.

This policy shift has meant that while governments still devote considerable resources to supporting basic research and the creation of knowledge in pursuit of broad societal goals, S&T policy has come to overlap with industrial policy in several key areas. (In the United States, the term "industrial policy" has for the last few years been quietly dropped from public discourse, as it has become a lightening rod for critics of intrusive government. Meanwhile, it has been replaced by S&T policy, which is a less value-laden term politically, but which is used to mean the same thing.) For purposes of this research, I will use the term S&T policy, which in this case is understood to refer to policy measures which aim at creating, diffusing and using scientific and technical knowledge in pursuit of industrial policy objectives, notably the creation of competitive advantage for home-based industries.

As noted below, high technology products account for an increasing share of world trade. Trade in high technology products has several unique characteristics, including the predominance of intraindustry trade, primarily of intermediate products, among countries with similar factor endowments, under conditions of imperfect competition and increasing returns to scale (Krugman, 1990; Scherer, 1992; Tyson, 1992; Noponen, Graham and Markusen, 1993). The unique conditions of high technology trade strike at the key policy prescription arising from Ricardian theory: That free trade will maximize national welfare. In contrast, high technology trade raises the possibility that certain policy measures could shift the composition of international economic specialization in a country's favor by creating comparative advantage (Krugman, 1980). As Skolnikoff (1992) emphasizes:

> Success in technology-intensive trade is determined not by a state's endowment in natural resources or productive land, but rather by the skills of its people, the quality of its science and technology, its capacity for technological innovation, and the effectiveness of policy and management. In short, comparative advantage in technological goods is "created" by a society through its policies and human abilities (p. 227).

This viewpoint is echoed by Scherer (1992), who states that a nation's international comparative advantage in high-technology goods is not something which nations inherit by virtue of historical natural endowments, but rather something which "must be strugggled for and earned through superior technological innovativeness" (p. 5).

The type of comparative advantage referred to by Skonikoff and Scherer is qualitatively different from traditional notions of comparative advantage. The latter are based on price-based competition, where "competitiveness" is essentially a problem of increasing productivity through cost-cutting. Industries where price competition is the dominant strategic imperative tend to be characterized by widely available technologies and relatively low entry barriers. Advocates of the traditional notion of competitiveness believe that "correct" macroeconomic policies, in terms of monetary growth, fiscal policy and exchange rate determination, are the keys to assuring long-term competitiveness for a nation's industries. However, industries characterized by the need for constant innovations in product and processes can escape the imperative of price-based competition, generating quasi-rents from imperfect competition (Best, 1990; Storper, 1995). In these industries, according to Storper (1995), competitiveness "...is to seek greater differentiation of products at any given moment, while constantly adapting the configuration of products and processes in order to anticipate, and outrun, attempts at imitation by competitors" (p. 291). Storper then posits that those firms, sectors, regions or countries that can learn more rapidly or more efficiently than their counterparts become competitive because their knowledge constitutes an asset that cannot be immediately copied.

The notion that comparative advantage can be created is based on the recognition that technological development is a cumulative and evolutionary process which varies across firms and regions. As noted by Patel & Pavitt (1991), "...country specific factors create both the general conditions that determine the volume of technological activities, and the specific inducement mechanisms that determine their direction. These lead to accumulated firm-specific advantages that are reflected in international patterns of trade, production and related technological activities" (p. 18). The exact institutional arrangements and cultural conventions which impact both the generation and diffusion of scientific and technical knowledge in a country are referred to as the "national system of innovation" (Lundvall, 1992; Nelson, 1993). As defined by Lundvall (1992), a system of innovation is:

> ...constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge...a national system encompasses elements and relationships, either located within or rooted inside the borders of a nation state (p. 2).

Lundvall notes that technical progress is not regarded as a goal in itself, but that national governments engage in policies which promote innovations based on the assumption that innovations promote economic growth. This assumption is built upon the idea, first articulated by Schumpeter (1942), that the only kind of competition which really counts is competition "...from the new commodity, the new technology....This kind of competition is much more effective than the other [i.e. price-based competition] as a bombardment is in comparison with forcing a door" (p. 84, cited in Nelson, 1996, p. 89). Innovation is defined as "a new use of pre-existing possibilities and components.... Almost all innovations reflect already existing knowledge, combined in new ways" (Lundvall, 1992, p. 8). Nelson (1993) posits that "successful innovation in high technology industries often is not so much a matter of invention, as it is a matter of design, in the sense of trying to devise a product or process that will achieve a desirable cluster of performance characteristics, subject to certain cost constraints" (p. 8).

To state that innovation represents an act of building upon that which already exists is to recognize that innovation is a process rather than a single event (Lundvall, 1992). This process requires two key elements: interactive learning and collective entrepreneurship (Lundvall, 1992).

Interactive Learning and Collective Entrepreneurship

In an important Chapter on institutional learning in Lundvall's 1992 book on national systems of innovation, Johnson outlines the connections between a nation's institutional arrangements and its ability to innovate. These arrangements can, according to Johnson, facilitate or retard technical change. Drawing on the work of Douglas (1987), Johnson notes that institutions affect technical change by influencing the cognitive processes of their members, thus affecting learning. This influence derives from the fact that learning is rarely done in isolation of interpersonal relations. Learning is predominantly interactive, according to Johnson, because it depends critically upon the degree to which different skills and types of knowledge are combined to solve problems. Since learning is a social process, Johnson concludes that it is fundamentally "shaped by institutions" (p. 31).

Johnson concedes that there are differing forms of learning, some of which, such as individual imprinting of individual experiences on one's memory and rote learning, which involve little human interaction. However, he stresses that technical change often requires high levels of conversation, defined as "...sequences of exchanges of messages between different people in different departments and at different levels, within firms and between firms. Furthermore, the more technically or scientifically advanced the innovations, the more complicated the communications process they usually require" (p. 31). Many of these interactions take place in the context of company efforts to increase knowledge to stimulate innovation. Johnson categorizes these efforts as a form of learning called "learning by searching" or simply "searching." This searching could be conducted within the boundaries of a firm's existing capabilities and financial objectives. Alternatively, Johnson notes that searching could be conducted by organizations such as universities which are not pursuing immediate economic objectives, but which are instead attempting to expand the boundaries of knowledge. This type of basic research Johnson refers to as "learning by exploring" or simply "exploring." Finally, Johnson points out that new knowledge often arises from day-to-day operations that were not specifically undertaken to generate it, but were simply done to complete regular assigned tasks. This type of learning Johnson labels "learning by producing," or simply "learning."

Regardless of whether new knowledge is the result of searching, exploring or learning, Johnson concludes that the generation of new knowledge results from within the economy, and so innovation can be considered an endogenous process. Thus he concludes that innovations are based upon both the institutional and production arrangements of the economy:

> If innovation reflects learning, and if learning is interactive, it follows that innovation is rooted in the institutional setup of the economy. And if learning partly emanates from routine activities in economic production, innovation must also be rooted in the prevailing economic structure, since different technological opportunities, income elasticities and linkages between industries make learning in some industries and periods much easier than in other industries and periods (p. 34).

Not only do institutional arrangements influence learning and innovation, but these arrangements vary across countries. Therefore, the ability to engage in learning and innovating varies across countries. As Dosi, Pavitt & Soete (1990) note, countries vary in the level and direction of their technological activities due to cross-national differences in the way national systems of innovation evaluate and deal with the inherent uncertainty of technological innovations. "Myopic" systems tend to overlook the cumulative nature of technological innovations, and tend to evaluate technological activities on the basis of short-term pecuniary returns. This results in high rates of discount to prospective future returns. However, "dynamic" systems adopt a long-term perspective, and evaluate technological activities on the basis of potential new markets and the build-up of accumulated knowledge which can be leveraged into future applications and opportunities. Whether a given national system is "myopic" or "dynamic," according to Dosi et al, is in turn a function of the returns to innovation built into the financial system, the extent to which a country's large firms are based upon rigid adherence to short-term financial yardsticks and to existing definitions of divisional boundaries, and of the learning capacities of firms in the country. The latter, in turn, depend upon the country's general educational level, the level of engineering and scientific competence of its managers, workforce skills, and on the degree to which there is effective communication within and between firms in the country. The factors which determine whether a given national system of innovation is "myopic" or "dynamic" constitute, according to Dosi et al, the "learning universe" within which economic activities occur. Dosi et al conclude that the elements of this learning universe plays a critical role in the shaping of a nation's technological output:

> ....through their effect on the knowledge accumulated in companies' R&D facilities, universities, etc.; the forms of organisation of labour, commodity and financial markets; the social/cultural determinants of the baskets of consumption, and, of course, direct forms of political intervention related to innovation policies and, more generally, to economic management (p. 111).

If certain institutional arrangements can promote learning and thus innovation, and if these arrangements vary across countries, then one could conclude that certain countries have designed "better" institutional arrangements to promote learning and innovation, and that these arrangements should be emulated by countries who aspire to equal levels of technological sophistication.

Indeed, the idea of countries attempting to copy another country's "recipe" for technological dynamism goes back at least to the mid-nineteenth century when Friedrich List studied what types of policy measures Prussia should adopt to catch up to England's advanced level of industrialization. According to Freeman (1995), List's 1841 work "The National System of Political Economy" might just as well have been titled "The

National System of Innovation." As a result of List's work, among others, the Prussian state adopted several institutional responses to its technological lag behind England. These included the establishment of an extensive system of technical education and training, based upon a network of Technical Training Institutes, non-teaching academies, museums, and expositions; the importation of the latest British machine tool technology for reverse-engineering and for training of Prussian workers; a program to attract British machine tools craftsmen to Prussia; and a wide-ranging program for providing technical advice and financial aid to inventors (Freeman, 1995).

So successful were the Prussian efforts at emulating and overtaking England that the United States looked to Germany as a model for organizing its university research system in the early part of the twentieth century (Ostry & Nelson, 1995). This emulation of other countries' institutional mix for innovation continued during the first four decades after WWII, as most industrialized nations looked to the United States as the model for how to best organize so as to promote technological advance. Then, beginning in the early 1980's, many European countries and, to an extent, the United States, began to look towards Japan as having the "right mix" for assuring technological prowess. More recently, Japan has begun to emulate some aspects of the European and American national systems of innovation (Ostry & Nelson, 1995).

Can Innovation Be Copied?

As noted above, countries have at different times attempted to emulate various features of those national systems of innovation that have appeared to be most successful in promoting innovation and technological dynamism. If these efforts were successful, this would suggest that over time we would see both a homogenization of national systems of innovation toward some type of "optimal" mean, and a diffusion of technological abilities across countries to the point where there would be no discernible cross-national differences in technological skills. Moreover, if this was indeed the case, then national systems of innovation would take on less importance as an explicator of a country's capacity to innovate and secure technological advantage. According to this line of reasoning, the importance of country-specific national systems of advantage would be further diminished by the worldwide trend of globalization, advanced by the explosion of foreign direct investment over the past thirty years. The globalization trend, as practiced by a growing legion of Multinational Enterprises (MNE's), means that national differences in innovative capabilities ultimately are leveled through FDI.

As stated by Ohmai (1990):

> Today, if a corporation does not like its government, it can move its headquarters to other, more hospitable places....When money, goods, people, information and even companies crisscross national borders so freely, it makes no sense to talk of 'American industrial competitiveness' (p. 199).

In fact, a substantial body of literature confirms that despite ongoing efforts at copying what are seen as optimal features of other countries' national systems of innovation, despite increasing FDI and the entire trend toward globalization, the unique characteristics of a country's national system of innovation still play a critical role in determining the technological sophistication and competitiveness of a country's firms. In other words, location still matters.

Kogut (1991) posits that not only do trade and investment patterns not equalize areas of technological strength across countries, but that they tend to reflect and reinforce existing areas of strength for each country. He also concludes that sustained absolute country advantages are based on "persisting variation of organizational and institutional capabilities among countries" (p. 34). Kogut rejects that notion that simple imitation and increased spending on R&D by a country can outweigh the existing trajectory of differential technological development among countries since the impact of investments in technological development is governed as much by the "efficiency of organizing principles as by the absolute level of expenditure." One of the key determinants of the extent to which firms and organizations in a country adopt new technologies is their level of knowledge, which Kogut describes as being expressed both organizationally and institutionally. That is, a firm's capabilities consist of its organizing abilities to transform the expertise of its employees into saleable products. These capabilities are found in the "routinized expectations" developed in any organization, which are in turn built upon a foundation of cumulative and shared experiences. In other words, Kogut posits that "learning is localized because knowledge is institutionally structured in on-going and enduring relationships. To adopt new practices requires a change in these relationships" (p. 40). This leads Kogut to observe that adoption of new ways of doing things requires changes in the way groups behave and react. This observation is at the heart of cross-national differences in innovation, according to Kogut, since some institutionalized relationships span firms and sectors.

The capabilities of firms in a country to transform employees' expertise into new products are not entirely endogenous to each firm, but rather are also dependent on the strength of firms' institutional relationships with customers, suppliers, and research institutions. Kogut notes that the importance of these institutional relationships is often underestimated if one focuses on purely domestic competition, as these relationships are often public goods to all domestic competitors. However, international competition highlights the importance of these broader national differences and their influence on the success of individual firms. Kogut concludes, therefore, that "the capabilities of a firm are nested in wider institutional capabilities of a country" (p. 40).

Patel (1995), in a study of the US patenting activities of almost 600 large firms between 1969 and 1990, found no systematic evidence to support the notion that there has been a widespread globalization in the production of technology. Rather, for the "overwhelming majority" of firms studied, technological activities were conducted close to the firm's home base. What internationalization of technology that was uncovered in Patel's study was found to be primarily influence by the need to tailor products to local market conditions rather than "...by supply side reasons concerned with exploiting the science and technology base of the host country" (p. 152).

Archibugi & Michie (1995) distinguish between three different dimensions of "techno-globalism": Global exploitation of technology, that is efforts by firms to realize profit from innovation by marketing it in foreign markets; global technological collaboration, which refers to sharing of know-how between firms and research institutions of different countries; and, global generation of technology, which refers to R&D conducted by MNE's. Arhibuigi & Michie conclude that in all three areas, the configuration of the national system of innovation has retained its importance: Global exploitation of technology is dependent on the regimes which national governments establish to permit innovations to be introduced and marketed within their respective borders; international collaboration only occurs to the extent that a given country's firms and/or research institutions offer some type of technical unique expertise; and international generation of technology is still largely confined to the home states of MNE's.

That there are important cross-national differences in national systems of innovation, and that these differences cannot easily be overcome or erased by emulation through government policies or FDI is supported by Bartholomew (1997), in a study of national systems of biotechnology innovation. She concludes that to the extent that national systems of innovation are products of historical development and cultural evolution in each country, the institutional arrangements which constitute such systems are deeply rooted in the societies that produce them. Efforts at emulation of certain putative optimal institutional arrangements to promote innovation must be both "culturally sustainable in the long run" and "seek harmony with the internal coherence of the [existing] national system" (p. 262). She cites as support for this contention the inability of the United Kingdom (UK) to easily copy either the Japanese model of large-scale government coordinated programs of inter-firm cooperation in pre-competitive biotechnology, or the American model of small entrepreneurial start-ups emerging from the country's universities. In both cases, the UK lacked the historical and cultural antecedents to make such systems succeed. What ultimately emerged as the socially accepted national system of biotechnology innovation for the UK was a middle ground between the Japanese and American models, which fit with existing cultural and institutional mores within the country. Bartholomew concludes that national patterns of biotechnology R&D are molded by the precise configuration of country-specific institutional arrangements into a system of innovation which may support or impede knowledge flows and innovation between and within firms and research organizations. Moreover, she concludes that "the particular national path of technological development in turn reinforces, or even magnifies, country-specific patterns of organization" (p. 262). Each country's national system, she further concludes, can be considered the embodiment of a set of technical, institutional and organizational capabilities which together represent a society's preferred solution to the challenge of innovation in biotechnology.

That location matters in determining which country's firms will be successful innovators and competitors is the central point of Porter (1990), in an exhaustive case analysis of the national systems of innovation of several countries. Porter firmly rejects the notion that increased globalization means that all country's capabilities become homogenized, and that every country can simply emulate the best practices of the supposed winners in the global marketplace in order to achieve an equally successful competitive position:

> Competitive advantage is created and sustained through a highly localized process. Differences in national economic structures, values, cultures, institutions and histories contribute profoundly to competitive success. The role of the home nation seems to be as strong or stronger than ever (p. 19).

CHAPTER FOUR

Industrial Districts or Regional Clusters

A substantial body of literature has been developed around the concept of the industrial district. Alfred Marshall (1920) studied turn-of-the-century groupings of producers in Britain and Germany, such as Lancashire (textiles), Sheffield and Solingen (cutlery). The industrial structures of the districts he studied were composed of small, locally-owned firms. Moreover, given that scale economies in the Marshallian districts were low, large firms were not a threat to dominate the district. The Marshallian districts were fairly self-contained units, with limited connections to external firms and a high degree of intradistrict trade based on long-term contracts and commitments between buyers and sellers found within the district. Marshall posited that firms within the district benefited in three key ways: Concentrated firms in the same industry allowed the creation of a pooled labor market, particularly for workers with the specialized skills needed by the industry in question; encouraged the formation and provision of various specialized supporting services needed for the ongoing operation and success of the industry, including maintenance and repair expertise, and "patient capital" offered by institutions within the district; and, facilitated rapid flows of information and ideas between firms in the district, even in the absence of formal cooperation between member firms. This was described by Marshall in his often-cited phrase that "the mysteries of the trade become no mystery; but are as it were in the air..."

The flow of information and ideas between firms in the Marshallian district was facilitated by a high level of inter-firm mobility by workers in the district which translated into a commitment by workers to the district, rather than to individual firms. As well, with limited out-migration of workers, over time the districts developed both a strong local cultural identity and extensive ties between workers. It is noteworthy that the benefits of localizing in the Marshallian district were based on firms drawing on these external economies, and did not require conscious cooperation among firms in the district (Markusen, 1996).

An extension of the Marshallian industrial districts has been the numerous case studies done on clusterings of firms in Italy [the so-called "Italianate" districts, to use the terminology of Markusen (1996)] (Piore & Sabel, 1984; Sabel, 1989; Best, 1990). These districts are groupings of small, highly innovative firms organized along craft-like rather than mass-production principles which have been able to compete in the global marketplace in several industries, including knitwear, ceramics and construction machinery. Members of these districts compete, but also collaborate, in the development of new technologies and methods, and find themselves in rotating roles as suppliers, customers and partners. Contributing to a high level of inter-firm cooperation are extensive networks of institutions that bind otherwise-competing firms together in a variety of activities, such as trade associations, guilds, unions and cooperatives for purchasing materials, marketing regional products, securing credit, and supplying semi-finished inputs.

An essential element of the Italianate district is the competitive focus of firms in the district. As described by Best (1990), firms in these districts are not organized according to traditional mass-production/price-competition principles, but rather are "entrepreneurial," defined as competing on the basis of innovations in products, production process and/or organization. In this context, the district develops a series of consultative and cooperative links between mutually dependent firms. The balance between cooperation and competition is ensured by a network of inter-firm institutions, which not only manage the common programs which member firms agree to but also ensures that competition among members does not degenerate into price-oriented competition which inhibits future investments in innovations.

So influential has the Italianate districts model been that it has become, for some authors, the sole model of industrial districts. For example, Feigenbaum & Smith (1993), in describing the Maryland biotechnology cluster, offer the following definition of an industrial district:

> An industrial district is a set of geographically concentrated, generally monopolistically competitive firms and associated institutions closely connected not only through specialization in subdivided production stages and exchange of intermediate goods and services and other usual linkages, but typically also through exchange of personnel and ideas, making use of joint infrastructure, including basic research, educational and training institutions, to which they contribute in some fashion (p.107).

Notwithstanding the attraction of the Italianate model, Markusen (1996) has identified three other variants of the industrial district which depart from the Marshallian/Italianate paradigm. The first she labels the "hub and spoke district." Internal economies of scale and scope are large in these districts, leading to the presence of one or several large firms which act as anchors or hubs to the regional economy, with suppliers and related service providers fanning out around these hub firms in a spoke-like arrangement. Another key difference between the hub-and-spoke district and the Marshallian/Italianate version is the nature of linkages between firms in the district. In the hub-and-spoke district, the hub firms' most important linkages are with customers, suppliers and competitors outside the district. Though the hub firms are located in the district, they are prepared to deploy their resources wherever their respective strategic plans dictate. Their actual linkages with small firms in the district may be extensive, but they will be on the basis of the latter serving as dependent suppliers to the dominant hub firms. What cooperation there is between the hub firms and their suppliers in the district will focus on upgrading supplier quality. It is also possible that the hub firms will have quite limited linkages to the smaller firms located in the district.

Cooperation among competing firms in the district, an essential characteristic of the Italianate paradigm, is noticeably absent in the hub and spoke district, which lacks some of the shared governance structures that characterize the Italianate model, as well as the readily available "patient capital" for prospective start-ups. In terms of the district's workers, the hub firms serve as the preferred alternative, and workers will readily leave the district's small firms to join the hubs. One important similarity with the Marshallian/Italianate models is that hub-and-spoke districts also develop distinctive local cultures built around the activities of the district. This local industrial culture leads to the development of a substantial body of expertise among the district's workers, and to the formation of specialized business service providers.

The second alternative Markusen offers to the Marshallian/Italianate paradigm is the satellite platform, a concentration of branch facilities of externally-based multi-plant firms. Given that the control centers for plants in the satellite platform are outside of the district, that the plants are usually from a wide range of industries, and that the plants usually buy from and sell to externally-based suppliers and clients, the extent of linkages between firms in the satellite platform district is extremely limited. Not surprisingly, satellite platforms lack the patient capital and shared institutions that are prevalent in the Italianate districts.

The third alternative which Markusen presents is the "state-anchored" district, where some type of public or non-profit institution functions as the key anchor tenant in a district. There are significant economies of scale in such districts, which explains the large size of the anchoring public or non-profit institutions. Given their size, networks of suppliers develop within the district to serve the institutions' needs, and the linkages between the institutions and the local supplier network is generally quite extensive. In contrast to the Marshallian/Italianate models, local firms do not play a key role in state anchored districts. There will not be an elaborate network of governance institutions to stabilize markets and reduce risk. Workers' loyalties will be first to the large institutions and /or large supplier firms in the district, then to the district, and finally to firms.

How and Why are Industrial Districts Formed?

The question of why some regions develop into successful industrial clusters and others do not is complex. Lured by the prospect of creating the next Silicon Valley, governments at various levels throughout the world have used a variety of incentives in attempting to attract and retain firms in a wide range of industries. All too often, these efforts fail to achieve their ambitious goals. To understand what is required to form an ongoing industrial district, it is necessary to understand the internal dynamics of such groupings, and to focus on how these dynamics produce benefits for firms found within them.

A critical environmental factor contributing to the rise of industrial districts has been the dizzying rate of technological advances in the industrialized world. These advances have led to high-technology products accounting for an increasing share of world trade. Between 1966 and 1986, goods classified as "technology intensive" increased their share of world manufactured exports from 14% to 22% (Tyson, 1992). High technology industries are defined by Tyson (1992) as industries in which knowledge is the key source of competitive advantage, and by Scherer (1992) as industries whose output incorporates relatively high levels of R&D inputs, either directly in the final production process or indirectly via the sophistication of intermediate goods used in the production process. High technology industries are particularly attractive to policymakers concerned with economic development. This attraction stems from the well-documented impact which high-technology industries have on wages, productivity and technological development in their respective host economies (Katz & Sommers, 1989; Scherer, 1992).

The growing importance of trade in high technology products has had profound implications for the theoretical basis of trade theory and for the location of particular economic activities. Classical trade theory was predicated on Ricardian comparative advantage theory, refined by Heckscher-Olin and Samuelson, which states that countries specialize in certain goods based on factor endowments, and then trade under conditions of perfect competition and constant returns to scale with other countries who have specialized in other goods and who have complementary needs. However, trade in high technology products frequently consists of intraindustry trade, whereby countries with similar factor endowments exchange goods that are basically similar, under conditions of imperfect competition and increasing returns to scale. An important feature of intraindustry trade is that the goods exchanged are mainly intermediate goods, sold by producing firms to other producers.

Given the homogeneity of national factor endowments for these types of goods, the determination of which country produces what goods for intraindustry trade is primarily driven by attempts by firms to exploit increasing returns to scale (Krugman, 1990; Tyson, 1992; Nopowan, Graham and Markusen, 1993). In fact, the presence of increasing returns to scale is in turn an important explicator of geographical clusterings of firms engaged in the provision of intermediate goods. As noted by Krugman (1991):

> If there were no economies of scale in the production of intermediate

> inputs, then even a small-scale center of production could replicate a large one in miniature and still achieve the same level of efficiency. It is only the presence of increasing returns that makes a large center of production able to have more efficient and more diverse suppliers than a small one (p. 49).

The existence of increasing returns in the production of intermediate products, and in particular of high technology intermediate products, reinforces the attraction of existing industrial districts, resulting in a self-perpetuating cycle. As Elstrom (1997) notes, in describing Silicon Valley:

> With so many tech players in one place, things work better—suppliers and customers can meet faster, info flows more quickly, new ventures are easier to launch. Success becomes a gravitational force, pulling in more people, money, and technology (p.142).

The above discussion still does not address why some areas are able to begin industrial districts, or more particularly, why firms which locate in some regions are able to succeed and serve as the nuclei for subsequent clusterings of firms in the same industry. This question is all the more challenging given that the diffusion of standardized technologies across borders is today quite rapid. As Storper (1992) posits, "...the hardware applied to a given production task in the industries of the major industrial countries is increasingly similar" (p. 64).

Since imitators can rapidly catch up to any competitor employing standardized technologies, how and why is it that firms from some regions prosper on a consistent basis? Dosi, Pavitt & Soete (1990) offer the notion of technological mastery leading to absolute advantages, which they define as advantages based on productivity gaps so significant that they are impervious to input price changes. In particular, they focus on improvements in product technology leading to continuous increases in product variety. This corresponds to what Best (1990) refers to as "the entrepreneurial firm," which he defines as "an enterprise that is organized from top to bottom to pursue continuous improvement in methods, products and processes" (p. 2).

Storper (1992) builds on these notions of the firm to posit that "technological advantage exists when the actors in a given place possess products, processes, and attendant knowledge that permit them to produce better things than other places, or simply permit them to produce goods and services not elsewhere available" (p. 65). The process of continuous innovation which creates an endless stream of new and improved products through a dynamic redeployment of specialized production skills and equipment is referred to by Storper as "product-based technological learning" (PBTL).

Storper then suggests that the linkage between PBTL and industrial districts is built firstly upon the reality that competition on the basis of skill and knowledge increasingly depends on resources that lie outside the boundaries of major firms, and thus are not entirely appropriable by them. However, the obvious solution to this solution—vertical integration, with acquired assets made increasingly specific to proprietary processes in order to minimize costs—is not readily available to firms in industries characterized by rapid technological evolution. Rather, these firms must retain a certain degree of flexibility to avoid "lock-in" and be able to switch to new products and processes as the competition and market dictates. The need to avoid lock-in is underscored by Best (1990), who notes that the entrepreneurial firm "seeks a competitive edge by superior product design, which may or may not lead to lower costs, but it demands organizational flexibility" (p. 3).

The solution to this dilemma is the production network, characterized by a significant degree of vertical (and probably, horizontal) disintegration of the production system, whether inter-organizationally (independent firms) or intra-organizationally (between units of production within a firm). Storper (1992) describes a production network as being "...neither a firm (hierarchy) nor a system of market transactions...it is, instead, a set of units joined in relatively durable relationships through an "organized market" involving some degree of cooperation or, at least, symmetry of power relations" (p. 79). Members of the production network, according to Storper, may not have general purpose assets that permit them to sell their outputs on the open market, yet they may also lack specific assets that are amenable to vertical integration. Rather, he states, "they are specialized to a given range of activities, involving particular competencies on the parts of firms and units" (p. 79). By including some units with high internal scale economies for certain functions or by aggregating several producers in the same sector and thus creating the benefits of external scale economies in lieu of internal economies, the production network thus achieves a compromise between the conflicting needs of cost minimization and avoidance of lock-in outlined above. In other words, the network allows participants to minimize the risks associated with asset specificity while gaining access to new forms of technology through various cooperative arrangements with other network members.

The notion of joint technological development by network members sets Storper's vision of the production network apart from more traditional models of inter-firm relations offered by Coase (1937) and Williamson (1985). In these paradigms of inter-firm behavior, firms engage in relations with other firms in the pursuit of cost minimization. Storper's production network is predicated on the ability of members of the network to draw on other members' resources to generate new innovations while minimizing the risk of "lock-in." In other words, the presence of learning in the so-called PBTL network results, according to Storper, in "more dense" relationships between network members than would be the case if simple Williamsonian cost minimization were the dominant motivator for network adherence. In particular, Storper states that "...where rapid learning is taking place, the transactional structure is likely to involve constant negotiation, renegotiation, and dependence on achieved understandings as the basis of achieving common reinterpretations of new evidence and opportunities" (p. 84). The existence of this ongoing process of learning/negotiation between network members dictates, according to Storper, that the PBTL production network be based on agglomeration, since it is the most effective way to manage these exchanges.

That learning requires an essentially interactive process is further posited by Johnson (1992), who states that the degree to which different skills and types of knowledge are combined and influence each other is a critical determinant of learning. Johnson goes on to say that since innovation depends on learning, "innovation may accordingly be viewed as basically a collective activity: an outcome of communication and interaction between people" (p. 34).

The Nature of Exchanges Among Firms in a District

Florida (1996) found clear evidence of these types of "dense" relationships between manufacturers and their suppliers and customers in the American Midwest. Examining the rates of adoption and diffusion of such new manufacturing techniques as continuous improvement and codependent relations with suppliers, Florida found that clear majorities of the almost 2,000 firms surveyed reported that they interacted with their customers in the early stages of product design, participated in evaluations of their facilities and methods done by customers, delivered on a just-in-time basis to their main customers, and involved their suppliers in the design and development of new products. Florida also found a high degree of concentration and integration among survey respondents and their suppliers, with significant percentages of inputs coming from suppliers located either in the respondent's home state or in the Midwest.

Gertler (1995) focused on the impact of geographic and cultural propinquity on the adoption of advanced manufacturing techniques such as computer-controlled metal-cutting and forming, and robot-assisted injection molding machines, by firms in a variety of sectors in Ontario. Specifically, Gertler examined the linkages between users and suppliers of these technologies. Over half of the respondents reported that proximity to suppliers within the same region (defined as within a 75 km radius) was important in adopting a given technology. This response was based primarily on the ability of nearby suppliers to provide service and spare parts more readily, as well as on the easier communication both in terms of language and logistics offered by colocation of suppliers and users. More significantly, Gertler found that a degree of cultural commonality, defined as "both a shared code of communication as well as a common legacy of industrial practices and institutions" is a critical influence in determining sources of technology adoption. Moreover, Gertler's study found that both users and suppliers felt that the ultimate success of any technological adoption depended on frequent site visits between user and producer, particularly during the installation and initial operation phases of the technology in question. The likelihood of such visits, Gertler found, was inversely related to the distance between supplier and user.

Lundvall (1992) addresses the issues of geographic and cultural propinquity raised by both Florida and Gertler in terms of their impact on innovation. He notes that when certain cultural differences exist between parties engaged in an interactive situation, such as producers and users of an innovation, some types of messages become more difficult to transmit and decode. This is particularly true of complex and rapidly-changing messages, "combining explicit information with tacit assumptions regarding mutual obligations..." (p. 56). These are precisely the types of communication most likely to characterize producers and users of an innovation. Lundvall goes on to make a distinction between incremental and radical innovations. In the former, he argues that the continuous nature of innovation will mean complex and highly changing messages transmitted between producers and users of the innovation. In such a situation, Lundvall argues that geographic propinquity by producers to "advanced" users, and vice versa, can in and of itself be a source of competitive advantage. In the case of "radical" innovation, Lundvall argues that both geographic and cultural closeness between producers and users of the innovation are critical: The lack of established standardized criteria for evaluating the innovation "implies that 'subjective' elements in the user-producer relationships — like mutual trust and even personal friendship—will become important" (p. 58). Meanwhile, the difficulty in adequately explaining the innovation or its benefits increases the need for 'hands-on' experimentation by prospective users, thus increasing the importance of face-to-face contact and thus geographic propinquity.

If a geographic concentration of firms in the context of a PBTL-based production network is the key to competitive success in knowledge-based industries, what factors promote or impede the relationships and exchanges of information essential to giving network members the asset flexibility they require? Does simple geographic propinquity suffice to produce these exchanges? Does the existence of pooled and jointly financed specialized service providers to the industry promote informational exchanges and cooperation among network members? In other words, does the clustering together of a group of firms in the same industry, who form some type of local organization to market their products, train workers, or lobby for local interests, result in the "dense" types of learning-based interchanges referred to by Storper? As Feigenbaum & Smith (1995) note, these type of exchanges reinforce the sense among cooperating firms of sharing a common economic fate.

What factors do promote the give-and-take of ideas and information so crucial to the success of a PBTL network? Sabel (1989) points to the existence of trust between network members, which is established "...through common education and professional experiences, reinforced at times by ethnic allegiances or—cause or consequence of economic success? —local pride" (p. 47). Lundvall (1992) also underscores the importance of trust among members of a network engaged in interactive learning, and notes the corrosive effect that a lack of mutual trust has on the interactive learning process. While common experiences as a builder of trust suggests that biological family ties are necessary in network formation, Sabel points out that professional solidarity can take the place of familial solidarity as the foundation of trust, and hence of significant exchanges between network members.

Storper (1992b) identifies a body of conventions in a given network as being the essential element for ensuring that PBTL occurs among network members. He describes the conventions of a given production network as the "principles of mutual engagement" that are accepted by network participants. These conventions may be explicit or implicit, and constitute the rules and practices that help network participants reconcile differing notions of product quality, innovation, and standards of value. In other words, network members must subscribe to its conventions to feel sufficient confidence to enter into relationships based on learning with other network members.

Policy Implications

The existence of increasing returns to scale and imperfect competition in high technology trade strikes at the key policy prescription arising from Ricardian theory: That free trade will maximize national welfare. In contrast, high technology trade, with its unique conditions, raises the possibility that certain policy measures could shift the composition of international economic specialization in a country's favor by creating comparative advantage (Krugman, 1980). As Skolnikoff (1992) emphasizes:

> Success in technology-intensive trade is determined not by a state's endowment in natural resources or productive land, but rather by the skills of its people, the quality of its science and technology, its capacity for technological innovation, and the effectiveness of policy and management. In short, comparative advantage in technological goods is 'created' by a society through its policies and human abilities (p. 227).

High technology industries, defined as industries in which knowledge is the key source of competitive advantage (Tyson, 1992) are particularly attractive to policymakers concerned with economic development. This attraction stems from the well-documented impact which high-technology industries have on wages, productivity and technological development in their respective host economies.

Inspired by the success of some of the better-known industrial districts, policymakers around the world have tried to find the secret for creating "sticky" industrial districts, defined by Markusen (1996) as the ability of a district to both attract and retain firms. There is, she notes, no magic elixir to governments to instantly transform a region into a "sticky" industrial district:

> In reality, sticky places are complex products of multiple forces: corporate strategies, industrial structures, profit cycles, state priorities, local and national politics. Their success cannot be studied by focusing only on local institutions and behaviors, because their companies (through corporate relationships, trade associations, trade, government contracts), workers (via migration and international unions) and other institutions (universities, government installations) are embedded in external relationships both cooperative and competitive—that condition their commitment to the locality and their success there (p. 310).

Reich (1990) argues that a highly educated workforce is the main anchor for and attraction to knowledge-intensive industries. Reich bases his position on the homogeneity of factor endowments, noted previously. The one factor of production that is not readily transferable across borders is a nation's workforce. It should be noted that the notion that the presence of a labor force with the "right" skill and knowledge mix can shape the nature of economic activities in a region is not new, and has been addressed by several researchers. Jorgenson (1984) examined the contribution of education to economic growth in the United States, finding that about 11% of growth between 1948 and 1973 could be attributed to education. Duffy (1988) attributed many of the competitive difficulties of American firms in the late 1980's to deficiencies in the American educational system, in particular relative to the practices of Japan and Germany. Bishop (1989) focused on the connection between rising (and falling) educational achievement and productivity changes in the United States and found a relationship between educational achievement and labor quality. Puri and Suchon (1987) found significant relationships between post secondary enrollments and both trade balances overall and balances of payments for technological services.

However, as Storper (1995) notes, reliance on improvement of factor supplies, coupled with conservative macroeconomic policies as a putative replacement for more activist policy measures, has had a fairly disappointing record in changing the composition of economic activity in several countries. Even in Japan and Germany, he points out, training and educational systems do not alone explain competitive success of Japanese and German firms in various industries, with both countries relying heavily on a variety of more activist policy measures.

Other researchers have attempted to catalogue the characteristics of successful industrial districts in order to produce lists of the supposedly necessary attributes which a region must offer to attract and retain knowledge-intensive industries. For example, Malecki (1986) found that scientists and engineers preferred to live in urban centers which offered opportunities for both intellectual stimulation and job mobility, while at the same time having an attractive quality of life and efficient infrastructure. Saxenian (1994), in a detailed case study of Silicon Valley and Boston's Route 128, noted the crucial role played by the large research universities and venture capital firms in stimulating the formation of and growth of knowledge-intensive production networks. Storper (1992) notes that while these factors are important, a focus on the readily apparent attributes needed by a region to spawn and develop knowledge-intensive production networks merely leads to a cookie-cutter approach to policy, which can be applied in any circumstance. Rather, he stresses that the processes of innovation and learning are extremely complex and depend not only on discrete, readily observable factors, but on interactions among and expectations of firms and people involved in these processes, in other words, the conventions referred to earlier. In this sense, Saxenian's (1994) case study of Silicon Valley and Route 128 is particularly revealing, in that it juxtaposes the extensive learning that goes on between firms in Silicon Valley to the secretive modus operendi that has developed among firms in the Route 128 district.

These two differing approaches to interfirm relations are, she argues, a direct function of divergent conventions between the two districts.

If the vision offered by Storper and Saxenian is indeed accurate, then the key question for policymakers in terms of how to form and nurture successful geographic agglomerations of knowledge-intensive firms is not what discrete factors have to be built or bought for a given region, but what type of policy measures can be devised which will encourage the "dense" relationships and exchanges among firms in a given area. If such relationships can be encouraged, then the firms in the region can draw on each others' respective strengths and skills to engage in the kind of continuous innovation which is the essence of establishing and maintaining competitive advantage in knowledge-intensive industries. Indeed, this notion that promoting agglomeration of firms in a given industry, with the express purpose of taking advantage of inter-firm learning, could be a legitimate public policy goal and has been embraced by some researchers who have previously been sharply critical of industrial policy initiatives, most notably Krugman (1993).

However, it should be noted that there is not a clear consensus among researchers that this is indeed the optimal direction for public policy. In a survey of almost 1,400 U.S.-based metalworking firms, Harrison, Kelley & Gant (1996) found that sectoral specialization in a given region (defined as a county for this paper) had "almost no" explanatory power in determining whether or not metalworking firms in the region would adopt new programmable automation technology. Similarly, Cornish (1997), in a survey of 168 Canadian software producers, found that the degree to which firms have access to timely and accurate market intelligence is not necessarily positively influenced by location in an agglomeration of firms. She went on to say that given the wide range of product types and markets represented in her study, it was "unlikely" that this finding was unique to the software industry. Porter (1990) diverges from most of the works on industrial districts in his emphasis on unrelenting rivalry and competition between firms as the key determinant of ultimate success. It is only by being exposed to continuous competitive pressure, he argues, that firms will be forced to make the kind of investments that lead to innovations. In this sense, he is in favor of competing firms being grouped closely together but not to foster greater inter-firm cooperation that would tend to reduce competitive pressures. Rather, he advocates promoting regional groupings of firms primarily because such agglomeration leads to even more visible competitive pressure, where the rivalry between firms "often goes beyond the purely economic and can become emotional and even personal" (pp. 118 -119).

Moreover, Porter (1990) argues against public policy initiatives which have the formation of regional agglomerations as an explicit goal. Though conceding that policies designed to offer specialized factors such as research institutes and improved infrastructure can reinforce such clusters once they are formed, he is emphatic that government's role in this area, is to reinforce market forces rather than replace them:

> Government policy will be far more likely to succeed in reinforcing an existing or nascent industry cluster than in trying to promote an entirely new one...Governments have a poor track record in selecting sectors where the subtle conditions for national advantage are present. The presence of an established cluster signals the presence of some favorable determinants of competitive advantage, raising the odds that governmental investments will bear fruit (pp. 655-656).

Lundvall (1992) supports this contention when he states that clusters of users and producers might be "footloose ex ante—small accidents may determine where the first units are located—but ex post—they will become strongly rooted in regional or national networks of user-producer relationships, giving them a comparative advantage in national and international competition" (p. 59).

Indeed, some authors (Evans & Wurster, 1997) have concluded that the need for geographic propinquity to conduct a "dense" relationship has been significantly reduced or even eliminated due to recent advances in information technology. Firms have traditionally faced a trade-off between the need to transmit high volumes of customized information on an interactive basis, and the need to have their information reach large numbers of recipients. The former imperative has been usually satisfied by geographic proximity to information recipients and/or by investment in extensive infrastructures (sales forces, publications, branch networks). The latter imperative has in the past been satisfied by relying on various media that offered extensive reach, but could not carry the customized information or provide interactivity. With advances in communications and information technology, this forced choice has been eliminated and the need for proximity to key recipients of information has been drastically altered. According to this vision, firms have or will soon have the capability to conduct interactive exchanges involving complex information regardless of the location of the intended recipient. However, the scenario which Evan & Wurster outline ignores the critical factor of mutual trust which must be developed for exchanges of complex and highly sensitive information among firms.

CHAPTER FIVE

The "Sound Finance" School of Thought

A significant constraint on S&T policies has been the ascendancy over the past ten years of the "sound finance" school of thought among policymakers in North America. This school of thought mirrors the shift to the right that occurred in American society in the late 1970's and 1980's, and which has occurred in Canada since the mid 1990's. The origins of the movement in the United States can be traced to widespread public disenchantment with the Keynesian policies of the Great Society era (Ginzberg, 1987). Meanwhile, a number of economists in the United States began publishing works that provided a theoretical basis for rejecting activist policy measures, ostensibly on the grounds that such initiatives were inflationary (Lucas, 1981; Sargent, 1986). This hostility to government activism culminated in the United States with the 1994 congressional elections which saw seventy-six new Republicans elected to the House of Representatives on the basis of a promise to drastically shrink the size and scope of the U.S. government.

The shift to the right occurred much later in Canada, but did finally arrive in response to widespread concern over the size of the federal and provincial deficits which had developed during the late 1980's. The result was the election of provincial governments committed to drastic reductions in government spending, notably in Ontario and Alberta, and to the federal Liberal government making deficit reduction its number one policy priority.

The "sound finance" school is based upon a number of misconceptions about government deficits. These include:

1) A government must manage its finances the same way individuals and businesses do: Excessive debt represents a claim by others on the government and so should be avoided.

2) Government deficits will "crowd out" domestic private investment by causing inflation and increasing interest rates.

3) High deficits lead to inflation, since the central bank will tend to monetize the deficit.

4) Deficits represent a burden on future generations: Ultimately, the debt will have to be repaid through increased taxes imposed on future generations.

Each of the above notions is highly questionable yet they have gained a surprising level of public acceptance. For example, many of the definitions of government debt and deficits used in the public discourse have been sloppy at best and simply incorrect at worst (Eisner, 1986; Chorney, 1989; 1996; Heilbroner & Bernstein, 1989). Chorney (1996) notes that the popular press typically cites the gross debt figures, which are derived from the public accounts. However, Chorney states that the more accurate figure for computing the relationship between public debt and GDP is the net debt – that is, public debt less financial assets held by the public sector – which is taken from the public accounts. Using this latter figure, Chorney shows how government debt as a percentage of GDP for the years 1991 through 1993 was dramatically lower for all G-7 countries except Italy. For example, in Canada's case, gross debt/GDP for the three years studied was 77.5%, 83.3% and 88.3%, respectively. In contrast, net debt/GDP for the same period was only 43%, 49.3% and 55.0%, respectively.

The proposition that both governments and individual households must avoid debt since a claim imposed by others overlooks the reality that most government debt in North America is owned by domestic investors. Hence, repaying government debt simply involves a transfer of resources within the polity (Heilbroner & Bernstein, 1989). It should be noted that in Canada, most federal government debt is owned by Canadian investors. However, it is also true that a significant portion of the debt issued by provincial governments and their agencies is held by foreigners. This does raise implications for exchange rate management for the Canadian dollar.

The notion of government spending "crowding out" private investment is simply implausible, given the substantial slack that exists in the Canadian economy, and numerous structural changes in the global economy that militate against a return of high inflation (Chorney, 1989; Pennar, 1993).

In any case, the claim that current levels of public debt are "too high" overlooks the key measure of indebtedness—debt to GNP/GDP—which relates the level of debt to the economy's assets and hence its capacity to repay. Current debt/GNP ratios in both Canada and the United States, while higher over the past decade, are still well below post -WWII highs (Chorney, 1989; 1996; Heilbroner & Bernstein, 1989). While it is true that monetizing government deficits can lead to inflation, the fact is that in Canada monetized debt as a percentage of broadly defined money supply has steadily shrunk since the late 1950's to the point where, by 1989, it stood at only 7.5%. Meanwhile, no significant correlation exists between inflation and monetization of government debt at rates of below 20% of broadly defined money supply (Chorney, 1991; 1996).

Finally, "the burden on future generations" idea overlooks the fact that as governments cut back investments in infrastructure, they not only make their jurisdictions a less attractive place to invest, but also pass the deferred maintenance bill on to the very same future taxpayers they are claiming to protect. As Chorney (1996) states, future generations may pay taxes to finance the debt, but they also inherit the bonds issued to create the debt. More importantly, he continues,

> But they [future generations] also inherit the capital infrastructure in health, education, roads, research and development that are financed by present-day levels of indebtedness. Furthermore, the reduction in the unemployment rate brought about by a programme of deficit-financed investment in public works and investment in the skills and education of people produces capital goods and services that would not otherwise exist (p. 360).

While not advocating wasteful or inefficient government spending, many professional economists have nonetheless demonstrated that a short-term fixation on the level of a government's deficit or debt can result in dysfunctional long-term policy decisions. These decisions actually increase the deficit and accumulated debt by suppressing tax-generating economic activities while overstating the extent of the current problem.

However, despite the shaky theoretical foundations of the sound finance school, it has come to dominate the public policy discourse in both Canada and the United States over the past few years, with major consequences for S&T policy. For example, in Ontario, the Progressive Conservatives under Mike Harris won a strong majority government in the June, 1995 provincial elections, and was re-elected in 1999. The heart of the Conservative campaign was a promise to reduce provincial spending by $6 billion, introduce a 30% cut in the provincial income tax over three years, and balance the province's budget by the year 2001. Between July and November of 1995, the Harris government announced cuts of almost $2.8 billion dollars to provincial spending. Though social services bore the brunt of the cuts, numerous S&T programs also were reduced or eliminated.

These cutbacks to Ontario S&T programs were announced without any analysis on the part of the government on the relative impacts of various government expenditures, or on the economic activity and subsequent tax revenue generated by provincial S&T initiatives. Cuts were generally announced on an across-the-board basis, with S&T lumped together with a variety of social programs and subsidies under the heading of "handouts" that had to be eliminated by a fiscally responsible government. In announcing the November 1995 round of cuts, the Minister responsible for economic development repeated the "sound money" argument against S&T initiatives:

> We intend to get spending under control and reduce the burden of debt. We believe that getting our financial house in order will put the province on the road to prosperity....Economic growth is not created through government assistance. We are not in the business of giving corporate hand-outs or grants to businesses. We simply cannot justify using public funds to give one company an advantage over another. We have no alternative but to significantly reduce our spending and strictly control our expenditures. We must put our fiscal house in order to restore economic growth in Ontario (Canada Newswire: Government of Ontario Press Release, Nov. 2, 1995).

The Ontario government's tendency to label all forms of assistance to industry as "hand outs" that are inherently wasteful was demonstrated in the case of the McDonnell Douglas wing assembly plant in Mississauga, Ontario. In response to the company's announcement that it might shift up to one-quarter of the jobs at the plant overseas absent federal or provincial government help in making process improvements at the facility, a spokesman for the Harris government simply repeated its opposition to business subsidies. He then added that "if they [McDonnell Douglas] can get money out of this government, they'd be doing something nobody else could do" (Fitzpatrick, 1996, p. 14). [The controversy was ultimately resolved when Boeing took ownership of the plant as part of its 1997 takeover of McDonnell Douglas. In June, 1998, Boeing announced that it was discontinuing production of the MD-11 model and that the Mississauga plant would be shut down by the end of 1999].

A more dramatic example of the impact of the sound finance school on S&T policy concerns the federal Defense Industry Productivity Program (DIPP), discussed in Chapter 6.

CHAPTER SIX

The Worldwide Aerospace Industry

Definition

There is a certain degree of confusion regarding the definition of the "aerospace industry" and the issue of which firms and types of activities should be included under this rubric. Part of this confusion stems from common practice of using the term "aerospace industry" synonymously with "aircraft industry." The "aircraft industry" refers to firms that fall under Standard Industrial Classification (SIC) code 3211, the Aircraft and Aircraft Parts Industry. This definition encompasses firms that manufacture aircraft and aircraft assemblies, engines, equipment and parts, and/or offer repair services for aircraft, aircraft engines or aircraft parts (Industry Canada, 1995). American studies of this industry refer to it as the "aeronautics industry" (United States General Accounting Office (GAO), 1994).

However, not all of the equipment which goes into an aircraft is produced by firms in the "aircraft industry," as defined by SIC code 3211. For example, avionics such as electronic navigational equipment and various on-board control systems are produced by firms classified within SIC code 3359 (Other Electronic Equipment Industries) or SIC code 3361 (Electronic Computing and Peripheral Equipment Industry). Various parts of the airframe and engine may be produced by firms in SIC 2999 (Other Rolled, Cast and Extruded Non-Ferrous Metal Products Industries). As well, pieces of parts which go into an aircraft may have been formed and shaped by firms in SIC 3081 (the Machine Shop Industry). Finally, equipment and devices essential for monitoring various stages of the production process for aircraft and aircraft parts may be produced by firms included in

SIC 3911, Indicating and Recording Industry. Given the rather narrow scope of the term "aircraft industry" when defined only by SIC code 3211, there is some merit to the American term "aeronautics industry," which is defined as having three components—airframe, engine and equipment (GAO, 1994).

The "aerospace industry" is a term commonly used in the popular press, trade journals and some internal industry documents. It is meant to refer to firms engaged in the "aircraft industry," as well as to firms who produce space- and missile-related items, together with firms offering equipment related to the production, operation and maintenance of aircraft (Industry Canada, 1995). In Canada, the "aircraft industry" represents approximately two-thirds of the employment, output and exports of the Canadian aerospace and defense-related industries (Industry Canada, 1995).

Notwithstanding the rather broad scope of the "aerospace industry" definition, this paper uses the term in lieu of the statistically neater but more restrictive "aircraft industry" definition. This is in recognition of the important place which several Quebec-based firms such as CAE Electronics and a host of SME's play in the "aircraft-related" sector, as well as the fact, alluded to above, that many essential components of modern aircraft are produced by firms not categorized under SIC code 3211. However, given that the Canadian aerospace industry is dominated by firms engaged in the "aircraft industry," the discussion of industry dynamics will concentrate on trends in this field, and less attention will be given to firms engaged in space- and missile-related activities.

Industry Structure

The worldwide aircraft manufacturing industry is characterized by a well-recognized hierarchy, which is based on successive levels of skills and resources. At the apex of the industry are a small number of prime manufacturers ("primes") which are able to design, integrate, gain regulatory certification for and ultimately market complete aircraft. The primes' skill rests in being able to coordinate a highly labor-intensive integration of literally thousands of parts from a diverse supplier base into an extremely complex final product. Primes must also establish a global marketing network and an effective product support system. As discussed below, these tasks must all be done in an environment characterized by high financial, technological and market risk (Industry Canada, 1995).

Below the primes are a more numerous group of second-tier supplies of proprietary subsystems, such as wing assemblies, landing gear or engines. Second-tier suppliers add value for the primes by offering highly specialized engineering skills related to their respective subsystems and extensive knowledge of state-of-the-art manufacturing and advanced materials technologies, as well as by coordinating their own diverse supplier bases and integrating the parts from these suppliers into the subsystems (Industry Canada, 1995).

Suppliers in the third-tier do not require capabilities in the areas of design, parts integration and marketing. These firms operate on a "build to print" system. They add value to the primes and second-tier suppliers by developing competencies in advanced manufacturing techniques so that they can be certified as eligible suppliers to the industry. Such certification requires state-of-the-art manufacturing capabilities, ability to work with advanced materials and extensive record-keeping systems to monitor quality control. These requirements also apply to those third-tier firms involved in repair and overhaul (R&O) of aircraft and aircraft engines (Industry Canada, 1995).

Entry barriers into the industry are quite high. These generally stem from the massive R&D investments typically required, coupled with the long pay-back period which producers must confront. New products generally require three to five years of significant R&D investment before they are ready for market. Annual cash flow from operations typically only turns positive seven to nine years into the life of a new aerospace product, while cumulative net cash flow generally only becomes positive after fifteen years (Aerospace Industries Association 1996A, Industry Canada, 1995).

Compounding the risk and raising the barrier to new entrants is a recent trend which has seen customers, particularly the military, becoming increasingly price-conscious. This has meant that suppliers are now under intense pressure to focus on design and process improvements that can shorten development and manufacturing cycle times, allowing them to bring new products to market sooner and at reduced cost (Industry Canada, 1996).

While there are extensive entry barriers for each tier, it is important to note that a not uncommon pattern in the industry has been for firms to begin as third-tier R&O providers, typically to support a major equipment acquisition by a public sector entity such as the military or a state-owned airline, and then to progress on to parts manufacture. Some of the firms making this transition have then gone on to acquire competencies in design and development of proprietary products. Finally, some of these firms may continue to develop their skills to the point where they are able to integrate parts from their own diverse supplier base and offer a complex system or sub-system (Industry Canada, 1995). However, those firms who do not make the ultimate step to developing and marketing their own proprietary products may nonetheless have broadened their skills to the point where they can bid on work associated with a wide range of aircraft types. These firms can therefore compete in global markets for certain types of jobs. Not surprisingly, given the relatively smaller number of firms able to produce proprietary products, the fiercest competition exists at the level of second- and third-tier firms who have limited their activities to build-to-print operations.

Demand Patterns and Forecasts

The market for aerospace products is characterized by a high degree of risk. Demand for aerospace products is highly volatile, with civilian aircraft sales a direct function of the demand for air travel, which is turn depends on disposable income and the state of the business cycle. Meanwhile, sales for military-related items are a function of government budgetary considerations and a wide range of political considerations. An illustration of the tight connection between orders and the state of the economy is the rate of orders for new commercial airplanes, which rose dramatically through the late 1980's, going from just over six hundred units in 1986 (7% of the world airline fleet) to almost seventeen hundred units in 1989 (almost 21% of world fleet). Following the onset of the post-Gulf War recession in 1990, orders collapsed, dropping to just over one thousand units in 1990 (10% of world fleet), and bottoming out at fewer than one hundred units at the height of the recession in 1993 (less than one percent of world fleet). With the onset of the recovery in 1993-94, orders began to rise again, going back to almost one thousand units (9% of world fleet) by 1996 (Boeing, 1997A).

Forecasts for the industry are at present quite optimistic. Annual deliveries of commercial jets with one hundred or more seats are expected to increase from about 400 units in 1996 to between 700 and 800 units in 1998 (Boeing, 1997A). Longer term, the market for new commercial jets is equally bullish. The world airplane jet fleet is forecast to grow from the current 11,500 units to almost 17,000 units by 2006, and 23,600 units by 2016 (Boeing, 1997b). Altogether, some 16,160 new commercial airplanes are expected to be sold over the next twenty years, with a combined market value of some $1.1 trillion U.S. (Boeing, 1997b)

The market for civilian aircraft is generally broken down into the following segments: Large commercial jet transports, defined as those seating 100 or more passengers; regional jet transports, which seat less than 100 passengers; turboprop or commuter aircraft, which seat between 15 and 75 passengers; and general aviation, which includes corporate aircraft, helicopters, personal-use and utility aircraft (Industry Canada, 1995). For 1996, total deliveries of aircraft worldwide (excluding sales of subsystems, subcomponents, parts, and repair and overhaul services) were estimated at $U.S. 70 billion, allocated as follows:

Military aircraft: 38.5%
Large commercial jets: 47.1%
Regional/commuter aircraft: 6.4%
General aviation: 8.0% (Industry Canada, 1996).

Several developments and trends have contributed to an optimistic outlook for the industry over the next decade. World airline operating profits have recovered from their 1990-92 collapse, and were estimated at close to $18 billion in 1996, almost double the previous high of $10 billion attained in 1988 (Boeing, 1997a). This dramatic turnaround is attributed to a strong macroeconomic climate, continuing increases in air traffic, and ongoing efforts by airlines around the world to improve operating efficiencies (Boeing, 1997a). World airline traffic rose by 6.7% in 1996, a significant increase over the 5.5% average annual growth which characterized traffic worldwide between 1991 and 1995 (Boeing, 1997a). This increase has been primarily attributed to strong increases in Asia-Pacific traffic.

In contrast to Asia-Pacific carriers, who have responded to the increase in traffic of the mid-1990's by adding capacity, airlines in Europe and the United States have accommodated greater numbers of air travelers by increasing load factors. This increase has, in turn, contributed significantly to the strong profitability increases of European and American carriers (Boeing, 1997a). Moreover, historical experience has shown that airlines in general find it more lucrative to handle added demand for air travel by increasing flight frequencies and offering new city-pair services rather than putting larger-capacity planes on existing routes (Boeing, 1997b). In other words, airlines generally favor frequency over aircraft size (Boeing, 1997b). This, too, contributes to optimism over future aircraft orders.

Adding to the generally bullish outlook for the aircraft industry is the ongoing need of carriers to replace a significant portion of their fleet. Part of this replacement is targeted at the large number of aircraft added in the 1960's, which are today increasingly costly to operate (Boeing, 1997a). Secondly, American and European carriers are faced with rapidly-approaching deadlines to attain Stage 3/Chapter 3 noise limits. To comply with these limits, airlines must either replace or retire older models, or replace the engines on older planes (referred to in the industry as "hush-kitting"). There are indications that airlines, particularly in Europe, prefer to replace older models with newer, quieter and more fuel-efficient models rather than resorting to hush-kitting

(Boeing, 1997a).

The combined effect of the above trends is an anticipated increase in the world fleet of commercial jets from 11,500 at the end of 1996 to almost 17,000 by 2006, and over 23,000 by 2016 (Boeing, 1997b). This translates into a combined market for various forms of commercial jets of approximately U.S. $490 billion between 1996 and 2006, and almost U.S. $1.1 trillion between 1996 and 2016 (Boeing, 1997b).

The buyers for aircraft are generally either airlines, armed forces or large corporations. These buyers tend to be highly sophisticated and demanding in terms of their demands for performance, quality and safety. Second- and third-tier suppliers selling to primes are therefore subject to at least the same level of demanding specifications as those imposed on the primes by their buyers. Moreover, buyers for aircraft tend to have the power to demand favorable purchasing terms. This stems from the fact that aircraft orders from each airline customer are infrequent and quite sizeable (Industry Canada, 1995). Orders from large corporations for business aircraft and from smaller commuter airlines are not as large as those placed by larger airlines. Still, these buyers tend to have some power over suppliers given the prospect of subsequent sales of spare parts and replacement aircraft and the highly competitive nature of these markets (Industry Canada, 1995).

Collaboration in the Aerospace Industry

Given the high level of R&D expenditures and extreme market volatility which characterize the aerospace industry, firms in the industry have increasingly looked to collaborative arrangements as a way of reducing risk as well as pursuing other objectives.

These strategies have been pursued in two broad areas: More extensive relationships with key suppliers; and international collaborative efforts (Industry Canada, 1995). Regarding the former, second-tier suppliers have increasingly been asked to become "risk-sharing partners." In previous traditional buyer-supplier relationships, second-tier suppliers were able to recoup at least some of their initial non-recurring investment in a new system early in the program under terms of the supplier contract. These contracts also usually obligated the purchaser, which was typically a prime, to buy a stipulated number of components or systems, regardless of final demand for the aircraft. In contrast, the new "risk-sharing partner" arrangement means that second-tier suppliers will be bearing the same market risk as the prime manufacturer and will only be able to recoup their non-recurring investment if the program in question is successful. Similarly, demand for the component or system being supplied will be a direct function of market demand for the entire aircraft or system rather than of any predetermined figure stipulated in the supply contract (Industry Canada, 1995).

Both "risk-sharing partner" relationships and various international collaborative arrangements represent forms of formalized collaboration which, according to Anderson (1995), encompass a broad range of short-term and long-term arrangements that lie between outright merger/acquisition and arms-length market transactions. As Anderson (1995) notes, collaboration involves the externalization of some elements of the production process, though the commitment to externalize does not involve the complete sharing of operations that would occur in a merger or acquisition. Collaboration can be, according to Anderson's (1995) taxonomy, research-oriented, technology-oriented, or market-oriented. Research-oriented collaboration is intended to pool efforts and resources involved in R&D; technology oriented collaboration is aimed at technology sharing, co-operative production arrangements, or various customer-supplier agreements; market-oriented collaboration aims at attaining synergies in distribution, service, and market-access. Anderson points out that firms who combine different phases of the production process are in effect attaining a form of quasi-vertical integration, while firms who develop relationships within the same mode of collaboration (e.g., two firms who pool production technologies and resources to share new process innovations) attain a form of quasi-horizontal integration. Anderson (1995) studied over 500 collaboration agreements in the global aerospace industry which were concluded between 1980 and 1990 and found that more than 80% of them involved research and/or technology development. In contrast, only 16% of the agreements covered in Anderson's study were based on some form of market orientation.

Dussauge & Garrette (1995) approached collaboration in the aerospace industry by focusing on horizontal relationships between competitors, studying international strategic alliances and joint ventures created between 1950 and 1990. They identified four classes of alliances: R&D agreements, where various aspects of the research effort are allocated to different partner firms; Unstructured Co-production Projects, where no new legal entity is created, and specific modules of the development and production process are allocated to partner firms while both carry out marketing in their respective areas; semi-structured projects, which also involve assigning particular modules of development and/or production to specific partner firms but which include the creation of a separate legal entity to handle sales and marketing; and business-based ventures, where the entire business is assigned to a separate legal entity, which in turn is generally dominated by one of the partners.

CHAPTER SEVEN

Government Policy and the Aerospace Industry

Governments around the world have traditionally considered the aerospace industry critical to national interest, and hence worthy of extensive government involvement in various forms. The importance attached to the industry has stemmed from many factors. Firstly, there is the obvious national security link in terms of the industry's defense-related output and its contribution to a country's national defense efforts (Industry Canada, 1995; Aerospace Industries of America (AIA), n.d.). The national defense linkage alone has been a sufficiently strong reason for governments in several countries to support the development of indigenous aerospace industries (Aerospace Industries Association of Canada (AIAC), 1992). Beyond the national security connection, there are other factors which have propelled governments to intervene in the aerospace industry. The industry's output represents a key link in a nation's transportation system (AIA n.d.). The industry's key role in the transportation network has made many countries reluctant to find themselves totally dependent on foreign aerospace suppliers (AIAC, 1992). For example, while recognizing that subsidies can distort the marketplace, the European Community/Union has permitted extensive subsidization of the Airbus consortium by several European governments. One of the rationales adopted by European officials has been that subsidies to Airbus will ensure the continued survival of a major competitor in the jetliner business, thus serving the "general interest" (AIAC, 1992).

The economic impacts of the industry are also considerable, and are not lost on policymakers. The industry offers high-value-added, high-skill and high-wage jobs. It is also a major producer of new technologies which are often disseminated to other industries in a country (Industry Canada, 1995). The aerospace industry is heavily export-oriented and is major contributor to the balance-of-payments of all major producing countries .

Finally, the element of national prestige should not be overlooked. Indigenous aerospace production is considered as confirmation that a country has attained the pinnacle of economic development. Many governments are determined to capture the "high tech" cachet of the industry and extend it to other exports (Industry Canada, 1995; AIAC, 1992).

Forms of Government Involvement in the Industry

Direct Government Procurement

Governments have been most active in the aerospace industry in their roles as purchasers of a substantial share of the industry's output, primarily for military use. These purchases have influenced the industry in the following ways:

i) Government funding for development of aircraft such as military tankers and transport has subsidized manufacturers of civilian passenger and transport models. It is frequently claimed, for example, that both the Boeing 707 and 747 were originally developed for the United States military (the 707 was sold to the military as the KC-135 tanker, while the 747 was designed to be a troop carrier). According to this argument, U.S. Department of Defense (DoD) funding enabled Boeing to design, develop and test the prototypes of both models, which were then modified to meet civilian market requirements. U.S. industry spokespeople strongly deny the validity of this scenario, and insist that all American producers fund development of civilian products with private funds, and that civilian and military businesses are kept highly segregated. Moreover, they deny the plausibility of this charge, given the divergence in mission and performance requirements of military and civilian models (AIA, n.d.).

ii) Government purchases of military products result in higher volumes, thus allowing domestic vendors to lower unit costs on civilian products.

It is also argued that by allowing domestic vendors to allocate overhead over greater volumes, government procurement of military products gives domestic aerospace firms access to economies of scale they otherwise would not have. Moreover, by sharing production facilities between civilian and military products, domestic vendors can realize significant economies of scope. This scenario is acknowledged by U.S. producers, though they insist that its importance has been overstated (AIA, n.d.).

iii) Military and civilian programs may share a common technology and production base, resulting in significant savings to domestic firms who produce for both the military and civilian market.

Advocates of this point of view compare it to the KC-135/707 case, noted above, as well as to both General Electric and Pratt and Whitney, whose successful large jet engine lines were, until recently, based entirely on spinoffs of models developed for and sold to DoD (Industry Canada, 1995). Again, American industry representatives strongly deny the validity of this scenario, noting the wide discrepancy in technologies required for the military and civilian markets (AIA, n.d.). In fact, contrary to past trends, the flow of ideas and technologies has increasingly been going from the civilian market to the military sector (AIA, n.d.; Branscomb, 1993).

Government procurement of aerospace products has not only taken the form of military purchases. Until recently, public ownership of major national airlines was the norm throughout most of the world. For example, European state-owned airlines have often found themselves under direct political pressure to purchase Airbus aircraft (Letovsky, 1993).

Direct Government Ownership

In instances where governments have been unwilling to see domestic aerospace firms collapse, with the attendant loss of jobs and skills, they have not hesitated to step in and take direct stakes in major producers within their borders. For example, both the British and French governments have owned and provided financing for British Aerospace and Aerospatiale, respectively.

Direct Subsidies for R&D

Various forms of subsidies for R&D have been the most widespread and controversial modes of government involvement in the industry. The ongoing imperative for heavy R&D expenditures, coupled with long payback periods, noted above, have created a powerful motivator for aerospace firms to seek government financial assistance, particularly in the early stages of product development. This assistance has taken the form of grants, tax reductions, soft loans and/or government loan guarantees. Many governments have supported aerospace R&D to develop technology and products for national security (GAO, 1994). As well, governments of several nations have provided "launch aid" to help domestic firms with the high costs of designing, producing and bringing to market new civil aircraft and engine models. For example, different sources have estimated the amount of launch aid given to the Airbus consortium by various European governments at between $7 and $13 billion (AIA, n.d.; AIAC, 1992). This aid has been primarily in the form of success-dependent loans, repayment of which coming from a percentage of the profits realized once a pre-established number of aircraft was sold. European governments have long claimed that such a repayment mechanism negates any charges that the launch aid is a subsidy. However, U.S. government studies revealed that, as of 1993, Airbus had repaid only $3.5 billion of the over $13 billion in launch aid which it has received since the early 1970's (GAO, 1994).

Under the auspices of the General Agreement on Tariffs and Trade (GATT), some twenty countries with firms in the aerospace industry negotiated the GATT Civil Aircraft Code in 1979. This code was basically a free trade agreement for the industry, eliminating all tariffs on civil aircraft, their parts and components, civil aircraft engines and flight simulators. The agreement also attempted to prohibit forced licensing requirements and discriminatory procurement, though some observers questioned whether it ever really achieved these latter two objectives (AIAC, 1992). With regard to subsidies, the 1979 Aircraft Code did establish that subsidies granted for research and pre-competitive development could trigger countervailing duties. However, the Code did not include a prohibition on subsidies to domestic aerospace firms. The participants in the 1979 Code agreed to deal with this issue in the context of the multilateral subsidies code that was to be negotiated as part of the subsequent GATT round, the so-called

Uruguay round. This decision meant that just as GATT opened up the aerospace industry to a significant increase in competition by eliminating tariffs in the industry, it did not attempt to impose any discipline on producing countries that may have been tempted to subsidize their domestic firms to exploit the new opportunities (AIAC, 1992).

The Agreement on Subsidies and Countervailing Measures (SCM), negotiated as part of the Uruguay round, continued to make research and pre-competitive subsidies for civil aircraft development actionable (i.e., they could trigger countervailing duties), but, in an important change, direct forgiveness of royalty-based loans due to project failure was no longer actionable. Under the terms of the Agreement, any subsidy greater than 1% ad valorem, and which resulted in demonstrable injury to an importing country's market, could trigger countervailing duties. Moreover, subsidies which resulted in injury in third markets could be actionable at any level of subsidy.

According to U.S. industry sources, subsidies for R&D in the aerospace industry result in several distortions to the marketplace. Firstly, basic go/no-go decisions are heavily skewed by subsidies. For example, between the end of WWII and 1995, U.S. commercial aircraft makers launched 11 new programs which made just over 7,700 deliveries, or an average of over 700 units per program. In contrast, European aircraft makers had 10 program starts with 1,581 deliveries, or an average of only 158 aircraft per program (AIA, n.d.). Secondly, by eliminating the need to meet market-oriented borrowing criteria, subsidies allow a recipient firm to come to market much earlier than would otherwise be the case. This means that a subsidized firm can sustain its R&D efforts for a new product and bring the product to market before any sales have been received for the model in question. This first-to-market advantage could, in turn, allow the subsidized firm to define the terms of competition for the model in question. Finally, by eliminating the need for market-based borrowing, subsidized firms can continue producing inventory in the face of downturns in demand, thus exerting downward pressure on prices.

Financing Assistance

Given the large R&D expenditures which characterize product development in the industry, aerospace firms have always been aggressive exporters. The availability of government-supported export financing has, in turn, always been a critical piece of the marketing mix for aerospace firms. Being able to offer prospective foreign customers long-terms loans at favorable interest rates has traditionally been a critical factor in selling major aircraft or engine models, as it is ultimately factored into buyers' pricing calculations. So important is this source of government support that, for many years, the United States' official export financing agency, the Export-Import Bank of the United States, was known unofficially as "the Boeing Bank."

CHAPTER EIGHT

The Canadian Aircraft Industry

The aircraft industry in Canada dates back to the opening years of World War I when Curtiss-Wright of the United States established an aircraft assembly plant in Toronto. Through the 1920's and 1930's, various American and British firms set up assembly and R&O plants and facilities in Canada. These included Pratt & Whitney, de Havilland and Vickers. Meanwhile, a variety of firms engaged primarily in the manufacture of other forms of transportation equipment, including ships, trams, buses and railway cars, and set up their own aircraft manufacturing and/or R&O plants in various locations across the country.

World War II marked a seminal point in aircraft production in Canada. Employment skyrocketed, from barely 1,000 in the mid-1930's to over 75,000 by 1943 (Industry Canada, 1996). This coincided with a rapid gearing up of Canadian production which ultimately supplied over 10,000 aircraft of various types to the Allied war effort. The huge increase in output of the 1938-1943 period also marked the direct entry of the federal government into management and ownership of several Canadian aircraft producers (see below).

By 1943, employment in the Canadian aircraft industry was already in steep decline (Industry Canada, 1996). As the war ended, several Canadian manufacturers and a number of foreign-owned plants, such as Boeing in Vancouver and Fairchild in Montreal, were closed, while the two firms taken over by the government during the war were privatized. One of these, Victory Aircraft (formerly National Steel Car, based in Malton, Ontario) was purchased by A.V. Roe of the United Kingdom, while the other, Canadair (formerly Canadian Vickers in Montreal) was sold to General Dynamics of the U.S.

However, military demand associated with the Korean War and Cold War tensions drove output and employment back up strongly, beginning in the late 1940's and continuing until the late 1950's. During this time, both Canadair and de Havilland engaged in several large-scale licensing contracts based on American-designed aircraft to fulfill both Canadian and U.S. needs.

In addition to supporting the Canadian aerospace industry by procuring directly for its own defense needs, the Canadian government negotiated the U.S./Canadian Defense Production Sharing Program, under which Canadian suppliers could bid for U.S. DoD contracts on an equal footing with American firms. This program was supplemented in 1963 by the Defense Development Sharing Agreement, under which Dod agreed to provide at least 25% of R&D costs undertaken by Canadian firms on selected projects intended for U.S. and/or Canadian defense needs.

The increase in output to meet the needs of the Korean and Cold Wars saw the development and growth of cutting edge design and production capabilities in Canada. These were based primarily on the skills and aptitudes brought to the country by a sizable group of skilled tradespeople and aircraft engineers who emigrated from Europe after WWII. This nucleus of talent soon began to produce a number of state-of-the-art product offerings, including the first North-American designed commercial jet, the Avro Jetliner, launched in 1949 (though ultimately unsuccessful); Avro's CF-100 all-weather long range interceptor for the RCAF; Canadair's Northstar transport aircraft (a modification of the Douglas DC-4, and purchased in large numbers by Trans-Canada Airlines); and de

Havilland's DHC-2 Beaver (1947), DHC-3 Otter (1951) and DHC-4 Caribou (1958), all of which incorporated short take-off and landing (STOL) technology (Industry Canada, 1996).

In the mid-1950's, Avro began development of a new supersonic interceptor that was to have far-reaching consequences for the direction of the Canadian aircraft industry. The plane, the CF-105 Arrow, was intended to be used by the RCAF to intercept Soviet bombers should they attack North America. Unveiled on October 4, 1957, the Arrow promised to be the most advanced in the world, and with the new specially-designed Iroquois engine being developed for the plane by Orenda Aircraft of Ontario, would ultimately be capable of Mach 1.98 (nearly twice the speed of sound), unprecedented at that time. However, in 1959, John Diefenbaker's Conservatives were elected to government on an austerity platform. Diefenbaker cancelled the $400 million Arrow program, opting to purchase some $200 million worth of Bomarc missiles from the United States for the air defense role originally planned for the Arrow. The results of the cancellation for the Canadian aircraft industry were, in the short term, devastating since 14,500 Avro employees were fired (Johnson, 1997). These included many of the best and the brightest aircraft engineers and tradespeople in the world. For example, the Arrow's chief engineer, James Floyd, moved to the UK, where he worked on development of the Concorde supersonic jet. Another 26 Avro engineers moved to the U.S. to work for the National Aeronautics and Space Administration (NASA) on the Gemini and Apollo space programs. One of this group also went on to become one of the designers of the space shuttle (Johnson, 1997). As a result of the cancellation of the Arrow, employment in the aircraft industry in Ontario alone fell from 21,400 in 1958 to

8,400 in 1960, and the Canadian industry went into a fifteen year decline that lasted until the mid-1970's (Industry Canada, 1996).

However dramatic the impact of the Arrow cancellation was on the Canadian industry in the short-term, the long-term consequences were actually quite beneficial. The Canadian industry realized that to survive, it would have to reduce its dependence on Canada's defense establishment, and focus instead on developing proprietary products for the civilian market. Since the Canadian civil market was quite small, this meant developing products that would be accepted in the global marketplace.

The early and mid-1960's saw de Havilland introduce the DHC-6 Twin Otter which incorporated the new PT6 turboprop engine developed by Pratt & Whitney Canada, with both products gaining wide acceptance among foreign buyers. Canadair, though still focused on fulfilling Canadian military requirements, developed the CL-215 water bomber. Also during this period, Douglas Aircraft of the U.S. purchased the former A.V. Roe facilities in Malton, Ontario and converted them into a build-to-print plant for production of wings for all its DC-9 and later, DC-10 models. Canada's network of second-tier suppliers was further strengthened in 1972 when Boeing opened a significant parts production facility in Winnipeg.

The late 1960's to mid-1970's were characterized by precipitous declines in output and employment at Canada's two prime airframe producers, Canadair and de Havilland. Neither of the companies' foreign owners (General Dynamics of the U.S. and Hawker-Siddeley of the UK, respectively) were willing to support the investments needed to create new products. Faced with the risk of both firms going out of business, resulting in a loss of talent and expertise similar to that which followed the Arrow cancellation, the federal government purchased both of them between 1974 and 1976.

Starting in the mid-1970's, the Canadian aircraft industry began to pull out of its prolonged period of decline. Backed by more than $3 billion of federal government funding, de Havilland developed and successfully introduced the Dash 7 and 8 turboprop commuter aircraft, while Canadair brought out the Challenger executive jet. Between 1976 and 1981, employment in the industry increased from just under 24,000 to almost 40,000 (Industry Canada, 1996).

Further boosts to the Canadian industry occurred in the 1980's. In 1980, the federal government purchased 138 F-18 fighters from McDonnel Douglas. As part of an extensive offset agreement associated with the F-18 acquisition, major technology transfers were made by McDonnel Douglas to a group of Canadian-based firms, led by Canadair, who were to be involved in maintenance of the planes. Then, in the mid-1980's, Bell Textron of the United States opened a major production facility at Mirabel, Quebec and gave it a world product mandate for all the company's civilian small helicopters. This mandate has since been expanded to the point where all of Bell's non-military output is concentrated at Mirabel. In 1986, the federal government privatized both de Havilland, which it sold to Boeing, and Canadair, which was sold to Bombardier. This latter sale proved to be quite significant for the Canadian industry, as it gave Bombardier, previously a maker of light rapid transit rail cars, an entree into the aircraft industry. The company expanded this beachhead in 1989, acquiring Short Brothers of the UK and Learjet of the U.S.

Bombardier's rapid acquisition of aerospace expertise created a momentum for the company. In 1990, its Canadair subsidiary launched the Regional Jet program. In 1991, Bombardier announced the launch of its Global Express executive jet, capable of flying nonstop from New York to Tokyo. In 1992, Bombardier's dominant position in the Canadian aerospace industry was strengthened when the company acquired de Havilland from Boeing.

The extent of the recovery of the Canadian aircraft industry from the depths of the early 1970's is apparent from a cursory review of output and employment statistics. From some 96 firms employing just over 23,000 employees earning $221 million of salaries and wages and producing $486.9 million in output in 1979, the aircraft sector has grown to some 193 firms in 1995, employing just under 39,000 workers earning $1.87 billion in wages and salaries and producing some $7.24 billion worth of finished goods (Industry Canada, 1995).

Most firms in the Canadian and Quebec industry are third-tier firms. They tend to be Canadian-owned, employ fewer than fifty employees, and sell the bulk of their output to Canadian customers (Industry Canada, 1995). The industry is considered to be "moderately" concentrated, with twenty percent of firms which employ more than 100 workers accounting for over 90 percent of total industry employment and output (Industry Canada, 1995).

The Quebec sector consists of approximately 215 firms, mainly centered in and around Montreal. The two primes are Bombardier, with its Canadair unit in Montreal producing the Regional Jet (RJ) and Challenger executive jets, and Bell Helicopter Textron, of Mirabel, producing civilian helicopters. The main second-tier firms are Pratt & Whitney Canada (turbojet and turboprop engines) and Allied Signal-Montreal (fuel control systems).

CHAPTER NINE

Federal Government Policies for the Aerospace Sector

The Defense Industry Productivity Program (DIPP)

The Defense Industry Productivity Program (DIPP) was established in 1959 to develop defense-related and civilian aerospace industries in Canada and ran until terminated by the federal government in 1995. The program was a response to the high level of direct and indirect support which foreign governments were giving to their defense contractors and aerospace firms, and to the high level of technical and financial risk which has characterized the development and sale of strategic and aerospace goods. DIPP was administered through Industry Canada. It offered to firms conducting defense-related R&D and/or production in Canada financial support referred to as "contributions," for the following purposes:

i) R&D costs, including engineering, materials, testing equipment and CAD equipment and systems;
ii) Source establishment, including engineering studies, CAD/CAM systems applied to manufacturing and production, and costs associated with experimental production;
iii) Capital assistance, including facilities modernization or the purchase of advanced machine tools or others machines or systems that improve production efficiency;
iv) Market feasibility, including the costs of marketing research and costs associated with user sampling.

It is important to point out that compliance with DIPP eligibility criteria did not assure automatic funding. DIPP publications pointed out that "DIPP assistance is discretionary and also depends upon the industry development strategic objectives of Industry Science & Technology Canada, now Industry Canada (ISTC) for the related industrial sector, the need for assistance, and the availability of DIPP funds" (Industry Canada, 1992, p. 1). It is also noteworthy that DIPP contributions were only disbursed after the recipient firm had actually incurred the expenses being supported. To give firms an assurance that they would be reimbursed for DIPP-supported outlays, DIPP issued binding contracts which constituted a commitment to cover identified eligible expenses once they were incurred.

DIPP contributions were classified as either Outright Contributions (i.e., no repayment required); Repayable Contributions (i.e., mandatory repayment); or Conditional Repayable Contributions (i.e., repayment would be required only if the recipient firm reached a certain sales or profit level on the product(s) being supported by DIPP). Contributions made for capital equipment acquisitions or modernization were automatically considered repayable. Repayment terms were typically set at ten years. However, shorter (or longer) repayment terms could be negotiated depending on the useful life of the asset(s) purchased with DIPP assistance. DIPP contributions were originally intended to be repayable on an interest-free basis. However, as a result of GATT commitments, in particular the agreement on subsidization of aerospace products, the Canadian government had to ensure that something at least resembling prevailing commercial rates was charged on outstanding balances.

Contributions that support R&D were usually classified as Conditional Contributions, to reflect the fact that the R&D may not have been successful. The sales or profit level which would trigger repayment of a Conditional Repayable was typically negotiated up front between Industry Canada and the recipient firm. Repayment was set up on a royalty basis, with the recipient firm repaying DIPP with a portion of sales proceeds. The establishment of a repayment schedule on a per-unit royalty basis effectively made the federal government a risk sharing partner in the R&D which it supported through DIPP.

In the late 1980's, DIPP's annual budget peaked at about $240 million. Cutbacks to the program through the 1990's, implemented as part of an overall reduction in government expenditures, reduced its budget to the $150 million range. The budget for the 1994/95 fiscal year, DIPP's last, was $143,793,000, compared to $166,882,597 for 1993/94 (J. Woodside, personal communication, March 15, 1995). The 1995-96 federal budget, announced by Finance Minister Paul Martin on February 27, 1995, was presented as the ultimate confirmation that the Chretien government was indeed serious about addressing Ottawa's deficit. The budget included deep cuts to Industry Canada, with the Department's budget reduced from $1.2 billion to $500 million by 1998, and almost 1,500 cut from its staff. The budget cuts eliminated nine funding programs run by Industry Canada, and wound down another 34 industrial assistance programs, including DIPP. In effect, DIPP was barred from funding any new projects and was completely eliminated once the projects in its current pipeline were completed.

During its 36 years in operation, DIPP invested $3.6 billion in the Canadian aerospace industry. During that time, cumulative sales by the industry exceeded $160 billion. This meant that, on average, one dollar invested by the government in DIPP stimulated $25 in Canadian aerospace industry sales, of which $18 was exported (AIAC, 1996).

The crucial role of DIPP, as explained to the author in various personal communications, was in helping applicant firms' cash flows. For high-technology products such as aerospace, where each new generation represents a significant improvement in performance at generally lower cost, innovating firms are caught in a squeeze: At the precise time that R&D expenditures on new model developments are heaviest, cash flow is often impaired because customers start to hold back or cancel orders for existing models in anticipation of buying the new, improved models. By offering innovating firms cash contributions while they were incurring R&D expenses, DIPP helped firms get through the cash flow squeeze and bring the new model to market. Then, with the new model generating sales revenue, recipient firms could repay DIPP as cash flows improved. This arrangement, according to several industry spokespeople, was extremely favorable compared to the alternative in the United States, where firms engaged in military or dual-use R&D were eligible for the Tri-Services Tax Credit. However, a tax credit does not help a firm during the cash flow squeeze described above, and in any case its value is contingent upon the firm's ultimate tax liability. In contrast, as one industry spokesperson explained to the author, once a firm received a DIPP contract which outlined precisely what the program would contribute, "we could go to the finance people... and give them solid curves showing cash flow" (D. Gregory, personal communication, March 22, 1995).

Several firms contacted by the author were extremely critical of the decision to terminate DIPP. Various company spokespeople emphasized that their firms have had to continuously evaluate what their R&D dollars buy in Canada compared to the United States. Among the factors built into companies' calculations were such elements as the prevailing exchange and interest rates, Medicare, and DIPP. One company spokesperson stated flatly that "...if our Canadian operation is going to compete with our U.S. facilities [for R&D projects] on the basis of tax credits [alone], it will be extremely difficult."

DIPP had another important consequence for aerospace R&D activities undertaken in Canada. In the absence of DIPP or an alternative, several Canadian producers may have continued to conduct R&D on new models in Canada, but final production of finished product may have been shifted offshore. Under DIPP guidelines, new technologies developed with DIPP contributions had to be substantially produced in Canada. Without DIPP funding, firms conducting R&D in Canada would not have been subject to such a restriction.

Looking at DIPP from the point of view of the OECD taxonomy of industrial policy measures, we can say that it appears to fall within the second category of "market-oriented" industrial policies, namely those focused on aiding industry without targeting specific ones. As noted above, the main emphasis of these types of measures are "to improve the inputs available to industry" (p. 13). This category includes various investment tax credits, general subsidies for R&D expenditures, measures to improve the skills of the labor force, investments to upgrade infrastructure, and the provision of consulting services to economic agents. There is no evidence that DIPP was intended to target particular industries or technologies, other than the broad categories of defense or civilian aerospace or space goods. Nor is there any evidence that DIPP's funding reflected a top-down decision by Ottawa to "pick winners" by backing a narrow group of firms or industries. The application for the program specifically stated that funding was available to any firm in Canada undertaking a project for development and/or manufacture "...of defence, civilian aerospace and space products..." (Industry Canada, 1992, p. 1). Moreover, the listing of DIPP funding recipients over its last two years of operations, given in the Appendix, confirms the program supported a broad spectrum of activities.

Did DIPP "dull incentives and create an attitude of dependence?" Did the fact that DIPP contributions sometimes turned out to be outright grants, in the case of Non-repayable Contributions, or repayable over an extended period of time represent the kind of subsidy that Porter (1990) rejects? A close examination of DIPP's guidelines would suggest that the answer to both questions is "no." To begin with, DIPP contributions never represented funds that replaced investments made by applicant firms. To receive DIPP funds, applicants had to first commit to investing in their respective projects, paying all the costs. Moreover, DIPP guidelines made it clear that the program was not an entitlement and that full compliance with the program's eligibility criteria did not guarantee funding. DIPP publications emphasized that funding under the program was discretionary and depended on ISTC's own objectives for the applicant's industry, the demonstrated need, and the availability of funds. In other words, DIPP could not reduce a firm's incentive to innovate because the firm had to first make the commitment to invest in the innovation before it could seek funds from the program. The firm therefore had to ensure that its project was commercially viable before investing in it. Moreover, the repayable nature of most DIPP contributions made it even more critical that the applicant firm ensured the commercial viability of its proposal. As one company representative stressed to the author. "we have to do it smart because it has to be repaid...it [DIPP funding] has to be very strategically factored into marketing and production strategy for the product, since a portion [of revenue] will be going back to the Canadian government" (D. Gregory, personal communication, March 22, 1995). Therefore, rather than dulling a firm's drive for innovation, DIPP as it was constituted, actually reinforced it.

Despite clear indications that DIPP impacted technology decisions made by

Canadian aerospace firms, it would appear that no attempt was made by the federal government to consider this impact prior to announcing the program's termination. Like the business that responds to falling sales revenue by cutting advertising, it seems that the federal government did not undertake any cost-benefit analysis of its decision to terminate DIPP. Rather, political imperatives, coupled with a desire to reduce the federal budget deficit as quickly as possible, led to the decision. It is possible that the federal government accepted the popularly-held belief that all industrial assistance programs were "subsidies" that merely transferred producer surplus into the hands of firms that didn't need the money and would undertake the project being supported even in the absence of government funds. As Alan Nymark, Assistant Deputy Minster of Industry stated in a speech shortly after the 1995-96 Martin budget was announced:

> We...have been undergoing in the past year quite a massive re-engineering of government. In Canada, the federal government has made the decision to reduce the Department of Industry by forty-two and a half percent over three years. It has, in essence, announced a total elimination of all subsidies to firms by the Department....We did not quite eliminate subsidies to aerospace firms, but we have essentially reduced them to almost negligible amounts...we have turned the corner. We have taken action. We have reduced the size of government in its dealings with the private sector, and we have moved towards elimination of subsidies at the firm level (Nymark, 1995).

Technology Partnerships Canada (TPC)

On March 12, 1996, the federal government partially reversed its decision to end financial support to the Canadian aerospace industry. Industry Minister John Manley announced the creation of a loan and investment fund called Technology Partnerships Canada. The fund—initially set at $150 million for 1996-97 and projected to increase to $250 million by 1998-99— would be based on providing repayable loans or investments which generated a financial return to the government. In fact, Minister Manley raised the possibility that "the federal government may actually get back more than it puts into some of these projects" (Toulin, 1996). In announcing the new program, the government indicated that it expected that the fund would become at least half self-sufficent within ten years (Industry Canada home page, http://strategis.ic.gc.ca/SSG/mot00036.e.html).

The fund would provide between 25% and 30% of the funding of development costs for particular projects, with priority given to those projects ready for market and with a strong chance of generating export earnings. Other criteria included the applicant's technical and managerial capabilities, the need for TPC support to permit the project to move forward, and the applicant's ability to repay TPC funds based on a risk-reward sharing arrangement.

Funding decisions would be made by a Technology Advisory Board, chaired by the Ministry of Industry, but composed of experts from the private sector. This structure was established to avoid accusations that government bureaucrats were trying to "pick winners." As Minister Manley stated in making his announcement, "We're [the government] not going to rely on our judgment. We're going to ask the private sector to tell us what they see as coming down the track that Canada should be a world leader on" (Toulin, 1996).

Creation of the TPC was a direct result of industry dissatisfaction with the government's 1995 decision to terminate the DIPP program. Several major Canadian aerospace firms had threatened to take key R&D programs offshore if Ottawa did not renew some type of support. For example, Pratt & Whitney Canada had made it known that it was considering moving development of the PW150 turboprop for the Bombardier de Havilland Dash 8-400 regional airliner overseas if no replacement for DIPP was found ("Canada starts,"1996). In his announcement, the Minister conceded that it was apparent to Ottawa that "...some sort of public support is required in key sectors to match public subsidies to foreign competitors" ("Canada starts," 1996).

TPC was originally presented as being aimed at a variety of industries, ranging from environmental sciences aerospace to defense, and at a range of technologies, ranging from productivity-enhancing manufacturing techniques to advanced materials management to information management. (Industry Canada home page, http://strategis.ic.gc.ca/SSG/ mot00034.e.html). However, most of the fund's high profile initiatives, out of a total of approximately $332 million in financing, announced since its inception have been in the aerospace area. Among them:

> October 1996: An $87 million investment in the R&D on improving fuel efficiency and performance for Bombardier Canadair's proposed 70-passenger Regional Jet. The funds, repayable on a royalty basis, represented approximately 25% of total eligible R&D costs.
>
> December 1996: A $57 million investment to develop a 70-passenger version of De Havilland, Inc.'s Dash 8 regional aircraft. The Dash 8 would be a higher-speed, stretched version of the company's successful 35-50 seat Dash 8 line. Deliveries of the new version, the Dash 8-400, are projected to begin in 1999. TPC funds would be repaid on a royalty basis.
>
> January 1997: A $100 million repayable investment to help Pratt & Whitney Canada complete work on its PW 150 turboprop engine, destined to power the de Havilland Dash 8-400 series, and a $47 million repayable investment to support R&D on reducing aircraft design cycle time and on improving engine performance.
>
> March 1997: A $32 million investment to assist CAE Electronics Ltd, of Montreal, to begin its VISTEC (Visual Technologies) project, aimed at developing state of the art image generating and display devices to be used in the company's flight simulators for civilian and military markets.
>
> April 1997: An $8.4 million repayable investment in the establishment of a new aircraft engine development and manufacturing plant owned by

Orenda Aerospace Corporation in Truro, NS.

April 1997: Two repayable investments totaling $12.7 million to assist AlliedSignal Aerospace Canada of Etobicoke, Ontario to develop the power management generating system for the de Havilland Dash 8-400 aircraft and to develop and improve the VSCF advanced power system which the firms sells for large civilian and military aircraft.

April 1997: A $3.25 million repayable investment to assist Fleeet Industries Ltd. of Fort Erie, Ontario in carrying out a contract to design and produce aircraft wing components for the McDonnel-Douglas MD-95.

In fact, more than 87% of the total of $332 million in financing that TPC has announced since it was created have gone to two firms, Bombardier and Pratt and Whitney (Karl, 1997).

CHAPTER TEN

Quebec Government Industrial Policies

Goals and Objectives

Of the various industrial policy objectives noted above, those which focus on government "targeting" of certain industries or sectors have come to be most closely associated with the term industrial policy and have generated the most controversy. The rationale for Quebec industrial policies which pursue these two objectives has been that:

> ...les industries du futur qui en sont maintenant à leurs premiers balbutiements deviendront tellement populaires et profitables qu'il est indispensable pour le Canada—et pour le Québec—de s'y tailler une place (Watson, 1994, p. 27).

The objectives of industrial policies listed by Magaziner & Reich and cited above follow from the widespread perception that one of the principal functions of government is to create jobs, either through subsidies or tax incentives (Watson, 1994).

Quebec's industrial policies have pursued most of the above-noted objectives at one time or another. However, a unique feature of Quebec's various initiatives has been the pursuit of a ninth objective, one whose importance has frequently overridden the weight assigned to any other industrial policy objective. This objective has been the creation and support of a francophone business class. This objective dates back to the earliest days of Quebec's Quiet Revolution in the late 1950's and early 1960's. At that time, there was no managerial class to speak of in francophone Quebec society, and there were hardly any large-scale firms owned and operated by francophones. In 1961, francophones comprised almost 80% of the Quebec population, but owned only 22.5% of the province's manufacturing sector, 26% of its financial institutions, and less than 7% of the Quebec mining industry (Fraser, 1987). Most existing francophone businesses were small and mid-sized family firms whose growth was severely limited by a lack of access to large-scale financing. This lack of capital was a result of the anglophone/francophone divide that existed in the Quebec economy. As described by Fraser (1987):

> In the 1960's, French-Canadian entrepreneurs were on the black list. The anglo-capitalists in Montreal formed an exclusive business and social network—the centre of which was the Mount Royal Club and to a lesser extent the St. James Club—whose members controlled the large, four-pillar institutions that financed industry...the francophone business confrerie, a segregated group over at the Club St-Denis was, for the most part, peripheral (p. 76).

The lack of availability of large-scale financing for francophone firms in turn reinforced the continued absence of a francophone managerial class. As Fraser (1987) noted, "with little hope of growth, passing weak companies from one generation to the next was pointless and many entrepreneurs sold out in order to avoid death duties" (p. 76). Not only were francophone-owned large-scale businesses a rarity in Quebec up until the 1960's, francophones—and for that matter the French language—were strongly underrepresented in the ranks of middle and senior management of large, national firms headquartered in Quebec. Even though they represented only 20% of the Quebec population in the 1960's, anglophones represented 80% and 60%, respectively, of middle and senior management positions in such corporations. Worse, less than 15% of anglophone senior managers spoke French, while almost 80% of francophone senior managers spoke English (Fraser, 1987).

The result of this marginalization of francophones in the business world of Quebec was vividly described by Jacques Parizeau, former Premier of Quebec:

> Everything that was of any importance in the economy was controlled by people who were from the outside. French Canadians were like cows in a field watching a train go by....In the business world, that made us vulnerable to the permanent threat of blackmail which the anglo

Establishment always held over our heads (cited in Fraser, 1987, pp. 70, 73-74).

To create a significant francophone managerial class and to overcome the financial barriers which had previously handicapped existing francophone businesses, the various groups involved in reforming Quebec society in the early 1960's agreed on the need for massive state intervention in the economy (Averyt, 1986; Arbour, 1993). This intervention was aimed at giving francophones the confidence to compete at the highest levels of industry, and at giving francophone entrepreneurs a source of financing for the expansion of their businesses from small- and mid-sized concerns to large corporations capable of competing on a world scale.

Quebec has over the years pursued a tenth industrial policy objective. However, in this respect, Quebec is far from unique. This objective is one of responding to short-term political imperatives to save jobs in a particular firm, industry or region in difficulty through various investments, loan guarantees or tax breaks. This type of action is typically referred to as a "bail out" and though a form of industrial policy, is not associated with the more purposeful, comprehensive industrial policies which one thinks of when considering examples of successful industrial policy regimes.

Strategies and Tactics of Quebec Industrial Policies

From the early 1960's on, successive Quebec governments have adopted several strategies in pursuit of their industrial policy objectives. Some of these have changed as a result of changes in the political leadership in Quebec. For example, the "grappe" (industrial cluster) strategy announced by then-Industry Minister Gerald Tremblay in

December, 1991, was dropped by the Parti Quebecois government which came into office in the fall of 1994. Other strategies have proven to be more durable, and have spanned several Quebec governments. Among these strategies are:

1) Creating pools of capital controlled by and available to francophone Quebecers;
2) Creating institutions and fiscal incentives that will ensure that francophone Quebecers own a greater share of the province's business sector;
3) Giving francophone managers the opportunity to rise to the highest levels of large-scale enterprises;
4) Using the Quebec government to break down the barriers which have existed against francophones in the world of business.

Successive Quebec governments since 1960 have carried out a number of policy initiatives as part of the four strategies noted above. These initiatives can be grouped into three broad tactical groups, as follows:

1) The creation of parastatal enterprises. Most of these are, according to their charters, independent of the provincial government. In fact, they come under its control by virtue of the National Assembly's power to appoint or dismiss their respective Chief Executive Officers (CEO's). Examples of this type of institution are Hydro-Quebec and the Caisse de dépot et placement du Québec. There are other parastatals which do not have formal Crown Corporation status and are explicitly mandated to follow the instructions of the Quebec government. The prime example of this type of institution is the Societe de developpement industriel (SDI).

2) Tax incentives aimed at promoting investments in common stock by Quebecers. The prime example of this kind of initiative was the Regime d'Epargnes Actions (REA), or Quebec Stock Savings Plan. The Plan, introduced in 1979, was initially quite successful. It allowed Quebec taxpayers to receive deductions from

provincial income tax of up to 100% of the value of investments in new public stock issues of firms whose head offices were in Quebec. Between 1979 and 1992, Quebecers invested over $7.5 billion in Quebec firms under the REA program (Suret, 1994). However, in the last few years, the scope of the program has steadily diminished to the point where the provincial government has basically wound down the program.

3) Tax incentives and subsidies aimed at increasing the amount of R&D conducted in Quebec and at promoting the diffusion of technological innovations throughout the province.

Parastatal Enterprises

Beginning in 1962, successive Quebec governments created a number of parastatal enterprises. These parastatals enabled Quebec to take several steps on the road to achieving the goal of building a francophone managerial class: They offered francophone managers and technicians important training grounds where they could prepare for high levels of responsibility in industry (Averyt, 1986); they could, through selective procurement policies, funnel orders to emerging francophone firms (Averyt, 1986); and they could channel Quebecers' savings toward providing financing for francophone entrepreneurs, thus helping Quebec "become independent of big Anglo-Saxon capital" (Arbour, 1993, p. 160).

Caisse de dépot et placement du Québec

The Caisse de dépot et placement was created by the Quebec government in 1965 to administer the pension contributions made by Quebec workers to 13 bodies, of which the most important is the Régie des rentes du Québec, the provincial pension fund. In addition to the Regie des rentes, the other bodies which entrust their funds to the Caisse include the Régime des retraites des fonctionnaires du Québec (Quebec civil servants pension fund); la Commission de la construction, la Commission de la santé et de la securité de travail, and eight other smaller funds. The primary objective of the Caisse is to make profitable and safe investments so that it can maximize the returns and minimize the risk for the funds entrusted to it, while maintaining the capital it has accumulated. This emphasis on profitability and security of investments is extremely important. For example, in the case of funds administered by the Caisse for the Régie des rentes du Québec, the lower the rate of return on these funds, the more the Quebec government would have to increase mandated contributions or increase taxes to pay for seniors' pensions.

However, in addition to its profitability and safety objective, the Caisse has always had another important goal, that of contributing to the economic development of Quebec. This goal was not explicitly stated in the legislation which created the Caisse, but was included in then-Premier Jean Lesage's 1965 speech to the National Assembly in which he announced creation of the Caisse. In the absence of explicit legislative guidelines, the definition of "contributing to the economic development of Quebec" has been open to interpretation. Some have stated that the Caisse was formed "in order to provide a large source of capital for the government and for francophone enterprises"

(Averyt, 1986, p. 169). Others have suggested that the Caisse was formed to "buffer the Quebec government against bullying by anglo capitalists, especially in the bond market" (Fraser, 1987, p. 80). According to this interpretation, "the Caisse became a kind of defensive central bank, buying up Quebec bonds whenever the government needed to borrow, thus reducing the government's abject dependence on the [anglo] syndicate for debt issues" (Fraser, 1987, p. 81). Still others have suggested that the Caisse was intended to become a "conquering government agency," taking over the responsibilities previously given to other, smaller Quebec parastatals in order to "fundamentally modify the industrial structure of Quebec" (Arbour, 1993, p. 32). Specifically, the Caisse has at times used its financial clout to promote the creation of a francophone managerial class, to maintain corporate head offices in Quebec, and to support the international expansion of francophone Quebec firms.

Jean Lesage always insisted that the Caisse's economic development role was to be subordinated to the pursuit of secure and profitable investments. This dual mandate, and the subordination of economic development to profitability, has always been officially acknowledged by Caisse management. For example, in a 1993 speech, then-President and Chief of Operations Guy Savard stated:

> Our dual mandate represents a tremendous challenge and is a constant balancing act for our institution. We have an economic development role, which some people confuse with granting subsidies to companies. The Caisse is not—and has never been—a subsidy granting institution. Our returns over the past decade could not have been what they are if that were the case (Savard, 1993, p. 32).

Officially, the Caisse is independent of the government of Quebec, though the Minister of Finance is responsible for the Caisse. Day-to-day decision making and investment management are conducted by a full time staff of financial analysts and investment specialists. The legislation creating the Caisse stipulated that both its Chairman/Chief Executive Officer and President/Chief Operating Officer were to be appointed by the provincial government for ten-year terms and that they could only be relieved of their posts by an act of the National Assembly. Moreover, the legislation forbade any government intervention in the management of the fund. However, as will be seen below, the provincial government could influence the Caisse through its nomination of the two senior officers, and by packing the Board of Directors.

As of the end of 1997, the Caisse's assets totaled $63.6 billion, making it the largest fund in Canada, and among the top fifteen in North America and top one hundred in the world. For 1997, the Caisse registered a 13.0 % return on its portfolio (Caisse de Depot, 1997). Between 1993 and 1997, the Caisse registered an average annual return of 12.5 %, whereas during the ten-year period 1988-1997 its average annual yield was 11.1% (Caisse de Depot, 1997). According to Caisse management, its track record has consistently exceeded the reference indices of its various investment vehicles, "...which places it among the fund managers with the best performance in North America" (Savard, 1993, p. 32). Slightly over one half of the Caisse's portfolio is concentrated in bonds (approximately $32.7 billion), with approximately 50% of that figure placed in bonds issued by the government of Quebec or Hydro Quebec. (It is important to note, however, that the Caisse is under no legal obligation to purchase Quebec bonds. This is in contrast to such mandates which are imposed on more than one half of the state employee pension funds in the United States). The Caisse's portfolio also includes, as of the end of 1997, approximately $29.5 billion in shares and convertible securities; $1.49 billion in mortgages; a real estate portfolio valued at approximately $ 2.5 billion; and approximately $1.6 billion in various short-term investments (Caisse de Depot, 1997).

Notwithstanding several high profile disasters which the Caisse embarked upon in the 1980's, such as the ill-fated takeover of the Steinberg retailing chain, it would be unfair to neglect the many success stories the Caisse has been involved in. Returning to Magaziner & Reich's list of industrial policy objectives, specifically that of promoting "... industrial restructuring, including mergers and joint ventures, which enhance the competitive position of home-based industries," the Caisse invested $6 million to assist with the merger of three small Quebec grocery chains in 1967. The merged unit went on to become Provigo, now the dominant force in Quebec food retailing. The Caisse's original investment increased in value four-fold by 1977.

Again drawing on Magaziner & Reich's (1982) list of objectives, in particular that of promoting the growth "...of high-technology industries through financial support of R&D, high risk investment and new market development," in 1979 the Caisse invested $700,000 in a small pharmaceutical company based in Laval, Laboratoires Nordic. In 1989, when the company was purchased by the multinational Marion Merrel Dow, the Caisse's investment was worth $68 million. (It is interesting to note that shortly after the takeover, Marion Merrel Dow moved its headquarters from Toronto to Montreal.)

Several Quebec entrepreneurs owe much of their success to timely investments by the Caisse. For example, Andre Chagnon was a small-scale operator of cable television companies in the 1960's. In 1972, Chagnon enlisted the aid of the Caisse to purchase National Cablevision, then one of the largest cable firms in the Montreal area. The Caisse invested $3.2 million in the transaction. The takeover of National Cablevision was the start of a period of phenomenal growth for Chagnon's cable television operations.

Today, his company, Videotron, is the largest cable operator in Quebec, and second largest in Canada. As well as cable television companies, Videotron owns television channels in Quebec, the U.S. and France. The Caisse continues to own approximately 27% of Videotron stock.

Aerospace involvement.

The Caisse's involvement in the aerospace sector has, until recently, been quite limited. The Caisse was not involved in financing any of the primes or major second-tier firms in the province through the 1970's and 1980's. In marked contrast to its timely and early intervention in some of the most successful francophone entrepreneurial firms of the 1960's, 70's and 80's, the Caisse was notably absent as Bombardier proceeded to acquire a series of aerospace firms in Canada, the United States and the United Kingdom. According to a senior Caisse official, "...la startégie [of Bombardier] n'était pas claire...comment un gars peut-il acheter des entreprises en faillite...on [the Caisse] n'avait pas la foi..." (Jean Claude Cyr, personal communication, August 11, 1998). The Caisse's reluctance to directly enter into the aerospace sector only changed in 1995, when it entered into a private placement to finance the development of Bombardier's Global Express executive jet. In effect, the Caisse agreed to purchase conditional sales orders which the company had from various air carriers. Unlike traditional receivable financing (or "factoring"), this transaction meant that the Caisse was purchasing contracts which clients had entered into to buy the Global Express if the plane met certain performance standards and was delivered by a stipulated time frame. According to the Caisse, the transaction involved a guarantee from certain key sub-suppliers who would assume the liability if Bombardier was unable to produce and deliver the planes. The Caisse assumed the financial risk of the buyers defaulting on the payment terms once the planes were delivered. It is important to note, however, at the time the Caisse made this commitment, Bombardier had not even developed a working prototype of the airplane. However, it is also important to emphasize that the Caisse did not enter into the Bombardier deal because it was targeting the aerospace sector. Rather, some of its personnel had expertise and contacts in the sector at a time when the Caisse was aggressively looking for new investment opportunities (Jean-Claude Cyr, personal communication, August 11, 1998). The Caisse approached Bombardier and asked how it could support the company's activities. What emerged as the firm's most pressing need was patient capital financing for the Global Express project. Caisse officials were emphatic that the private placement was done strictly on financial terms, and was not motivated by any industrial policy imperatives (Jean-Claude Cyr, personal communication, August 11, 1998). Rather, Caisse officials described the transaction as a market based investment which flowed from its historical roots:

> La transaction a été faite strictement sur les bases du marché mais l'approche a été influencée par notre volonté de mettre nos capitaux au service des entreprises québecoises...dans ce sens, même si cela s'est fait sur une base d'affaires, l'approche respectait notre culture (Jean-Claude Cyr, personal communication, August 11, 1998).

More recently, however, the Caisse has begun to turn its attention to the province's third-tier suppliers. This shift reflects the Caisse's recognition that "...les primes n'ont pas besoin de la Caisse...le développement de l'industrie passe par la concentration des sous traitants et ainsi nous avons une intervention ciblé sur le troisième niveau." (Jean-Claude Cyr, personal communication, August 11, 1998).

In 1995, the Caisse formed a specialized subsidiary, Sofinov, to handle targeted investments in various industries. One of the mandates of this subsidiary was to make investments in small and mid-sized industrial firms in the province. In 1995, the Caisse's strategy toward the sector took a major step forward with the creation of a specialized financing subsidiary, Sofinov, based in Montreal. Sofinov, which essentially acts as a venture capitalist, is organized along industry lines with vice-presidents in charge of health/biotechnology, information technologies, and industrial technolgies. Each of the three industrial groupings is staffed by personnel with extensive experience in and technical knowledge of their respective areas. As of the end of 1997, Sofinov had a portfolio of some seventy-seven investments in various firms, with a portfolio value of approximately $448 million (Caisse de Depot, 1997). The Caisse's goal for Sofinov with respect to Quebec-based third-tier suppliers in the aerospace sector appears to be to offer small (i.e., up to $1 million) financing packages to assist firms who wish to diversify their customer base away from a total or near-total reliance on one prime or second-tier buyer (Jean-Claude Cyr, personal communication, August 11, 1998).

Caisse involvement in pharmaceuticals.

The Caisse has, over the past five years, become extremely active in the province's pharmaceutical/biotechnology sector. However, unlike its involvement in Quebec's aerospace sector, which can be characterized as somewhat timid and reactive, the agency's investments in the pharmaceutical/biotechnology sector reflect a coherent plan that has been developed over several years.

The Caisse's first investment in the sector was the acquisition of a significant position in Bio Chem Pharma, a Montreal-based manufacturer originally developed by the federal government and then privatized almost at its inception in the 1980's. This investment was made because the Caisse had a staff member with extensive experience in and knowledge of the sector (Jean-Claude Cyr, personal communication, August 11, 1998). Beginning in 1993, the Caisse began implementing a targeted strategy toward the sector, based on its in-house expertise, to become a more active player in the sector's financing. As explained by a senior Caisse representative:

> Déjà à ce moment-là c'était clair que l'industrie pharmaceutique était en bonne santé au Québec. Nous avons eu des entreprises, des coûts compétitifs, pour développer de nouveaux produits. Notre bonne connaissance de l'industrie nous a permit d'offrir de bons services financiers....Gràce à nos connaissances, nous étions plus agressifs que d'autres...(Jean-Claude Cyr, personal communication, August 11, 1998).

The Caisse's strategy at this point was to offer financing for R&D, particularly for trials, to Quebec-based firms on the condition that the development work be done in Quebec (Jean-Claude Cyr, personal communication, August 11, 1998). The Caisse's returns were generated by negotiating a percentage of licensing revenues derived from the new products. While the Caisse insisted on having development work which it financed conducted in Quebec, it could not insist that actual production be done within the province. However, according to a Caisse representative, "...la prochaine fois qu'ils [recipient firms] construisent une usine, nous voulons qu'ils considèrent Montréal...les gens qui ont développé le produit sont ici... (Jean-Claude Cyr, personal communication, August 11, 1998).

In 1995, the Caisse's strategy toward the sector took a major step forward with the creation of its specialized financing subsidiary, Sofinov, based in Montreal, described above. As noted previously, one of Sofinov's vice-presidents is responsible for the health/biotechnology sector. In 1997, Sofinov created two subsidiary firms, T2C2/Bio and T2C2/Info, in order to acquire patents in the biotechnology and information technologies fields, respectively, and then license these patents to firms willing and able to develop the products and bring them to market.

Since 1998, the Caisse's strategy toward the pharmaceutical/biotechnology sector has moved into a new stage. Recognizing the global nature of the industry, the Caisse has begun forming alliances with several of the major multinational pharmaceutical firms based outside of Quebec. According to a Caisse representative, the objective of these alliances is for the Caisse "...d'acquérir l'intelligence du secteur, qui est mondial..." (Jean-Claude Cyr, personal communication, August 11, 1998). A major element of this new strategy is to build a worldwide network of partners. The aim here is to build on the Caisse's extensive experience with and knowledge of the pharmaceutical /biotechnology sector to develop the financing of bio-tech products as an industry in its own right, with Montreal as a major hub of global activity. As described by a Caisse spokesperson:

> La gestion des capitaux de risque pour la biotechnologie est devenu un secteur. Nous avons décidé de faire plus de financement à l'étranger pour développer ce secteur....On batit une réseau international...on invite nos partenaires à investir ici....L'objectif est de faire de Montréal un des ports de financement de la biotechnologie dans un réseau international, avec les autres joueurs... (Jean-Claude Cyr, personal communication, August 11, 1998).

Not only does the Caisse's efforts at building international partnerships aim at building up the nascent biotechnology financing sector in Montreal, but they are also aimed at attracting more R&D and production work to the city. As explained by a Caisse spokesperson, "Une entreprise de biotechnologie en Californie va considérer Montréal comme centre de financement...on envisage que ces gens vont considérer Montréal comme centre de conception et de production"... (Jean-Claude Cyr, personal communication, August 11, 1998).

Contrasting the Caisse's role in the aerospace and pharmaceutical/biotechnolgy sectors, a Caisse spokesperson conceded that while both industries are similar in terms of being knowledge-intensive and highly globalized, there were important differences in the Caisse's approach and strategy to each of the two sectors. These differences stem primarily from the fact that the Caisse developed a much more extensive inventory of knowledge and familiarity with the pharmaceutical/biotechnology sector than with the aerospace sector. As explained by a Caisse spokesperson, "...on est plus créatif dans le secteur biopharmaceutique parce qu' on a développé des expertises dans le secteur...on peut proposer des conditions intéressantes..." (Jean-Claude Cyr, personal communication, August 11, 1998). Moreover, the rapid acquisition of such expertise allowed the Caisse to be a much earlier participant in the development of the province's pharmaceutical/biotechnology sector than was the case with the aerospace sector. In particular, the Caisse's investment in the early stages of Biotech Pharma, noted above, represented an important boost to what became one of the most successful locally-owned firms in the industry. In contrast, the Caisse conceded that "...nous n'étions pas là pour Bombardier au début...c'est dans le secteur pharmaceutique que nous sommes intervenus beaucoup plus tôt" ... (Jean-Claude Cyr, personal communication, August 11, 1998).

Tax Incentives for R & D

Quebec's approach to technology and to the role of government in fostering technology in the province was initially proclaimed in the PQ government's document "Batir le Quebec," published in 1979. This document was followed by a more detailed discussion of the role of technology on Quebec's economy, "Le Virage Technologique," published in 1982 by then-Minister of Economic Development Bernard Landry. Kresl (1983), in a review of the two documents, states that the three main goals which emerged for Quebec technology policy from these documents were:

i) to stimulate the economy, improve productivity and create jobs;
ii) to promote a change in the composition of goods produced in Quebec factories toward those with higher income elasticities of demand;
iii) to further the participation of francophones in the economy so as to lessen their dependence on "foreign" decision makers.

The PQ's principal means for stimulating R&D in Quebec was the introduction in 1983 of generous tax incentives, with then-Finance Minister Jacques Parizeau announcing a 10% refundable tax credit on R&D salaries paid in Quebec. Since their introduction, the tax credits have been increased to between 20% and 40% of R&D salaries (firms with assets in excess of $25 million can only claim 20% of R&D salaries). The tax credits have also been extended to cover the salary component of funds paid by private sector firms to universities under the terms of a research contract. Finally, the Quebec government grants a two-year tax holiday on the salaries paid to researchers brought in from abroad.

It is important to note that the Quebec tax credits are supplemented by an investment tax credit from the federal government of between 20% and 35% of R&D expenditures. Combining these two tax credits makes it extremely attractive for firms to conduct R&D work in Quebec. Palda (1994) notes that of the four provinces in which 90% of all Canadian R&D is conducted, Quebec offers the lowest after-tax costs per dollar of R&D. Combining both federal and Quebec tax credits, Palda also notes that Canada/Quebec are the most favorable tax areas for conducting R&D among the ten leading industrialized countries.

In 1985, newly-elected Quebec Premier Robert Bourassa published “Le Defi Technologique,” in which he criticizes the “interventionism” of the PQ and states that government's proper role is to create a favorable business climate through general macro economic measures. However, in 1988 the Liberal government organized a “technology summit” which brought together several hundred representatives of industry, government and the research community. Partly as a result of that gathering, Bourassa introduced in the May 1989 provincial budget the Fonds de developpement technologique (FDT), whose mandate was to subsidize eligible R&D conducted by Quebec firms. The FDT was modeled after various projects conducted in Europe, Japan and the United States, whereby public funds were used to subsidize R&D conducted by consortia of private sector firms, by industry associations, and by industry-university partnerships. The government's original aim was to disburse $350 million in R&D subsidies between 1989 and 1994. The main priority areas for the FDT were to be so-called “projects mobilisateurs,” defined as projects having important externalities; in other words, projects giving firms who did not participate directly in the original R&D the opportunity to benefit from new technologies discovered through adoption or imitation. The “projects mobilisateurs” were to account for $215 million of the $350 million disbursed by the FDT. Secondary priorities were set for environmental research ($50 million);

small and mid-sized business R&D ($35 million); and university-industry joint projects ($50 million). By the end of 1993, the FDT had authorized $184 million in subsidies, and had actually disbursed $63 million (Palda, 1994).

Combining the availability of Quebec and federal R&D tax credits with subsidies from the FDT, Palda (1994) calculates that for a Quebec-based small or mid-sized firm, a $10 million R&D project, divided equally between R&D expenses covered by tax credits and other expenses covered by the FDT, would only cost $3,171,840 after taxes. The remaining $6,828,160 is paid by a $2.5 million FDT subsidy, a $2,0000,000 Quebec tax credit, a $600,000 federal tax credit, $462,000 in Quebec tax savings as a result of deductions, and $1,266,160 of federal tax savings.

To support his contention that Quebec firms under-invest in research, Palda (1994) shows that between 1985 and 1989 private sector R&D as a percentage of GDP averaged only 0.81% in Quebec, compared to 1.05% in Ontario, 1.34% in France and 1.46% in the United Kingdom. However, these figures do not reflect the true impact of the FDT, which was only created in mid-1989. A much more positive evaluation of the results of Quebec's R&D incentives to the private sector is given by Duhamel (1995). He cites Statistics Canada data showing that as of 1992, Quebec was the only province where private sector research activities accounted for more than half of all R&D work: In Quebec, the private sector invested $1.4 billion of the $2.8 billion in R&D expenditures made in the province. In comparison, Duhamel notes that the private sector financed only 40.9% of all R&D expenditures made in Ontario in 1992. Moreover, Duhamel (1995) points out that Quebec's share of private sector industrial R&D has increased steadily since 1988, rising from 26.7% in that year to 33.3%; meanwhile, Ontario's share has declined from 55.2% to 50.3%. Finally, including R&D work directly financed by the public sector, Duhamel states that R&D work in Quebec increased by 43% between 1988 and 1992, whereas the growth rate for all of Canada for the same period was only 24.8%. While it is difficult to attribute these trends solely to Quebec government policies, it is noteworthy that the period of time cited by Duhamel coincides with that of the operation of the FDT.

Palda (1994) is emphatic that the Quebec government is simply incapable of evaluating the results of its technology initiatives. He notes that, as in other countries, Quebec presents disbursements in lieu of actual results. Lacking, he says, is concrete information on what Quebec technology has actually accomplished:

> Les rapports gouvernementaux n'indiquent jamais la mesure des résultats obtenus dans le cadre de projets innovateurs financés par les deniers publics: brevets obtenus par les entreprises bénéficiant de subventions, changement de productivité, voire même simple dénombrement des innovations comme cela l'a été fait aux Etats-Unis. Il nous est donc impossible de juger si le gouvernment de Québec a, par sa politique technologique, stimulé la croissance économique sur son territoire (p. 104).

Recent Developments in Quebec Industrial Policy

The Industrial Clusters Strategy

In December, 1991, then-Minister of Industry, Commerce and Technology Gerald Tremblay announced a new, comprehensive industrial strategy for Quebec. The strategy was called the industrial cluster approach, and was inspired by the work of Harvard University professor Michael Porter's 1990 work, The Competitive Advantage of Nations. Tremblay announced that the goal of the strategy was to create jobs in Quebec by moving from a mass production economy to a higher value added economy.

Specifically, the strategy was to be aimed at getting Quebec firms to do more secondary processing of the province's resources. The strategy was to focus on those sectors and activities "which add most value to our products in all sectors of the economy" (Tremblay, 1993). These were identified by Tremblay as residing in thirteen industrial clusters ("grappes" in French). Clusters are groups of firms in the same sector of activity that alternate between competing and cooperating among themselves. Porter (1990) describes the intense competition that exists between firms in a sector as a key driver for firms to make the investments and changes necessary to increase productivity. At the same time, Porter describes how firms in a sector can come together to exchange ideas, join in pre-competitive R&D efforts, and fund training centers to produce specialized staff needed for the sector. In his December, 1991 presentation, Tremblay identified five Quebec industrial clusters which were considered to be already globally competitive (aerospace; pharmaceutical products; information technology products; electrical power generation and transmission equipment; and metal and mineral processing). He also identified eight clusters as "strategic," in that these sectors offered the promise of contributing to the province's economic development, though they had not as yet attained a sufficient level of global competitiveness.

In terms of what the Quebec government intended to do for, to, or with these clusters, Tremblay was somewhat vague. He insisted that the strategy was not predicated on any large-scale subsidies or expenditures by the Quebec government. Tremblay did say that the government would play a secondary role, acting as a catalyst in the formation and growth of the clusters, and ensuring that the overall macro environment of Quebec was competitive. The main role in the strategy would be given to the private sector firms, who would have to collaborate among themselves:

> Dans un monde de plus en plus compétitif, le succès ne sera plus jamais le fruit d'efforts individuels déployés pour atteindre des objectifs à court terme, mais il découlera dorénavant de la mise en commun de nos efforts (cited in Turcotte, 1991, p. A1).

This secondary role for government was also inspired by and consistent with Porter (1990) who emphasized that while government policy usually plays a small role in the start-up of geographic clusters of related firms, policies designed to offer specialized factors such as research institutes and improved infrastructure certainly can and do reinforce such clusters once they are formed.

The only concrete action which the Quebec government undertook as part of the clusters strategy was to institute the $35 million Fonds de partnerait sectoriel (Sectoral Partners Fund) in late 1993. The bulk of the funds—$20 million—was to be directed at projects with a high level of synergy; in other words, projects that would contribute to the growth of an existing industrial cluster or of a sub-cluster. This included financing pilot plants and support for the commercialization or promotion of specific products or services directed at a given sector. The remaining funds were to be used to promote the formation of industry groups and to promote greater cooperation among Quebec firms.

By late 1994, the Quebec government was claiming considerable success for its industrial clusters strategy. Government spokespeople pointed to an increasing number of strategic alliances, synergistic projects and consultation arrangements among Quebec firms in the same sector (De Smet, 1994). Three industrial clusters had gone so far as to form incorporated associations with their own boards of directors. Additional impetus to inter-firm consultation in Quebec had been given by the Quebec government in April, 1994 when it formed an "enlarged consultation board," which allowed representatives of various intermediary groups—such as The Canadian Bankers' Association, the Association of Consulting Engineers of Quebec, and the Order of Chartered Accountants of Quebec—to meet with representatives of industry sector groups to find out what work was going on within industrial clusters.

The industrial clusters strategy did not have a dramatic impact on the Quebec aerospace sector. The sector was not one of the three that created governing councils as a result of the new provincial government strategy. However, it has been pointed out that the Quebec aerospace sector was in some ways already more advanced than others in the province in terms of cooperation and communication among its member firms (G. Brabant, personal communication, November 28, 1997). For example, the sector had been holding regular dinner meetings involving both small- and medium-sized suppliers and larger prime contractors for several years (see below). Similarly, the Quebec Ministry of Industry, Commerce, Science and Technology had been circulating a newsletter to all firms in the sector since the mid-1980's (see below). The industrial clusters strategy did, however, lead to the establishment by the Ministry of Industry of two working committees in the sector, one dealing with quality certification, the other with R&D issues facing the sector. The Quality Committee included representatives of various prime, second- and third-level firms and met twenty-five times between 1992 and 1995 (G. Brabant, personal communication, November 28, 1997). It dealt primarily with ways to inform and educate small- and medium-sized firms in the sector about ISO 9000 certification. Since 1995, the committee has met only infrequently and on demand of firms in the sector. Similarly, the R&D Committee has met on an as-needed basis only since its inception. Both the R&D and Quality Committees may have been formed by firms in the sector even without Minister Tremblay's strategy, but the consensus in the sector is that the publicity and expectations which accompanied the announcement of the strategy motivated and advanced creation of both bodies (G. Brabant, personal communication, November 28, 1997).

The industrial clusters strategy was not without its critics. Jean-Pierre Le Goff, a professor at l'ecole des Hautes Études Commerciales (HEC), charged that the industrial clusters were an artificial construct which only existed in the minds of certain researchers and bureaucrats. Moreover, he attacked the broad scope of the strategy outlined by Gerald Tremblay. Specifically, Le Goff said that had the Minister given priority to five or so competitive clusters, then one could have described the industrial cluster initiative as a real strategy. By defining over thirty clusters in his announcement, however, according to Le Goff, "... cela veut dire que l'on veut faire plaisir à tout le monde. Il n'y a plus d'orientation politique précise à ce moment-là" (cited in De Smet, 1994).

This criticism was shared by the Parti Québécois, which took power again in Quebec in October, 1994. In November, 1994, the new Minister of Industry, Commerce Science and Technology Daniel Paille announced the end of the industrial cluster strategy. Paille dismissed the linkages between Michael Porter's work and the reality of the Quebec economy: "Ce qui s'applique à Harvard ne s'applique nécessairement à Baie-St-Paul" (quoted in F. Tremblay, 1994). Paille echoed Prof. Le Goff's criticisms regarding the lack of focus in the clusters strategy, stating that it was impossible to excel in several sectors at the same time: "Il faut choisir nos priorites. Il faut cibler davantage" (cited in F. Tremblay, 1994). Paille went on to state that the PQ government's new industrial strategy would be more oriented to the regions of Quebec and to small- and mid-sized businesses. It is, it should be noted, not inconceivable that some degree of political calculation was involved here on the Minister's part, insofar as the Parti Quebecois' support has traditionally been stronger in outlying regions of the province and among the owner/managers of small and mid-size firms in these regions, as opposed to among the senior managers of large-scale firms headquartered around Montreal.

Other Quebec Government Policies Aimed at the Aerospace Sector

Through the Ministry of Industry, Commerce, Science and Technology, the Quebec government has developed several modest initiatives over the years aimed at promoting the province's aerospace sector and at developing linkages among its member firms. The Ministry's Aerospace Industry Materials and Defense directorate has, since 1987, organized a regular series of four "Club Aerospatial" dinner meetings each year. Typically, between fifty and sixty firms are represented at each dinner (G. Brabant, personal communication, November 28, 1997). At these meetings, the Ministry will feature a presentation by a speaker related to a topic of interest to firms in the sector. Occasionally, Ministry Officials themselves will make a presentation.

However, the real goal of these meetings is to bring together the CEO's of the small- and medium-sized supplier firms in the sectors with buyers from the larger firms. In fact, the dinners are the only organized forum where Quebec aerospace firms of all sizes regularly meet to promote business exchanges (G. Brabant, personal communication, November 28, 1977). In order to facilitate contact between smaller firms and the buying officers from the primes, tables are designated for each prime contractor and a buying agent from the designated firm hosts the table. The Ministry has been successful in getting the primes to attend the dinners on a regular basis. When asked about how receptive the primes would be to meeting potential new suppliers from among the sector's small- and medium-sized firms given the connections the primes may already have with suppliers from outside Quebec, a representative of the Ministry said that it was definitely in the primes' interest to meet as many such potential suppliers as possible. As the representative noted, the primes "...have many needs, and even when they already have established suppliers, there may be problems with those suppliers" (G. Brabant, personal communication, November 28, 1997).

The Ministry's strategy of using such dinner meetings to promote contacts between small- and medium-sized suppliers and the larger primes in the province is actually only a phase in the province's efforts to develop the sector. A Ministry representative noted that while many of the small suppliers in the sector only exist because of their ties to firms such as Bombardier and Pratt & Whitney, these firms are well-placed to begin exporting to prime contractors outside of Canada. These firms are then targeted for informational mailings and other contacts by the Ministry promoting various opportunities abroad.

Another longstanding Quebec government initiative to promote linkages among firms in the sector has been the newsletter put out by the Aerospace Materials & Defense Industries Directorate, "L'Aérospatial." Published since the mid-1980's, this newsletter includes announcements of new contracts won by sector members, descriptions of new programs offered by various training institutes and educational institutions in the province, and brief descriptions of emerging technologies in the sector.

The Directorate has, in conjunction with Industry Canada, also prepared a directory of firms in the sector. This directory, which is updated every two to three years, is made available both to primes looking for potential suppliers in the province, and to SME's so that they can locate potential partners.

In response to an increasing industry trend toward risk-sharing partnerships and strategic alliances, discussed above, the Directorate has moved to encourage greater collaboration among the SME's in the sector. Towards that end, it has begun publishing a one-page bulletin where firms looking for specific skills and resources can advertise their needs. This classified ad-type document is distributed to all firms in the sector. The Directorate also promotes partnerships among SME's in the sector more directly by drawing on the personal connections which its officers have (G. Brabant, personal communication, November 28, 1997). In response to an inquiry from an SME looking for a partner with a particular configuration of skills, a Directorate representative may directly contact a firm he/she is familiar with and who seems to have the requisite skills, and suggest a meeting with the inquiring firm (see Exhibit 2 for sample copy).

Looking at the various roles which the Ministry of Industry, Commerce, Science and Technology through its Aerospace Materials and Defense Industries Directorate play in the sector, one can almost conclude that the Ministry functions as a type of trade association for firms in the sector. Indeed, several SME's in the sector have questioned the need to undertake the effort and expense of forming a trade association for the sector, given the Ministry's programs to date (G. Brabant, personal communication, November 28, 1997). [In fact, a trade association for SME's in the sector, the Quebec Aerospace Association (QAA), was created in June, 1997].

Finally, the Quebec government has had a special $10 million fund, the Quebec

Aerospace Investment Fund, to support aerospace investments in the province. The Fund was created following the province's Economic Summit, held in the fall of 1996. However, the Fund is not an ongoing program. According to MIC officials, it was established solely to support a small number of aerospace projects which had sought funding from provincial programs which were subsequently discontinued during Quebec's budget cutting exercises of 1995 and 1996. Those projects that did receive support from the fund were given reimbursable loans similar to those given by the federal government's Technology Partnership Canada (TPC) program, discussed above. MIC officials have stressed that the fund is not open for new applications and contains no provision for assisting aerospace projects beyond those specifically identified when the fund was created.

Forms of Inter-firm Collaboration in the Quebec Aerospace Sector

The Quebec aerospace sector has developed several mechanisms and institutions for producing the skilled manpower needed by its member firms. These institutions have been the product of close collaboration between government at various levels, educational bodies, unions and the private sector.

The oldest such institution is the Centre d'adaptation de la main-d'œuvre aérospatiale au Québec (CAMAQ), which was formed in 1978. CAMAQ's mission is to serve as a vehicle by which firms in the sector can communicate their training needs to Quebec's various educational institutions. Toward this end, CAMAQ works with secondary and post-secondary institutions to develop training programs needed by the sector. CAMAQ also conducts studies to forecast future manpower and skill needs of the sector. For example, in July 1997 CAMAQ conducted a survey of the 214 firms in the Quebec aerospace sector to forecast hiring needs for various types of workers through 1999. Finally, CAMAQ has cooperated with various government bodies to develop new public-sector programs and institutions which may address these needs. For example, CAMAQ worked with the Commission des écoles catholiques de Montréal (CECM) to establish the Ecole des Métiers de l'aérospatiale de Montréal (ENAM), a specialized training school for production workers for the aerospace industry.

CAMAQ is funded by the federal and provincial governments. It has a small full-time secretariat based in Montreal. CAMAQ membership was originally confined to the thirteen largest aerospace firms in Quebec, all of which are either prime or second-tier suppliers to the industry, and to four unions. However, in the past few years, SME's have been allowed to participate in CAMAQ discussions. The bulk of these discussions occur in the context of several ongoing committees which bring CAMAQ members together. There are committees for universities; high schools and trade schools; human resource directors; in-house training programs; and computer-assisted design (CAD) training. Each of these committees meets between five and six times per year and the meetings are characterized by a high level of interchange between members (S. Tremblay, personal communication, December 12, 1997).

As noted above, ENAM, founded in 1994, was the result of collaboration between CAMAQ and CECM and was a response to the perceived shortage of skilled assembly workers for Quebec aerospace firms. ENAM is a specialized training center offering 10-16 month programs for high school graduates leading in aerospace industry machining techniques; aircraft structural assembly; aircraft mechanical assembly; and aircraft electrical assembly. The school currently has approximately 700 students. Industry involvement occurs on several levels. Four of the largest aerospace firms in the province (P&W; Orlicon; Spar and CAE) serve on the Pedagogy Committee of the school. A number of firms in the province's aerospace sector have made important donations of equipment to the school. Finally, several of the school's instructors are provided by firms in the sector (M. Desjardins, personal communication, May 14, 1997).

The Ecole de technologies supérieures (ETS) was formed in 1974 as a branch of l'Université du Québec. Though not a specialized aerospace industry training outlet, it nonetheless is important to the sector. Its mission is to promote university-level training and research in applied engineering and technology. ETS offers four bachelor's programs in engineering, including construction; mechanical; electrical; and automated production. ETS's degree programs are the only ones in Quebec specifically tailored for students who have completed a technical CEGEP diploma. ETS also offers a master's program in systems technologies and numerous specialized training certificate programs.

Cooperation with the aerospace industry at ETS stems from the school's unique cooperative learning model, which requires that each student participate in three internship/apprenticeship periods at various stages of his/her degree program. These internships, each of which last between four and eight months, are paid by the site firm. The heavy reliance on internship/apprenticeships affords benefits to both ETS' students and to firms who participate in the program. For students, the time spent at firms represents "real world" training and the chance to become known to a potential employer. In fact, more than 40% of ETS graduates find their first job with the firm where they did their internship (ETS brochure, undated). For employers, using ETS students as interns/apprentices allows firms to take on workers who have state-of-the-art technical skills at relatively modest wage rates, as well as the chance to get to know prospective future employees. As well, firms who pay interns/apprentices can get a refundable tax credit or deduct the salary from the province's 1% training surtax. ETS currently has approximately 2,200 students at its Montreal campus. Since its formation, the school has placed 10,000 interns/apprentices in over 4,000 firms throughout Quebec. Several of the larger aerospace firms in the province have been ongoing sites for ETS interns (J. Fortin, personal communication, May 15, 1997).

CAMAQ worked with five post-secondary institutions in Quebec (Concordia, l'École Polytechnique, Laval, McGill and Sherbrooke) to develop a joint master's degree program in aerospace engineering. The program is coordinated through a committee known as Committe industries/universites de la materise en genie aeronautique et spatial (CIMGAS). Students apply to one of the five institutions and receive their degree from that institution. However, students are required to take a stipulated minimum number of specialized courses at two of the other participating institutions. The degree offers speciality areas in aeronautics and propulsion, avionics, materials and structures, and space technologies. Involvement of the Quebec aerospace sector is on several levels. Firms in the sector are called upon to serve as internship/apprenticeship sites for students in the program. These internships are paid by the site firms. As well, firms regularly provide case study material for students. Finally, several of the firms in the sector meet regularly with CIMGAS to develop new curricular offerings in the program.

CHAPTER ELEVEN

Interview Group Findings

Paradigmatic Shift

The consensus, supported by every firm in the group, was that there has indeed been a profound change in the nature of buyer/supplier relationships in the aerospace industry. The traditional model, particularly for the third-tier firms, was the "build to print" paradigm described previously. Under this arrangement, a first- or second-tier firm would essentially design what it wanted and then give its specifications and the accompanying blueprints to the supplier or sub-supplier in the next tier down. The basic message was "deliver or else," and it was incumbent on the supplier to deal with any problems which might arise in delivering the specified parts or products within the demanded delivery schedule.

The paradigmatic shift which has occurred in the aerospace industry has resulted in much greater involvement of suppliers and even to an extent, third-tier sub-suppliers in the design of parts and components. One prime described the design process as one where "...the suppliers are working with us in the same room, on the same computer for 6 to 12 months doing the overall design. Then, they go back to their shops to design the details regarding casting, machine parts, connections" (p1, personal communication, July 6, 1998). A second-tier firm noted this closer and earlier participation both in its role as a supplier and as a buyer: "We have much denser relationships with the primes.... We're now involved in the design of the aircraft...we are telling them [the primes] how to design an airframe..." (s1, personal communication, April 22, 1998). The same second-tier firm described how it now seeks greater and earlier input from their sub-suppliers. The firm noted that its new product development teams are composed not only of representatives of key internal constituencies (R&D, manufacturing, marketing), but also of external stakeholders, including suppliers and end users. The product development process becomes, according to this firm, a "constant iteration between team members" (s1, personal communication, April 22, 1998).

At the same time, several firms noted how second-tier firms have been given total responsibility for the design, production and delivery of entire systems in aircraft, basically changing their role from simply that of a supplier of parts or components to a project manager and systems integrator (s1, personal communication, April 22, 1998). This new role, in turn, transferred down to some of the third-tier firms. As the same second-tier firm pointed out, "We are forcing down to our suppliers this same thing [i.e., a systems integration role]" (s1, personal communication, April 22, 1998). One of the third-tier firms in the group described how it had, at the request of its second-tier buyer, moved into the design and development of entire sub-systems, and that it was now offering the buyer a complete parts and inventory management system for all the components associated with that sub-system (t2, personal communication, June 3, 1998).

The flow of information down the chain in the context of these "denser" relationships varies across firms. One prime noted that they would only send their personnel to a supplier if there was a particular problem which required joint solution. This could occur, for example, if drawings provided by the prime were unclear. However, this firm said that while "our objective is to find suppliers who can do the job without our involvement, it's almost a fact of life that we have to [either send personnel to the supplier's site or have the supplier's staff come to them]" (p1, personal communication, July 6, 1998). A second-tier firm noted how there is a significant flow downward to its sub-suppliers, of both "...our management systems and our technologies..." (s1, personal communication, April 22, 1998). A prime pointed out that there was significant "push down" of new processes to its supplier base via the incorporation of process improvements in the specifications given to vendors.

Third-tier firms in the group noted how the quantity, quality and direction of information has changed in the new environment. One third-tier firm noted how their past relationship with their major account, a second-tier firm, was previously all "build to print," and that the most technical support they had received in the past was the loan of some older machines. In contrast, the third-tier firm pointed out how the same buyer had just sent several key personnel to spend time on site, assisting the supplier in everything from process improvements to scheduling.

Moreover, the presence of production personnel from the buyer on the third-tier firm's site resulted in a flow of ideas up the chain, in marked contrast to the more compartmentalized and unidirectional arrangement of the past. The third-tier firm offered the example of how the specifications prepared by the buyer called for an extra "dressing" (i.e., buffing), which, in the opinion of the third-tier firm's production staff, would weaken a key welding point. The buyer's chief welder came on site and after discussion with the third-tier firm's staff, agreed to change the specification. As the manager of the third tier firm noted, "Before, you just talked to specifications....Now, you meet a real human being, and you can show him how it could be done better....There were always a lot of things we could do in a better way but that was all lost, there was no human interaction, just the specs" (t1, personal communication, May 27, 1998). One of the primes in the group agreed that there could be an upward flow of ideas and information, particularly from some of the larger third-tier firms who had the resources to acquire new machinery in response to product improvements included in specifications sent from the buyer. These third-tier firms could, according to this prime, be an important source of ideas regarding productivity enhancements for such technology.

Another third-tier firm noted that the second-tier firms are much more likely to share expertise and ideas with them than ever before. Part of this is the logic of subcontracting. As the firm noted, “Tous ce qui'ils [the second-tier firms] donnent aux fournisseurs ils sont capables a faire eux memes, mais c'est moins cher” (t2, personal communication, June 3, 1998). However, this firm stressed how the second-tier firms benefited from greater information sharing with their sub-suppliers not only due to cost savings. “Ils [the second-tier firms] apprendent de nous autres....Ils font certaines choses de la meme facon depuis 25 ans....Nous faisons la meme chose avec des nouvelles idées” (t2, personal communication, June 3, 1998). This third-tier firm even noted that some of its second-tier buyers will now help them to find key parts or materials needed to fill an order. At the same time, this firm noted that closer relationships with their second-tier customers allowed the company to plan its investments and training programs for up to two years in advance.

This perception, however, was not universal. One second-tier firm noted that while it observed much greater collaboration and two-way interchange of information between primes and second-tiers, its relationships with its third-tier supplier base were still heavily based on the traditional build-to-print paradigm. In fact, this firm said that as far as several other primes and second-tier firms were concerned, when it came to dealing with the third-tier suppliers, "they [prime and second-tier buyers] talk partnership but still practice build-to-print" (s2, personal communication, September 10, 1998). The same firm expressed skepticism about the notion of partnerships with third-tier firms:

> The word partnership implies it's a two-way street....In our industry, for many buyers dealing with the third-tier, partnership means telling them [third-tier suppliers] 'you take the risk of funding the non-recurring expenses, but we can move the business at any time' (s2, personal communication, September 10, 1998).

However, the same firm agreed that collaboration among primes and second-tier suppliers is indeed a fact of life in the industry today. Describing the extensive consultations that go on between their technical personnel and those of the primes with whom they are working, the firm said that "at a certain level, it's hard to tell who is the prime's guy and who's our guy" (s2, personal communication, September 10, 1998).

This new climate of "denser" relationships between buyers and sellers, in which buyers and sellers collaborate to find solutions and exchange information, corresponds to Storper's vision of the production network, described above, wherein continuous innovation occurs as a result of an ongoing redeployment of skills and equipment among firms and whereby members of the network draw on each others' resources and expertise.

Reasons for Paradigmatic Shift

All of the firms in the group mentioned reduced product development cycle times as a primary driver for closer buyer-supplier collaboration. A second-tier firm pointed out that the five year development cycle for the system it specialized in had been reduced to two. This, in turn, was driven by the reduced development cycles for airframes, which meant that suppliers could no longer develop systems and components based on what they thought the primes would be needing. Rather, reduced airframe development cycles meant that suppliers had to be involved in initial design or they would be too late to adapt whatever system or component they produced to the specific needs of the new airframe model. A third-tier firm noted that "...il y a dix ans, nous avions huit mois pour déveloper de nouvelles pièces...maintenant, c'est huit semaines" (t2, personal communication, June 3, 1998). It is important to note, however, the increased buyer-supplier collaboration was also a factor which contributed to shortening product development cycle times.

Another factor propelling the move to increased collaboration with suppliers is the increasing complexity of products in the industry. As one prime expressed this situation, "the more complex the product, the more dependent you are on others...no one can do it all, there are too many steps" (p2, personal communication, July 21, 1998). This too is consistent with the Storperian vision of the production network, which is a rational response to a technological environment where competition on the basis of skill and knowledge demands resources that lie outside the boundary of any one firm and are not entirely appropriable by it. As Storper posits, with increasing complexity, comes increasing interdependence among firms in the network. This prime described the situation as follows: "If someone else can do it, you stick to your knitting...however, the more you outsource, the more you have to negotiate with others..." (p2, personal communication, July 21, 1998). This too, corresponds with Storper's description of the dynamic of the production network, where inter-firm learning occurs through a series of transactions characterized by continuous negotiations and renegotiations.

Upgrading of Skills by Firms in the Sector

The constant flow of ideas and information among buyers and suppliers at the three levels of the aerospace industry ultimately results in a significant upgrading of skills and capabilities in the supplier base. One third-tier firm described the process as follows:

> Nous demandons au client ce qu'on peut faire pour mieux servir...nous avons amélioré nos techniques à cause de leurs besoins....Nous demandons [au client]: Nous n'avons jamais fait cela—montrez nous comment (t2, personal communication, June 3, 1998).

This notion of being forced to improve to meet the needs of an increasingly demanding buyer corresponds to the dynamic described by Porter (1990) whereby a region characterized by demanding and globally competitive buyers stimulates a constant upgrading process among the supplier base in that region. As one of the third-tier firms in the group stated, "ils [the buyers] demandent plus, mais ils nous appuient comme jamais auparavant" (t2, personal communication, June 3, 1998).

In fact, the new skills and capabilities developed by second- and third-tier firms to meet the needs of one buyer can, subject to intellectual property issues, be leveraged to allow the supplier to seek new buyers in international markets. For example, the third-tier firm described above, who had moved into the design and development of entire sub-systems for its main second-tier buyer, pointed out that this capability and comprehensive service could be offered to a wide range of customers beyond the original buyer for whom it had been developed.

The move into new markets is the result not only of technology transfer from buyers to suppliers but, as noted by one third-tier firm, by the added credibility they gain by presenting themselves as a long-term supplier to an internationally-known second-tier buyer. A prime corroborated this process, noting that "many small firms have told us that they got business from foreign systems suppliers (i.e., second-tier firms) due to their connection with us"(p1, personal communication, July 6, 1998).

Trust Among Firms in the Sector

Again, there was universal agreement in the group that in the new operating environment of the aerospace industry, there was much greater trust between buyers and suppliers. One of the third-tier firms stated, "il y a un grand changement...beaucoup plus de fidélite envers les fournisseurs..." (t2, personal communication, June 3, 1998). As one of the prime firms noted, in lieu of purchasing a particular design, buyers are increasingly looking to their suppliers to design solutions. To do this, buyers have to be willing to share information about what problems they are encountering or expecting "so that suppliers can see what we are trying to achieve with the aircraft" (p1, personal communication, July 6, 1998). How does this trust develop, and what is it based on?

Most certainly, legal protections are an important element of creating a comfort level which permits buyers to share proprietary information with suppliers. As one prime noted, "We protect ourselves with a tight contract before we give a package to bid on...intellectual property protection allows us to keep our niches...you can't reverse engineer our products...we will pursue vendors who misuse our intellectual property (p2, personal communication, July 21, 1998). However, another second-tier firm emphatically stated that "...if we didn't have trust, legal mechanisms wouldn't be enough" (s1, personal communication, April 22, 1998). Another second-tier stated that trust is built on legal protections, "...but in the context of negotiations legal documents become quite thick and once you get past that, at a working level, on the shop floor, in the engineering offices, relationships matter" (s2, personal communication, September 10, 1998).

Trust among buyers and suppliers is also built up over time based on successful collaboration. As another prime put it, "...as we go through a number of development programs, we develop trust based on their [the supplier's] performance...we feel comfortable with them and them with us..." (p1, personal communication, July 6, 1998). Being willing to offer extra value and service also is an important element in building confidence. One of the third-tier firms described how it maintained a highly specialized repair service capability for a major second-tier buyer, even though the process generated very little revenue. Nonetheless, the buyer appreciated the extra effort and investment that the third-tier was willing to make.

Another element that is crucial in building trust is a commitment to flexibility by the suppliers. In particular, this means an extremely high degree of responsiveness to buyer needs, at times in excess of what is stipulated in written agreements. One of the primes noted that this willingness to go above and beyond what was contractually required constituted a crucial unwritten understanding in the industry:

> We have to see them [the suppliers] as not only meeting but exceeding our requirements...They have to be flexible as our needs change in a fast-changing market...the ones who go beyond the letter of an agreement are the ones we look to... (p1, personal communication, July 6, 1998).

Another crucial unwritten understanding in the industry is a willingness to learn. That is, suppliers have to be seen by the buyers as willing to adapt their practices in response to buyer suggestions, particularly in the case of technology transfer down the chain. As one second-tier firm stressed, "some suppliers refuse to learn...they tell us 'you're not going to tell me how to run my business'" (s1, personal communication, April 22, 1998). This firm stated flatly that "if suppliers are not prepared to work with us, we phase them out (s1, personal communication, April 22, 1998).

As posited by Storper (1992b), the existence of such unwritten understandings, which he refers to as "conventions," is an essential characteristic of a production network characterized by PBTL. Storper emphasizes that only when network members subscribe to the conventions of the network do they feel sufficiently comfortable to engage in relationships based on learning with other firms in the network. This certainly appears to be the case in the Quebec aerospace sector: Only when primes and second-tier firms see that third-tier suppliers are prepared to accommodate their needs and adapt operations based on new technologies and skills transmitted down from the buyers do these firms feel justified in entering into an ongoing relationship.

Risks Associated with the New Industry Paradigm

Concomitant with the development trust is a winnowing of the number of suppliers. As buyers in the industry share more and more proprietary information with their supplier base, they will want to limit this flow to a select group of firms. One of the primes stated that "...we foresee having fewer suppliers and closer relationships, even with the third-tier...we're confident that we can replicate many of our concepts down to the third-tier" (p1, personal communication, July 6, 1998).

The reliance on a smaller supplier base does, however, pose risks for both buyers and sellers. For suppliers, increasingly large orders from one buyer could create a potential for dependence. In reality, none of the suppliers expressed concern for such a situation. One third-tier firm stated "ils [their buyers]...ont besoin de nous...les entreprises au deuxième niveau se rendent compte qu'elles sont aussi bonnes que leur fournisseurs...s' ils veulent améliorer 10%, les fournnisseurs doivent améliorer 10%" (t2, personal communication, June 3, 1998).

A second-tier firm also conceded that suppliers had a high degree of leverage in the current industry environment: "Suppliers today know they have us...there is undercapacity in the industry" (s1, personal communication, April 22, 1998). A third-tier firm, while acknowledging its dependence on its second-tier buyer, also pointed out that "...if we don't make this part, no one else will...it's costly for them [the buyer] to switch suppliers" (t1, personal communication, May 27, 1998). One of the primes corroborated this, stating "when we dedicate ourselves to bringing a supplier on line [i.e., up to their standards], we can't easily change suppliers" (p2, personal communication, July 21, 1998). Another third-tier firm, alluding to the risks of technological lock-in described by Storper, stated that the current shortage of technicians in the sector meant that buyers were increasingly dependent on their suppliers to avoid costly short-term investments in productive capacity and capabilities (t2, personal communication, June 3, 1998). One second-tier firm agreed that the current capacity constraints in the industry meant that the third-tier had an unusual degree of power in their relationships with second-tier and prime buyers. This meant, according to this firm, that these smaller shops received extensive technical support from their buyers. However, the same firm stated that the move towards consolidating the supplier base had ominous implications for several of the third-tier firms: "...When the downturn hits, many of these small firms are vulnerable..." (s2, personal communication, September 10, 1998).

It is noteworthy that each of the firms in the group, regardless of which level they occupied in the industry's hierarchy, felt that there was a degree of mutual dependence between buyers and sellers. This corresponds to Storper's vision of the production network as a grouping of firms characterized by cooperation and/or "symmetry of power relations" (p. 79).

The upgrading of the supplier base, described above, also poses risks to the prime or second-tier firm who transfers ideas: As suppliers improve their capabilities, they can and do pursue business from other primes and second-tier firms. These buyers constitute the competition for the prime or second-tier who made the original technology transfer. As one second-tier firm emphasized, "We don't want a supplier taking our ideas and suggesting things to the competition that they didn't know before" (s1, personal communication, April 22, 1998). However, the same firm stated:

> If a supplier works with us, they enhance their ability to bid on international contracts....We engage in continuous improvement with our suppliers. We know that they can then bid on competitors' jobs. However, that's part of the upgrading of our supplier base....If we don't do it, we're in trouble....You'd like to control it, but you can't (s1, personal communication, April 22, 1998).

To summarize, it would appear that the Quebec aerospace sector does correspond to what Storper refers to as a production network. Owing to the increasing complexity of both the end product and its components, no one firm is able to entirely appropriate all the product and process skills and technologies within its own boundaries. Firms in the sector are therefore obliged to look outside their own resources. However, the rapid changes in the marketplace militate against vertical integration to acquire these skills and technologies. Firms are therefore led to enter into a series of long-term relationships with other firms in the sector to jointly develop new innovations and solve ongoing production problems. These relationships are increasingly "dense" in the Storperian sense, characterized by an ongoing process of bi-directional learning transmitted through continuous negotiations between buyers and sellers of components and processes. These buyer-seller relationships are based on both cooperation and a degree of symmetry of power, in this case a two-way dependency. The relationships are, moreover, founded on the basis of trust which in turn is built upon a series of unwritten understandings and conventions.

Role of Public Policy in Promoting Relationships Among Firms in the Sector

One of the questions which the research set out to examine was what role, if any, public policy has played in promoting both the trust that exists within members of the Quebec aerospace sector and any ongoing product-based technological learning among members. In other words, has public policy contributed to the sector's ability to engage in continuous innovation?

The consensus in the group was that while there were a number of public policy initiatives which were helpful in promoting contacts and exchanges among buyers and suppliers in the Quebec aerospace sector, none of the firms felt that the relationships that had developed were the direct result of public policy initiatives. It was felt that these relationships developed due to the imperative of constantly shrinking product development cycles, described above.

Several public policy initiatives were cited as being helpful and in some cases quite important in fostering various inter-firm connections and collaboration. The regular Club Aerospatiale dinners organized by the Quebec Ministry of Industry, Commerce, Science and Technology (MICST), described above, were mentioned by a number of the firms as being quite useful. One prime stated that the meetings were "…informal but very beneficial… let's sit down informally [with potential suppliers] and discuss…we've met companies there and then had them meet with our designers, engineering and buying departments" (p1, personal communication, July 6, 1998). A third-tier firm, discussing the efforts of MICST, including the Club Aerospatial and sector newsletter published by the Ministry, conceded that:

> Ce n'est pas pour cela que nos liens avec les primes et les deuxièmes niveaux se créent…mais nous devons attirer l'attention pour dire que nous sommes capables de produire certaines pièces…nous devons toujours rencontrer les acheteurs, ce que les soupers et les bulletins nous permettent de faire" (t2, personal communication, June 3, 1998).

A second-tier was equally direct: "These relationships have developed totally independent of public policy. They are a commercial necessity" (s2, personal communication, September 10, 1998).

However, while none of the firms would attribute the level of collaboration and trust that exists in the sector to specific public policy measures, firms at all three tiers in the industry agreed that such collaboration and trust would not happen unless Quebec had the primes and second-tier firms in the first place. This, it was agreed, was heavily influenced by public policy. In other words, for PBTL in the Storperian sense to occur, it was necessary to have a core of firms who had the technical and managerial skills to transfer to their supplier base. Only when this core of firms was in place could the sector see the kind of collective learning via ongoing downloading of competencies which we are now witnessing. This notion was expressed in different ways. One third-tier firm, discussing the know-how it had received and new competencies it had been required to adopt to maintain its sales to a key second-tier buyer, stated simply "s' ils [the buyer] n'avaient pas eu de programme de développement, nous ne serions pas en affaires maintenant..." (t2, personal communication, June 3, 1998). The firm went on to say that "s'il n'y avait pas les grandes entreprises [i.e., primes and large second-tier firms], il n'y aurait pas de transfert de technologie...si une région peut attirer un deuxième tier, vous avez la base..." (t2, personal communication, June 3, 1998). One of the second tier firms, who has since diversified its business, stated flatly that "this company would not exist if it were not for ____[p2]" (s2, personal communication, September 10, 1998).

Speaking to the importance of having primes and large second-tier firms to act as a magnet for other firms in the industry, one of the primes in the group described how cost considerations and the need for negotiation between buyer and supplier resulted in a cluster, once established, building on itself to draw in new firms:

> If we have a supplier in, say, Moncton, then they are spending too much money moving parts and semi-finished product back and forth to Quebec....We also prefer that suppliers be close so that we can negotiate quickly, face-to-face... [communication] technology can move information, not people (p2, personal communication, July 21, 1998).

This statement appears to support Lundvall's (1992) contention that it is precisely communications involving complex and rapidly changing messages which are most likely to characterize producers and users of an innovation, and to require both geographic and cultural propinquity.

Another prime, speaking to the same dynamic, described how it had been able to convince a key supplier to relocate operations from the U.S. to the Montreal area in the early 90's. While the effort to get the supplier to move was partly in response to a need to increase Canadian content, the prime stressed that a more important imperative was to "help our supply chain by getting that work done locally" (p1, personal communication, July 6, 1998).

One of the primes in the group described another dynamic which worked to draw firms in the sector together around a few key buyers:

> We don't like to have a supplier only selling to us due to production cycle issues....If you [a supplier] have only one product or service, then you need to make as many contacts as possible to diversify your business....Again, if you're in New Brunswick, your marketing costs to make those contacts are very high (p2, personal communication, July 21, 1998).

It would appear, therefore, that for PBTL based on aerospace technology to occur within a given concentration of firms, there has to be a critical mass of prime and/or second firms in the region. This leads inevitably to a question which the present research originally did not set out to answer—whether or not public policy was instrumental in the development of the sector to begin with. A review of the history of the Quebec aerospace sector suggests that the sector's genesis did have its roots in various public policy initiatives, though these initiatives were undertaken to achieve various national goals beyond local industrial development. In particular, the Montreal area developed an extensive network of machine shops due to its role as a major port and as the eastern hub of the transcontinental railway, one of the earliest and most important federal government transportation initiatives. The Second World War was a crucial point in the development of the Quebec aerospace sector, as Canadair grew as a result of major military contracts for the Allied war effort. During the Cold War, Canadair again was awarded numerous contracts for the Canadian military. The one instance where a major aerospace firm was established in Quebec primarily due to industrial policy initiatives was the arrival of Bell Helicopter Textron in 1976, described above.

However, attributing the existence of the Quebec aerospace sector, and in particular the continued presence of a few prime and second-tier firms who act as the catalysts for an ongoing process of PBTL, to the effects of WWII or the Cold War, or for that matter to a series of incentives given in the mid 1970's, misses the point. It does not address why these firms have continued to stay in Quebec. In order to answer this question, one has to first return to the definition of high technology trade cited above: products where competitive success is entirely dependent on Schumpterian competition, based on constant product and process improvements derived from ongoing innovation. The new products created by this ongoing innovation require resources, both human and financial. As noted by several authors, while public policy has generally been unsuccessful in identifying and attempting to develop the innovations needed for success in the market, it does have a key role in providing the environment—i.e., the resources—whereby such innovation can be undertaken by the private sector. To the extent, therefore, that public policy measures at the federal, provincial and local level can facilitate the acquisition by Quebec's prime and second-tier firms of the human and financial resources needed for them to engage in continuous innovation, then these measures will assure that these firms will remain in the province. As one of the primes said, "companies will continue to stay here as long as they can develop their new products here…public policy has to be supportive of that environment" (p2, personal communication, July 21, 1998).

It is precisely here where the "sound finance" school of thought, described above, poses the greatest threat to the continued presence of prime and second-tier aerospace firms in Quebec, and by extension, to the ongoing ability of the Quebec aerospace sector to engage in the PBTL so crucial to its long-term viability. Firms at all three tiers were emphatic that federal and provincial austerity programs were directly impacting their ability to secure the resources needed for ongoing innovation.

The first area where this emerged was in the supply of technically-trained CEGEP and university graduates. One of the second-tier firms identified this as a major concern in terms of their ongoing operations:

> We don't hire anyone without CEGEP...the bar has been raised...the shop floor needs to understand computers. The problems are the high drop-out rate from high schools and the fact that universities, due to government cutbacks, are cutting the number of graduates, especially in the science/technology field (s1, personal communication, April 22, 1998).

One of the primes also identified human resources as a key public policy challenge. The firm cited comparatively high personal taxes, which have created a "brain drain" of technically trained Canadians toward other jurisdictions, notably the United States, where lower taxes and higher wages translate into a higher standard of living. It is noteworthy that the firm emphasized that official data on the supply of technical workers was an inaccurate gauge of the scope of the problem: "You can't look at StatsCan data showing immigration and out-migration data....One immigrant engineer, who lacks experience with you, does not equal one Canadian engineer who has experience in your firm" (p2, personal communication, July 21, 1998).

The other factor which this firm cited was inadequate production of technically trained CEGEP and university graduates, particularly for the unique needs of the aerospace sector. However, the shortage of technically trained employees is most keenly felt by the smaller, third-tier firms. As one of the second-tier firms conceded, "budget cutbacks reduce the number of grads, but we can get what we need...we hire fifty to a hundred per year, even in downturns...we want to keep renewing the pool" (s1, personal communication, April 22, 1998). What this means is that the third-tier firms find it most difficult to meet their hiring needs. As one of these firms stated, "they [primes and larger second-tier firms] have a monopoly on the best grads...we have to be lucky" (t1, personal communication, May 27, 1998). One of the second-tier firms stressed that the best thing public policy could do for firms in the third-tier would be to help them acquire the skills and knowledge infrastructure needed to diversify their business:

> A lot of small firms expect the government to open doors for them....I'd look at government helping those companies to develop the infrastructure necessary to move up the chain....There is some knowledge these firms [third-tier] suppliers don't have....Neither the primes nor the second-tier are going to hold your hand....Public policy could be really useful in that regard, not spending money wining and dining the primes at air shows (s2, personal communication, September 10, 1998).

The second area where government austerity initiatives have had an impact is on the provision of financial resources to support ongoing innovation by the sector. Several of the firms in the group described how the new criteria being applied for Technology Partnership Canada funding were making it increasingly less attractive for firms to seek TPC support. One prime described the transition from DIPP to TPC and the concomitant change in TPC criteria as follows:

> TPC has become a financial arm of the government rather than a technical arm. They are applying financial criteria to decide funding and repayment. They've become just another bank...[For example] they won't fund a project if we have already started preliminary R&D....They don't

realize that we can't wait for them to decide" (p1, personal communication, April 22, 1998).

Another prime also expressed concern over the change in orientation represented by TPC, in particular the government's stated desire to have at least 50% of the fund regenerated through royalty income by 2003 (see above):

> They [the federal government] are trying to meet the public outcry over subsidies, but they are becoming too zealous…the repayment terms and conditions of TPC are going beyond reality….If you receive $10 million, but the product is a winner, you could end up repaying $50 million…So, the government will look for solid projects instead of risk projects which could advance technology (p2, personal communication, July 21, 1998).

The result of the ascendancy of the sound finance school of thought in the case of support for the Quebec aerospace sector has been, according to this firm, "a reduction in the total amount of dollars, a reduction in the amount of sharing by the government, and a reduction in the number of risk projects they do. So, you have a reduction in the investment in Canadian R&D in this sector" (p2, personal communication, July 21, 1998). The net result of this situation, according to this firm, is that "this could cause us to go elsewhere to fund risk projects (p2, personal communication, July 21, 1998).

It is difficult to assess the likelihood of a large scale transfer of aerospace activity out of the Quebec sector towards more favorable environments. However, the discussions with the firms in the interview group did confirm that were such an out-migration to occur, particularly at the level of prime and second-tier firms, then the upgrading of the supplier base which has been going on as part of the new paradigm of buyer-supplier relationships in the industry would effectively cease. Not only would the key sources of technical knowledge no longer be present in the sector, but the suppliers would be deprived of the "demanding buyers," (to use Porter's (1990) terminology), who are so essential to continuous innovation. Nor should one assume that foreign buyers would or could take the place of local primes and second-tier buyers. As one second-tier firm stressed:

> I don't think that primes elsewhere would use Canadian suppliers, if they didn't see that those suppliers were not supplying someone like us locally....Major primes in other countries wouldn't recognize the capabilities of Canadian suppliers (s1, personal communication, April 22, 1998).

In other words, if public policy does not create an environment in which primes and second-tier firms can acquire the resources necessary for ongoing innovation, then these firms will go elsewhere. If and when they do, the supplier base, comprised of third-tier firms, will not be able to engage in PBTL and will atrophy. Herein lies the nexus between public policy and PBTL, at least as far as the Quebec aerospace sector is concerned.

In order to gauge whether the Quebec aerospace sector has been the beneficiary of extensive versus limited public policy support, the thesis will, as noted in the methodology section above, attempt to outline the scope of public policy support for the province's pharmaceutical sector. This description, which follows, will provide a baseline level against which the level of support extended to the aerospace sector can be compared.

CHAPTER TWELVE

The Canadian Pharmaceutical Industry

The Canadian pharmaceutical industry consists of about one hundred and fifty firms. The industry can in fact be divided into three or even four sub-groups. The brand name industry consists of slightly over sixty firms, and is dominated by the Canadian subsidiaries of large foreign-owned multinationals. The so-called generic industry has over fifty firms, the most important of which are two large Canadian-owned firms. The non-prescription sector includes about forty firms. In addition to these three groupings, there are another 200 or so firms in the biotechnology sector, many of which have entered into various forms of strategic alliances with companies in the pharmaceutical industry.

As of 1995, the industry employed about 21,000 people, with approximately 90% of that figure concentrated in and around Montreal and Toronto. Over half total industry sales as well as most industry R&D is conducted by Quebec-based firms (Snyder, 1992). Another indicator of the strength of the Quebec pharmaceutical sector is the related biotechnology sector in and around Montreal. Since 1986, more than fifty new biotech firms have been formed in the city (Branswell, 1997). Quebec attracted over half of the $1 billion invested in biotechnology in Canada during 1996 (McGovern, 1997).

The industry demands a highly educated workforce, with almost 50% of employees being college graduates (Price Waterhouse, 1996). Moreover, the industry is expected to become even more knowledge-based in the future in light of the increasing importance of R&D, and so this figure is expected to increase (Price & Waterhouse, 1996). The pharmaceutical industry is one of the largest sources of R&D investments in the country, typically spending over 10% of sales revenue in any given year. For 1994, the industry spent almost $645 million on R&D, or almost 10% of all industrial R&D in Canada for the year (Coopers & Lybrand, 1996). However, when R&D figures for each of the three sub-groupings in the industry are examined, this figure is actually higher. The branded firms, who are represented by the Pharmaceutical Manufacturers Association of Canada, reported 1994 R&D expenditures of $561 million. The fifty or so companies who comprise the generic industry, represented by the Canadian Drug Manufacturers Association, spent approximately $84 million that year, with the two largest firms referred to earlier accounting for almost 90% of that figure. Finally, the firms in the non-prescription sector, represented by the Non-prescription Drug Manufacturers Association of Canada (NDMAC) estimated that they spent about $30 million on R&D (Coopers & Lybrand, 1996).

Public Policy and the Pharmaceutical Industry in Canada

A 1996 study of the industry commissioned by Industry Canada's Health Industries Branch and conducted by Coopers & Lybrand Consulting outlined four key external factors that determined the R&D environment for pharmaceutical firms. These factors included the investment climate; government support programs; the regulatory climate; and the supportive resources available to the industry. Each of these four areas includes areas of public policy involvement and are described below.

a) Investment climate: According to the Coopers & Lybrand report, this factor incorporates issues such as low cost capital; favorable tax incentives; procurement policies; and an "internationally competitive" intellectual property regime.

The first area is heavily influenced by government's overall macro-economic policies in terms of interest rate determination. However, there are two fairly focused areas where public policy has a critical impact on the industry: tax incentives for R&D, and the intellectual property regime.

The Canadian federal tax system allows for full deduction of current R&D expenditures, as well as for capital expenditures made on machinery and equipment needed for R&D. The federal code also gives a fairly generous tax credit for qualifying R&D expenses incurred in Canada (20% of R&D expenses for large firms, 35% for smaller firms). Moreover, some provinces, such as Quebec, have made their own provincial tax codes extremely favorable to R&D conducted within their borders, as noted above. In fact, the after-tax cost of one dollar of R&D work conducted in Quebec for 1994 was only $0.479, well below the $0.507 figure for Ontario, the $0.527 figure for the state of California, or the $0.670 and $0.607 figures reported for the UK and France, respectively (Coopers & Lybrand, 1996).

A crucial area of public policy involvement in the pharmaceutical industry is that of the intellectual property protection regime. This includes such issues as the duration of patents, the period of exclusive protection, treatment of so-called generic drugs, and the entire question of compulsory licensing.

The industry is somewhat unique with respect to the question of intellectual property protection since it is subject to a particularly high level of regulatory scrutiny before new products are approved for sale. This has meant that the traditional 20 year period of patent protection has been significantly reduced for pharmaceutical firms. It is not uncommon for a new drug in Canada to need between ten and twelve years after its patent has been filed to gain regulatory approval. This has reduced the period of protection to between eight and ten years for drug firms. Moreover, from 1969 to 1987, the main piece of intellectual property legislation covering the pharmaceutical industry, Bill C-102, gave only four years of patent protection to developers of new drugs and introduced compulsory licensing. This meant that generic manufacturers were permitted to import patented ingredients used to make branded drugs. The generic firms could then produce copies of the branded drugs in return for payment of a 4% royalty to the patent holder. Given that Canada has traditionally been a very small market for the large, multinational branded manufacturers and hence would not have an impact on their global level of R&D, the framers of C-102 saw compulsory licensing as a way for Canada to "free-ride" on the innovation activities of the multinationals while limiting their potential monopoly power in the Canadian market (Anis & Wen, 1998).

In 1987, the Conservative government of Brian Mulroney passed C-22, which continued compulsory licensing but required generic manufacturers to wait between seven and ten years after the patented product came to market to begin selling copies of the original version (the shorter term applying if ingredients could be obtained in Canada). C-22 further stipulated that protection for patent holders would be the lesser of seven years or the remainder of the life of the patent after all pre-marketing clinical trials had been completed. Finally, C-22 created a unique body, the Patented Medicine Prices Review Board (PMPRB) which was mandated to ensure that the branded manufacturers did not take advantage of their newly expanded patent protections to unduly increase the prices of their drugs. The branded manufacturers also undertook to spend 10% of their sales on R&D by 1996.

In 1993, the Mulroney government replaced C-22 with a more ambitious reform, C-91. This new bill came as a result of extensive lobbying by the branded manufactures and by Canada's main trading partners in the context of the Uruguay Round of GATT negotiations. C-91 gave 20 year patent protection from the date of filing for all works involving intellectual property rights and eliminated compulsory licensing except for those licenses granted before December 20, 1991. Generic manufacturers in effect now had to wait until the patent on a branded drug expired before they could produce and market copycat versions. The bill placed intellectual property protection in Canada on a par with the regime applicable in all other GATT/WTO member states. It is noteworthy that Quebec was the only province to officially support both Bill C-22 and Bill C-91, in all likelihood anticipating a significant increase in investment in the province by PMAC. In fact, as of the beginning of 1993, Quebec adopted a policy of reimbursing pharmacists for the actual purchase costs of all products, rather than capping reimbursements at the lowest price available. This policy change meant that the province's pharmacists were no longer required to use generic drugs and could instead fill their prescriptions based on acquiring higher cost branded products. At the same time, Quebec medicare adopted a policy of reimbursing pharmacists a flat $7 for every drug dispensed (ie. the dispensing fee, which is the source of pharmacists' profits), regardless of what it cost to fill the prescription. These two measures removed much of the incentive for pharmacists to turn to generic drugs for their customers. As a result, generics' market share in Quebec was only 34% in 1999, significantly lower than the 44% national average (Heinrich, 1999, May 4). According to a spokesman for the Coalition of Physicians for Social Justice, a group critical of Quebec's drug policy, the province could save as much as $67million each year if generics increased their market share in Quebec up to the prevailing Canadian average of 44%. The Coalition also claims that easing patent protection on brand name drugs would save Quebec an additional $25 million per year (Heinrich,, 1999 June 3).

Members of PMAC, representing the branded manufacturers, committed to significantly increasing their R&D spending in Canada in response to the tightening of the Canadian intellectual property protection regime. In fact, R&D expenditures by PMAC members went from $166 million in 1988 to $561 million in 1994 (Coopers & Lybrand, 1996). By 1996, the figure had reached $624 million (Wayne, 1997). It should be noted, however, that a significant portion of these incremental R&D funds were allocated to clinical trials rather than fundamental discovery research aimed at creating new drugs (Coopers & Lybrand, 1996). Moreover, as part of their commitment to increase R&D in Canada, PMAC's sixty-two members had committed to spending up to $200 million over five years on university research, including a "significant" amount on personnel and training (Wayne, 1997). These funds were to have been distributed through a new partnership between PMAC and the federal government's MRC, with the latter agreeing to provide an incremental one dollar for every four that a PMAC member committed to a peer-reviewed approved project. However, by the end of 1996, the new partnership, called the PMAC/MRC Health Program, had generated only $65 million in support, much of which went to projects already under review, and many university researchers were expressing fears that support from the Program simply meant a reduction in other MRC funding (Wayne, 1997).

Another element of C-91 was a broadened mandate to the PMPRB to establish and enforce pricing guidelines of branded drugs. Several observers have noted that since C-91 has passed, the branded drug manufacturers have not used their quasi-monopoly powers to unduly increase their prices (Camadj, 1996; Anis & Wen, 1998).

b) Government support programs: The Coopers & Lybrand report includes an acceptable level of basic research funding and established technology transfer capabilites in this category. The main federal government body supporting health research in Canada is the Medical Research Council (MRC) which awards grants for training of and salary support to researchers as well as for ongoing operating costs of medical research labs and facilities. MRC does not, however, give funding for research infrastructure construction and development. In response to an ongoing austerity program at the federal level, MRC's share of total medical R&D in Canada has declined from 39% in 1981 to 24% in 1992/93 (Coopers & Lybrand, 1996). At the same time, MRC's share of total federal government R&D expenditures has remained constant at 7% between 1993-94 and 1996-97 (Warda & Zieminski, 1996). Therefore, MRC's declining share of total medical R&D is a direct function of reduced overall R&D funding by the federal government.

Since 1983, Quebec has subsidized health research and researchers through a provincially-funded non-profit organization, the Fonds de la recherche en santé du Québec (FRSQ). The FRSQ administers a range of training awards, scholarships, grants to teams, groups and research institutes, subsidies for research and support for diffusion of scientific discoveries in the health field. However, the FRSQ's budget is fairly small

($2.3 million as of 1995) (Government of Quebec, Ministry of Industry, Commerce, Science and Technology, Web site, http://www.micst.gouv.qc.ca/R-D/quebec.html).

c) Regulatory Climate: The report includes under this heading factors such as quick regulatory approval of both experimental and new drugs, as well as of patent applications, coupled with pricing and reimbursement policies and measures which impact market access. The main regulatory agency for the pharmaceutical industry in Canada is the federal Health Protection Branch (HPB). Drawing on data supplied by the HPB, Coopers and Lybrand (1996) found that there had been a marked improvement in the median approval time for applications for brand name drugs in Canada, from almost 38.1 months in 1994 to 19.6 months in 1995. However, Canada still lagged considerably behind leading pharmaceutical nations such as the U.S. and the UK in terms of approval times. For example, of forty-two new drugs approved during 1991 in other industrialized countries, only one was approved for sale in Canada (Quebec Industrial Atlas, 1993).

d) Supportive Resources: This factor includes the quality and supply of trained personnel, the caliber of local scientific institutions and the overall quality of life. The overall perception of Canada' health care infrastructure, including its universities, research institutes and educational system, is that it is quite sound (Coopers and Lybrand, 1996). However, as both the federal and provincial governments continued with their budget cutback programs through the early and mid-1990's, concerns began to be raised about the erosion of research facilities and equipment at many Canadian universities. In October, 1996, the Canadian Association of University Teachers, the Consortium of Scientific and Educational Societies, and the Association of Universities and Colleges of Canada issued a joint statement claiming that as a result of ongoing cuts in both federal and provincial funding, Canada's ability to innovate was "at risk" (Lewington, 1996, p. A51). The groups demanded the creation of a $6 billion joint federal-provincial fund to help universities repair and upgrade facilities and libraries and purchase new technologies.

In response to these concerns, the federal government announced in its 1997 budget the creation of a new independent non-profit organization, the Canada Foundation for Innovation. The Foundation, which was to receive an initial infusion of $800 million from Ottawa, would fund a variety of research infrastructure projects by universities, hospitals, and privately run research institutes. Eligible projects would include capital expenditures, establishment of computer networks and communication linkages, and the creation of research data bases and information processing capabilities. In announcing the creation of the Foundation, Industry Canada estimated that the new initiative would be disbursing about $180 million annually over the first five years of the program's existence. The Foundation would fund up to 40% of a project's costs, with the balance coming from private industry, charitable groups and private donors.

Almost as soon as it was announced, the Foundation found itself at the center of controversy. On December 8, 1997, Quebec Education Minister Pauline Marois announced that Quebec-based universities and research institutions that accepted funds from the Foundation would find their provincial grants reduced by an equivalent amount. The Minister explained her position by saying that the Fund represented yet another attempt by Ottawa to dictate priorities in an area of provincial jurisdiction. She noted that unless Quebec could decide where the Foundation's funds would be used with respect to Quebec institutions, "Quebec's priorities will be at the mercy, in effect, of pan-Canadian arbitrages, carried out by a board of directors who will obey completely different imperatives" (cited in Thompson, 1997). The Minister went on to say that the Foundation would simply duplicate provincial research funding efforts (Thompson, 1997). Finally, Minister Marois pointed out that the Foundation would impose an additional burden on Quebec's already strained budget, since it would pay for the construction of new facilities, while Quebec would be ultimately asked to provide support for ongoing operating expenses of these facilities. However, less than one week later, the Quebec government relented in its opposition to the Foundation. Intergovernmental Affairs Minister Jacques Brasssard announced that instead of boycotting the Foundation, the Quebec government would evaluate projects from Quebec-based research institutions and submit a list of the projects it felt deserved support on to the Foundation.

Another element of infrastructure support has been the federally funded Biotechnology Research Institute (BRI) in Montreal, one of five biotech research centers across Canada run by the National Research Center. Each of the five centers has its own mandate, with Montreal's focused on pharmaceuticals and soil decontamination. The institute cost over $60 million to build and costs about $23 million per year to operate (McGovern, 1997). BRI employs some 230 researchers, with another 290 researchers from private industry and universities using its facilities (McGovern, 1997). The Institute's original mandate was to engage in generic research, which would fall somewhere between and link basic research being conducted in universities and more applied research being conducted by industry (Carney, 1997). Over the years, the Institute has expanded its role and works with the private sector in joint research, providing either expertise or licensing compounds or processes to companies. In 1996, it earned about $4 million from various contracts with private firms, and as of mid-1997, it had over $40 million in outstanding partnership agreements (McGovern, 1997). As well, BRI has come to be seen as an important training ground for scientists, a developer of personnel for the region's pharmaceutical and biotech firms, and an incubator site for start-ups, providing everything from lab and office space to small-scale production facilities (Carney, 1997).

Differences in Public Policy Orientation Between the Aerospace and the Pharmaceutical Sectors

A review of the data would seem to confirm that both the aerospace and pharmaceutical sectors have been the beneficiaries of extensive public policy support at both the federal and provincial level. In particular, using the Quebec pharmaceutical sector as a baseline to gauge whether the aerospace sector has been the object of a high or low level of public policy support, a review of the data would lead one to conclude that the fairly extensive support given to the pharmaceutical sector has been matched, albeit in different forms, by the level of support accorded the province's aerospace sector.

At the federal level, both sectors have benefited from the generous tax treatment of R&D, described above. In terms of direct federal financial assistance for R&D, while the aerospace sector benefited from DIPP and its successor, TPC, the pharmaceutical sector has been able to draw on R&D support from the federal government's MRC, described above, and more recently, the Canada Foundation for Innovation. The federal government has been involved over many years in extensive negotiations to establish an international regulatory climate for the global aerospace industry. These negotiations produced the 1979 GATT Civil Aircraft Code and the Agreement on Subsidies and Countervailing Measures (SCM) which arose in the context of the GATT/WTO Uruguay Round of 1986-1994 (see above). The analog to this high level of involvement in negotiating an overall regulatory context for the industry, in the case of pharmaceuticals, has been the federal government's extensive modifications of the intellectual property regime since 1987, in particular Bills C-22 and C-91. In fact, as noted above, C-91 was itself a direct by-product of the GATT/WTO Uruguay round, since one of the federal government's objectives in tabling the legislation was to bring the Canadian intellectual property regime into line with obligations Canada would assume as part of the round's associated negotiations on patents and copyright protections (see above).

At the provincial level, some differences emerge in the nature of, but not necessarily the level of, public policy support. As noted above, Quebec's tax treatment of R&D has been quite generous, not only compared with other Canadian provinces but relative to other jurisdictions. Quebec's Ministry of Industry, Commerce, Science, and Technology (MICST) has functioned for several years as a de facto trade organization for the province's aerospace sector, trying to match buyers and sellers in the industry through periodic dinner meetings and through various publications circulated throughout the sector. There is no direct analog of provincial involvement in the pharmaceutical industry. However, as noted above, the Caisse de depot et placement, the provincial pension fund managing authority, has been much more active as an investment banker and venture capitalist in the province's pharmaceutical sector than in its aerospace sector.

As noted, this differential is due both to differing levels of sectoral expertise within the Caisse, and to differences in the needs of the two sector's firms.

CHAPTER THIRTEEN

Conclusions

Evolution of Public Policy Initiatives

A review of the historical evolution and current state of the Quebec aerospace sector reveals that there been a dramatic shift in the nature of public policy towards the sector in the last fifty years. This shift has mirrored a broader transformation in the definition of the term "industrial policy" in most industrialized countries. This shift can best be described by referring to Tables 1 and 2 below:

Table 1: Taxonomy of Industrial Policy Initiatives in Canada involving Aerospace Sector 1940-96

	Reactive	Anticipatory
Targeted	Direct government ownership	Direct Procurement Defence Industry Productivity Program (DIPP)
Generic	Technology Partnership Canada (TPC) Export Financing	R&D Tax Credits

Table 1 presents a way of classifying public policy initiatives involving the aerospace industry in Canada over the fifty-six year period 1940-1996. The table is broken down, on the horizontal axis, by the extent to which a given policy was reactive or anticipatory in the sense defined by Atkinson and Coleman (1989). On the vertical axis, the classification is determined by the extent to which a given policy initiative was targeted at the aerospace industry, or whether it was more generic and open to a broader range of industries.

As noted previously, the Canadian government has felt compelled to take direct control of aerospace firms at two distinct historical points: Firstly, during WWII, Ottawa took over National Steel Car of Malton, Ontario (renamed Victory Aircraft), and Canadian Vickers of Montreal (renamed Canadair). Both firms were privatized subsequent to the war, with Victory sold to A.V. Roe of the U.K. and Canadair sold to General Dynamics of the U.S. Then, in the mid 1970's, Ottawa re-entered the aerospace sector, purchasing both de Havilland and Canadair from their foreign owners. Again, the federal government ultimately privatized both entities, selling de Havilland to Boeing and Canadair to Bombardier in the late 1980's. Both instances of direct federal government ownership of aerospace firms can be seen to be highly reactive to particular circumstances of the times, while being specifically targeted at the aerospace sector: In the first instance, Ottawa felt compelled to maintain production of aircraft to support the war effort. Both firms nationalized during the war were privatized once the war ended and the imperative of military production was over. In the second instance, the federal government feared that a major exodus of engineering and scientific talent would result from the failure of the country's two main airframe producers, both of whose foreign parent firms were unwilling to make new investments in product development. De Havilland and Canadair were privatized only after their respective product lines had been bolstered by new models developed thanks to extensive infusions of capital from the federal government.

It could be said that direct procurement by the federal government, largely for military purposes, was a more anticipatory type of policy measure, while still being targeted at the aerospace sector. While procurement for the WWII effort could be seen as a reaction to events of the moment, subsequent Canadian government efforts in the area of direct procurement suggest an attempt to bolster Canadian capabilities in the sector. As described above, the Canadian government negotiated the Defense Development Sharing Agreement with the United States in 1963, thus giving Canadian aerospace firms access to R&D funds from the U.S. Department of Defense. The ill-fated Arrow program, had it been allowed to proceed, could have been the springboard for a major Canadian initiative into jet transport. Meanwhile, the Canadian government's extensive purchases of military aerospace products during the 1940's and 1950's coincides with a period of unprecedented new product development by the country's airframe firms. The present research did not address the question of whether or not development of an indigenous Canadian aerospace capability was actually a federal government goal at that time. However, as described previously, government procurement for military purposes can, for a variety of reasons, result in increased development of new products aimed at the civilian market. It is not unreasonable to speculate that Ottawa had precisely this type of dynamic in mind as it funneled large military orders to Canadian firms in the 1940's and 1950's.

The Defence Industry Productivity Program (DIPP), established in 1959, was another initiative which could be considered as both targeted at the aerospace industry and part of a more anticipatory approach to industrial policy. Regarding the extent to which DIPP was a targeted program, it is true that any firm involved in defense contracting was eligible for the program.. However, as noted previously, the high level of support which was being given by foreign governments to their respective national aerospace firms, and the high level of technical and financial risks associated with the aerospace industry were key factors in the federal government's decision to begin the program. Over its thirty-six years of operation, DIPP invested $3.6 billion in the Canadian aerospace sector (see Chapter 9), by far the largest amount of any sector which received DIPP funding. As for DIPP's classification as a more anticipatory program, the discussion of the program in Chapter 9 above noted that funding was by no means automatic, and depended upon "the industry development strategic objectives of Industry Canada" (Industry Canada, 1992, p.1).

The introduction of Technology Partnerships Canada (TPC) in March, 1996 can be seen to be a reactive measure. As discussed above, DIPP was terminated in 1995, largely due to political pressure on the federal government to reduce its expenditures. The Canadian aerospace industry, and in particular several high-profile prime and second-tier firms, made their dissatisfaction with the DIPP cancellation known, and threatened to relocate key R&D programs elsewhere unless there was some replacement for it. Ottawa's creation of TPC can be seen to be a reaction to the unforeseen industry response to the DIPP decision. Regarding the extent to which TPC is a targeted or generic program, the federal government has, as noted above, always presented the program as being open to a wide range of industries and technologies. For purposes of Table 1, I have classified the program therefore as generic. However, as noted above, the reality of TPC has been that most of its funding to date has gone towards aerospace-related projects and firms, and so a case could be made that TPC is in fact a targeted program.

The other program in the reactive/generic quadrant is export financing. In Canada, this is offered by the Export Development Corporation (EDC) , a crown corporation. Though the paper did not discuss EDC activities directly, it did outline in Chapter 7 how export financing can play an important role in the marketing of aerospace products to foreign buyers. This type of a program can be considered reactive, as most industrialized countries have established export financing programs to level the playing fields for their respective exporting firms in the face of competitors' own such financing vehicles. Indeed, reacting to competitor nations' newest export financing program and/or pricing has long been the main driver for new initiatives in this area (Letovsky, 1990). It is difficult to consider export financing a targeted program, as export finance agencies are usually mandated to support any firm engaged in bona fide export transactions. However, the share of total export financing volume taken up by any one sector could give an export financing program the appearance of being targeted at that sector. As noted in Chapter seven, this was the case in the United States during the 50's, 60's, and 70's, when the U.S. government's EXIMBANK was known informally as "the Boeing Bank".

The last element in the taxonomy is the "anticipatory/generic" quadrant. Here we find R&D tax credits. As discussed in Chapter ten, Quebec's extensive system of R&D tax credits was the direct result of two key economic development strategy papers issued by the Parti Quebecois government of 1976-84. Both papers articulated a series of goals for Quebec technology policy, foremost of which being a change in the composition of what was produced in the province. However, the R&D tax credit program introduced by the province beginning in 1983 never stipulated that only certain sectors would be eligible. In fact, the way the program has been monitored [or, as described by Palda (1994), not monitored] by the Quebec government seems to confirm that no precise targeting was ever envisaged.

Table 2: Taxonomy of Industrial Policy Initiatives in Canada involving Aerospace Sector 1996-99

	Provincial	Federal
Financial	Quebec Aerospace Investment Fund Caisse de dépot investments	Technology Partnerships Canada (TPC)
In kind	Networking Dinners Sector Newsletter De facto trade association Support for specialized training institutions (ENAM, ETS)	

Table 2 above presents a taxonomy of industrial policy initiatives which differs from that presented in Table 1. This new taxonomy reflects two significant shifts in industrial policy: A progressive "downloading" of industrial policy to the provincial level, as the federal government has steadily reduced its involvement in support of specific industries; and an increase in public policy aimed at promoting the diffusion of skills and ideas within a given industrial cluster rather than at supporting the competitive position of a given firm.

The top left quadrant of Table 2 includes two programs which are reminiscent of the "targeted/reactive" quadrant of Table 1. The Quebec Aerospace Investment Fund was a limited duration program of reimbursable loans introduced by the provincial government in late 1996. The program was begun in response to industry complaints about the abrupt cancellation of several Quebec government programs which left a number of aerospace firms in the province scrambling for funding. However, as noted above, the Fund was strictly a limited initiative, and no new applications were being accepted beyond those firms covered by the program at its inception.

The second element of the "provincial/financial" quadrant includes investments in the aerospace sector by the Caisse de depot et placement, a provincial government agency. The types of investments which the Caisse has made thus far in the sector appear to be reactive, in the sense that the agency has responded to specific proposals submitted to it by firms in the sector, as in the case of the Bombardier financing package described above. The Caisse has not, until recently, considered itself to have extensive experience in the sector. This perception has engendered a degree of caution on the Caisse's part with respect to the aerospace sector. Proof of this conservatism is the fact that the Caisse was not a factor in financing the meteoric growth of Bombardier. However, as noted above, the creation of the Caisse's new Sofinov subsidiary, with its cadre of specialists with in-depth knowledge of the aerospace sector, has given the agency a powerful new tool to make more strategic investments in the sector.

The "in-kind/provincial" quadrant includes a variety of initiatives undertaken by the Quebec government and its agencies which do not involve the direct transfer of funds to firms in the aerospace sector. Rather, these initiatives aim to provide various common goods which are useful both to individual firms in the sector, and to the Quebec aerospace sector as a whole. The organizing of periodic networking dinners and the publication of a newsletter/bulletin by the Quebec Ministry of Industry, Commerce, Science and Technology (MICST), described above, are attempts by the province to build and strengthen linkages among firms in the sector, particularly between prime and second-tier firms on the one hand and the larger number of small third-tier firms on the other. Similarly, MICST's periodic efforts at bringing together aerospace firms in the province by acting as a referral source also reflects a desire to build and strengthen these linkages. Provision of these types of services by MICST has, as discussed in Chapter 10, made the ministry into a de facto trade organization for the Quebec sector, particularly for its smaller third-tier firms who did not, until recently, have the resources to start and maintain their own trade group.

To the extent that the provincial government has been involved in funding some of the specialized training institutes that have developed in and around Montreal, it can be said that it is also providing a form of in-kind service to firms in the sector. Again, this type of public policy initiative does not involve a direct transfer of funds to any recipient firm. Rather, it can be considered as an effort, to use the OECD's description cited previously, to "improve the inputs available to industry" (OECD 1992, p. 13).

The shift from federal to provincial programs can be explained by several factors discussed previously in the paper: Certainly, the ascendancy of the sound finance school of thought has cast a number of public policy initiatives targeted at industry into the category of "wasteful public spending" that have to be eliminated if "government is to live within its means." The cancellation of DIPP by the federal government can certainly be attributed to a political climate in which expenditure reductions become the dominant, if not the only priority being pursued by the government. However, it would be simplistic to attribute the federal government's progressive withdrawal from direct financial support of the aerospace industry to sound finance alone. Several other developments have contributed to Ottawa's steady reduction in support offered to the industry, and to the provinces (in this case Quebec) replacing this support with the type of in-kind programs described here.

One such development is the entire series of GATT/WTO obligations undertaken by Canada since the 1979 agreement on aircraft subsidies negotiated as part of the Tokyo Round. These obligations have put all forms of federal support for Canadian-based aerospace firms under unprecedented scrutiny, and created an environment where government funding on anything but the strictest repayment terms will trigger some type of countervailing action by a competitor nation. Proof of the high burden of proof which public policy initiatives aimed at the aerospace sector must overcome can be found in the 1998 complaint lodged with the WTO by Brazil as part of the ongoing battle for market share between Bombardier and the Brazilian firm Embraer. The Brazilians have accused Bombardier of having received actionable subsidies from Ottawa in the form of loans from the TPC program (Morton, 1997).

Indeed, it may be that the shift from federal to provincial initiatives can be further explained by the GATT/WTO regime to the extent that junior-level government programs have historically been less visible to foreign governments and hence less risky for those firms benefiting from them. The activities of MICST in acting as a form of matchmaker for Quebec's aerospace firms is not something which is as apparent to overseas governments as a loan from TPC which is announced in the media, or a financing package offered by EDC and communicated directly to foreign buyers. Nonetheless, it could be argued that MICST's activities have constituted a de facto subsidy by at times obviating the need for Quebec aerospace firms to pool their own resources to fund and operate a trade group.

Another possible driver for the down-shifting of public policy from the federal to the provincial level may be found in the dynamics of industrial cluster formation. As noted above by several of the interview group members, there are sound business reasons why firms at all three levels of the industry may at times insist on geographic propinquity with their suppliers and sub-suppliers. The growth of the Quebec sector reflects this logic. At the same time, as noted above, the Quebec aerospace sector's growth has outpaced that of aerospace sectors in other provinces. This may create a difficult political situation for the federal government in terms of offering "too much" direct support to the Quebec sector. Indeed, Karl's (1997) criticism of the TPC, to the effect that the program constitutes some sort of preferential treatment for a handful of politically well-connected (read "Quebec-based"?) firms, may be illustrative of this point. Regardless of the economic benefits, the amount of support which the federal government can direct to the aerospace sector, particularly when that sector's activities are increasingly concentrated in

Quebec, may be limited by political calculations based on the real or imagined resentments of other provinces. For example, Manitoba is the site of a number of aerospace firms, including a Boeing parts plant employing more than 500 and Bristol Aerospace, a Winnipeg firm which began operations in 1930. Bristol expects to expand its workforce from 900 to almost 1,100 between 1997 and 2000 as a result of new contracts won to produce parts for the Boeing 737 (Canadian aerospace companies, 1997).

The second shift in public policy, from direct financial support of specific firms to the provision of in-kind services delivering common goods to the entire sector, can also be explained by several developments. Here again, sound finance's influence cannot be completely discounted: In the face of public antipathy to ambitious spending programs, initiatives such as organizing networking dinners, publishing newsletters and placing a few phone calls to bring together possible buyers and suppliers seem quite modest and hence politically defensible. However, as with the case of the apparent shift from federal to provincial support, sound finance cannot be the only explicator.

The GATT/WTO regime may also be a factor in understanding the shift from direct financial support to in-kind provision of common goods. The latter has generally been upheld by GATT/WTO panels as being permissible, despite the financial savings which publicly funded common-goods offer to firms who benefit from them.

Other developments which may help account for this shift are the increasing complexity of products offered by the aerospace sector, the heightened competitiveness of the industry, and the resultant compression of product development cycles. As discussed above, Storper (1992) has posited that the only rational response of firms to greater product complexity and shortened development cycles driven by increasingly sophisticated buyers is the production network based on Product Based Technological Learning (PBTL). Such a network recognizes that acquisition of all skills and knowledge needed to successfully compete in such an environment is beyond the resources of any one firm. Storper further posits that any attempt at resource acquisition via vertical integration raises the risk of technological "lock-in" to unacceptable levels. A Storperian production network, as described above, requires an extensive web of relationships among firms at various stages of the value chain. These relationships provide the forum for "learning" among firms with distinctive competencies. The idea of public policy focusing on funneling financial resources to a small group of firms (the old "national champions" model) becomes unworkable if the appropriate goal is the fostering of a production network wherein PBTL occurs. In such a situation, public policy initiatives aimed at bringing firms together and promoting the building of trust and the exchange of ideas may have more impact than giving direct financial support to one firm who in any event may lack all the expertise and resources necessary for success.

As noted in Chapter 11, the Quebec aerospace sector does have the characteristics of a Storperian production network. The increasing complexity of both end products and components in the aerospace industry has, as noted, forced firms in the sector to look outside their boundaries for the resources and skills needed to innovate. The Quebec government's efforts at promoting interfirm connections through the hosting of networking dinners and the publication of a sector newsletter can thus be seen to be an appropriate response to the imperative of building and reinforcing a Storperian production network in the province.

At the same time, the building of a Storperian production network assumes that communication among firms in the network can occur. As discussed above, several researchers have noted the importance of trust in facilitating such inter-firm communication. Such trust is built up in many ways, including common professional experience, social interactions and legal protections. However, a number of the interview group members stressed that trust in the aerospace sector has to be earned over time by the timely provision of high quality products. It follows that the better trained and more qualified a firm's personnel is, the more likely that the firm will be able to earn the trust of other members of the production network. In this sense, provincial government support for various specialized training institutes producing skilled employees for the aerospace sector can be seen as an indirect, but important contributor to promoting inter-firm trust: As Quebec's aerospace firms benefit from the pool of skilled employees which these institutes produce, they can be expected to produce higher-quality products which, in turn, leads to buyers looking on these firms with greater confidence. Such confidence, according to the model of the Storperian production network described above, leads to even denser communications among firms in the network.

Comparison of Quebec Aerospace and Pharmaceutical Sectors

One question which should be examined at this point is how closely, if at all, do the two industrial clusters described here fit with the notion of a Storperian production network based on PBTL? This question is important, if only because it leads to another question about the direction of public policy: If an appropriate goal for public policy is to foster and support the growth of Storperian production networks, then policy initiatives which lead to the formation of industrial clusters not based on PBTL may be creating groupings that are not sustainable in the long-run. This point stems from the nature of competition in high-technology sectors which, as noted above, is predicated on continuous innovation. Such innovation in knowledge-intensive industries depends on firms acquiring skills and competencies through learning from and collaborating with production network members rather than by traditional vertical integration. However, this point is only true if the nature of the industry in question is such that the risk of technological lock-in arising from firm efforts to acquire all skills and resources needed for success through vertical integration is indeed unacceptable. If this is not the case, then the need to engage in PBTL is significantly reduced, if not obviated entirely. In such an industry, firms can acquire within their own boundaries the skills and resources needed for new product development and introduction, and so the need for learning from and collaboration with other network members is eliminated.

To address this question, a comparison of the Quebec aerospace and pharmaceutical sectors is given below in Table 3

Table 3: Comparison of Quebec Aerospace and Pharmaceutical Sectors.

	Aerospace	Pharmaceutical
Complexity of product and components	End products: High Components: High	End products: High Components: Moderate
Resources and skills appropriable by one firm	No – industry tiers	Yes
Interfirm exchange of ideas	High – bidirectional learning across industry tiers	Low – emphasis on legal protection of proprietary knowledge
Interfirm exchange of personnel	Permanent: Low Ad hoc: Moderate	No
Specialized capital providers	- Defence Industry Productivity Program (DIPP) - Technology Partnership Canada (TPC) -Sofinov (Caisse de Dépot)	- Canada Foundation for Innovation -Sofinov (Caisse de Dépot)
Dedicated Educational institutions	-École des Métiers de l'aérospatiale de Montréal (ENAM) -École de Technologies Supérieures (ETS) -Committee industries/ universités de la maîtrise en génie aéronautique et spatial (CIMGAS)	-University departments/ Medical schools -Biotechnology Research Institute (BRI)
Industry Discussion Forums	- Centre d'adaptation de la main-d'oeuvre au Québec (CAMAQ) -MICST networking dinners - Trade associations: Aerospace Industries Association of Canada(AIAC) -Quebec Aerospace Association (QAA)	– Trade associations: Pharmaceutical Manufacturers Association of Canada (PMAC) - Non-prescription Drug Manufacturers Association of Canada (NDMAC)
Common Service Providers	-Ministry of Industry, Commerce, Science, & Technology (MICST) - Trade associations	- Biotechnology Research Institute (BRI) - Trade associations
Established conventions	Via trust based on track record, legal protections	Via legal protections

The two industries differ in terms of the complexity of products and components. While both completed fixed and flexible wing aircraft and pharmaceuticals are extremely complex, it could be argued that there is a difference in the complexity of components. Some components of aircraft and helicopters – such as the engines and guidance systems – are extremely complex and require their own network of second-tier suppliers supervising a cadre of third-tier sub-suppliers, as described above. In contrast, production in the pharmaceutical industry is usually done in the confines of a single firm, and a coordination of teams of suppliers and sub-suppliers to deliver complex sub-systems and sub-components is rarely required.

This distinction explains the second row of the table, wherein it is noted that generally no one firm in the contemporary aerospace industry can reasonably expect to appropriate all the resources and skills necessary to produce the end product or even a major sub-system. This reality provides the rationale for the aerospace industry's well defined tier system, based on a progressive increase in complexity of tasks and coordination among sub-suppliers. In contrast, the pharmaceutical industry is one where a producer can attempt to appropriate all the skills and resources needed to produce a new medication.

The aerospace industry's well-established division of labor among its three tiers not only promotes, but requires, that there be extensive exchanges of information among firms in each of the tiers. This bi-directional flow of ideas was confirmed in earlier sections of this paper both in the review of literature on the industry and through the interview group interviews. Again, the pharmaceutical industry does not require as much coordination and cooperation with sub-suppliers. Firms in the industry have invested considerable efforts in lobbying for strengthened intellectual property protection regimes so that they can more readily acquire the resources and skills they need to develop new products.

A review of the interview group findings did not suggest that there is extensive mobility among firms in the aerospace industry. If anything, the lack of movement of skilled personnel downward in the industry's tier structure, and the advantages which higher-level firms have in recruiting graduates from the industry's specialized training institutions, were noted above as being concerns of some of the third-tier firms in the interview group. However, it was also noted that firms in the aerospace industry have placed personnel on site at lower-tier suppliers and sub-suppliers on an ad hoc basis to resolve production issues and problems. A review of the literature on the pharmaceutical industry seemed to confirm that given the relatively secretive nature of the industry, inter-firm mobility is low, and given the lack of extensive collaboration with suppliers, ad hoc posting of personnel on a supplier's site is equally rare.

Both the aerospace industry and the pharmaceutical industries have had access to publicly-supported specialized capital providers over the years. In the former case, the federal government's initial program was the Defence Industry Productivity Program (DIPP), described above. Since 1996, DIPP's role has been taken over by Technology Partnership Canada (TPC) which, though officially presented as being aimed at a range of sectors, has as noted above emerged as a de facto aerospace industry program.

At the federal level, the pharmaceutical industry has, as noted in Chapter 13, traditionally received funding for research from the Medical Research Council. As noted above, in response to concerns that federal and provincial cutbacks had done severe harm to university-based research, the federal government established the Canada Foundation for Innovation in 1997. The Foundation is aimed at supporting investments to the overall research infrastructure for the pharmaceutical and health industries.

At the provincial level, both the aerospace and pharmaceutical industries have access to Sofinov, a subsidiary of the Caisse de depot et placement. As described earlier, Sofinov possesses in-house expertise to evaluate opportunities in both industries, and to involve itself relatively aggressively in the early stages of new product launches.

Similarly, both the aerospace and pharmaceutical sectors in Quebec possess several publicly-funded dedicated training institutions. In the case of the aerospace sector, these range from l'École des métiers de l'aérospatiale de Montréal (ENAM), which is truly focused on the aerospace sector, to l'École de Technologies Supérieures (ETS) which is more of a general technical institute. As well, Chapter 10 described the efforts by several firms and universities in the province to establish and operate the joint masters degree in aerospace engineering (CIMGAS). The pharmaceutical industry, in contrast, has drawn personnel from university chemistry and biology departments, and from university-affiliated medical schools. As well, Chapter 13 noted how the federally-funded Biotechnology Research Institute in Montreal has been a training ground for scientists who subsequently went on to work for private sector pharmaceutical firms.

Both sectors have several forums for inter-firm dialogue and networking. In the case of the aerospace sector, there is the national trade organization, the Aerospace Industries Association of Canada (AIAC). There is also, as noted in Chapter 10, a relatively new trade association at the provincial level, the Quebec Aerospace Association (QAA). In addition to these trade organizations, firms in the sector interact at several levels. Chapter 10 outlined how the Centre d'adaptation de la main-d'oeuvre au Québec (CAMAQ), funded by the federal and provincial governments, has established committees which have brought firms from the three tiers of the industry together to deal with personnel and training issues facing the industry. As well, the Quebec's Ministry of Industry, Commerce, Science and Technology (MICST) has been very active in linking firms in the sector, both through organizing of periodic networking dinners and by publishing sectoral newsletters and "babâlliards", both described in greater detail above.

Collaboration in the pharmaceutical sector seems to have been focused on lobbying for various versions of optimal intellectual property regimes by the two main industry trade groups, the Pharmaceutical Manufacturers Association of Canada (PMAC) for the branded manufacturers, and the Non-perscription Drug Manufacturers Association of Canada (NDMAC) for the so-called generic producers.

Both sectors also have common service providers which perform several roles. As already noted, both sectors have trade associations at the national and/or provincial level. In the case of the aerospace sector, Chapter 10 described how MICST has functioned as a de facto trade organization over the years, actively promoting linkages among potential buyers and suppliers in the sector. The role of BRI for the pharmaceutical sector has been, as discussed in Chapter 13, to fill in the gap between basic research conducted at universities and applied research done in the private sector. However, BRI has expanded on that mandate and now licenses both compounds and processes to firms in the sector, as well as acting as an incubator for start-ups in the sector, providing trained personnel, office space and production facilities.

Finally, a key difference between the two sectors lies in the nature of what Storper terms the "conventions" in the industry. In the case of the aerospace industry, these conventions are built partially on legal protections but, as revealed in the interview group findings, primarily on the trust that comes from an established record of delivering products that meet or exceed buyer expectations. The interview group participants suggested that given the close collaboration that exists between buyers, suppliers and sub-suppliers, legal protections were at times irrelevant or inapplicable. In contrast, considerable attention has been given by firms in the pharmaceutical industry to having an "appropriate" intellectual property protection regime which serves as the ultimate defining mechanism for conventions in the industry.

To summarize, though both the Quebec aerospace and pharmaceutical sectors share some common characteristics, it appears that the nature of the former lends itself more readily to the type of inter-firm learning and collaboration characteristic of the Storperian production network. In that case, public policy initiatives aimed at promoting linkages among firms in the sector are congruent with the imperative of acquiring the skills and resources needed for continuous innovation in ways other than through traditional vertical integration. In contrast, the pharmaceutical industry seems to lend itself to a more compartmentalized sector, where the priority is on guarding and exploiting proprietary knowledge. Public policy initiatives aimed at facilitating the protection of proprietary knowledge would be congruent with such an industrial environment. For both sectors, however, public policy initiatives aimed at enhancing the skill level of the workforce and at encouraging ongoing R&D would be appropriate.

Research Hypotheses

As noted above, the aim of this research was to validate one of the three following hypotheses:

> 1) The Quebec aerospace sector is a physical agglomeration of firms that has evolved as a result primarily of market forces, including the international division of labor, competitive advantages of particular firms, and various profit-maximizing strategies adopted by various firms. Relationships among firms in the sector are driven purely by traditional models of inter-firm relations whereby firms deal with other firms to achieve cost minimization. There is little if any learning between firms in the sector. Public policy's role in creating and nurturing the cluster has been mainly in the form of various reactive industrial policy measures, and has had a marginal role in its evolution.
>
> 2) The Quebec aerospace sector is indeed a production network in the Storperian sense, characterized by a high degree of trust between members and an ongoing process of product-based technological learning. The sector owes its success to its ability to continually innovate due to an ongoing re-deployment of specialized learning skills and resources among its members. However, this situation has materialized solely as a result of private sector activities, with public policy being largely irrelevant in nurturing or strengthening these trends.
>
> 3) The Quebec aerospace sector is indeed a production network in the Storperian sense, characterized by a high degree of trust between members and an ongoing process of product-based technological learning. The sector owes its success to its ability to continually innovate due to an ongoing re-deployment of specialized learning skills and resources among its members. Public policy, undertaken under the aegis of an "anticipatory" industrial policy outlook, has played a meaningful role in promoting both the trust that exists between members of the Quebec aerospace sector and the actual PBTL that goes on within it. Public policy has therefore contributed to the sustainability of the Quebec aerospace sector by contributing to its ability to engage in continuous innovation.

It was my contention that the data would support the third hypothesis. In other words, I expected to find that there is an extensive network of connections among firms in the Quebec aerospace sector, that these connections involve a high level of inter-firm learning, that firms in the sector have a high level of trust such that they can engage in the kinds of data exchange necessary to practice PBTL, and finally, that public policy had played a significant role both in creating the climate of trust necessary for PBTL to occur, and in fostering the ongoing exchanges among firms.

Based on a review of both the primary and secondary data gathered for this project, I believe that some validation has been found for both the second and third hypotheses. As noted previously, the Quebec aerospace sector does display the characteristics of a production network in the Storperian sense: Firms in the sector are obliged, due to increasing technological complexity, to seek additional skills and resources. However, due to increasingly shortened product life cycles, appropriation of these skills and resources via vertical integration is seen as increasingly risky. Firms in the sector have therefore moved into a new paradigm in their relationships with suppliers and sub-suppliers, whereby they are entering into a series of long-term relationships with their suppliers to jointly develop new products and processes. As noted, these relationships are increasingly "dense" in the Storperian sense, characterized by an ongoing process of bi-directional learning (Product Based Technological Learning or PBTL) transmitted through continuous negotiations between buyers and sellers of components and processes. These buyer-seller relationships are, moreover, based on both cooperation and a degree of symmetry of power, the latter due primarily to the existing industry-wide capacity shortage serving to somewhat offset the traditional power of large buyers. As well, firms in the sector have come together to form a number of institutions which serve the sector and which provide a variety of forums for interfirm discussion and collaboration. Finally, relationships among firms in the sector are based on a high level mutual trust, which in turn is built not only upon traditional legal protections but also upon a series of unwritten understandings ("conventions" in the Storperian sense) which enable buyers in the sector to increase their reliance on a steadily smaller number of suppliers with whom they transfer increasing amounts of sensitive proprietary data.

The series of interviews conducted with firms at all three levels of the Quebec aerospace sector further confirmed that public policy was not critical in the development or evolution of these buyer-seller relationships. In this sense, the second hypothesis seemed to be validated. However, the firms who participated in the interviews also agreed that without a critical mass of prime and second-tier firms to generate new products and process innovations and managerial know-how, learning along the lines of Storperian PBTL would not occur. It was also agreed that given the dynamics of the global aerospace sector, primes or second-tier firms based abroad could not take the place of such firms based in Quebec to initiate the PBTL process. Finally, the consensus of the group was that public policy, primarily in the areas of direct financial support for R&D, tax regimes at both the corporate and individual levels, and publicly-funded technical and scientific education, was critical in creating a climate whereby innovation in the sector could occur. The interviewees stressed that this was how public policy was central in determining whether primes and second-tier firms would remain in any given jurisdiction. This would lend support to the third hypothesis.

In order to resolve this apparent contradiction, further research would have to be conducted both with respect to Quebec and other jurisdictions. Regarding the province of Quebec, this research did not examine the overall state of public education in the province. Questions such as the trend of provincial support for education, the number of technical and scientific graduates over the years, drop-out rates and any possible correlation between these figures and the output of high technology firms in the province would have to be conducted. As noted above, Puri & Suchon (1997) conducted this type of research at the national level. It would be necessary to replicate their study, which related the level of technical and scientific education in a number of countries to their respective balances of trade in high-technology goods, at the provincial level. Moreover, Puri & Suchon did not examine cross-national flows in Foreign Direct Investment (FDI) for high technology goods. To support the contention that any jurisdiction which did not adequately support technical and scientific education would suffer an exodus of high-tech firms, one would have to examine this type of data.

More importantly, to accurately determine the impact of public policy on the ability of a jurisdiction to attract and retain a self-sustaining production network in the Storperian sense, one would have to broaden the above research to the full range of possible public policy support. In other words, some type of correlation would have to be found between cross-national flows of FDI and trade balances in high technology sectors on the one hand, and levels of public policy not only for technical and scientific education, but also for all the types of public policy support described in this paper: Financial assistance for private sector R&D (e.g., DIPP/TPC, Caisse de depot); government involvement in the negotiation of an appropriate legal and regulatory climate (e.g. negotiations of international agreements such as the Agreement on Subsidies and Countermeasures for the aerospace sector, and Bill C-91 for the pharmaceutical sector); establishment of support services (such as the activities of Quebec's MICST and the federal government's BRI in Montreal). Using FDI flows as a surrogate indicator of the establishment of new production networks and trade surpluses as an indicator that production networks within a jurisdiction were successful in innovating and hence competing in high-technology products, future researchers would have to conduct a longitudinal study spanning several different fiscal regimes (i.e., periods of extensive public policy expenditures alternating with periods of austerity) to examine what positive or negative correlations may exist. Clearly, negative correlations between FDI flows and positive trade balances on the one hand, and levels of public policy support on the other hand, would lend powerful support to the third hypothesis of this research.

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Appendix A: Interview Protocol for Private Sector Firms

1. Tell me about the origins of your firm and its involvement in the aerospace industry.

2. Tell me where your firm fits in the existing hierarchy of buyers/vendors in the aerospace industry. What role does your firm play in the industry?

3. Describe the nature of your relationship with your customers and with your vendors in terms of:

   a) Training;
   b) information flows;
   c) criteria for being selected as a vendor/selecting a vendor;
   d) means of ensuring that you are meeting customer needs and that your vendors are meeting your needs;
   e) importance of contractual/legal protections in your relationships with buyers and vendors.

4. Has your relationship with your customers and/or vendors changed over the years? If so, how?

5. What has been the role, if any, of public policy at either the provincial or federal level, in developing and/or strengthening the relationships between your firm and your buyers and vendors?

6. What, in your opinion, should be the role of public policy in supporting the Quebec aerospace sector?

Appendix B: Summaries of company interviews

1. S1 April 22, 1998

This firm is a major second-tier supplier of subsystems to the industry. The firm's spokesperson stressed that from their perspective, the build-to-print paradigm was a thing of the past. The firm has taken on total responsibility for the performance of its subsystems. This transition has seen the firm increasingly take on the role of coordinator of its own sub-supplier network. Along with this trend, the firm has increasingly downloaded responsibilities to members of its supplier chain. Meanwhile, the firm has, according to its spokesperson, winnowed down its supplier base. This entire situation has, as described during the interview, resulted in much denser relationships both with the prime customers and the third-tier suppliers. The firm's spokesperson described how trust was built up in the industry as a result of long-term relationships. The firm worked with its third-tier suppliers toupgrade their skills, but it knew that one result of such a process could be that over time, these suppliers could bid on job for the firm's competitors. This was an inevitable part of the upgrading process which the firm recognized. At the same time, it expected that its suppliers would not take skills and ideas they had acquired from the firm and providing information to competitors which the latter did not already know. The firm's spokesperson also noted the importance of public policy in attracting large-scale primes and second-tiers to a given area. As he put it, "Without majors, there are no suppliers."

2. T1, May 27, 1998

T1 is a small precision machine shop specializing in machining, welding, finishing, assembly and testing of aircraft engine parts, particularly fuel system components. The majority of the company's sales are to one major second-tier buyer. The company's President noted how its relationship with its major buyer followed the traditional "build to print" paradigm, but that in the past few years there had been a qualitative change in this arrangement. Now, the second tier firm is much more involved in face-to-face dealings with T1. The President conceded that these discussions had frequently been triggered by quality or scheduling problems at T1, and that the second-tier buyer's staff had been sent to T1's facility to correct perceived deficiencies. [In fact, on the day the author visited T1, several of the second-tier buyer's staff were on-site, attempting to resolve ongoing production problems.] Notwithstanding the apparent power of the buyer over T1, the President insisted that T1 had been able to show certain techniques and practices to the buyer that had proven to be important and useful.

3. T2 June 3, 1998

This firm is a third-tier supplier which specializes in the manufacture of tooling for inspection, production and maintenance, as well as in the manufacture of various parts. The firm's President outlined its relationship with its main clients, primarily second tier manufacturers, and how this relationship had become much more of a partnership over the past few years. While conceding that his firm would not be in business were it not for its buyer's own vendor development program, the President also insisted that the second tier firms relied on firms such as his. The President stressed that while he and his staff are constantly seeking how they can better serve their customers, he also emphasized how the firm's customers are showing greater commitment to his company. This commitment had allowed T2 to acquire new skills and to better plan its capital investment and employee training programs.

4. P1 July 6, 1998

This prime described how its older models had been built along the traditional "build to print" paradigm, with the firm designing all components and sending blueprints out to its supplier base. Now, the firm's spokesperson explained how some of its suppliers work with them "in the same room, on the same computer" for up to 12 months on the overall design of the finished product. These suppliers then go back to their respective shops to design the details. While stressing that this new collaborative model would be the company's direction for all future projects, the spokesperson also emphasized that this shift applied almost exclusively to its relationships with the second-tier suppliers. Regarding the issue of trust, the firm described how it had worked to progressively reduce its supplier base with whom it is building stronger relationships. The spokesperson stressed the importance of suppliers showing a willingness to be flexible as the firm's needs changed in a rapidly evolving marketplace. The spokesperson described how some Quebec government initiatives – such as the quarterly club Aerospatiale dinners – had been very beneficial in establishing preliminary contacts with potential suppliers.

5. P2 July 21, 1998

This prime stressed the importance of having as many of its suppliers as close to it as possible, to facilitate negotiations and face-to-face problem solving. The company's spokesperson also emphasized the impracticability of any one firm in the aerospace sector being able to "do it all", and that increasingly firms such as P2 were dependent on outsiders. This increasing reliance on suppliers meant that P2 was involved in much more negotiation than before. The firm's spokesperson spent some time describing how P2 had developed the local supplier base, and how it had invested considerable time and resources in upgrading the local suppliers' skills. This investment, though to P2's benefit, also meant that P2 was increasingly reliant on its suppliers. P2's spokesperson described how the firm had pushed new skills and knowledge down the chain through the specifications it gave its suppliers. At the same time, P2 increasingly looks to its suppliers to provide ideas and information on various production and design issues. P2 stressed the importance of public policy in creating a climate that was conducive to innovation in the aerospace industry. This meant, according to P2's spokesperson, that public policy had to induce firms to engage in R&D and/or ensure that the resources for R&D were readily available.

6. S2 September 10, 1998

The firm is a manufacturer and assembler of sheet metal components using a wide range of specialized processes. It acts as a second-tier supplier for one Quebec-based prime, performing the design, development, fabrication and assembly of a key navigational sub-system. The firm also acts as a third-tier machine shop for another Quebec-based prime. The bulk of the interview focused on the former role. In that capacity, the firm is much more involved in integrating the work of its own network of sub-suppliers. The firm prides itself on having not only the manufacturing skills typical of a second-tier supplier, but also advanced engineering capabilities which are much rarer at this level of the industry. The firm noted that there had indeed been a paradigmatic shift in the industry in terms of much greater supplier involvement in design processes, but that this trend was largely limited to second-tier suppliers. In contrast, the firm's spokesperson felt that third-tier suppliers were still operating, and expected to operate, on the traditional build-to-print model, notwithstanding industry-wide rhetoric to the contrary. The firm's General Manager felt that the strong relationships which had developed in the Quebec aerospace sector were a matter of commercial necessity rather than public policy. However, he stressed that public policy could be crucial in the locational decisions of primes and major second-tier firms, the "teachers" of the industry as he described them. The firm's General Manager emphasized that while legal documents in the business could be quite involved, the reality of the new paradigm was that trust developed among firms based on experience and working together.

Appendix C: Listing of Recipients of funding from Defence Industry Productivity Program (DIPP) 1992-93, 1993-94

INDUSTRY, SCIENCE AND TECHNOLOGY
$1,324,581,743
Department $704,593,323

INDUSTRY, SCIENCE AND TECHNOLOGY PROGRAM $704,593,323

	$
Grants to non-profit organizations to promote economic co-operation and development $445,000	
• The Niagara Institute Niagara-on-the-Lake Ont	300,000
Grants to non-profit organizations—Canada Awards for Excellence $150,335	
• The Conference Board of Canada Ottawa Ont	150,335
Grants to the Working Ventures Fund $2,500,000	
• Working Ventures Canadian Fund Inc Toronto Ont	2,500,000
Grants to the Province of Quebec institutions, individuals and other organizations in accordance with Canada/Quebec and subsidiary agreement $1,683,590	
• CAE Electronics Ltd St-Laurent Que	139,514
• Hydro-Quebec Lac Shawinigan Que	323,234
• Ibex Technologies Inc Montreal Que	107,496
• Teleglobe Inc St-Laurent Que	110,912
Grants under the Canada Scholarships Program $14,929,800	
Grant to the Royal Society of Canada $1,000,000	
• The Royal Society of Canada Ottawa Ont	1,000,000
Grant to the Canadian Institute for Advanced Research $3,750,000	
• The Canadian Institute for Advanced Research Toronto Ont	3,750,000
Grant to the International Human Frontier Science Program Organization $500,000	
• IHFSPO Strasbourg Cedex France	500,000
Contributions for initiatives under the National Entrepreneurship Policy $849,310	
• Fondation de l'Entrepreneurship Charlesbourg Que	125,000
• National Entrepreneurship Dev Institute Montreal Que	364,000
Contribution to the Canada/China trade council $347,176	
• Canada/China Trade Council Toronto Ont	347,176
Contributions under the technology for environmental solutions initiative $191,987	
• Mobile Computing Corporation Toronto Ont	153,161

Contributions under the Defence Industry Productivity Program $[illegible]

	$
• AAATS Aerospace Inc St-Bruno Que	1,085,862
• Airtronic Metal & Machine Parts Limited Scarborough Ont	325,000
• AIT Advanced Information Tech Corp Nepean Ont	243,190
• Allied Signal Aerospatial Canada Inc Ville St-Laurent Que	2,584,224
• Allied-Signal Aerospace Canada Rexdale Ont	10,738,245
• Alupower Canada Ltd Kingston Ont	353,863
• Applied Silicon Inc Ottawa Ont	143,757
• Atlantis Aerospace Corporation Brampton Ont	1,315,696
• AWSM Division of Avcorp Industries Inc Chomedey Laval Que	182,488
• Ballard Battery Systems Corporation North Vancouver BC	369,920
• Bodco Division of Geraden Inc Chomedy Laval Que	327,500
• Bell Helicopter Textron Mirabel Que	3,824,733
• Bon Machine Products Co Inc Brampton Ont	383,000
• BM Hi-Tech Inc Collingwood Ont	141,740
• Boeing Canada Tech Ltd Winnipeg Division Winnipeg Man	3,235,867
• Bombardier Inc Groupe Canadair Montreal Que	3,481,483
• Bomem Inc Quebec Que	141,518
• Bristol Aerospace Limited Winnipeg Man	879,839
• CAE Electronics Ltd St-Laurent Que	8,954,967
• Cancoid Limited Whitby Ont	363,843
• Canadian Aircraft Products Div of Avcorp Richmond BC	189,888
• Canadian Marconi Company Montreal Que	14,044,106
• Canstar Div of Alcatel Canada Wire Ltd North York Ont	418,003
• Caoutchouc Acton Limitée (Les) Acton Vale Que	397,000
• Cesaroni Technology Inc Scarborough Ont	194,145
• Chocopee Manufacturing Limited Kitchener Ont	422,116
• Codalex Ltee/Ltd Montreal Que	106,417
• Com Dev Atlantic Ltd Moncton NB	125,000
• Com Dev Limited Cambridge Ont	5,696,876
• Computing Devices Canada Ltd Ottawa Ont	5,626,525
• CPS Industries Inc Montreal Que	522,157
• CRL Technologies Incorporated Dorval Que	214,551
• Cyclone Manufacturing Inc Mississauga Ont	275,425
• C-Tech Ltd Cornwall Ont	486,448
• Dalsa Inc Waterloo Ont	592,766
• deHavilland Inc Downsview Ont	2,091,180
• Dominion Engineering Ltd Gloucester Ont	112,400
• Dowty Aerospace Toronto Ajax Ont	4,301,394
• DP Digital Precision Inc Laval-des-rapides Que	101,802
• DY-4 Systems Inc Nepean Ont	3,011,563
• Eaglesonic Industries Inc Weston Ont	180,284
• EDO Canada Limited Calgary Alta	138,732
• Entreprises Roger Gagnon Inc (Les) St-Laurent Que	316,149
• Epro Machine Ltd Fruitland Ont	415,000
• Eurocopter Canada Limited Fort Erie Ont	135,307
• Fag Bearings Limited Stratford Ont	1,545,787
• Fleet Aerospace Corporation Toronto Ont	145,638
• Gallium Software Inc Kanata Ont	573,872
• Gamops Ltd Gloucester Ont	119,304
• GMA Cover Corp Guelph Ont	981,966
• Guideline Instruments Ltd Smiths Falls Ont	101,563
• Haley Industries Limited Haley Ont	811,295
• Hermes Electronics Limited Dartmouth NS	666,082
• Heroux Inc Longueuil Que	870,728
• Hughes Leitz Optical Technologies Ltd Midland Ont	434,526
• IMP Aerospace Components Ltd Amherst NS	1,941,413
• Indal Technologies Inc Mississauga Ont	160,690
• Industrial Processing Cambridge Ont	155,078
• International Custom Products Scarborough Ont	136,559
• International Submarine Engineering Ltd Port Coquitlam BC	157,163
• IO Bass & Associates Ltd Mississauga Ont	155,278
• KB Electronics (1989) Limited Bedford NS	857,384
• Les Technologies industrielles SNC Inc Le Gardeur Que	1,453,719
• Liburdi Engineering Limited Hamilton Ont	121,675
• Linamar Machine Limited Guelph Ont	2,518,463
• Litton Systems Canada Limited Etobicoke Ont	6,591,160
• Lockheed Canada Incorporated Ottawa Ont	1,989,982
• Lucas Aerospace Inc Microwave Tech Div Mississauga Ont	138,750
• Macdonald Dettwiler & Associates Ltd Richmond BC	1,034,041
• Machinerie A P Inc Dorion Que	172,883
• Macair Inc Saint-Laurent Que	688,815
• Menasco Aerospace Ltd Oakville Ont	5,117,363
• Mecatec Incorporated Sherbrooke Que	349,436
• Mosaman Data Systems Limited Delta BC	447,380
• Mitel Corporation Kanata Ont	307,100
• Narrowband telecommunications Research Burnaby BC	166,678
• Newbridge Networks Corp Kanata Ont	146,259
• Novatronics Inc Stratford Ont	315,454
• Oerlikon Aerospace Inc St-Jean-sur-Richelieu Que	1,322,481
• Olympic Gear & Manufacturing Inc Bramalea Ont	497,661
• Optech Inc North York Ont	938,483
• Paramax Systems Canada Winnipeg Man	2,834,220
• Pratt & Whitney Canada Inc Longueuil Que	39,413,761
• RACE Technologies Inc Vancouver BC	121,252
• Racal Filter Technologies Ltd Brockville Ont	214,418
• Radarsat International Inc Ottawa Ont	107,423
• Raytheon Canada Limited Waterloo Ont	2,670,967
• Remac Inc Chambly Que	341,333
• SED Systems Inc Saskatoon Sask	770,177
• Sensor Corporation Kanata Ont	659,078
• Skywave Electronics Ltd Kanata Ont	125,000
• Spar Aerospace Ltd Advanced Tech Sys Brampton Ont	727,159
• Spar Aerospace Ltd Applied Systems Group Kanata Ont	625,022
• Spar Aerospace Ltd Gears/Transmissions Toronto Ont	724,021
• Spar Aerospatiale Limitee Ste-Anne-de-Bellevue Que	6,763,710
• Spectron of Canada Limited London Ont	192,027
• Sumitec's Limited Calgary Alta	795,590
• Streicor Industries Inc Buchans Nfld	118,977
• Technologies MTB Inc (Les) Dorval Que	154,330
• Tecsmatec Inc Laval Que	150,195

INDUSTRY, SCIENCE AND TECHNOLOGY—*Continued*

	$
• Thomson-Gordon Limited Burlington Ont	225,647
• Triple Metal Products Ltd Scarborough Ont	244,508
• Vadeko International Inc Mississauga Ont	1,818,153
• Valcom Ltd Guelph Ont	162,636
• Vestshell Inc Montreal Nord Que	247,038
• Virtual Prototypes Inc Montreal Que	151,060
• Walbar Canada Inc Mississauga Ont	539,009
• Zenon Environmental Systems Inc Burlington Ont	803,879
• Zuest Electronics Inc Mississauga Ont	530,396
Contributions to Marine Industries Limited $2,784,700	
• Le Groupe MIL Inc Montreal Que	2,784,700
Contributions under sector campaigns $19,577,399	
• A G Simpson Co Limited (Cambridge) Cambridge Ont	157,694
• Abitibi Price Inc Technology Centre Mississauga Ont	388,995
• Abitibi Price Lumber & Panel Sales Div Mississauga Ont	1,001,600
• Asia Pacific Foundation of Canada Vancouver BC	166,667
• Bureau de Promotion des Industries du bois Ste Foy Que	473,580
• Canadian Apparel Manufacturers Institute Ottawa Ont	292,154
• Canadian Association of Fish Exporters Ottawa Ont	291,832
• Canadian Forest Products Ltd Vancouver BC	207,410
• Canadian Pulp and Paper Association Montreal Que	997,485
• Canadian Wine Institute Mississauga Ont	673,382
• Canadian Wood Council Ottawa Ont	220,328
• Council of Forest Industries of BC Vancouver BC	2,974,925
• Domtar Inc Research Centre Senneville Que	213,959
• E J Green and Company Limited Winterton Nfld	186,199
• Fisheries Council of British Columbia Vancouver BC	108,420
• Fisheries Council of Canada Ottawa Ont	269,517
• Fletcher Challenge Canada Ltd Vancouver BC	267,259
• Forest Engineering Research Inst Pointe Claire Que	168,871
• J S McMillan Fisheries Ltd Vancouver BC	154,605
• Kvaerner Hymac Inc Laval Que	419,801
• MacMillan Bloedel Limited Vancouver BC	545,663
• National Research Council Ottawa Ont	100,000
• New Brunswick Salmon Growers Association St George NB	135,004
• Produits Forestiers Maibec Quebec Inc St-Raymond Que	280,644
• Pulp and Paper Research Institute of Canada Pointe-Claire Que	3,343,070
Contributions to strategic technologies $15,623,858	
• Aquatech Corporation Calgary Alta	234,809
• Biomira Inc Edmonton Alta	1,710,673
• Biotech Environmental Inc Hamilton Ont	156,750
• Camoplast Inc Sherbrooke Que	214,806
• Canstar Sports Group Inc St Jerome Que	161,246
• Centre de Recherche Informatique de Ml Montreal Que	749,915
• Centre Valvue Inc Montreal Que	1,129,583
• CTF Systems Inc Port Coquitlam BC	729,790
• Exports Packers Co Ltd Winnipeg Man	178,000
• Federation des Producteurs de Porc (Que) St-Hyacinthe Que	112,426
• ICI Canada Inc (Biological Products) Mississauga Ont	123,500
• Inco Limited (Inco Tech Div) Toronto Ont	257,715
• JOII Rubber Investments Limited Leamington Ont	186,335
• Jeldon Diagnostics Inc Scarborough Ont	143,630
• Paradigm Biotechnologies Partnership Toronto Ont	431,091
• Precarn Associates Nepean Ont	3,137,028
• Pulp and Paper Research Institute of Canada Pointe-Claire Que	140,309
• Q-Life Systems Inc Kingston Ont	114,769
• Rasquest International Inc Ville Saint-Laurent Que	144,883
• Scaffold Connection Management Inc Fort Saskatchewan Alta	518,114
• Scien Division of MDS Health Group Ltd Thornhill Ont	409,992
• Sherritt Gordon Limited Fort Saskatchewan Alta	564,111
• Silvagen Inc Halifax NS	194,103
• Societe de Recherche SNC Inc Montreal Que	386,734
• Terra Nova Biotechnology Co Ltd St John's Nfld	104,128
• The Electrofuel Manufacturing Co Ltd Toronto Ont	353,275
Contributions to the St-Lawrence River environmental technology program $5,521,388	
• Envirotem Inc Temiscaming Que	108,049
• PPG Canada Inc Div Pr Chemiques Industriels Beauharnois Que	457,000
• Pulp and Paper Research Institute of Canada Pointe-Claire Que	318,021
• Repap Enterprises Inc Montreal Que	4,179,106
• Saucy Inc (FF) Riviere-du-Loup Que	378,412
Contributions to non-profit organizations and commercial operations in support of tourism $256,087	
• World Tourism Organization Sherbrooke Que	256,087
Contributions under the microelectronics and systems development program $15,291,236	
• Allied Optonics Inc Burlington Ont	493,436
• Cami Computer Network Architecture Stittsville Ont	465,782
• Carp Systems International Inc Kanata Ont	602,744
• Dees Communications Engineering Ltd Delta BC	349,133
• Dynapro Systems Inc New Westminster BC	1,604,035
• Electrohome Ltd Kitchener Ont	296,910
• Fiberlign Div of Preformed Line Prod Nepean Ont	211,095
• Gandalf Canada Ltd Nepean Ont	1,367,758
• Gennum Corporation Burlington Ont	635,467
• Matrox Electronic Systems Ltd Dorval Que	1,004,794
• Mitel Corporation Kanata Ont	3,275,524
• Newbridge Networks Corp Kanata Ont	3,463,353
• QCC Communications Corporation Saskatoon Sask	133,721
• SAME Windsor Ont	439,592
• Seftec Systems Ltd Port Coquitlam BC	188,390
• SR Telecom Inc St-Laurent Que	370,088
• Ultra Optec Inc Boucherville Que	237,069
Contributions for the advanced train control system $733,275	
• CN Operations Montreal Que	217,239
• SEL Division Alcatel Canada Inc Weston Ont	459,287
Contributions under the technology outreach program and the technology opportunities in Europe program $12,730,340	
• AMEC Halifax NS	190,472
• AXYS Environmental Systems Ltd Sidney BC	174,196
• Canadian Advanced Ind Materials Forum Toronto Ont	157,344
• Canadian Industrial Innovation Centre Waterloo Ont	992,535
• Canadian Institute of Biotechnology Ottawa Ont	603,581
• Canadian Plastics Institute Don Mills Ont	279,825
• Centre canadien d'Innovation Industrielle Montreal Que	175,898
• Centre de Recherche Informatique de Montreal Montreal Que	229,152
• Centre des Techno Textiles (Que) Inc St-Hyacinthe Que	514,652
• Centre des Technologies Gazieres Montreal Que	1,075,314
• Centre for Cold Ocean Resources Engineering St John's Nfld	606,048
• Centre International des Grands Projets Montreal Que	175,000
• Composite Materials Technology Centre St-Jerome Que	705,873
• Groupe DMR Inc Montreal Que	315,970
• Hydrogen Industry Council of Canada Midland Ont	250,565
• Industrial Research & Development Institute Ancaster Ont	410,439
• Management of Tech & Innovation Inst Ancaster Ont	429,008
• MITEC Ottawa Ont	251,122
• National Quality Institute Ottawa Ont	463,802
• National Wireless Communications Vancouver BC	736,485
• SIRICON Montreal Que	417,798
• Strategic Microelectronics Consortium Kanata Ont	468,781
• Technomar Canada Rimouski Que	569,752
• Welding Institute of Canada Oakville Ont	822,114
• Zenon Environmental Inc Burlington Ont	858,201
Contribution to Lavalin Trenton Works $3,033,448	
• Royal Bank Quebec International Centre Montreal Que	638,704
• Trenton Works Lavalin Inc Trenton NS	2,394,744
Contributions to the advanced manufacturing technology application program $2,965,005	
• Canadian Manufacturer's Association Etobicoke Ont	193,080
• The Society of the Plastics Ind of Cda Don Mills Ont	172,700
Contribution to the Sudbury Neutrino Observatory $1,834,000	
Contributions under the acid rain abatement program $4,318,923	
• Hudson Bay Mining & Smelting Co Ltd Flin Flon Man	4,318,922
Contributions to Quebec relating to completion of work on Canadian Patrol Frigate (CPF) and Tribal Update and Modernization (TRUMP) Vessels $125,363,512	
• Societe Generale de Financement du Quebec Montreal Que	125 363,512

INDUSTRY, SCIENCE AND TECHNOLOGY
$1,258,068,218
Department $544,013,127

	$
INDUSTRY, SCIENCE AND TECHNOLOGY $542,387,597	
Grants to non-profit organizations to promote economic co-operation and development $387,200	
• The Niagara Institute Niagara-on-the-Lake Ont	770,000
Grant Canada—Israel Industrial R & D Foundation $1,000,000	
• Canada—Israel Industrial R & D Foundation Ottawa Ont	1,000,000
Grants to the Working Venture Fund $2,250,000	
• Working Ventures Canadian Fund Inc Toronto Ont	2,250,000
Grants to the province of Quebec institutions, individuals and other organizations in accordance with Canada/Quebec and subsidiary agreement on Science and Technology $417,600	
Grants under the Canada Scholarships Program $21,420,250	
Grant to the Royal Society of Canada $750,000	
• The Royal Society of Canada Ottawa Ont	750,000
Grant to the Canadian Institute for Advanced Research $1,940,000	
• The Canadian Institute for Advanced Research Toronto Ont	1,940,000
Grant to the International Human Frontier Science Program Organization $450,000	
• IHFSPO Strasbourg Cedex France	450,000
Prime Minister's awards for teaching excellence in science, technology and mathematics $851,000	
Grant Dr Michael Smith Promotion Endowment $500,000	
• Vancouver Foundation Vancouver BC	500,000
Contributions to non-profit organizations to promote economic co-operation and development $185,070	
Contributions for initiatives under the National Entrepreneurship Policy $217,000	
• National Entrepreneurship Dev Institute Montreal Que	217,000
Contribution to the Canada/China trade council $270,000	
• Canada/China Trade Council Toronto Ont	270,000
Contributions under the technology for environmental solutions initiative $1,540,553	
• Halozone Recycling Inc Mississauga Ont	354,561
• Inipex Inc Fleurimont Que	100,000
• Mobile Computing Corporation Toronto Ont	262,223
• Trojan Technologies Inc London Ont	312,011
• Zenon Environmental Systems Inc Burlington Ont	327,813
Contributions under the Defence Industry Productivity Program $166,882,597	
• AASTRA Aerospace Inc [illegible] Ont	225,436
• Aerospace Welding Inc Blainville Que	384,677
• Aircraft Appliances & Equipment Limited Bramalea Ont	153,972
• AIT Advanced Information Tech Corp Nepean Ont	966,778
• AlliedSignal Aerospace Canada Etobicoke Ont	9,425,414
• Apollo Management Ltd Dorval Que	165,100
• Applied Silicon Canada Inc Ottawa Ont	989,920
• Atlantis Aerospace Corporation Brampton Ont	1,338,173
• Ballard Battery Systems Corporation North Vancouver BC	661,408
• Bell Helicopter Textron Mirabel Que	5,108,177
• Boeing Canada Tech Ltd Winnipeg Division Winnipeg Man	3,698,483
• Bombardier Inc Groupe Canadair Montreal Que	20,875,323
• Bristol Aerospace Limited Winnipeg Man	630,504
• CAE Electronics Ltd St-Laurent Que	9,848,997
• CAL Corp Ottawa Ont	226,790
• Camotoid Limited Whitby Ont	330,843
• Canadian Marconi Company St Laurent Que	10,765,709
• Centroid Technology Inc Scarborough Ont	126,338
• [illegible] Atlantic Ltd Moncton NB	154,844
[illegible]	[illegible]

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• Dalsa Inc Waterloo Ont	890,821
• Devtek Aerospace Canada Limited Milton Ont	1,454,085
• Diamond Aircraft Canada Corp London Ont	1,000,000
• Dowty Aerospace Toronto Ajax Ont	5,685,053
• DY-4 Systems Inc Nepean Ont	1,299,232
• Engineering Industries Ltd Weston Ont	318,707
• English Plastics Brampton Ont	481,[illegible]
• Equipement Militaire Mil-Quip Inc Boucherville Que	158,519
• Eurocopter Canada Limited Fort Erie Ont	2,600,011
• Fleet Aerospace Corporation Toronto Ont	103,267
• FRE Composites Inc St Andre Est Que	127,447
• Gallium Software Inc Nepean Ont	336,176
• Genesys Ltd Gloucester Ont	255,635
• GMA Cover Corp Guelph Ont	633,065
• Haley Industries Limited Haley Ont	1,210,919
• Hermes Electronics Limited Dartmouth NS	1,080,933
• Heroux Inc Longueuil Que	171,000
• Hochelaga Aerospace Inc Laval Que	358,440
• Hughes Leitz Optical Technologies Ltd Midland Ont	731,309
• IMP Aerospace Components Ltd Amherst NS	298,871
• Indal Technologies Inc Mississauga Ont	399,832
• Industrial Rubber Co Bathurst NB	392,790
• JO Reeve & Associates Ltd Mississauga Ont	136,741
• KB Electronics (1989) Limited Bedford NS	677,772
• Les technologies Industrielles SNC Inc Le Gardeur Que	923,398
• Littlemill Engineering Limited Hamilton Ont	136,[illegible]7
• Litton Systems Canada Limited Etobicoke Ont	4,315,680
• MacDonald Dettwiler & Associates Ltd Richmond BC	1,645,805
• McDonnell Douglas Canada Ltd Toronto AMF Ont	1,958,970
• Menasco Aerospace Ltd Oakville Ont	5,656,345
• Messier Incorporated Sherbrooke Que	126,564
• Motorola Data Systems Limited Delta BC	304,247
• Newbridge Telecommunications Research Burnaby BC	162,911
• Novatronics Inc Stratford Ont	225,760
• Orthane Aerospace Inc St-Jean-sur-Richelieu Que	103,791
• Optech Inc North York Ont	572,305
• Outillages Avior Inc Montreal Que	118,348
• Pratt & Whitney Canada Inc Longueuil Que	56,181,700
• Precl-Can Inc St-Laurent Que	135,365
• R A C E Technologies Inc Vancouver BC	242,005
• Raytheon Canada Limited Waterloo Ont	1,811,170
• SEDO Ltee Granby Que	171,525
• Spar Aerospace Ltd Ste-Anne-De-Bellevue Que	6,288,565
• Standen's Limited Calgary Alta	508,371
• Technologies MPB Inc (Les) Dorval Que	225,694
• Tecmotiv Corporation Concord Ont	241,107
• [illegible] and Tool Limited Scarborough Ont	109,170
• Unisys GSG Canada Inc Winnipeg Man	[illegible]
• [illegible] International Inc Oakville Ont	414,843
• Valcom Aero Technologies Inc Mississauga Ont	300,397
• Varian Canada [illegible] Georgetown Ont	519,673
• Vestshell Inc Montreal-Nord Que	143,[illegible]
• Walbar Canada Inc Mississauga Ont	320,894
• Westcam A Div of Istec Inc Hamilton Ont	387,412
• West Heights Mfg Kitchener Ont	435,830
• Windsor Gear & Drive Inc Fenwick Ont	168,075
• Zenon Environmental Systems Inc Burlington Ont	379,277
Contribution to Bombardier/de Havilland $81,351,166	
• de Havilland Inc Downsview Ont	81,351,166
Contribution to Marine Industries Ltd $121,580	
• Le Groupe MIL Inc Levis Que	121,580
Canadian Network for the Advancement of research, industry and education $3,500,000	
• Canarie Inc Ottawa Ont	3,500,000
Contributions under sector campaigns $24,501,570	
• Abitibi Price Inc Technology Centre Mississauga Ont	558,914
• Asia Pacific Foundation of Canada Vancouver BC	218,322
[illegible]	105,000