Development Dynamics of a Startup Innovation Cluster: the ICT Sector in New Brunswick

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12 March 2003
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To appear as Chapter 5 in Clusters Old and New: the Transition to a Knowledge Economy in Canada's Regions, ed. David A. Wolfe. Montreal: McGill-Queen's University Press, 2003.

executive summary

This paper describes and analyzes the development of the Information and Communication Technology (ICT) sector in New Brunswick and discusses the clustering behavior of firms in this sector. The NB ICT sector contains about 240 firms, of which 189 participated in our survey.

In the first part of the paper the ICT sector and its subsectors are defined. We use largely conventional definitions of the ICT sector, except that our survey also encompasses the e-learning industry (which is more properly considered a user of ICT products and services than a supplier of them). We do not consider other intensive users of ICTs such as contact centers, governments, or e-commerce retailers. Our qualitative analysis includes the telecommunications industry, since NB Tel/Aliant has played a flagship modernizer role in the New Brunswick ICT industry. Our survey excludes NB Tel/Aliant but includes its spinoffs and affiliates.

The second part of the paper reviews the factors that condition competitiveness in the ICT industries and discusses them in terms of cluster models. We focus on drivers of clustering and on the particular needs of ICT firms to develop long distance linkages for business development, marketing, and service, although technology and human resources may be procured locally. We conclude this section with the suggestion that although the Porterian five forces certainly condition competitveness in the ICT sector, Porter's "diamond" model of clusters does not apply well to ICT industries. In particular, the early stages of ICT cluster development almost always require external market drivers.

The third part of the paper describes the rise of the ICT sector in New Brunswick and discusses the sequence of programs and players, beginning with the alliance between NB Tel and the provincial government and ending with the recent rationalization of the regional telecom industry and the entry of highly upgraded federal and provincial programs and institutions.

The fourth part of the paper provides a quantitative analysis of the NB ICT sector in terms of revenues, employees, ownership, growth patterns, innovation, and geographic location of firms. This portrait shows that the IT portion of the ICT industry earns at least a half-billion dollars per year and employs more than 4,000 people. Between 1999 and 2001 it experienced strong growth. Fredericton has the greatest number of IT firms, Saint John the greatest number of IT employees, and Moncton the strongest IT revenue stream. The NB ICT sector is largely outward-looking with export markets primarily in Central Canada and the United States. New firm formation peaked in 1997. Innovation of new products and services is positively correlated with export performance. Of particular interest is the presence of four or five dozen "gazelle" or very fast-growing IT firms in New Brunswick.

The paper concludes with some suggestions regarding the promotion of further development of the sector. Two pathways appear especially promising: incubation of indigenous "born global" IT firms, and attraction to New Brunswick of IT-intensive subsidiaries that will use New Brunswick as an export platform.

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Introduction

New Brunswick is a province in Maritime Canada, a "lagging region" whose exports are dominated by raw or semi-finished natural resources. Unemployment is much higher than in central Canada, population growth is slow, out-migration is common, and the region has become dependent on transfer payments from the Federal government for economic survival. Once a prosperous region, Maritime Canada's fortunes changed with Confederation when political power and public investments shifted to central Canada.

In a bid to diversify its economy and grow new sources of income and employment, New Brunswick began in the late 1980s to promote and encourage the development of an information and communication technology (ICT) industry. This initiative was designed and led primarily by the provincial government in partnership with NBTel, the incumbent telephone company. Nearly 15 years later, New Brunswick has an ICT industry that rivals its tourism industry in wealth-generation capacity, and the province has attracted a segment of ICT-intensive users, the contact center industry, that employs around 14,000 people. More than 200 ICT firms, most of them small and locally owned, are active in New Brunswick. Around fifty of these firms report gazelle-like growth in the recent past and many predict strong growth over the next three years. Nearly two-thirds of aggregate revenues from IT are generated in markets outside of Atlantic Canada. Among the main exporters are eleven "foreign" ICT firms (i.e. ones not under local control) – perhaps the beginning of a role for New Brunswick as a regional ICT production-platform as found in Ireland or Singapore.

The outlines of other familiar models of ICT agglomeration are not as clear. New Brunswick's indigenous flagship modernizer, NBTel, has been absorbed into the Bell Canada telecommunications conglomerate. The local ICT industry has not developed an apparent unique specialization around a novel technology with extraordinary export growth potential, as was the case in the Scandinavian wireless cluster (Richards, 2001). The relative neglect of ICT R&D in the university and public sectors in New Brunswick until the late 1990s has not made the province attractive to technology prospectors and risk investors and has undoubtedly constrained the emergence of indigenous new technology-based firms. However, New Brunswick has several advantages, including new public IT R&D institutions, a population of experienced and committed ICT entrepreneurs, and a promising emerging ICT export capability.

In this chapter we use the term "cluster" to refer to an aggregation of related firms in a geographically bounded area. In this sense, the New Brunswick ICT sector is a cluster. More stringent definitions of "cluster" require clearer specification of the nature and scope of local inter-firm traded and untraded interdependencies, which may result from co-location of related firms, co-located segments of a value chain, or inter-firm networks (Gordon and McCann, 2000). Qualitative evidence suggests that local inter-firm linkages having to do with technology sourcing or subcontracting in the ICT sector are only modestly developed in New Brunswick. The New Brunswick ICT sector can therefore be considered a relatively shallow innovation cluster, but this is not surprising considering the youth of the New Brunswick ICT industry. Firms in the New Brunswick ICT cluster cannot count on easy access to certain kinds of competitiveness-enhancing local externalities and untraded interdependencies of the sorts found in world-leading ICT clusters. In this respect New Brunswick firms are at a disadvantage when compared to

competitors in more mature clusters. New Brunswick firms are not unaware of these locational diseconomies and the successful ones find ways to compensate for them through long-distance networking and business development activities, giving the New Brunswick ICT sector extensive extra-local linkages.

Although growth potential of some ICT subsectors (especially telecommunications equipment) is not bright in the near term, the information and communications technology revolution is far from over. Many economic opportunities not yet engendered by this revolution remain to be created or captured. Because of its above-average growth potential and multiplier effects, the ICT sector is often regarded as a strategic driver of national or regional economic development.[1] The continued expansion of New Brunswick's ICT sector will require a very different mixture of elements and policies than in the past decade, with much stronger investment in R&D and business development. While the New Brunswick domestic market for ICT products and services has grown substantially and is expected to continue to grow, it may incubate but it certainly cannot drive the development of world-class ICT firms. To expand, the New Brunswick ICT sector must vigorously export. The principal challenge that the New Brunswick ICT sector faces is to strengthen its performance as a competitive, largely outward-facing ICT industry. Denser and more highly specialized intra-cluster linkages will form as the industry increases its export intensity.

Below we describe and analyze the New Brunswick experience in developing an indigenous advanced technology sector, the Information and Communication Technology (ICT) sector. We provide an overall assessment of the New Brunswick model of startup ICT cluster develop-

[1] In this paper the term "region" refers to Atlantic Canada.

ment in a small open regional economy, and we discuss the challenges facing the growth and expansion of this cluster.

The Information and Communication Technologies (ICT) Sector

ICT firms share the common feature of being "primarily engaged in producing goods or services, or supplying technologies, used to process, transmit, or receive information" (April, 1999). In other words, the ICT sector is a supplier of infrastructure, products, and services to the many ICT-using industries.

ICTs can be grouped broadly into telecommunications, other ICT services, software, and hardware segments. However, a conventional statistical definition of the ICT sector did not exist in Canada until the late 1990s. The recently adopted North American Industry Classification System (NAICS) defines the sector in terms of equipment and component manufacturing, goods related services (primarily wholesalers, distributors, and leasers), and intangible services (software publishers, cable program distributors, telecommunication carriers and resellers, information and data processing services, equipment repair, and computer systems design). Information technology training is also conventionally included in the ICT sector.

The ICT sector is a large and growing sector in technologically advanced economies. In 2001 it accounted for an average of 8.3% of GDP in the 28 OECD countries, and demand for ICT goods and services reached 2.1 trillion U.S. dollars in these countries the same year (OECD,

2002). Canada's economy is slightly more ICT-intensive than the OECD average.[2] The Canadian sector included around 31,000 establishments and 542,000 employees in 2000. It had revenues of about $132 billion and accounted for about 10% of Canadian exports (Industry Canada, 2001). The Canadian ICT sector grew about four times faster than the Canadian economy as a whole until 2001, and accounted for nearly 20% of Canadian GDP growth between 1997 and 2001 (Industry Canada, 2002). Employment in the ICT sector grew about 3.5 times as fast as employment economy-wide (ibid). Employees in this sector earned about 50% more than the average wage.

ICTs are highly R&D intensive. In 1998, the top 20 IT firms in the world spent on average 7% of their revenues on R&D (OECD 2000). In countries with the highest degree of specialization in ICT equipment manufacturing (Finland, Sweden, Korea, and Japan), business R&D spending by ICT manufacturing industries currently ranges from about .7% to about 1% of GDP. The portion of R&D spent by ICT service industries by the most highly specialized countries (Sweden, Finland, Korea, and Norway) is in the range of .15% to .2% of GDP. In Canada, rates of R&D spending on ICT manufacturing and services R&D are respectively about .4% and .09% of GDP (OECD, 2000). In 2001, firms in Canada spent about $5.6 billion on ICT R&D, representing nearly 46% of private sector R&D in the country. Nearly 78% of private sector intramural ICT R&D spending in Canada was in telecommunication, electronic, or computer equipment

[2] That is, ICTs amounted to about 8.5% of GDP in Canada in 2001, according to the OECD (2002). It is very difficult to make reliable historical comparisons among ICT sectors because of recent changes in statistical conventions having to do with measurement of ICT activity. It was not until 1998 that OECD countries reached agreement on definition of the ICT sector, based on the International Standard Industrial Classification (ISIC). In 2002 Canada implemented most of the North American Industry Classification System (NAICS), although data for some subsectors were not available and R&D data remained based on the old SIC system. See Industry Canada (2002).

manufacturing industries; ICT service industries accounted for the remainder (Industry Canada, 2001).

Commercialization of new ICTs requires highly specialized management and financial services. R&D spending on ICTs and venture financing are each highly concentrated in three Canadian city-regions (Ottawa, Toronto-Waterloo, and Montreal). The Canadian venture capital industry, two-thirds of which is located in central Canada, has developed a high degree of specialization in ICTs; in 1999 about two-thirds of the $2.7 billion in venture investments went to firms involved in communications/networking, computers, the Internet, or electronics (Davis, 2003).

Competitiveness and clustering in ICT industries

Many public and private actors are looking at economic development as a process of development of "clusters" of inter-related industries and support institutions. Most industries exhibit clustering behavior (Krugman, 1994). Clustering "is so pervasive that it appears to be a central feature of advanced industrial economies" (Porter, 1990: 149). Clustering suggests that "instead of lying solely within the firm, the true origin of competitive advantage may be found in the firm's proximate or local environment" (Porter, 1994: 451). Co-located firms can produce increasing returns to scale when they complement each other, share common assets such as specialized labor or specialized services, and compete against each other. These increasing returns take the form of knowledge spillovers, untraded interdependencies such as coordination activities, and acceleration of technological diffusion along the value chain (Bekar and Lipsey, 2002).

The cluster approach to local economic development is an improvement over older neo-classical approaches in which the key variable to manipulate was the capital-labor production function. By bringing technology and learning into the equation, and by bringing an industrial organization analytical framework into play, the range of relationships and variables that are germane to the development of competitiveness increases considerably. Cluster models can help to shed light on the ways that business variables within the firm and in its environment affect the competitiveness of the firm and, by extension, of the region.

Much of the discussion about firm clustering and economic development focuses on well-known clusters, seeking to extract learnings and apply them elsewhere in support of new cluster development and capture of economic rents at the local or regional level. Miller and Côté's *Growing the Next Silicon Valley* (1987), a good example of older prescriptive literature on innovation clustering, points to the importance of locally available technological, financial, and HR factors and to the need for business leadership and market-oriented policy incentives. However, the list of cluster-affecting variables put forward in 1987 has not evolved much since then. If many local cluster development initiatives seem like shake-and-bake policy exercises, it is because the concept of cluster has become "chaotic", taking on a very wide range of meanings with respect to the geographical configurations and internal socioeconomic dynamics of clusters (Martin and Sunley, 2002).

Porter's five-forces of competition framework (Porter, 1980) and his "diamond" model of competitiveness (Porter, 1990), seminal contributions to the discipline of strategic management,

have provided by far the most influential conceptual framework that practitioners use to think about the geographical determinants of competitive advantage. According to the diamond model, competitive advantage is produced by co-located firms in relation to local factor conditions, supporting industries, demand conditions, and firm strategy, structure, and rivalry. This model has been extensively discussed elsewhere (see for example Davies and Ellis, 2000) and need not be redescribed here.

The Porter diamond model has three shortcomings that limit its utility to guide the development of competitiveness in an emerging ICT cluster like New Brunswick's. The first shortcoming is the well-known ambiguity in the Porter model regarding the geographical boundaries of the "home base" (Davies and Ellis, 2000). Originally, Porter used the diamond model to explain the sources of *national* competitive advantage: the "home base" was a huge landscape encompassing the factor conditions, demand conditions, supporting industries, and the market in which firms played out their strategies. As many critics pointed out, this way of understanding the structure of competitiveness is particularly inappropriate to small, open economies in which many firms' assets (technological and financial factors, customers, and suppliers) and much of the significant market rivalry to which the firms are exposed are located in some other region or country. A "small economy almost certainly lacks at least one strong corner" of the diamond (ibid: 1204). City-regions or local regions are even less likely to provide all or most of the necessary elements of a "home base." In other words, highly extraverted small economic regions do not and cannot internalize most of the competitiveness-enhancing factors identified in the Porter diamond model. Moreover, by definition in export industries customers do not co-locate with producers; in natural resource-based industries the value-added activities rarely are co-located

with the resource. As we shall see, in ICT industries geographically extensive value chains are the norm. The key issues in the development of any agglomeration are: which segments of the value chain are co-located, what externalities are produced by the co-location, and what competitive advantages do firms in those segments derive from the externalities? As a way of identifying and conceptualizing key conditioners of competitiveness in the firm's proximate or distant business environment the Porter framework is useful, but as a script for cluster formation it is much less so. In particular, it makes the production of local collective efficiencies or externalities through the co-location of value chain segments appear to be the determinant of competitiveness. However, in early stages of cluster formation such co-locations are probably best regarded as consequences rather than causes of competitiveness. Particularly in the start-up stage of cluster formation, much evidence suggests that linkages to growth drivers in external markets are the critical success factor.

A second shortcoming of the diamond model of cluster-based competitiveness is that it underestimates features of information and communication technologies that affect the spatial organization of economic activity. ICTs have both centrifugal and centripetal effects on business location. Centrifugal effects occur as ICTs weaken the economic logic that underpin conventional firm boundaries by decreasing coordination, communication, and transaction costs. This has happened especially in the vertical dimension, where a strong negative relationship exists between intensity of IT use and vertical integration (Hitt, 1999).[3] As ICTs embodied in software or machinery are adopted by user industries, transaction, communication, and coordination costs decrease and businesses are confronted with a broadened range of location options (Kolko, 2001;

[3] Vertical disintegration of value chains has gone very far in the computer hardware industry, where offshore subcontracting for electronic component production has induced the emergence of several Asian innovation clusters.

Möslein, 2001). Spatial convergence (deconcentration) of economic activity can take place. Furthermore, IT-enablement of business process outsourcing allows remote delivery of an increasing variety of services, which are usually specific value chain segments located in places that are selected according to cost, infrastructure, and skill factors. Also, ICT firms are usually advanced users of ICTs for purposes of coordination and communication with their geographically extensive networks of allies, suppliers, customers, and complementors. Virtualization of extensive extra-local relationships is a common feature in ICT industries, resulting in a bewildering variety and range of strong and weak relationships among firms.

At the same time, because providers of ICT products and services require access to highly skilled personnel and knowledge-producing infrastructure (both of which traffic in tacit knowledge), they tend to be geographically concentrated. The more highly skilled the personnel and the more specialized the infrastructure required to produce and deliver the ICT, the more likely the ICT production activities will be concentrated in a few specialized locations. For example, Koski, Rouvinen and Ylä-Anttila (2001) find strong evidence of concentration and specialization of ICT-related R&D and production activities in Europe, and Kolko (2001) finds patterns of highly specialized IT concentrations in the US. As we mentioned earlier, in Canada ICT R&D and ICT-related venture capital activities are concentrated in the region bounded by Waterloo, Toronto, Ottawa, and Montreal.

A third shortcoming of the diamond model is that, like other theories of agglomeration, it needs to help us to understand the origins and early development dynamics of clusters – especially the relationships between intra-cluster organization of production and drivers of growth.

External economies are outcomes of clustering as well as conditioners of further clustering. Untraded interdependencies or sources of externalities that characterize mature clusters – highly specialized professional services, infrastructure, technical labor, experienced serial entrepreneurs, collective institutions and governance mechanisms, and network of local subcontractors – take time to develop. Although small or incipient clusters are also embedded in a local milieu, it seems unlikely that most of the commonly found local linkages in an incipient cluster can drive a growth phase. Local linkages in early-stage clusters result from embeddedness in a local milieu – a local market, for example, or in local scientific, technical, or business institutions. Such a milieu may provide an intimate or nurturing niche that shelters a firm from outside competition, but it also may breed an inward-orientation. Growth comes from external market drivers, and clustering occurs as local producers reconfigure to create and take advantage of local externalities and external market opportunities. Inward-oriented ICT sectors face typical challenges in their transition to outward-orientation and competitiveness in larger markets (Chudnovsky and López, 2002). These include access to the innovation support services that public policy can provide – education and training, public good R&D, infrastructure, protection of intellectual property rights – and also firm-level or "micro-determinants" of growth that must be developed through business acumen and efforts, such as quality assurance, identification of market opportunities, network relationships, and management skills. For these reasons, growth in a domestic market is negatively related to internationalization (Elango, 1998).

The spatial characteristics of markets for ICT products and services require careful consideration. The telecommunications side of the ICT sector remains a regulated industry, and incumbent local exchange carriers (ILECs) enjoy several significant advantages. The computing

and software side of the ICT sector is characterized by "Wintelist" patterns of industrial governance in which the value chain is horizontally layered and vertical "co-opetitive" relationships exist among firms that sell complementary products while also competing with one another (Bresnahan and Richards, 1999; Hart and Kim, 2002). Most ICT-based industries are network industries in which complementarities, standards-based compatibility, consumption externalities, switching costs, lock-in, path dependency, positive feedback, substantial producer rents, and huge demand-side economies of scale are common economic and strategic parameters (Shapiro and Varian, 1999; Shy, 2001).

ICTs yield economic benefits in two ways: from rents and spillovers generated by successful providers of ICT products and services, and from increases in productivity and value-add when users adopt ICTs embodied in products or services. ICTs are "General Purpose Technologies" (Bresnahan and Trajtenberg, 1995) that can be modified and configured in support of a wide range of business objectives, including increased transactional efficiency, product/service innovation, complementarity with other products or services, and high customization of products or services (Amit and Zott, 2001; Keil et al., 2001). For many firms it has not been a simple matter to learn to use these technologies to produce business value. Research in the late 1980s and early 1990s found an IT "productivity paradox" at the individual firm level and also at the aggregate level. Recent research now emphasizes the contingency of positive firm-level return on IT investments on the effectiveness of practices of "co-invention" of value by IT users (Bresnahan and Greenstein, 2001; Dehning and Richardson, 2002).

The implications of the co-invention process for the geographical dimensions of ICT firms' business activities need to be noted. The co-invention process can be risky and expensive. The decision to purchase a product requiring significant user co-invention (for example, an enterprise application) is made not just on the basis of the functionality of the product, but also in terms of the ability of the vendor or its affiliates to supply a range of management consulting, support, and training services. These are usually customized services based on tacit knowledge, and their delivery requires physical presence at the customer's site. In other words, complex products entail complex services. Network forms of affiliation in the servicing of ICT users' complex products are common. These must be as geographically extensive as the vendor's customer base. To be successful, ICT product/service providers must commercialize their products or services via systems integrators, co-marketing agreements with other firms, strategic alliances, OEMs, or consortia. This form of economic organization is common in the software industry. Small producers of packaged software can piggyback on hardware manufacturers' distribution channels, while small producers of "bespoke" or customizable software need export sales staff and service affiliates (Bell, 1997). In each of these cases, participation in networks of providers of complementary assets is a critical success factor for ICT firms. This is why the "home bases" of ICT firms are usually geographically extensive rather than intensive, encompassing technology sourcing arrangements and alliances for delivery of support services or co-marketing of products through complementors that are located in key markets.

Selecting and entering an external market is one of the most important strategic decisions that a fledgling ICT firm can make. Incumbent ICT firms usually occupy "markets with substantial producer rents, like ICT today, [that] are characterized by powerful forces that make a direct

assault on an existing market position unpromising" (Bresnahan, Gambardella, and Saxenian 2002: 9). Latecomers may find unoccupied or poorly defended niches, but frontal attacks on major incumbents are very risky. To establish themselves, new entrants have to "turn away from established sources of rents to define new ones and (at least initially) make their relationship with existing technologies and clusters complementary rather than competitive" (ibid.). Heeks and Nicholson (2002) identify the following critical success factors in the development of the Indian, Irish, and Israeli software export industries: links to strong external demand, a national supportive vision and strategy, and international linkages through a diaspora.

To summarize, the development of competitive advantage in a regional ICT industry is very strongly conditioned by prior developments in the industry, especially with respect to existing geographic patterns of economic and technological activity and market structures. Start-up latecomer clusters face different development conditions than already established ones did. When ICT horizontal market layers mature they may remain stable for a decade or longer, providing great protection to incumbents. Proper sequencing and targeting of new ICT product/service offerings so that they provide the right value to the right customers at the right moment in the development of the right market requires either extraordinarily complex business capabilities or plain good fortune. Entrepreneurs in startup clusters cannot take advantage of a wide range of competitiveness-enhancing local externalities that are available in established clusters and so they face higher costs and risks in developing their business. They need to undergo accelerated external market learning to avoid being locked into their local or regional market. Early successes that grow into major revenue streams may put the local ICT industry on a specialization trajectory through processes of path dependent development. The development of

complementarities and specialties that may eventually allow rents to be earned requires outward-looking behavior and linkages with a myriad of players outside the local market. Collaboration among geographically proximate firms can usefully focus on policy advocacy, overseas marketing, market research, and sharing of effective business practices (Heeks and Nicholson, 2002), but it is an open question whether or which other kinds of local collective efficiencies can provide a competitive edge to an incipient cluster before it enters its growth phase.

The Development of the New Brunswick ICT Sector

The development of ICTs in New Brunswick has taken place in three phases. In the first phase, lasting from the 1960s until the mid-1980s, the provincial government and the large firms in the province upgraded their administrative and production capabilities, creating a local market for ICT products and services that was largely supplied by vendors and consulting companies who established a presence in the province to service this market. The local telephone company NBTel embarked on a twenty-year build-out of the provincial telecommunications infrastructure, using technology sourced from Northern Telecom and Bell Canada to provide digitally-switched telecommunications services to business customers and service throughout New Brunswick. Modernization of the public sector's mapping and land records management system and associated deepening of surveying and geomatics engineering programs in the University of New Brunswick stimulated the development of the first commercialized local IT-related specialty, geomatics. New Brunswick, a leader in GIS in the late 1980s, lost its leadership as international competition intensified (Wilson, 1999). Caris, a UNB spinoff and one of New Brunswick's

premier independent software firms in 2002, is presently the major representative of this specialization in geomatics.

In the second phase, lasting from the mid-1980s until the late 1990s, ICTs were identified as a development priority by the provincial government (notably during the ten-years of the McKenna government, 1987-1997) and by the provincial phone utility, NBTel, which played a modernizing role in the provincial economy. An early investor in digital infrastructure, by 1993 NBTel was the country's first telco with an all-digital switching network. In competition with Fundy Cable, NBTel launched the buildout of a round-the-province optical fiber ring. NBTel developed international recognition in the telecommunications industry as an artful deployer of advanced telecommunications technologies. It sourced telecommunications applications through Stentor Alliance members, especially Nortel and Bell Canada, and deployed them in New Brunswick in a "Living Lab" environment focusing on factors influencing business and individual customer acceptance and use of new products and services.

With the deregulation of the telecommunications industry and the rise of the internet after 1993, industry players became increasingly interested in delivering "convergent" multimedia broadband applications to consumers and businesses in order to complement basic telephone service revenues. NBTel's executives "decided to take advantage of converging technologies by discarding the telco's image as a telephone service provider and re-envisioning it as an electronic services integrator" (Henderson, 1998: 1). NBTel's digital switching network allowed it to introduce a variety of novel call management services. In 1994 NBTel dazzled the telecom world with its Call Mall (Vista 350) screen phone, designed for home shopping. In 1996 NB Tel

launched its VideoActive (Vibe) network, a broadband network designed to deliver multimedia services to homes. Vibe was estimated to require an investment of $350 million dollars to fully build out in New Brunswick.

NBTel's Living Lab developed into a successful for-fee service to client telcos. NBTel was soon regarded by telecommunications industry analysts as one of the best small telephone companies in North America. Its partner Nortel, supplier of digital switches and other telecommunications equipment, showcased NBTel around the world as an example of how a "smart dwarf" incumbent telco could catalyze regional development (Canadian Business, 1995; Cavill, 1999). Nortel and the Province of New Brunswick worked with the State Government of Tasmania to implement the New Brunswick model of regional development based on public-private partnership and expansion of telecommunications services, and a number of other Australian regions have implemented versions of it (Cavill, personal communication). NBTel's ability to productize its experience to provide turnkey build-operate-transfer "telco in a box" services to small regional telcos was identified as a potentially important tradeable service in the emerging Atlantic Canada information highway cluster (Nordicity, 1997).

In addition to leading the industry in the introduction of interactive products and services, NBTel through its holding company Bruncor acted as a flagship modernizer in New Brunswick by spinning off or acquiring specialized IT companies to develop products in emerging areas. By 1999 it had established about ten spinoffs or affiliates. Three were software firms (Innovatia, with an e-learning portfolio; iMagic, a digital television software provider; and Genesys, a call center software developer). Three others provided interactive services and applica-

tions: NBTel Interactive, a provider of Interactive Voice Response services; HealthFutures, a provider of interactive network applications to the healthcare industry; and New North Media, a provider of screen phone-based marketing and information applications. Datacor was established to provide data processing services and NBTel Mobility to provide cellular telephone services. Bruncor also purchased Prexar, an ISP in Maine, and acquired MITI, the former JD Irving IT department, when the Irving firms divested their IT interests.[4] MITI, widely regarded in New Brunswick as an exemplary pioneer IT firm, became part of Xwave, one of the largest systems integration firms in Canada, when the four provincial telephone companies merged in 1999.

NBTel and Bruncor's executives from this period were boosters who were proud to build the New Brunswick economy through business excellence, urban redevelopment projects, and partnership with the provincial government. NBTel's partnership with the provincial government during the McKenna years focused on the development and expansion of the Information Highway in the province, with three intended outcomes: all New Brunswick citizens were to be given access to IT-enabled services; New Brunswick was to become the North American contact center capital, with expected economic and technological spillovers; and large firms were to be encouraged to locate their IT work in New Brunswick (Courvisanos, 1997).[5] The recruitment of contact centers to employ New Brunswick's workforce had clear economic value for NBTel and political value for the government. The McKenna government vigorously pursued contact centers and information technology companies to interest them in the province, using as attractions New Brunswick's access to state-of-the art digital infrastructure, competitively priced technical

[4] The Irving Oil IT department was transferred to IBM in the framework of Irving's strategic outsourcing relationship with the latter.
[5] This was one element of the larger economic development and modernization program pursued by the McKenna government; see Savoie (2001).

and service labor, a variety of financial incentives including training grants and forgivable loans, and the favorable quality of life in the province.

The provincial government also honored its commitment to make the Information Highway accessible to New Brunswickers by linking all schools to the internet, vigorously promoting distance education and IT-enabled advanced training, participating as the pilot province in a large implementation of the federal Community Access Program, investing in e-health initiatives, streamlining and IT-enabling the Department of Human Resources Development, and placing over 150 services online through Service New Brunswick (Cavill, 1999).

Early academic critics of this entry strategy have focused either on the quality of jobs created by the contact centers (e.g. Rose, 1995) or on the limited extent to which the "McKenna Miracle" had modified the economic structure of New Brunswick (eg. Milne, 1996). With the advantage of greater hindsight we can offer a more nuanced appraisal of the strengths and weaknesses of the New Brunswick model in its second phase. Its strengths were that it stimulated the development and management of local and regional demand for ICT products and services, on the one hand, and positioned New Brunswick to be a provider of competitive low-cost IT-enabled services, on the other. It brought a population of contact centers to the province and also induced the birth or transplantation of a variety of other ICT firms offering high value-added IT-enabled services, notably software developers and e-learning (advanced training) firms, a segment of the ICT industry in which New Brunswick presently has around thirty active firms. Under this model, a surge of ICT firm births or establishments took place between 1995 and 1999,

peaking in 1997.[6] New Brunswick's entry strategy helped to change the outside world's perception of the province, eliminating the "drive-through province" image and giving New Brunswick a favorable cachet. It positioned the province to capture some of the growth of the Internet boom of the late 1990s, and it certainly raised expectations among New Brunswickers about the role of ICTs in their economic and social future.

The universities, NB Power, NBTel, and the provincial state are the four traditional economic development motors of New Brunswick over which the provincial government has had some leverage. An important shortcoming of the "McKenna Miracle" with respect to the development of a New Brunswick ICT cluster is that the McKenna government did not include New Brunswick universities in its modernization effort.[7] In Savoie's assessment,

> …it is surprising that McKenna did nothing [with respect to the universities]. He neither challenged them to increase their research and development nor did he ask university administrators to alter the status quo in their own institutions. In addition, he never initiated a debate, let alone take concrete action, on possible changes to the governance structure of New Brunswick universities (Savoie 2001: 116).

The McKenna Miracle did not induce significant investment in the development of ICT R&D capability in New Brunswick post-secondary institutions. The amount of research dollars that scholarly granting agencies spent in New Brunswick universities flatlined for nearly a decade beginning in the late 1980s, and New Brunswick's research intensity remained comparable to

[6] See below. Fifty-three percent of all ICT firms in New Brunswick active in 2001 were established between 1995 and 1999.
[7] NBPower was not extensively enrolled in the modernization effort, either (Savoie, 2001).

that of Romania, with the second-lowest per capita R&D performance in Canada. Between 1989 and 1999, New Brunswick's share of national R&D expenditures declined from 1.5% to one percent.

As it was, in the 1990s the province's community colleges, private technical schools, and universities produced more than enough of the junior IT personnel needed by industry. The province's largest post-secondary facility in computer science, the University of New Brunswick's Faculty of Computer science, participated in the production of a pool of technical labor by maintaining a largely teaching orientation throughout the 1990s. This orientation, along with the relatively lower salaries offered, made recruitment and retention of faculty members a challenge. In 1999 this Faculty, with 26 FTE faculty members, had nearly twice the number of enrolments as comparable Faculties of Computer science and less than one-third the annual NSERC operating and strategic grants (Faculty of Computer Science, 1999). However, it won a comparable level of non peer-adjudicated and contract research funding, a reflection of its involvement with the New Brunswick ICT industry.

Technological change and volatility in the business world began to erode New Brunswick's ICT development model by the late 1990s. It was no longer novel to have a fully digital telecommunications infrastructure. The contact center industry was maturing. The information highway had been built out in all cities and most towns in North America. The costly home-grown hybrid technology underpinning NBTel's broadband service Vibe had to be abandoned in favor of DSL, a simpler, less expensive industry standard. In the third phase of New Brunswick's ICT development story, massive changes in the telecommunications industry quickly re-

duced the scope of the strategic relationship between the provincial government and NBTel. The four provincial telephone companies of Atlantic Canada merged to form Aliant in 1999. This merger caused concern in New Brunswick regarding the future geographical deployment of Aliant's business activities in the region. However, within less than a year the Canadian telecommunications conglomerate BCE – already a large minority shareholder in Aliant - had purchased majority control of Aliant. Initially BCE remained committed to its "convergence strategy" in which it sought to offer dozens of new interactive broadband products and services, although the ultimate objective of convergence seems to have been the creation of a vertically integrated Canadian content-and-distribution conglomerate encompassing print, interactive and broadcast media, and telecommunications (Angus, 2002). However, when losses in its portfolio caused BCE's financial position to worsen in the wake of the technology meltdown, BCE's CEO Jean Monty, the champion of the convergence strategy, resigned and the firm began to reduce its exposure to "non telecom-centric" activities. In 2000 Aliant spokespersons described the firm's goals for 2003 as doubling revenues since 1999 and diversifying the firm's revenue base away from core Atlantic Canada telecommunications business. In 2002 the goals were recast as maintenance of overall profitability, increased operational efficiency, exit from non-core activities, and alignment with Bell Canada (Philips, 2002). Cash generated by the financially healthy Aliant in Atlantic Canada is helping to balance the books in Montreal, producing a "giant sucking sound" in the regional telecommunications industry. New product development in Aliant has been slowed or halted under the new regime, and competing products in the Aliant family, such as iMagic's DTV Manager software for delivery of digital television over copper wires, have been passed over in favor of BCE's ExpressVu satellite technology for delivery of bundled voice, television and Internet access, resulting in the withdrawal of Aliant's flagship VibeVision

digital television service. Affiliated firms such as Prexar and Xwave are being sold, and Aliant's engineering groups have been transferred to BCE. Insiders believe that Aliant is destined to become a regional sales and maintenance branch of BCE.

Thus the traditional corporate champion for ICT development in New Brunswick has left the field. In its place, initiative has shifted back to the public sector. In 2000 the Federal Government produced a $700M Atlantic Investment Program intended to help build regional self-sufficiency. The AIP contains a $300M Atlantic Innovation Fund administered by ACOA. When this fund issued a call for proposals in 2001 it received requests for eight times more funds than were available, a reflection of the dearth of R&D money in Atlantic Canada. The Federal government's National Research Council has introduced a program of innovation cluster development in the region, establishing an e-business research institute on the UNB campus in Fredericton. By late 2002 this institute had gained a high profile within the New Brunswick ICT sector, with more than a hundred firms expressing interest in R&D collaboration and commercialization.

Bernard Lord's Conservative government, elected to office in 1999, did not initially express an economic development agenda emphasizing ICTs. However this government has since greatly strengthened its commitment to innovation-based economic development. Its 2002-2012 economic development framework identifies innovation, exports, and productivity as its goals and proposes a spectrum of coordinating groups, tax credits, agendas, funds, and cluster-development initiatives as its implementing mechanisms.

To summarize: technology-based economic development in New Brunswick still requires a great deal of "pulling against gravity" (Savoie, 2001). New Brunswick has seen three generations of models of intervention to harness ICT for economic purposes in New Brunswick over the past fifteen years. Local champions and home-based institutions have been the critically important players in the start-up stage of the New Brunswick ICT sector. However, volatility in the telecommunications sector has reduced the strategic leverage that New Brunswick might expect to gain from the incumbent regional telecommunications firm. Provincial and federal actors are managing the first generation of public R&D-oriented innovation support institutions for the ICT sector that New Brunswick has seen. The countercyclical strategic roles played by governments and the recent ramp-up of ICT R&D mechanisms in the public sector are notable events in the development of the New Brunswick ICT sector. In the following section we provide a detailed analysis of the New Brunswick ICT sector and identify its current development challenges.

Analysis of the New Brunswick ICT Sector

The ICT sector as defined by OECD countries overlaps with the infrastructure and applications software layers of the "internet economy" (Cisco Systems and University of Texas, 1999) but excludes the top two layers (internet intermediaries and internet commerce) that comprise many of the business activities often associated with information industries: multimedia, content developers or aggregators, market makers, pure play or click-and-mortar internet retailers, or IT-enabled services such as e-learning firms, customer contact centers, or business process outsourcers. These and the definitional and measurement issues previously mentioned complicate the comparison of ICT or e-commerce sectors among countries. In New Brunswick the ICT sec-

tor is generally understood to encompass telecommunications, software, IT services, multimedia, and IT-based advanced training. Sometimes IT-enabled services such as customer contact centers and IT-enabled retailing (e-commerce) are included in discussions of the New Brunswick ICT sector, be we exclude them here. We do not include Aliant in our quantitative portrait of the NB ICT sector, but we include its spinoff and subsidiary firms that are active in New Brunswick.[8]

Basic metrics

Table 1 provides basic metrics of the New Brunswick ICT sector. This sector comprises around 240 firms (of which 189 participated in our survey), with supporting institutions and infrastructure. The NB ICT sector encompasses about 3900 IT workers (4540 New Brunswick-based workers in total) and another 3,300 New Brunswick-based technical and administrative workers in Aliant. This total of around 7,800 workers represents about 2.3% of the New Brunswick labor force. In comparison, the New Brunswick contact center industry employs 14,000 workers (4.2%), the healthcare/social assistance sector employs 40,000 workers (12%), the manufacturing sector, 39,000 workers (11.7%), and agriculture 6,000 (1.8%). The ICT sector is very young: more than seventy percent of currently existing IT firms in New Brunswick are ten years old or less. The NB ICT sector generated between $500M and $770M in revenues in 2001, making it slightly smaller than the tourism sector (about $800M). Sixty-three percent of its IT revenues

[8] Data presented in the following pages were collected through a survey of the New Brunswick ICT sector performed under contract to the National Research Council and the Atlantic Canada Opportunities Agency and through a series of about 45 in-depth interviews with firms and other ICT players in New Brunswick conducted under the auspices of the SSHRC-funded Major Collaborative Research Initiative on Innovation Systems and Economic Development: The Role of Local and Regional Clusters in Canada.

were earned from markets outside of Atlantic Canada. New Brunswick ICT firms reported an average three-year growth rate of 177% for the period 1999-2001.

[put Table 1 here]

Relative size

The New Brunswick ICT sector is tiny by world standards: it contains fewer than one-tenth the number of firms found in a major North American city with IT specialization such as Seattle. If New Brunswick's 7,800 workers in IT and telecommunications were all considered ICT workers, the New Brunswick pool would be about one-eighth the size of the Finland ICT cluster labor pool. With 200 to 250 ICT firms, New Brunswick's ICT sector is about one-seventh the size of the Pittsburgh IT cluster. New Brunswick is still far from obtaining its "share" of Canadian ICT activity. With 2.4% of Canada's population, New Brunswick has around .8% of Canada's ICT firms and ICT workers and around .6% of Canada's ICT revenues.[9]

Since was is not possible usefully to classify the firms into industry segments or subsectors on the basis of SIC or NAICS codes, firms responding to our survey of the New Brunswick ICT sector were classified into seven ICT industry subsectors on the basis of self-reported company descriptions and existing classification systems used by regional development agencies or government: systems integrators, internet solutions, advanced training, software development, consulting, telecommunications, and multimedia.[10] Table 2 provides basic information about the distribution and characteristics of firms in these subsectors. Systems integrators are the largest firms in terms of numbers of employees and revenue. They have on average fifteen times more

[9] New Brunswick's share of Aliant's revenues are not included in these estimates.
[10] On the survey see Schaefer et al. (2002).

employees and earn twenty-five times more revenue than internet solutions firms. Multimedia firms have the smallest average revenue – less than a half million dollars. Systems integrators, advanced training firms, consulting, and software developers account for over eighty-seven percent of the New Brunswick ICT industry gross revenues.

[put Table 2 here]

Revenues and employees are very highly concentrated in a small number of firms. Ten percent of the firms in the sector earn around three-quarters of the IT revenues; one-fifth of the firms earn more than four-fifths of the revenues. Distribution of employees is only slightly less skewed. The ten largest firms in terms of IT employment employ 51% of all IT employees in firms in New Brunswick. We estimate that these firms earned around fifty-five percent of the New Brunswick ICT sector's IT revenues in 2001 (Aliant excluded).

Status

One hundred fifty-eight (83.6%) of the hundred eighty-nine responding firms are independent – i.e. owned and operated by persons resident in New Brunswick. Seventeen firms (9% of the total) are branches, and twelve firms (6.3%) are subsidiaries. Independent firms are on average much smaller than branches or subsidiaries. With 52% of the IT employees, independent firms earn 44.8% of the IT revenues (see Table 3).

[put Table 3 here]

Age of firms

The New Brunswick ICT sector is very young: the average age of firms in 2001 was about 8 years. The sector grew slowly until 1993 and then expanded rapidly until 1997 (see Figure 1). Forty-three percent of ICT firms in New Brunswick in 2001 were established between 1993 and 1997, the years of active recruitment and ICT boosterism on the part of the McKenna government. Figure 2 shows the patterns of annual births or establishments of ICT firms in New Brunswick by industry subsector. It shows that the consulting subsector was the first to firmly establish a foothold, followed by the multimedia and software development subsectors, the advanced training subsector, and finally the internet solutions subsectors. The systems integration subsector is the latest arrival. All subsectors shared in the 1993-1997 growth boom, although growth of the internet solutions subsector lagged the others by around two years.

[put Figure 1 here]
[put Figure 2 here]

Geographic distribution of ICT firms within New Brunswick

Unlike other provinces in Atlantic Canada, New Brunswick has not evolved from a rural society into one in which a single large capital city services a hinterland of relatively small towns. Instead, New Brunswick has developed a pattern of polynucleated urbanization centered on three small cities (Saint John, Fredericton, and Moncton) in the southern part of the province and a number of towns (Edmunston, Grand Falls, Bathurst, Campbellton, Miramichi) in the northern part. About half of the New Brunswick population lives in rural areas. In terms of business culture and outlook, it would be harder to find three more different cities than Fredericton, Saint

John, and Moncton. Fredericton is the seat of provincial government and the headquarters of the University of New Brunswick, proximate to public decisionmaking and public R&D resources. Moncton has a conspicuously entrepreneurial and service-oriented culture, and Saint John has a strong corporate and industrial presence. Table 4 shows the distribution of ICT firms, IT revenues, and IT employees within New Brunswick. IT revenues and employees are approximately equally distributed among the three cities, although Saint John has the most IT employees and Moncton the greatest gross revenue from IT. Fredericton has the greatest number of ICT firms – around one-third of all ICT firms in New Brunswick. The three cities account for around 79% of New Brunswick's ICT firms and 94% of its IT revenues and IT employees. Clearly, the ICT sector has not demonstrated strong employment- or revenue-generating effects in New Brunswick's rural areas or small towns.

[put Table 4 here]

Growth

Table 5 shows reported growth in revenue for ICT firms in New Brunswick for the period 1999-2001 and forecasts for 2002-2004. New Brunswick ICT firms report an aggregate average growth rate of 177% in the period 1999-2001 and forecast a more aggressive 317% growth rate for the period 2002-2004. Independent firms grew 188% in 1999-2001 and expect to grow nearly 350% between 2002 and 2004. Branches report a much slower three-year growth rate (94%) and forecast a similar growth rate for 2002-2004. Subsidiaries report growth rates similar to branches (119%) but expect to see this growth more than double in 2002-2004.

[put Table 5 here]

Systems integrators and telecommunications firms experienced the fast growth in 1999-2001 and anticipate the sharpest drops in growth rates in 2002-2004. Of all subsectors, software development firms anticipate the greatest surge in growth between the two periods.

To put the growth rate of the New Brunswick ICT sector into perspective, consider the number of "gazelle" firms in the sector in the period 1999-2001. To qualify as a "gazelle" a firm must grow at a rate of twenty percent per year for at least five years from a base of at least $100,000 (Case, 1996). This amounts to an increase of 73% over three years. Using these criteria, fifty-two of the responding firms in our survey qualify as gazelles for the period 1999-2001. This proportion of fast-growing firms is an order of magnitude greater than the number of "gazelle" firms in a general population of SMEs (Orser, Hogarth-Scott, and Riding, 2000).

Markets

New Brunswick's ICT industry services five distinct markets: the local New Brunswick and regional Atlantic Canada markets (which for many firms is one market), the rest of Canada (essentially Central Canada), the United States, and other international customers. New Brunswick's ICT sector is already primarily export-oriented. About 63% of New Brunswick's IT revenues are generated outside of Atlantic Canada (see Figure 3). The United States accounts for more than one-third of New Brunswick's ICT revenues. The New Brunswick market accounts for 30% of IT revenues and the rest of the region, less than 7%. Twelve percent of New

Brunswick's IT revenues are generated internationally outside of the US, and 16% are generated in Central Canada.

[put Figure 3 here]

Most of New Brunswick's IT revenues in a given geographic market are generated by a small number of firms, and this is especially so outside of Atlantic Canada. Around 40% of New Brunswick's international (non U.S.) revenues are earned by a single firm, about 70% by the top five firms, and about 90% by the top ten firms earning international revenues. The U.S. market is the fastest-growing external source of demand for New Brunswick's ICT products and services. The top five revenue earners in the U.S. market earn around two-thirds of New Brunswick's IT revenues in that market. External markets are crucial sources of revenue for New Brunswick-based systems integrators, internet solutions, advanced training, and software development firms. Software development is the only subsector to tap into an international market outside of the United States, while consulting companies are quite embedded in the New Brunswick market, a reflection of possibly weak export potential.

Innovation

Fifty-nine percent of New Brunswick ICT firms report that they are engaged in R&D (but only 31% report use of Scientific Research and Experimental Development Tax Credits). Forty-eight percent of New Brunswick ICT firms' gross revenues was generated by an average of 4.8 new products or services introduced in the past three years. New Brunswick ICT firms report an average of 1.1 world-first innovations per firm in the past three years and 1.8 Canada-firsts. All

told, New Brunswick ICT firms report the introduction of nearly eight hundred new products and services and one hundred eighty-two world-first products, services, or processes in the past three years (see Table 6).

[put Table 6 here]

Sources and Drivers of Growth in the New Brunswick ICT Sector

What explains the growth of the New Brunswick ICT sector? The short answer is ability to quickly respond to the extraordinary domestic, regional, and external market opportunities of recent years. The sector almost doubled in size between 1999 and the end of 2001. If revenues were to expand according to the forecasts made by firms, New Brunswick ICT firms would earn $1.4B in IT revenues by the end of 2004, representing a near-tripling of the sector's size since 2001. The export share (Canada excluding Atlantic Canada, the U.S., and other international markets) would increase to 72%. The key questions are whether the forecasts were realistic and whether the expansion is sustainable. In 2002 many segments of the ICT industry imploded, registering the first negative growth in memory.

To identify specific patterns of growth in the New Brunswick ICT industry, we classified the 179 firms for which we had market share data into four categories, according to their ownership and export orientation as follows:

Quadrant 1: independent exporters (65 firms)	Quadrant 2: branches and subsidiaries that export (11 firms)
Quadrant 4: independent firms that export little or not at all (84 firms)	Quadrant 3: branches and subsidiaries that export little or not at all (19 firms)

- Quadrant 1 firms are independent (i.e. not under the control of a firm from outside New Brunswick) and earn 25% or more of their IT revenues from outside of Atlantic Canada. Sixty-five firms are in Quadrant 1. These are home-grown ICT firms with an export orientation.

- Quadrant 2 firms are under external control and the New Brunswick operation earns 25% or more of its IT revenues from outside the region. These are either subsidiaries or branches of firms that are set up to use their New Brunswick operation as an export platform.

- Quadrant 3 firms are under external control and their New Brunswick operation earns less than 25% of its IT revenues from outside the region. These are subsidiaries or branches of firms that come to New Brunswick to deliver products and services to clients in New Brunswick and Atlantic Canada. Nineteen firms are in Quadrant 3.

- Quadrant 4 firms are independent and earn less than 25% of their IT revenues from outside the region. These are firms that either basically oriented toward the local and re-

gional market, or have export ambitions but have not yet begun to generate export revenues, or they are firms in a startup mode that do not yet have revenues. Eighty-four firms are in Quadrant 4.

Table 7 provides information about the revenues, growth rates, and sizes of firms in each quadrant according to industry subsector. Figures 4 and 5 use two constructs (extent of use of public innovation support mechanisms, and degree of firm-level innovation effort) to estimate the differences in innovation strategies and capabilities according to quadrant and industry subsector. From the information provided in these tables and figures we can identify patterns of behavior within the New Brunswick ICT industry mix, and from there identify several key policy issues.

[put Table 7 here]

Among independent exporters (Quadrant 1), internet solutions, software developers, and advanced training firms form the core of New Brunswick's indigenous capability in ICTs. These firms account for around $150M in revenues and report very high growth rates. Export-oriented independent ICT consulting and telecommunications firms generate modest revenue (<$25M). As independent indigenous firms that export, firms in Quadrant 1 need to compete at least partially on the basis of technological capability and have no way of getting differentiating technology without producing it themselves. This is why firms in Quadrant 1 have high indices of firm-level innovation and use innovation support programs more intensively than firms in other quadrants (see Figures 4 and 5).

[put Figures 4and 5 here]

Of the eleven firms in Quadrant 2, two are branches, seven are subsidiaries, and two are firms with other relationships with external parents. Nearly all of the IT revenue in Quadrant 2 is earned by a half-dozen systems integration and advanced training firms. Firms in Quadrant 2 have high indices of innovation but make moderate to low demands on the domestic public innovation support system (see Figures 4 and 5). These firms generally take advantage of R&D tax credits, IP protection, and applied R&D assistance. Quadrant 2 firms reflect the aspiration of New Brunswick to serve as an export platform for ICT transplant firms. However, at present only one major transplant firm has been attracted to New Brunswick. The other Quadrant 2 firms generating the bulk of IT revenue are home grown firms – either subsidiaries of firms that were once headquartered in New Brunswick, or homegrown firms that have since become subsidiaries of other firms. Much greater attention needs to be given to growing the population of Quadrant 2 firms in New Brunswick.

In Quadrant 3 are firms that come to New Brunswick to provide products and services to the local market. Almost all revenues are earned by large computer and management consulting firms with accounts in the provincial government or among New Brunswick's large corporations. Of the nineteen firms in this quadrant, fifteen are branches. Firms in this Quadrant have relatively low indexes of innovation and make moderate to low demands on the innovation support infrastructure because they are supplied with knowledge and technology by their parent companies (Figures 4 and 5). Moreover, firms in Quadrant 3 often do not have a mandate to conduct R&D.

Quadrant 4 contains eighty-four mainly small firms that generate a total of $48M of IT revenues. Concentrations exist in internet solutions, software development, consulting, and multimedia. These firms all face significant growth challenges and it is likely that growth potential varies greatly by firm and subsector. Nearly 20% of the firms in this quadrant had no revenues in 2001, and quadrant 4 firms report very slow growth since 1999 (but anticipate nearly 900% growth to 2004). As expected, Quadrant 4 firms have relatively low indices of innovation and make relatively few demands on the innovation support system because they face greater obstacles to R&D than other firms. A challenge for economic developers and policymakers is to improve the successful incubation rate of these firms and assist them to step up to exporting capability so that they may tap into sources of growth. The development of deeper R&D capability in the province may help firms that are presently in Quadrant 4 to graduate to Quadrant 1. Furthermore, as Aliant sheds its innovation and product development functions, senior managers and engineers are leaving the company to establish new firms, with probable near-term changes in the characteristics of Quadrant 1 firms.

Conclusions and issues for further research

The New Brunswick ICT sector is a very young sector that is characterized by a population of mainly small recently-established firms and strong recent aggregate growth. This sector contains a group of two or three dozen leading firms that account for a large fraction of the sector's employment and revenues. Further research is required on this early-stage cluster in order to better

understand its growth processes and dynamics and to devise an agenda for strategic business development under difficult economic circumstances.

We urge caution in using the Porter diamond model of national competitive advantage as a blueprint for development of the New Brunswick ICT cluster or, for that matter, other regional groupings of ICT industries. ICT firms' linkages can be local, regional, national, or international depending on the subsector in question, the ownership structure of the firm, the firm's market orientation, and the purpose of the linkage. The ICT sector is so highly extraverted and the New Brunswick and regional markets so small that the "home base" of the industry (comprised especially of suppliers, competitors, and customers) is distributed among several places. We need a model of early-stage firm clustering in an open regional economy that recognizes the long distance networks that ICT firms routinely develop and maintain.

In New Brunswick, the clearest patterns of ICT firm linkages with the local milieu are via the technical labor force, the regional telecommunications service provider, the local and regional markets for ICT products and services, and to some extent the local and regional markets for innovation support and industrial incentives. These appear to have been the local externalities that facilitated the incubation of the sector in the 1990s. Other subtler characteristics of the New Brunswick milieu that affect ICT firm emergence, growth, and performance are not well documented, but they certainly include a place-related sense of quality of life among technical workers and entrepreneurs that gives them a strong preference for working in New Brunswick, if their business or professional goals can be met. We will investigate these qualitative factors of ICT sector development in a future paper.

The New Brunswick ICT sector contains a population of more than four dozen "gazelle" firms. This extraordinary concentration of fast-growing technology-based firms qualifies New Brunswick as a "dynamic region" (Julien and Lachance, 2001). The development trajectories and growth strategies of these firms is of great interest in understanding the early stages of cluster formation.

The absorption of Aliant by BCE is resulting in the resignation of a number of regional corporate leaders and managers. These experienced individuals have personal savings and industry contacts, and many appear to be establishing firms of their own. Perhaps one silver lining in the restructuring of the Atlantic Canadian telecommunications industry will be the incubation of a new generation of startup firms and the seeding of the next development phase of the local and regional ICT cluster. It is important to undertake ongoing research on new firm formation in the New Brunswick ICT sector.

Further research is also needed on the differences among kinds of firms with respect to type, purpose, significance, and geographic distribution of linkages. What are the factors in the local milieu that encourage new firm formation, and what are the factors that stimulate ICT firms' export growth, attract firms to locate in New Brunswick, or induce spinoffs from firms that are already established in New Brunswick? The five most important kinds of development pathways in the ICT sector are individual entrepreneurial startups, corporate entrepreneurial startups, transplants, foreign servicers of local accounts that are attracted to the local market, and development of exportable ICT products and services as a complement to a core non-ICT busi-

ness. Each pathway implies different kinds of relationships with customers, suppliers, and supporting institutions, and a different orientation towards local, regional, or international markets. Most ICT subsidiaries and some branches in New Brunswick have an export orientation. The factors that induce externally-controlled firms to develop export activities from a New Brunswick base need to be better understood.

An export orientation is definitely associated with greater innovation intensity, greater use of public innovation support services, and a mandate to generate earnings outside of New Brunswick. This is prima facie evidence that New Brunswick-based ICT firms are finding ways to compete on the basis of differentiated products and services rather than simply on the basis of price, as might be expected from product-cycle stages-of-growth theories of cluster development. Here again, further research is needed.

Has the presence of a significant contact center industry begun to induce a local supplier industry? Local upstream technology linkages to the contact center industry do not appear to have developed extensively, except in the case of Aliant as a supplier of technology solutions and also perhaps in the case of the training industry. The potential of IT-enabled services to induce localized backward and forward linkages requires further research.

Endogenous high-quality demand from New Brunswick's major corporations and public agencies for ICT services has resulted in the attraction of external suppliers to the New Brunswick market to service major accounts. Further investigation of the contribution of local demand to cluster development is necessary.

Although the local or regional markets could grow enough through public sector spending in e-health or e-government projects or through private spending on ICT goods or services to provide growth opportunities to New Brunswick ICT firms, the further expansion of the sector clearly depends on the development of deeper and broader export capability. This can happen when current exporters tap into new fast growing markets, when firms in Quadrant 4 learn to export, when transplants are attracted to New Brunswick, when export-oriented corporate venturing occurs in already-established firms in New Brunswick, or when subsidiaries of branches win export mandates. Since each of these development pathways is more difficult than usual in a time of depressed ICT spending, strategic business development is in many respects the principal management and policy challenge facing the New Brunswick ICT sector at present.

Acknowledgements

Research the results of which are reported here was supported by a grant from the Social Sciences and Humanities Research Council on Innovation Systems and Economic Development: The Role of Local and Regional Clusters in Canada. Collection of survey data was supported by a contract with the National Research Council and the Atlantic Canada Opportunities Agency. We are grateful for this support. We also wish to acknowledge with thanks the participation of over 200 persons from the New Brunswick ICT community in survey interviews, and the valuable assistance provided by federal, provincial, and local government agencies in the development of our database of New Brunswick ICT firms.

Bibliography

Amit, Raphael, and Christophe Zott, 2001. "Value Creation in e-Business," Strategic Management Journal 22(6-7), 493-521.

Anonymous, 1995. "The Smart Dwarf: Tiny New Brunswick Tel Has Everything Going Against It. So Why is It Acclaimed as One of the World's Most Advanced Phone Companies?" Canadian Business 68(2), 72-74.

April, Daniel, 1999. Defining the Information and Communication Technology Sector. Adoption of the of OECD Definition and Introducing the North American Industry Classification System. Report prepared for Industry Canada. http://strategis.ic.gc.ca/SSG/it00957e.html

Angus, Ian, 2002. "Who Put the Con in Convergence," Telemanagement no. 191, January, 1-6.

Bekar, Clifford, and Richard G. Lipsey, 2002. "Clusters and Economic Policy," ISUMA, Spring, 62-70.

Bell, Jim, 1997. "A Comparative Study of the Export Problems of Small Computer Software Exporters in Finland, Ireland, and Norway," International Business Review 6(6), 585-604.

Bresnahan, Timothy, Alfonso Gambardella, and Annalee Saxenian, 2002. "'Old Economy' Inputs for 'New Economy' Outcomes: Cluster Formation in the New Silicon Valleys,' paper pre-

sented at the DRUID Summer Conference on Industrial Dynamics of the New and Old Economy-Who is Embracing Whom?" Copenhagen, June.

Bresnahan, Timothy, and Shane Greenstein, 2001. "The Economic Contribution of Information Technology: towards comparative and user studies," Journal of Evolutionary Economics 11(1), 95-118.

Bresnahan, Timothy, and John Richards, 1999. "Local and Global Competition in Information Technology," Journal of the Japanese and International Economies 13, 336-371.

Bresnahan, Timothy F., and Manuel Trajtenberg (1995). "General purpose technologies: engines of growth?" Journal of Econometrics 65(1): 83108

Case, John, 1996. "The Age of the Gazelle," Inc. – the Magazine for Growing Companies, May 15, p. 44.

Cavill, Marina, 1999. "Telecommunications as a Catalyst for Regional Development: the New Brunswick Example," Telecommunications Journal of Australia 49(2), 1-12.

Chudnovsky, Daniel, and Andrés López (2002). The Software and Information Services Sector in Argentina. Pros and Cons of an Inward-Oriented Development Strategy. WIDER Discussion Paper 2002/92, United Nations University, Helsinki

Cisco Systems and University of Texas, 2001. Measuring the Internet Economy. www.netindicators.com [retrieved 20 June 2001].

Courvisanos, Jerry, 1997. "Investment in Innovation: an 'Instrumental Analysis' Based on the Tasmanian and New Brunswick Information Strategies," paper presented at the Conference of Economists '97, Hobart.

Davies, Howard, and Paul Ellis, 2000. "Porter's Competitive Advantage of Nations: Time for the Final Judgment?" Journal of Management Studies 37(8), 1189-1213.

Davis, Charles H. (2003). "Venture Capital in Canada: a Maturing Industry, with Distinctive Features and New Challenges," in D. Çetindamar, ed., The Growth of Venture Capital: A Cross-Cultural Comparison. Greenwich, CT: Quorum Books, in press.

Dehning, Bruce, and Vernon J. Richardson, 2002. "Returns on Investment in Information Technology: a Research Synthesis," Journal of Information Systems 16(1), 7-30.

Elango, B., 1998. "An Empirical Examination of the Influence of Industry and Firm Drivers on the Rate of Internationalization by Firms," Journal of International Management 4, 201-221.

Faculty of Computer Science, 1999. Research Plan 2000-2005. Faculty of Computer Science, University of New Brunswick, unpublished.

Gordon, Ian R., and Philip McCann, 2000. "Industrial Clusters: Complexes, Agglomerations, and/or Social Networks?" Urban Studies 37(3), 513-532.

Hart, Jeffrey A., and Sangbae Kim, 2002. "Explaining the Resurgence of U.S. Competitiveness: the Rise of Wintelism," Information Society 18, 1-12.

Heeks, Richard, and Brian Nicholson, 2002. Software Export Success Factors and Strategies in Developing and Transitional Economies. University of Manchester: Development Informatics Working Paper Series.

Henderson, Mark, 1998. "The New Brunswick Telephone Company Limited: Restructuring Under a New Vision," unpublished business teaching case, Electronic Commerce Centre, University of New Brunswick – Saint John.

Hitt, Lorin, 1999. "Information Technologies and Firm Boundaries: Evidence from Panel Data," Information Systems Research 10(2), 134-149.

Julien, Pierre-André, and Richard Lachance, 2001. "Dynamic Regions and High-Growth SMEs," Human Systems Management 20(3), 237-249.

Industry Canada, 2002. Information and Communications Technologies Statistical Overview. Information and Communications Technologies Branch, Spectrum, Information Technologies

and Telecommunications Sector, Industry Canada, April.
[http//strategis.ic.gc.ca/SSG/it00957e.html]

Industry Canada, 2001. Canada's Information and Communication Technologies Trade Performance 1993-2000. ICT Branch, SITT, Industry Canada, October.

Keil, Thomas, Eero Elorant, Jan Holmstrom, Eila Jarvenpaa, Minna Takala, Erkko Autio, and David Hawk, 2001. "Information and Communication Technology Driven Business Transformation – a Call for Research," Computers in Industry 44(3), 263-282.

Kolko, Jed, 2001. "Silicon Mountains, Silicon Molehills. Geographic Concentration and Convergence of Internet Industries in the U.S," Discussion Paper 2001/2, World Institute for Development Economics Research, United Nations University.

Koski, Heli, Petri Rouvinen, and Pekka Ylä-Anttila, 2001. "ICT Clusters in Europe. The Great Central Banana and the Small Nordic Potato," Discussion Paper 2001/6, World Institute for Development Economics Research, United Nations University.

Krugman, Paul, 1996. "Location and Competition: Notes on Economic Geography," chapter 16 in R. Rumelt, D. Schendel and D. Teece, eds., Fundamental Issues in Strategy. Boston: Harvard Business School Press, pp. 463-494.

Martin, Ron, and Peter Sunley, 2003. "Deconstructing Clusters: Chaotic Concept or Policy Panacea?" Journal of Economic Geography 3(1), 5-35.

Miller, Roger, and Marcel Côté, 1987. Growing the Next Silicon Valley. Lexington, Mass.: Lexington Books.

Milne, William J., 1996. The McKenna Miracle: Myth or Reality? Toronto: University of Toronto monograph series on public policy and public administration no. 3.

Möslein, Kathrin M., 2001. "The Location Problem in Electronic Business," Proceedings of the 34th Hawaii International Conference on System Science, http://www.hicss.hawaii.edu/HICSS_34/PDFs/OSGLO04.pdf

Nordicity Group, Syntel, and Horizon, 1997. Prospects for Growing Knowledge-based Industrial Clusters in Atlantic Canada. Report prepared for the Atlantic Canada Opportunities Agency, June.

OECD, 2000. Information Technology Outlook. Paris: Organisation for Economic Cooperation and Development.

Orser, Barbara J., Andy Hogarth-Scott, and Allan L. Riding, 2000. "Performance, Firm Size, and Management Problem Solving," Journal of Small Business Management 38 (4), 42-59.

Philips, Andrew, 2002. "Aliant Expects Challenging Year," New Brunswick Telegraph Journal, December 18, pp. D1-D2.

Porter, Michael, 2000. "Location, Competition, and Economic Development: Local Clusters in a Global Economy," Economic Development Quarterly 14(1), 15-34.

_____, 1994. "Toward a Dynamic Theory of Strategy," chap. 15 in R. Rumelt, D. Schendel and D. Teece, eds., Fundamental Issues in Strategy. Boston: Harvard Business School Press, pp. 423-462.

_____, 1990. The Competitive Advantage of Nations. New York: Free Press.

Richards, John, 2001. "Clusters, Competition, and 'Global' Players in ICT Markets – the Case of Scandinavia," Stanford Institute for Economic Research Discussion Paper 00-46.

Rose, Jonathan W., 1995. "The Selling of New Brunswick: Fibre Optics or Optical Illusion?" pp.171-188 in D. Brown and J. Rose, eds., Canada: the State of the Federation 1995. Kingston: Queen's University Institute of Intergovernmental Relations.

Savoie, Donald J., 2001. Pulling Against Gravity: Economic Development in New Brunswck During the McKenna Years. Ottawa: The Institute for Research on Public Policy.

Schaefer, N.V., S.L. Katz, and S. Neily, 2002. Innovation Clusters Research and Development. Baseline Report. University of New Brunswick, Faculty of Administration: report prepared for the Atlantic Canada Opportunities Agency and the National Research Council, unpublished.

Shapiro, Carl L., and Hal R. Varian, 1999. Information Rules. Cambridge, Massachusetts: Harvard Business School Press.

Shy, Oz, 2001. The Economics of Network Industries. Cambridge, England: Cambridge University Press.

Wilson, Joely, 1999. "Innovation Systems and the Geomatics Industry in New Brunswick," upublished manuscript, University of New Brunswick-Fredericton.

Yakabuski, Konrad, 2001. "No More POTS," Report on Business, February 23. http://www.globetechnology.com/archive/20010223/RO03POTS.html [retrieved 13 February 2003]

Table 1: The New Brunswick ICT sector at a glance, ca. early 2002

- Number of firms: 247 (see note i below).
- Number of firms participating in survey: 189
- Gross Revenues, estimate 1: $755.4M (note ii)
- Gross Revenues, estimate 2: $600.3M (note iii)
- Gross Revenues from IT: $478.4 M (note iv)
- Mean revenues per firm: $3.7M
- Total number of employees: 4550 (note v)
- Mean number of employees: 24
- number of IT employees: 3862 (note vi)
- Percentage of firms employing fifteen or fewer employees: 75%
- Percentage of responding companies indicate that they had created a new product, service, or process in the preceding three year: 91%
- Percentage of responding firms generating revenues outside of New Brunswick: 72%
- Percentage of aggregate IT revenues generated outside of Atlantic Canada: 63%
- Average age of firm: 8 years
- Average growth rate in IT revenues in the three years period 1999-2001: 177%
- Percent independent (i.e. owned and operated by individuals residing in New Brunswick): 84%

Notes on methodology

i. The population of firms was identified by pooling information from lists of firms provided by the former New Brunswick Information Technology Association, the New Brunswick Economic Development Commissions, Business New Brunswick's IT Directory; Export New Brunswick's IT Directory, Strategis, Industry Canada, and ACOA. Three hundred and sixty-nine firms were identified. We then excluded Aliant (but not its subsidiaries), crown corporations, government agencies and departments, firms that were not deriving revenue from IT related products or services such as accounting or marketing firms or contact centers, retail companies not offering value-added IT products or services, and companies without an active website. This resulted in a list of two hundred and forty-seven IT firms, of which one hundred and eighty-nine participated in the survey sponsored by the National Research Council and ACOA. Detailed results of this survey are reported in Schaefer et al., 2002. In-depth interviews were conducted with approximately 50 firms and policy actors under a related project sponsored by SSHRC.

ii. This estimate includes all NB-generated revenues of participating firms. It uses the median value of each revenue category in the questionnaire (i.e. for the category $1M to $5M, $2.5M was used). For firms in the "greater than $50M" category, revenues were estimated at $75M. The revenues of the thirty-nine non-participating firms and nineteen non-responding firms were estimated to be the average revenue of the 159 firms with 50 or fewer employees.

iii. This estimate includes only the NB-based revenues of firms responding to the survey. For the three firms in the $50M+ category, revenues were estimated to be $50M.

iv. This estimate multiplies estimate 2 (above) by the percentage of reported revenues generated by IT. The average ratio of IT revenues/all revenues of the population of surveyed firms was .81.

v. This metric includes all NB-based employees of all responding firms.

vi. This metric assumes that the ratio of IT employment/total NB employment of responding firms is the same as the ratio of IT revenues/all NB revenues of the same firms.

Table 2: New Brunswick's ICT firms by Industry Subsector

		Gross Revenues from IT (estimated)			Gross Revenues 2001 (Estimated)			Number of Employees NB			
		Mean	Sum	Col Sum %	Mean	Sum	Col Sum %	Mean	Sum	Col Sum %	Valid N
industry subsector	Systems Integrators	25237.50	100950.00	21.1%	25837.50	103350.00	17.2%	108.67	652.00	14.4%	N=6
	Internet Solutions	1007.09	37262.50	7.8%	1140.54	42200.00	7.0%	7.33	300.50	6.6%	N=41
	Advanced Training	3948.80	90822.50	19.0%	4736.96	108950.00	18.1%	42.48	1232.00	27.1%	N=29
	Software Development	2609.28	112199.25	23.5%	3605.81	155050.00	25.8%	22.50	1147.50	25.3%	N=51
	Consulting	3846.14	111538.00	23.3%	5493.10	159300.00	26.5%	23.79	832.50	18.3%	N=35
	Telecommunications	2025.00	18225.00	3.8%	2127.78	19150.00	3.2%	24.80	248.00	5.5%	N=10
	Multimedia	491.83	7377.50	1.5%	820.00	12300.00	2.0%	7.50	127.50	2.8%	N=17

Revenue figures are in 1000 dollars.
Examples of firms in each subsector:

- Systems integrators: OAO, Xwave, Anyware
- Internet solutions: Kinek, Infiknowledge, Crescent Studio
- Advanced training: SmartForce, Innovatia, LearnStream
- Software development: Spielo, Caris, Whitehill
- Consulting: CGI, IBM, Fujitsu
- Telecommunications (excluding Aliant): iMagic TV, Dramis Network, Group Telecom
- Multimedia: Entertaining Knowledge, In Color, Sonoptic

Table 3: status of ICT firms in New Brunswick, 2001

		Type of Business				
		Independent	Branch	Subsidiary	Other	Total
Gross Revenues 2001 (Estimated)	Mean	2212.31	10634.62	10477.27	25175.00	3751.88
	Sum	296450.00	138250.00	115250.00	50350.00	600300.00
Gross Revenues from IT (estimated)	Mean	1707.52	7191.54	9638.64	25026.25	2989.84
	Sum	228807.25	93490.00	106025.00	50052.50	478374.75
Number of Employees NB	Mean	16.30	38.91	83.08	153.00	24.02
	Sum	2575.50	661.50	997.00	306.00	4540.00
number of IT employees	Mean	12.73	36.43	77.52	150.45	20.44
	Sum	2012.07	619.27	930.20	300.90	3862.44
	Valid N	N=158	N=17	N=12	N=2	N=189

Gross revenue figures are in 1000 dollars.

Table 4: Distribution of ICT firms, revenues, and employees in New Brunswick

		Gross Revenues from IT (estimated)			number of IT employees			
		Mean	Sum	Col Sum %	Mean	Sum	Col Sum %	Valid N
Region	Fredericton	2268.09	133817.50	28.0%	19.09	1221.52	31.6%	N=64
	Moncton	3907.33	168015.00	35.1%	22.10	1038.82	26.9%	N=47
	Saint John	5605.25	151341.75	31.6%	35.74	1358.27	35.2%	N=38
	Miramichi - Bathurst - Campbellton	1098.00	10980.00	2.3%	9.80	127.39	3.3%	N=13
	Edmunston - Grand Fall	162.50	812.50	.2%	2.56	20.50	.5%	N=8
	Sackville	141.88	567.50	.1%	2.13	8.50	.2%	N=4
	other	1070.04	12840.50	2.7%	5.83	87.45	2.3%	N=15
Total		2989.84	478374.75	100.0%	20.44	3862.44	100.0%	N=189

Gross revenue figures are in thousands of dollars.

Table 5: Reported and Expected Rates of Revenue Growth in New Brunswick ICT firms, 1999-2001 and 2002-2004

		% change in Revenues past 3 years	% chg in Revenues in Next 3 Years	difference in growth rates, 2004-2001 and 2001-1998
Type of Business	Independent	188.04	347.11	156.42
	Branch	94.00	92.30	-28.65
	Subsidiary	119.44	268.33	46.25
	Other	217.50	125.00	-92.50
industry subsector	Systems Integrators	306.20	165.00	-141.20
	Internet Solutions	214.50	300.10	69.03
	Advanced Training	126.08	183.52	55.83
	Software Development	213.13	630.11	422.45
	Consulting	82.03	96.52	2.69
	Telecommunications	269.78	98.30	-167.22
	Multimedia	161.29	277.47	111.93
Total		176.84	317.49	131.84

Table 6: innovation in NB ICT firms

Rows		industry subsector							Total
		Systems Integrators	Internet Solutions	Advanced Training	Software Develop-ment	Consulting	Telecom-munications	Multi-media	
New Product Lines and/or Services (3 yrs)	Mean	6.5	4.0	5.8	6.7	2.6	4.0	2.5	4.8
	Sum	39.0	144.0	163.5	322.0	68.0	16.0	39.5	792.0
Other Major Innovations (Processes) (3 yrs)	Mean	17.0	4.7	1.0	1.5	2.6	4.0	.5	2.8
	Sum	102.0	167.5	28.5	71.0	66.0	16.0	7.0	458.0
World firsts - Products, Services, or Processes	Mean	2.7	.7	1.2	1.9	.5	1.3	.3	1.2
	Sum	16.0	25.5	32.5	87.0	11.0	5.0	5.0	182.0
Canada firsts - Products, Services, or Processes	Mean	.2	.5	.8	4.6	1.1	.8	.3	1.8
	Sum	1.0	19.0	21.5	214.0	26.0	3.0	4.0	288.5
Company firsts - Products, Services, or Processes	Mean	20.7	7.4	4.0	1.9	3.9	4.5	1.7	4.5
	Sum	124.0	265.0	109.0	87.0	90.0	18.0	25.5	718.5
% of Gross Revenues Generated by Products/services Commercialized in the Past 3 Years	Mean	43.8	53.9	53.7	57.5	26.5	43.0	32.7	47.7

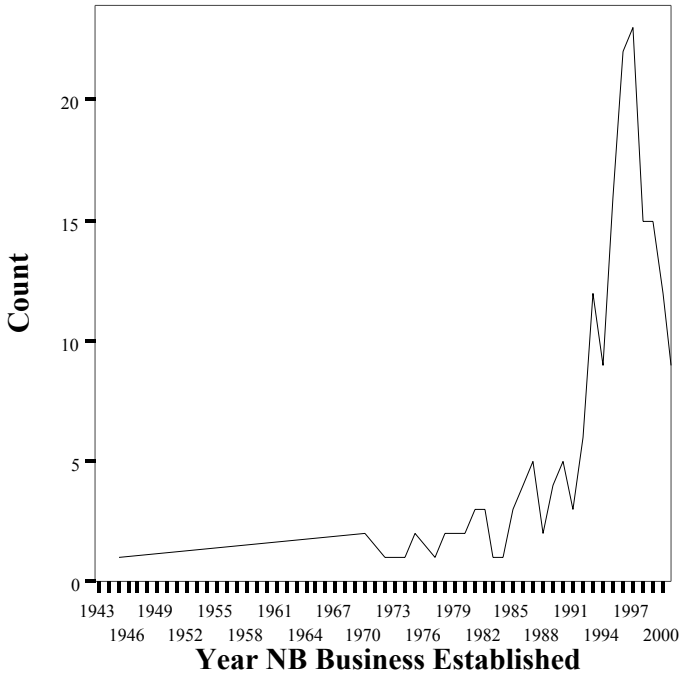
Table 7: Revenues, Growth Rates, and Sizes of NB ICT Firms According to Market Orientation, Industry Subsector, and Ownership*

				quadrant				
				1.00	2.00	3.00	4.00	Total
industry subsector	Systems Integrators	A	Mean	.	50000.00	.	475.00	25237.50
			Sum	.	100000.00	.	950.00	100950.00
		B	Mean	1001.00	225.00	.	40.00	306.20
		C	Mean	30.00	122.50	.	275.00	165.00
	Internet Solutions	A	Mean	2954.00	.	50.00	295.10	1007.09
			Sum	29540.00	.	50.00	7672.50	37262.50
		B	Mean	446.33	.	300.00	120.06	214.50
		C	Mean	483.95	.	500.00	218.56	300.10
	Advanced Training	A	Mean	2296.82	16833.33	1886.25	1246.67	3948.80
			Sum	25265.00	50500.00	11317.50	3740.00	90822.50
		B	Mean	198.33	60.00	113.83	7.00	126.08
		C	Mean	320.83	62.50	95.50	8.00	183.52
	Software Development	A	Mean	3916.99	50.00	3000.00	591.59	2856.39
			Sum	101841.75	50.00	3000.00	6507.50	111399.25
		B	Mean	386.90	.	100.00	-99.55	234.99
		C	Mean	689.11	1000.00	115.00	732.73	680.60
	Consulting	A	Mean	2725.00	.	10343.75	1052.24	3846.14
			Sum	10900.00	.	82750.00	17888.00	111538.00
		B	Mean	26.00	.	96.29	92.65	82.03
		C	Mean	126.60	500.00	55.81	83.09	96.52
	Telecommunications	A	Mean	4375.00	.	750.00	870.00	2025.00
			Sum	13125.00	.	750.00	4350.00	18225.00
		B	Mean	733.33	.	45.00	36.60	269.78
		C	Mean	165.00	.	30.00	58.60	98.30
	Multimedia	A	Mean	208.75	400.00	.	638.06	491.83
			Sum	835.00	800.00	.	5742.50	7377.50
		B	Mean	330.00	200.00	.	82.00	161.29
		C	Mean	306.25	400.00	.	253.70	277.47

A: estimated gross revenues from IT
B: % change in IT revenues in past 3 years
C: expected % in IT revenues in next 3 years

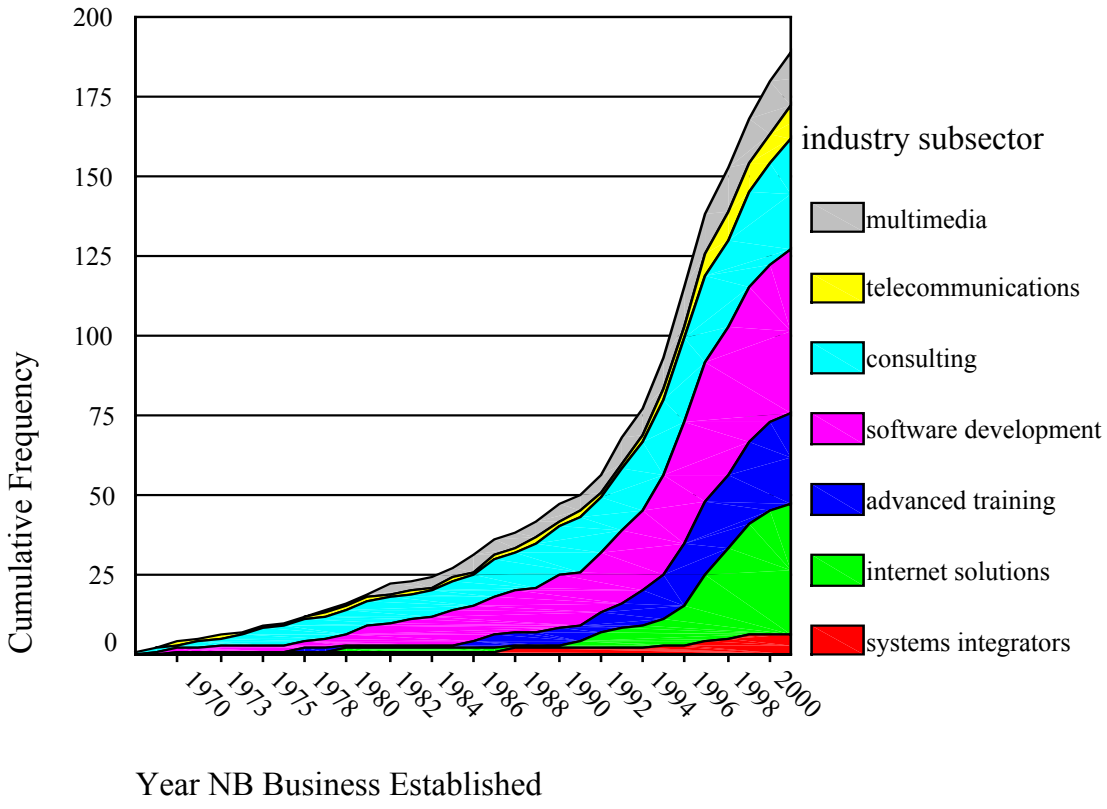
* Firms in Quadrant 1 are independent and earn 25% or more of their IT revenue from outside of Atlantic Canada. Firms in Quadrant 4 are independent and earn less than 25% of their IT revenue from outside of Atlantic Canada. Firms in Quadrant 2 are under external control (i.e. are branches or subsidiaries) and the New Brunswick operation earns 25% or more of its IT revenue from outside of Atlantic Canada. Firms in Quadrant 3 are under external control and their New Brunswick operation earn less than 25% of their IT revenue from outside of Atlantic Canada. Revenues are expressed in thousands of dollars.

Figure 1: year of birth or establishment of ICT firms in New Brunswick



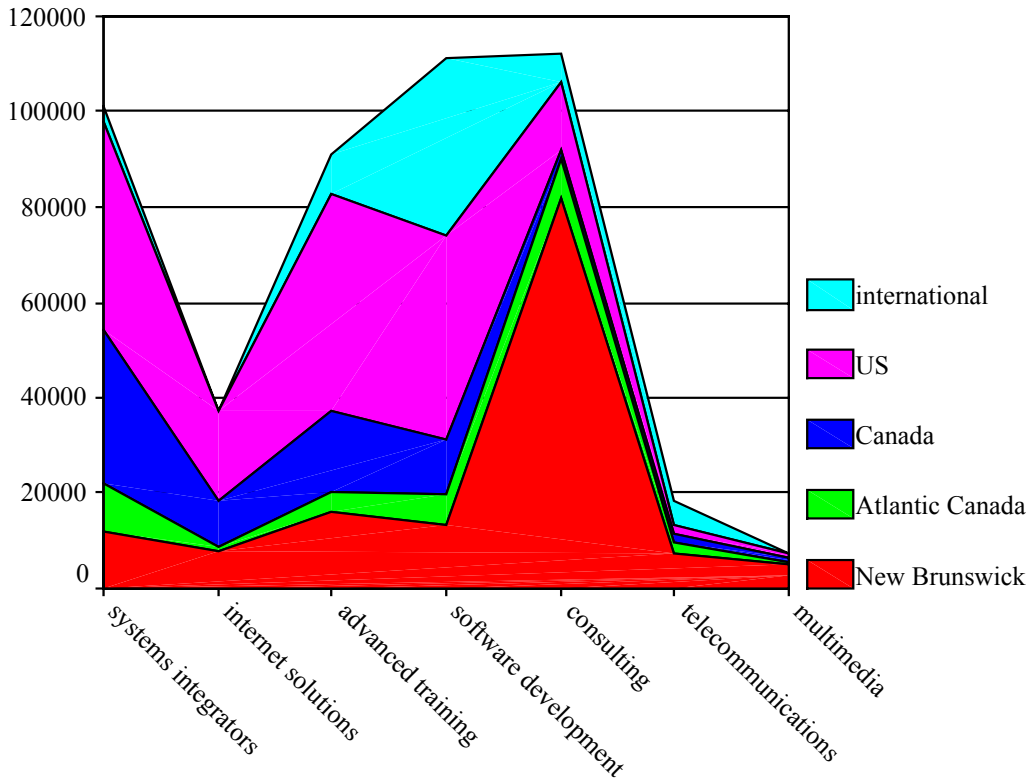
Note: data show year of establishment in New Brunswick of ICT firms active in New Brunswick in late 2001. No data on exits are available.

Figure 2: Establishment of Firms by Date and Industry Subsector in New Brunswick



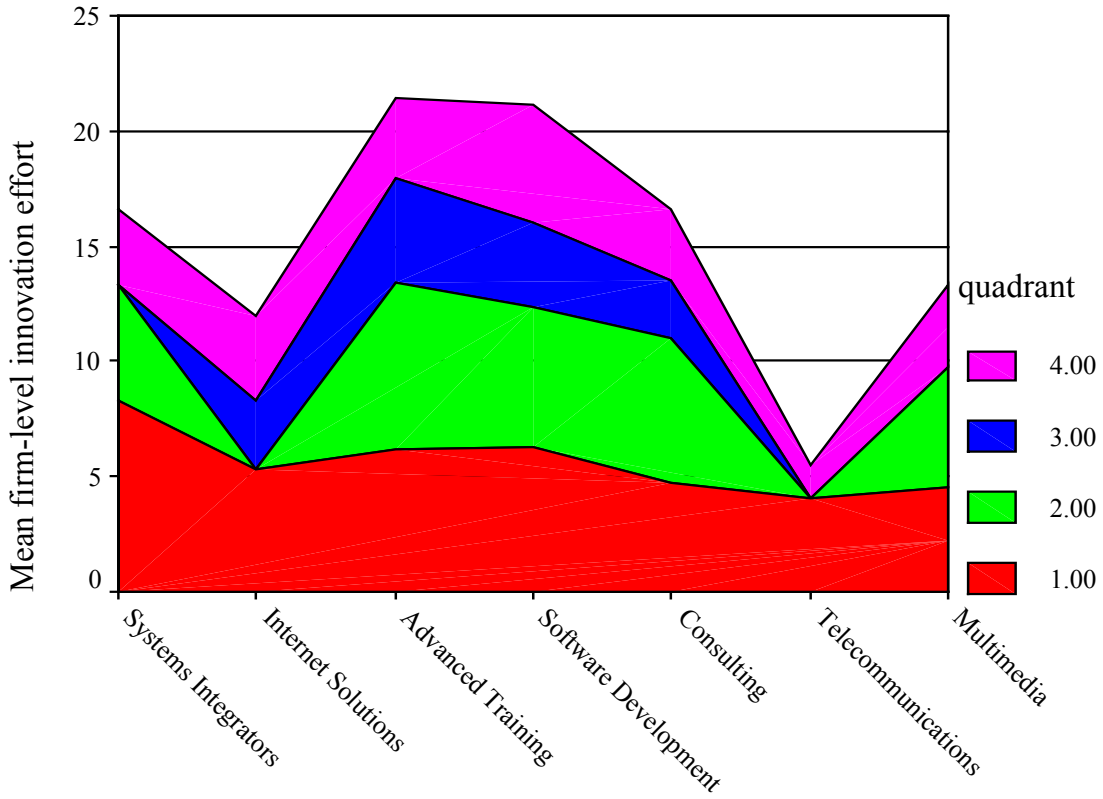
Note: data refer to data of birth or establishment in New Brunswick of ICT firms active in New Brunswick in 2001. No data are available regarding firm exits.

Figure 3: 2001 IT Revenues by Subsector and Geographical Location of Market



Figures are in thousands of dollars. See text for explanation of geographical location of market.

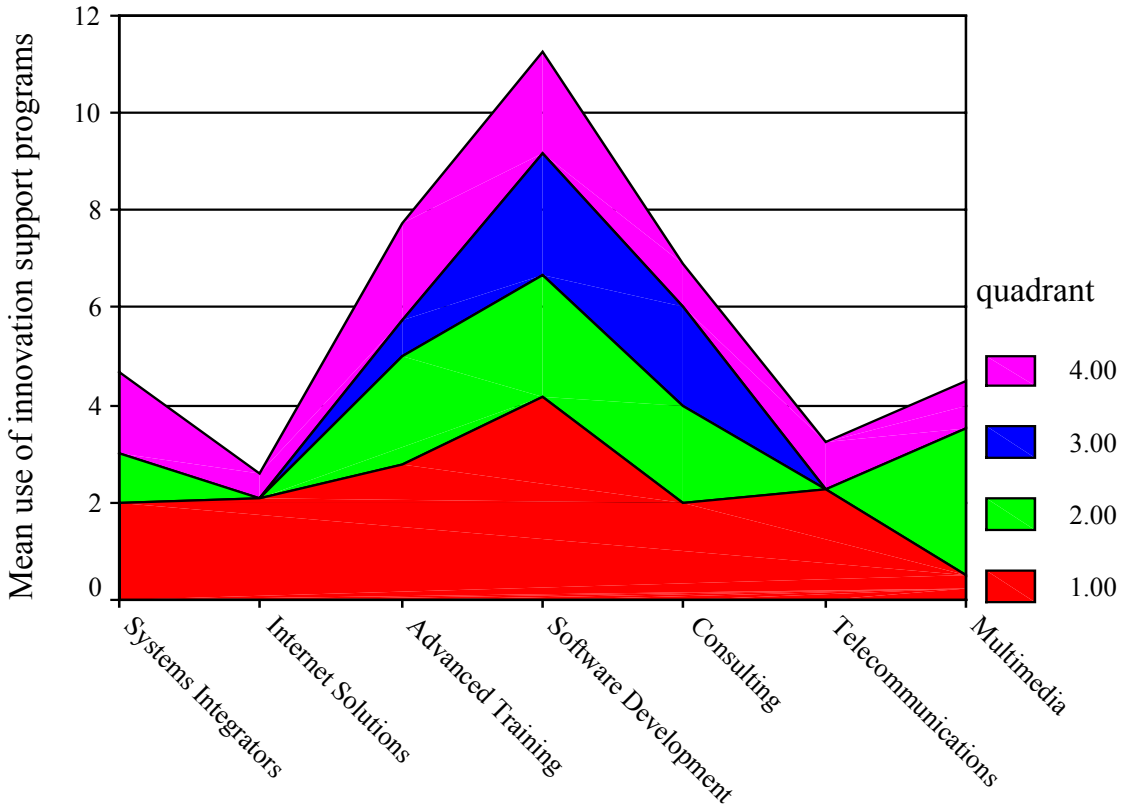
Figure 4: New Brunswick ICT Firms' Degree of Innovation by Industry Subsector and Quadrant



Quadrant 1: independent exporters. Quadrant 2: externally controlled exporters. Quadrant 3: externally controlled non-exporters. Quadrant 4: independent non-exporters. For further explanation of the quadrant construct, see Table 8.

The composite metric of in-firm innovation efforts is constructed as the sum of responses as follows: 1 if new products/services were introduced in the past three years; 1 if number new processes were introduced in past three years; 1 if the firm claimed world firsts; 1 if the firm claimed Canada firsts; 1 if the firm claimed firm firsts; percent of revenues produced by products/services introduced in the past three years*100; 1 if the firm was an R&D performer; 1 if employees were assigned to R&D; 1 if employees were assigned to commercialization.

Figure 5: New Brunswick ICT Firms' Use of Public Innovation Support Programs and Services by Industry Subsector and Quadrant



Quadrant 1: independent exporters. Quadrant 2: externally controlled exporters. Quadrant 3: externally controlled non-exporters. Quadrant 4: independent non-exporters. For further explanation of the quadrant construct, see Table 8.

The composite metric of innovation support program use s is constructed of the sum of responses to the following questions (1=yes): use of NRC services; use of IRAP; use of CISTI; use of the Canadian Technology Network; contact with the Institute for Information Technology in Ottawa; application to the Atlantic Innovation Fund; use of ACOA services or programs; use of Scientific Research and Experimental Development Tax Credits; use of intellectual property protection in past three years.