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Research Paper

The Canadian Economy in Transition

A decade of growth: The emerging geography of new economy industries in the 1990s

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Preface

Economic analysts have expressed significant interest in the transition of the industrial base towards knowledge-intensive production. A central aspect of this transition is the growth and development of industries that provide the technological and scientific foundations for what is often termed the New Economy. This paper explores the geographic structure of two innovative sectors: (1) information and communications technology (ICT) industries, and (2) science-based industries. ICT industries develop and support products that are at the heart of the technology revolution. Science-based industries make important contributions to systems of innovation via large investments in research and development (R&D) and human capital.

This empirical study develops a geographic profile of ICT and science-based industries in Canada. It investigates differences in the evolution of these industries across provincial boundaries, along the urban/rural hierarchy, and in different metropolitan areas. Patterns of ICT and science-based growth are examined by focusing on changes in employment intensity between 1990 and 2000. The paper also investigates why certain cities have enjoyed more intensive growth in their local ICT economies than other cities.

Executive Summary

This paper explores the geography of the New Economy in Canada. It profiles two innovative business populations: (1) industries that develop and support information and communications technologies (ICTs), and (2) industries that place a strong emphasis on scientific knowledge via their investments in research and development and skilled labour. We examine growth trends in ICT and science-based industries by comparing their employment profiles in 1990 and 2000. These comparisons are made at the provincial level, across urban and rural areas, and finally, across all major Canadian cities.

Our central objective is to learn more about the geographic evolution of certain industry clusters, clusters that are generally viewed, by economists and business analysts, as vanguards of the new economy. We ask whether there has been significant employment growth in these industries over the last decade, and specifically, whether certain locations, be they provinces, urban/rural areas or individual cities, have benefited more from this growth than others. To address this, we focus both on the *level* and *intensity* of ICT and science-based employment—comparing both the absolute size of ICT and science-based workforces in different locations, along with the proportional representation of ICT and science-based workers within local and regional economies.

Our analysis is designed to shed some light on a number of very basic questions about the structure of New Economy industries. How large are these industries? How much ICT and science-based growth comes from new entrants? How does the growth of ICT or science-based employment in Ontario compare with growth in Alberta? How large is Ottawa's ICT base relative to Toronto's? How large is the ICT industry in Ottawa and Toronto when viewed in relation to the size of the local economy? Which cities have made the greatest strides towards developing these industries? Which cities are falling behind?

We also examine a series of possible explanations for why certain locations develop more intensive ICT-based economies than others. Studies that examine the growth of new industries have emphasized the comparative advantages of locating in large, diversified urban areas. New industries that locate in large cities are said to benefit from spillovers from other industrial sectors (e.g., skilled labour, innovative production methods). Other research has stressed the importance of intra-industry spillovers—the benefits that firms in a given sector can realize from locating near other firms in the same industry. The inter-firm networks that can take root in high-tech clusters represent one such example. In our analysis, we use multivariate methods to ask whether certain urban characteristics—the size of the employment base, the degree of industrial diversification, and the development of other science-based industries—are useful predictors of local ICT-intensity.

We highlight several of our major findings below.

- Employment in ICT industries expanded rapidly during the 1990s. The ICT sector—a collection of 19 individual manufacturing and service industries—increased its employment by over 70% during the decade; by 2000, approximately 560,600 workers were employed in ICT industries. Employment in science industries—other R&D and skill-intensive industries that are not part of the ICT sector—increased at a much slower pace (10%) during the 1990s. By 2000, some 541,100 workers were employed in 37 science-based industries.

- Firms in the ICT sector employed 4.1% of all paid workers in 2000, up from 2.7% in 1990. Growth in ICT employment accounted for one in six jobs created in the 1990s. Firms in science industries accounted for some 4% of total employment—both in 1990 and in 2000.

- New businesses play a critical role in ICT-based growth. In 2000, 74% of workers in ICT industries were located in business establishments that came into existence after 1990. In non-ICT science-based industries, this figure stands at 68%.

- Ontario enjoyed the fastest growth in ICT employment during the 1990s (95%). By 2000, 5.4% of all paid workers in Ontario were employed in the ICT sector. Quebec and British Columbia had the next highest ICT employment shares, at 4.0% and 3.5%, respectively.

- Alberta enjoyed the fastest employment growth in science-based industries (61%). By 2000, Alberta had the highest share of science-based employment (5.0%), followed closely by Quebec (4.7%). At 4.1%, Ontario had the third highest share of science-based employment, down from 4.6% in 1990.

- The evolution of Canada's ICT sector is a disproportionately urban phenomenon. As of 2000, Canada's three largest cities—Toronto, Montreal and Vancouver—were home to 61% of the ICT workforce. This figure stood at 53% in 1990. After accounting for differences in the size of urban economies, larger cities still tend to have higher concentrations of ICT workers than smaller cities.

- By 2000, Ottawa-Hull emerged as the New Economy leader in terms of the relative size of its ICT workforce (9.1% of local employment). This said, Ottawa's ICT workforce in 2000 was only one-quarter the size of Toronto's.

- Hamilton made substantial inroads in developing its ICT economy. ICT employment in Hamilton increased from approximately 2,500 workers in 1990 (a 1.1% share of the local economy) to 16,000 a decade later (a share of 5.9%).

Chapter 1. Introduction

We often associate particular locations—cities, regions, and even provinces—with particular industries. We tend to see the world in terms of farming and fishing communities, commercial and financial centres, tourist havens, oil-producing regions, automobile-manufacturing centres, and government towns. Rooted in the historical development of industries, these labels are used to convey basic differences in social, political and economic geography.

While such labels are simplifications—and potentially inaccurate representations when applied to large, cosmopolitan centres, and/or diverse economic regions—they create strong impressions about the degree of economic vibrancy at work within a particular location. They say something about the extent to which certain communities, cities or regions are embracing forward-looking (growing) industries, or clinging to the traditional (declining) industries of the past.

Ottawa's recent economic transformation is illustrative. Once regarded as a staid, government town, Ottawa is now portrayed in the popular media as a dynamic, high-tech hub, on par with other high-tech hubs such as Silicon Valley and Route 128 around Boston. Hence, in relatively short order, Ottawa has emerged as a high-tech leader, a key stakeholder in industries that many economists and business analysts regard as pillars of the New Economy—an economy increasingly defined by technological innovation and knowledge management.

This paper explores the emerging geographic structure of the New Economy in Canada. It profiles two innovative business populations: (1) industries that develop information and communications technologies (ICTs), and (2) industries that place significant emphasis on scientific knowledge via investments in research and development and skilled labour.

We undertake the analysis with several basic questions in mind. First, how large is the New Economy—or at least industries that business analysts tend to associate with the development of the New Economy? Have both ICT and science-based industries grown rapidly in the last decade? To what extent have certain locations, be they provinces or individual cities, benefited more from this growth than others? What factors help explain why certain urban areas develop more intensive ICT-based workforces than other urban areas?

We examine trends in ICT and science-based industries by comparing their employment demographics in 1990 and 2000. These comparisons are made at the provincial level, across urban and rural areas, and finally, across all major Canadian cities.

The study is organized as follows. Section 2 outlines the principles that give rise to our ICT and science-based classifications. The data sources used for our employment profile are outlined in Section 3. Section 4 provides a brief overview of growth trends in ICT and science-based industries during the 1990s. Section 5 outlines a series of research issues that motivate our geographic profile. Empirical results for provinces, urban/rural areas, and major cities are reported in Section 6. Multivariate regressions that explore differences in local ICT intensity are presented in Section 7.

Chapter 2. Measuring the New Economy: ICT and science-based industries

Proponents of the New Economy speak of the fundamental economic transformation brought about by the widespread integration of advanced computer-based technologies—a transformation that can be studied and evaluated primarily in two ways. One approach is to examine the impact that new technologies have had on the way firms organize and compete. A second approach examines relationships between technology inputs and different aspects of macroeconomic performance, such as trend growth and aggregate productivity. There is also considerable interest, in academic and policy circles, in learning more about the industrial dimensions of the New Economy—industries at the leading edge of this general economic transformation.

We begin by asking "What is the New Economy?" or, more to the issue raised above, "Which industries serve to define it?" A comprehensive examination of what the New Economy is (or is not) is well beyond our present scope here.[1] As Stiroh (1999) notes, despite the general proliferation of New Economy commentary and analysis, there remains considerable debate over its basic characteristics. Here we chart an easier course, and start with the simple proposition that the New Economy can be studied by focusing on different sets of industries—industries that make up the technology sector and industries that have a significant scientific base.

We start with an industrial classification developed by the OECD that identifies a small set of manufacturing and service industries as information and communications technology (ICT) based. Widely regarded as the technological backbone of the New Economy, these industries are those that "electronically capture, transmit and display data and information" (Statistics Canada, 2001). In Canada, the ICT sector spans 19 individual industries, 10 in manufacturing and nine in services.[2] In manufacturing, ICT industries

> "(m)ust be intended to fulfil the function of information processing and communication including transmission and display" and "(m)ust use electronic processing to detect, measure and/or record physical phenomena or to control a physical process" (OECD, 2000: p. 7).

[1] See Beckstead and Gellatly (2003) for a more thorough discussion of New Economy themes.

[2] This definition is based on the 1980 Standard Industrial Classification.

For services, ICT industries offer products that

> "must be intended to enable the function of information processing and communications by electronic means" (OECD, 2000: p. 7).

Examples of ICT manufacturing include firms that operate in the electronic parts and components and computing equipment industries. ICT services include *inter alia* firms in the computer services and telecommunications carriers industries.[3] Much of ICT employment is concentrated in services, particularly in the two industries noted above. Business establishments in computer services account for nearly 40% of total ICT employment, while those in the telecommunications carriers industry account for roughly 20%.

An ICT-based approach to measuring the New Economy is *output-based*; that is, it focuses squarely on industries that are involved in the development, delivery and support of advanced technological products and services. We can take an alternative approach to identifying New Economy industries by shifting our emphasis away from products, or outputs, and on to production inputs—investments in knowledge and human capital. Knowledge-based investments such as R&D are often used as an indicator of an industry's technological prowess. For example, the OECD (1997) has used R&D-to-sales ratios to develop lists of "high-technology industries". Similarly, the human capital characteristics of an industry, such as the extent to which its workforce is comprised of professional and technical workers, is an additional means of quantifying an industry's knowledge-base. Here we combine these two inputs—R&D and human capital—to identify a group of industries where investments in scientific knowledge are a relatively more important part of the production process.

We adopt the classification system developed by Lee and Has (1996) and later refined by Baldwin and Johnson (1999). To identify science industries, three R&D variables were used—the industry R&D-to-sales ratio, the share of R&D personnel to total employment and the share of professional R&D personnel to total employment—along with three measures of human capital—the shares, respectively, of post-secondary workers, knowledge workers, and scientists and engineers, all expressed in relation to total industry employment. Science industries are those that fall into the top one-third of industries for two of the three R&D measures and two of the three human capital measures.

This emphasis on scientific and technical knowledge gives rise to a view of the New Economy that is broader in scope than that afforded by focusing strictly on the ICT, or information technology, sector. The science sector identified by Baldwin and Johnson (1999) spans 56 individual industries, 36 in manufacturing and 20 in services. One can envisage the science sector as an extension of the ICT sector, as 16 of the 19 individual ICT industries examined herein (the exception being three ICT-based wholesaling industries) are also classified as science-based.

[3] For a list of individual industries, see Appendix A.

In this analysis, we restrict our tabulations on science to the subset of science industries that are not classified as ICT-based.[4] This provides readers with two statistical yardsticks—ICT industries and non-ICT science industries (hereafter science-based industries)—that describe different aspects of the New Economy landscape. Many of the industries that make up the ICT sector (e.g., computer services and computers and telecommunications products) produce goods and services that are synonymous with the information technology revolution. But ICT industries do not possess a monopoly on industrial innovation. Science-based industries outside of the ICT sector also make large contributions to systems of innovation via their investments in R&D and human capital. And this collection of science industries includes many examples of operating environments that are widely regarded as dynamic and knowledge-intensive (e.g., scientific and technical services and pharmaceuticals).

We have opted for this dual ICT/science framework because it enriches our understanding of high-technology employment transitions in different cities and regions. Certain locations may have experienced rapid gains in ICT-based employment; for other locations, the transition to the New Economy may be driven by employment creation in other knowledge-intensive sectors.

Can either of these industrial aggregates, ICT or science-based industries, provide us with a definitive measure of the amount of New-Economy activity in a particular location? In our view, no. Recent firm-level research by Baldwin and Gellatly (1999, 2001) has demonstrated that industry-level characterizations anchored around notions of technological prowess obscure a tremendous amount of firm-level heterogeneity—masking, in effect, an entire range of strategic and technological variation among the firms that, taken together, comprise an industry. However, industry-level taxonomies can be expected to yield useful characterizations of the *average firm* within a particular operating environment, or useful descriptions of the operating environment itself.

In their profile of new entrants in science-based industries, Baldwin and Johnson (1999) found that these firms face, on average, different competitive pressures than businesses in other sectors. Entrants in science environments face more consumer uncertainty and higher levels of competition around innovative products. These firms invest more heavily in innovation and technology, and place greater stress on developing a wider array of internal competencies related to marketing, management and human resources.

These profiles support the view that firms in science industries have, on balance, a more knowledge-intensive focus than firms found elsewhere. But they should not be used to infer that all firms within these industries have developed scientific or knowledge-intensive competencies, or that one city, region or province is necessarily more “scientific” than another. Baldwin and Gellatly (1999, 2001) found that there are large numbers of what could appropriately be termed New Economy firms operating well outside the boundaries of New Economy industries; what is more, not all firms in New Economy industries are

[4] See Appendix B.

knowledge or science-based. Ideally, statistics on the New Economy should be developed from data on the scientific capabilities of all firms in the economy. Absent such data, this paper relies on industry-level statistics. It should be recognized that neither our ICT nor our science-based taxonomies capture the full development of the New Economy.[5]

What our profile can contribute is some basic understanding of how employment dynamics in these chosen industries are evolving, by asking whether certain locations appear to be gaining more of a foothold in ICT and science-based industries than others. ICT and science industries factor heavily into the economy's competitive position. ICT industries have been described as a "driving force" in the Canadian economy during the last decade, due to high rates of output and employment growth, and strong commitments to R&D and international trade (Statistics Canada, 2001). The science sector includes manufacturing industries such as petroleum, aircraft and chemical industries—many of which are highly innovative and depend heavily on advanced technical knowledge (Baldwin and Hanel, 2003). Science also brings dynamic services such as architecture, engineering and scientific and technical services into our analysis of employment transitions.

5 For an alternative approach that classifies workers as either high- or low-knowledge, see Beckstead and Vinodrai (2003).

Chapter 3. Data source

Our employment profile requires microdata on the geographic characteristics of the business sector. This information can be obtained from Statistics Canada's Business Register (BR).[6] We decided on the BR as our principal data source because it has two desirable properties—business coverage and industrial detail. The BR contains detailed information on the sales, employment, 4-digit industry and geographic location of all business establishments operating in Canada.[7] The concept of a business establishment used by the BR is analogous to the plant-level within a firm's organizational structure. The vast majority of Canadian businesses, some 91%, maintain only a single establishment within their operating structure. Many large firms, however, maintain multiple establishments, or plants, within their operating structure.

The establishment profiles on the BR are updated on a continuous basis. Our analysis of New Economy industries is based on year-end images from the BR, first, in 1990, and then again in 2000. We selected this ten-year interval for two reasons:

1) This interval is long enough to observe significant, non-transitory changes in the evolution of the business and employment mix in different locations; and

[6] It is this data source that allows accurate sample frames to be drawn for Statistics Canada's business survey program. While the agency has long had a centralized BR, this was traditionally supplemented with specialized lists that were used to support specific survey programs. Beginning in the late 1980s, many of these data sources were integrated into the central BR, thereby increasing its coverage of the business population. In support of this strategy, additional resources were devoted to maintaining the database. As a result, the BR now offers, in a single location, an extremely comprehensive picture of Canadian businesses.

[7] Many readers will note that our analysis of industrial structure is based on Standard Industrial Classification (SIC) industries, and not the more recent North American Industrial Classification System (NAICS) standard. Many of the analysis files produced from the BR are "double-coded", that is, they assign both SIC and NAICS industries to all business units. NAICS-based definitions of ICT and science-industries have also been developed; for an overview of the former, see Statistics Canada (2001). While, in principle, it is preferable to utilize the more recent of the two industrial standards, tabulations based on NAICS industries are not generally available outside of recent years. As our objective is to examine long-run employment transitions, we have opted to use SIC industries, as this gives us consistent ICT and science-based definitions in both analysis periods, 1990 and 2000.

2) This ten-year interval captures the expansionary phase in the growth and development of the New Economy. Many macroeconomic analysts fix the early 1990s as its start date, triggered by the U.S. economic expansion. Our employment statistics for 2000 capture the final stage of this growth phase, prior to the subsequent tumult in technology markets.

Because our profile is based on ten-year comparisons, we must ensure that the geographic treatment of different locations is consistent over time. Accordingly, we have applied Statistics Canada's 1996 Standard Geographical Classification to all establishments in both years.

Based on our preliminary research, we are confident that data from the BR can be used to produce accurate estimates of the share of employment accounted for by ICT and science industries in different cities and regions. While we are confident in these shares, we have less confidence in the employment levels derived from the BR. This is because the BR is subject to periodic administrative updates that can affect estimates of the level, or stock, of employment over time.[8]

For this reason, we have chosen to generate 'synthetic' estimates of ICT and science-based employment. These estimates are obtained by using the ICT and science-based employment shares from the BR in conjunction with data from Statistics Canada's Labour Force Survey. We rely on the Labour Force Survey to obtain estimates of aggregate (i.e., national) employment in 1990 and 2000. We then *allocate* a portion of total employment to each industry-geography combination based on the employment shares obtained from the BR. The net result is a more reliable set of employment data to support our geographic profile.

8 It is worth emphasizing that the Business Register was designed as a sample frame, not a micro-level time series database. The rules that govern the administration of the Register are designed accordingly.

Chapter 4. Growth trends in ICT and science industries

The ICT and science-based economy grew rapidly during the 1990s. ICT employment increased by over 70 percent, from about 325,000 workers in 1990 to over 560,000 workers in 2000 (Table 1a). Firms in the ICT sector employed 4.1% of all paid workers in 2000, up from 2.7% in 1990 (Table 1b). Science-based employment grew at a much slower pace—10% between 1990 and 2000 (Table 1a). Moreover, the share of employment in science-based industries fell slightly over the study period (see Table 1b). Most of the growth in New Economy industries was concentrated in the ICT sector.

Table 1a. Aggregate measures of the ICT and science-based sectors in Canada

Paid Workers	1990	2000	Absolute change between periods	Percentage change between periods
ICT	324,700	560,600	235,900	72.6 %
Science-based	490,800	541,100	50,200	10.2 %
Canada	12,080,800	13,555 600	1,474,800	12.2 %

Note: Numbers may not add due to rounding.

The expansion of ICT industries during the 1990s is likely the result of the emergence of new firms, rather than the growth of existing firms. Empirical studies of the entry process have shown that the impact of new entrants on industrial structure is substantial (Baldwin, 1995). All industries, in varying degrees, exist in a continuous state of competitive reorganization in which successful entrants acquire market share from declining firms. One means of gauging differences in the importance of entry is to ask what percentage of total employment in 2000 was found in newer establishments—business operations that have come into existence after 1990. This is a broad concept of entry as it captures employment creation in brand new firms as well as business restructuring in established firms. It does, however, provide a base measure of the amount of competitive turbulence that exists in different industry climates.

Table 1b. Shares of the ICT and science-based sectors in Canada			
Paid Workers	Share 1990	Share 2000	Change in Share
ICT	2.7%	4.1%	53.8%
Science-based	4.1%	4.0%	-1.8%

For the economy as a whole, 62% of total employment in 2000 was located in newer (post-1990) establishments. Among ICT industries, the impact of newer establishments is even more apparent. Seventy-four percent of the ICT workforce in 2000 was located in establishments that came into existence after 1990. During this decade, the ICT population increased sharply from 14,500 establishments to 36,600 establishments. Entrants also play a critical role in science industries—68% of science-based employment in 2000 was found in post-1990 establishments.

In subsequent sections, we turn our attention to the geographic evolution of ICT and science-based industries.

Chapter 5. Geographic perspectives on industry evolution

A geographic analysis of New Economy industries is illuminating in light of the widely held view that innovative industries *specialize* by developing in a few select geographic areas. We begin by first asking *why* we frequently associate certain industries with particular areas. It has been shown that economic activity across industries tends to be spatially concentrated (Ellison and Glaeser, 1997). One of the most widely accepted explanations for this is the concept of agglomeration economies. Agglomeration economies include the benefits that flow from localization and urbanization.

Localization economies help to explain why plants in the same industry tend to locate in the same place. Marshall (1920) and Krugman (1991) argue that the benefits of localization are the result of external economies generated by thick local labour markets, access to specialized intermediate inputs, and technological spillovers within industries. In addition, Krugman (1991) argues that industry concentration is the result of a process of cumulative causation where minor differences between locations lead to large differences in terms of industry growth. In other words, once an industry starts in a particular place, often by accident, it will tend to accumulate in that location because the external economies associated with agglomeration increasingly reinforce the industry as it grows.

While localization economies can help explain why firms locate in a particular place, urbanization economies help explain why it may be advantageous for plants in different industries to locate in the same urban centre. Jacobs (1969) and Duranton and Puga (2001) argue that the benefits of urbanization are based on spillovers across industries when firms locate in large diversified cities. Firms in one industry can learn and borrow ideas from other industries, particularly as they develop new products and production processes. Since large urban areas tend to have diversified economies, these locations may have a comparative advantage in attracting New Economy industries.

Explanations for patterns of geographic concentration, particularly insofar as these involve clusters of highly innovative firms, have also emerged from research on networking and clustering. Oerlemans, Meeus and Boekema (2001) review the explanations for clustering, ranging from (1) static productivity advantages (e.g., spatial clusters afford firms better access to inputs and knowledge), (2) entry advantages (i.e., existing clusters make it easier to start new firms because of the availability of inputs), to (3) innovator advantages (i.e., clusters allow innovators to react more expeditiously to rapidly changing technological environments). In all these cases, geographic proximity helps facilitate the flow of resources, knowledge and communication, encouraging inter-firm cooperation in situations where cooperation is beneficial.

We should stress that it is not the aim of this analysis to formally evaluate these theoretical propositions. Our intent is simply to construct a geographic profile that can be used as a guidepost for subsequent studies, many of which can deal more formally with the theoretical underpinnings of New Economy industries. This said, the relevance of these theoretical propositions is not lost here, as these help to shape what we may expect to observe.

There are two views regarding expected geographic growth patterns in New Economy industries. The first is that the traditional benefits of agglomeration no longer hold for these industries. Labour may be far more mobile in these industries as a result of advances in transportation and telecommunications. Technological spillovers may occur over greater distances and may require less face-to-face contact. One possible characteristic of the New Economy is that physical proximity no longer matters, or matters less, due to the advent of new technologies. As a consequence, New Economy firms may no longer have to locate close to one another in order to take advantage of localization economies, nor would they have to locate in large, diverse cities where urbanization economies are most apparent.

The second view is that while there may be technological forces that work against industry concentration, these may be offset by the clustering and networking advantages that arise from developing highly localized clusters. In Feldman's (1999) review of the economic literature on where innovation occurs, the author notes the impact that science-based spillovers can have on local patterns of entrepreneurship, innovation and productivity. If this is the case, there may be very strong incentives for New Economy industries to continue to cluster together. In the next section, we investigate which perspective is more consistent with long-run employment transitions in New Economy industries.

Chapter 6. Geographic development of New Economy industries

New industries are a source of dynamism. They can infuse local economies with new sources of entrepreneurial zeal and investor optimism. Much has been made of the transformative potential of knowledge industries and new technologies. In this section, we ask whether different geographic regions—provinces, urban-rural areas and cities—are sharing in the growth of ICT and science-based industries.

6.1 Provincial ICT and science-based economies

Among the provinces, Ontario has the largest employment in ICT industries along with the highest share of employment in ICT industries (Table 2).

In 2000, one in twenty workers (5.4%) in Ontario was employed in the ICT sector. Ontario also exhibited the highest growth rate in ICT employment over the last decade (95%). The three other provinces with large employment bases—Quebec, British Columbia and Alberta—also had comparatively large ICT employment shares in 2000, driven by high rates of growth during the 1990s. Conversely, smaller provinces exhibited more modest ICT sectors.

Ontario also had the largest science-based employment base in both 1990 and 2000, despite a decline during the 1990s. In 1990, workers in science-based industries accounted for 4.6% of Ontario workers; by 2000, this science employment share had declined to 4.1%.

This decline contrasts with the growth in science-based employment in Quebec and Alberta—the second and third most important science-based employers in 2000—whose shares of science-based workers exceeded Ontario's by 2000.

Explanations of industrial development based on agglomeration effects suggest that new clusters tend to locate in areas with well-developed industrial sectors. At a very basic level, provincial growth trends in ICT industries are consistent with this view, as it is the larger provincial economies that have experienced more employment growth and business creation in these sectors. Provincial economies, however, are heterogeneous entities—the sum of a diverse range of local economic circumstances, across urban and rural regions and different urban areas. Perhaps then, it is not merely the size of provincial economies that supports the development of New Economy industries, but the fact that these new industries flourish in large urban centres. Differences between provinces may be due in part to the influence of urban agglomerations. We examine urban and rural patterns of ICT and science-based growth below.

Table 2. Provincial employment aggregates for ICT and science-based sectors in Canada

Province/Territory**	ICT paid workers 1990*		ICT paid workers 2000*		Change
Ontario	150,300	(3.1)	293,000	(5.4)	95.0%
Quebec	72,500	(2.5)	114,000	(4.0)	57.4%
British Columbia	35,100	(2.4)	63,700	(3.5)	81.1%
Alberta	28,100	(2.4)	46,100	(2.9)	64.0%
Manitoba	12,200	(2.8)	12,900	(2.5)	6.2%
Saskatchewan	10,100	(2.8)	9,200	(2.3)	-8.9%
Nova Scotia	8,300	(2.6)	10,100	(2.7)	22.2%
New Brunswick	4,200	(1.6)	6,700	(2.2)	58.1%
Newfoundland	2,700	(1.8)	3,400	(1.7)	25.9%
Prince Edward Island	600	(1.0)	900	(1.4)	57.1%
Territories	700	(2.0)	600	(1.2)	-13.1%
Canada	*324,700*	*(2.7)*	*560,600*	*(4.1)*	*72.6%*

Province/Territory**	Science-based paid workers 1990*		Science-based paid workers 2000*		Change
Ontario	227,200	(4.6)	218,300	(4.1)	-3.9%
Quebec	118,400	(4.1)	133,200	(4.7)	12.5%
British Columbia	49,000	(3.3)	55,600	(3.0)	13.5%
Alberta	49,400	(4.1)	79,700	(5.0)	61.3%
Manitoba	16,900	(3.9)	17,900	(3.4)	5.9%
Saskatchewan	8,800	(2.4)	13,300	(3.3)	51.1%
Nova Scotia	7,400	(2.3)	8,700	(2.3)	17.6%
New Brunswick	6,600	(2.5)	7,100	(2.4)	7.6%
Newfoundland	5,200	(3.5)	4,700	(2.4)	-9.6%
Prince Edward Island	1,000	(1.7)	1,400	(2.1)	40.0%
Territories	900	(2.4)	1,200	(2.2)	33.3%
Canada	*490,800*	*(4.1)*	*541,100*	*(4.0)*	*10.2%*

Province/Territory**	Total paid workers 1990	Total paid workers 2000	Change
Ontario	4,918,000	5,378,600	9.4%
Quebec	2,887,300	2,854,400	-1.1%
British Columbia	1,462,500	1,826,400	24.9%
Alberta	1,192,400	1,583,500	32.8%
Manitoba	428,800	521,200	21.5%
Saskatchewan	363,800	400,000	10.0%
Nova Scotia	323,700	377,900	16.7%
New Brunswick	258,500	301,000	16.5%
Newfoundland	151,500	194,400	28.4%
Prince Edward Island	58,500	66,300	13.3%
Territories	35,800	51,900	44.8%
Canada	*12,080,800*	*13,555,600*	*12.2%*

* Brackets indicate percentage share of total paid workers in province.

** Sorted by total paid workers in 2000. The individual territories have been combined due to data limitations.

Note: Numbers may not add due to rounding.

Table 3. Urban/Rural groups	
Urban/Rural group	**Definition**
CMA-large	Census Metropolitan Area (CMA) with population greater than 1,000,000. (e.g. Toronto)
CMA-medium	Census Metropolitan Area (CMA) with population of 500,000 to 999,999. (e.g. Calgary)
CMA-small	Census Metropolitan Area (CMA) with population of 100,000 to 499,999. (e.g. Victoria)
CA-large	Census Area (CA) with population of 50,000 to 99,999. (e.g. Charlottetown)
CA-small	Census Area (CA) with population of 10,000 to 49,999. (e.g.Yellowknife)
*Strong MIZ**	Census Subdivision (CSD) with a commuting flow of 30% or more (at least 30% of the total employed labour force living in CSD work in any CMA/(CA) urban core).
Moderate MIZ	Census Subdivision (CSD) with a commuting flow of 5% to 30%.
Weak MIZ	Census Subdivision (CSD) with commuting flow of 0% to 5%.
No MIZ	Census Subdivision (CSD) with no communters or population less than 40 people.

* Metropolitan influence zone.

6.2 Urban and rural ICT and science-based economies

We first classify large urban centres into five size groups based on their population characteristics (see descriptions in Table 3). Smaller centres (e.g., towns and rural communities) are grouped into four different categories based on the percentage of workers in these locations that commute to urban areas.[9] Accordingly, the taxonomy captures the economic influence of large urban areas on small and rural communities.

New Economy industries are a disproportionately urban phenomenon. The largest urban centres (populations of 1,000,000 or more) had the highest employment shares in ICT and science industries, both in 1990 and in 2000 (Table 4).

The growth of ICT industries in the largest urban centres has been comparatively rapid. In 1990, ICT-based employment in these cities amounted to 3.8% of their total labour force; by 2000, this increased to 6.6%. Science-based industries did not undergo a similar expansion in the largest urban centres, as their share of the local employment base fell from 5.1% to 4.9%. The size of urban areas has some bearing on the development of local ICT sectors, as both employment shares and growth rates tend to decline across progressively smaller urban areas. A different pattern emerges for science-based industries. Science-based employment is far more common than ICT employment in many rural categories (in both reference periods), and many smaller locations exhibited modest science-based growth in the 1990s.

The pattern of employment growth in ICT industries is consistent with the agglomeration thesis: innovative industries acquire significant benefits from locating and growing in large, developed areas. For science-based industries, employment gains have been more equitably distributed across the urban/rural spectrum, suggesting agglomeration economies are not as important.

[9] For discussion, see Rambeau and Todd (2000) and McNiven, Puderer and Janes (2000).

Table 4. Urban/Rural employment aggregates for ICT and science-based sectors in Canada

Urban/Rural group	ICT paid workers 1990*		ICT paid workers 2000*		Change
CMA-large	206,000	(3.8)	387,500	(6.6)	88.1%
CMA-medium	47,800	(3.0)	81,000	(3.8)	69.4%
CMA-small	36,500	(2.4)	49,900	(2.8)	36.7%
Total CMA	290,300	(3.4)	518,400	(5.3)	78.6%
CA-large	16,700	(1.6)	19,600	(1.8)	17.0%
CA-small	10,100	(1.4)	11,700	(1.4)	15.5%
Total CMA/CA	317,100	(3.1)	549,600	(4.7)	73.3%
Strong MIZ	3,500	(1.2)	3,600	(1.0)	1.2%
Moderate MIZ	1,600	(0.2)	3,700	(0.6)	130.6%
Weak MIZ	2,400	(0.4)	3,500	(0.4)	46.4%
No MIZ	100	(0.2)	200	(0.2)	70.2%
Total Non-CMA/CA	***7,600***	***(0.4)***	***11,000***	***(0.6)***	***43.9%***
Total Canada	324,700	(2.7)	560,600	(4.1)	72.6%

Urban/Rural group	Science-based paid workers 1990*		Science-based paid workers 2000*		Change
CMA-large	272,800	(5.1)	284,800	(4.9)	4.4%
CMA-medium	72,300	(4.5)	100,300	(4.8)	38.7%
CMA-small	51,600	(3.4)	57,000	(3.2)	10.5%
Total CMA	396,800	(4.6)	442,100	(4.5)	11.4%
CA-large	44,500	(4.3)	40,300	(3.6)	-9.4%
CA-small	19,000	(2.6)	17,800	(2.1)	-6.3%
Total CMA/CA	460,200	(4.5)	500,400	(4.3)	8.7%
Strong MIZ	8,300	(2.8)	12,000	(3.4)	44.6%
Moderate MIZ	12,200	(1.7)	13,700	(2.2)	12.3%
Weak MIZ	9,600	(1.5)	13,200	(1.7)	37.5%
No MIZ	500	(0.6)	1,800	(2.0)	260.0%
Total Non-CMA/CA	***30,600***	***(1.7)***	***40,700***	***(2.2)***	***33.0%***
Total Canada	490,800	(4.1)	541,100	(4.0)	10.2%

Urban/Rural group	Total paid workers 1990	Total paid workers 2000	Change
CMA-large	5,396,600	5,836,600	8.2%
CMA-medium	1,614,000	2,110,800	30.8%
CMA-small	1,528,300	1,805,000	18.1%
Total CMA	8,538,900	9,752,400	14.2%
CA-large	1,034,600	1,109,600	7.3%
CA-small	729,000	831,000	14.0%
Total CMA/CA	10,302,400	11,693,100	13.5%
Strong MIZ	298,000	352,800	18.4%
Moderate MIZ	739,700	633,600	-14.3%
Weak MIZ	663,300	787,900	18.8%
No MIZ	77,300	88,200	14.1%
Total Non-CMA/CA	***1,778,300***	***1,862,500***	***4.7%***
Total Canada	12,080,800	13,555,600	12.2%

* Brackets denote percentage share of total Paid Workers within group.
Note: Numbers may not add due to rounding.

We can quantify growth trends in urban/rural areas using location quotients. A measure of the intensity of industry formation in a particular location, the location quotient is defined as

(1) $$lq_{ir} = \frac{e_{ir}}{\sum_i e_{ir}} \Big/ \frac{E_i}{\sum_i E_i}$$

where e_{ir} is the employment in industry *i* in location *r*, $\sum_i e_{ir}$ is total employment, summed across all industries in location *r*, E_i is total (i.e., national) employment in industry *i*, and $\sum_i E_i$ is total (national) employment in all industries.

A location quotient can be interpreted as follows. If the location quotient for location *r* is *greater than 1*, then employment in industry *i* is *over-represented* in region *r* relative to the national share. Conversely, if the location quotient for region *r* is *less than 1*, then employment in sector *i* is *under-represented* in that region. For this exercise, we treat each category in the urban/rural hierarchy as a separate geographic region. Location quotients are plotted in Figures 1a and 1b.

Figure 1a. Urban/Rural group location quotients for ICT employment

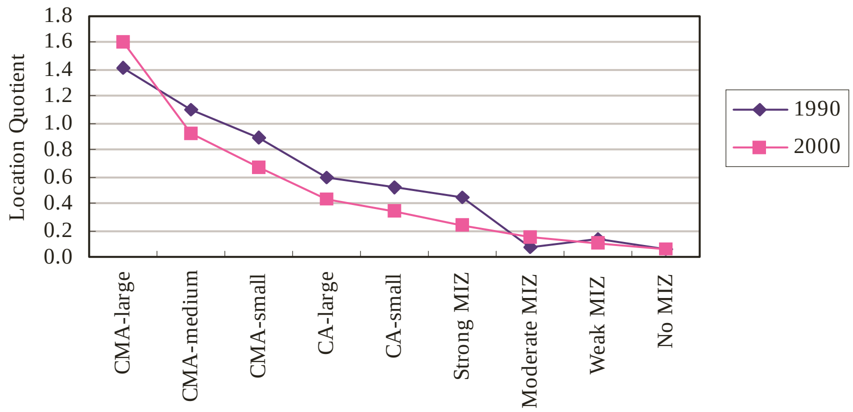
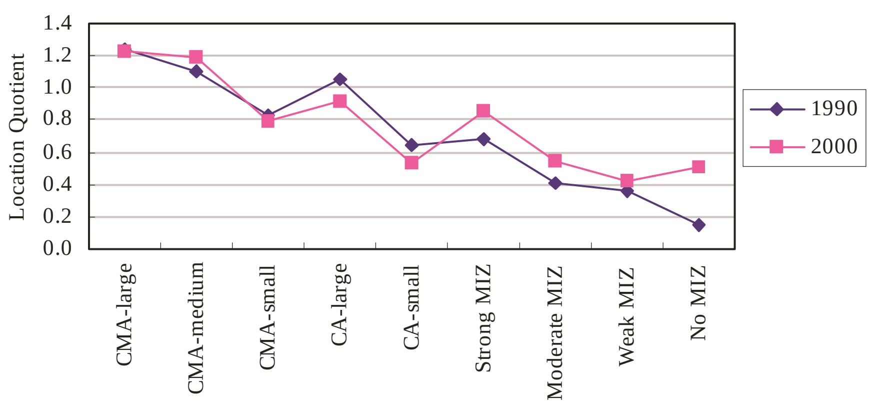


Figure 1b. Urban/Rural group location quotients for science-based employment



Location quotients in both ICT and science-based industries decline in the transition from urban to rural locations. Relative to the national average, ICT and science-based employment is over-represented in the largest urban centres. This is particularly true of ICT industries, which obtained a higher location quotient in the largest cities in 2000 than in 1990 (see Figures 1a and 1b). This again supports the view that ICT industries derive benefits from locating in well-developed urban areas. Over the 1990s, ICT employment in smaller urban and rural locations has become less representative of national trends.

6.3 Growth of local ICT and science-based clusters

Sections 6.1 and 6.2 illustrated that ICT and science-based industries have a stronger foothold in larger provinces and urban areas. In what follows, we provide a more explicit accounting of ICT and science-based growth at the local level. Tables 5a and 5b rank 25 major metropolitan areas by their total employment in ICT and science-based industries. We also report their relative ranking in 1990, along with the magnitude of the employment change in these industries between our two observation years.

We focus initially on total employment in ICT and science-based industries in order to better understand how the size of these sectors compares across cities. By 2000, Toronto's ICT sector had grown to roughly 195,000 workers, a local ICT workforce over twice as large as Montreal's, and roughly four times the size of Ottawa's. The number of workers employed in ICT industries increased for most cities over the 1990s, the major exceptions being Oshawa and Regina. ICT employment growth, however, is far from uniform. Hamilton had over five times as many ICT workers in 2000 than in 1990, growing from the 13^{th} largest local ICT economy to the 7^{th} largest. Calgary witnessed over a 200% increase in its ICT base, moving from the 7^{th} largest ICT sector to the 5^{th} largest. Toronto, home to the largest ICT workforce in both periods, enjoyed very rapid growth in this sector.

Among the larger cities with substantial science-based workforces, Calgary, Edmonton and Montreal enjoyed the highest employment growth (in absolute and percentage terms) over the decade. Patterns of local ICT and science-based development can give rise to divergent impressions about how different locations are gaining a foothold in New Economy sectors. Calgary and Ottawa-Hull exhibited very similar employment gains in the ICT sector; however, in science industries, Calgary's employment grew while Ottawa-Hull's fell.

We next examine the importance of ICT and science-based employment to these local communities. Tables 6a and 6b rank the 25 Canadian CMA cities by their employment shares in both the ICT and science-based sectors in 2000, and examine whether these industries are becoming a more, or less, significant part of the local industry mix.

In the main, cities with high levels of employment in ICT and science-based industries are also those in which these sectors represent more significant portions of the local economy. Canada's largest cities, Toronto and Montreal, both increased their share of ICT employment during the 1990s. Toronto moved from 8^{th} to 2^{nd} in terms of its ICT intensity; Montreal improved from 10^{th} to 5^{th}.

Relationships between absolute size and local intensity, however, are not completely congruous. In 2000, Vancouver ranked third and fourth in terms of the absolute size of its ICT and science-based sectors, but dropped to 7th and 10th after controlling for the size of its local economy.

Which cities are making the greatest transitions towards ICT and science-based workforces? By 2000, Ottawa-Hull emerged as the New Economy leader in terms of its local representation of ICT industries (9.1% of paid workers). Hamilton has made substantial strides over the last decade in developing its ICT workforce. ICT employment in Hamilton increased from approximately 2,500 workers in 1990 (representing a 1.1% share of local employment) to 16,000 a decade later (a share of 5.9%). Calgary had the largest concentration of workers in science industries in both reference periods (7.3% of employment in 1990 and 7.7% of employment in 2000). Montreal also made significant gains in science industries during the decade—improving its science share from 4th in 1990 to 2nd in 2000.

Table 5a. CMA cities ranked by total paid workers in ICT sector in 2000

City (rank 1990)	ICT sector paid workers 1990	2000	Absolute change	Percentage change
1. Toronto (1)	85,600	194,800	109,200	127%
2. Montreal (2)	54,300	89,500	35,300	65%
3. Vancouver (4)	31,000	54,000	23,000	74%
4. Ottawa-Hull (3)	35,000	49,100	14,100	40%
5. Calgary (7)	7,600	24,800	17,200	226%
6. Edmonton (5)	19,100	18,400	-700	-4%
7. Hamilton (13)	2,500	16,200	13,700	551%
8. Winnipeg (6)	11,900	12,500	600	5%
9. Kitchener (11)	3,300	9,200	5,800	175%
10. Quebec (9)	6,700	9,100	2,300	34%
11. Halifax (9)	6,700	8,500	1,700	26%
12. Regina (8)	7,100	6,000	-1,200	-17%
13. Victoria (17)	2,200	5,000	2,800	125%
14. London (13)	2,500	4,200	1,700	66%
15. Saint John (11)	3,300	3,200	-100	-2%
16. St. John's (16)	2,400	3,000	600	24%
17. Saskatoon (13)	2,500	2,500	100	4%
18. Windsor (20)	800	1,500	700	86%
18. Oshawa (18)	1,900	1,500	-400	-22%
20. Sherbrooke (19)	1,100	1,400	300	26%
21. St. Catharines-Niagara (23)	500	1,200	700	141%
22. Trois-Rivières (24)	400	800	400	105%
23. Sudbury (24)	400	700	400	109%
23. Chicoutimi-Jonquière (21)	700	700	0	-6%
25. Thunder Bay (22)	600	500	-100	-12%
Total CMA	***290,300***	***518,400***	***228,100***	***79%***
Total Canada	324,700	560,600	235,900	73%

Table 5b. CMA cities ranked by total paid workers in science-based sector in 2000

City (rank 1990)	Science-based sector paid workers 1990	2000	Absolute change	Percentage change
1. Toronto (1)	124,600	123,800	-800	-1%
2. Montreal (2)	90,500	102,700	12,200	13%
3. Calgary (4)	27,500	45,500	18,000	65%
4. Vancouver (3)	39,500	41,500	2,000	5%
5. Edmonton (6)	16,900	23,100	6,200	37%
6. Ottawa-Hull (5)	18,300	16,900	-1,400	-8%
7. Winnipeg (7)	14,500	15,100	600	4%
8. Kitchener (8)	10,200	10,700	500	5%
9. Hamilton (9)	8,400	9,500	1,100	13%
10. Quebec (12)	5,000	7,100	2,100	42%
11. Halifax (10)	5,400	6,300	900	17%
12. Windsor (16)	4,000	5,700	1,700	43%
13. Regina (15)	4,400	4,900	500	11%
14. Saskatoon (17)	2,500	4,400	1,900	76%
14. St. Catharines-Niagara (10)	5,400	4,400	-1,000	-19%
16. London (13)	4,900	4,100	-800	-16%
17. St. John's (14)	4,600	3,300	-1,300	-28%
18. Victoria (19)	1,600	2,600	1,000	63%
19. Chicoutimi-Jonquière (21)	1,300	2,400	1,100	85%
20. Sherbrooke (18)	2,200	2,000	-200	-9%
21. Oshawa (19)	1,600	1,500	-100	-6%
21. Trois-Rivières (22)	1,200	1,500	300	25%
23. Saint John (23)	900	1,100	200	22%
23. Sudbury (25)	700	1,100	400	57%
25. Thunder Bay (23)	900	900	0	0%
Total CMA	***396,800***	***442,100***	***45,300***	***11%***
Total Canada	490,800	541,100	50,300	10%

Note: Numbers may not add due to rounding.

Table 6a. CMA cities ranked by paid worker shares in ICT sector in 2000

City (rank 1990)	ICT sector paid worker shares 1990 (share)	2000 (share)	Change in share
1. Ottawa-Hull (3)	35,000 (5.7)	49,100 (9.1)	61%
2. Toronto (8)	85,600 (3.6)	194,800 (7.3)	102%
3. Saint John (1)	3,300 (7.6)	3,200 (5.9)	-22%
3. Hamilton (21)	2,500 (1.1)	16,200 (5.9)	447%
5. Montreal (10)	54,300 (3.4)	89,500 (5.7)	69%
6. Regina (2)	7,100 (6.5)	6,000 (5.3)	-19%
7. Vancouver (6)	31,000 (3.9)	54,000 (5.1)	30%
8. Kitchener (15)	3,300 (1.9)	9,200 (4.5)	133%
8. Halifax (5)	6,700 (4.5)	8,500 (4.5)	0%
10. Calgary (14)	7,600 (2.0)	24,800 (4.2)	109%
11. Edmonton (4)	19,100 (4.6)	18,400 (3.3)	-28%
11. Winnipeg (7)	11,900 (3.7)	12,500 (3.3)	-12%
13. St. John’s (9)	2,400 (3.5)	3,000 (3.1)	-12%
13. Victoria (15)	2,200 (1.9)	5,000 (3.1)	64%
15. Quebec (12)	6,700 (2.5)	9,100 (2.9)	17%
16. Sherbrooke (15)	1,100 (1.9)	1,400 (2.4)	27%
17. Saskatoon (11)	2,500 (2.6)	2,500 (2.3)	-9%
18. London (18)	2,500 (1.5)	4,200 (2.1)	43%
19. Trois-Rivières (22)	400 (0.9)	800 (1.7)	92%
20. Oshawa (13)	1,900 (2.1)	1,500 (1.4)	-31%
21. Chicoutimi-Jonquière (19)	700 (1.4)	700 (1.3)	-12%
22. Sudbury (24)	400 (0.6)	700 (1.2)	92%
23. Thunder Bay (20)	600 (1.2)	500 (1.0)	-18%
23. Windsor (23)	800 (0.7)	1,500 (1.0)	49%
25. St. Catharines-Niagara (25)	500 (0.4)	1,200 (0.8)	104%
Total CMA	***290,300 (3.4)***	***518,400 (5.3)***	***56%***
Total Canada	324,700 (2.7)	560,600 (4.1)	54%

Table 6b. CMA cities ranked by paid worker shares in science-based sector in 2000

City (rank 1990)	Science-based sector paid worker shares 1990 (share)	2000 (share)	Change in share
1. Calgary (1)	27,500 (7.3)	45,500 (7.7)	6%
2. Montreal (4)	90,500 (5.6)	102,700 (6.5)	16%
3. Kitchener (3)	10,200 (5.9)	10,700 (5.3)	-11%
4. Toronto (5)	124,600 (5.2)	123,800 (4.6)	-12%
4. Chicoutimi-Jonquière (19)	1,300 (2.5)	2,400 (4.6)	82%
6. Regina (10)	4,400 (4.0)	4,900 (4.4)	10%
7. Edmonton (8)	16,900 (4.1)	23,100 (4.2)	2%
8. Saskatoon (17)	2,500 (2.6)	4,400 (4.0)	53%
8. Winnipeg (7)	14,500 (4.6)	15,100 (4.0)	-13%
10. Vancouver (6)	39,500 (5.0)	41,500 (3.9)	-21%
10. Windsor (14)	4,000 (3.4)	5,700 (3.9)	16%
12. Hamilton (12)	8,400 (3.6)	9,500 (3.4)	-6%
12. Sherbrooke (11)	2,200 (3.8)	2,000 (3.4)	-11%
14. Halifax (13)	5,400 (3.5)	6,300 (3.3)	-5%
14. St. John’s (2)	4,600 (6.5)	3,300 (3.3)	-50%
16. Ottawa-Hull (15)	18,300 (3.0)	16,900 (3.1)	6%
17. Trois-Rivières (17)	1,200 (2.6)	1,500 (3.0)	16%
18. St. Catharines-Niagara (8)	5,400 (4.1)	4,400 (2.8)	-31%
19. Quebec (21)	5,000 (1.8)	7,100 (2.3)	24%
20. London (16)	4,900 (2.9)	4,100 (2.1)	-27%
21. Saint John (20)	900 (2.0)	1,100 (1.9)	-7%
22. Sudbury (24)	700 (1.3)	1,100 (1.8)	36%
22. Thunder Bay (21)	900 (1.8)	900 (1.8)	0%
24. Victoria (24)	1,600 (1.3)	2,600 (1.6)	24%
24. Oshawa (21)	1,600 (1.8)	1,500 (1.6)	-15%
Total CMA	***396,800 (4.6)***	***442,100 (4.5)***	***-2%***
Total Canada	490,800 (4.1)	541,100 (4.0)	-2%

Note: Numbers may not add due to rounding.

Chapter 7. Exploring factors behind local ICT intensity

Much of the employment growth in ICT industries has been concentrated in large, diversified cities. By 2000, the four metropolitan areas with the largest contingents of ICT workers—Toronto, Montreal, Vancouver and Ottawa-Hull—accounted for 69% of total employment in information technology industries, up from 63% in 1990. We observed earlier that the intensity of local ICT employment (i.e., the ICT workforce expressed as a percentage of the local employment base) varies systematically with community size. The largest urban centres enjoy ICT employment shares that exceed the national average, while smaller cities and rural areas lag behind the national average, the degree of under-representation increasing as one moves progressively down the urban/rural continuum. The gulf between urban and rural ICT employment has widened over the course of the decade—by 2000, larger cities had improved their position relative to the national average, while those in smaller communities had lost ground.

In this section, we use regression techniques to examine possible explanations for observed differences in ICT intensity across urban locations. We focus exclusively on the ICT sector, because many business analysts view ICT industries as the vanguard of the New Economy. Following the research on urbanization and industry formation, we investigate whether differences in local ICT intensity are associated with the size of the local employment base or, more narrowly, with the level of industrial diversification that exists within an urban area.[10] Related dimensions of urbanization, both the size of the labour pool and the amount of industrial diversification are posited to be catalysts for the development of the ICT sector.

We also include a variable in our regression analysis that examines whether patterns of local ICT intensity move in parallel with employment trends in other science industries—industries that exhibit a strong commitment to scientific knowledge, but that are not included in the ICT sector. Within local economies, ICT and science-based industries may develop in tandem if production technologies and labour skills are highly transferable between New Economy sectors.

We divide our regression exercise into two parts. First, we examine differences in the level of ICT intensity in each of the two periods, t = 1990 and 2000. Our estimation equation takes the form:

[10] Industrial diversification, as measured by the number of different industries operating within a city, varies directly with the size of the paid worker population (Table 7).

Table 7. Diversification of CMA cities: Number of industries

City*	Total industries 2000		
	All**	S-B	ICT
Montreal	819	37	19
Toronto	809	37	19
Vancouver	790	35	19
Calgary	753	37	19
Edmonton	743	36	19
Winnipeg	738	35	19
Quebec	700	32	18
Ottawa-Hull	697	29	19
Hamilton	692	32	19
Halifax	645	29	18
Kitchener	643	30	18
London	636	28	16
St. Catharines-Niagara	623	25	16
Victoria	603	19	14
Saskatoon	601	27	16
St. John's	579	19	13
Windsor	569	23	13
Regina	567	23	15
Chicoutimi-Jonquière	534	22	14
Oshawa	533	18	17
Sherbrooke	533	20	16
Trois-Rivières	530	20	12
Saint John	496	18	15
Thunder Bay	479	18	12
Sudbury	463	16	13

* Ranked by total number of industries (All).
** All is out of 860 4-digit SICs, science-based has 56 industries and ICT has 19.

(2) $$INT_i^t = \alpha^t + \beta_1^t EMP_i^t + \beta_2^t DIV_i^t + \beta_3^t SCI_i^t + u_i^t$$

where INT_i^t is the share of local workforce employed in ICT industries, EMP_i^t is total employment (a measure of size), DIV_i^t is the number of industries (a measure of industrial development), and SCI_i^t is the share of workers employed in non-ICT science industries (a measure of complementarity). The sample is all 137 Canadian urban areas *i* with 10,000 or more residents—that is, all 25 Census Metropolitan Areas (CMAs) and all 112 Census Agglomerations (CAs).

Our second regression exercise focuses on the growth of local ICT coverage between 1990 and 2000. We can express equation (2) in each time period as

(3a) $$INT_i^{90} = \alpha^{90} + \beta_1^{90} EMP_i^{90} + \beta_2^{90} DIV_i^{90} + \beta_3^{90} SCI_i^{90} + u_i^{90}$$

(3b) $$INT_i^{00} = \alpha^{00} + (\beta_1^{90} + \delta_1) EMP_i^{00} + (\beta_2^{90} + \delta_2) DIV_i^{00} + (\beta_3^{90} + \delta_3) SCI_i^{00} + u_i^{00}$$

where the coefficients on the explanatory variables in year 2000 (equation 3b) capture the joint effect of the 1990 coefficient, β^{90}, and the change in the coefficient over the period δ. Taking the first-difference of equations (3a) and (3b) we have

(4) $$\Delta INT_i = \Delta\alpha + \beta_1^{90}\Delta EMP_i + \delta_1 EMP_i^{00} + \beta_2^{90}\Delta DIV_i + \delta_1 DIV_i^{00} + \beta_3^{90}\Delta SCI_i + \delta_3 SCI_i^{00} + \Delta u_i$$

This equation can be used to examine whether the growth in local ICT coverage over the two periods (measured as the difference in the local ICT employment share) is linked to changes in the size of the local employment base and industry mix and to employment growth in other science industries.

7.1 ICT intensity in 1990 and 2000

Results for equation (2), which evaluates differences in ICT coverage in 1990 and 2000 separately, are reported in Table 8.

In 1990, only the number of industries, our proxy for industrial diversification, has any significant impact on local ICT intensity. Cities with more diversified industrial landscapes tend to exhibit higher ICT employment shares. The size of the local economy, captured separately via differences in the local employment base, is not related to ICT intensity. Nor is there any evidence that ICT shares are correlated with employment shares in other, non-ICT science industries. In 2000, both proxies for urbanization (*EMP* and *DIV*) are positively associated with variation in ICT intensity. Once again, no evidence of employment symmetries between ICT and science-based industries is apparent.[11]

Table 8. Local ICT intensity (equation 2): 1990 and 2000

	Share of ICT workers in local economy (1990)	Share of ICT workers in local economy (2000)
Intercept	-7.52E-04	-1.78E-03
	(0.88)	(0.67)
Total employment	-2.90E-09	1.50E-08
	(0.75)	(0.01)
Number of industries	4.79E-05	4.54E-05
	(0.001)	(0.001)
Share of workers in other	1.81E-03	4.57E-02
(non-ICT) science industries	(0.97)	(0.49)
R^2 (adj)	0.10	0.29

P=values in parentheses.

[11] We have estimated equation 2 via least squares. There are two possible limitations to this approach. First, local ICT employment shares are bounded by 0 and 1 which can bias the estimated coefficients. We can evaluate whether these bounds on the dependent variable affect our regression results by estimating a logistic version of equation 2 which forces the predicted values to fall within the (0,1) interval. Results from the logistic model were qualitatively identical to those presented above. A second difficulty with equation 2 is that the value of the ICT employment share, the LHS variable, is partially determined by the local employment base, a RHS proxy for urbanization. This raises the spectre of spurious correlation. An investigation of this issue did not yield any strong evidence that spurious correlation was conditioning our results.

Table 9. Changes in ICT intensity (equation 4)	
	Differences in local ICT employment coverage (2000 - 1990)
Intercept	-3.51E-05
	(0.99)
Change in total employment (2000 - 1990)	-3.47E-08
	(0.40)
Employment (2000)	1.97E-08
	(0.01)
Change in industry mix (2000 - 1990)	2.35E-05
	(0.70)
Number of industries (2000)	6.31E-06
	(0.53)
Change in employment intensity in non-ICT science industries (2000 -1990)	-5.73E-02 (0.24)
Percentage of workers in other (non-ICT) science industries (2000)	-9.38E-02 (0.13)
R^2 (adj)	0.08

P=values in parentheses.

7.2 Growth in ICT intensity during the 1990s

We formally examine changes in local ICT coverage over the ten-year period via the first differences model outlined in equation 4 (Table 9).

The first differences model does not yield strong results. Only the coefficient on total employment (2000) is significantly related to changes in ICT intensity. From equation 4, this parameter effectively captures the (significant) change in the employment coefficient over the two time periods, apparent from the cross-sectional regressions reported in Table 8. While ICT employment shares in both 1990 and 2000 are related to the amount of industrial diversification within a local economy, changes in ICT intensity over the decade are not correlated with the expansion (or contraction) of the local industry base. It is possible that the correlation between ICT intensity and industrial diversification observed in each period is due to the presence of an omitted fixed effect that is correlated with industrial diversification, the influence of which is negated when moving to the first differences growth model.

Our multivariate analysis suggests that agglomeration economies play an increasingly important role in the formation of ICT industries. The information technology sector is an increasingly urban phenomenon. Cities with large employment bases and diversified industrial structures have a more intensive stake in the ICT economy. Patterns of local diversification appear to be associated with differences in ICT intensity in both 1990 and 2000. During the 1990s, there is evidence that community size, not changes in the industry mix, is the main factor driving ICT growth.[12]

[12] Our conclusion that agglomeration economies support the development of ICT industries extends beyond the largest urban areas—areas which house a considerable share of total ICT employment. To confirm a general relationship between ICT intensity and urbanization, we removed the three largest metropolitan areas from our data—Toronto, Montreal and Vancouver—and re-estimated equations 2 and 4. The results for this restricted sample are qualitatively identical to those reported above.

These multivariate exercises help corroborate the positive correlation between ICT intensity and urbanization apparent in our bivariate tabulations. They also provide us with a starting point from which to extend our explanatory framework in subsequent analyses. To develop a satisfactory explanation of local patterns of ICT intensity and ICT growth, more work is required. Much of this involves obtaining a more comprehensive set of covariates to control for differences in urban dynamics. In particular, better measures of localization are needed, variables that reflect the idiosyncratic characteristics of different cities. The proximity of research or technical universities is one factor that has been posited to influence the location decisions of science and technology-based firms. Basic differences in local labour quality and access to start-up funding are other factors that may explain the formation of technology sectors.

Chapter 8. Conclusion

This paper provides a first look at the geography of the New Economy across the national landscape. We concentrate on employment trends in two industrial sectors (1) a collection of ICT-producing industries, and (2) a broader collection of science-based industries. Both are linked to the development of the New Economy. Firms in ICT industries develop and support innovations that provide the technological foundations for the New Economy. Firms in the science sector make substantial contributions to knowledge creation by investing heavily in R&D and human capital.

In many cases, growth in local New Economy industries has been driven by employment creation in the ICT sector. Montreal and Toronto are cases in point. Montreal gained approximately 47,500 workers in New Economy industries between 1990 and 2000. Of those workers, 35,000 were located in ICT industries. In Toronto, the centrality of ICT industries is even more extreme. The size of Toronto's ICT sector more than doubled over the course of the 1990s, while employment in non-ICT science industries declined. Calgary presents a slightly different view. One-half of that city's employment gains in New Economy sectors occurred in non-ICT science industries.

Which cities are gaining a foothold in the New Economy? Ottawa-Hull and Hamilton have both made considerable inroads in shifting their local employment base towards ICT industries. But Toronto and Montreal are the New Economy bellwethers—first, because of the sheer numbers of ICT and science-workers in these cities, and second, because both enjoyed strong growth in their local ICT economies. Our results provide some preliminary evidence that urbanization economies support the development of local ICT industries. Both the size of the local employment base and the amount of industrial diversification in the local economy appear to play a role in conditioning differences in ICT coverage across urban areas. Information technology industries are becoming an increasingly urban phenomenon.

Our results also highlight basic differences in the geography of ICT- and science-based employment growth. While science-based industries also concentrate in urban areas, they have less of a tendency to do so than ICT industries. Both ICT and science-based industries make heavy use of urban knowledge workers. But ICT industries are newer; science-based industries are more mature. This suggests that it is newness, and not simply a requirement for knowledge workers, that has helped to fuel the urbanization of the ICT sector.

Appendix A: ICT industries

ICT manufacturing

SIC code	Description
3341	Record Player, Radio and Television Receiver Industry
3351	Telecommunication Equipment Industry
3352	Electronic Parts and Components Industry
3359	Other Communication and Electronic Equipment Industry
3361	Electronic Computing and Peripheral Equipment Industry
3362	Electronic Office, Store and Business Machine Industry
3369	Other Office, Store and Business Machine Industry
3381	Communications and Energy Wire and Cable Industry
3911	Indicating, Recording and Controlling Instruments Industry
3912	Other Instruments and Related Products Industry

ICT services

SIC code	Description
4814	Cable Television Industry
4821	Telecommunication Carriers Industry
4839	Other Telecommunication Industries
5743	Electronic Machinery, Equipment and Supplies, wholesale
5744	Computer and Related Machinery, Equipment and Software, wholesale
5791	Office and Store Machinery, Equipment and Supplies, wholesale
7721	Computer Services
7722	Computer Equipment Maintenance and Repair Industry
9913	Office Furniture and Machinery Rental and Leasing Industry

Appendix B: Science-based industries (not classified as ICT-based)

Science-based goods

SIC code	Description
0231	Agricultural Management and Consulting Services
0239	Other Services Incidental to Agriculture n.e.c.
3111	Agricultural Implement Industry
3121	Commercial Refrigeration and Air Conditioning Equipment Industry
3191	Compressor, Pump and Industrial Fan Industry
3192	Construction and Mining Machinery and Materials Handling Equipment Industry
3193	Sawmill and Woodworking Machinery Industry
3194	Turbine and Mechanical Power Transmission Equipment Industry
3199	Other Machinery and Equipment Industries, n.e.c.
3211	Aircraft and Aircraft Parts Industry
3371	Electrical Transformer Industry
3372	Electrical Switchgear and Protective Equipment Industry
3379	Other Electrical and Industrial Equipment Industries
3611	Refined Petroleum Products Industry (except lubricating oil and grease)
3612	Lubricating Oil and Grease Industry
3699	Other Petroleum and Coal Products Industries
3711	Industrial Inorganic Chemical Industries n.e.c.
3712	Industrial Organic Chemical Industries n.e.c.
3721	Chemical Fertilizer and Fertilizer Materials Industry
3722	Mixed Fertilizer Industry
3729	Other Agricultural Chemical Industries
3731	Plastic and Synthetic Resin Industry
3741	Pharmaceutical and Medicine Industry
3791	Printing Ink Industry
3792	Adhesives Industry
3799	Other Chemical Products Industries n.e.c.
3913	Clock and Watch Industry
3914	Ophthalmic Goods Industry
4911	Electric Power Systems Industry

Science-based services

SIC code	Description
4611	Natural Gas Pipeline Transport Industry
4612	Crude Oil Pipeline Transport Industry
4619	Other Pipeline Transport Industries
7751	Offices of Architects
7752	Offices of Engineers
7759	Other Scientific and Technical Services
9611	Motion Picture and Video Production
9619	Other Motion Picture, Audio and Video Services

Appendix C: Examining ICT growth from different data sources

Our geographic analysis of ICT and science-based industries is based on Statistics Canada's Business Register (BR)—a comprehensive database of all Canadian businesses with paid employees. The BR is the centralized survey frame that supports the Agency's business survey program.

In this analysis, we have profiled growth trends in ICT and science-based industries across different urban areas using two "data snapshots" from the BR—the first corresponding to the 1990 BR and the second taken from the 2000 BR. We have used the BR for our geographic profile because it allows us to evaluate changes in ICT and science-based industries between 1990 and 2000 using a consistent geographic definition of different urban areas in each of the two time periods. This consistent urban geography is based on Statistics Canada's 1996 Standard Geographical Classification. Accordingly, then, our view of Edmonton, Sherbrooke or Halifax is the same in both 1990 and 2000—each corresponds to physical portrait of these cities taken in 1996. We have chosen "to hold geography constant" because this allows us to study the dynamics of ICT and science-based employment within well-defined urban areas, without having to worry that changes in urban boundaries (e.g., municipal annexations and amalgamations) are affecting our results. We also chose the BR because it provides more accurate and more detailed industry classifications than other large-scale employment databases.

While the coverage afforded by the BR is advantageous, we should stress that the BR, like all databases, is not without its limitations. These limitations warrant formal discussion here because our growth comparisons can create strong impressions about the degree to which different communities are gaining a foothold—or losing ground—in what many view as dynamic, forward-looking industries. Accordingly, we need to be certain that our employment profile is not unduly shaped by issues related to data quality and data coverage. Several of these issues warrant discussion and are taken up below.

1. Large employment changes due to small numbers of firms

It is certainly possible that changes in ICT intensity, especially in small and medium-sized metropolitan areas, are sensitive to high levels of job creation and destruction in what amounts to relatively small numbers of firms. This raises the possibility that administrative events that signal the creation (or destruction) of certain business units in the database may have a significant impact on patterns of local ICT growth. Analytically, then, our chief concern is that these employment changes in the database reflect *actual* employment events, and not purely *administrative* events that cause the administrators of the BR to "birth" or "death" business units with large number of employees.

We addressed this issue by performing a straightforward outlier analysis that involved the manual inspection of business units with the largest employment changes in our database between the two reference periods. In particular, we focused on large employment changes in ICT industries that occurred in areas with modest employment bases, and investigated whether these changes were consistent with actual employment events that had occurred in these local areas. On balance, our outlier analysis suggests that our growth profile is not unduly influenced by administrative changes in the database that do not reflect actual patterns of employment creation and destruction.

2. Improvements in data coverage from the Business Register

A second, and far more involved, issue centres on whether yearly data snapshots from the BR can be used to draw reliable conclusions about ICT intensity and growth, both in the aggregate and for specific urban areas. The BR was not designed as a micro-time series. Its purpose is to provide the Agency with a comprehensive picture of the Canadian business sector from which representative firm and establishment samples can be drawn. In recent years, Statistics Canada has made substantial investments in the BR in order to improve its timeliness and its coverage of the business population. Accordingly, more recent "snapshots" from the BR may afford a more comprehensive view of the business population. This raises the possibility that improvements in the database between our two reference years, 1990 and 2000, may lead us to overestimate the amount of growth that has actually occurred in certain urban areas.

Before we discuss employment growth, we need to understand how the BR measures employment within individual firms. The BR is updated continuously from tax data, based on payroll deduction accounts. Complex multi-establishment firms are updated by regular profiling visits whereby detailed information is collected on the legal and operating structure of the firm. In order to minimize the impact of seasonal fluctuations in hiring, the administrators of the BR analyze monthly employment levels within the firm and then report the maximum value as being representative of the year. Other things equal, this should produce higher employment estimates than other sources.

What impact does this have on the size and growth of the ICT economy? We addressed the issue of size by comparing our BR-based estimate of the ICT sector to an earlier study. A recent profile of the Canadian ICT sector (Statistics Canada, 2001) estimated[13] that ICT industries accounted for 3.5% of total employment in 1998. From 1998 BR data files, we estimated an aggregate ICT employment share of 3.6%. While the relative size of the ICT economy is about the same in both cases, we noted that the number, or volume, of workers

[13] Data on employment were obtained from the various surveys of industrial production and supplemented with data from the Survey of Employment, Payrolls and Hours (SEPH). See Notes, Methodologies and Data Sources in Statistics Canada (2001) for more information.

giving rise to these employment shares differs quite significantly. Essentially then, while the "share of the pie" attributable to ICT industries is comparable (at least for 1998, the most recent year for which we could compare the two studies), our BR-based estimate of the "pie" is larger. As noted above, this result is expected—given that the BR focuses on the concept of maximum employees. However, when we examined employment levels over the 1990-2000 period—that is, the growth in employment over our reference period—we found a dramatic increase in BR employment in 2000 without a corresponding shift in the size of the business establishment population. This increase in employment was due to a recent administrative update—one that will affect our estimates of the volume of ICT and science-based employment growth that has occurred in different locations.

3. Data base strategy

In order to study the geographic dimensions of New Economy industries, our data source needs to provide us with employment estimates with a high degree of industrial and geographical detail. Our decision was to combine the strengths of the BR with those of another source of employment data, the Labour Force Survey (LFS). One of the Agency's flagship surveys used in the production of employment statistics and labour market analysis, the LFS is widely recognized as a source of accurate employment estimates at the national, or aggregate, level. This household survey provides a comprehensive picture of economic activity for both manufacturing and service industries.

The BR is a source of detailed information on the industrial and geographic composition of the employer business population in Canada. It was not intended, however, to mimic the LFS as a vehicle to provide timely estimates of employment levels. In order to produce the most relevant set of employment data on the New Economy, the share of jobs for each industry and city—where these shares are calculated using the industrial and geographic detail from the BR—were used to disaggregate the most comprehensive data available on total paid workers.[14] Simply put, our data strategy thus involves calculating BR-based estimates of the *share* of ICT and science-based employment in different locations, and then benchmarking these shares to the Paid Worker series from the LFS in order to obtain estimates of the amount of ICT and science-based employment in different locations.

4. Comparing the ICT sector on the Business Register and the Labour Force Survey

The decision to proceed in this manner grew out of a series of benchmarking exercises where the BR was evaluated against the LFS. The purpose of these comparative exercises was to evaluate whether or not any systematic bias exists—in other words, would we arrive at a different set of conclusions about ICT coverage in certain locations if our analysis was

[14] The Productivity Program of Statistics Canada provides estimates of the paid worker population for all of Canada. Over 98% of paid workers are provided by the LFS, but adjustments are made for each of the components excluded by the survey (Canadian Armed Forces, Indian Reserves, and the Territories).

based on a different data source? Before we attempt to answer this question directly, we must stress that comparisons are often difficult due to substantial differences in concepts, methods and coverage across data sources. The present case is no exception. Some explanation of the methodologies used by the BR have been described above; below we review several of the more substantive methodological differences between the BR and the LFS.

In the present context, there are two data issues that affect BR to LFS comparability. First, the LFS is a household survey, not a business survey, that is, it surveys "people" not "firms". The BR is firm-based. Workers in the employ of more than one firm are counted multiple times in the BR, because the BR is a count of total employment compiled largely from payroll tax accounts for individual businesses. From this perspective, it would be more appropriate to say that the BR provides a count of jobs rather than a count of employees. As noted earlier, this estimate of total jobs is akin to one of "maximum" jobs because it is based on the maximum number of jobs within a firm over the course of the year. In our LFS database, a worker who holds multiple jobs is counted only once, irrespective of the number of jobs held. Consequently, if all other things are equal, the existence of multiple jobholders should give rise to larger BR-based estimates of both total and ICT labour involvement than that expected from the LFS.[15] As to whether this yields higher ICT or science-based labour shares, either generally or for specific locations, depends on whether ICT or science-based workers are more or less likely to be multiple job-holders than workers in other industries. A second factor worth noting—potentially important in the present context—is that the LFS data does not hold constant the geographic boundaries associated with different urban areas.

Other differences between the LFS and the business-based employment estimates have been described and quantified in Pold (2001).[16] Some of the factors affecting comparability are outlined below.

- Since the LFS is a household survey, its estimates of employment by industry are based on the feedback provided by survey respondents. In particular, the question posed by the LFS is not sufficiently detailed to identify the specific unit within the business organization for which the industry is to be determined. As a result, the level of industrial detail is limited to a 3-digit SIC (a more aggregate industrial classification than that used in this study to define ICT and science industries).

- Proxy reporting is another potential source of error in determining the nature of business for the employer of other household members. Though the occupation may be relatively clear to the other members of the household, the nature of the business activity of the

[15] To ensure comparability, we have excluded self-employed workers from our LFS data.

[16] In Pold's study, the LFS was compared with the Survey of Employment, Payrolls and Hours (SEPH). For background on differences between the LFS and business-based employment estimates, see Statistics Canada (1987).

employing firm may not be quite so clear, especially if the firm is diversified in its activities. On the other hand, the industry of employment for the BR and business surveys is assigned to the individual establishment. Though most firms are comprised of a single establishment, over a third of all employment is associated with multi-establishment firms. Often such complex firms are also multi-industrial in their make-up. Identifying the particular industry of an individual establishment in such a firm would be difficult to achieve in a household survey. For a business survey, however, the detailed industrial classification of all establishments is provided by the BR.

- Being a household survey, the LFS classifies employed individuals geographically to their place of residence and not to their place of work. On the other hand, the BR's establishments are all classified to the location of the economic activity. So to the extent that some individuals commute beyond the boundaries of the CMA or CA in which they live, such differences will contribute to discrepancies between the business survey and household survey labour estimates.

There is no ideal model for making transparent comparisons. Our goal is to ensure that our profile of New Economy industries and cities is not unduly influenced by the idiosyncrasies of a particular database. Benchmarking exercises should allow us to draw some qualitative impressions about the reliability of the estimates reported herein. Here we focus exclusively on ICT industries (as opposed to our larger class of science industries) since ICT industries are the driving force behind employment trends in the New Economy. We structured these exercises around the following two major issues:

1) To what extent do the BR and LFS yield comparable impressions of ICT employment and total employment levels across different urban areas?

2) To what extent do the BR and the LFS yield similar impressions about relative ICT employment shares across different urban areas, as measured in earlier and later periods?

For the above exercises, we use a benchmarked version of the BR—the version that ultimately forms the basis for our analysis. (Once again, this version of the BR database takes ICT employment shares directly from the BR and uses these to benchmark to the LFS paid worker series).

4.1 Levels of ICT and total employment across major cities

We selected 1990 as the basis for our comparisons. We were not able to compare the two data sources in 2000 because the LFS converted to the new North American Industrial Classification System (NAICS) in 1998. (The BR introduced NAICS in 1997, but continues to classify business by both SIC and NAICS.) By using 1990 as our reference year, we retain our original classification structure.

(1) Total employment across CMAs

In the aggregate, the distribution of total employment across the 25 CMAs is highly correlated across the two data sources. The correlation coefficient based on total CMA employment from the 1990 (benchmarked) BR and the 1990 LFS is 99.5%. This, of course, does not ensure that the absolute levels of employment are consistent across data sources (correlation coefficients are based upon deviations from the means). That said, our basic picture of how total employment is distributed across CMAs is virtually identical using either the benchmarked BR data source or the LFS data.

(2) ICT employment across CMAs

Our next exercise compared levels of ICT employment across CMAs using the LFS and the benchmarked BR. But before we can calculate ICT employees we need to determine how to best apply the industrial definition of ICT to each data source. As noted in Appendix A, ICT industries are specified in terms of 4-digit industries. Applying this definition to the BR is straightforward since all establishments are classified at the 4-digit level. The LFS, however, only produces industry estimates at the 3-digit level. Though some 3-digit industries, such as 335 (communication and other electronic equipment), fit perfectly with the ICT definition, other 3-digit industries contain a mix of ICT and non-ICT industries. After looking at the share of ICT activity in the latter class of industries, we eliminated a small group of 3-digit industries from the (LFS-based) definition of the ICT sector.[17] In spite of these exclusions, the resulting coverage of the ICT sector was still high (approximately 94% to 98%).

The correlation between ICT employment levels across CMAs was 98.4%, indicating that each data source provides a nearly identical picture of how ICT workers are distributed over the CMA landscape. Though differences in employment levels may exist, cities with relatively large ICT workforces in one file tend to have similarly large workforces in the other.

4.2 Share of local employment in ICT industries

Our analysis deals extensively with ICT intensity—defined as the share of the local workforce employed in ICT industries. Accordingly, we compared ICT shares from our two sources—the benchmarked BR data and the LFS data. Here the correlation dropped to 77.0%, indicating that there is a moderate-to-strong tendency for the two data sources to generate the same patterns of ICT intensity across CMA cities. As noted above, the LFS data provides a limited view of local ICT intensity because of limitations on the amount of industrial detail collected by the survey.

[17] Three 3-digit SICs were dropped from the LFS: 481 (telecommunication and broadcasting), 579 (wholesaling of other machinery, equipment and supplies and 991 (rental and leasing of machinery and equipment).

Table C1. Paid worker shares in ICT sector in 1990 by CMA: Comparison of ICT sector paid worker shares from the BR and LFS

City (*)	BR paid workers			LFS paid workers			Difference in shares
	ICT sector	All industries	ICT shares from the BR	ICT sector	All industries	ICT shares from the LFS	
St. John's (9)	2,400	70,300	3.5%	2,000	73,900	2.7%	0.8
Halifax (5)	6,700	151,400	4.5%	5,500	148,800	3.7%	0.8
Saint John (1)	3,300	43,500	7.6%	2,800	53,000	5.3%	2.3
Chicoutimi - Jonquière (19)	700	49,600	1.4%	300	59,900	0.5%	0.9
Quebec (12)	6,700	270,400	2.5%	5,300	288,700	1.8%	0.7
Sherbrooke (15)	1,100	58,300	1.9%	1,300	60,000	2.2%	-0.3
Trois-Rivières (22)	400	46,900	0.9%	900	55,500	1.6%	-0.8
Montreal (10)	54,300	1,612,600	3.4%	56,700	1,398,500	4.1%	-0.7
Ottawa - Hull (3)	35,000	618,000	5.7%	27,900	462,600	6.0%	-0.4
Oshawa (13)	1,900	89,000	2.1%	3,700	119,200	3.1%	-1.0
Toronto (8)	85,600	2,373,100	3.6%	104,000	1,946,500	5.3%	-1.7
Hamilton (21)	2,500	232,600	1.1%	5,900	292,900	2.0%	-0.9
St. Catharines - Niagara (25)	500	131,800	0.4%	2,300	163,000	1.4%	-1.0
Kitchener (15)	3,300	171,200	1.9%	5,300	176,700	3.0%	-1.1
London (18)	2,500	169,500	1.5%	6,300	179,600	3.5%	-2.0
Windsor (23)	800	118,800	0.7%	1,500	114,700	1.3%	-0.6
Sudbury (24)	400	54,600	0.6%	1,200	66,600	1.8%	-1.2
Thunder Bay (20)	600	48,700	1.2%	900	56,700	1.6%	-0.4
Winnipeg (7)	11,900	318,200	3.7%	9,800	299,600	3.3%	0.5
Regina (2)	7,100	109,400	6.5%	4,100	87,800	4.7%	1.9
Saskatoon (11)	2,500	96,300	2.6%	2,500	88,600	2.8%	-0.3
Calgary (14)	7,600	376,600	2.0%	11,300	358,100	3.2%	-1.1
Edmonton (4)	19,100	416,200	4.6%	10,800	385,800	2.8%	1.8
Vancouver (6)	31,000	792,900	3.9%	29,000	735,400	3.9%	0.0
Victoria (15)	2,200	119,100	1.9%	2,300	117,900	2.0%	-0.1
Total CMA	*290,300*	*8,538,900*	3.4%	*303,700*	*7,789,600*	3.9%	-0.5

(*) Denotes rank based on ICT paid worker share from BR in 1990.

As a final exercise, we quantify the impact of different data sources on our profile of local ICT-intensity by reporting ICT employment shares and rankings for all CMAs in 1990—based first on the benchmarked BR data source that we have used for this study, and then on the LFS using its industrial and geographic detail (Table C1).

References

Baldwin, J.R. 1995. *The Dynamics of Industrial Competition: A North American Perspective*. Cambridge: Cambridge University Press.

Baldwin, J.R. and G. Gellatly. 1999. “Developing High-Tech Classification Schemes: A Competency-based Approach.” In *New Technology-based Firms in the 1990s* (vol. 6). Edited by R. Oakey, W. During and S.-M. Mukhtar. Amsterdam: Pergamon.

Baldwin, J.R. and G. Gellatly. 2001. “A Firm-Based Approach to Industry Classification: Identifying the Knowledge-based Economy.” In *Doing Business in the Knowledge-based Economy*. Edited by L. Lefebvre, E. Lefebvre and P. Mohnen. Boston: Kluwer Academic Publishers.

Baldwin, J.R. and P. Hanel. 2003. *Innovation and Knowledge Creation in an Open Economy*. Cambridge University Press.

Baldwin, J.R. and J. Johnson. 1999. *The Defining Characteristics of Entrants in Science-based Industries*. Catalogue No. 88-517. Analytical Studies Branch. Ottawa: Statistics Canada.

Beckstead, D. and G. Gellatly. 2003. *The Growth and Development of New Economy Industries*. The Canadian Economy in Transition Research Paper Series 11-622MIE2003002. Analytical Studies Branch. Ottawa: Statistics Canada.

Beckstead, D. and T. Vinodrai. 2003. *Dimensions of Occupational Changes in Canada’s Knowledge Economy, 1971-1996*. The Canadian Economy in Transition Research Paper Series 11-622MIE2003004. Ottawa: Statistics Canada. Forthcoming.

Dumais, G., G. Ellison and E.L. Glaeser. 1997. *Geographic Concentration as a Dynamic Process*. Working Paper 6270. Cambridge, MA: National Bureau of Economic Research.

Duranton, G. and D. Puga. 2001. “Nursery Cities: Urban diversity, process innovation, and the life cycle of products.” *American Economic Review*. 91,5: 1454-1477.

Ellison, G. and E.L. Glaeser. 1997. “Geographic Concentration in U.S. Manufacturing Industries: A Dartboard Approach”. *Journal of Political Economy*. 105, 5: 889-927.

Feldman, M.P. 1999. “The New Economics of Innovation, Spillovers and Agglomeration: A Review of Empirical Studies”. *Economics of Innovation and New Technology* 8: 5-25.

Jacobs, J. 1969. *The Economy of Cities*. New York: Random House.

Krugman, P. 1991. *Geography and Trade*. Cambridge: The MIT Press.

Lee, F.C. and H. Has. 1996. “A Quantitative Assessment of High-Knowledge Industries Versus Low-Knowledge Industries.” In *The Implications of Knowledge-Based Growth for Micro-Economic Policies*. Edited by P. Howitt. Calgary: University of Calgary Press.

Marshall, A. (1920) *Principles of Economics*. 8th Edition. London: Macmillan.

McNiven, C., H. Puderer and D. Janes. 2000. *Census Metropolitan Area and Census Agglomeration Influenced Zones (MIZ): A Description of the Methodology*. Geography Working Paper Series 92F0138MPE2000002. Geography Division. Ottawa: Statistics Canada.

Organisation for Economic Cooperation and Development (OECD). 1997. *Science, Technology and Industry*. *Scoreboard of Indicators.* Paris.

Organisation for Economic Cooperation and Development (OECD). 2000. *Measuring the ICT Sector.* Paris.

Oerlemans, L.A.G., M.T.H. Meeus and F.W.M. Boekema. 2001. “Firm clustering and innovation: Determinants and effects” *Papers in Regional Science*. 80: 337-356.

Pold, H. 2001. *Employment: A Tale of Two Sources.* Ottawa: Statistics Canada memo.

Rambeau, S. and K. Todd. 2000. *Census Metropolitan Area and Census Agglomeration Influenced Zones (MIZ) with Census Data*. Geography Working Paper Series 92F0138MIE2000001. Geography Division. Ottawa: Statistics Canada.

Statistics Canada. 1987. *Labour Force Information.* Catalogue No. 71-001. Ottawa: Statistics Canada.

Statistics Canada. 2001. *Beyond the Information Highway: Networked Canada.* Catalogue No. 56-504. Ottawa: Statistics Canada.

Stiroh, K.J. 1999. “Is There a New Economy?” *Challenge*. July-August, 82-101.