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Assessing the Growth of the New Economy across Canadian Cities and Regions: 1990-2000

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Abstract. 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 empirical study develops a geographic profile of New Economy industries in Canada across the urban/rural hierarchy and in different metropolitan areas between 1990 and 2000. The study also investigates whether measures of agglomeration economies are correlated with the increased incidence of New Economy industries across different locations over the study period. The study shows that the employment growth in New Economy industries through the 1990s has been primarily an urban phenomenon and that agglomeration economies have played an increasingly important role in the formation of these industries.

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

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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.

During the 1990s, science and technology industries that form the backbone of the New Economy were important sources of innovation and growth.[2] This study explores the emerging geographic structure of the New Economy in Canada between 1990 and 2000. It profiles two innovative business populations: industries that develop information and communications technologies (ICTs); and 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? To what extent have both ICT and science-based industries grown in the last decade? To what extent have certain locations, be they rural/urban areas 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? With respect to this last question, we are particularly interested in the effect of agglomeration economies on the growth of ICT industries.

The study is organized as follows. The principles that give rise to our ICT and science-based classifications are described in Section 2. The data sources used for our employment profile are outlined next (Section 3), followed by a brief overview of growth trends in ICT and science-based industries during the 1990s (Section 4). The research issues that motivate our geographic profile are discussed in Section 5. Empirical results for urban/rural areas and major cities are reported in Section 6. Multivariate regressions that explore differences in local ICT intensity are then presented (Section 7). We close the study in Section 8 with a brief review of our findings.

[2] Sakurai, Ioannidis, and Papaconstantinou (1996) find evidence that ICT industries played a major role in the generation and acquisition of new technologies across a subset of Organization for Economic Cooperation and Develoopment (OECD) countries. More recent work by Gordon (2000) suggests most multifactor productivity (MFP) growth in the United States in the late 1990s came from productivity improvement within ICT producing industries, while Pilat, Lee, and van Ark (2002) find evidence that ICT producing industries made sizable contributions to MFP growth in several OECD countries. Finally, Beckstead and Gellatly (2003) found for Canada that ICT industries enjoyed comparatively high rates of MFP growth.

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, which industries serve to define it? A comprehensive examination of what the New Economy is (or is not) well beyond our present scope here.[3] As Stiroh notes (1999), 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.

Of course, industry taxonomies provide a relatively coarse measure of the new economy. Ideally, one would want to identify the New Economy by using firm-level data from special surveys to develop high-tech classifications directly from the innovation, technology and human capital characteristics of firms (Baldwin and Gellatly 1999). These surveys, however, typically do not have large enough samples to provide useful comparisons across cities (or other geographic units) nor do they typically track changes over time.

Here we focus on firms that operate in industrial environments that place proportionately more stress on advanced technology (ICT), or on value-added inputs such as research and development (R&D) or skilled labour (the basis for our science classification). We start with an industrial classification developed by the OECD that identifies a small set of manufacturing and service industries as being 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" (SIEID, 2001). In Canada, the

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

ICT sector spans 19 individual industries, 10 in manufacturing and 9 in services.[4] In manufacturing, ICT industries:

> "(m)ust be intended to fulfill 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: 7).

For services, ICT industries offer products that

> "must be intended to enable the function of information processing and communications by electronic means" (OECD 2000: 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.[5] Much of ICT employment is concentrated in services, particularly in the two industries noted above. Business establishments in computer services account for nearly 40 percent of total ICT employment, while those in the telecommunications carriers industry account for roughly 20 percent.

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 research and development (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.

To identify science industries, we adopt the classification system developed by Lee and Has (1996) and later refined by Baldwin and Johnson (1999). Three R&D variables were used—the industry R&D-to-sales ratio, the share

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[4] This definition is based on the 1980 Standard Industrial Classification (SIC).
[5] For a list of individual industries, see Appendix A.

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.[6]

In this analysis, we restrict our tabulations on science to the subset of science industries that are not classified as ICT-based. This provides 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 computer and telecommunications equipment) 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.

3. Data Source

Our employment analysis requires micro-data on the geographic characteristics of the business sector. This information can be obtained from Statistics Canada's Business Register(BR). We decided on the Business Register as

[6] For a list of individual industries, see Appendix B.

our principal data source because it has two desirable properties—business coverage and industrial detail. The Register 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 Register is analogous to the plant-level within a firm's organizational structure. The vast majority of Canadian businesses, some 91 percent, maintain only a single establishment within their operating structure. The use of establishment-level data is advantageous in the current context, in that it provides for more accurate estimates of the geographic distribution of employment within multi-plant firms—businesses that maintain two or more establishments in their operating structure.

The establishment profiles on the Business Register are updated on a continuous basis. Our analysis of New Economy industries is based on year-end images from the Business Register, 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 business and employment mix in different locations; and

(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 Business Register can be used to produce accurate estimates of the share of employment accounted for by ICT and science industries in different cities and urban/rural regions. While we are confident in these shares, we have less confidence in the employment levels derived from the Business Register. This is because the Register is subject to periodic administrative updates that

[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 Industry Classification System (NAICS) standard. 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 years, 1990 and 2000.

can affect estimates of the level, or stock, of employment over time.[8] This required us to adopt a different strategy to obtain the employment estimates for cities and urban/rural regions—effectively benchmarking data on the share of ICT and science-based employment in different locations (obtained directly from the Business Register) against aggregate employment data derived from Statistics Canada's Labour Force Survey (LFS).

The LFS is widely recognized as an accurate source for Canadian employment estimates at the national, or aggregate, level. Estimates of total paid workers for both analysis years (1990 and 2000) were derived from the LFS.[9] In order to obtain more reliable employment estimates for different locations, industry/location shares from the BR were used to apportion the aggregate paid worker series to specific cities and urban/rural areas. For example, according to the 2000 BR, ICT employment in Toronto amounted to 1.4 percent of all paid worker jobs (nationally), and 7.3 percent of paid worker jobs in Toronto. In order to obtain a more reliable estimate of the number of ICT paid worker jobs in Toronto, we multiplied the former share of 1.4 percent (the percentage of national paid worker jobs accounted for by ICT employment in Toronto) by the national estimate of total paid workers derived from the LFS (13,555,600). This yields an ICT employment estimate of 194,900 for Toronto, to coincide with its local ICT employment share of 7.3 percent (see Table 4). The net result of this estimation process is a more reliable set of employment data to support our geographic profile[10].

4. Growth Trends in ICT and Science-Based Industries

The ICT and science-based economy grew rapidly during the 1990s. ICT employment increased by 70 percent, from about 325,000 workers in 1990 to just over 552,000 workers in 2000 (Table 1a). Firms in the ICT sector employed 4.1 percent of all paid workers in 2000, up from 2.7 percent in 1990 (Table 1b). Science-based employment grew at a much slower pace—10 percent between 1990 and 2000 (Table 1a). Moreover, the share of employment in science-based industries fell slightly over the study period (see Table 1b).

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[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.

[9] The Productivity Program at Statistics Canada produces estimates of the paid worker population for all of Canada. Over 98 percent 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).

[10] See Appendix C in Beckstead *et al.* (2003) for a more extensive discussion of these estimation issues.

Table 1a. Paid worker jobs in ICT and Science-based sectors in Canada

	1990	2000	Absolute Change 1990-2000	Absolute Change 1990-2000
ICT	324,700	552,200	227,500	70.1
Science-Based	490,800	541,400	50,600	10.3
Canada	*12,080,800*	*13,555,600*	*1,474,800*	*12.2*

Source: Special tabulation, Business Register

Table 1b. Share of paid worker jobs in ICT and Science-Based sectors in Canada

	1990	2000	Share Change
ICT	2.7%	4.1%	51.6%
Science-Based	4.1%	4.0%	-1.7%

Source: Special tabulation, Business Register

Table 4. Cities (CMAs) ranked by paid worker shares of total employment in ICT/Science-Based sectors in 2000.

ICT Sector Paid Worker Shares				
Rank	City (rank 1990)	1990 (share*)	2000 (share*)	Change in Share
1.	Ottawa – Hull (3)	35,000 (5.7)	49,200 (9.1)	61%
2.	Toronto (8)	85,000 (3.6)	194,900 (7.3)	102%
3.	Saint John (1)	3,300 (7.6)	3,200 (5.9)	-22%
4.	Montreal (10)	54,300 (3.4)	89,600 (5.7)	69%
5.	Regina (2)	7,100 (6.5)	6,000 (5.3)	-19%
6.	Vancouver (6)	31,000 (3.9)	54,000 (5.1)	30%
7.	Kitchener (15)	3,300 (1.9)	9,200 (4.5)	133%
8.	Halifax (5)	6,700 (4.5)	8,500 (4.5)	0%
9.	Calgary (14)	7,600 (2.0)	24,800 (4.2)	109%
10.	Edmonton (4)	19,100 (4.6)	18,400 (3.3)	-28%
11.	Winnipeg (7)	11,900 (3.7)	12,500 (3.3)	-12%
12.	St. John's (9)	2,400 (3.5)	3,000 (3.1)	-12%
13.	Victoria (17)	2,200 (1.9)	5,000 (3.1)	64%
14.	Quebec (12)	6,700 (2.5)	9,100 (2.9)	17%
15.	Hamilton (21)	2,500 (1.1)	7,500 (2.8)	162%
16.	Sherbrooke (16)	1,100 (1.9)	1,400 (2.4)	27%
17.	Saskatoon (11)	2,500 (2.6)	2,600 (2.3)	-9%
18.	London (18)	2,500 (1.5)	4,200 (2.1)	43%
19.	Trois-Rivieres (22)	400 (0.9)	800 (1.7)	92%
20.	Oshawa (13)	1,900 (2.1)	1,500 (1.4)	-31%
21.	Chicoutimi – Jonquiere (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%
24.	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)***	***510,000 (5.2)***	***54%***
	Total Canada	***324,700 (2.7)***	***552,200 (4.1)***	***52%***

*Parentheses denotes percentage shares of total paid worker jobs within each CMA. Source: Special tabulation, Business Register

Table 4 Continued. Cities (CMAs) ranked by paid worker shares of total employment in ICT/Science-Based sectors in 2000.

Science-Based Sector Paid Worker Shares				
Rank	City (rank 1990)	1990 (share*)	2000 (share*)	Change in Share
1.	Calgary (1)	27,500 (7.3)	45,600 (7.7)	6%
2.	Montreal (4)	90,600 (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)	123,900 (4.6)	-12%
5.	Chicoutimi – Jonquiere (19)	1,300 (2.5)	2,400 (4.6)	82%
6.	Regina (10)	4,400 (4.0)	5,000 (4.4)	10%
7.	Edmonton (9)	16,900 (4.1)	23,100 (4.2)	2%
8.	Saskatoon (17)	2,500 (2.6)	4,400 (4.0)	53%
9.	Winnipeg (7)	14,500 (4.6)	15,100 (4.0)	-13%
10.	Vancouver (6)	39,400 (5.0)	41,500 (3.9)	-21%
11.	Windsor (14)	4,000 (3.4)	5,800 (3.9)	16%
12.	Hamilton (12)	8,400 (3.6)	9,500 (3.5)	-2%
13.	Sherbrooke (11)	2,200 (3.8)	2,000 (3.4)	-11%
14.	Halifax (13)	5,300 (3.5)	6,300 (3.3)	-5%
15.	St. John's (2)	4,600 (6.5)	3,200 (3.3)	-50%
16.	Ottawa – Hull (15)	18,300 (3.0)	16,900 (3.1)	6%
17.	Trois-Rivieres (18)	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)	4,200 (2.1)	-27%
21.	Saint John (20)	900 (2.0)	1,000 (1.9)	-7%
22.	Sudbury (24)	700 (1.3)	1,100 (1.8)	36%
23.	Thunder Bay (23)	900 (1.8)	900 (1.8)	0%
24.	Victoria (25)	1,500 (1.3)	2,600 (1.6)	24%
25.	Oshawa (22)	1,600 (1.8)	1,600 (1.6)	-15%
	Total CMA	***396,800 (4.6)***	***442,400 (4.5)***	***-2%***
	Total Canada	***490,800 (4.1)***	***541,400 (4.0)***	***-2%***

*Parentheses denotes percentage shares of total paid worker jobs within each CMA. Source: Special tabulation, Business Register

Most of the growth in New Economy industries was concentrated in the ICT sector.

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 is 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.

For the economy as a whole, 62 percent of total employment is located in newer (post-1990) establishments. Entrants play a slightly larger role in science industries, with 68 percent of science-based employment found in post-1990 establishments. It is in ICT industries where the impact of newer establishments is most apparent. Seventy-four percent of the ICT workforce in 2000 is 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. In sectors driven by new entrepreneurial opportunities, rapid rates of growth are to be expected. ICT industries develop, deliver and support new computer-based technologies, and strong rates of growth in the plant population mirror concomitant increases in the demand for new technological products and services.[11] In subsequent sections, we turn our attention to the geographic evolution of ICT and science-based industries. We begin by first reviewing several theoretical perspectives that are used to explain the geographic concentration of industry.

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) has argued 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 ur-

[11] For detailed empirical evidence on the growth of ICT investment in Canada, see Armstrong *et al.* (2002).

banization 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. Orelemans, 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 other 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 from 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 positive 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.

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 to what extent different geographic regions—urban-rural areas and cities—are sharing in the growth of ICT and science-based industries.

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 2). 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.[12] The resulting taxonomy captures the economic influence of large urban areas on small and rural communities.

Table 2. Definitions of urban/rural classifications

Urban/Rural Group	Definition
CMA-large	Census Metropolitan Area (CMA) w/population greater than 1,000,000. (e.g. Toronto)
CMA-medium	Census Metropolitan Area (CMA) w/population of 500,000 to 999,999. (e.g. Calgary)
CMA-small	Census Metropolitan Area (CMA) w/population of 100,000 to 599,999. (e.g. Victoria)
CA-large	Census Area (CA) w/population of 50,000 to 99,999 (e.g. Charlottetown)
CA-small	Census Area (CA) w/population of 10,000 to 49,999 (e.g. Yellowknife)
Strong MIZ[a]	Census Subdivision (CSD) with a commuting flow of 30 percent or more (at least 30 percent of people 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 commuters or population less than 40 people.

[a] MIZ = Metropolitan Influenced Zones

New Economy industries are a disproportionately urban phenomenon. The largest urban centres (populations of 1,000,000 or more) have the highest employment shares in ICT and science industries, both in 1990 and in 2000 (Table 3).

The growth of ICT industries in the largest urban centres has been comparatively rapid. In 1990, ICT-based employment in these cities amounted to

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

3.8 percent of their total labour force; by 2000, this increased to 6.6 percent. 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 percent. 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.

Table 3. Urban/Rural Employment Aggregates for ICT and Science-Based Sectors in Canada

Urban/Rural Group	*ICT Paid Workers*		
	1990*	2000*	Change
CMA-large	206,000 (3.8)	387,700 (6.6)	88.3%
CMA-medium	47,800 (3.0)	72,300 (3.4)	51.2%
CMA-small	36,500 (2.4)	49,900 (2.8)	36.8%
Total CMA	*290,300 (3.4)*	*510,000 (5.2)*	*75.7%*
CA-large	16,700 (1.6)	19,600 (1.8)	17.1%
Ca-small	10,100 (1.4)	11,700 (1.4)	15.6%
Total CMA/CA	***317,100 (3.1)***	***541,200 (4.6)***	***70.7%***
Strong MIZ	3,500 (1.2)	3,600 (1.0)	1.2%
Moderate MIZ	1,600 (0.2)	3,700 (0.6)	130.8%
Weak MIZ	2,400 (0.4)	3,500 (0.4)	46.5%
No MIZ	100 (0.2)	200 (0.2)	70.3%
Total Non-CMA/CA	***7,600 (0.4)***	***11,000 (0.6)***	***44.0%***
Total Canada	**324,700 (2.7)**	**552,200 (4.1)**	**70.1%**

Table 3. Continued

Urban/Rural Group	*Science-Based Paid Workers*			*Total Paid Workers*		
	1990*	2000*	Change	1990	2000	Change
CMA-large	272,900 (5.1)	285,000 (4.9)	4.4%	5,396,600	5,840,300	8.2%
CMA-medium	72,300 (4.5)	100,400 (4.8)	38.8%	1,614,000	2,103,400	30.3%
CMA-small	51,600 (3.4)	57,100 (3.2)	10.6%	1,528,300	1,806,200	18.2%
Total CMA	*396,800 (4.6)*	*442,400 (4.5)*	*11.5%*	*8,538,900*	*9,749,900*	*14.2%*
CA-large	44,400 (4.3)	40,400 (3.6)	-9.1%	1,034,600	1,110,400	7.3%
Ca-small	19,000 (2.6)	17,900 (2.1)	-6.0%	729,000	831,600	14.1%
Total CMA/CA	***460,200 (4.5)***	***500,700 (4.3)***	***8.8%***	***10,302,400***	***11,691,900***	***13.5%***
Strong MIZ	8,200 (2.8)	12,000 (3.4)	46.1%	29,000	353,100	18.5%
Moderate MIZ	12,200 (1.7)	13,600 (2.2)	11.7%	739,700	634,000	-14.3%
Weak MIZ	9,600 (1.5)	13,300 (1.7)	37.7%	663,300	788,400	18.9%
No MIZ	500 (0.6)	1,800 (2.0)	272.3%	77,300	88,200	14.2%
Total Non-CMA/CA	***30,600 (1.7)***	***40,700 (2.2)***	***33.3%***	***1,778,300***	***1,863,700***	***4.8%***
Total Canada	**490,800 (4.1)**	**541,400 (4.0)**	**10.3%**	**12,080,800**	**13,555,600**	**12.2%**

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.

An additional means to quantifying the relative importance and growth in ICT and science-based industries across urban/rural areas are location quotients. A relative measure of the intensity of industry formation in a particular location, the location quotient is defined as

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

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. 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.

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 obtain a higher location quotient in the largest cities in 2000 than in 1990 (see Figures 1a and b). This again supports the view that ICT industries derive benefits from locating in larger urban areas. Over the 1990s, ICT employment in smaller urban and rural locations has become less representative of national trends.

Growth of local ICT and science-based clusters: The last section illustrated that ICT and science-based industries have a stronger foothold in larger urban areas. In what follows, we provide a more explicit accounting of ICT and science-based growth at the local level. We do so by ranking the largest 25 Canadian 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 each local industry mix.

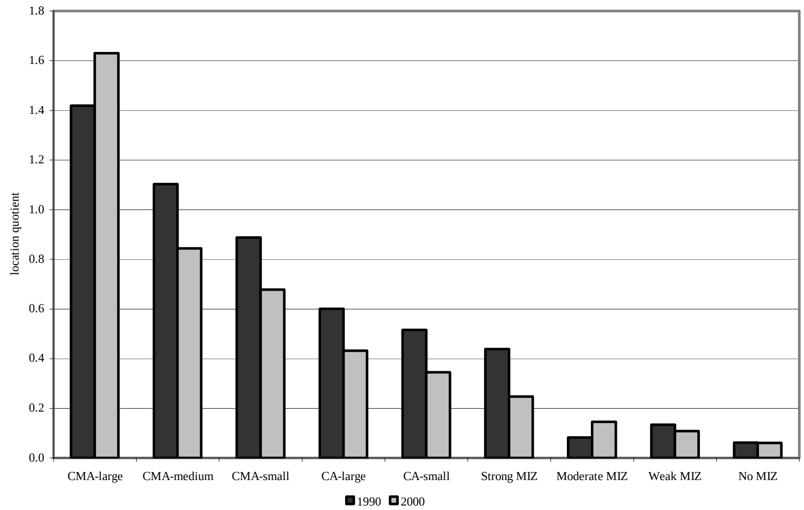

Figure 1a. ICT employment location quotients by urban/rural classification
Source: Special tabulation, Business Register

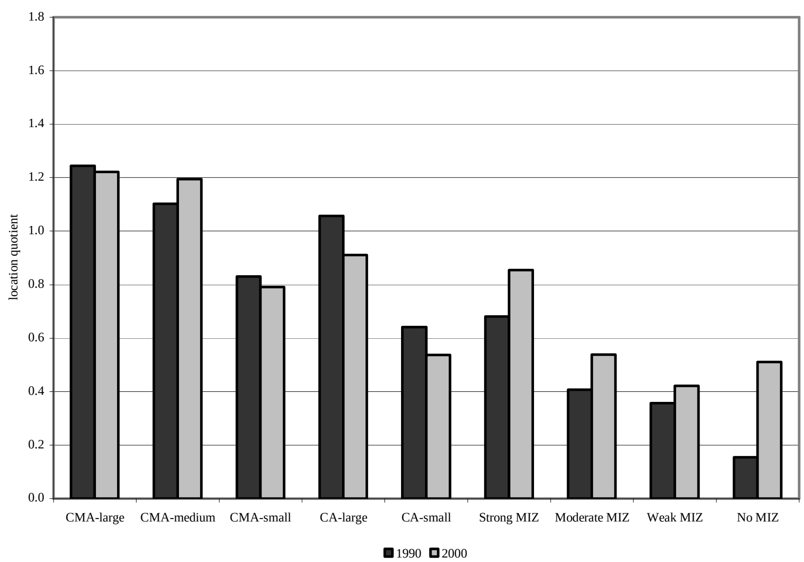

Figure 1b. Science-based employment location quotients by urban/rural classification
Source: Special tabulation, Business Register

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 8th to 2nd in terms of its ICT intensity; Montreal improved from 10th to 4th .

Relationships between absolute size and local intensity, however, are not completely congruous. In 2000, Vancouver ranked 3rd and 4th in terms of the absolute size of its ICT and science-based sectors respectively, but dropped to 6th and 10th after controlling for the size of its local economy. Nevertheless, small cities (e.g., Trois-Riviéres, Sudbury, Oshawa) tend to have the smallest shares of ICT and science based employment.

Which cities are making the greatest transitions towards ICT and science-based workforces? By 2000, Ottawa-Hull emerged as Canada's high-tech leader in terms of its local representation of ICT industries (9.1 percent of Ottawa-Hull's paid workers are employed in ICT industries, up from 5.7 percent a decade earlier). Calgary had the largest concentration of workers in science industries in both reference years (7.3 percent of employment in 1990 and 7.7 percent 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.

7. Exploring Factors behind Local ICT Intensity

The last section has demonstrated that much of the employment growth in ICT industries has been concentrated in large cities. By 2000, the four metropolitan areas with the largest contingents of ICT workers—Toronto, Montreal, Vancouver and Ottawa-Hull—accounted for 69 percent of total employment in ICT industries, up from 63 percent 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 shifts 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.

These broad empirical findings suggest the location of ICT sector is driven, at least in part, by agglomeration economies and that the influence of these economies has increased over time. Yet our analysis to this point has been limited to essentially biavariate cross tabulations. In this section, we use regression techniques to formally test the effect of several measures of agglomeration economies on observed differences in ICT intensity across urban locations.

We focus exclusively on the ICT sector, because it has experienced the most dynamic growth over the study period. 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. 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:

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

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 science-based industries (a measure of complementarity). The sample is all 137 Canadian urban areas 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 intensity between 1990 and 2000. We can express equation (2) in each time period as

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

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

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

(4)

$$\Delta INT_i = \Delta\alpha + \beta_1^{90}\Delta EMP_i + \delta_1 EMP_i^{00} + \beta_2^{90}\Delta DIV_i + \delta_1 DIV_i^{00} + \beta_3^{90}\Delta$$

This equation can be used to examine whether the growth in local ICT intensity 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 science-based industries.

ICT intensity in 1990 and 2000: Results for equation (2), which evaluates differences in ICT intensity in 1990 and 2000 separately, are reported in Table 5.

Table 5. Local ICT intensity (equation 2): 1990 and 2000

Variable Name	Description	Share of ICT workers in local economy	
		1990	2000
Intercept		-00075	-00063
		(0.8784)	(0.8884)
EMP	Total employment	-0.0335	0.2380
		(0.7512)	(0.0099)
DIV	Number of industries	0.3592	0.3437
		(0.0010)	(0.0003)
SCI	Share of workers in Science-based industries	0.0031	0.0521
		(0.9701)	(0.5009)
F		5.77	18.30
		(0.0010)	(<0.0001)
Adj R^2		0.10	0.28
N		137	137

Note: With exception of the intercept terms, all parameters are expressed in their standardized (beta) coefficient form. Standardized coefficients measure the change in the dependent variable (in standard deviations) resulting from a one standard deviation change in the independent variable. P-values are reported in parentheses below each coefficient and the F statistics.

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 independently to ICT intensity. Nor is there any evidence that ICT shares are correlated with employment shares in science-based industries. In 2000, both proxies for urbanization (*EMP* and *DIV*) are positively associated with variation in ICT intensity. This suggests that the agglomeration economies enjoyed by large urban centers served as important determinants of local ICT intensity during years in which employment in this sector grew substantially. Urban size advantages became critical as larger cities enjoyed more success in attracting ICT employment—above and beyond the gains that result from higher levels of industrial diversity. Therefore, agglomeration economies appear to be working both through the benefits of industrial diversity, which is consistent with Jacobs' type urbanization economies. The increasing importance of urban size is more difficult to interpret. It may be that larger cities have thicker labour markets that are important to new, innovative industries like ICT. Yet there may be other factors correlated with size (e.g., access to large research universities or well developed transportation infrastructure) that may also influence the location of ICT industries. There is no evidence of employment symmetries between ICT and science-based industries in either of our reference years.[13] Therefore, there does not appear to be strong spillovers between R&D and human capital intensive science-based industries and ICT industries.

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 6).

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 5. This reinforces the increasing importance of urban size, or scale, advantages in attracting new economy industries. 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 corre-

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[13] 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.

lated with industrial diversification, the influence of which is negated when moving to the first differences growth model.[14]

Table 6. Changes in ICT intensity (equation 4)

Variable Name	Description	Differences in ICT employment shares (2000 – 1990)
Intercept		-0.000035
		(0.9933)
ΔEMP	Change in total employment (2000 – 1990)	-0.1063
		(0.3762)
EMP	Employment (2000)	0.4204
		(0.0026)
ΔDIV	Change in industry mix (2000 – 1990)	0.0575
		(0.6174)
DIV	Number of industries (2000)	0.02704
		(0.8029)
ΔSCI	Change in employment intensity of Science-based industries (2000 – 1990)	-0.0892
		(0.3163)
SCI	Percentage of workers in other Science-based industries (2000)	-0.1200
		(0.1965)
F		2.76
		(0.0148)
Adj R^2		0.07
N		137

Note: With exception of the intercept term, all parameters are expressed in their standardized (beta) coefficient form. Standardized coefficients measure the change in the dependent variable (in standard deviations) resulting from a one standard deviation change in the independent variable. P-values are reported in parentheses below each coefficient and the F statistic.

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 look 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.[15]

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 explana-

[14] See Wooldridge (1999, Chapter 13) for a brief discussion of first-difference models and the bias introduced by fixed effect.

[15] 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.

tory 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 (venture) capital funding are other factors that may explain the formation of technology sectors.

8. Conclusions

This study provides a first look at the geography of the New Economy across the Canadian 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 science-based industries declined. Calgary presents a slightly different view. One-half of that city's employment gains in New Economy sectors occurred in science-based industries. While some variation across urban centers can be expected because of concomitant differences in industrial composition and comparative advantage, our results demonstrate that the characteristics of local high-technology economies can vary significantly between cities. At the local level, there are different paths to the New Economy.

This study also underscores the general importance of geographic factors to patterns of employment creation in high-technology sectors. Employment growth in technology industries is highly focused at the top end of the urban/rural hierarchy, suggesting that agglomeration economies constitute a major factor in the development of emergent industries. Our results provide evidence that urbanization economies foster the development of local ICT industries. Both the size of the local employment base and the amount of industrial diversification in the local economy play a role in conditioning differences in ICT intensity across urban areas. Information technology industries are becoming an increasingly urban phenomenon.

Our final and concluding point is with respect to policy. Through the 1990s many regions and cities sought to attract New Economy industries in general, and ICT industries in particular, because they were seen as forward-looking growth industries. Our results point strongly to the fact that these new industries are particularly attracted to large and diversified cities. These are characteristics that are not easily influenced by policy—they are exogenous. Although it would be unwise to conclude that policy instruments have no effect on the ability of regions to attract New Economy industries, these results do suggest that several of the most important factors may be beyond the reach of policymakers.

Appendix A: 1CT industries

SIC Code	*Description*
Manufacturing	
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
Services	
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 at 1CT-based)	
SIC Code	*Description*
Manufacturing	
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 and Coal Products Industries
3612	Lubricating Oil and Grease Industry
3699	Other Petroleum and Coal Products Industry
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
Services	
0231	Agricultural Management and Consulting Services
0239	Other Services Incidental to Agriculture n.e.c.
4611	Natural Gas Pipeline Transport Industry
4612	Crude Oil Pipeline Transport Industry
4619	Other Pipeline Transport Industries
4911	Electric Power Systems Industry
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

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