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Dimensions of occupational changes in Canada's knowledge economy, 1971-1996

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Preface

This paper examines the emergence of the knowledge economy by examining the increasing importance of high-knowledge occupations over the period 1971-1996. It reports that the importance of knowledge occupations has continuously increased over the last three decades. It also examines differences in the changes that have occurred for different knowledge professions—managers, professionals and technical occupations, for industries and for geographic areas. It finds that the increase in the proportion of the labour force that is classified to knowledge occupations was widespread. It occurred for professionals, managers, and technical occupations. It occurred across most industries. It occurred across different regions. It occurred in both the female and male labour force. While there are differences in the rates of growth in some areas, the most important conclusion to emerge from the study is that the growth of skills, as proxied by the importance of knowledge occupations, was widespread and not restricted to narrow areas of interest, such as popularly defined high-tech sectors.

For additional analysis on Canada's knowledge workers that includes data for 2001, please see "Knowledge workers in Canada's economy, 1971-2001" (11-624-MIE No. 004).

Executive Summary

Recent discussions of the 'new economy' sometimes leave the impression that it is a phenomenon that emerged only in the 1990s and that it is restricted to a small high-tech sector. Using data on individual firms taken from a survey, Baldwin and Gellatly (1998) challenge the latter view and argue that high-tech firms can be found in many industries. This paper uses an alternate source of micro-data to investigate the issue further. It uses Census of Population data to classify workers into the more knowledge-intensive occupations and then investigates how the share of these workers has varied over time and across sectors. In doing so, it allows us to investigate whether the emergence of the 'knowledge economy' has occurred only recently and whether is it restricted to relatively few sectors.

The paper is organized around a key set of questions:

1) *Has the knowledge economy grown dramatically only in recent years or has it been a continuous process over the 1971-1996 period?*

   The knowledge segment of the workforce has grown at about the same rate over each of the last three decades.

2) *Have one group of knowledge workers grown faster than others?*

   Professionals and managers have grown more than technical occupations.

3) *Has the educational attainment of the different groups increased at different rates?*

   The probability of a university degree has increased most in professional occupations. Only 44% of professional occupations had a post secondary degree in 1971 but 68% had such a degree in 1996.

4) *Have relative earnings in the knowledge occupations increased?*

   While knowledge based occupations have significantly higher wage rates, their relative advantage has not increased over most of the period.

5) *Has the importance of knowledge workers increased more in one industrial sector than another?*

Growth in the proportion of workers who are knowledge workers has been about equal in both goods and service industries.

Within the business sector, there are large differences in the percentage of employment that is found in knowledge based occupations, with finance, insurance, real estate, communications and mining having the highest percentages in 1996. But growth has been relatively widespread across all individual industries, thereby demonstrating that the knowledge economy has penetrated all industries.

6) *Have knowledge workers grown equally in both the male and female segments of the labour force?*

A greater percentage of males are in knowledge occupations than females. Over time, the increase in the business sector has been faster for males than for females.

7) *Has the evolution of the knowledge sector influenced some regions more than others?*

Increases in the share of employment in knowledge occupations have occurred across all regions. Ontario and Quebec experienced the greatest percentage point changes. However, this is primarily the effect of industrial and urban structure. After we allow for industry and urbanization differences in a multivariate analysis, there are few significant differences between provinces.

Throughout the study period, the percentage of workers in knowledge occupations was much higher in urban than in rural areas, but this disparity has lessened over the study period.

Chapter 1. Introduction

It is often claimed that there have been substantial shifts within the Canadian and global economies and that a 'new economy' is emerging or has already emerged.

The new economy is described in the media, policy documents, and academic literature as being increasingly based upon knowledge where human capital, skills, innovation and technology are necessary to be competitive. A number of studies have sought to understand the nature and extent of the structural changes that are occurring globally and within Canada in response to, or as part of, this shift towards a 'new economy'.

Many of these studies have defined knowledge intensity at the industry-level (Lee and Has, 1996; Gera and Mang, 1997). These studies implicitly assume that industries are homogenous in nature—that entire industries can be defined as belonging to the new economy while others are separate from it. In contrast, there are those who argue that the emerging 'new economy' is not restricted to a handful of industries but is more pervasive, involving a series of changes in the nature of work and production driven by technological advance, as well as other factors (Lavoie and Roy, 1998). For example, Baldwin and Gellatly (1998) use results of a survey on financing and operating practices to examine the innovative capacity of newly formed firms. They find that the existence of high-technology firms is not confined to industries commonly thought of as being high-technology industries.

Normally, industries are classified in a dichotomous fashion as either belonging or not belonging to the new economy because the data that are commonly available and that are used for classification purposes pertain to the industry as a whole as opposed to firms within the industry—measures of R&D intensity, technology use, output, employment and productivity growth.

An exception is provided by Baldwin and Gellatly (1998) who use a survey of new firms to classify each firm as being high knowledge as opposed to low knowledge to calculate the percentage of the producers within each industry that fit the profile of high knowledge firms. But surveys such as this are rare and the fact that they have only been recently developed means they do not permit us to compare changes over time.

An alternate source of micro-data that allows a more detailed examination of the composition of an industry is provided by information on the nature of the workforce in an industry. Data on occupations of workers allow an alternate method of classifying an industry as being one that relies heavily on skilled workers of a certain type. As such, occupational data

allow us to examine how intense the knowledge activity is within an industry. Moreover, data on occupations have been collected for several decades and thus potentially allow us to plot changes over time.

Of course, many studies of changes that have occurred over time are hampered by shifts or breaks in classifications or by a lack of consistent data sources. This is also the case for occupational data. Occupational classifications have changed frequently, some times drastically. In 1991, Statistics Canada introduced a new Standard Occupational Classification (SOC) that replaced the 1980 SOC. The new classification "differs substantially in structure and content from earlier systems" (Marshall, 1996). One of the goals of this paper is to attempt to overcome these changes by creating a concordance based on aggregate-level occupation groups using previous taxonomies and average wage rates.

This paper contributes to the discussion of Canada's 'new economy' by addressing a number of related questions:

- To what extent has there been growth in knowledge-based occupations and what are the dimensions and characteristics of this change between 1971 and 1996?
- How has the growth of knowledge-based occupations differed across Canadian industries?
- Are there geographic or regional differences in the development and growth of a knowledge-based economy?

We use the Canadian Census of Population and occupational classifications derived therefrom to address these questions. Data from the 1971, 1981, 1986, 1991, and 1996 Censuses are employed to examine how the proportion of knowledge-based occupations has changed over this 25-year period.

The remainder of the paper is organized as follows:

Chapter 2 provides an overview of previous research that has classified and defined Canada's knowledge-based economy. Chapter 3 introduces and develops the taxonomy used in this paper to define knowledge-based occupations. Chapter 4 presents an overview of how Canada's knowledge-based economy has evolved over the 25-year period between 1971 and 1996 and examines the gender, education, wage, and sectoral characteristics of this change. Chapters 5 and 6 extend this analysis to examine the industrial and geographic dimensions of Canada's evolving knowledge-economy in more detail. Chapter 5 examines 15 broad industries within the business sector through an occupational lens. Due to the heterogeneity of the manufacturing sector, we examine this sector in more detail. Chapter 6 investigates how the business sector has evolved across Canada's vast landscape by examining the regional and urban-rural dimensions of this evolution. Chapter 7 uses a multivariate analysis to determine whether or not geographic differences persist after controlling for differences in industrial structure. A summary of our key findings and their importance is presented in chapter 8.

Chapter 2. Defining the 'New Economy'

Studies that have addressed the emergence or evolution of the so-called 'new economy' have defined the new economy in different ways. Some have adopted a firm- or industry-based level of analysis to identify and measure shifts in the Canadian economy, while others have examined the same issue from a human capital or labour market perspective.

In the first case, technology use, research and development (R&D) intensity, and other measures of technological advance have been used to argue that the Canadian economy is undergoing (or has undergone) a significant transformation. Some have examined employment, output and productivity changes from an industrial perspective to make a similar argument (Gera and Massé, 1996; Gera and Mang, 1997).

In contrast, others have adopted a skill-based approach, using educational attainment, training, and occupation to examine the changing dimensions of Canada's human capital stock and the Canadian labour market (Lavoie and Roy, 1998; Boothby, 1999; Baldwin and Johnson, 1996; Gera, et al., 1999).

There is no single or perfect measure of knowledge intensity, production or use. These alternatives provide different insights into the complexities associated with an evolving and changing economy (Howitt, 1996). This study takes a human capital approach to defining and examining the evolution of Canada's knowledge-based labour force across regions and industries. To start with, we provide a review of previous empirical studies that have examined Canada's knowledge-based economy.

Lee and Has (1996) focus on defining high technology and knowledge-intensive industry sectors by ranking industries based on a number of human capital and research and development measures. The authors identify three human capital measures: the proportion of scientific personnel, the proportion of persons with post-secondary education, and the proportion of knowledge workers within an industry. Using the 1980 SOC, they define knowledge workers as belonging to occupations in natural sciences, engineering and mathematics, education, managers and administrators, social sciences, law and jurisprudence, medicine and health, and writing.

Gera and Massé (1996) use Statistics Canada's input-output tables to examine how Canada's industrial structure has changed over the period between 1971 and 1991 from an employment perspective. They divide the manufacturing sector into three sectors (high, medium and low knowledge) using a number of different classification schemes that discriminate on the

basis of knowledge, technology, wage, and skill intensity. The service sector is divided into three sub-sectors based on level of knowledge intensity. They find that employment growth has been concentrated in high skill, high wage, science-based, high technology, and high knowledge industries.

The approaches of both Lee and Has (1996) and Gera and Massé (1996) mask the heterogeneity of firms and labour markets within industries. To overcome this, other researchers have tried to address the measurement of knowledge intensity using occupation-based approaches. Following approaches used in the United States, Lavoie and Roy (1998) study employment change in Canada between 1971 and 1991. They classify workers into five occupational groupings (knowledge, management, data, services, and goods) based on the 1980 SOC. Arguing that knowledge workers are not a homogenous group, they subdivide knowledge workers into five groups: pure science, applied science, computer science, engineering, and social sciences and humanities.

Using census data from 1971, 1981, 1986, and 1991[1], Lavoie and Roy (1998) examine the growth of occupation groups and find that employment in what they define as knowledge-based occupations grew faster than other categories, with the exception of management occupations. Boothby (1999) modifies Lavoie and Roy's classification system by distinguishing between skilled and unskilled goods workers and further subdividing data workers into those who manipulate data and those who apply (but do not create) a high degree of knowledge in their tasks. Using data from the International Adult Literacy Survey (IALS), Boothby (1999) examines the differences in knowledge and literacy skills of particular occupational groupings. He finds that basic skills such as reading and writing are pervasive across occupational categories, but that knowledge workers, data workers, and managers use these skills more intensively and that knowledge workers have higher levels of education than other occupations.

Gera, et al. (1999) use the framework developed by Lavoie and Roy (1998), as well as the National Occupational Classification[2] (NOC) to classify industries by the skill levels of the workers employed therein. They ask whether skill intensity rose across industries between 1981 and 1994, and whether or not biased technological change was the main reason for an increased demand for skilled workers. Using data from a number of different Statistics Canada surveys, their results indicate that skill intensity increased over the period, especially in the service sector. Moreover, most industries increased their percentage of knowledge workers, suggesting that a shift towards a knowledge-based economy was pervasive across industrial sectors. Using a shift-share analysis, Gera et al. (1999) determine that within-industry shifts accounted for most of the upskilling in the labour force.

Recently, Statistics Canada investigated the movement of knowledge workers between Canada and other countries, with particular emphasis on the United States (Zhao et al., 2000a, 2000b). This study uses the 1991 SOC to define fourteen broad knowledge-based occupational categories, ranging from engineers, doctors, and teachers to athletes, writers, and entertainers.[3] Using data from a wide variety of Canadian and American sources, Zhao et al. (2000a, 2000b) find that there is a 'brain drain' to the United States in occupations and

industries viewed as being ‘knowledge-based’. However, this is tempered by a ‘brain gain’ of educated migrants from elsewhere. Moreover, the magnitude of these gains and losses is relatively small, although there has been an upward trend in emigration in recent years.

Endnotes

[1] Lavoie and Roy (1998) provide 1996 estimates using Statistics Canada's Labour Force Survey (LFS) since this survey maintains occupational coding that uses the 1980 SOC. Census data for 1996 uses the 1991 SOC, which can not be easily mapped into their occupational framework.

[2] The NOC is maintained by Human Resources Development Canada (HRDC) and divides workers into four skill levels (excluding managers): professional workers (skill level A), technical skilled workers (skill level B), intermediate workers (skill level C), and unskilled workers (skill level D). This classification is linked to the 1980 SOC.

[3] Since the data used to discuss occupations are from the post-1991 period, the authors did not have to address the issues related to disparate classification schemes.

Chapter 3. Data and definitions

As discussed above, studies that have focussed on the human capital elements of the knowledge economy have encountered the problem of defining 'knowledge workers'. Some studies have tried to examine knowledge from the perspective of education level or 'skill'. Others have used occupational definitions. As a result of a new Canadian standard adopted in 1991, difficulty arises in using occupational definitions to study changes over time since there have been significant changes in the way that occupations were defined and coded. While a number of Canadian studies have defined knowledge workers from an occupational perspective, none have developed a mechanism or means for overcoming this data discontinuity over time to study changes since 1971 into the 1990s. In this chapter, we present a method for overcoming this break in occupational classifications, thereby allowing for the analysis of changes in broad occupation categories over the last thirty years.

The analysis presented in this paper uses data from the 1971, 1981, 1986, 1991, and 1996 Censuses. As is often the case in time series analysis, there are problems related to historical comparability and definitional consistency. Specifically, changes occur in the definition of the labour force and the classification of industries and occupations. A number of steps were taken to overcome these problems.

First, we limit our discussion to the employed labour force, using the 1971 Census labour force activity concept to ensure consistency and historical comparability.[4] Second, industrial sectors are defined using the 1980 Standard Industrial Classification (SIC). Industry data for the 1971 and 1981 Censuses used the 1970 SIC. Thus, these data are adjusted to ensure comparability over the entire 25-year study period. The 1986 Census has industry level data for both of these industrial classifications and, therefore, provides a mechanism for building a concordance to adjust the 1971 and 1981 Census data to the 1980 SIC (see Appendix 1).

More problematic is the creation of consistent occupational groups. In this paper, we create a taxonomy that uses 47 broad occupation groups that we use to track changes over time.[5] We then create a statistical concordance between the 1971, 1980, and 1991 SOC systems to allocate each individual to one of these 47 broad occupational categories. This provides consistent occupational groups for our analysis. Given the complexities of creating a statistical concordance, in this chapter we provide only a summary of this exercise (refer to Appendix 2 for details).

We define 47 occupation groups based on the 1991 classification. Drawing upon previous work, we identify several of these as heavily involving knowledge workers (see Lee and Has, 1996; Lavoie and Roy, 1998; Zhao, et al., 2000a). We recognize that all occupations require a knowledge base, but we define a set as requiring a different knowledge base and for this study refer to this group as being 'knowledge workers'. Knowledge workers are defined using the 1991 SOC. Eight of the forty-seven occupation groups were considered to be knowledge-based. When uncertainty arose as to whether a particular occupation should be classified to one of the broad knowledge categories, we used relative wage rates to determine which of the 47 broad occupational groupings it should be assigned to (see Appendix 2).

The knowledge occupations fall into three broad classes. These are:

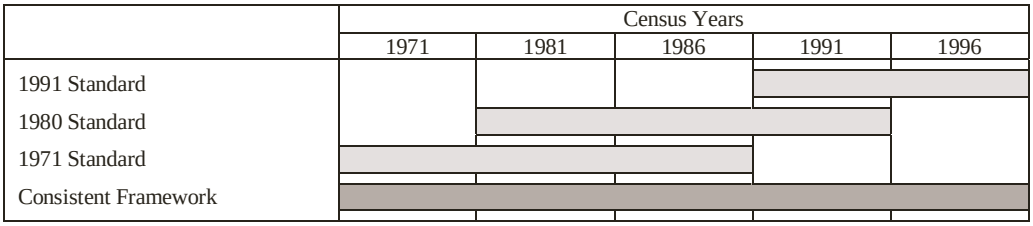
- *professional occupations*—characterized by high relative wages and a high proportion of persons who have completed university-level education;
- *management occupations*—characterized by high relative wages but with a lower proportion of persons who have completed university-level education; and
- *technical occupations*—characterized by lower relative wage rates and a high proportion of persons with post-secondary education or above.

The specific 1991 SOC occupations included in the three knowledge worker categories are described in Table 1.

Following the creation of the 47 occupation groups, a method of concordance was developed to assign the occupations in the censuses before 1991 to one of these groups. There are three different occupational systems—one each associated with the 1971, 1980 and 1991 SOC systems. Figure 1 depicts the availability of occupational data for each Census year.

We produce a statistical concordance between the three systems and the 47 broad occupational categories based on the 1991 Standard Occupational Classification. We then use this grouping to produce consistent estimates of the size and extent of the knowledge-based economy over time.

Figure 1. Conceptualizing an occupational concordance



Note: Census data from 1976 were not available for this analysis.

Table 1. Description of 'knowledge worker' categories

Type of Knowledge Worker	Description
Professional occupations	· Auditors, accountants and investment professionals · Human resources and business service professionals · Physical science professionals · Life science professionals · Civil, mechanical, electrical and chemical engineers · Other engineers · Architects, urban planners and land surveyors · Mathematicians, systems analysts and computer programmers · Physicians, dentists and veterinarians · Optometrists, chiropractors and other health diagnosing and treating professionals · Pharmacists, dietitians and nutritionists · Therapy and assessment professionals · Judges, lawyers and Quebec notaries · Policy and program officers, researchers and consultants · University professors and assistants · College and other vocational instructors · Secondary and elementary school teachers and counselors · Librarians, archivists, conservators and curators · Writing, translating and public relations professionals · Creative and performing artists
Management occupations	· Legislators and senior management · Administrative services managers · Managers in engineering, architecture, science and information systems · Sales, marketing and advertising managers · Managers in financial and business services · Managers in communication (except broadcasting) · Managers in health, education, social and community services · Managers in public administration · Managers in art, culture, recreation and sport · Managers in primary production (except agriculture) · Managers in manufacturing and utilities
Technical occupations	· Technical occupations in physical sciences · Technical occupations in life sciences · Technical occupations in civil, mechanical and industrial engineering · Technical occupations in electronics and electrical engineering · Technical occupations in architecture, drafting, surveying and mapping · Other technical inspectors and regulatory officers · Transportation officers and controllers · Nurse supervisors and registered nurses · Medical technologists and technicians (except dental health)

Note: Occupation descriptions are based on the 1991 Standard Occupational Classification. See also Appendix 2.

Endnotes

[4] While the Census labour force concept has remained reasonably constant between 1971 and 1996 there have been some minor changes to the concept, as well as to the questions asked and the processing procedures used. See Statistics Canada (1999) for a discussion of changes in the Census labour force concepts used over the period between 1971 and 1996.

[5] While detailed occupational information would be more desirable than aggregate groups, it is difficult to maintain detail over the study period due to the disparate nature of the occupational classification systems.

Chapter 4. Changing dimensions of Canada's knowledge base

This chapter examines the occupational shifts between 1971 and 1996 by applying the consistent occupational framework developed in chapter 3 to Census data. In doing so, we examine the education, gender, sectoral and wage dimensions of this change, especially for the knowledge-based occupations.

4.1 Overall change

Between 1971 and 1996, Canada experienced a substantial increase in its knowledge worker base.[6] Moreover, the knowledge worker segment of the employed labour force grew faster than the overall workforce (Figure 2).

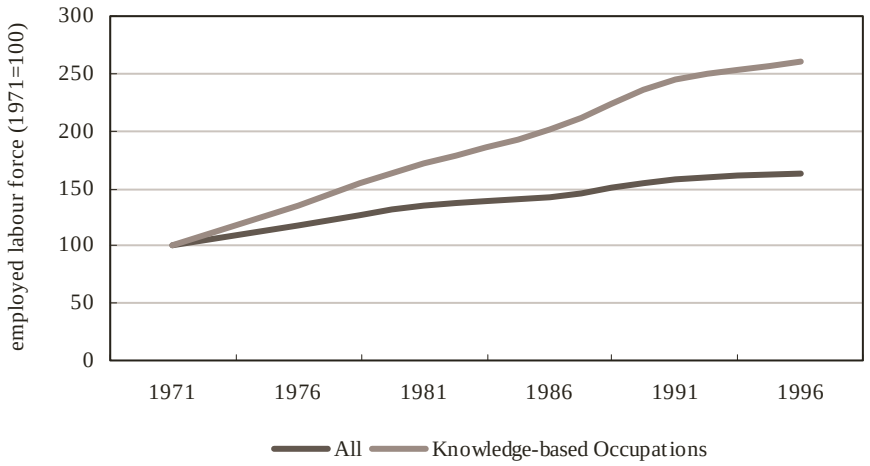
Evidence that the proportion of the employed labour force in knowledge occupations has steadily increased is presented in Table 2. In 1971, only 14% of the employed labour force were in knowledge occupations; by 1996, this had increased to 22%. While this increase was experienced by all three groups of knowledge workers, professional occupations account for the largest proportion of knowledge workers throughout the study period. However, growth over the period was highest in management occupations (225%) as compared to professional occupations (43%) or technical occupations (31%).[7]

Table 2. Employed labour force by occupation, 1971-1996

	Share of employment[1] (%)					
	1971	1976[2]	1981	1986	1991	1996
All Knowledge-based occupations	*13.8*	*15.7*	*17.5*	*19.5*	*21.5*	*22.2*
Management occupations	1.6	2.6	3.6	4.6	5.4	5.2
Professional occupations	8.7	9.3	9.9	10.8	11.3	12.4
Technical occupations	3.5	3.7	4.0	4.2	4.7	4.6
All other occupations	*86.2*	*84.3*	*82.5*	*80.5*	*78.5*	*77.8*
All occupations	**100**	**100**	**100**	**100**	**100**	**100**

[1] Defined as the employed labour force using the 1971 Census labour force concept.
[2] Data for 1976 is estimated as the midpoint between 1971 and 1981.

Figure 2. Change in employment, 1971-1996 (1971=100)



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.
Data for 1976 is estimated as the midpoint between 1971 and 1981.

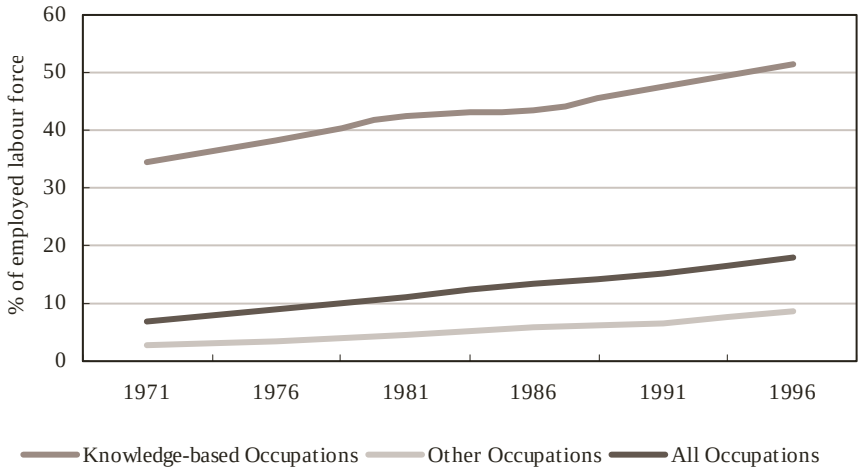
4.2 Educational attainment

In this section, we examine the extent to which knowledge workers are typified by higher levels of education and how this has changed through time. The general increase in the education level of the workforce in general over the past few decades has been well-documented (Gera and Massé, 1996; Picot and Heisz, 2000). Therefore, our findings should be placed in the context of this phenomenon.

We use two education variables to investigate the prevalence of higher levels of education in the workforce and how this varies across occupation classes. First, we examine the proportion of the workforce with a university-level or professional degree. The second measure takes a broader approach to higher education and includes all persons in the employed labour force who have any post-secondary education.

There has been an increase in the proportion of the labour force that has completed a university-level degree (Figure 3); this concurs with other studies. It is also evident that there is a significant difference in the incidence of degree completion between knowledge-based occupations and other occupations. In 1971, 34% of knowledge workers had university level degrees compared to slightly less than 3% of other workers. By 1996, more than half of the people in knowledge-based occupations had university-level degrees compared to less than 10% of other occupations and 20% of the total employed labour force. While knowledge-based occupations have a significantly larger proportion of degree holders, the proportion of degree holders is growing faster in other occupational groups (Table 3). These findings confirm that the upskilling of the workforce has affected all occupations within the labour force, but that there are still occupational groups that have relatively higher levels of education.

Figure 3. Employed labour force with university-level degree, 1971-1996



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.
Data for 1976 is estimated as the midpoint between 1971 and 1981.
Degree completion includes the completion of bachelor, professional, masters or doctorate level university degree.

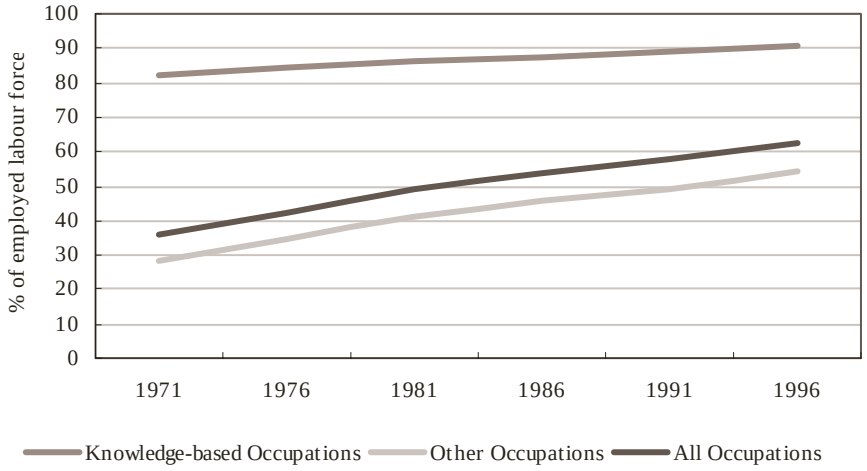
Within knowledge-based occupations, it is evident that there is a general increase in the proportion of persons with degrees in professional and technical occupations (Table 3). In 1971, slightly less than 45% of professionals had university degrees; by 1996 this had increased to slightly less than 70%. While professionals represent the group with the highest proportion of university graduates, the highest growth rate was experienced in the technical occupation group. The proportion of management occupations with university degrees was relatively constant over the study period and—in fact—experienced a decrease during the 1980s. This may reflect the differences in the types of work done by managers and the value placed on work experience rather than formal education in the ability of managers to perform their tasks (Lavoie and Roy, 1998).

Table 3. Educational attainment by occupation—degree completion (%), 1971-1996[1]

	1971	1976[2]	1981	1986	1991	1996	Growth[3]
All knowledge-based occupations	*34.3*	*38.3*	*42.4*	*43.6*	*47.7*	*51.3*	*1.6*
Management occupations	37.4	34.3	31.3	33.2	37.8	40.9	0.4
Professional occupations	44.4	51.9	59.3	60.3	66.4	68.4	1.7
Technical occupations	7.7	9.1	10.5	11.9	14.2	17.2	3.3
All other occupations	*2.7*	*3.6*	*4.5*	*5.9*	*6.5*	*8.6*	*4.8*
All occupations	**7.1**	**9.1**	**11.2**	**13.3**	**15.3**	**18.0**	**3.8**

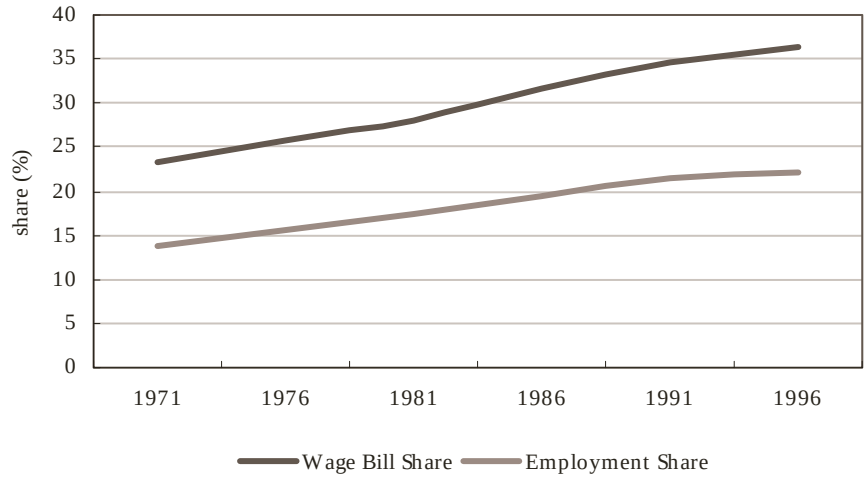
[1] The employed labour force is defined using the 1971 Census labour force concept. Includes completion of bachelor, professional, masters or doctorate level university degree.
[2] Data for 1976 is estimated as the midpoint between 1971 and 1981.
[3] Average annual compound rate of growth between 1971 and 1996.

Figure 4. Employed labour force with post-secondary education, 1971-1996



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.
Data for 1976 is estimated as the midpoint between 1971 and 1981.
Post-secondary education includes any college, university or other training.

Figure 5. Wage bill and employment shares for knowledge-based occupations, 1971-1996 (in percentage)



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.
Data for 1976 is estimated as the midpoint between 1971 and 1981.

The trend towards a more educated labour force can be seen even more clearly if we extend our definition of educated persons to include persons with any post-secondary education. Between 1971 and 1996 the proportion of the total employed labour force with some post-secondary education increased from slightly more than 35% to over 60% (Figure 4). There is a higher proportion of persons with post-secondary education in knowledge-based occupations compared to other occupations, although this gap is slowly narrowing.

Table 4. Educational attainment by occupation—post-secondary education[1] (%), 1971-1996							
	1971	1976[2]	1981	1986	1991	1996	Growth[3]
All knowledge-based occupations	*82.0*	*84.2*	*86.4*	*87.2*	*89.2*	*90.9*	*0.4*
Management occupations	69.9	71.3	72.8	75.0	78.9	81.5	0.6
Professional occupations	85.4	88.1	90.7	91.3	93.9	94.7	0.4
Technical occupations	79.1	83.6	88.0	89.9	89.7	91.4	0.6
All other occupations	*28.2*	*34.6*	*41.1*	*45.5*	*49.2*	*54.5*	*2.7*
All occupations	**35.6**	**42.3**	**49.0**	**53.6**	**57.8**	**62.6**	**2.3**

[1] The employed labour force is defined using the 1971 Census labour force concept. Post-secondary education includes any college, university or other training.

[2] Data for 1976 is estimated as the midpoint between 1971 and 1981.

[3] Average annual compound rate of growth between 1971 and 1996.

The general upskilling of the labour force can be seen in the growth rates of the various occupation groups (Table 4). It is not surprising that growth is highest outside of the knowledge-based occupations, since the latter group already had high proportions of educated persons. By 1996, more than 90% of knowledge-based occupations were held by persons with at least some level of post-secondary education. When the education measure is broadened to include any level of post-secondary education, the differences between professional and technical occupations are greatly reduced and—in fact—there is a higher proportion of educated persons in the technical group compared to the management category.

4.3 Earnings and wages of knowledge-based occupations

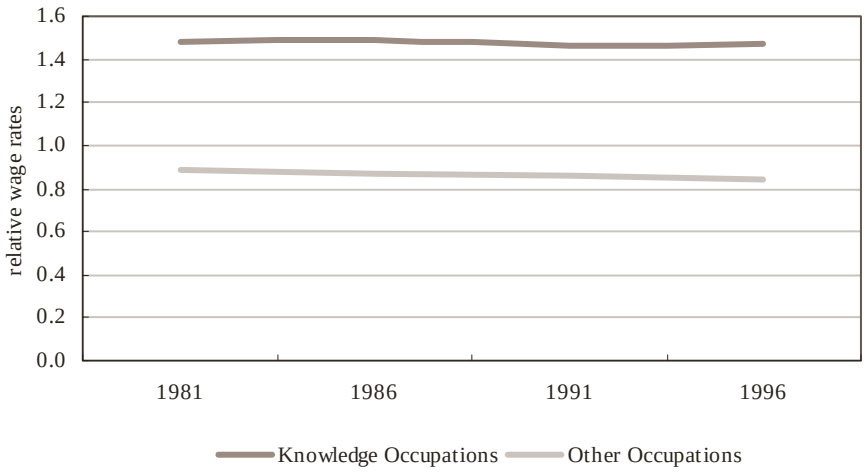
At the root of many discussions surrounding the knowledge economy is the notion that knowledge-based jobs receive higher levels of compensation. We use relative average hourly wage rates to determine if knowledge-based occupations receive higher levels of compensation (relative to all occupations) and whether this has changed substantially over the study period.

Estimates of hours were not available for 1971. Consequently, this part of the analysis only covers the period from 1981 to 1996. Additionally, some error is introduced in estimating the total number of hours worked using Census data due to differences in the reference periods for the variables needed to calculate the total number of hours worked in a year (see Appendix 2 for a discussion of these data limitations).

Overall, there is a significant difference between the wage rates of knowledge-based occupations and other occupations (Figure 6). Knowledge occupations maintained wage rates that were substantially higher over the period. There was very little change in the relationship between wage rates for knowledge-based occupations and overall wage rates. Moreover, the average hourly compensation rate for occupations outside of the knowledge group has declined slightly (relative to overall average wage rates) over the period between 1981 and 1996.

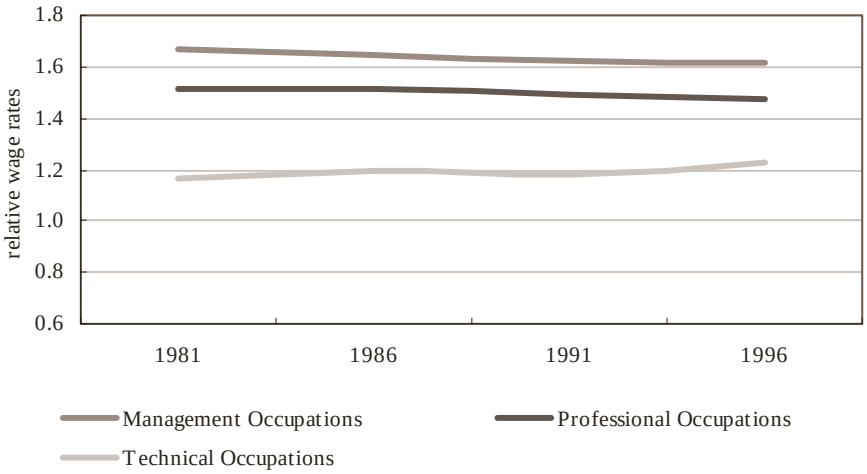
We examine the three knowledge-based occupation groups (management, professional, and technical occupations) separately. There is a hierarchy in the relative levels of compensation received by each group with managers receiving the highest wages and technical workers receiving the lowest. However, all receive higher wages relative to other occupations (Figure 7).

Figure 6. Relative average hourly wage rates by occupation, 1981-1996



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.
Relative wage rates are equal to one if wage rates are equal to the wage rates for the employed labour force.

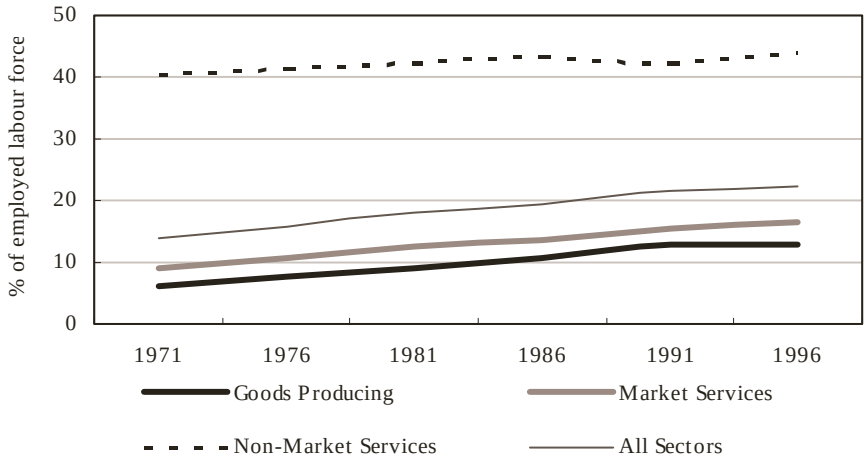
Figure 7. Relative average hourly wage rates for knowledge-based occupations, 1981-1996



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.
Relative wage rates are equal to one if wage rates are equal to the wage rates for the employed labour force.

While there was stability in the overall relative wages of knowledge-based occupations, there are differences within this group. Both management and professional occupations have experienced a decline in their relative wage rates between 1981 and 1996, whereas technical occupations have experienced an increase in their relative wages during this same period.

Figure 8. Knowledge intensity by sector, 1971-1996



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.

Data for 1976 is estimated as the midpoint between 1971 and 1981.

4.4 Shifts in Canada's knowledge base: Sectoral evidence

For the purposes of this analysis, we divide the overall economy into three sectors: goods producing[8], market services, and non-market services.[9] It is evident that the growth in Canada's knowledge-based economy has been spurred by growth in the business sector (goods producing and market services). Both the goods producing and market services sector experienced an increase in their level of knowledge intensity (Figure 8). In 1971, the market services sector was slightly more knowledge intensive than the goods producing sector (9% as compared to 6%). In 1996 this remained true, as knowledge intensity had increased to 17% in the market services sector and 13% in the goods producing sector. The public sector (non-market services) had a much higher level of knowledge intensity throughout the study period, rising from 40% to 44%. This is not surprising given that we define knowledge workers broadly and include a large number of occupations that are primarily in the public sector, such as doctors, nurses, and university professors. Over the study period there was a much smaller increase in the level of knowledge intensity within the non-market service sector.

As Table 5 indicates, the increase in knowledge intensity has been concentrated in the business sector (goods producing and market services). While the market service sector had a higher proportion of knowledge workers, the goods producing sector experienced a higher growth rate. Growth was strong through the 1970s and 1980s; however growth in knowledge intensity declined in the early 1990s. It is interesting to note that while overall growth in knowledge intensity was low in the early 1990s, the market services sector had a higher growth rate during this period. While the knowledge intensity of the non-market services sector is high, it has had a much slower growth rate over the 25-year study period.

Table 5. Average annual growth rates of knowledge intensity by sector (%), 1971-1996					
	1971-81	1981-86	1986-91	1991-96	1971-96
Goods producing	3.9	2.9	3.9	0.4	3.0
Market services	3.4	1.5	2.9	1.2	2.5
Non-market services	0.4	0.5	(0.4)	0.6	0.3
All sectors	**2.4**	**2.2**	**1.9**	**0.6**	**1.9**

Note: Knowledge intensity is measured as the employment share of knowledge-based occupations. Average annual growth rates are calculated as compound rates of growth. Includes only the employed labour force defined using the 1971 Census labour force concept.

The shift of employment from the goods-producing sector to the service sector has been well documented. However, despite stagnation in the overall level of employment in the goods producing sector, the number of knowledge workers in this sector continued to increase until the 1990s (Figure 9). In the market services sector, the overall level of employment increased, as did the number of knowledge workers. Indeed, the growth in the absolute number of knowledge workers in both the goods producing and market service sectors outpaced the growth of each sector as a whole.

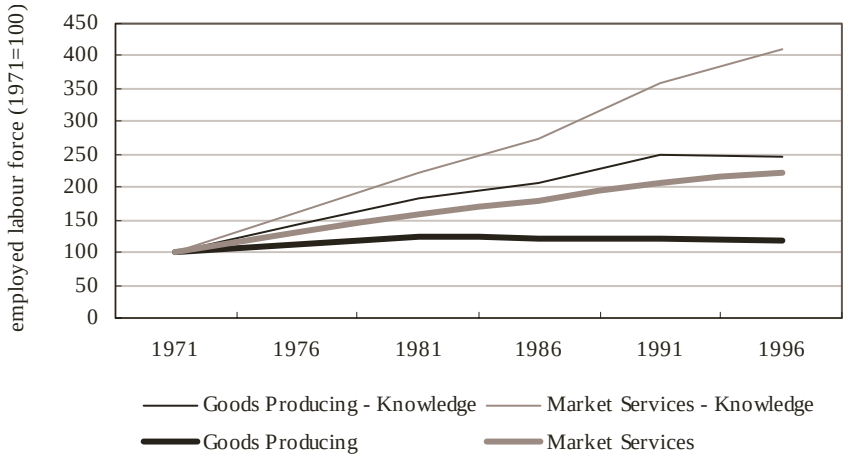
The market service sector has a higher proportion of employment in knowledge-based occupations compared to the goods producing sector. In addition to small differences in the size and growth rate of each sector, there are some differences in the composition of the knowledge-based workforce (Table 6).

Growth levels in the management category are high across each sub-sector. It should be noted that some of the growth prior to 1981 in this category is artificial, as it results from changes in the occupational coding procedures used between the 1971 Occupational Classification Manual (OCM) and the 1980 Standard Occupational Classification (SOC) (Lavoie and Roy, 1998). While there may be upward bias in these estimates, it affects each sector equally. The management category exhibits consistent growth until the 1990s, when there is a slight decline in the proportion of managers.

Table 6. Composition of knowledge-based occupations in the business sector, 1971-1996							
	Share of employment[1] (%)						
	1971	1976[2]	1981	1986	1991	1996	Growth[3]
Business sector	**7.7**	**9.4**	**11.1**	**12.4**	**14.6**	**15.4**	**2.8**
Management	1.3	2.3	3.4	4.2	5.5	5.2	5.8
Professional	4.5	5.0	5.6	6.2	6.6	7.6	2.1
Technical	1.9	2.0	2.1	1.9	2.5	2.6	1.3
Goods producing	**6.3**	**7.7**	**9.2**	**10.6**	**12.8**	**13.0**	**3.0**
Management	1.2	2.1	3.1	4.1	5.3	5.1	6.0
Professional	3.3	3.6	3.9	4.4	4.3	4.6	1.3
Technical	1.8	2.0	2.1	2.1	3.2	3.4	2.5
Market services	**8.9**	**10.7**	**12.5**	**13.5**	**15.6**	**16.6**	**2.5**
Management	1.4	2.5	3.6	4.3	5.5	5.3	5.6
Professional	5.6	6.2	6.8	7.3	7.9	9.0	1.9
Technical	2.0	2.1	2.2	1.9	2.2	2.2	0.5

[1] Includes only the employed labour force defined using the 1971 Census labour force concept.
[2] Data for 1976 is estimated as the midpoint between 1971 and 1981.
[3] Average annual compound rate of growth between 1971 and 1996.

Figure 9. Change in employment by sector, 1971-1996 (1971=100)



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.
Data for 1976 is estimated as the midpoint between 1971 and 1981.

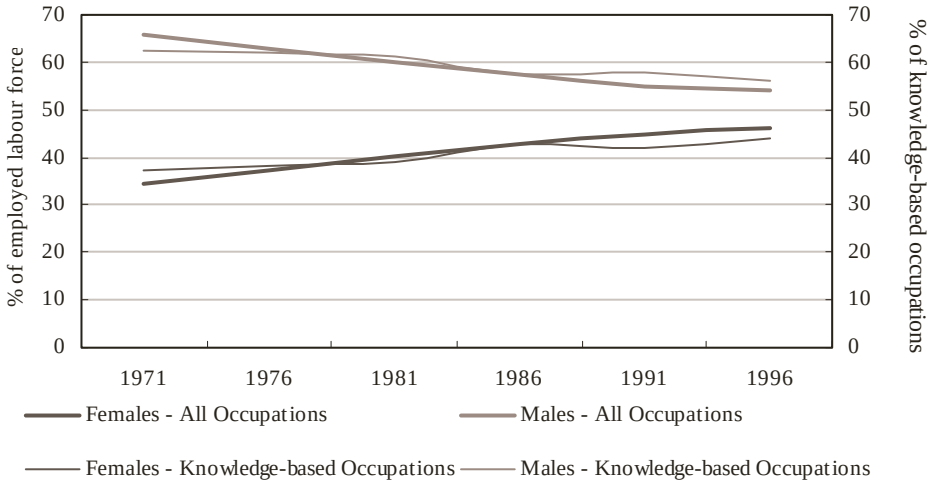
The real differences lie in the proportion of technical and professional occupations within each sector. Each sector had a similar proportion of knowledge workers in technical occupations until the mid-1980s, when the proportion of technical workers began to grow in the goods producing sector whereas it remained relatively constant in the market services sector. The shares of professional occupations increased in both the goods producing and market services sector. While growth in professional occupations was much higher in the market services sector, growth in technical occupations was much higher in the goods producing sector.

4.5 Gender dimensions of Canada's knowledge base

It has been well documented that women have substantially increased their presence in the workforce over the past few decades (Drolet, 2000; Picot and Heisz, 2000). In this section we investigate whether or not these gender shifts in the overall labour force are reflected in the knowledge-based labour force. As we can see in Figure 10, the gender composition of knowledge-based occupations closely mirrors the composition of the total employed labour force. However, it is evident that the pace of change is slower in knowledge-based occupations compared to all occupations. In the early portion of the study period, females accounted for a greater proportion of the knowledge-based workforce than they did in the overall workforce. By the end of the study period, the opposite was true.

To remove the effect of growth in the overall labour force, we examine the proportion of knowledge-based occupations within each gender group. The subset of the male employed labour force that is knowledge-based has grown faster than its female counterpart (Table 7). Growth has been concentrated in the management group for both males and females, although this is more pronounced for females.

Figure 10. Composition of employed labour force by gender and occupation, 1971-1996 (in percentage)



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.

Data for 1976 is estimated as the midpoint between 1971 and 1981.

As noted previously, within each group the overall proportion of knowledge-based occupations has been similar with women having a slightly higher proportion in the early period and men having a higher proportion in the later part of the period. When this is further divided into the three main groups of knowledge-based occupations, we can see that the proportion of professionals within each group is similar. However, on a proportional basis, more female knowledge workers are in technical occupations and more male knowledge workers are in management occupations.

In the previous section, we illustrated that there were differences between sectors in the economy. Specifically, the business sector (goods producing and market services industries) and the public sector (non-market services) have experienced significantly different growth rates. Therefore, in the following sections we examine gender differences in the business and public sectors separately.

Table 7. Composition of knowledge-based occupations by gender (all sectors), 1971-1996

	Share of employment[1] (%)						
	1971	1976[2]	1981	1986	1991	1996	Growth[3]
Both	**13.8**	**15.9**	**17.5**	**19.5**	**21.5**	**22.2**	**1.9**
Management	1.6	2.8	3.6	4.6	5.4	5.2	4.7
Professional	8.7	9.4	9.9	10.8	11.3	12.4	1.4
Technical	3.5	3.8	4.0	4.2	4.7	4.6	1.2
Females	**15.1**	**16.2**	**17.0**	**19.5**	**20.0**	**21.1**	**1.3**
Management	0.8	1.5	1.9	3.0	3.3	3.5	6.1
Professional	9.3	9.5	9.6	10.7	11.0	12.3	1.1
Technical	5.0	5.3	5.4	5.8	5.7	5.4	0.3
Males	**13.2**	**15.8**	**17.9**	**19.5**	**22.6**	**23.1**	**2.3**
Management	2.1	3.5	4.7	5.8	7.1	6.6	4.7
Professional	8.4	9.3	10.1	10.8	11.6	12.4	1.6
Technical	2.7	2.9	3.1	2.9	3.9	4.0	1.7

[1] Includes only the employed labour force defined using the 1971 Census labour force concept.
[2] Data for 1976 is estimated as the midpoint between 1971 and 1981.
[3] Average annual compound rate of growth between 1971 and 1996.

4.5.1 Gender differences in the business sector

Similar to the overall economy, the trend in the changing gender composition of the knowledge-based workforce has followed that of all occupations in the business sector (Figure 11). However, there remains a large difference in the distribution of the total employed labour force and the knowledge-based employed labour force in the business sector. The knowledge workforce is composed of a higher proportion of males compared to the overall business sector labour force.

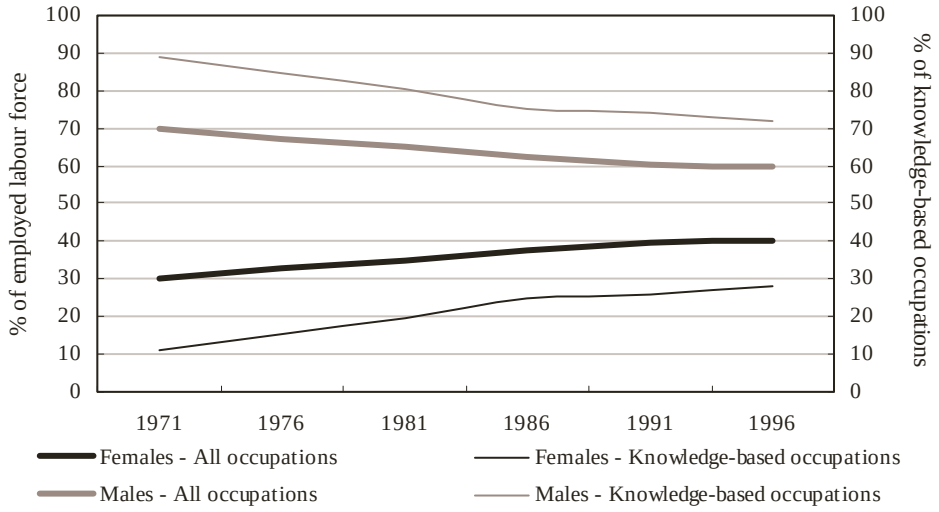
In the business sector, the proportion of knowledge workers was substantially higher in the male employed labour force compared to the female employed labour force (Table 8). In 1971, slightly less than 3% of the female employed labour force was in knowledge-based occupations compared to almost 9% of the male employed labour force. By 1996, slightly less than 11% of the female employed labour force was knowledge-based compared to 18.5% of the male employed labour force.

Table 8. Composition of knowledge-based occupations by gender (business sector), 1971-1996

	Share of Employment[1] (%)						
	1971	1976[2]	1981	1986	1991	1996	Growth[3]
Both	**7.7**	**9.7**	**11.1**	**12.4**	**14.6**	**15.4**	**2.8**
Management	1.3	2.5	3.4	4.2	5.5	5.2	5.8
Professional	4.5	5.1	5.6	6.2	6.6	7.6	2.1
Technical	1.9	2.0	2.1	1.9	2.5	2.6	1.3
Females	**2.9**	**5.1**	**6.3**	**8.2**	**9.6**	**10.8**	**5.3**
Management	0.5	1.3	1.8	2.6	3.2	3.4	8.1
Professional	2.0	3.0	3.7	4.8	5.2	6.3	4.8
Technical	0.5	0.7	0.8	0.8	1.1	1.1	3.3
Males	**9.6**	**11.9**	**13.8**	**14.9**	**17.9**	**18.5**	**2.7**
Management	1.6	3.1	4.3	5.2	6.9	6.4	5.8
Professional	5.5	6.1	6.6	7.1	7.5	8.4	1.7
Technical	2.4	2.7	2.9	2.6	3.4	3.6	1.6

[1] Includes only the employed labour force defined using the 1971 Census labour force concept.
[2] Data for 1976 is estimated as the midpoint between 1971 and 1981.
[3] Average annual compound rate of growth between 1971 and 1996.

Figure 11. Composition of employed labour force by gender and occupation (business sector), 1971-1996 (in percentage)



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.
Data for 1976 is estimated as the midpoint between 1971 and 1981.

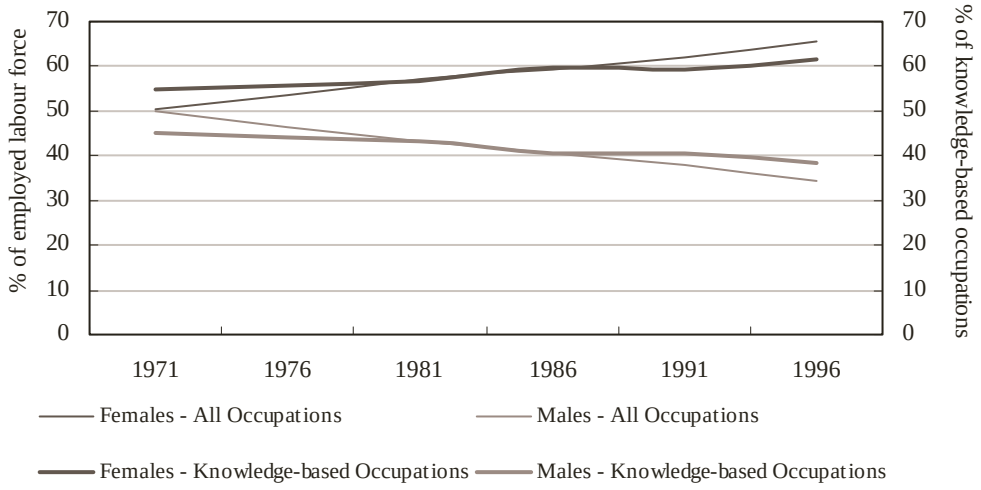
Contrary to the economy as a whole, the proportion of female knowledge workers has grown faster than its male counterpart. However, similar to the overall trend, growth was highest for both males and females in the management group, although the growth rate for women was much higher. The largest gains for women were in the shares for management and professional occupations.

4.5.2 Gender differences in the public sector

Similar to the business sector, the trend in the changing gender composition of the knowledge-based workforce has followed that of all occupations in the public sector (Figure 12). Again, the pace of change in the knowledge-based workforce in the public sector lags that of the public sector as a whole. As in the business sector, the proportion of the workforce accounted for by women is increasing. However, in this case, the shift is from an even split between males and females towards a workforce that is made up of over 65% females.

Again, to remove the effect of growth in the public sector labour force, we examine the proportion of knowledge-based occupations within each gender group. Overall, the proportion of females in knowledge-based occupations decreased slightly from 1971 to 1996, whereas the proportion of males has increased (Table 9). This change is reflected in the growth rates for each group. For men, growth was spread across all three knowledge-based occupation groups whereas for women high growth in the management group was offset by declines in the proportions of professional and technical occupations. Unlike the business sector, the female knowledge worker population is more heavily weighted towards technical occupations. This is not the case within the male knowledge worker population. The male knowledge worker population is composed of a high proportion of professional and management occupations.

Figure 12. Composition of the employed labour force by gender and occupation (public sector), 1971-1996 (in percentage)



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.

Data for 1976 is estimated as the midpoint between 1971 and 1981.

Table 9. Distribution of knowledge-based occupations by gender (public sector), 1971-1996

	Share of employment[1] (%)						
	1971	1976[2]	1981	1986	1991	1996	Growth[3]
Both	**40.3**	**41.4**	**42.2**	**43.2**	**42.4**	**43.7**	**0.3**
Management	3.5	4.2	4.7	5.8	5.2	4.9	1.4
Professional	26.6	26.4	26.3	25.9	25.7	27.7	0.2
Technical	10.3	10.8	11.1	11.6	11.5	11.1	0.3
Females	**44.2**	**42.8**	**41.9**	**43.4**	**40.4**	**41.2**	**-0.3**
Management	1.6	2.1	2.5	3.7	3.4	3.5	3.2
Professional	26.8	24.7	23.4	23.2	22.3	23.9	-0.5
Technical	15.8	15.9	16.0	16.5	14.6	13.8	-0.5
Males	**36.5**	**39.8**	**42.5**	**42.9**	**45.7**	**48.6**	**1.2**
Management	5.4	6.7	7.7	8.8	8.1	7.6	1.4
Professional	26.4	28.4	30.1	29.8	31.3	34.8	1.1
Technical	4.7	4.7	4.6	4.4	6.4	6.2	1.1

[1] Includes only the employed labour force defined using the 1971 Census labour force concept.
[2] Data for 1976 is estimated as the midpoint between 1971 and 1981.
[3] Average annual compound rate of growth between 1971 and 1996.

4.6 Summary

Overall, we have seen that the proportion of the employed labour force that was knowledge-based has increased from slightly less than 14% to over 22% between 1971 and 1996. This suggests that the supply of skilled, knowledge-based workers has increased through this period. The general increase in the level of education across the employed labour force provides further evidence of the changes that have been taking place in the labour force.

It is important to note that the profile of knowledge-based occupations is different from other parts of the labour market. First, despite increases in the level of education achieved across all occupations, the proportion of people in knowledge-based occupations who have completed university remains substantially higher. Moreover, by 1996, more than 90% of knowledge workers had at least some post-secondary education compared to just over 50% in the remainder of the workforce. Second, relative wage rates for persons in knowledge-based occupations are substantially higher than overall wage rates throughout the period.

While the increase in the knowledge base of the economy has been widespread, there are some differences beneath the surface. First, while the proportion of knowledge-based occupations grew at a compound rate of 1.9% per year between 1971 and 1996, this rate varies substantially between the broad sectors of the economy. Second, the business sector grew at an annual rate of 2.8% (3.0% in the goods producing sector and 2.5% in the market services sector). Canada's public sector, comprised of government, health and education services, had a labour force with a high proportion of knowledge workers, but exhibited a very low growth rate of 0.3% per year. The business sector, like the overall economy, witnessed the highest growth rates in management occupations.

Second, there are some differences in the proportion of men and women within knowledge-based occupations beyond the differences associated with the general structure of the labour force. Overall, the proportion of the male labour force in knowledge-based occupations grew faster than the proportion of the female labour force in knowledge-based occupations. There are greater gender differences when we examine the business and public sectors separately. In the business sector, knowledge-based occupations accounted for an increasing percentage of workers in both the male and female labour forces. While growth rates for female knowledge workers were higher than for male knowledge workers, a substantially higher proportion of the male labour force was in knowledge-based occupations compared to the female labour force. Within the male public sector workforce, there has been an increase in the proportion of knowledge-based occupations, whereas the opposite is true of the female public sector workforce. These changes are reflected in their growth rates. However, growth rates for female managers were higher than for other knowledge-based occupations across all sectors.

As we have shown in this section, the business sector has been the key engine for the growth and shift towards a more knowledge intensive economy within Canada. Therefore, in the next two chapters, we examine differences within the business sector. Chapter 5 examines the differences across industries in more detail. Chapter 6 examines whether or not there are geographical dimensions to shifts in the Canadian experience. Finally, chapter 7 uses a multivariate analysis to determine whether or not these geographic and industrial patterns persist after controlling for industrial and spatial structure.

Endnotes

[6] While the term 'knowledge worker' has been used extensively in both the popular and academic press, in this paper it refers to the 3 broad groups of knowledge-based occupations (management, professional, technical) as described in chapter 3. The term 'knowledge intensity' refers to the proportion or percentage of knowledge workers within a given class or category of the employed labour force.

[7] Growth in the management category has been documented elsewhere. Differences in the coding procedures between the 1971 OCM and the 1980 SOC result in an upward bias in the growth of the management category between 1971 and 1981. Moreover, it is often difficult to assign managers to specific managerial occupations if the respondent does not provide detailed information (see Picot and Lavallée, 1986; Lavoie and Roy, 1998; Marshall, 1996).

[8] In this analysis, the goods producing sector includes agriculture; fishing and trapping; logging and forestry; mining, quarrying and oil wells; manufacturing; and construction. Our convention differs slightly from the 1980 Standard Industrial Classification in which the 'other utility industry' (part of the Communication and Other Utility industry division) is classified as part of the goods producing sector. For ease of exposition, we treat the 'other utility industry' as a service in order to draw simple distinctions between industry divisions—the industry level used throughout most of this paper.

[9] Non-market services include government, educational, and health and social services. It should be noted that even though there are crown corporations and some private firms operating in these industries, these are excluded from the business sector in this analysis. Similarly, there are some non-commercial enterprises operating in the goods producing and market services sectors.

Chapter 5. Shifts in Canada's knowledge-base: Industry dimensions

Previous studies have provided evidence that output and employment growth has been particularly concentrated in high-technology industries (Lee and Has, 1996; Gera and Massé, 1996; Gera and Mang, 1997). However, other studies have indicated that the growth of knowledge-based occupations has not been limited to industries commonly thought of as high-technology (Lavoie and Roy, 1998). In this study, we ask if this growth has been concentrated in some industries or whether it has been dispersed across the Canadian economy. Thus, this chapter explores how the growth in knowledge occupations has varied across Canada's industries.

Similar to the trend we saw at the aggregate sector level, there has been an increase in the level of knowledge intensity across all industry divisions, with the exception of the accommodation, food, and beverage services industry (Table 10). This suggests that the increase in knowledge intensity (i.e., the proportion of the employed labour force in knowledge-based occupations) has been pervasive and has affected all aspects of the Canadian economy.

The largest absolute increases in the level of knowledge intensity were seen in the logging and forestry (14%), wholesale trade (13%), finance and insurance (14%), and business services industries (10%). While the latter three are in the market service sector, the former is in the goods producing sector and is related to natural resources.

The data suggest that most of the industries in the primary sector (agriculture; fishing and trapping; logging and forestry; and mining, quarrying, and oil wells) experienced high average annual increases in their level of knowledge intensity. This is an interesting finding given that these same sectors have experienced declining employment shares throughout the study period.

In the market services sector, the highest rate of growth was experienced in wholesale trade. Despite a substantial increase in the proportion of knowledge workers, the business services industries posted lower levels of annual growth. This is probably due to the fact that the business services sector was much more knowledge intensive throughout the entire 25-year period.

As seen above, there were high rates of growth in knowledge intensity in sectors not often associated with the 'new economy'. To further explore this finding, we examine only the changes and growth of professional occupations related to the natural and applied sciences,

Table 10. Knowledge intensity[1] by industry in the business sector, 1971-1996

Industry division	Share of employment[2] (%)							
	1971	1976[3]	1981	1986	1991	1996	Change[4]	Growth[5]
Agriculture and related services	0.6	0.9	1.3	1.8	3.3	3.6	3.1	7.8
Fishing and trapping	2.3	3.8	5.3	4.1	6.8	7.8	5.4	4.9
Logging and forestry	6.3	9.2	12.1	13.3	15.3	19.9	13.6	4.7
Mining, quarrying and oil wells	13.9	16.8	19.8	23.2	24.4	23.4	9.5	2.1
Manufacturing	7.9	9.5	11.1	13.1	16.5	16.5	8.6	3.0
Construction	4.6	4.9	5.2	6.0	7.3	7.2	2.5	1.8
All goods producing industries	***6.3***	***7.7***	***9.2***	***10.6***	***12.8***	***13.0***	***6.8***	***3.0***
Transportation and storage	7.1	8.7	10.3	11.2	10.3	9.8	2.7	1.3
Communication and other utility	13.8	16.9	20.1	20.7	24.2	23.6	9.8	2.2
Wholesale trade	6.5	7.5	8.5	10.2	17.0	19.0	12.5	4.4
Retail trade	3.2	3.3	3.4	4.0	4.5	3.8	0.7	0.8
Finance and insurance	19.5	23.1	26.7	30.8	28.1	33.6	14.2	2.2
Real estate operator and insurance agent	6.9	8.8	10.7	11.0	12.1	13.0	6.1	2.5
Business service	40.6	42.0	43.4	44.4	48.2	50.6	10.0	0.9
Accommodation, food and beverage services	1.2	1.3	1.3	1.8	2.2	1.2	0.0	-0.1
Other services	6.4	9.0	11.6	11.5	12.4	12.6	6.1	2.7
All market services	***8.9***	***10.7***	***12.5***	***13.5***	***15.6***	***16.6***	***7.6***	***2.5***
Total business sector	**7.7**	**9.4**	**11.1**	**12.4**	**14.6**	**15.4**	**7.8**	**2.8**

[1] Knowledge intensity is measured as the employment share of knowledge-based occupations.
[2] Includes only the employed labour force defined using the 1971 Census labour force concept.
[3] Data for 1976 is estimated as the midpoint between 1971 and 1981.
[4] Difference in employment shares between 1971 and 1996. Numbers may not add due to rounding.
[5] Average annual compound rate of growth between 1971 and 1996.

a category that includes scientists, engineers, and computer specialists. This sub-group of workers is often considered to be at the forefront of technological advance and innovation, viewed as key ingredients in the development of the 'new economy' (Lee and Has, 1996).

Overall, professionals in sciences-related occupations increased their share from 1.8% to 3.0% of the employed business sector labour force over the 25-year study period (Table 11). In 1971, there was a slightly higher proportion of science-related professionals in the goods producing sector (2.0%) compared to the market services sector (1.6%). By 1996, the reverse was true. Only 2.8% of the employed labour force in the goods producing sector were science-related professionals, as compared to 3.1% in the market services sector.

There was an absolute increase in the proportion of science-related professionals across almost all industry divisions, with the exception of construction where there was a slight decline, and in the accommodation, food, and beverage services industry where there was little change over the study period. These same two industries were the only industries to experience declines rather than growth on average in the proportion of science-related professionals over the 25-year period. The largest increases were experienced in logging and forestry (2%), finance and insurance (2%), and business services (4%). Business services was characterized by a very high proportion of scientific personnel, followed by communications and other utilities and mining, quarrying, and oil wells.

Similar to the overall trend for knowledge-based occupations, when we examine only science-related occupations there is growth across most industry sectors. Again, this suggests

Table 11. Proportion of professionals in science-related occupations[1] by industry in the business sector, 1971-1996

	Share of Employment[2] (%)							
Industry	1971	1976[3]	1981	1986	1991	1996	Change[4]	Growth[5]
Agriculture and related services	0.1	0.2	0.2	0.3	0.4	0.4	0.3	5.6
Fishing and trapping	0.8	1.5	2.1	1.4	1.0	1.3	0.4	1.7
Logging and forestry	2.1	2.5	2.8	3.0	2.8	4.3	2.2	2.9
Mining, quarrying and oil wells	6.6	7.4	8.1	9.5	8.6	7.9	1.3	0.7
Manufacturing	2.4	2.5	2.6	3.1	3.1	3.6	1.2	1.6
Construction	1.4	1.4	1.5	1.4	1.3	1.2	-0.2	-0.6
All goods producing industries	***2.0***	***2.2***	***2.4***	***2.7***	***2.6***	***2.8***	***0.8***	***1.4***
Transportation and storage	1.4	1.4	1.3	1.8	1.4	1.5	0.1	0.3
Communication and other utility	4.5	5.2	5.8	5.9	5.9	5.8	1.3	1.0
Wholesale trade	0.8	0.9	1.0	1.2	1.6	1.9	1.0	3.2
Retail trade	0.1	0.1	0.1	0.2	0.3	0.2	0.1	2.2
Finance and insurance	1.6	1.9	2.3	3.2	3.5	3.9	2.4	3.8
Real estate operator and insurance agent	0.8	0.8	0.8	0.7	0.8	0.9	0.2	0.8
Business service	11.4	12.4	13.4	13.9	13.9	15.5	4.2	1.3
Accommodation, food and beverage services	0.0	0.0	0.1	0.1	0.1	0.0	0.0	-1.0
Other services	0.3	0.3	0.4	0.4	0.4	0.4	0.1	1.0
All market services	***1.6***	***1.9***	***2.2***	***2.5***	***2.8***	***3.1***	***1.5***	***2.8***
Total business sector	**1.8**	**2.0**	**2.3**	**2.6**	**2.7**	**3.0**	**1.2**	**2.1**

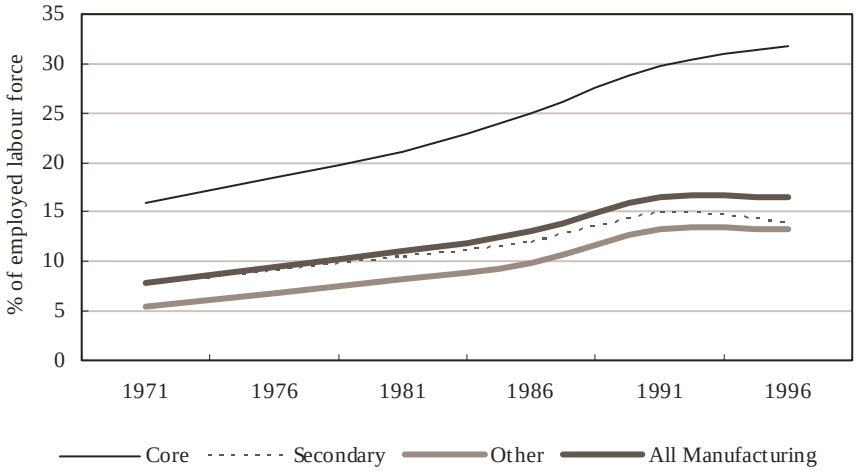
[1] Represents the employment share of professional occupations related to natural and applied sciences.
[2] Includes only the employed labour force defined using the 1971 Census labour force concept.
[3] Data for 1976 is estimated as the midpoint between 1971 and 1981.
[4] Difference in employment shares between 1971 and 1996. Numbers may not add due to rounding.
[5] Average annual compound rate of growth between 1971 and 1996.

that the demand for highly skilled and educated workers is pervasive across the business sector. Moreover, high growth rates were experienced in sectors which have been typified as requiring lower levels of knowledge and skills such as logging and forestry, as well as agriculture and related services.

Finally, given the breadth of activities in the manufacturing sector and its importance to Canada's gross domestic product (GDP) and employment, we examine the changing composition of knowledge-based occupations in this sector. We adopt a taxonomy for classifying the manufacturing sector into three groups according to their level of innovativeness: core, secondary, and other (Robson, et al., 1988). The core sector is characterized as being highly innovative, producing mainly innovations and technologies used within the sector and by other sectors. The secondary sector is viewed as being less innovative and uses technologies produced within the sector and by the core sector. It also produces innovations that are adopted by the 'other' sector, although to a lesser extent than the core sector. Finally, the 'other' sector creates new processes by absorbing the innovations created by the core and secondary sectors.

Over the 25-year study period, the proportion of the employed labour force in knowledge-based occupations has increased across the manufacturing sector. However, when we divide the manufacturing sector into the three sectors based on their characteristic levels of innovativeness, we see that there are some substantial differences between these sectors that are maintained over time (Figure 13). The core manufacturing sector has the highest

Figure 13. Proportion of knowledge-based occupations in Canadian manufacturing by Robson[1] innovative sector, 1971-1996



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.
Data for 1976 is estimated as the midpoint between 1971 and 1981.

[1] See Robson et al., 1988.

proportion of knowledge-based occupations, followed by the secondary manufacturing sector, and then the remainder of the manufacturing sector. It is evident that the most significant difference is between the core manufacturing sector and the other two manufacturing sectors.

Table 12 shows the changes by knowledge-based occupation across the three sectors of the Canadian manufacturing industry, as well as average annual growth rates. The core sector has the highest proportion of knowledge workers across all categories and experienced the largest increases, more than doubling its proportion of knowledge-based employment. It is also interesting to note that, despite possessing lower levels of knowledge-based employment, the 'other' manufacturing sector had the highest growth rate and more than doubled its proportion of knowledge-based employment. The management category experienced the largest increases and high growth rates across all manufacturing sectors.

Table 12. Composition of knowledge-based occupations in manufacturing by Robson[1] innovative sector, 1971-1996

	Share of Employment[2] (%)							
	1971	1976[3]	1981	1986	1991	1996	Change[4]	Growth[5]
Manufacturing	**7.9**	**9.5**	**11.1**	**13.1**	**16.5**	**16.5**	**8.6**	**3.0**
Management	1.6	3.0	4.3	5.6	7.7	7.1	5.5	6.2
Professional	4.1	4.2	4.3	5.1	5.3	5.8	1.7	1.4
Technical	2.3	2.4	2.5	2.5	3.5	3.6	1.4	1.9
Core	**15.8**	**18.4**	**21.1**	**25.0**	**29.7**	**31.7**	**15.9**	**2.8**
Management	2.2	4.1	6.0	8.0	11.0	10.2	8.1	6.4
Professional	7.8	8.3	8.7	10.6	10.6	12.6	4.8	1.9
Technical	5.8	6.1	6.4	6.4	8.1	8.8	3.0	1.7
Secondary	**7.6**	**9.0**	**10.4**	**11.9**	**14.8**	**13.8**	**6.2**	**2.4**
Management	1.4	2.7	3.9	4.9	6.5	5.7	4.3	5.8
Professional	3.9	4.0	4.1	4.7	4.9	4.7	0.8	0.8
Technical	2.3	2.4	2.4	2.3	3.4	3.4	1.1	1.6
Other	**5.4**	**6.8**	**8.2**	**9.8**	**13.2**	**13.2**	**7.8**	**3.6**
Management	1.5	2.8	4.0	5.1	7.3	7.0	5.5	6.4
Professional	2.9	3.0	3.0	3.5	3.8	4.2	1.3	1.5
Technical	1.0	1.1	1.1	1.2	2.1	2.0	1.0	2.7

[1] See Robson et al., 1988.
[2] Includes only the employed labour force defined using the 1971 Census labour force concept.
[3] Data for 1976 is estimated as the midpoint between 1971 and 1981.
[4] Difference between 1971 and 1996. Numbers may not add due to rounding.
[5] Average annual compound rate of growth between 1971 and 1996.

Chapter 6. Geographic dimensions of Canada's evolving knowledge economy

While a number of studies have examined the industrial dimensions of the evolving knowledge economy, few have explored the geographic dimensions of Canada's knowledge-based economy from an occupational perspective. In this chapter, we pose two questions. First, we ask how the knowledge economy has developed across Canada's provinces and regions. Second, we ask if there is an urban-rural dimension to this development.

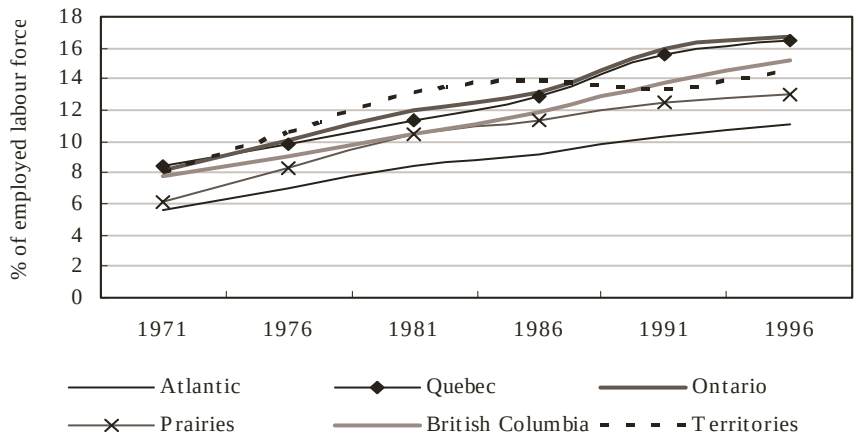
To explore whether there are geographic differences in the development of Canada's knowledge-based economy (defined from an occupational perspective), we examine the changing proportion of knowledge workers found across Canada's ten provinces and two territories.[10] A steady increase in the proportion of knowledge-based occupations was experienced across all of Canada's provinces and territories (Table 13). The highest proportions of knowledge-based workers were found in Quebec and Ontario, followed by Alberta, British Columbia and the Territories. These same provinces and territories also experienced the largest increase over the 25-year study period. There were very few differences in the average annual compound growth rates between the provinces and territories. However, growth rates were slightly higher in Saskatchewan, New Brunswick and Prince Edward Island.

Table 13. Proportion of knowledge-based occupations by province, 1971-1996

	Share of Employment[1] (%)							
	1971	1976[2]	1981	1986	1991	1996	Change[3]	Growth[4]
Newfoundland	5.8	6.8	7.8	8.6	9.8	11.1	5.2	2.6
Prince Edward Island	3.7	5.2	6.7	6.8	7.7	8.6	4.9	3.4
Nova Scotia	6.1	7.6	9.2	9.8	11.1	11.4	5.3	2.5
New Brunswick	5.4	6.9	8.4	9.2	10.3	11.2	5.8	3.0
Quebec	8.4	9.9	11.3	12.9	15.5	16.5	8.1	2.7
Ontario	8.2	10.1	12.0	13.2	16.0	16.7	8.5	2.9
Manitoba	6.2	7.6	9.1	9.9	11.2	11.7	5.5	2.6
Saskatchewan	3.9	5.3	6.7	7.6	8.6	9.0	5.2	3.4
Alberta	7.4	9.9	12.4	13.5	14.4	14.7	7.4	2.8
British Columbia	7.7	9.1	10.5	11.9	13.8	15.2	7.5	2.7
Yukon Territory	8.1	10.4	12.7	12.5	13.3	14.8	6.7	2.4
Northwest Territories	7.9	10.8	13.6	14.8	13.4	14.3	6.4	2.4
CANADA	**7.7**	**9.4**	**11.1**	**12.4**	**14.6**	**15.4**	**7.8**	**2.8**

[1] Includes only the employed labour force defined using the 1971 Census labour force concept.
[2] Data for 1976 is estimated as the midpoint between 1971 and 1981.
[3] Difference between 1971 and 1996. Numbers may not add due to rounding.
[4] Average annual compound rate of growth between 1971 and 1996.

Figure 14. Knowledge intensity by region, 1971-1996



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.
Data for 1976 is estimated as the midpoint between 1971 and 1981.

For ease of exposition, we illustrate this trend graphically for Canada's six main regions: Atlantic, Quebec, Ontario, Prairies, British Columbia and the Territories[11] (Figure 14). The Ontario and Quebec regions had similar patterns of growth increasing from just over 8% to approximately 17% over the 25-year period. The Prairies experienced a sharp increase in the 1970s, but growth flattened in the 1980s and 1990s. A similar pattern can be noted for the Territories.

This regional trend can be seen in Table 14, which shows the average annual rates of growth across all five regions. As seen earlier, growth was strongest in the early period and slowed considerably in the 1990s. It is also evident that—in the long run—all six regions experienced similar growth rates, with the knowledge-based labour force growing by approximately 2.8% per year.

Even though these regions have similar growth rates, there are differences in the geographic structure of these regions that may explain the absolute differences in the proportion of knowledge workers. One plausible explanation for these absolute regional disparities is the degree of urbanization in each region. Ontario, Quebec, and British Colombia, with the highest proportion of knowledge workers, are also home to Canada's largest urban centres, as well as a number of small- and medium-sized cities. Furthermore, predominantly rural areas are often construed as being backwaters of the 'new economy'. The Prairie and Atlantic regions have more rural areas, but are also home to some of Canada's larger urban centres (e.g., Calgary, Edmonton, Winnipeg, Regina, and Saskatoon in the Prairies and Halifax, St. John's, and Fredericton in the Atlantic region). Therefore, we examine whether or not there is an urban-rural dimension to the development of Canada's knowledge-based labour force.

Table 14. Average annual knowledge intensity growth rates by region (%), 1971-1996					
	1971-1981	1981-1986	1986-1991	1991-1996	1971-1996
Atlantic region	4.2	1.6	2.4	1.3	2.7
Quebec region	3.0	2.6	3.8	1.2	2.7
Ontario region	3.8	2.0	3.9	0.9	2.9
Prairies region	5.5	1.6	1.9	0.8	3.0
British Columbia	3.1	2.6	2.9	2.0	2.7
Territories	5.1	1.1	-0.8	1.7	2.4
Overall	**3.8**	**2.2**	**3.3**	**1.1**	**2.8**

Table 15. Urban-rural definitions based on Census data	
Category	Description
Urban	Minimum population of 1000 and population density of at least 400 persons per square kilometre
Large Urban Areas	Urban population of at least 100,000
Medium Urban Areas	Urban population between 30,000 and 100,000
Small Urban Areas	Urban population of less than 30,000
Rural	Population less than 1000 or population density of less than 400 persons per square kilometre

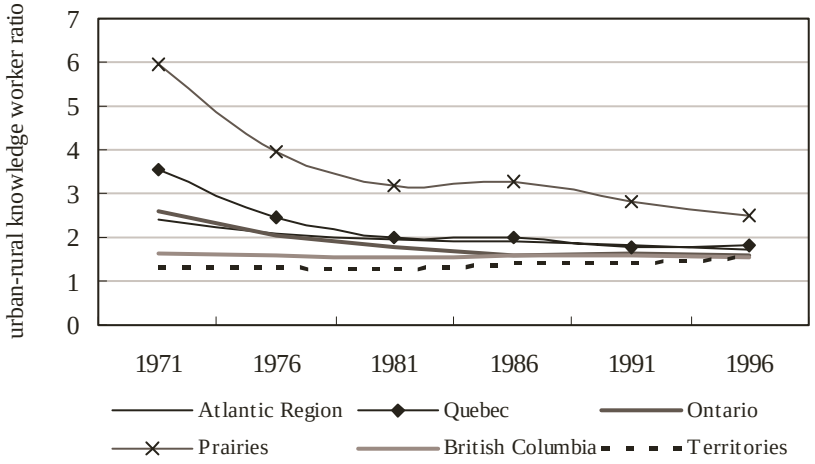
Note: See Statistics Canada (1999) for more discussion of the urban area concept. For reasons of historical comparability, there were some limitations to the urban size categories we could develop.

Canada's urban-rural hierarchy can be delineated in a number of different ways (see Du Plessis, et al., 2001). In this paper, we utilize Statistics Canada's census definition of 'rural' areas, which identifies rural areas on the basis of population size and density. Urban areas are defined as those areas that have a minimum population of 1000 and a population density of at least 400 persons per square kilometre, based on the previous census.[12] All persons living outside of these centres are considered part of the rural population. Using this definition, we first divide Canada's population into urban and rural sub-populations. We further sub-divide the urban population into three categories based on population size (Table 15).

We examine how the urban-rural relationship has changed across Canada. Again, for ease of exposition, we examine differences across Canada's six major regions. First, we investigate how the urban-rural split manifests itself across Canada's regions. Second, we further disaggregate the urban component into the three categories described in Table 15 by examining the overall national urban-rural hierarchy and then the extent to which this hierarchy exists across Canada's regions.

Throughout the study period, the level of knowledge intensity was much higher in urban areas than in rural areas, but this disparity lessened over the study period in all regions except for British Columbia and the Territories (Figure 15). The biggest change occurred in the 1970s when the differences between urban and rural areas were reduced considerably over the decade. This gap was reduced even further throughout the 1980s and 1990s. In this period, Canada's regions (with the exception of the Prairies region) converged to have similar urban-rural ratios with urban areas having a knowledge-based workforce that was between 1.5 and 1.8 times larger on a proportional basis. In the Prairies region, the urban areas continued to have an even higher proportion of knowledge workers compared to rural areas.

Figure 15. Ratio of urban-rural knowledge intensities by region, 1971-1996



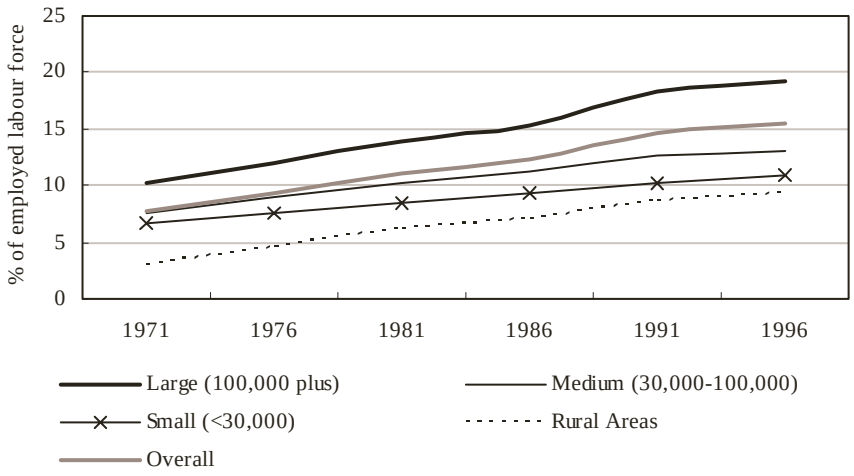
Note: Includes only the employed labour force defined using the 1971 Census labour force concept.
Data for 1976 is estimated using 1971 and 1981 data.

We extend this analysis to examine the full urban-rural hierarchy, rather than using just a simple urban-rural split. We examine the extent to which this hierarchy exists at the national level and how it has changed through time. As can be seen in Figure 16, there is a clear correlation between urban population size and the level of knowledge-intensity. There have been some shifts in the nature of this relationship. Over the 1971 to 1996 period, the largest gains have been in the rural areas and large urban areas. There has been a divergence in the levels of knowledge intensity between the largest urban centres and other parts of the country. Moreover, the data indicate a convergence in the levels of knowledge intensity between rural areas and small- and medium-sized urban areas. However, it is important to note that the level of knowledge intensity has increased across all parts of Canada's urban-rural hierarchy over the study period.

This trend becomes more evident in examining average annual growth rates for knowledge-based occupations across Canada's urban-rural hierarchy (Table 16). The rate of growth was highest in rural Canada. Rural employment in knowledge-based occupations grew at slightly less than 5% per year over the 25-year study period, higher than in urban areas of any size. Within urban areas, the highest rates of knowledge-based employment growth were experienced in the largest urban centres.

The hierarchy observed at the national level can also be seen across Canada's regions, with large urban centres having the highest proportion of knowledge-based occupations and rural areas having the lowest (Table 16). However, the degree to which this hierarchy exists differs between regions. The hierarchy is most pronounced in the Prairies region and least pronounced in British Columbia.

Figure 16. Knowledge intensity across Canada's urban-rural hierarchy, 1971-1996



Note: Includes only the employed labour force defined using the 1971 Census labour force concept.
Data for 1976 is estimated as the midpoint between 1971 and 1981.

Overall, these data indicate that the sites of the so-called new economy are not limited to one specific region of Canada, nor is it solely a phenomenon occurring in Canada's largest urban centres. However, the data do suggest that large urban centres are faring better than other urban areas. Moreover, rural areas are converging with these smaller centres in terms of their proportion of knowledge-based occupations. It is not clear from this picture whether or not urban-rural differences and regional disparities are heightened or lessened after accounting for industrial structure. Thus, the last chapter of this paper addresses the combined effects of geographic and industrial structure.

Table 16. Knowledge intensity by region across the urban-rural hierarchy, 1971-1996

	Share of employment[1] (%)						
	1971	1981	1986	1991	1996	Change[2]	Growth[3]
CANADA	**7.7**	**11.1**	**12.4**	**14.6**	**15.4**	**7.8**	**2.8**
Urban	*9.0*	*12.6*	*13.9*	*16.4*	*17.1*	*8.1*	*2.6*
Large	10.1	13.9	15.4	18.3	19.1	9.0	2.6
Medium	7.7	10.3	11.2	12.7	13.1	5.4	2.2
Small	6.6	8.5	9.3	10.2	10.9	4.3	2.0
Rural	*3.0*	*6.1*	*7.0*	*8.7*	*9.3*	*6.4*	*4.7*
Atlantic region	**5.6**	**8.5**	**9.2**	**10.4**	**11.1**	**5.4**	**2.7**
Urban	*7.5*	*10.8*	*11.8*	*13.2*	*13.9*	*6.3*	*2.5*
Large	10.8	14.3	15.0	17.0	17.1	6.3	1.9
Medium	8.6	12.0	13.4	14.2	15.3	6.7	2.3
Small	5.8	8.1	8.6	9.4	10.1	4.3	2.2
Rural	*3.1*	*5.6*	*6.2*	*7.3*	*8.0*	*4.9*	*3.8*
Quebec	**8.4**	**11.3**	**12.9**	**15.5**	**16.5**	**8.1**	**2.7**
Urban	*9.6*	*12.6*	*14.4*	*17.2*	*18.2*	*8.7*	*2.6*
Large	10.9	13.9	15.8	18.9	20.2	9.3	2.5
Medium	7.0	10.2	11.1	13.4	13.7	6.7	2.7
Small	6.6	8.1	9.2	10.8	11.6	5.0	2.3
Rural	*2.7*	*6.3*	*7.3*	*9.7*	*10.1*	*7.4*	*5.4*
Ontario	**8.2**	**12.0**	**13.2**	**16.0**	**16.7**	**8.5**	**2.9**
Urban	*9.2*	*13.0*	*14.2*	*17.3*	*17.9*	*8.7*	*2.7*
Large	10.0	13.9	15.2	18.7	19.4	9.4	2.7
Medium	8.0	11.2	11.6	13.5	13.8	5.8	2.2
Small	7.2	9.1	9.8	11.1	11.5	4.3	1.9
Rural	*3.6*	*7.3*	*8.8*	*10.6*	*11.1*	*7.6*	*4.7*
Prairies	**6.1**	**10.5**	**11.4**	**12.5**	**13.0**	**6.9**	**3.0**
Urban	*8.7*	*12.8*	*14.0*	*15.1*	*15.4*	*6.8*	*2.3*
Large	9.7	14.4	15.8	17.2	17.7	8.0	2.4
Medium	5.7	8.4	10.3	10.8	10.3	4.6	2.4
Small	6.0	8.7	9.2	9.3	9.7	3.7	1.9
Rural	*1.5*	*4.0*	*4.3*	*5.4*	*6.2*	*4.7*	*6.0*
British Columbia	**7.7**	**10.5**	**11.9**	**13.8**	**15.2**	**7.5**	**2.7**
Urban	*8.5*	*11.3*	*12.8*	*14.8*	*16.2*	*7.7*	*2.6*
Large	9.4	13.0	14.6	17.2	18.5	9.1	2.7
Medium	6.5	8.7	10.1	11.0	12.1	5.6	2.5
Small	6.7	7.7	8.7	9.1	10.6	4.0	1.9
Rural	*5.2*	*7.3*	*8.1*	*9.3*	*10.6*	*5.4*	*2.9*
Territories	**8.0**	**13.2**	**13.9**	**13.4**	**14.5**	**6.5**	**2.4**
Urban	*8.8*	*14.3*	*15.5*	*15.4*	*17.1*	*8.3*	*2.7*
Large	-	-	-	-	-	-	-
Medium	–	-	-	-	-	-	-
Small	8.8	14.3	15.5	15.4	17.1	8.3	2.7
Rural	*6.6*	*11.1*	*11.1*	*10.9*	*11.1*	*4.5*	*2.1*

[1] Includes only the employed labour force defined using the 1971 Census labour force concept.
[2] Difference between 1971 and 1996. Numbers may not add due to rounding.
[3] Average annual compound rate of growth between 1971 and 1996.

Endnotes

[10] In 1999, the Northwest Territories was divided into two portions: Nunavut and the Northwest Territories. However, given that the data cover the period from 1971 to 1996, the Northwest Territories are treated as a single entity.

[11] The Atlantic region includes Newfoundland, Prince Edward Island, Nova Scotia, and New Brunswick. The Prairies region includes Alberta, Saskatchewan, and Manitoba.

[12] While the Census definition remained constant for the 1981, 1986, 1991 and 1996 Census, the 1971 definition is slightly different. For 1971, the minimum density requirement was 1000 persons per square mile (or approximately 386 persons per square kilometre). Additionally, all incorporated cities, towns, and villages with a population over 1000 were included in the urban component (see Statistics Canada, 1999).

Chapter 7. Regional differences and industrial structure

The previous chapters demonstrated that there are differences across the urban-rural hierarchy, as well as across provinces and industries and that there have been some shifts over the 25-year study period within the business sector. However, the differences across these parameters were investigated separately. Therefore, in this chapter, we perform a multivariate analysis to determine whether or not there are differences between provinces after controlling for differences in industrial and spatial structure. To do this, we estimate the probability of an individual being a knowledge worker in the business sector using microdata from each of the 1971 and 1996 Censuses.

We use the following model specification:

$$K_i = f(P_i, I_i, U_i)$$

where K_i takes on a value of one if a persons belongs to a knowledge occupation and zero otherwise. P_i refers to the province in which the individual lives, I_i represents industry in which he/she works, and U_i represents the individual's location within the urban-rural hierarchy.

The model was estimated separately for each of the 1971 and 1996 Censuses.

7.1 Dependent variable

The dependent variable is a dichotomous variable measuring the incidence of knowledge-based occupations. The variable takes a value of one if the respondent reports belonging to a knowledge-based occupation. Otherwise it takes a value of zero. A knowledge-based occupation is defined as being a professional, management, or technical occupation in the framework developed and used in this paper.

7.2 Explanatory variables

We investigate the combined effects of three of the variables explored in previous chapters of this analysis: industry, province, and level of urbanization. A set of twelve binary variables captures the province or territory of the respondent. To capture differences in the spatial structure and organization, we use four binary variables, representing Canada's urban-rural continuum. Finally, 15 binary variables correspond with the industry divisions used earlier

in the paper and are used to capture industry effects in the business sector. The descriptive statistics associated with the dependent and independent variables for the beginning and end periods of the study can be found in Table 17 (1971) and Table 18 (1996).

7.3 Estimation procedures

Since the dependent variable is a dichotomous variable, we use a logit regression in order to overcome the problems associated with using other regression methods.[13] In order to examine the effects of spatial and industrial structure, as well as geographic variation across Canada, the following logistic regression model (logit) is specified as follows:

$$K = \beta_0 + \beta_1 * IND + \beta_2 * PROV + \beta_3 * URBAN + \varepsilon$$

where *K* refers to a variable indicating the presence of a knowledge-based occupation. IND, PROV, and URBAN refer to the explanatory variables for industry, province, and level of urbanization respectively.

7.4 Empirical results

The results of the logistic regression models can be found in Table 19 and Table 20 for the beginning and end periods. The regressions are estimated against an individual from Ontario, in a large urban centre, working in the 'other services' industry division.

In both of the models (1971 and 1996), most of the explanatory variables are statistically significant. However, in each case, there are over two million observations. Therefore, most variables will be significant regardless of their quantitative effect on the outcome. Therefore, we also provide probability estimates to place the signs and strength of the coefficients in context. Probability estimates are calculated by estimating the logit equation at the sample means.[14]

There is a change in the overall magnitude of the estimated probabilities between 1971 and 1996 since the overall observed probability of being a knowledge worker in Canada's business sector increased from 7.7% to 15.4%. Therefore, in this context, we only examine relative differences and changes. In both 1971 and 1996, there are strong industry effects, weaker urban-rural and virtually no real provincial effects. Each of these is outlined below.

As discussed earlier, there are differences amongst industries. The magnitude and differences of the probabilities in each year suggest that the industry effect is much larger than either the provincial or urban-rural effect. In 1971, the probability of being a knowledge worker was highest in the business services industry (36%), followed by finance and insurance (17%), mining, quarrying, and oil wells (15%), and the communication and other utilities industry (13%). By 1996, the probability of being a knowledge worker had increased in most industries. The highest probability of being a knowledge worker was still in the business services industries (48%), followed by finance and insurance (32%), mining, quarrying, and oil wells (26%), logging and forestry (24%), and communication and other utilities (23%). This confirms the findings presented earlier in this paper, which suggested that

these industries had a high proportion of knowledge workers, but that there were increases across most industries. In each year, the probability of being a knowledge worker was lowest in the retail trade and accommodation, food, and beverage services industries.

In both years, there are highly statistically significant differences between urban and rural areas. The probability of being a knowledge worker increases with the level of urbanization. In 1971, the probability of being a knowledge worker in large urban centres (6.7%) was more than double that of rural areas (3.1%). In 1996, the probability of being a knowledge worker increased with urbanization from 7.7% in the most rural areas to 12.5% in the largest urban centres. Therefore, after controlling for differences in province and the industry of work, a worker in a rural area is less likely to be in a knowledge-based occupation than a worker in a more urbanized area.

After controlling for spatial and industrial structure, there are very few real differences between the provinces and territories. In 1971, there are some differences across the provinces and territories, but in many cases these are not statistically significant. Only workers in Quebec and the Yukon Territory have a higher probability of being a knowledge worker compared to Ontario. However, the differences in the estimated probabilities are very small. In 1996, differences across the provinces and territories remain and may have widened, since in several cases (e.g. Prince Edward Island, Northwest Territories) differences in the estimated probability of being a knowledge worker have become statistically significant. However, once again the differences in the estimated probabilities are small. Overall, these findings suggest that the observed differences between the provinces are a function of industrial structure and—to a lesser extent—the degree of urbanization.

Table 17. Descriptive statistics for dependent and independent variables (1971)

Variable	Description	Mean	Standard deviation
Dependent variables			
KNOW	Incidence of knowledge-based occupation	0.08	0.26
Independent variables			
Province			
PROV10	Newfoundland	0.03	0.17
PROV11	Prince Edward Island	0.00	0.07
PROV12	Nova Scotia	0.03	0.17
PROV13	New Brunswick	0.02	0.15
PROV24	Quebec	0.24	0.43
PROV35	Ontario	0.38	0.49
PROV46	Manitoba	0.05	0.22
PROV47	Saskatchewan	0.05	0.21
PROV48	Alberta	0.08	0.27
PROV59	British Columbia	0.11	0.31
PROV60	Yukon Territory	0.00	0.05
PROV61	Northwest Territories	0.00	0.05
Urban/rural continuum			
URBAN1	Rural area	0.24	0.04
URBAN2	Small urban area	0.19	0.39
URBAN3	Medium urban area	0.08	0.28
URBAN4	Large urban area	0.49	0.50
Industry division			
INDA	Agriculture and related services	0.08	0.27
INDB	Fishing and trapping	0.01	0.08
INDC	Logging and forestry	0.01	0.12
INDD	Mining, quarrying and oil wells	0.03	0.16
INDE	Manufacturing	0.27	0.44
INDF	Construction	0.08	0.28
INDG	Transportation and storage	0.07	0.25
INDH	Communication and other utility	0.04	0.20
INDI	Wholesale trade	0.05	0.23
INDJ	Retail trade	0.15	0.35
INDK	Finance and insurance	0.04	0.20
INDL	Real estate operator and insurance agent	0.02	0.13
INDM	Business service	0.03	0.18
INDQ	Accommodation, food and beverage services	0.05	0.23
INDR	Other services	0.07	0.26

Note: Includes only the employed labour force (1971 concept) within the business sector as defined in this paper.

Table 18. Descriptive statistics for dependent and independent variables (1996)			
Variable	Description	Mean	Standard deviation
Dependent variables			
KNOW	Incidence of knowledge-based occupation	0.15	0.36
Independent variables			
Province			
PROV10	Newfoundland	0.01	0.11
PROV11	Prince Edward Island	0.00	0.07
PROV12	Nova Scotia	0.03	0.16
PROV13	New Brunswick	0.02	0.14
PROV24	Quebec	0.23	0.42
PROV35	Ontario	0.38	0.48
PROV46	Manitoba	0.04	0.20
PROV47	Saskatchewan	0.04	0.19
PROV48	Alberta	0.11	0.31
PROV59	British Columbia	0.13	0.34
PROV60	Yukon Territory	0.00	0.05
PROV61	Northwest Territories	0.01	0.09
Urban/rural continuum			
URBAN1	Rural area	0.24	0.43
URBAN2	Small urban area	0.13	0.33
URBAN3	Medium urban area	0.09	0.28
URBAN4	Large urban area	0.55	0.50
Industry division			
INDA	Agriculture and related services	0.05	0.22
INDB	Fishing and trapping	0.00	0.07
INDC	Logging and forestry	0.01	0.09
INDD	Mining, quarrying and oil wells	0.02	0.13
INDE	Manufacturing	0.18	0.38
INDF	Construction	0.07	0.25
INDG	Transportation and storage	0.06	0.23
INDH	Communication and other utility	0.04	0.20
INDI	Wholesale trade	0.06	0.25
INDJ	Retail trade	0.16	0.37
INDK	Finance and insurance	0.05	0.22
INDL	Real estate operator and insurance agent	0.02	0.16
INDM	Business service	0.08	0.28
INDQ	Accommodation, food and beverage services	0.09	0.28
INDR	Other services	0.10	0.30

Note: Includes only the employed labour force (1971 concept) within the business sector as defined in this paper.

Table 19. Logit Model Results of Industrial and Spatial Structure Effects (1971)

Variable	Description	Coefficient[1]	Estimated probability
Intercept		-2.497 ***	–
Province			
PROV10	Newfoundland	0.001	5.2
PROV11	Prince Edward Island	-0.013	5.2
PROV12	Nova Scotia	-0.035 *	5.0
PROV13	New Brunswick	-0.088 ***	4.8
PROV24	Quebec	0.036 ***	5.4
PROV35	Ontario[2]	–	5.2
PROV46	Manitoba	-0.146 ***	4.5
PROV47	Saskatchewan	-0.204 ***	4.3
PROV48	Alberta	0.009	5.2
PROV59	British Columbia	-0.015	5.2
PROV60	Yukon Territory	0.232 ***	6.5
PROV61	Northwest Territories	0.122	5.2
Urban/rural continuum			
URBAN1	Rural area	-0.812 ***	3.1
URBAN2	Small urban area	-0.359 ***	4.8
URBAN3	Medium urban area	-0.213 ***	5.5
URBAN4	Large urban area[2]	–	6.7
Industry division			
INDA	Agriculture and related services	-1.908 ***	0.9
INDB	Fishing and trapping	-0.581 ***	3.3
INDC	Logging and forestry	0.375 ***	8.2
INDD	Mining, quarrying and oil wells	1.050 ***	14.9
INDE	Manufacturing	0.217 ***	7.1
INDF	Construction	-0.285 ***	4.4
INDG	Transportation and storage	0.146 ***	6.6
INDH	Communication and other utility	0.849 ***	12.6
INDI	Wholesale trade	-0.008	5.8
INDJ	Retail trade	-0.730 ***	2.9
INDK	Finance and insurance	1.195 ***	16.9
INDL	Real estate operator and insurance agent	0.017	5.8
INDM	Business service	2.229 ***	36.3
INDQ	Accommodation, food and beverage services	-1.693 ***	1.1
INDR	Other services[2]	–	5.8

[1] Denoted as follows: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

[2] Category excluded from the regression analysis.

Note: Includes only the employed labour force (1971 concept) within the business sector as defined in this paper.

Table 20. Logit model results of industrial and spatial structure effects (1996)

Variable	Description	Coefficient[1]	Estimated probability
Intercept		-1.769 ***	–
Province			
PROV10	Newfoundland	-0.074 ***	9.8
PROV11	Prince Edward Island	-0.105 ***	9.6
PROV12	Nova Scotia	-0.137 ***	9.3
PROV13	New Brunswick	-0.040 **	10.1
PROV24	Quebec	0.061 ***	11.1
PROV35	Ontario[2]	–	10.5
PROV46	Manitoba	-0.228 ***	8.6
PROV47	Saskatchewan	-0.324 ***	7.8
PROV48	Alberta	-0.051 ***	10.0
PROV59	British Columbia	0.002	10.5
PROV60	Yukon Territory	0.355 ***	14.3
PROV61	Northwest Territories	0.304 ***	13.7
Urban/rural continuum			
URBAN1	Rural area	-0.538 ***	7.7
URBAN2	Small urban area	-0.468 ***	8.2
URBAN3	Medium urban area	-0.298 ***	9.6
URBAN4	Large urban area[2]	–	12.5
Industry division			
INDA	Agriculture and related services	-0.983 ***	4.8
INDB	Fishing and trapping	-0.180 ***	10.2
INDC	Logging and forestry	0.818 ***	23.5
INDD	Mining, quarrying and oil wells	0.953 ***	26.0
INDE	Manufacturing	0.332 ***	15.9
INDF	Construction	-0.570 ***	7.1
INDG	Transportation and storage	-0.233 ***	9.7
INDH	Communication and other utility	0.765 ***	22.5
INDI	Wholesale trade	0.484 ***	18.0
INDJ	Retail trade	-1.265 ***	3.7
INDK	Finance and insurance	1.221 ***	31.5
INDL	Real estate operator and insurance agent	0.005	11.9
INDM	Business service	1.911 ***	47.8
INDQ	Accommodation, food and beverage services	-2.462 ***	1.1
INDR	Other services[2]	–	11.9

[1] Denoted as follows: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

[2] Category excluded from the regression analysis.

Note: Includes only the employed labour force (1971 concept) within the business sector as defined in this paper.

Endnotes

[13] See Baldwin, et al. (2000) for further discussion of model choices for dichotomous dependent variables.

[14] Probabilities (p) are estimated using the following equation: $p = \exp(\hat{a}x) / [1 + \exp(\hat{a}x)]$.

Chapter 8. Conclusion

In this paper, we used an occupational framework to examine the changing knowledge-intensity of the Canadian economy over time, how it varied across industrial sectors, and whether or not there were regional or urban-rural dimensions to these shifts. Overall, we have seen that knowledge intensity has increased across Canada.

However, even though we see that the shift towards a more knowledge-intensive economy has been a widespread and gradual process, there are some underlying differences across the boundaries of wages, education, gender, industries and geography. Knowledge workers have higher wage rates and higher levels of education. Shifts in the gender composition of the knowledge-based workforce have followed the trends in the overall labour force, although at a slightly slower pace. It is interesting to note that in the business sector, women knowledge workers as a percentage of the female labour force have grown faster than their male counterparts.

While most industries have undergone an increase in knowledge intensity over the study period, the level of knowledge intensity is highest in the non-market (public) sector, but the highest levels of growth have been in the business sector. Business sector industries such as business services, mining, and finance have exhibited higher levels of knowledge use compared to others. We find that after controlling for differences in industrial and spatial structure, there are only very small differences across Canada's provinces. However, there are urban and rural differences that persist through the study period. The probability of being in a knowledge-based occupation increases with the level of urbanization.

Our analysis confirms the findings of previous studies and indicates that the shift towards a more knowledge intensive economy *has been a gradual process*, ongoing since at least 1971. Moreover, this increase has been experienced to some extent across all sectors of the Canadian economy. The sites of the knowledge-based economy are widespread, reaching across industries, provinces and the urban-rural divide. This suggests a general upskilling of the Canadian labour force and an increase in the importance and use of skills, knowledge, and human capital amongst firms and industries competing in the new economy.

Appendix 1: A method of creating a file of occupational groups from Census data over the period 1971-1996

Summary

This paper describes how a longitudinal classification of occupational categories was developed using the 1971, 1981, 1991 and 1996 censuses. The standard occupational classifications used in the 1970s differed slightly from the 1980s. But both of these classifications differed substantially from the one used in the 1990s.

Several steps were involved. They were:

1) Given that the 1991 Standard Occupational Classification (SOC91) was the most recent classification system available for Census data, the structure of the SOC91 was used as the framework for delineating the knowledge categories. The classifications available from the 1996 Census were allocated to a set of knowledge categories (largely based on previous research) or a set of remaining categories (mainly based on the 2 digit level of aggregation)—there were 47 categories in total.
2) When the assignment of a detailed category to the aggregate was uncertain, a Tukey test was used; this test was based on similarity of the average wage of the individual category and the aggregate.
3) A classification procedure was then developed to assign a four-digit 1980 SOC to the 47 group total. A forced one-to-one match was made using a proportional matrix created from the 1991 Census that was double-coded on both the 1980 and the 1991 Standard Occupational Classifications. This allowed the Census data from the 1980s to be assigned to the 47 occupational categories.
4) A concordance was developed from the 1970 SOC to the 1980 SOC and then the procedure outlined in step 3 is employed to classify the 1970 census data into our 47-occupation framework.

Introduction

Statistics Canada maintains a Standard Occupational Classification system that is periodically updated. The most recent update resulted in a major overhaul of the classification scheme, which "differs substantially in structure and content from earlier systems" (Marshall, 1996). While necessary to maintain currency in the concepts being used to define occupations, such a change poses a number of challenges for researchers and analysts. Specifically, the ability to conduct research over time that incorporates occupation is significantly hindered by the existence of disparate systems and a lack of a straightforward statistical concordance

between them. In particular, at the finest level of detail, the 1980 and 1991 occupational classification systems contain numerous many-to-many matches, which make concordances at this level problematic.

While the merit of a statistical occupational concordance is recognized, such a tool is generally not used at the most detailed occupational level due to the significant differences in the structure, composition, and content between the 1980 and 1991 Standard Occupational Classifications.[15] The complexity of such a task has meant that, in most analyses that have been conducted of a particular labour force phenomenon that cover the last thirty years, occupation has been excluded from consideration.

While concordances at a detailed level may be difficult to create, it is easier and more defensible to use a concordance that employs broader more aggregate occupational groups. This appendix describes the method that was used to overcome the discord between the 1971, 1980 and 1991 classification schemes to create a set of categories for this study.

The appendix is divided into two parts. First, a framework for defining 47 categories of knowledge and non-knowledge based occupations is presented and applied to the 1991 Standard Occupational Classification. This is done using 1991 Census data.

In the second part, we address the issue of occupational concordances and the problems arising from the incompatibility between the 1980 and 1991 Standard Occupational Classifications. We outline the method that is used to assign occupations defined under the 1980 Standard Occupational Classification to the same 47 broad occupational categories. This concordance is then extended to the 1971 Occupational Classification Manual. The result is a framework that provides occupational groupings that cover the period from 1971 to present.

A framework for knowledge intensive and non-knowledge intensive occupations

Our work has two objectives. First, we are interested in the construction of a manageable number of occupational groupings that can be followed through time. Second, we want to ensure that the occupational groups include several "knowledge worker" categories, since the main purpose of this paper is to study how the importance of knowedge workers has changed over time.

To do so, we define and develop an aggregate classification system that involves about 47 categories and then present a method for assigning the detailed 1991 Standard Occupational Classification to each member of this aggregate occupational framework. In the small number of cases where there was some doubt about the aggregate category to which the individual 1991 classifications should be classified, we use relative wage rates to determine the inclusion or exclusion of specific detailed occupations on the margins of these aggregate groupings.

When it comes to defining the aggregate classes that are considered as 'knowledge' workers, we make use of information derived from previous research. Previous studies have defined 'knowledge workers' based on occupational classification structures, as well as additional information on education and skill levels (Zhao, et al., 2000a, Lavoie and Roy, 1998, Gera, et al., 1999).

We build on this tradition by identifying three broad knowledge worker categories within our 47 broad occupational aggregates. The knowledge worker occupations contain a total of eight components:

1. Management Occupations.

2. Professional Occupations:
   - Science and engineering professionals;
   - Business professionals;
   - Health professionals;
   - Arts and culture professionals; and
   - Education, law and social science-related professionals.

3. Technical Occupations:
   - Technical occupations related to science and engineering; and
   - Technical occupations related to health.

There are two main steps required to implement this framework. First, a method for assigning specific detailed occupations to an aggregate knowledge or non-knowledge (residual) category using the 1991 Standard Occupational Classification must be devised. Second, in order to provide time series data, a concordance between the three standards used to classify occupations over the period 1971-1996 must be created.

Data sources and limitations

In the next sections, we address this first challenge by discussing the data sources and limitations, as well as the method used to apply our framework to the 1991 Standard Occupational Classification. Following this, the latter part of our discussion addresses the issue of how we built the occupational concordances for previous census years.

In the first part of this analysis, we use the 1991 Census (20% sample) to group occupations into 47 knowledge and non-knowledge categories. In the second part of the analysis, which includes the creation of an occupational concordance between the 1971, 1980, and 1991 classifications and these 47 occupational categories, we use the 20% samples from the 1981, 1986, 1991, and 1996 Censuses.

There are two significant limitations to the data that are used here that should be kept in mind but that are common to all studies using Census data to study trends in hours worked. First, not all of the data used to create total hours worked per worker refer to the same time period. For example, the variable 'hours worked per week' refers to the reference week in

the Census year, whereas 'the number of weeks worked' refers to the number of weeks worked in the previous year. We make the standard assumption that the wages and weeks reported from the previous year reflect the respondent's current working conditions (i.e., occupation, industry, etc.) and we calculate the total number of hours worked in a year by multiplying the number of weeks worked (previous year) and the number of hours worked in the reference week (in the Census year). Thus, some error may be introduced during the calculation of the number of total hours worked in a year (necessary for calculating average wage rates).

The second limitation is related to the accuracy of occupational coding on the Census. Occupation coding is a difficult task because it is dependent upon the description provided by the respondent. The coding error rate is felt to be high for certain occupation variables, particularly for management categories (Statistics Canada, 1999). For example, in the management category, there are 26 groups using the 1980 Standard Occupational Classification and 43 groups using the 1991 Standard Occupational Classification and it is difficult to assign one of these specific occupations to an individual record if the respondent simply says their primary task is "managing" (Marshall, 1996).

Responses to the 1991 Census were coded independently using each of the 1980 and 1991 Standard Occupational Classifications thereby providing information on the relationship between these two classification schemes. Similarly, each of the 1981 and 1986 Censuses were coded using both the 1971 and 1980 classifications.

It is important to outline one key difference in the procedures for coding occupations using the 1971, 1980 and 1991 occupational classification schemes. In the 1971 Occupation Classification, if a respondent did not state their occupation (and the respondent had an occupation), it was coded as '0000', meaning that there was no occupation information. In the 1980 Standard Occupation Classification, an imputation procedure was performed to assign an occupation code at the 3-digit level if it was not stated. In the 1991 Standard Occupation Classification, an imputation procedure was performed to assign an occupation code at the 4-digit level if it was not stated. Occupation was imputed for 3% to 4% of records in the population over 15 years of age. In cases where we could identify imputed occupations (i.e., data coded using the 1971 and 1980 classifications), these data are excluded from the creation of occupation groupings and in creating the occupational concordances since the treatment of imputations varies greatly over the twenty-five year study period.

Applying the occupational framework to the 1991 standard occupational classification

Using the 1991 Standard Occupation Classification at the 4-digit level (514 unit group occupations), the detailed job descriptions and titles in the 1991 Standard Occupation Classification manual, as well as reference to previous studies, we made a preliminary assignment of 4-digit occupations to the eight knowledge categories developed in our framework.

Initially, our classification included (in most cases) entire 2-digit (major group) or 3-digit (minor group) occupation groups to our knowledge categories. This indicated that it was possible to simplify our classification procedure by operating at a more aggregate level. This is especially important since we had the additional task of creating a concordance through time.

Therefore, we chose to design our classification to identify knowledge-based occupations at the 3-digit level (minor group) and then assigned them to one of the eight knowledge worker categories. It should be noted that a large number of occupations were not assigned to any of the knowledge worker categories. These were assigned to 2-digit (major group) occupation groups based on their place in the 1991 occupation structure.

In the small number of cases where there was doubt about whether a particular detailed occupational class belonged to one of the aggregate knowledge groups, the Tukey test of means was employed. The Tukey test determines how similar or different the means of a particular variable are over a set of classes and provides output showing which classes have similar means by grouping them together.[16] In this case, we used the natural logarithm of wage rates for each occupational group for the grouping test since the project ultimately was intended to divide workers up by wage rates.

Hourly wage rates are calculated for persons in the labour force with an occupation by dividing total earnings by the total hours worked. Workers are excluded from the analysis if any of earnings, hours, and weeks worked had values of zero.

The Tukey test also allows us to control for a number of other variables. In this paper, we controlled for age, sex, class of worker, highest level of education, and 2-digit industry (defined by the 1980 Standard Industrial Classification).

On the basis of this analysis, a small number of 3-digit occupations were reassigned from their initial classification. For example, transportation officers and controllers (C17, including pilots) had initially been excluded from knowledge worker categories, but were ultimately included on the basis of high wage rates and the high level of skill and training required in these occupations. The Tukey test on wage rates also confirmed the exclusion of a small number of specific 3-digit occupations from the aggregate knowledge category. For example, managers in retail trade (A21) and managers in food services and accommodation (A22) were both excluded since they have significantly lower wage rates than other 3-digit managerial occupations included in our knowledge worker taxonomy. Based on this analysis, we finalized the 1991 components of our eight knowledge worker categories.

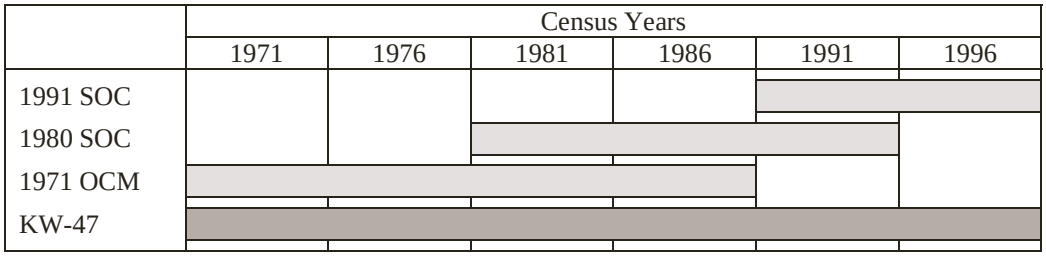
Finally, to verify that the forty-seven newly created occupation groups (eight knowledge worker categories and thirty-nine non-knowledge worker categories) were statistically different from each other in terms of average wage rates, we also applied the Tukey test. The test confirmed that the majority of the forty-seven occupational categories were distinct and that the groups exhibited very little overlap in terms of average wage rates. Thus, these forty-seven knowledge and non-knowledge occupational groupings were used in the final

occupational framework adopted in this paper to create a longitudinal concordance (Table 2A). We refer to this framework as KW-47.

Creating an occupational concordance over time

Having developed a 47 occupation grouping, we applied this framework to Census data that employed the 1971 and 1980 classification systems. The Standard Occupational Classification has experienced a number of changes and updates over the past thirty years, including substantial revisions in 1971 and 1991. This poses difficulties for conducting analysis over time.

Figure 1A. Conceptualizing an occupational concordance



In Figure 1A we show the occupational coding scheme used in each Census year between 1971 and 1996.

While a concordance between the 1971 and 1980 classification systems already exists since a similar though not completely identical structure was maintained between these census years, a concordance between these years and the 1991 occupational classifications presents a larger challenge. Radical changes were made to the occupational classification in 1991 as the classification scheme.

First, we consider the task of creating a concordance to express the 1980 Standard Occupational Classification in terms of its 1991 KW-47 equivalent. We then describe the task of expressing the 1971 Occupational Classification Manual in terms of its KW-47 equivalent (using its link to the 1980 Standard Occupational Classification as an intermediate step).

A concordance between the 1980 and 1991 standard occupational classification systems

There is a many-to-many relationship between the 1980 and 1991 Standard Occupational Classifications (i.e., an occupational group in 1980 is related to many occupational groups in 1991 and vice versa; there are very few one-to-one relationships).

Table 1A. Composition of the eight knowledge worker categories

Major group	Knowledge worker category		Occupations (1)	
Management	K1	Management	A01	Legislators and senior management
			A11	Administrative services managers
			A12	Managers in engineering, architecture, science and information systems
			A13	Sales, marketing and advertising managers
			A30	Managers in financial and business services
			A31	Managers in communication (except broadcasting)
			A32	Managers in health, education, social and community services
			A33	Managers in public administration
			A34	Managers in art, culture, recreation and sport
			A38	Managers in primary production (except agriculture)
			A39	Managers in manufacturing and utilities
Professional	K2	Business professionals	B01	Auditors, accountants and investment professionals
			B02	Human resources and business service professionals
Professional	K3	Science and engineering professionals	C01	Physical science professionals
			C02	Life science professionals
			C03	Civil, mechanical, electrical and chemical engineers
			C04	Other engineers
			C05	Architects, urban planners and land surveyors
			C06	Mathematicians, systems analysts and computer programmers
Technical	K4	Science – Technical occupations	C11	Technical occupations in physical sciences
			C12	Technical occupations in life sciences
			C13	Technical occupations in civil, mechanical and industrial engineering
			C14	Technical occupations in electronics and electrical engineering
			C15	Technical occupations in architecture, drafting, surveying and mapping
			C16	Other technical inspectors and regulatory officers
			C17	Transportation officers and controllers
Professional	K5	Health professionals	D01	Physicians, dentists and veterinarians
			D02	Optometrists, chiropractors and other health diagnosing and treating professionals
			D03	Pharmacists, dietitians and nutritionists
			D04	Therapy and assessment professionals
Technical	K6	Other health occupations	D11	Nurse supervisors and registered nurses
			D21	Medical technologists and technicians (except dental health)
Professional	K7	Education, law and social science-related	E01	Judges, lawyers and Quebec notaries
			E03	Policy and program officers, researchers and consultants
			E11	University professors and assistants
			E12	College and other vocational instructors
			E13	Secondary and elementary school teachers and counselors
Professional	K8	Arts and culture professionals	F01	Librarians, archivists, conservators and curators
			F02	Writing, translating and public relations professionals
			F03	Creative and performing artists

(1) Based on the 1991 Standard Occupational Classification.

Table 2A. Final occupational framework (KW-47)			
Broad occupation group		Occupation components (1)	
A	Management	A1	Specialist Managers (residual category)
		A2	Managers in Retail, Food, and Accommodation Services
		A3	Other managers, n.e.c. (residual category)
		K1	**Managers (A0, A1*, A3*)**
B	Business, finance and administration	B1	Finance and insurance administrative
		B2	Secretaries
		B3	Administrative and regulatory
		B4	Clerical supervisors
		B5	Clerical
		K2	**Business and finance – Professional (B0)**
C	Natural and applied sciences	**K3**	**Science – Professional (C0)**
		K4	**Science – Technical (C1)**
D	Health	D2	Technical and related (residual category)
		D3	Assisting occupations in support of health services
		K5	**Health – Professional (D0)**
		K6	**Health – Technical (D1, D2*)**
E	Social science, education, government service and religion	E0	Psychologists, social workers, etc. (residual category)
		E2	Paralegals, social services workers and occupations in education and religion, n.e.c.
		K7	**Social sciences and education – Professional (E0*, E1)**
F	Arts, culture, recreation and sport	F1	Technical occupations in art, culture, recreation, and sport
		K8	**Arts and culture – Professionals (F0)**
G	Sales and services	G0	Sales and services supervisors
		G1	Wholesale, technical, insurance, and real estate sales specialists and retail, wholesale and grain buyers
		G2	Retail salespersons and sales clerks
		G3	Cashiers
		G4	Chefs and Cooks
		G5	Occupations in food and beverage services
		G6	Occupations in protective service
		G7	Occupations in travel and accommodation
		G8	Childcare and homesupport workers
		G9	Sales and services occupations, n.e.c.
H	Trades, transport and equipment operators	H0	Contractors and supervisors in trades and transportation
		H1	Construction trades
		H2	Stationary engineers, power station operators and electrical trades and telecommunications operators
		H3	Machinists, metal forming, shaping and erecting
		H4	Mechanics
		H5	Other trades, n.e.c.
		H6	Heavy equipment and crane operators
		H7	Transportation equipment operators
		H8	Trades helpers, construction and transportation labourers
I	Occupations unique to primary industry	I0	Occupations unique to agriculture
		I1	Occupations unique to forestry, mining, oil and gas extraction, and fishing
		I2	Primary production labourers
J	Occupations unique to processing, manufacturing, and utilities	J0	Supervisors in manufacturing
		J1	Machine operators in manufacturing
		J2	Assemblers in manufacturing
		J3	Labourers in processing, manufacturing, and utilities

(1) Based on the 1991 Standard Occupational Classification.

Table 3A. Comparison of computer programmers and systems analysts using SOC-80 and SOC-91

	Number	Percentage
Computer Programmers and Systems Analysts (2183)	**149,885**	**100.0**
Records with SOC 1991 = C062	58,140	38.8
Records with SOC 1991 =C063	49,460	33.0
Records with other 1991 SOC codes	42,285	28.2
Number of other 1991 Codes	313	–
Computer Systems Analysts (C062)	**76,715**	**100.0**
Records with SOC 1980 = 2183	58,140	75.8
Records with imputed 1980 Code	2,325	3.0
Records with other 1980 SOC codes	16,250	21.2
Number of other 1980 Codes	277	–
Computer Programmers (C063)	**55,885**	**100.0**
Records with SOC 1980 = 2183	49,460	88.5
Records with imputed 1980 Code	1,690	3.0
Records with other 1980 SOC codes	4,735	8.5
Number of other 1980 Codes	218	–

Analysis of the 1991 Census provides statistical evidence that the concordance between the two classifications at the finest level of detail is imperfect. In most occupational classes, between 30% and 80% of the records do not follow the theoretical concordance. This is illustrated in Table 3A using 1991 Census data to show the relationship between the 1980 occupational classification for Computer Programmers and Systems Analysts (2183) and its theoretical 1991 counterparts: Computer Systems Analysts (C062) and Computer Programmers (C063).

It is evident that, while computer programmers and analysts (as identified by the 1980 classification) are only supposed to map into two occupational categories, this is true in only 71.8% of the cases. The remaining records (28.2%) are assigned to 313 different occupations. Similar patterns hold true in the reverse situation. Moreover, the computer programmer/analyst example is relatively simple. The theoretical concordance indicates that most occupations in 1980 (or 1991) have a large number of counterparts in 1991 (or 1980).

Our approach avoids having to work at the finest level of detail. By choosing some 47 more aggregate categories, these occupation groups are then traced back through time.

We use data from the 1991 Census to create a statistical, forced one-to-one concordance between the 1980 Standard Occupational Classification and the KW-47 Framework (defined using the 1991 Standard Occupational Classification).

It should be noted that we tested a number of different strategies for converting the 1980 Standard Occupational Classification (Input) to the 1991 Standard Occupational Classification (Output). These conversion levels are presented in Table 4A.

Table 4A. Conversion levels tested	
Input	Output
4-digit 1980 Standard Occupational Classification	4-digit 1991 Standard Occupational Classification
3-digit 1980 Standard Occupational Classification	3-digit 1991 Standard Occupational Classification
	KW-47 Occupational Framework

Note: Using 2-digit level occupations on the output side would not allow conversion to the KW-47 framework. The results for the 3- and 4-digit levels on the output side were converted to the KW-47 framework for analysis of the effectiveness of the forced one-to-one match.

We used three criteria to determine which conversion level was best:

1) To maximize the proportion of the input group that was classified to the output group;
2) To minimize the number of cases where less than 50% of the input group was classified to the output group; and
3) To minimize the number of missing KW-47 categories.

We found that our results were better when we used the greatest level of detail on the input side (i.e., 4-digit level occupations from the 1980 Standard Occupational Classification) and the lowest level of detail on the output side (i.e., the KW-47 Occupational Framework). Therefore, prior to creating the concordance, we converted 1991 occupation data to the KW-47 framework and used this to assign each 4-digit occupation (1980) to an occupation based on the KW-47 framework.

The forced one-to-one match was made using a proportional matrix created from the double-coded 1991 Census. The matrix included sets of input-output pairs, whereby each input group had one or (in most cases) many output groups. First, each 4-digit occupation (1980) was matched to a broad occupational category (A to J) based on the category accounting for the highest proportion of population-weighted records. Second, we matched each 4-digit occupation (1980) to the KW-47 group within the occupational category (A to J) selected in the previous step.

For example, a 4-digit occupation (1980) may be divided 90% to Management and 10% to Business and Finance. In that case, it would be assigned to the Management category. Within the Management category, we then chose the KW-47 group that accounted for the greatest proportion of population-weighted records. Using this method we were able to create a forced one-to-one conversion table, matching each 4-digit occupation (1980) to a single corresponding KW-47 group.

A concordance between the 1971 Occupational Classification Manual and the 1980 Standard Occupational Classification Systems

Deriving the concordance between the 1971 and 1980 classification systems was less complex. The majority of 4-digit occupations in the 1971 Occupational Classification Manual match one-to-one with their 1980 counterparts, since there were only minor revisions between 1971 and 1980 and few occupational groups were discontinued, aggregated, or split. Since

more than 90% of the records had the same occupation regardless of the classification system, a direct concordance between the two systems at the 4-digit level was used.

Using a method similar to that used to create a one-to-one relationship between the 1980 Standard Occupational Classification and the KW-47 framework, a forced one-to-one match was then made to the KW-47 framework using a proportional matrix created from the double-coded 1981 and 1986 Censuses. By converting 1971 occupations (4-digit level) to 1980 equivalents (4-digit level), we then reclassified the 1971 codes to the KW-47 framework.[17] Our results were similar regardless of whether the 1981 or 1986 Census was used to produce the concordance. The 1986 Census was ultimately chosen to produce the final concordance.

It should be noted that in our final tables which assign 4-digit level occupations (1980) to the KW-47 framework that there were three occupational categories (A1, B1, and G0, Table 2A) where there was no match based on our methodology. Given the discontinuities between the 1980 and 1991 standards, this is not unexpected. However, the application of this concordance is at an even more aggregate level and our estimates at this aggregate level are fairly robust.

Empirical results

In order to evaluate the robustness of the methodology employed, we present the trajectory of the 10 major groupings of our 47-category framework below but use two different methods to assign the 1990 data to our 47 groups.

Figure 2A classifies all census data on the basis of the SOC 1980 from 1981 up to and including 1991, while Figure 3A uses the SOC 1980 from 1981 but only up to 1986. The difference between the two then allows us to evaluate how much difference is made to the aggregate level that we are using here by the dramatic change in occupational classifications in 1991.

It is clear that the aggregate trends are more or less the same in both cases. We conclude that for aggregate analyses, our concordances give us more or less smooth trends.

Figure 2A. Converted to KW-47 framework using the following: 1971 occupations use OCM-70; 1976 is interpolated; 1981, 1986, and 1991 use SOC-80; 1996 uses SOC-91, by broad occupational categories

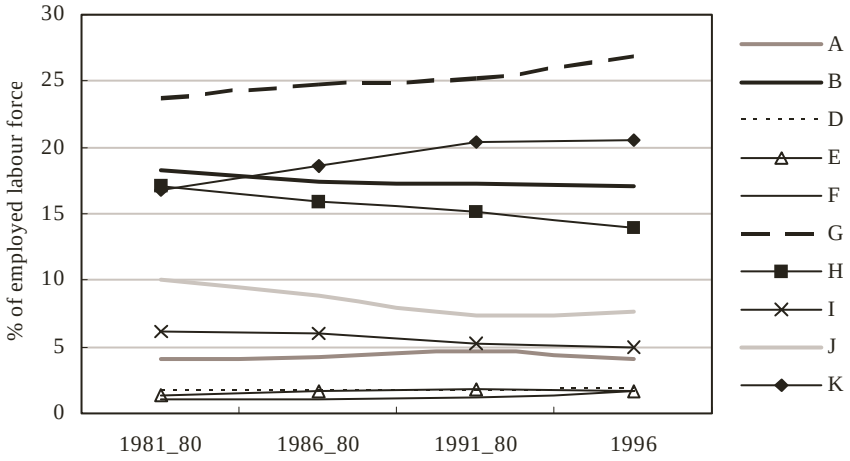
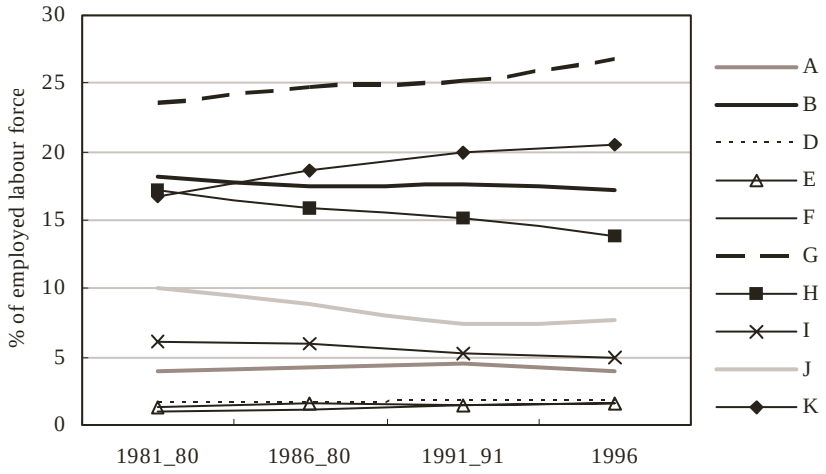


Figure 3A. Converted to KW-47 framework using the following: 1971 occupations use OCM-70; 1976 is interpolated; 1981 and 1986 use SOC-80; 1991 and 1996 use SOC-91, by broad occupational categories



Endnotes

[15] Similarly, there are differences between the 1971 and 1980 Standard Occupational Classification systems. However, the 1980 Standard Occupational Classification system involved only a minor revision of its predecessor.

[16] It is possible for a class to belong to more than one group.

[17] In almost all cases, a straightforward matching algorithm sufficed. However, there was one minor revision between the 1981 and 1991 Censuses in the coding procedure used for farming occupations under the 1980 Standard Occupational Classification. In the 1991 Census, all farmers were coded as '7111'. In the 1981 Census, farmers were coded either as '7113', '7115', or '7119'. Therefore, adjustments were made to ensure data consistency.

Appendix 2: Standard Occupational Classification Codes

Table 5A. 1991 Standard Occupational Classification Codes used to identify knowledge workers

Code	Knowledge Category	Description
A01.001	K1	Legislators and Senior Management
A11.011	K1	Administrative Services Managers
A12.021	K1	Managers in Engineering, Architecture, Science and Information Systems
A13.061	K1	Sales, Marketing and Advertising Managers
A30.012	K1	Managers in Financial and Business Services
A31.013	K1	Managers in Communication (except Broadcasting)
A32.031	K1	Managers in Health, Education, Social and Community Services
A33.041	K1	Managers in Public Administration
A34.051	K1	Managers in Art, Culture, Recreation and Sport
A38.081	K1	Managers in Primary Production (except Agriculture)
A39.091	K1	Managers in Manufacturing and Utilities
B01.111	K2	Auditors, Accountants and Investment Professionals
B02.112	K2	Human Resources and Business Service Professionals
C01.211	K3	Physical Science Professionals
C02.212	K3	Life Science Professionals
C03.213	K3	Civil, Mechanical, Electrical and Chemical Engineers
C04.214	K3	Other Engineers
C05.215	K3	Architects, Urban Planners and Land Surveyors
C06.216	K3	Mathematicians, Systems Analysts and Computer Programmers
C11.221	K4	Technical Occupations in Physical Sciences
C12.222	K4	Technical Occupations in Life Sciences
C13.223	K4	Technical Occupations in Civil, Mechanical and Industrial Engineering
C14.224	K4	Technical Occupations in Electronics and Electrical Engineering
C15.225	K4	Technical Occupations in Architecture, Drafting, Surveying and Mapping
C16.226	K4	Other Technical Inspectors and Regulatory Officers
C17.227	K4	Transportation Officers and Controllers
D01.311	K5	Physicians, Dentists and Veterinarians
D02.312	K5	Optometrists, Chiropractors and Other Health Diagnosing and Treating Professionals
D03.313	K5	Pharmacists, Dietitians and Nutritionists
D04.314	K5	Therapy and Assessment Professionals
D11.315	K6	Nurse Supervisors and Registered Nurses
D21.321	K6	Medical Technologists and Technicians (except Dental Health)
E01.411	K7	Judges, Lawyers and Quebec Notaries
E03.416	K7	Policy and Program Officers, Researchers and Consultants
E11.412	K7	University Professors and Assistants
E12.413	K7	College and Other Vocational Instructors
E13.414	K7	Secondary and Elementary School Teachers and Counsellors
F01.511	K8	Librarians, Archivists, Conservators and Curators
F02.512	K8	Writing, Translating and Public Relations Professionals
F03.513	K8	Creative and Performing Artists

Table 6A. 1981 Standard Occupational Classification Codes used to identify knowledge workers

Code	Knowledge Category	Description
1111	K1	Members of Legislative Bodies
1113	K1	Government Administrators
1130	K1	General Managers and Other Senior Officials
1131	K1	Management Occupations, Natural Sciences and Engineering
1132	K1	Management Occupations, Social Sciences and Related Fields
1133	K1	Administrators in Teaching and Related Fields
1134	K1	Administrators in Medicine and Health
1135	K1	Financial Management Occupations
1136	K1	Personnel and Industrial Relations Management Occupations
1143	K1	Production Management Occupations
1147	K1	Management Occupations, Transport and Communications Operations
1151	K1	Other Managers (Mines and Oil Wells)
1152	K1	Other Managers (Durable Goods Manufacturing)
1153	K1	Other Managers (Non-Durable Goods Manufacturing)
1155	K1	Other Managers (Transportation and Communication)
1157	K1	Other Managers (Service)
1158	K1	Other Managers (Other Industries)
1171	K2	Accountants, Auditors and Other Financial Officers
1173	K2	Organization and Methods Analysts
1176	K4	Inspectors and Regulatory Officers, n.e.c.
2111	K3	Chemists
2112	K3	Geologists
2113	K3	Physicists
2114	K3	Meteorologists
2117	K4	Physical Sciences Technologists and Technicians
2119	K4	Occupations in Physical Sciences, n.e.c.
2131	K3	Agriculturists and Related Scientists
2133	K3	Biologists and Related Scientists
2135	K4	Life Sciences Technologists and Technicians
2139	K4	Occupations in Life Sciences, n.e.c.
2141	K3	Architects
2142	K3	Chemical Engineers
2143	K3	Civil Engineers
2144	K3	Electrical Engineers
2145	K3	Industrial Engineers
2146	K3	Agricultural Engineers
2147	K3	Mechanical Engineers
2151	K3	Metallurgical Engineers
2153	K3	Mining Engineers
2154	K3	Petroleum Engineers
2155	K3	Aerospace Engineers
2156	K3	Nuclear Engineers
2157	K3	Community Planners
2159	K3	Professional Engineers, n.e.c.
2160	K4	Supervisors: Other Occupations in Architecture and Engineering
2161	K3	Surveyors
2163	K4	Draughting Occupations
2164	K4	Architectural Technologists and Technicians
2165	K4	Engineering Technologists and Technicians
2169	K4	Other Occupations in Architecture and Engineering, n.e.c.
2181	K3	Mathematicians, Statisticians and Actuaries
2183	K3	Systems Analysts, Computer Programmers and Related Occupations
2311	K7	Economists
2313	K7	Sociologists, Anthropologists and Related Social Scientists
2319	K7	Occupations in Social Sciences, n.e.c.
2341	K7	Judges and Magistrates
2343	K7	Lawyers and Notaries
2350	K8	Supervisors: Occupations in Library, Museum and Archival Sciences
2351	K8	Librarians, Archivists and Conservators
2391	K7	Educational and Vocational Counsellors

Table 6A. 1981 Standard Occupational Classification Codes used to identify knowledge workers – *concluded*

Code	Knowledge Category	Description
2711	K7	University Teachers
2719	K7	University Teaching and Related Occupations, n.e.c.
2731	K7	Elementary and Kindergarten Teachers
2733	K7	Secondary School Teachers
2739	K7	Elementary and Secondary School Teaching and Related Occupations, n.e.c.
2791	K7	Community College and Vocational School Teachers
2792	K8	Fine Arts Teachers, n.e.c.
2793	K7	Post-secondary School Teachers, n.e.c.
2797	K7	Instructors and Training Officers, n.e.c.
2799	K7	Other Teaching and Related Occupations, n.e.c.
3111	K5	Physicians and Surgeons
3113	K5	Dentists
3115	K5	Veterinarians
3117	K5	Osteopaths and Chiropractors
3119	K6	Health Diagnosing and Treating Occupations, n.e.c.
3130	K6	Supervisors: Nursing, Therapy and Related Assisting Occupations
3131	K6	Nurses, Registered, Graduate and Nurses-in-Training
3136	K5	Audio and Speech Therapists
3137	K5	Physiotherapists
3138	K5	Occupational Therapists
3151	K5	Pharmacists
3152	K5	Dietitians and Nutritionists
3153	K5	Optometrists
3155	K6	Radiological Technologists and Technicians
3156	K6	Medical Laboratory Technologists and Technicians
3162	K6	Respiratory Technicians
3311	K8	Painters, Sculptors and Related Artists
3330	K8	Producers and Directors, Performing and Audio-Visual Arts
3331	K8	Conductors, Composers and Arrangers
3332	K8	Musicians and Singers
3334	K8	Dancers and Choreographers
3335	K8	Actors/Actresses
3351	K8	Writers and Editors
3355	K8	Translators and Interpreters
3359	K8	Occupations in Writing, n.e.c.
5173	K2	Sales Agents and Traders, Securities
7516	K4	Log Inspecting, Grading, Scaling and Related Occupations
8535	K4	Electronic and Related Equipment Installing and Repairing Occupations, n.e.c.
8537	K4	Radio and Television Repairers
8585	K4	Business and Commercial Machine Mechanics and Repairers
8588	K4	Precision Instrument Mechanics and Repairers
8796	K4	Inspecting, Testing, Grading and Sampling Occupations: Other Construction Trades
9111	K4	Air Pilots, Navigators and Flight Engineers
9113	K4	Air Transport Operating Support Occupations
9151	K4	Deck Officers
9153	K4	Engineering Officers, Ship
9550	K1	Foremen/women: Electonic and Related Communications Equipment Operating Occupations, n.e.c.
9559	K4	Other Electronic and Related Communications Equipment Operating Occupations, n.e.c.

Table 7A. 1971 Occupational Classification Manual Codes used to identify knowledge workers

Code	Knowledge Category	Description
1111	K1	Members of Legislative Bodies
1113	K1	Government Administrators
1130	K1	General Managers and Other Senior Officials
1131	K1	Management Occupations, Natural Sciences and Engineering
1132	K1	Management Occupations, Social Sciences and Related Fields
1133	K1	Administrators in Teaching and Related Fields
1134	K1	Administrators in Medicine and Health
1135	K1	Financial Management Occupations
1136	K1	Personnel and Industrial Relations Management Occupations
1143	K1	Production Management Occupations
1147	K1	Management Occupations, Transport and Communications Operations
1151	K1	Other Managers (Mines and Oil Wells)
1152	K1	Other Managers (Durable Goods Manufacturing)
1153	K1	Other Managers (Non-Durable Goods Manufacturing)
1155	K1	Other Managers (Transportation and Communication)
1157	K1	Other Managers (Service)
1158	K1	Other Managers (Other Industries)
1171	K2	Accountants, Auditors and Other Financial Officers
1176	K4	Inspectors and Regulatory Officers, non-government
2111	K3	Chemists
2112	K3	Geologists
2113	K3	Physicists
2114	K3	Meteorologists
2117	K4	Physical Sciences Technologists and Technicians
2119	K4	Occupations in Physical Sciences, n.e.c.
2131	K3	Agriculturists and Related Scientists
2133	K3	Biologists and Related Scientists
2135	K4	Life Sciences Technologists and Technicians
2139	K4	Occupations in Life Sciences, n.e.c.
2141	K3	Architects
2142	K3	Chemical Engineers
2143	K3	Civil Engineers
2144	K3	Electrical Engineers
2145	K3	Industrial Engineers
2147	K3	Mechanical Engineers
2151	K3	Metallurgical Engineers
2153	K3	Mining Engineers
2154	K3	Petroleum Engineers
2155	K3	Aeronautical Engineers
2157	K3	Nuclear Engineers
2159	K3	Architects and Engineers, n.e.c.
2160	K4	Supervisors: Other Occupations in Architecture and Engineering
2161	K3	Surveyors
2163	K4	Draughtsmen
2165	K4	Architectural and Engineering Technologists and Technicians
2169	K4	Other Occupations in Architecture and Engineering, n.e.c.
2181	K3	Mathematicians, Statisticians and Actuaries
2183	K3	Systems Analysts, Computer Programmers and Related Occupations
2311	K7	Economists
2313	K7	Sociologists, Anthropologists and Related Social Scientists
2319	K7	Occupations in Social Sciences, n.e.c.
2341	K7	Judges and Magistrates
2343	K7	Lawyers and Notaries
2350	K8	Supervisors: Occupations in Library, Museum and Archival Sciences
2351	K8	Librarians and Archivists
2391	K7	Educational and Vocational Counsellors
2711	K7	University Teachers
2719	K7	University Teaching and Related Occupations, n.e.c.
2731	K7	Elementary and Kindergarten Teachers
2733	K7	Secondary School Teachers
2739	K7	Elementary and Secondary School Teaching and Related Occupations, n.e.c.

Table 7A. 1971 Occupational Classification Manual Codes used to identify knowledge workers – *concluded*

Code	Knowledge Category	Description
2791	K7	Community College and Vocational School Teachers
2792	K8	Fine Arts School Teachers
2793	K7	Post-secondary School Teachers, n.e.c.
2797	K7	Instructors and Training Officers, n.e.c.
2799	K7	Other Teaching and Related Occupations, n.e.c.
3111	K5	Physicians and Surgeons
3113	K5	Dentists
3115	K5	Veterinarians
3117	K5	Osteopaths and Chiropractors
3119	K6	Health Diagnosing and Treating Occupations, n.e.c.
3130	K6	Supervisors: Nursing Occupations
3131	K6	Nurses, Graduate, Except Supervisors
3137	K5	Physiotherapists, Occupational and Other Therapists
3151	K5	Pharmacists
3152	K5	Dietitians and Nutritionists
3153	K5	Optometrists
3155	K6	Radiological Technologists and Technicians
3156	K6	Medical Laboratory Technologists and Technicians
3311	K8	Painters, Sculptors and Related Artists
3330	K8	Producers and Directors, Performing and Audio-Visual Arts
3332	K8	Musicians
3333	K8	Dancers and Choreographers
3335	K8	Actors/Actresses
3352	K8	Writers and Editors
3355	K8	Translators and Interpreters
3359	K8	Occupations in Writing, n.e.c.
5173	K2	Sales Agents and Traders, Securities
7516	K4	Log Inspecting, Grading, Scaling and Related Occupations
8535	K4	Electronic and Related Equipment Installing and Repairing Occupations, n.e.c.
8537	K4	Radio and Television Service Repairmen
8585	K4	Business and Commercial Machine Mechanics and Repairmen
8588	K4	Precision Instrument Mechanics and Repairmen
8796	K4	Inspecting, Testing, Grading and Sampling Occupations, Construction, Except Electrical
9111	K4	Air Pilots, Navigators and Flight Engineers
9113	K4	Air Transport Operating Support Occupations
9151	K4	Deck Officers
9153	K4	Engineering Officers, Ship
9550	K1	Foremen: Electonic and Related Communications Equipment Operating Occupations, n.e.c.
9559	K4	Electronic and Related Communications Equipment Operating Occupations, n.e.c.

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