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## Analytical Paper

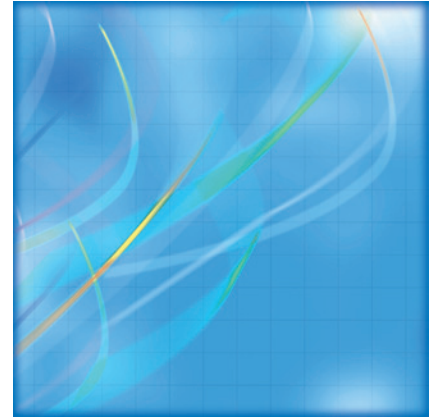
Insights on the Canadian economy

# Knowledge workers in Canada's economy, 1971-2001

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*This paper represents the views of the authors and does not necessarily reflect the opinions of Statistics Canada.*



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*Aussi disponible en français*

## *Abstract*

This paper examines the emergence of the knowledge economy by examining the increasing importance of high-knowledge occupations over the period 1971-2001. Contrary to the impression that is sometimes given by reports that just emphasize the recent rapid development of the high-tech information and communications technology sector, a more extensive examination of the presence of knowledge workers shows that the emergence of the knowledge economy has been more widespread and continuous than might otherwise be thought. This paper 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—and for different industries. 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. 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 an extensive profile of knowledge workers in Canada from 1971 to 1996—that includes both additional tabulations and more discussion of data and methods—please see “Dimensions of Occupational Changes in Canada’s Knowledge Economy, 1971-1996” (11-622-MIE No. 004).

*Keywords:* Canada, knowledge economy, occupation, industry.

## ***1. Introduction***<sup>1</sup>

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 a world of knowledge in which human capital, skills, innovation and technology are more necessary than ever in order 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.

Studies that have addressed the emergence or evolution of the so-called ‘new’ or ‘knowledge’ economy have defined the new economy in different ways. Some have adopted an industry-based level of analysis to identify and measure shifts in the Canadian economy, while others have examined the same issue using data on individual industry participants.

In the first case, technology use, R&D intensity, and other measures of technological advance have been used to classify whole industries as belonging to the ‘knowledge’ economy to argue that the Canadian economy is undergoing (or has undergone) a significant transformation (Lee and Has, 1996; Gera and Massé, 1996; Gera and Mang, 1997).

These studies implicitly assume that industries are homogenous in nature—that it is appropriate to classify entire industries as belonging to the new economy while entirely excluding others. 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). In this vein, 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 just to industries commonly thought of as being high-technology industries. They are found across all 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 and are not available for 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 in order 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 recently been developed means they do not permit us to compare changes over time.

Others have used an alternate approach to drill down into an industry to measure knowledge intensity by examining the skills of individual workers within industries—by using educational

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<sup>1</sup> A more detailed version of this paper can be found in Beckstead and Vinodrai (2003).

attainment, training, or 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, Gu and Lin, 1999).

These measures, when applied to individuals, allow a finer distinction to be made about the importance of the 'knowledge' economy, since they potentially allow statistics to be developed capturing the percentage of workers in an industry who are 'knowledge' oriented. These measures do not require a dichotomous classification of an industry as either being or not being 'knowledge' oriented—rather they permit statistics to be developed on what percentage of the industry (or its employees) are knowledge-oriented.

There is no single or perfect measure of knowledge intensity, production or use. The alternative described here provides different insights into the complexities associated with an evolving and changing economy (Howitt, 1996). Since earlier versions in this research series that are examining the emergence of the 'knowledge' economy in Canada have used the industry approach to classification (Beckstead and Gellatly, 2003; Beckstead, Brown, Gellatly and Seaborn, 2003), this paper adopts the human-capital approach to defining and examining the evolution of Canada's knowledge-based labour force across regions and industries in order to provide a balanced approach to the issue.

This paper uses data from the census of population 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 it is restricted to a relatively small number of 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 1971-2001 period?*
- 2) *Has one group of knowledge workers grown faster than others?*
- 3) *Has the educational attainment of the different knowledge worker groups increased at different rates?*
- 4) *Have relative earnings increased in the knowledge occupations?*
- 5) *Has the importance of knowledge workers increased more in one industrial sector than another?*

## ***2. Defining the workers at the core of the ‘knowledge’ economy***

The analysis presented in this paper uses data from the 1971, 1981, 1991 and 2001 Population Censuses to examine the importance of knowledge workers. The percentage of workers in different occupational classes is used to proxy the knowledge intensity of the economy or industrial sector. We limit our discussion to the employed labour force, using the concept of labour force activity in the 1971 Census to ensure consistency and historical comparability.<sup>2</sup> Industrial sectors are defined using the 1980 Standard Industrial Classification (SIC) from 1971 to 1996 and according to the North American Industrial Classification System (NAICS) in 2001.

The study makes use of a set of consistently defined occupational groups to examine the importance of knowledge workers. A taxonomy is developed that employs 47 broad occupational groups that we use to track changes over time.<sup>3</sup> More detail on this classification system is available in Beckstead and Vinodrai (2003). Drawing upon previous work, we identify several of these as heavily involving knowledge workers (see Lee and Has, 1996; Lavoie and Roy, 1998; Zhao, Drew and Murray, 2000). We recognize that all occupations require a common knowledge base, but we define a set of occupations as requiring a different knowledge base and for this study refer to this group as being ‘knowledge workers’.

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 occupations that fall in each class are reported in Appendix A, Table A1.

## ***3. Changing dimensions of Canada’s knowledge base***

Our objective is to provide measures of the pace of change in the knowledge sector over the last three decades of the twentieth century. In doing so, we examine how the share of workers in the knowledge occupations has changed over time, changes in education attainment in knowledge and other occupations, and wage dimensions of this change.

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<sup>2</sup> While the Census labour force concept has remained reasonably constant between 1971 and 2001, 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.

<sup>3</sup> 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.

### 3.1 Overall change

Between 1971 and 2001, Canada has almost doubled the percentage of its workforce who fall into the knowledge occupations—from 14% to 25%.<sup>4</sup> But this is not a new phenomenon that has emerged only in the 1990s as the Information and Communications Technology (ICT) sector experienced explosive growth. The increase has been occurring steadily decade by decade. It increased by 3.7 percentage points in the 1970s, 4.0 percentage points in the 1980s and 3.2 percentage points in the 1990s.

**Table 1. Employed labour force\* by occupation, 1971-2001**

	Share of employment* (%)			
	1971	1981	1991	2001
<i>All knowledge-based occupations</i>	13.8	17.5	21.5	24.7
Management occupations	1.6	3.6	5.4	6.1
Professional occupations	8.7	9.9	11.3	14.3
Technical occupations	3.5	4.0	4.7	4.4
<i>All other occupations</i>	86.2	82.5	78.5	75.3
<b>All occupations</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

\* Defined as the employed labour force using the 1971 Census labour force concept.

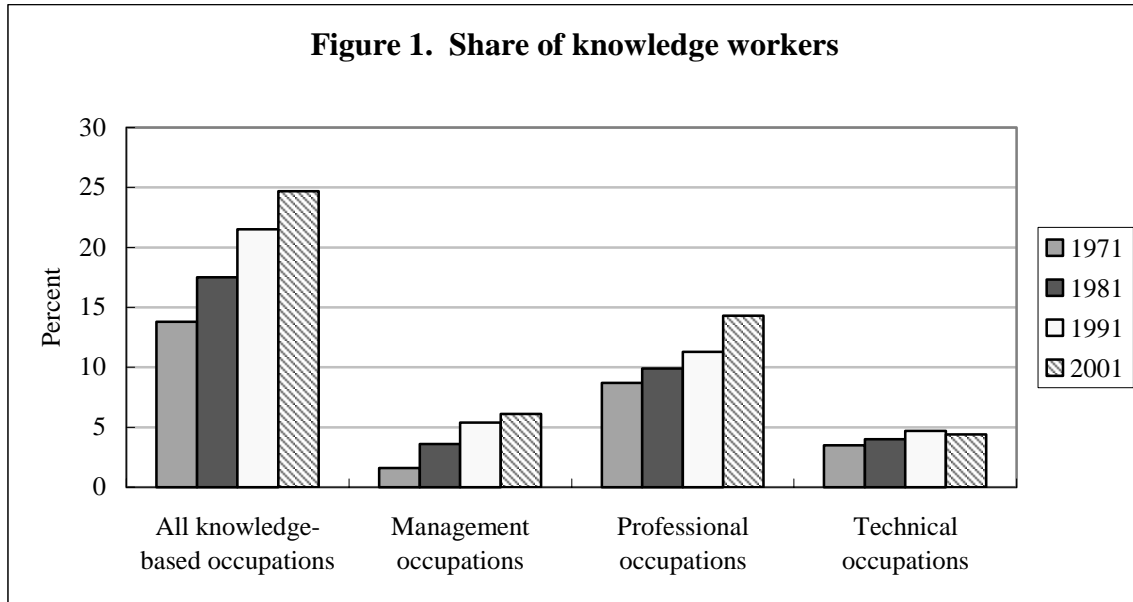
This increase was experienced by all three groups of knowledge workers—managers, professionals and technical occupations (Figure 1). The largest group of knowledge workers consists of those found in professional occupations. And the increase has been largest here. The second largest increase has occurred in management occupations.<sup>5</sup> The smallest increases have occurred in technical occupations. Growth has been continuous for management and professional occupations throughout the period—but fell behind in the 1990s for the technical occupations.

### 3.2 Educational attainment

Knowledge is determined by the capability, experience and education of the workforce. Formal education is seen to be a key input for the creation of the type of workforce that is needed in the knowledge economy. One way of testing this hypothesis is to examine the educational attainment of our knowledge workers and how this has changed through time.

<sup>4</sup> While the term ‘knowledge worker’ has been used extensively in both the popular and academic press, in this paper it refers to the three broad groups of knowledge-based occupations (management, professional, technical) as described in Section 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.

<sup>5</sup> Growth in the management category has been documented elsewhere. Differences in the coding procedures between the 1971 Occupational Classification Manual (OCM) and the 1980 Standard Occupation Classification (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).



We use the proportion of the workforce with a university-level or professional degree to investigate the prevalence of higher levels of education in the workforce and how this varies across occupation classes (Table 2).

There has been an increase in the proportion of the labour force that has completed a university-level degree. 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 2001, more than half of the people in knowledge-based occupations had university-level degrees compared to less than 10% of other occupations.

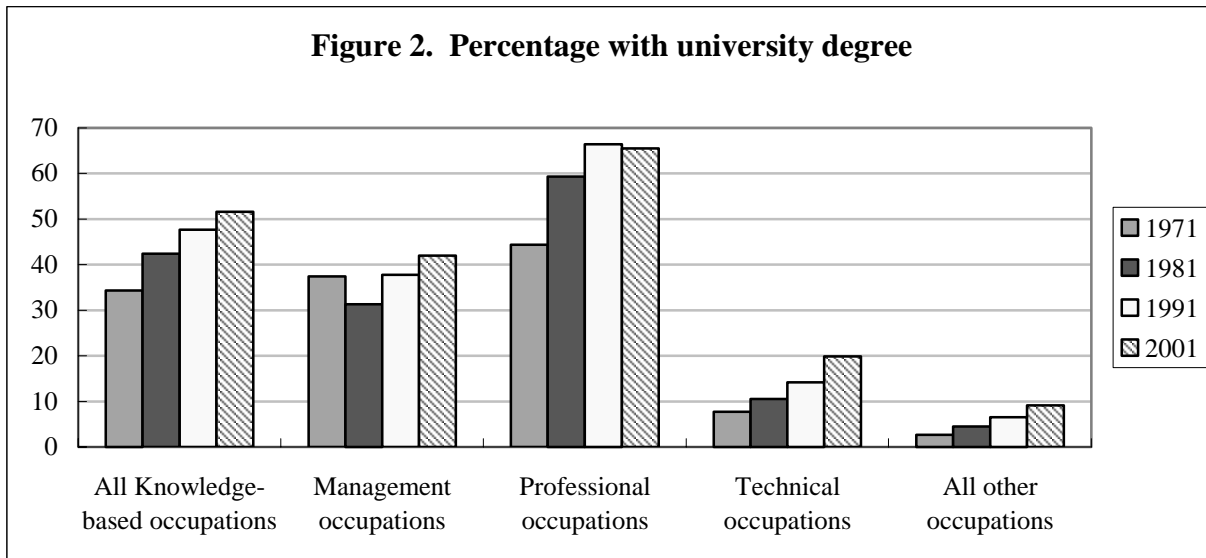
During the entire time period, the percentage point increase was greater for the knowledge than for the other occupations. But it did increase in the latter. These findings confirm that the upskilling of the workforce has affected all occupations within the labour force.

**Table 2. Educational attainment by occupation—percentage of occupations with university degree\* completion, 1971-2001**

	1971	1981	1991	2001
<i>All Knowledge-based occupations</i>	34.3	42.4	47.7	51.6
Management occupations	37.4	31.3	37.8	42.0
Professional occupations	44.4	59.3	66.4	65.5
Technical occupations	7.7	10.5	14.2	19.9
<i>All other occupations</i>	2.7	4.5	6.5	9.1
<b>All occupations</b>	<b>7.1</b>	<b>11.2</b>	<b>15.3</b>	<b>19.6</b>

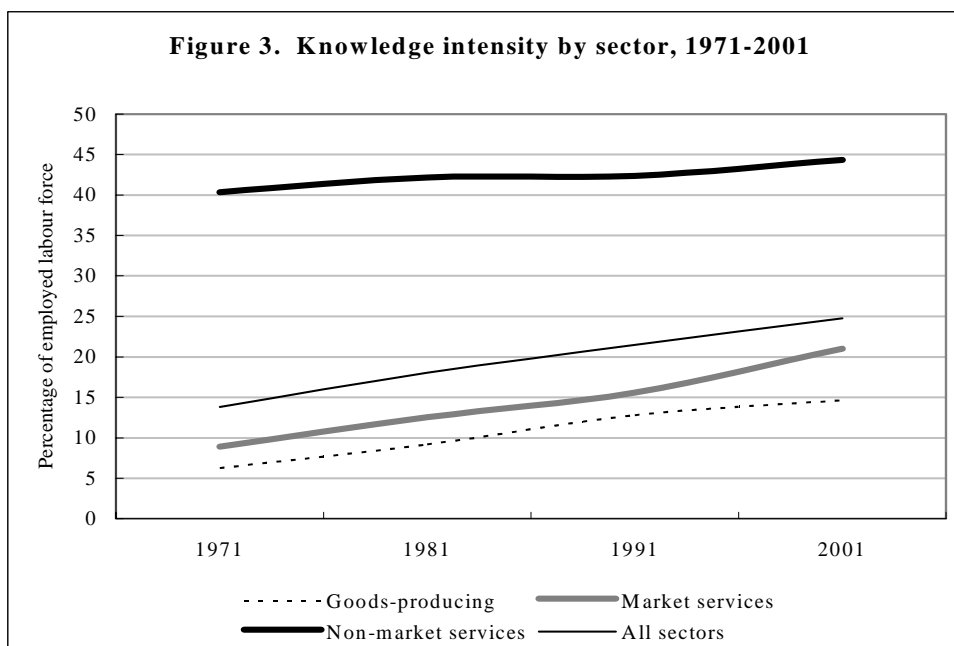
\* Includes completion of bachelor, professional, masters or doctorate level university degree.





Overall, the pace of the increase has been relatively steady over the three decades (Figure 2). But the overall trend is not the same within each of the subgroups. There has been a general increase in the proportion of persons with degrees in professional and technical occupations—but this increase for professionals did not continue in the 1990s, while it did for technical occupations.

In 1971, slightly less than 45% of professionals had university degrees; by 2001, this had increased to 66%. 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 1970s. 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).



### 3.3 Shifts in Canada's knowledge base: Sectoral evidence

Knowledge workers are present to different degrees across the industrial sector. The issue is whether knowledge workers have spread at different rates over the three decades. To examine whether the 'knowledge' economy has grown at different rates, we divide the overall economy into three sectors: goods producing<sup>6</sup>, market services, and non-market services and plot in Figure 3 the percentage of employment that consists of knowledge workers.<sup>7</sup>

There are substantial differences in the level of knowledge intensity as measured by the percentage of knowledge workers. In the non-market service sector, more than 40 percent of workers fall into the knowledge classifications. The service sector comes next with the goods-producing sector last.

Growth in the intensity of knowledge workers occurred primarily in the market sector. The public sector (non-market services) rose from 40% to only 44%. In contrast, the market services sector grew by about 12 percentage points while the goods-producing sector grew by about 8 percentage points.

<sup>6</sup> 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 industry division Communication and Other Utility Industries) 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 in Section 4 of this paper.

<sup>7</sup> 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.

#### ***4. Shifts in Canada's knowledge-base: Industry dimensions***

Knowledge workers then have been growing in importance in both the service and the business markets sectors over much of the last thirty years. Here we focus on the areas where knowledge workers are more concentrated. To do so, we examine the percentage of knowledge workers by industry division for the period from 1971-2001 (Table 3).<sup>8</sup>

The highest levels of knowledge intensity are found in health and education—two sectors where governments dominate in the provision of service. The other major sectors where a substantial number of workers fall in the knowledge sector are business services, finance and insurance, communications and utilities, oil and gas, and manufacturing.

In the non-market service sector, there has been an increase in knowledge intensity in general government services, but not in health or education. It is the flat trend in the latter two that accounts for the overall stagnation in non-market services.

Similar to the trend we saw in the aggregate business sector, there has been an increase in the level of knowledge intensity across all industry divisions in the market sector, with the exception of the accommodation, food, and beverage services industry. 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 business services industries (25 percentage points), finance and insurance (22 percentage points), and wholesale trade (17 percentage points)—all in the service sector. Communications and other utilities grew by some 10 percentage points over the 1971-1996 period. The latter are classified as part of the ICT sector (see Beckstead and Gellatly, 2003). It is therefore clear that the ICT sector was part of the knowledge revolution but did not lead the way over the last three decades.

In the goods sector, the largest increases occurred in oil and gas (12 percentage points). In addition, the forestry sector experienced rapid growth (some 14 percentage points from 1971-1996). These two components of Canada's natural resource sector were active participants in the emergence of the knowledge economy. The manufacturing sector actually trailed the old sector both in terms of level of knowledge intensity and in terms of growth (10 percentage points). If we break manufacturing into a core set of more innovative industries (pharmaceuticals, chemicals, instruments, electronics, machinery and equipment), knowledge intensity was highest in this group and growing more rapidly over this period (Beckstead and Vinodrai, 2003).

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<sup>8</sup> We use the SIC industry classification system from 1971-96 and NAICS in 2001. Industries defined in NAICS have been grouped to make them as comparable as possible to industries defined using the SIC classification system.

**Table 3. Knowledge intensity\* by industry in the business sector, 1971-2001**

Sector	Share of employment (%)**				
	1971	1981	1991	2001	1971-2001
Agriculture, Forestry, Fishing and Hunting	1.3	3.0	5.1	4.3	3.0
Mining, Quarrying, Oil and Gas	13.9	19.8	24.4	26.0	12.1
Manufacturing	7.9	11.2	16.5	18.0	10.2
Construction	4.6	5.2	7.3	7.6	3.0
Transportation and Storage	7.1	10.3	10.3	9.2	2.1
Communication and Other Utility	13.8	20.1	24.2	–	–
Wholesale Trade	6.5	8.5	17.0	23.1	16.7
Retail Trade	3.2	3.3	4.5	5.4	2.2
Finance and Insurance	19.5	26.7	28.1	41.7	22.2
Real Estate Operator and Insurance Agent	6.9	10.7	12.1	15.2	8.2
Business Service	40.6	43.4	48.2	65.8	25.2
Accommodation, Food and Beverage Services	1.2	1.3	2.2	1.4	0.2
Other Services	6.4	11.6	12.4	11.2	4.7

\* Knowledge intensity is measured as the employment share of knowledge-based occupations.

\*\* Includes only the employed labour force defined using the 1971 Census labour force concept.

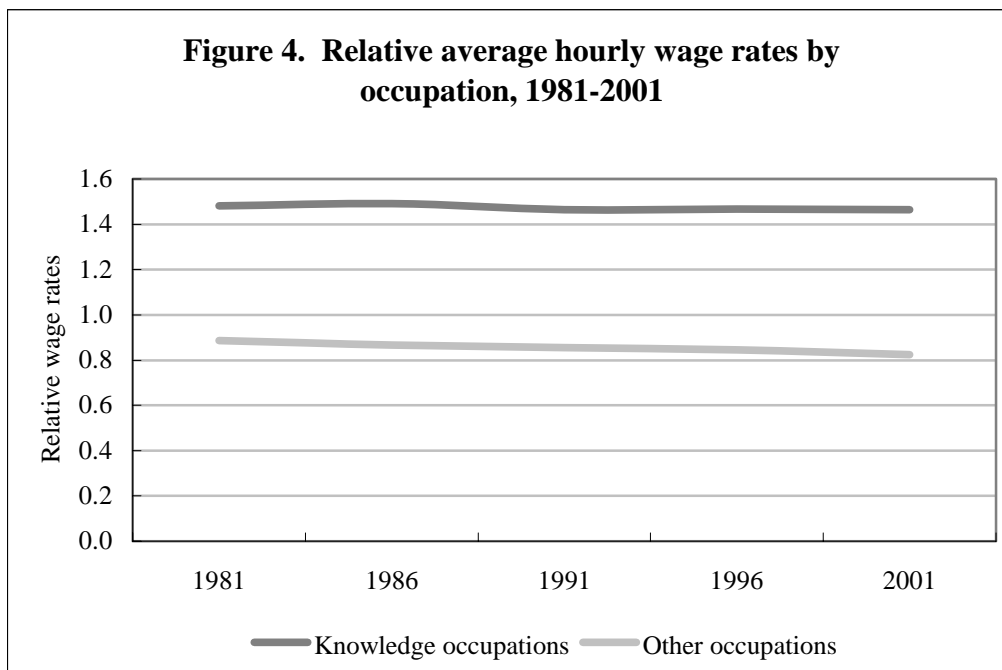
It is noteworthy however that in general the largest percentage point increases in knowledge intensity occurred in those industries that started in 1971 with above average knowledge intensity. The demand for skilled workers in these industries, which was already higher than average, moved even further ahead during this period.

### ***5. Earnings and wages of knowledge-based occupations***

Changes that have occurred in the distribution of knowledge workers have been more or less continuous over the last thirty years. 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 examine how the level of compensation in knowledge-based occupations has changed relative to all occupations over the study period.<sup>9</sup>

Overall, there is a significant difference between the wage rates of knowledge-based occupations and other occupations (Figure 4). 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. Despite the large percentage point gain in the number of workers who fall in the knowledge occupations, this group has seen its relative advantage maintained over the period.

<sup>9</sup> See Beckstead and Vinodrai (2003) for more detailed discussion of how this variable is measured.



## 6. Conclusion

In this paper, we have used occupational data of workers to examine how the knowledge-intensity of the Canadian economy has changed over time and how these changes have varied across industrial sectors. Our analysis indicates that the shift towards a more knowledge intensive economy *has been a gradual process*, ongoing since at least 1971.

This increase has been experienced to some extent across all sectors of the Canadian economy. Moreover, the pace of change over the last three decades has been relatively constant.

Knowledge workers have always had higher levels of education. But knowledge workers have increasingly come to possess a university degree. And this phenomenon has been proceeding at a uniform pace over the last three decades.

Knowledge workers receive higher incomes—and the advantage here has remained more or less constant even as the proportion of knowledge workers has increased.

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 industries. 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. However, the proportion of knowledge workers has not increased much in this sector. In contrast, 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.

Generally, it was those sectors that had the highest knowledge intensity at the beginning of the period that experienced the most growth in knowledge intensity.

In conclusion, the move towards a more highly-skilled workforce that is concentrated in a narrow range of occupations (associated with greater levels of formal educational training) has been taking place continuously over the last three decades across a wide range of industries. That does not mean that knowledge occupations are not concentrated. They are. And those industries with high concentrations of knowledge workers have seen the most growth in knowledge workers. But significant growth has been occurring continuously across a wide range of other industries as well.

## Appendix A

**Table A1. Description of 'knowledge worker' categories**

Type of knowledge worker	Description
<b>Professional occupations</b>	<ul style="list-style-type: none"> <li>• Auditors, accountants and investment professionals</li> <li>• Human resources and business service professionals</li> <li>• Physical science professionals</li> <li>• Life science professionals</li> <li>• Civil, mechanical, electrical and chemical engineers</li> <li>• Other engineers</li> <li>• Architects, urban planners and land surveyors</li> <li>• Mathematicians, systems analysts and computer programmers</li> <li>• Physicians, dentists and veterinarians</li> <li>• Optometrists, chiropractors and other health diagnosing and treating professionals</li> <li>• Pharmacists, dietitians and nutritionists</li> <li>• Therapy and assessment professionals</li> <li>• Judges, lawyers and Quebec notaries</li> <li>• Policy and program officers, researchers and consultants</li> <li>• University professors and assistants</li> <li>• College and other vocational instructors</li> <li>• Secondary and elementary school teachers and counselors</li> <li>• Librarians, archivists, conservators and curators</li> <li>• Writing, translating and public relations professionals</li> <li>• Creative and performing artists</li> </ul>
<b>Management occupations</b>	<ul style="list-style-type: none"> <li>• Legislators and senior management</li> <li>• Administrative services managers</li> <li>• Managers in engineering, architecture, science and information systems</li> <li>• Sales, marketing and advertising managers</li> <li>• Managers in financial and business services</li> <li>• Managers in communication (except broadcasting)</li> <li>• Managers in health, education, social and community services</li> <li>• Managers in public administration</li> <li>• Managers in art, culture, recreation and sport</li> <li>• Managers in primary production (except agriculture)</li> <li>• Managers in manufacturing and utilities</li> </ul>
<b>Technical occupations</b>	<ul style="list-style-type: none"> <li>• Technical occupations in physical sciences</li> <li>• Technical occupations in life sciences</li> <li>• Technical occupations in civil, mechanical and industrial engineering</li> <li>• Technical occupations in electronics and electrical engineering</li> <li>• Technical occupations in architecture, drafting, surveying and mapping</li> <li>• Other technical inspectors and regulatory officers</li> <li>• Transportation officers and controllers</li> <li>• Nurse supervisors and registered nurses</li> <li>• Medical technologists and technicians (except dental health)</li> </ul>

Note: Occupation descriptions are based on the 1991 Standard Occupational Classification.

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