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Science, Innovation and Electronic Information Division

Where are the Scientists and Engineers?

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… not applicable

0 true zero or a value rounded to zero

0^s value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded

^{p} preliminary

^{r} revised

x suppressed to meet the confidentiality requirements of the *Statistics Act*

^{E} use with caution

F too unreliable to be published

Note
Due to rounding, components may not add to the totals.

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Note of appreciation

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses and governments. Accurate and timely statistical information could not be produced without their continued cooperation and goodwill.

The science and innovation information program

The purpose of this program is to develop useful indicators of science and technology activity in Canada based on a framework that ties them together into a coherent picture. To achieve the purpose, statistical indicators are being developed in five key entities:

- Actors: are persons and institutions engaged in S&T activities. Measures include distinguishing R&D performers, identifying universities that license their technologies, and determining the field of study of graduates.
- Activities: include the creation, transmission or use of S&T knowledge including research and development, innovation, and use of technologies.
- Linkages: are the means by which S&T knowledge is transferred among actors. Measures include the flow of graduates to industries, the licensing of a university's technology to a company, co-authorship of scientific papers, the source of ideas for innovation in industry.
- Outcomes: are the medium-term consequences of activities. An outcome of an innovation in a firm may be more highly skilled jobs. An outcome of a firm adopting a new technology may be a greater market share for that firm.
- Impacts: are the longer-term consequences of activities, linkages and outcomes. Wireless telephony is the result of many activities, linkages and outcomes. It has wide-ranging economic and social impacts such as increased connectedness.

The development of these indicators and their further elaboration is being done at Statistics Canada, in collaboration with other government departments and agencies, and a network of contractors.

Prior to the start of this work, the ongoing measurements of S&T activities were limited to the investment of money and human resources in research and development (R&D). For governments, there were also measures of related scientific activity (RSA) such as surveys and routine testing. These measures presented a limited picture of science and technology in Canada. More measures were needed to improve the picture.

Innovation makes firms competitive and we are continuing with our efforts to understand the characteristics of innovative and non-innovative firms, especially in the service sector that dominates the Canadian Economy. The capacity to innovate resides in people and measures are being developed of the characteristics of people in those industries that lead science and technology activity. In these same industries, measures are being made of the creation and the loss of jobs as part of understanding the impact of technological change.

The federal government is a principal player in science and technology in which it invests over five billion dollars each year. In the past, it has been possible to say only *how much* the federal government spends and *where* it spends it. Our report Federal Scientific Activities, 1998 (Cat. No. 88-204) first published socio-economic objectives indicators to show *what* the S&T money is spent on. As well as offering a basis for a public debate on the priorities of government spending, all of this information has been used to provide a context for performance reports of individual departments and agencies.

As of April 1999, the Program has been established as a part of Statistics Canada's Science, Innovation and Electronic Information Division.

The final version of the framework that guides the future elaboration of indicators was published in December, 1998 (Science and Technology Activities and Impacts: A Framework for a Statistical Information System, Cat. No. 88-522). The framework has given rise to A Five-Year Strategic Plan for the Development of an Information System for Science and Technology (Cat. No. 88-523).

It is now possible to report on the Canadian system on science and technology and show the role of the federal government in that system.

Our working papers and research papers are available at no cost on the Statistics Canada Internet site at http://www.statcan.ca/cgi-bin/downpub/research.cgi?subject=193.

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The views expressed in this report represent those of the author and are not necessarily the opinions of Statistics Canada as a whole.

Highlights

Canada's employed scientists and engineers with earned doctorate degrees (PhD) were more concentrated in urban areas than the total employed Canadian labour force in 2001. Nine out of every ten science and engineering doctorate holders resided in a census metropolitan area (CMA).

Engineers and applied scientists had the highest science and engineering (S&E) employment rate and the highest unemployment rate in 2001. Engineers were also the most highly urbanized of the four S&E groups.

The 2001 Census of Population data revealed that the CMAs with the highest labour force concentration of S&E PhDs per 100,000 of the total labour force population were Kingston followed by Ottawa-Hull, Saskatoon and Victoria. Proportionately, the highest concentration of science and engineering PhDs in Canada's labour force is in the Kingston-Ottawa-Hull CMAs.

For CMAs that employed over a thousand PhDs, the west coast (Victoria) and east coast (Halifax) CMAs have, on average, the oldest employed PhDs whereas the younger employed PhDs were found in Canada's interior CMAs such as Québec City, Montréal and Toronto.

Four out of every five of Canada's scientists and engineers with doctorate degrees can be found in five key industrial sectors, namely, educational services; professional, scientific and technical services; health care and social assistance; public administration; and manufacturing. The manufacturing sector on average had the youngest employed PhDs while educational services and public administration had on average the oldest employed PhDs.

Two thirds (65%) of Canada's 100,000 employed PhDs were in the public sector and 35% were in the private sector in 2001. When the employed science and engineering doctorates are considered separately, 57% were employed in the public sector and 43% were employed in the private sector.

The difference in median full-time employment earnings between S&E and non-S&E doctorates was over $2,000 in favour of S&E doctorate holders. Median full-time earnings were the highest in the manufacturing sector largely due to the predominance of science and engineering doctorates.

Seven out of every ten S&E doctorates were in three occupational categories. The occupations were (1) university professors and post-secondary teachers, (2) natural and applied sciences, and (3) health occupations.

There may be a risk of shortage based on age replacement for university professors compared to other selected occupations. There was less than one replacement professor aged 35 to 44 years for every professor nearing retirement age (55 to 64) compared to three replacements for scientists and engineers in the natural and applied sciences occupation.

There was a relative decline in the proportion of PhDs who were university professors from 34% in 1986 to 24% in 2001 despite a 93% growth in the total number of PhDs over the same period.

The proportion of females at the doctorate degree level was 27%, an improvement of 15 percentage points over the past 25 years. Female doctorates are under represented especially in science and engineering, and particularly in the engineering field where they were less than one in ten.

Female PhD holders aged 25-64 years working full-year full-time earned on average 79% of their male counterparts in 2000. Women with PhDs performed better in the labour market when compared to Canadian women in general whose incomes averaged 71% of that of men. Female PhDs also earned 11 percentage points higher than the 68% value for university women with a bachelor's degree or higher.

Nearly 23,000 immigrants with PhDs came to Canada during the 10-year period prior to the 2001 Census. Of the nearly 23,000 immigrant PhDs between the 1991 to 2000 time period, about 18,000 (78%) were S&E PhDs. One quarter (25.2%) of the 23,000 immigrant PhDs were born in China, while 6.4% and 5.9% of them were born in India and the United States respectively.

Asia, and in particular China and India, have become the major source of foreign born PhDs since the beginning of the 1980s whereas the U.S. and U.K., the two dominant sources prior to 1981, have had declining shares of the total immigrant PhDs. The U.S. share, for example, went from a high of 24.1% over the 1971-1980 immigration period to a low of 5.9% over the 1991-2000 period while China's share went from a low of 2.4% to a high of 25.2% over the same immigration time periods

Immigrants and non-permanent residents combined represented a 60% share of Canada's total employed science and engineering doctorates in 2001, a much higher share than the 20% for the employed population at large. Canadian-born PhD holders were more concentrated in Non-S&E fields whereas the immigrant PhDs were more heavily concentrated in S&E fields, particularly in engineering and applied sciences along with mathematics, computer and physical sciences.

Preface

Canada’s universities have graduated over 3,000 individuals with doctorate degrees annually since 1992. The human capital investment in their post-secondary education and training produces highly skilled individuals some of whom go on to become the scientists and engineers (S&E) in Canada’s labour force as well as industry and academic leaders and pioneers in research, development, discoveries and innovations.

In Canada, there is in fact a high demand for knowledge and skills not only because of the ageing labour force population, but also because of the changes in advanced technologies and the knowledge-based global economy. Internationally, the demand for scientific talent is also very high on government agendas and was in fact the central issue discussed by science ministers from the Organisation for Economic Cooperation and Development (OECD) member countries and many other countries during an OECD conference at the end of January 2004. Cervantes (2004) pointed out that issues concerning the supply of PhDs were of great importance at the OECD conference because most research positions require PhD level training.

The importance of PhD training in the global knowledge-based economy is further reflected in the increasing numbers of people acquiring PhDs worldwide (OECD, 2003). Canada’s PhDs have also experienced unprecedented growth in numbers as well, posting a 93% increase over 15 years. In fact, the number of PhDs in Canada has nearly doubled from 67,000 in 1986 to 129,000 in 2001. PhDs have had significant growth since the compounded annual growth rate for PhDs from 1986 to 2001 was 6.2% whereas the compounded annual growth rate for the total labour force population aged 15 years and over was 1.3% for the same period.

Overall, there has been tremendous growth across all degree levels in Canada. Bordt, et al (2001), for instance, have shown that the number of degrees granted by Canadian universities has been increasing since 1982. In fact, there were over 1.1 million highly qualified people aged 25 to 64 that had doctorates, and masters’ degrees and other qualifications above the bachelor’s level in 2001. This was a 50% increase from 750,000 a decade earlier (Statistics Canada, 2003b).

Despite the growth in recent years, not much literature exists about the stock of scientists and engineers in Canada, especially at the doctorate degree level. Wendy Hansen (1999), one of the few detailed written sources, used 1996 Census data along with the 1980 Standard Industrial Classification to look at college and selected university degree levels of science and technology workers using the field of study classification.

The paramount question therefore is where are our scientists and engineers? For example, what industries are employing scientists and engineers and in what occupations? What are the labour market characteristics in terms of unemployment and income? Indeed, what are the geographic, age, and gender characteristics? Are there differences in terms of Canadian born and non-Canadian born scientists and engineers?

This study begins with an introduction of the topic, followed by an examination of the distribution of scientists and engineers based on their geographic place of residence. The second section examines the industry and occupational characteristics. The third and fourth sections investigate the gender and age distribution of scientists and engineers in Canada.

The fifth section looks at the income distribution of scientists and engineers. The next section discusses the impact of immigration on the supply of scientists and engineers in Canada, which is followed by conclusions.

Methodology and Data Notes

This study will attempt to answer some of the questions about scientists and engineers based on their major field of study (MFS) and the highest university degree obtained using 2001 Census of Population information. Four of the overall ten Census MFS possessing earned doctorate degrees will be used in the classification of scientists and engineers (S&E). They are: (1) agricultural, biological and veterinary sciences, (2) engineering & applied sciences, (3) health sciences, and (4) mathematics, computer and physical sciences. The remaining six MFS constitute the Non-S&E group. The S&E group or classification is therefore referring to natural sciences and engineering and the Non-S&E group is therefore referring to non-natural sciences and engineering.

One major advantage of using MFS is that it refers to the predominant discipline or area of learning and training of an individual's highest post-secondary degree. Secondly, the classification structure of the MFS variable can be used either independently or in conjunction with the highest degree variable. Thirdly, the major field concept also incorporates the notion of a sub-field or area of specialization. The area of specialization under the MFS approach also facilitates better peer group comparisons.

Scientists and engineers are not limited only to individuals with earned doctorates. Indeed, there are many Canadian scientists and engineers with medical degrees, masters' degrees, bachelor's degrees, as well as professional certificates above the bachelor's level. Including PhDs, there were 3.7 million Canadians who had a university degree at the bachelor's level and above in 2001 and over one million would fall under the S&E classification using the MFS and highest degree attained. See Appendix A.

The examination of science and engineering workers at the doctorate degree level is therefore looking at only one segment of our S&E labour force. For example, in 2001 there were over 603,000 employed S&E workers with bachelors' degrees and over 155,000 employed S&E workers with masters' degrees as well (Appendix A).

The term PhDs is used throughout the report to refer to both scientists & engineers with an earned doctorate degree as well as non-science and engineering earned doctorates. The 2001 Census information presented is for the labour force population aged 15 years and over, excluding institutional residents, during the reference week prior to May 15, 2001. Full-time employment and work activity data is therefore for the year 2000. Average and Median income figures are for the year 2000 unadjusted for inflation.

The study's main focus is on the 100,000 employed PhDs, particularly the 57,000 employed S&E PhDs, with special analytical emphasis on the 25 to 64 age group. In all tables presented, the figures may not add to totals either due to rounding or certain exclusions.

Total Labour Force Activity (in Reference Week): Refers to the labour market activity of the population 15 years of age and over in the week (Sunday to Saturday) prior to Census Day (May 15, 2001). Respondents were classified as either **employed**, or **unemployed**, or as **not in the labour force**. The **labour force** includes the **employed** and the **unemployed**.

Employed (in Reference Week): Persons who, during the week (Sunday to Saturday) prior to Census Day (May 15, 2001): (a) did any work at all for pay or in self-employment or without pay in a family farm, business or professional practice; and (b) were absent from their job or business, with or without pay, for the **entire week** because of a vacation, an illness, a labour dispute at their place of work, or any other reasons.

Unemployed (in Reference Week): Persons who, during the week (Sunday to Saturday) prior to Census Day (May 15, 2001), were **without paid work or without self-employment work** and were **available for work** and either: (a) had actively looked for paid work in the past four weeks; or (b) were on temporary lay-off and expected to return to their job; or (c) had definite arrangements to start a new job in four weeks or less.

Not in the Labour Force (in Reference Week): Refers to persons who, in the week (Sunday to Saturday) prior to Census Day (May 15, 2001), were neither employed nor unemployed. It includes students, homemakers, retired workers, seasonal workers in an "off" season who were not looking for work, and persons who could not work because of a long-term illness or disability.

For further reading of 2001 Census data notes, methodology and concepts please see Statistics Canada (2001) or visit www.statcan.ca/2001census.

Introduction

This particular study of Canada's stock of PhDs, and especially science and engineering doctorates, is an important contribution to the existing and growing body of literature on knowledge workers. The report offers a detailed labour force examination of PhDs based on their major field of studies (MFS). In actual fact, the labour market characteristics of Canada's scientists and engineers with earned doctorates under investigation is based on educational attainment and major field of study classification as opposed to a more narrowly defined study of scientists and engineers based solely on their occupational classification. Indeed, one of the major advantages of using MFS classification is that it refers to the predominant discipline or area of learning and training of an individual's highest post-secondary degree. PhDs broad occupational classification characteristics are also covered below and thus the report's unique approach supports the examination of Canada's S&E PhDs from the input side of human capital through their MFS as well as the output side using their occupational classification.

Canada's economic competitiveness depends to a large degree upon the contribution of the labour force to innovation and productivity growth. In today's knowledge-based economies, skilled workers are indispensable to an innovative economy (Boothy and Rainville, 2004). Paul Romer (1990) postulates that one of the key benchmarks of an economy's innovative capacity is the number of scientists and engineers involved in research and development.[1] Romer (1990: p.S99) points out that "the most interesting [and] positive implication of the model [of technological change] is that an economy with a larger total stock of human capital will experience faster growth."

In fact, knowledge workers in science and technology are often viewed as one of the engines that drive growth in all sectors of the economy (Beckstead and Gellatly, 2004). Other analysts such as Cervantes, (2004: p.1) emphatically affirm that "scientists and researchers are the backbone of knowledge-based economies" and without them countries would not have many of the technological advances now taken for granted such as the Internet, discoveries in medicine and healthcare along with engineering marvels such as electrical power generating stations. PhDs are, therefore, an important and vital piston in Canada's labour force engine since not only do they represent the highest educational attainment level in a knowledge-based economy, but they are also highly skilled industrial researchers and innovators, teachers and professors, along with being scientists and engineers.[2]

Canada's employed PhD holders represented slightly more than half of one percent of the total employed labour force in 2001. They also had a 3.7% unemployment rate in 2001, the lowest unemployment rate among the different educational attainment groups. Comparably lower levels of unemployment and higher employment rates are associated with higher levels of education in Canada's knowledge-based economy in 2001 (Table 1).

In fact, the doctorate degree unemployment rate was 4 percentage points below the 7.4% national unemployment rate, whereas the 8 million individuals with no degree, certificate, or diplomas were 4 percentage points above the national unemployment rate. Similarly, with an employment rate of 77.8%, PhD holders were 16 percentage points above the national mark of 61.5% but had an almost 40 percentage point difference in employment rate when compared to those with no degree, certificate or diplomas.

1. For more on Canada's R&D please see Statistics Canada, ***Estimates of Research and Development Personnel in Canada, 1979 to 2002*** by Janet Thompson, Cat. # 88F0006XIE No:008, May 2005.
2. See for example, "Prof says there's no hacker he can't foil" in the ***Toronto Star***, February 23, 2006, p.A20

Table 1 Canada's labour force activity by highest degree, certificate or diploma, 2001	Total labour force activity[3]	Employment rate	Unemployment rate
Total highest degree, certificate or diploma	**23,901,360**	**61.5%**	**7.4%**
Earned doctorate degree	128,625	77.8%	3.7%
University with BA and Above (Excluding PhD)	3,559,025	78.1%	4.7%
University certificate or diploma below bachelor	601,425	67.4%	5.5%
Non-university certificate or diploma (college)	3,578,400	75.8%	5.6%
Trades certificate or diploma	2,598,925	70.8%	6.8%
Secondary (high) school graduation certificate	5,499,885	66.1%	8.0%
No degree, certificate or diploma	7,935,075	40.6%	11.2%

Source: Statistics Canada, 2001 Census of Population.

There are four university degrees included in the university with BA and above (excluding PhD) category. They are: bachelors' degree, university certificates above the bachelor level, medical degree, and masters' degree. The certificate above the bachelor level is obtained following a first degree in the same field of study or following a masters' or first professional degree. These certificates are often found in applied engineering and high technology areas along with degree programs that have medical specializations (Statistics Canada, 2001: pp.112-123).

Of the nearly 129,000 PhDs, 77.8% or over 100,000 were employed in 2001. From the 100,000 employed PhDs, 57,000 (or 57%) were science and engineering (S&E) doctorates and about 43,000 were Non-S&E PhDs. Indeed, the 2001 Census figures reveal that there were over 11,000 employed agricultural, biological and veterinary scientists, 13,000 employed engineering and applied scientists, 12,000 employed health scientists, and over 20,000 employed mathematics, computer and physical scientists all with earned doctorate degrees (Table 2).

Of the four major S&E groups, engineers had both the highest employment rate (81%) and highest unemployment rate at 4.8% while the mathematics, computer, and physical scientists had the lowest (3.4%) unemployment rate. Agricultural, biological and veterinary sciences doctorate's unemployment rate was 3.6% and similarly those with doctorates in health sciences had a 3.5% unemployment rate. The high national employment rate for engineers and the comparably higher unemployment rate is an indication that there was an available amount of earned doctorates (approximately 800 unemployed) with engineering and applied sciences credentials that could fill any potential engineering employment vacancies in 2001. Indeed, engineers with doctorates in 2001 had a similar unemployment rate to individuals with PhDs in Humanities, the group with the highest unemployment rate in the Non-S&E field (Table 2).

3. Total labour force activity refers to the labour market activity of the population 15 years of age and over. It includes employed, unemployed and those not in the labour force at the time **(reference week)** of the 2001 Census. The labour force by definition is the employed and unemployed. The study's main focus is on the employed PhDs, however, the total labour force activity figures are used mainly in the calculation of employment rates as well as in the PhDs growth rate, distribution per 100,000, and in the total growth due to immigration.

Table 2 Canada's PhD labour force activity by major field of study, 2001	Total PhD labour force activity	Employment rate	Unemployment rate
Total major field of study	**128,625**	**77.8%**	**3.7%**
Total science and engineering	**72,780**	**78.4%**	**3.8%**
Total agricultural, biological and veterinary sciences	14,905	76.2%	3.6%
Total engineering and applied sciences	16,435	81.0%	4.8%
Total health sciences	15,700	77.9%	3.5%
Total math, computer and physical sciences	25,740	78.5%	3.4%
Total non-scientists and engineers	**55,845**	**76.9%**	**3.5%**
Social sciences	23,435	81.2%	2.8%
Education	8,930	72.3%	2.7%
Commerce, management and business administration	3,790	79.0%	4.3%
Humanities	17,730	73.3%	4.9%
Fine and applied arts	1,900	75.5%	3.0%

Source: Statistics Canada, 2001 Census of Population.

The Non-S&E PhDs had a slightly lower overall unemployment rate (3.5%) in comparison to the 3.8% for the S&E doctorates. The comparatively lower Non-S&E unemployment rate was due mainly to the less than 3% unemployment rate of PhDs in social sciences and education. The social sciences and education PhDs together represented nearly 60% of the Non-S&E PhDs total labour force activity in 2001. In fact, the employment rate of social scientists (81.2%) were comparable to the 81% rate for engineers, in contrast, social scientists had a much lower unemployment rate (2.8%) in comparison to the 4.8% for engineers (Table 2).

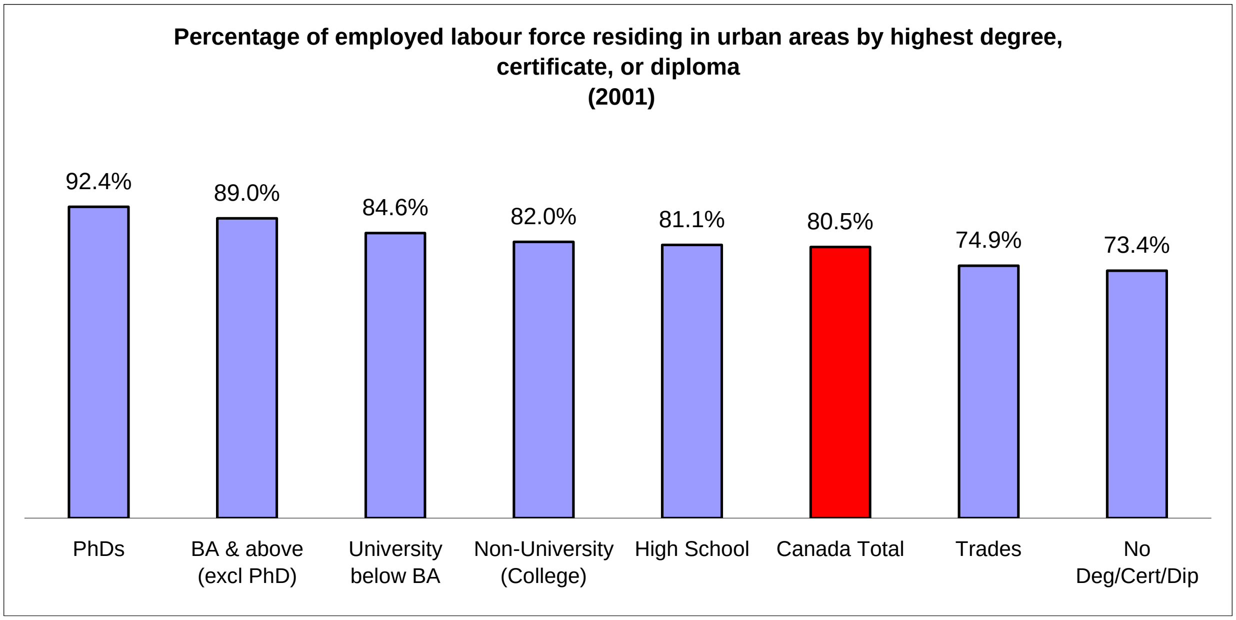
Geography

Canada's scientists and engineers are more likely to be concentrated in urban areas according to 2001 Census figures.

Employed PhDs are more concentrated in urban areas when compared to the overall distribution of Canada's total employed labour force population by highest degree, certificate or diploma (Figure 1).[4] In fact, at 92.4%, the doctorate degree holders were more concentrated in urban areas by about 12 percentage points than Canada's total employed labour force. Habtu (2003) also had similar findings which showed that 93% of Canada's information technology specialists were concentrated in urban areas as well. Geographic concentration of skills, especially in urban areas, is a key factor in the new knowledge-based economy.

4. An urban area has a minimum population concentration of 1,000 persons and a population density of at least 400 persons per square kilometre. All territory outside urban areas is classified as rural. Thus taken together, urban and rural areas cover all of Canada.

Figure 1

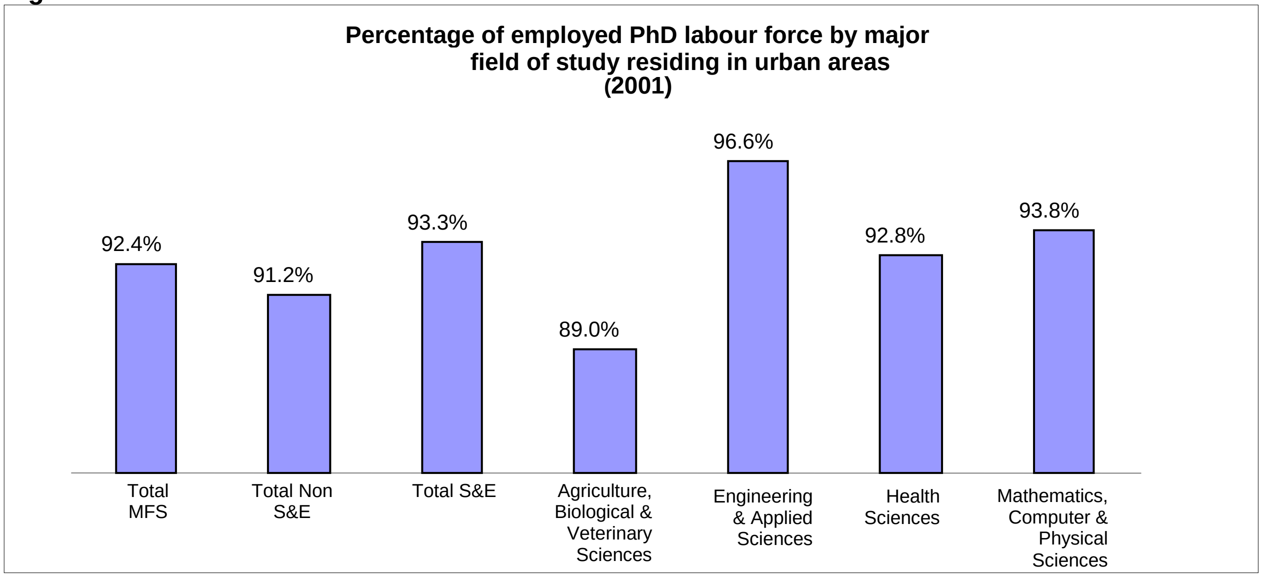


Source: Statistics Canada, 2001 Census of Population.

Indeed, Alasia (2005) in his review of skills, innovation and growth literature, for example, points out that most of the available evidence indicates that geography matters a great deal in the knowledge-based economy. One of the main reasons why geography matters according to Alasia (2005: p.4) is because “the declining cost of communication and transportation, combined with scale and agglomeration economies, have reinforced the process of geographic concentration of physical, technological and human resources in favor of large agglomerations.”

PhDs are more urbanized than the general labour force and the S&E PhDs are comparatively more urbanized, than the Non-S&E PhDs (Figure 2). Engineers are the most highly urbanized of the four S&E groups. The engineering and applied sciences group is three percentage points above the total S&E urbanized figure, whereas not unexpectedly the agricultural, biological veterinary sciences doctorates were 4 percentage points below the 93.3% total S&E mark. Agricultural and veterinary scientists in rural areas are a part of the reason for the lower percentage value.

Figure 2



Source: Statistics Canada, 2001 Census of Population.

In fact, for Canada's employed labour force of 15 million people in 2001, there were 4 urban workers for every 1 rural worker. For all employed PhDs, the ratio was 12 urban for every 1 rural. For the total S&E employed doctorates, the ratio increases to 14 urban for every 1 rural.

The most significant type of urban area for PhDs was census metropolitan areas (CMAs).[5] Indeed, Canada's scientists and engineers with doctorate degrees are like bright stars in the galaxy which seem to cluster around great centres of gravity. The centres of gravity in this case are CMAs. About nine out of every ten employed scientists and engineers were in a CMA in 2001, the highest concentration of all comparable levels of education in the employed labour force. In contrast, only two out of three employed persons (67%) resided in a CMA for Canada's total employed labour force.

Saskatchewan and New Brunswick were two provinces where the employed scientists and engineers were highly concentrated in urban areas when compared to the employed provincial labour force. In Saskatchewan, for example, there is a 32 percentage point difference between the 1,300 employed S&E PhDs urban concentration compared to the 480,000 total employed Saskatchewan workers that was 64% urban in 2001 (Table 3). Indeed, most of Saskatchewan's scientist and engineers with doctorates were concentrated in either Saskatoon or Regina.

5. Census metropolitan areas (CMAs) are defined around urban areas that have attained a population threshold of 100,000 or more persons.

Table 3 Urban percentage of employed labour force and scientists and engineers (S&E) PhDs per 100,000, by provinces and territories, 2001

	Total employed labour force	Total employed PhDs	Total S&E employed PhDs	S&E PhDs per 100,000 Total labour force activity
Canada	**80.5%**	**92.4%**	**93.3%**	**305**
Ontario	84.4%	93.9%	93.8%	356
Alberta	81.5%	93.7%	94.6%	323
British Columbia	84.9%	91.5%	93.5%	321
Quebec	81.3%	92.6%	93.7%	268
Nova Scotia	57.1%	81.3%	84.5%	245
Manitoba	73.9%	89.9%	89.1%	222
Saskatchewan	64.3%	94.4%	96.5%	213
Prince Edward Island	45.1%	68.1%	63.3%	187
New Brunswick	52.9%	78.5%	83.3%	186
Newfoundland and Labrador	65.0%	86.9%	88.4%	160
Northwest Territories	67.3%	81.8%	100%	111
Nunavut	43.2%	100%	100%	60
Yukon Territory	59.9%	40.0%	0.0%	44

Note: Provincial rankings are based on S&E PhDs per 100,000 Total Labour Force Activity.
Source: Statistics Canada, 2001 Census of Population.

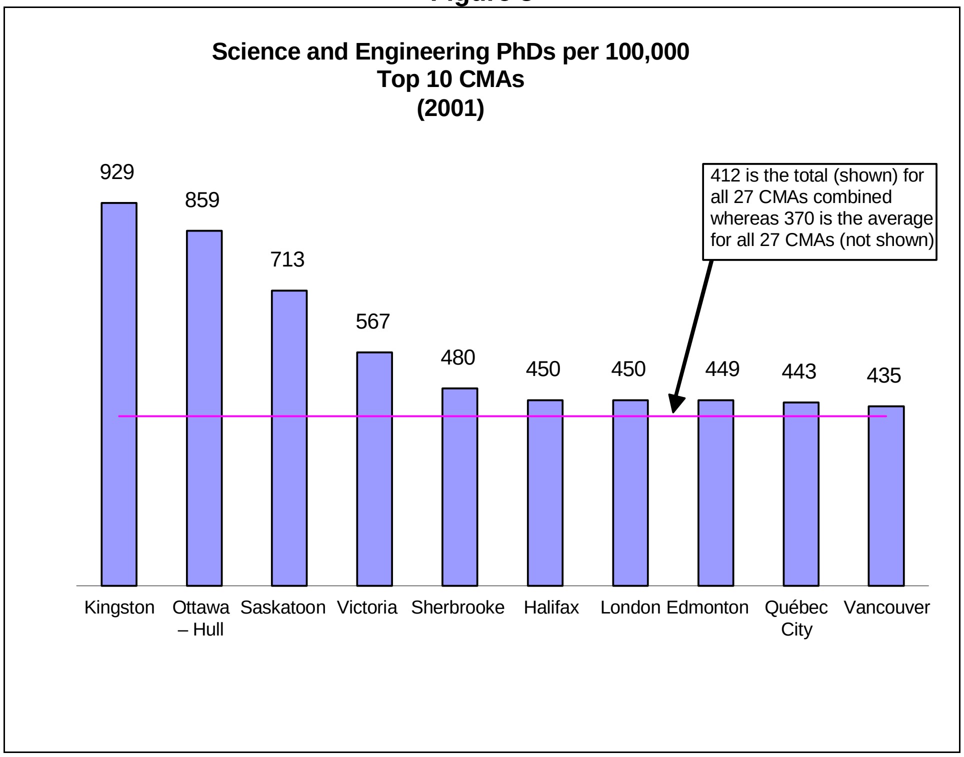
Ontario, Alberta, and British Columbia are the three provinces that were above the Canadian total in terms of the distribution of science and engineering doctorates per 100,000 of the total labour force activity in 2001. There were 305 S&E doctorates per 100,000 nationally and only those three provinces were above the national total.[6] Due to the high concentration of S&E doctorates in Halifax, Nova Scotia was fifth behind Quebec and well ahead of all the other Atlantic Provinces and Western Provinces such as Manitoba and Saskatchewan (Table 3).

6. Even though each of the northern territories does not have a 100,000 labour force population, the relative ratio is applicable for comparison since the measure normalizes the ratio of estimated total labour force activity of the S&E PhDs to the total provincial and territorial labour force activity. The average S&E PhDs per 100,000 for all thirteen provinces and territories is 207.

S&E PhDs are more concentrated in the Kingston-Ottawa-Hull CMAs

Examination of Canada's 27 CMAs in terms of the number of science and engineering earned doctorates per 100,000 of the CMA's total labour force activity in 2001 revealed that the CMA with the highest concentration of S&E PhDs was Kingston followed by Ottawa-Hull, Saskatoon and Victoria (see Appendix D).

Figure 3



Source: Statistics Canada, 2001 Census of Population.

Ottawa-Hull was expected to have a high concentration since 2001 Census figures on educational attainment (Statistics Canada, 2003a) have shown Ottawa-Hull to be the CMA with the highest proportion of university graduates with 35% of the 25 to 64 years old population having university education. Both Kingston and Ottawa-Hull CMAs' science and engineering labour force populations are in close proximity to each other.

Proportionately, the highest concentration of science and engineering PhDs in Canada's largest labour markets is therefore in the Kingston-Ottawa-Hull CMAs. Educational services, high technology and the public sector in Eastern Ontario are all competitive employers of the talented S&E PhDs.

The geographic concentration of S&E PhDs in the Kingston-Ottawa-Hull CMAs is also linked to industry where both public and private sectors were paying comparatively higher returns to both S&E and Non-S&E doctorates. Also, the younger (35 to 44 years old) S&E and Non-S&E doctorates' full time earnings were comparably higher in the Kingston-Ottawa-Hull CMAs.

Industry and Occupation

The majority of Canada's scientists and engineers can be found in five key industrial sectors and three main occupational categories

Industry

The 1997 North American Industry Classification System (NAICS) is used to classify the scientists and engineers.[7] More than four out of every five employed PhDs are found in five of the 20 major industrial sectors. That is to say, 86% of all employed PhDs and 87% of the employed S&E PhDs are found in educational services, professional, scientific and technical services, health care and social assistance, manufacturing, and public administration combined. In contrast, only 43% of Canada's total employed labour force is found in those five combined industrial sectors. In other words, the five combined industrial sectors therefore have a requirement for highly educated and highly qualified personnel.

The above findings are also consistent with the most recent survey of earned doctorates by Gluszynski and Peters (2005) which also revealed that 90% of graduates with firm employment plans reported four out of the five key industrial sectors above as their prime area of employment. The manufacturing sector was the lone exception.

Manufacturing was the exception possibly because there continued to be stronger demand in the other four industrial sectors. Of the five key industrial sectors, the unemployment rate in the manufacturing sector was the highest in 2001. PhDs in manufacturing had a 4.2% unemployment rate compared to 2.8% for educational services, 2.5% for professional, scientific and technical services, 2.2% for public administration, and 1% for health care and social assistance.

In 2001, Canada's educational services industry alone accounted for only a tiny fraction (6.7%) of the total employed labour force but it also represented a significant amount (44.3%) of all employed persons with an earned doctorate degree (Table 4). Similarly, in the United States, the U.S. National Science Foundation (2004) figures reveal that the majority of U.S. individuals with doctorate degrees (51%) worked in the academic sector in 1999.

Over 20,000 (35.3%) of the 57,000 employed science and engineering doctorates were in the educational services industry (Table 4). Lee and Has (1996) ranked educational services as the leading industry with the proportion of workers with post-secondary education and it is also ranked second only to professional, scientific and technical services in terms of its industrial proportion of knowledge workers. In 2001, professional, scientific and technical services were the second leading industry of employment for Canada's science and engineering doctorates behind educational services.

Science and engineering doctorates also had a presence in Non-S&E dominated industries as well which suggests that skills mobility is also an important aspect of the doctoral qualifications. For instance, three in ten employed PhDs in the arts, entertainment, and recreation industrial sector were S&E doctorates (Table 4).

7. The 1997 NAICS was used in the 2001 Census and has subsequently been revised in 2002. NAICS is revised every five years to ensure that the classification continues to reflect changes in the economy. The next revision to NAICS is for 2007. For the 1997 NAICS please see Statistics Canada (1998).

Table 4 Employed PhDs and employed scientists and engineers (S&E) PhDs by 20 major industrial sectors, 2001

Industrial Classification (1997 NAICS)	Canada total employed	Total employed PhDs	Total S&E employed PhDs	Employed S&E PhDs percent of total employed PhDs
Total industries	**14,695,135**	**100,045**	**57,090**	**57.1%**
Agriculture, Forestry, Fishing and Hunting	3.5%	0.5%	0.8%	84.4%
Mining and Oil and Gas Extraction	1.1%	0.6%	1.1%	94.6%
Utilities	0.8%	0.6%	0.9%	86.4%
Construction	5.4%	0.4%	0.5%	70.9%
Manufacturing	13.8%	5.2%	8.2%	89.7%
Wholesale Trade	4.5%	1.1%	1.6%	80.4%
Retail Trade	11.3%	1.3%	1.6%	69.6%
Transportation and Warehousing	5.0%	0.4%	0.4%	61.4%
Information and Cultural Industries	2.7%	1.7%	1.8%	58.0%
Finance and Insurance	4.2%	1.4%	1.2%	50.0%
Real Estate and Rental and Leasing	1.7%	0.5%	0.5%	53.8%
Professional, Scientific and Technical Services	6.4%	15.8%	21.0%	75.8%
Management of Companies and Enterprises	0.1%	0.1%	0.1%	61.1%
Administrative and Support, Waste Management and Remediation Services	3.8%	1.0%	0.9%	56.0%
Educational Services	6.7%	44.3%	35.3%	45.5%
Health Care and Social Assistance	10.0%	12.8%	13.6%	60.6%
Arts, Entertainment and Recreation	1.9%	1.4%	0.6%	27.2%
Accommodation and Food Services	6.5%	0.4%	0.4%	47.1%
Other Services	4.8%	2.6%	1.0%	20.6%
Public Administration	5.9%	7.7%	8.5%	63.0%

Source: Statistics Canada, 2001 Census of Population.

As employment in the goods-producing sectors such as manufacturing declines and employment in the knowledge-based service sectors gains more prominence in Canada's economy, it should be expected that knowledge-workers at the PhD level of education would also tend to be employed in the service-producing sectors and not so much the goods-producing sectors of the economy. In 2001, the goods-producing sector represented 24.6% of the entire employed labour force, 7.4% of all employed PhDs, and 11.5% of the total number of S&E employed PhDs.[8] Almost 93% of the 100,000 employed PhDs were therefore in the service producing sector (Table 4).

Based on the distribution across the twenty major industrial sectors, the educational services industry was one of the leading industries of employment for many of the science and engineering doctorates, except for those in health sciences. Scientists with earned doctorates in health sciences were predominantly employed in the health care sector of the economy. About half of the 12,000 employed individuals with doctorates in health sciences (48.9%) were in fact employed in the health care sector and only about three in ten were in educational services (Table 5). The majority of earned doctorates in the engineering and applied sciences field, on the other hand, were split between professional, scientific and technical services and the educational services sector.

8. The goods-producing sector is the combined total of manufacturing, construction, utilities, mining and oil and gas extraction, along with agriculture, forestry, fishing and hunting. The first five industries of Table 4 represent the goods-producing sector of the economy and the remaining fifteen are the service-producing sector.

Table 5 Employed scientists and engineers (S&E) PhDs by major field of study and 20 major industrial sectors, 2001

Industrial Classification (1997 NAICS)	Total science and Engineering	Total agricultural biological and veterinary sciences	Total engineering and applied sciences	Total health sciences	Total mathematics, computer and physical sciences
Total industries	**57,090**	**11,365**	**13,310**	**12,230**	**20,190**
Educational Services	35.3%	41.0%	29.8%	27.6%	40.5%
Professional, Scientific and Technical Services	21.0%	18.2%	28.8%	8.8%	24.7%
Health Care and Social Assistance	13.6%	9.9%	1.4%	48.9%	2.3%
Public Administration	8.5%	14.8%	7.7%	3.1%	8.7%
Manufacturing	8.2%	4.0%	15.3%	2.4%	9.3%
Information and Cultural Industries	1.8%	0.9%	2.9%	0.3%	2.4%
Retail Trade	1.6%	1.5%	1.1%	3.1%	1.2%
Wholesale Trade	1.6%	1.1%	2.3%	1.3%	1.7%
Finance and Insurance	1.2%	0.6%	0.9%	1.1%	1.9%
Mining and Oil and Gas Extraction	1.1%	0.2%	0.8%	0.1%	2.3%
Other Services	1.0%	1.5%	1.1%	0.7%	0.8%
Utilities	0.9%	0.3%	2.4%	0.0%	1.0%
Administrative and Support, Waste Management and Remediation Services	0.9%	1.1%	0.9%	0.8%	1.0%
Agriculture, Forestry, Fishing and Hunting	0.8%	2.1%	0.8%	0.4%	0.4%
Arts, Entertainment and Recreation	0.6%	1.5%	0.6%	0.3%	0.4%
Construction	0.5%	0.2%	1.5%	0.2%	0.3%
Real Estate and Rental and Leasing	0.5%	0.4%	0.6%	0.4%	0.5%
Transportation and Warehousing	0.4%	0.3%	0.9%	0.2%	0.4%
Accommodation and Food Services	0.4%	0.3%	0.5%	0.4%	0.3%
Management of Companies and Enterprises	0.1%	0.1%	0.1%	0.1%	0.1%

Note: Industrial sectors are ranked by highest to lowest Total Science & Engineering proportion.
Source: Statistics Canada, 2001 Census of Population.

Three of the top five industries that employ PhDs are predominantly public sector industries. That is, educational services, healthcare and social assistance along with public administration which includes all federal, provincial and local governments. The private sector on the other hand is mainly comprised of the 17 remaining industrial sectors, of which professional, scientific, and technical services along with manufacturing are the top two private sector industries employing Canada's PhD holders[9]. Two thirds (65%) of Canada's 100,000 employed PhDs were in the public sector and 35% were employed in the private sector in 2001. When the employed science and engineering doctorates are considered separately, 57% were employed in the public sector and 43% were employed in the private sector (Table 6).

There were six CMAs that employed over 2,500 S&E doctorates in 2001; namely, Toronto, Montréal, Vancouver, Ottawa-Hull, Calgary and Edmonton. The employed doctorates in the six CMAs together represented two thirds (64%) of the total employed S&E doctorates in Canada. Toronto proportionately had more employed S&E PhDs in the private sector (59%) whereas Edmonton proportionately employed more in the public sector (66%). There were more S&E PhDs in the public sector in Edmonton largely due to the fact that almost half of Edmonton's employed S&E PhDs (48%) were employed in the educational services sector, the highest percentage of the six selected CMAs. Nationally, one in three employed S&E PhDs were in educational services, but there were only one in six employed in Ottawa-Hull and one in five employed in Toronto (Table 6).

9. Public and private industrial sectors are classified based on majority employment in the aggregation of the 20 major industrial sectors of the 1997 NAICS. There are private firms that employ doctorates in educational services as well as health care and public administration in government-owned but company operated facilities, however, the data could not be disaggregated at the company or firm level and thus some of the individuals in those firms may be counted in the public sector aggregation.

Scientists and engineers with earned doctorates employed in public administration were predominantly located in the Ottawa-Hull CMA primarily due to employment with the federal government. Indeed, there were proportionately more employed science and engineering doctorates in public administration in Ottawa-Hull than there were in the other five CMAs combined. Public administration (29.7%) along with professional, scientific and technical services (27.6%) were the two leading industry of employment for science and engineering PhDs in Ottawa-Hull (Table 6).

Table 6 Employed scientists and engineers (S&E) PhDs by selected industry and by selected CMAs, 2001

	Canada	Toronto	Montréal	Vancouver	Ottawa-Hull	Calgary	Edmonton
Total industries	**57,090**	**11,330**	**8,465**	**5,475**	**5,615**	**2,750**	**2,740**
Educational services	35.3%	21.4%	37.3%	39.3%	16.5%	35.8%	48.0%
Professional, scientific and technical services	21.0%	24.6%	20.5%	24.1%	27.6%	26.5%	19.9%
Health care and social assistance	13.6%	17.2%	18.0%	12.4%	5.3%	9.5%	9.3%
Public administration	8.5%	2.6%	4.0%	2.6%	29.7%	2.9%	8.8%
Manufacturing	8.2%	13.2%	9.5%	3.7%	11.0%	4.0%	3.5%
All other industries combined	13.5%	21.0%	10.8%	17.8%	10.0%	21.3%	10.6%
Private sector total	**42.7%**	**58.8%**	**40.8%**	**45.6%**	**48.6%**	**51.8%**	**34.0%**
Public sector total	**57.3%**	**41.2%**	**59.2%**	**54.4%**	**51.4%**	**48.2%**	**66.0%**

Source: Statistics Canada, 2001 Census of Population.

Occupation

Canada's scientists and engineers with earned doctorates are involved in a wide variety of occupational roles and functions. The term scientists and engineers may have many definitions depending on one's perspective. None of them is perfect. In the United States for example, S&E are defined by the National Science Foundation (2004: pp. 3-6) using three main definitions for different analytical purposes. The three main definitions include: (1) occupation, (2) highest post-secondary degree earned, and (3) anyone with an S&E degree or occupation. The occupation definition alone in the U.S. National Science Foundation's classification sometimes excludes postsecondary teachers and university professors who could be counted in the S&E labour force and thus different surveys and coding rules must account for them. Indeed, medical researchers are included but not doctors or nurses; and computer hardware and software developers but not computer programmers or technicians although workers in these excluded occupations may have a substantial amount of scientific education and training.

The 2001 Census of Population information in Canada allows us to look at labour force population not only in terms of the highest degrees earned, but also from an individual's major field of study and their occupation via the 2001 National Occupational Classification for Statistics (Statistics Canada, 2001a). Consequently, this study's unique approach enables us to examine the S&E labour force characteristics both from the input field of study using MFS and the output or occupational classification using the National Occupational Classification for Statistics (NOCS). Indeed, the study's uniqueness is further demonstrated in the combination of MFS and occupation based on the OECD's Frascati Manual's occupational classification shown in Appendix B.[10] The proportion of employed S&E PhDs that are researchers (79%) is higher than the proportion of employed non-S&E PhDs (71%) based on the Frascati occupational classification.

Other than dentistry, there is rarely a one-to-one categorical concordance of the MFS classification to that of the NOCS categories. In other words, the highest degree obtained in a particular major field of study doesn't necessarily mean that there is an exact corresponding occupational classification that reflects the particular field of study. Many Canadians with earned doctorates become professors and are therefore classified by the NOCS under education as teachers and professors.

10. The totals shown in Appendix B differ slightly from those shown below in Table 7 because military occupations are excluded under the *Frascati* occupational classification. For more on the *Frascati Manual* please see (OECD, 2002).

Indeed, seven out of every ten employed science and engineering PhDs were mainly in three occupational categories. The occupations are (1) university professors, teaching and research assistants, (2) natural and applied sciences, and (3) health occupations. The figure rises to eight out of ten if management occupations are also included (Table 7).

Approximately one third (33.7%) of Canada's employed S&E doctorates were in the natural and applied sciences occupations in 2001. Occupations in the natural and applied sciences broad occupational category according to the 2001 NOCS are primarily concerned with conducting theoretical and applied research and providing technical support in natural and applied sciences including conducting experimental and theoretical research into physical and life sciences, applying scientific knowledge in engineering and architectural projects, and designing systems which make use of electronic data processing equipment in industrial and commercial situations (Statistics Canada, 2001a: p.72). Physicists, chemists, geologists, biologists, mathematicians, computer software engineers, civil, mechanical and chemical engineers are some examples of natural and applied sciences occupations. Almost half (46.4%) of the doctorates in the engineering and applied sciences field were in the natural and applied sciences occupations in 2001, the highest proportion of the four S&E groups (Table 7).

University professors alone numbered 31,000 in 2001, a 24% proportion of the 129,000 PhDs. Even though the number of university professors grew in absolute terms by 35% from 23,000 in 1986, there was a relative decline in the proportion of PhDs who were university professors when the 1986 and 2001 proportions are compared. Burke (1988) revealed that 34% of Canada's PhDs were university professors in 1986 whereas it was 24% in 2001, a decline of 10 percentage points over 15 years.[11]

Over 40% of the total employed Non-S&E PhDs were university professors, teaching and research assistants combined in 2001 whereas only about 27% of the total S&E doctorates were employed as university professors, teaching and research assistants (Table 7). The highest field percentage, however, were the employed PhDs from the fine and applied arts. Over half (51.6%) of the employed PhDs from the fine and applied arts major field of study were employed as university professors, teaching and research assistants combined (Table 7).

Table 7 Employed PhDs by major field of study and selected occupational categories, 2001

	Total occupations	Total university professors, teaching and research assistants	Total natural and applied sciences occupations	Total health occupations	Total management occupations	Total all other occupations combined
Total major field of study	**100,045**	**32.6%**	**20.0%**	**6.9%**	**11.4%**	**28.5%**
Total science & engineering	**57,095**	**26.7%**	**33.7%**	**11.2%**	**11.8%**	**16.5%**
Total agricultural, biological and veterinary sciences	11,365	31.4%	33.7%	4.8%	11.6%	18.5%
Total engineering and applied sciences	13,310	24.3%	46.4%	0.6%	13.9%	14.7%
Total health sciences	12,230	21.4%	10.7%	46.0%	7.6%	14.3%
Total math, computer and physical sciences	20,195	28.9%	39.3%	0.8%	13.2%	17.8%
Total Non-S&E	**42,950**	**40.4%**	**2.9%**	**1.2%**	**10.9%**	**44.5%**
Social sciences	19,025	35.5%	3.8%	1.7%	10.3%	48.7%
Education	6,455	34.5%	1.5%	1.3%	16.7%	45.9%
Commerce, management and business administration	3,000	44.7%	5.2%	1.0%	18.5%	30.7%
Humanities	12,990	48.4%	1.9%	0.7%	7.7%	41.4%
Fine and applied arts	1,435	51.6%	0.7%	0.0%	6.3%	41.5%

Source: Statistics Canada, 2001 Census of Population.

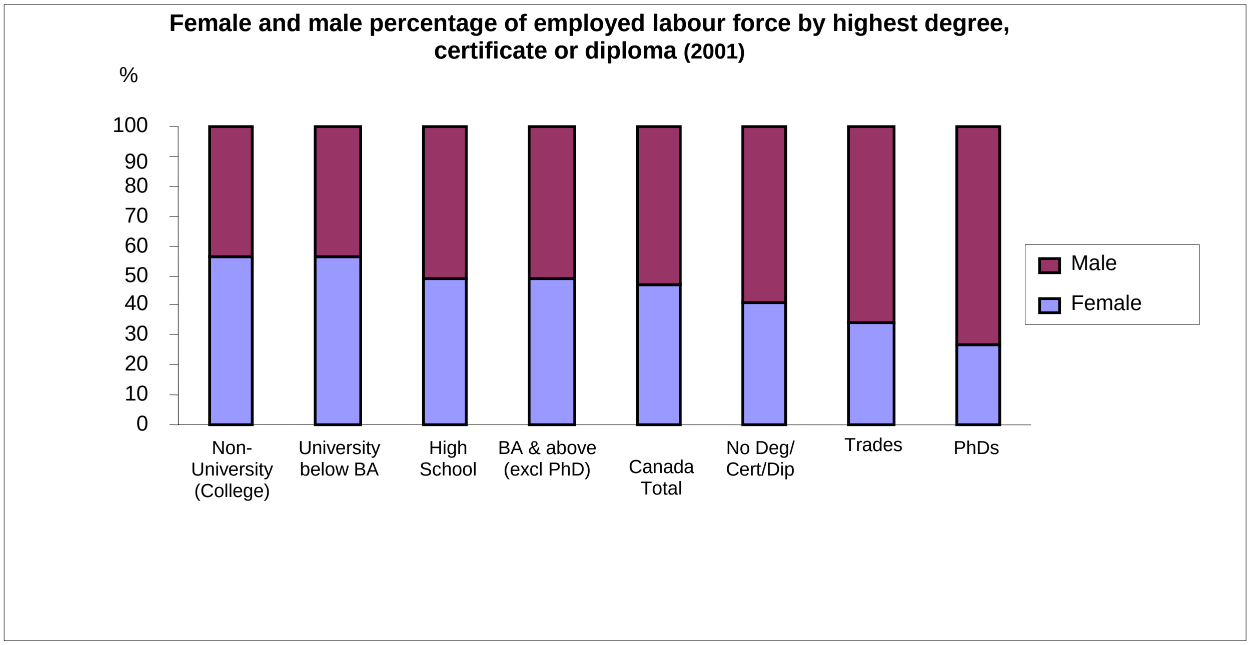
11. The proportional comparisons are based on total labour force activity for both 1986 and 2001.

Gender Differences

Employed women with PhDs are not only under-represented in science and engineering, but their numbers are also low across all major field of studies

World renowned female Canadian scientists such as Dr. Roberta Bondar and Dr. Nancy Olivieri are among a select few with doctorate degrees. According to 2001 Census information, 27% of all the employed PhD holders were women and 73% were men (Figure 4). The percentage of female PhDs in 2001 represents a fifteen percentage point rise since 1976 and a ten percentage point increase from 1986.

Figure 4



Source: Statistics Canada, 2001 Census of Population.

Canada's percentage of female PhD holders also compares favourably with the United States in terms of the gender gap among individuals with earned doctorate degrees. In 1999, women were only 24% of all doctorate degree holders in the United States according to the National Science Foundation (2004). The 2001 Census figures also reveal that employed women represented almost half (47%) of Canada's employed labour force of 15 million and 49% of the nearly three million employed persons with university degrees at the bachelors' level and above (Figure 4).

While women represented almost half of Canada's employed labour force population, only one in five employed S&E doctorates were women. Employed S&E PhDs were 80% male and 20% female, whereas employed Non-S&E PhDs were 38% female and 62% male for those aged 25-64 years. Employed women with Non-S&E PhDs (38%) were slightly higher than the women with S&E doctorates (20%) but still lower than the comparable 49% for employed women with university degrees at the bachelor's level and above (excluding PhDs).

The proportion of employed female S&E doctorates in the life sciences (health, agricultural, biological, and veterinary) is higher than the 27% proportion for all PhDs. They were comparably lower than the value for all PhDs if they were in engineering and applied sciences along with mathematics, computer and physical sciences. For example, the employed S&E doctorate percentage values were higher for women in health sciences (35%) and agricultural, biological and veterinary sciences (29%), but less than one in six for those in mathematics, computer and physical sciences (14.8%). In fact, employed women with S&E doctorates in physics (8.4%) were the lowest of the mathematics, computer and physical sciences group, followed by geology (12.2%) and computer science (14.9%).

Employed female doctorate holders in the field of engineering and applied sciences were less than one in ten. Only in architecture (23.9%) along with biological and chemical engineering (13.9%) were the proportion of women slightly higher than the total engineering and applied sciences 8.5% value. Employed women with doctorates in civil engineering (6.3%) were the lowest S&E value. Despite the low percentage of women in engineering, Finnie, Lavoie and Rivard (2001) has shown empirical evidence that women in engineering perform relatively well in the labour market especially when compared with women in other fields of study.

There is a ratio of four employed male doctorates for every one employed female doctorate in total science and engineering compared to the almost one-to-one ratio in Non-S&E fields of study such as education and fine and applied arts. The engineering numbers for females at the doctorate degree level may remain low as women, according to one recent source, seem to be turning away from the engineering field in universities.[12]

Of the five key industrial sectors, health care and social assistance followed by educational services represented the two sectors with the highest ratio of employed women to men in the overall economy in 2001 (Table 8). Galarneau (2004) in her examination of health care professionals has shown that the health care sector is predominantly female due to the high number of female nurses in healthcare occupations.

Two thirds (66.1%) of the persons employed in the educational services sector in Canada were women due to the high number of female teachers. It is the reverse however for those employed with doctorate degrees in educational services where 70% were male doctorates and 30% were female doctorates. For S&E doctorates in educational services, it was 78% male and 22% female (Table 8).

12. See for example, “A male bastion once more: Women turn away after years of gains. Universities try to lure them back” by Louise Brown in ***The Toronto Star***, October 11, 2005, p. A01

Table 8 Employed female industrial distribution by percentage, 2001

Industrial Classification (1997 NAICS)	Canada total employed female	University with BA and above (excluding PhDs) female	Total employed PhDs female	Total employed S&E PhDs female
Total industries	**46.9%**	**48.9%**	**27.1%**	**20.0%**
Health care and social assistance	81.7%	69.5%	39.8%	31.6%
Educational services	66.1%	66.0%	30.2%	21.9%
Finance and insurance	64.0%	44.5%	23.4%	18.0%
Accommodation and food services	59.6%	52.6%	28.2%	32.5%
Management of companies and enterprises	55.3%	44.6%	16.7%	18.2%
Retail trade	54.5%	51.2%	31.5%	25.5%
Other services	51.5%	52.5%	22.8%	28.4%
Arts, entertainment and recreation	48.0%	51.9%	35.3%	27.0%
Information and cultural industries	47.1%	46.9%	23.3%	12.9%
Public administration	46.8%	45.0%	24.3%	18.3%
Administrative and support, waste management and remediation services	45.6%	48.3%	25.9%	20.4%
Real estate and rental and leasing	44.8%	37.8%	20.2%	21.4%
Professional, scientific and technical services	44.1%	34.8%	17.8%	14.5%
Wholesale trade	31.9%	33.6%	20.0%	17.3%
Agriculture, forestry, fishing and hunting	29.9%	34.0%	16.5%	14.1%
Manufacturing	29.0%	28.8%	13.4%	12.7%
Transportation and warehousing	25.2%	31.9%	9.6%	11.8%
Utilities	25.0%	27.8%	11.2%	5.6%
Mining and oil and gas extraction	16.7%	22.5%	10.0%	8.1%
Construction	12.1%	19.7%	10.5%	4.9%

Note: Industrial sectors are ranked based on highest to lowest Canada total employed female percentage.
Source: Statistics Canada, 2001 Census of Population.

On average, employed female PhD holders were younger than the employed male PhDs by about four years whereas women were only one year younger than men for the entire employed labour force in 2001. The average age for all employed PhDs was 48, but the average for female PhDs was 45 and 49 for male PhDs. Female PhDs tend to be younger as their percentage has been increasing steadily in comparison to men. Canadian women with earned doctorates were 12% in 1976, 17% in 1986 and 27% in 2001 of total earned doctorates.

With an average age of 43, employed S&E female doctorate holders were on average four years younger than the S&E male doctorates, and five years younger than the 48 average for all PhDs in 2001. The employed S&E female PhDs in educational services and public administration were on average the oldest while those in manufacturing, health care and professional and scientific services were younger. A higher proportion (41%) of the total employed science and engineering female doctorates between the ages of 25 to 64 were found in the 35 to 44 age bracket, compared to only 35% for the employed male S&E doctorates.

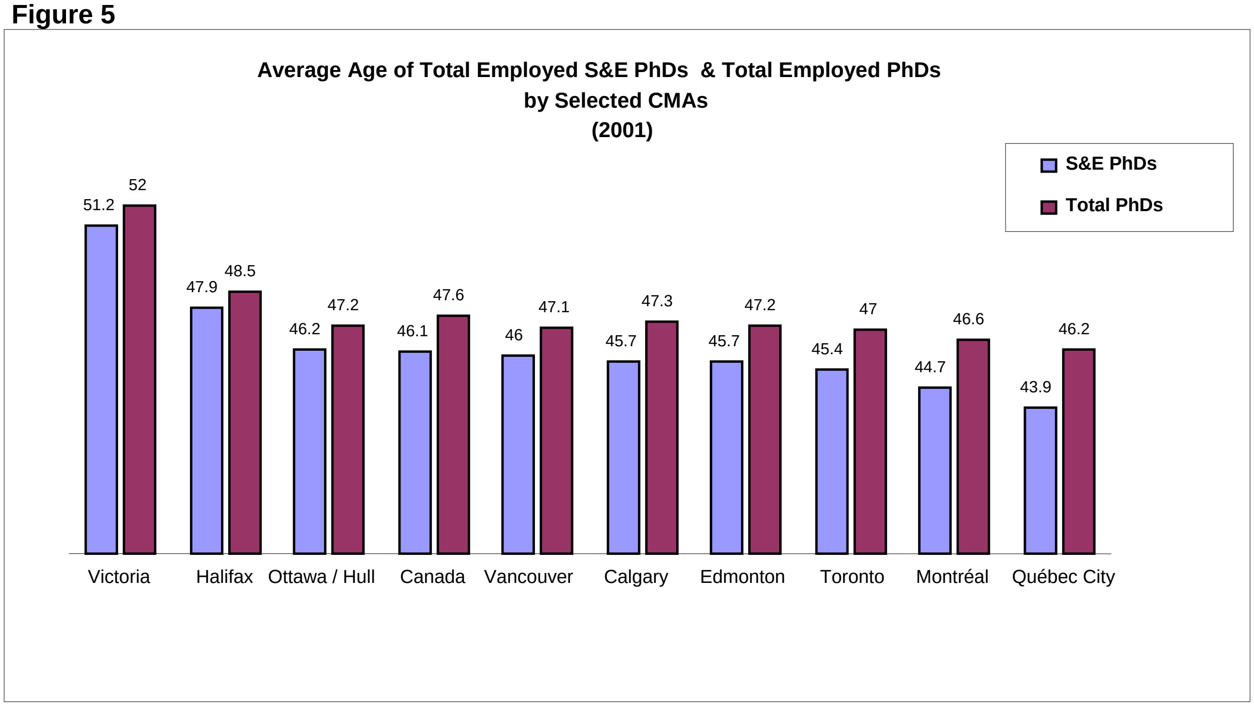
Age Characteristics

The east coast and west coast have older employed PhDs. The younger employed PhDs are found in Canada’s interior.

In terms of the geographic age distribution by CMAs, for the CMAs that employ over a thousand PhDs, Victoria and Halifax had on average the oldest employed PhDs whereas Montréal and Québec City had on average younger employed PhDs (Figure 5). The west coast and east coast therefore have on average the older employed PhDs.

Almost 70% of Victoria’s 2,000 employed PhDs and 60% of Halifax’s 1,900 employed PhDs were in the 45 to 64 years age range in 2001. In contrast, Toronto, Montréal and Québec City all had approximately 50% of their total employed PhDs in the 45 to 64 years age range.

Figure 5



Source: Statistics Canada, 2001 Census of Population.

The engineering and applied sciences along with health sciences employed doctorates were younger on average than the other employed S&E doctorates as well as other employed Non-S&E PhDs. The youngest employed S&E doctorates were in health sciences in the sub-field of pharmacy and pharmaceutical sciences along with the computer science sub-field under the mathematics, computer and physical sciences group. With an average age of 42 years, the two sub-fields were four years below the 46 average for all S&E employed doctorates, and six years younger than the 48 average for all employed PhDs. On the other hand, the oldest employed S&E doctorates were in the health sciences sub-field of surgery and surgical specialization with an average age of 52 years old, even higher than the 51 average for those employed in the Non-S&E field of education.

The science and engineering doctorates were younger on average basically due to the fact that many S&E PhD fields may have younger entrants and shorter times to complete their doctorate in comparison to some Non-S&E fields. Graduates from S&E fields such as computer science, chemistry, engineering, mathematics and other physical sciences had shorter times to completion compared to graduates from the field of education that are also older when they enter their doctoral programs. For instance, Gluszynski and Peters' (2005) examination revealed that the average age of the 2003-2004 graduates in the S&E field of chemistry was 31 compared to the 46 average graduation age for those in the Non-S&E field of education.

University and college professors along with those in the health sector have often been cited as occupations that may be at risk for shortages because of an aging labour force. The health sector is often identified because of the increased health care needs of an aging population, whereas university and college professors are identified because on average they are a lot older than the overall labour force. In 2001, 29% of professors were aged 55 years and over, much higher than the proportion of only 19% a decade earlier (Statistics Canada, 2003).

The average age of employed university professors was 49 in 2001. While 29% of the employed university professors were between 55 to 64 years old, only 23% of all employed persons with a doctorate degree were between 55 to 64 years old. One third, (33%) of all the employed male university professors were in the 55 to 64 age bracket compared to only 19% for female university professors in the older age bracket.

In 2001, there were 2.7 persons aged 20 to 34 years in the labour force for every participant aged 55 years and over, down from a ratio of 3.7 in 1981(Statistics Canada, 2003: p.5). In other words, there are fewer younger workers to replace the age group nearing retirement and thus shortages may occur in certain occupations.

There is indeed a potential risk of shortage based on age replacement for university professors compared to other selected occupations.[13] There was less than 1 replacement professor aged 35 to 44 for every professor aged 55 to 64 in 2001, compared to 1.3 replacements for all PhD occupations and 2.9 replacements for scientists and engineers in the natural and applied sciences occupational group (Table 9). The replacement numbers are low for university professors also because "universities have lost about 3,500 faculty since 1992 due in large part to many universities' inability to replace retiring faculty due to cuts to university core budgets" (Elliott, 2000).

Given the fact that almost a third of the university professors were in the 55 to 64 years age bracket and there were less than one younger replacement for those nearing retirement, there could be a potential shortage of professors at a time when Canada's knowledge-based economy may be demanding workers with higher levels of education. By contrast, for Canada's total employed labour force the ratio of replacement workers were 2.8 replacements for the 35 to 44 years age bracket for every one in the 55 to 64 years age group, and 2.2 replacements for the 25 to 34 years age group for every one in the 55 to 64 years age bracket. Since most PhDs enter the labour force in their early to mid thirties the comparative age group should be the 35 to 44 years age bracket (see Tables 9 and 10).

13. The risk assumes that professors will retire at age 65 notwithstanding the elimination of compulsory retirement in some institutions.

Table 9 Age replacement ratios for employed PhDs by selected occupations, (35 to 44 years/55 to 64 years), 2001	Total PhD occupations	University professors	Natural and applied sciences
Total major field of study	1.3	0.9	2.9
Total science and engineering	1.8	1.1	2.9
Total male PhDs	1.1	0.7	2.6
Total female PhDs	2.1	1.7	5.8

Source: Statistics Canada, 2001 Census of Population.

For the five key industrial sectors, the S&E replacement ratios were lower in comparison to total industries and total employed labour force for public administration and educational services because of the proportionately older university professors in educational services and older S&E PhDs in public administration (Table 10). The manufacturing sector, on the other hand, is comparatively less likely to experience a shortage of doctorates**.** There were almost four younger replacement doctorates for every one doctorate aged 55 to 64 years in the manufacturing sector which compares very favourably with the three younger replacements for the total employed workers in the manufacturing sector. On average, PhD holders in the manufacturing sector were younger than in educational services and public administration. Indeed, they are also younger because nine out of every ten are from the engineering and applied sciences and mathematics, computer and physical sciences groups combined. The two S&E groups also have comparatively shorter times to completion of their doctoral programs.

Table 10 Age replacement ratios for employed PhDs by key industries, 2001

	Total industries	Manufacturing	Professional, scientific, and technical services	Educational services	Health care and social assistance	Public administration
Total employed PhDs	1.3	3.5	1.8	1.0	1.7	1.4
Total S&E employed PhDs	1.8	3.6	2.2	1.3	2.1	1.4
Total employed labour force	2.8	3.3	3.1	2.3	2.9	3.7

Source: Statistics Canada, 2001 Census of Population.

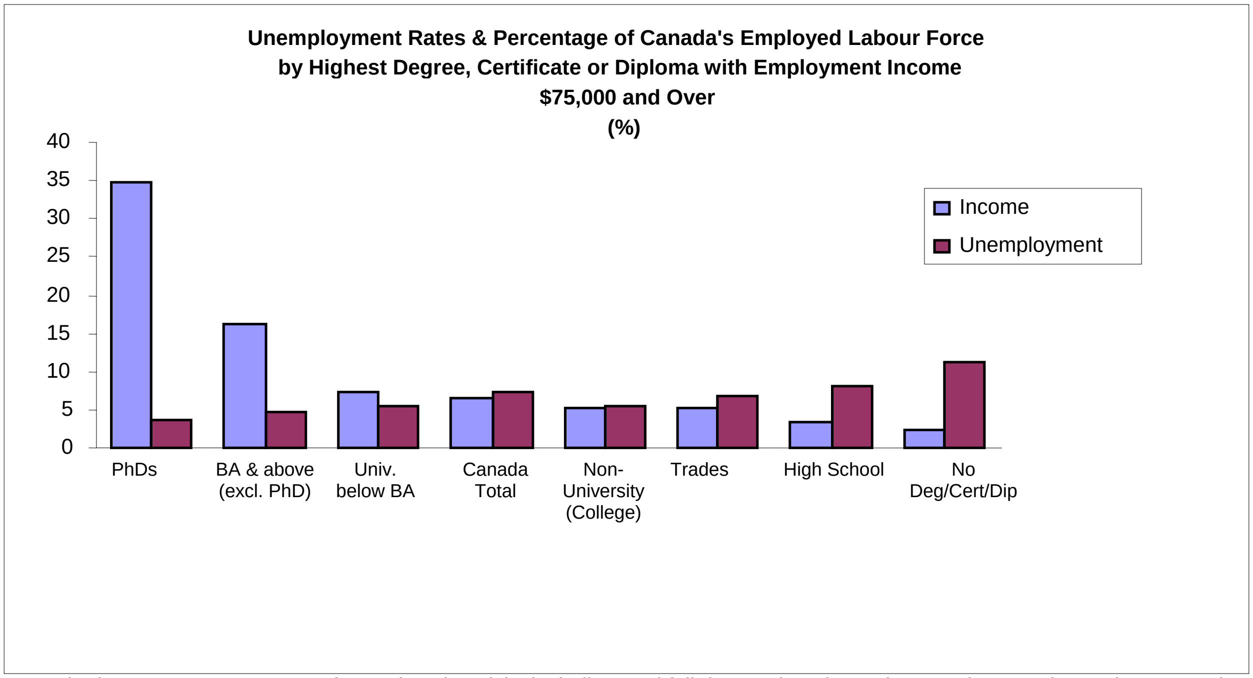
Income

Scientists and engineers with doctorate degrees had higher incomes and lower rates of unemployment in comparison to all other levels of education.

Scientists and engineers with PhDs perform quite well in the labour market according to the 2001 Census information. PhDs had comparably lower levels of unemployment and proportionately more of them were in the higher income bracket in comparison to all other educational levels.[14] In 2001, the PhDs' unemployment rate was 3.7% and more than one third (34.9%) of PhDs were in the higher income bracket compared to workers with a high school diploma who experienced an 8% unemployment rate and only 3% belonged to the higher income bracket. Proportionately the higher the level of educational attainment the lower the unemployment rate and proportionately more workers in the higher income bracket (Figure 6).

14. Employment income refers to total income received by persons 15 years of age and over during calendar year 2000 as wages and salaries, net income from a non-farm unincorporated business and /or professional practice and or net farm self-employment income.

Figure 6



Note: The income percentages are for total work activity including total full-time and total part-time employment for total ages, total sex and total major field of study.
Source: Statistics Canada, 2001 Census of Population.

Galarneau and Earl (1999) have shown that one of the most meaningful comparisons in explaining earning differences among individuals is the measure concerning full-year full-time workers. Further examination of PhDs working full-year full-time has revealed the fact that the science and engineering doctorates working full-year full-time perform quite well in the labour market with both higher average and higher median employment income in comparison to Non-S&E doctorate degree holders.

The empirical evidence from Finnie and Frenettte (2003: p.190) have demonstrated that field of study is an important determinant of university graduates earning levels and that “the effects of field of discipline on earnings appear to operate to some degree through the accumulation of greater labour market experience and other work-related characteristics (including occupation and industry) and are also perhaps associated with certain personal attributes which affect earnings, but “pure” discipline effects remain even after controlling for these influences.” Indeed, the field difference in median “full-year full-time” (FY-FT) employment earnings between S&E and Non-S&E doctorates was over $2,000 (Table 11).

Median FY-FT earnings in the manufacturing sector ($72,114) were the highest in Canada largely due to the S&E PhDs in manufacturing. Median FY-FT earnings in educational services ($71,333) were second primarily because of the older S&E and Non-S&E professors in educational services with greater labour market experience (Table 11).

Table 11 PhDs median employment income working full-year full-time in 2000 by five key industrial sectors of employment

Total major field of study	**Total industries**	**$69,732**
	Manufacturing	$72,114
	Educational services	$71,333
	Public administration	$69,981
	Professional, scientific and technical services	$69,321
	Health care and social assistance	$64,912
Total science and engineering	**Total industries**	**$70,105**
	Manufacturing	$74,815
	Public administration	$71,774
	Educational services	$70,743
	Professional, scientific and technical services	$69,760
	Health care and social assistance	$67,968
Total Non-S&E	**Total industries**	**$67,670**
	Educational services	$71,798
	Public administration	$68,085
	Health care and social assistance	$64,082
	Professional, scientific and technical services	$62,129
	Manufacturing	$53,111

Note: The term full-year full-time (FY-FT) refers to persons 15 years of age and over who worked 49-52 weeks (mostly full-time) in 2000 for pay or in self-employment.
Source: Statistics Canada, 2001 Census of Population.

Generally, the S&E PhDs have the favourable field difference in full time earnings, with the exception of educational services. S&E PhDs in manufacturing had the largest field difference in earnings (over $20,000) when compared to the Non-S&E PhDs in manufacturing (Table 11).

Female PhDs Average Employment Income Comparisons

On average, women between the ages of 25 to 64 years working full-year full-time earned 71% of what men aged 25 to 64 years working full-year full-time earned in Canada (Table 12). Comparatively, women with university education at the bachelors' level and above (excluding PhDs) aged 25 to 64 years working full-year full-time earned 68% of what men of the same age group and university qualifications earned. On the other hand, female PhDs and female S&E PhDs aged 25 to 64 years earned 79% and 76% respectively of what the male PhDs and male S&E PhDs earned. The 79% figure for all female PhDs is therefore 8 percentage points higher than the 71% mark for all of Canada's women aged 25 to 64 and 11 percentage points higher than the 68% value for university women with a bachelor's degree or higher.

Even though female PhDs aged 25 to 64 do comparatively better than other women in Canada's labour force, there is still a pay gap of over $17,000 between men and women with PhDs (Table 12). The pay gap is consistent with a recent U.S. study by Graham and Smith (2005) which shows that on average with any S&E degree in 1999, women working full-time earned 74% of what men earned and there was a pay gap of over $16,000. The study is one of the first to document gender differences such as S&E education, occupational variables, and sector of employment, and to show that they were all contributing factors in the total pay gap. Graham and Smith (2005) concluded that even after taking into account all of the above factors, U.S. women employed in S&E jobs still earn seven to eight percent less than men.

Table 12 Average employment income by sex and age (25 to 64) working full-year full-time in 2000

	Average income Canada total	Average income total university with BA and above (excl PhDs)	Average income total PhDs	Average income total S&E PhDs	Average income total Non-S&E PhDs
Total sex	**$44,759**	**$63,228**	**$76,776**	**$79,212**	**$73,277**
Female	$35,992	$49,952	$63,801	$62,973	$64,429
Male	$50,980	$73,508	$81,046	$82,804	$77,898

Note: The term full-year full-time (FY-FT) refers to persons 15 years of age and over who worked 49-52 weeks (mostly full-time) in 2000 for pay or in self-employment.
Source: Statistics Canada, 2001 Census of Population.

Immigration

Even though the proportion of immigrants with PhDs was lower between 1991 to 2000 in comparison to other degree levels, it was the period with the highest numbers of immigrant PhDs

According to the 2001 Census information, half (50.3%) of all the earned doctorate degree holders in Canada are immigrants. That is the highest percentage across all levels of education (Table 13).

Nearly 23,000 immigrants with PhDs came to Canada during the 10 year period prior to the 2001 Census, representing 35.4% of the 65,000 immigrant PhDs in Canada. The 23,000 number of immigrants with PhDs, however, represented less than 2% of Canada's 1.5 million total labour force immigrants who arrived between the years 1991-2000 (Table 13).

Table 13 Immigration by highest degree, certificate or diploma, 2001

	Total labour force activity	Immigrants percentage of total	Immigration period: 1991-2000	1991-2000 Percent of total immigrants	1991-2000 Percent of Canada total
Canada total	**23,901,355**	**21.5%**	**1,481,780**	**28.9%**	**100.0%**
PhDs	128,625	50.3%	22,900	35.4%	1.5%
BA and above (excl PhD)	3,559,025	28.2%	390,420	38.9%	26.3%
University below BA	601,425	29.6%	66,825	37.5%	4.5%
Non-University (college)	3,578,400	19.1%	162,905	23.8%	11.0%
Trades	2,598,925	19.8%	95,400	18.5%	6.4%
High school	5,499,890	18.7%	335,645	32.7%	22.7%
No deg/cert/dip	7,935,075	20.9%	407,680	24.6%	27.5%

Note: Immigrant doctorates include those who had a doctorate when they immigrated to Canada as well as those who earned their degree after they arrived.
Source: Statistics Canada, 2001 Census of Population.

The immigrant percentage of all PhDs has remained relatively stable since 1986 when it was 51%. However, as a reflection of increased global and Canadian demand for PhDs, the flow of immigrant PhDs in Canada has increased. For example, almost 20% or 6,500 of the 34,000 immigrant PhDs in 1986 arrived during the 10 year period before the 1986 Census (Burke, 1988), whereas 35% or 23,000 of the 65,000 immigrant PhDs arrived during the ten year period before the 2001 Census.

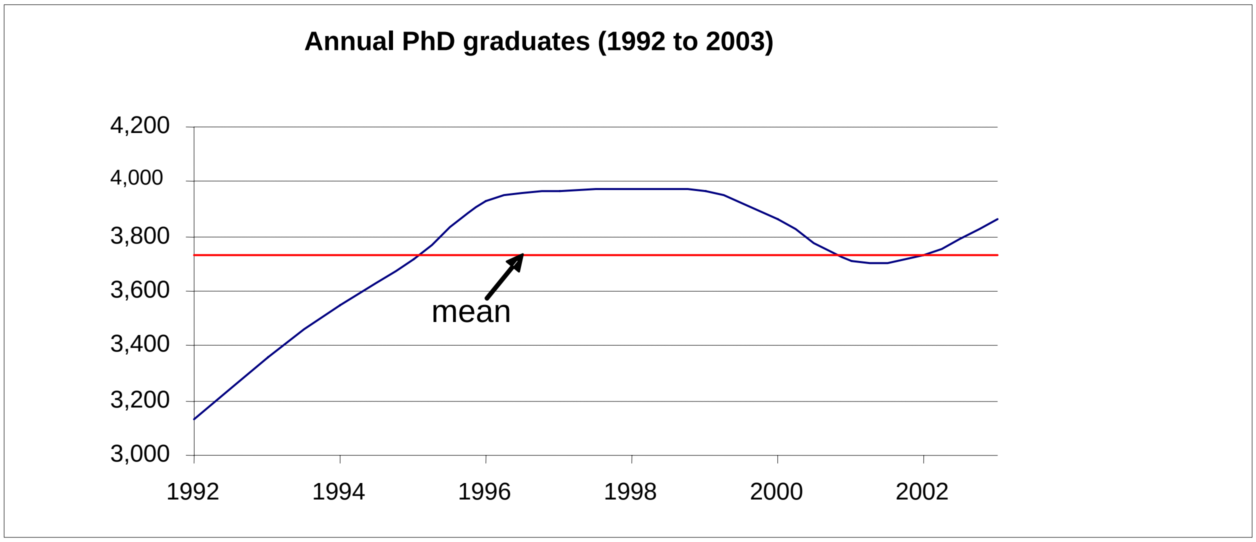
One of the main reasons for both the increases in immigrant PhDs as well as the higher concentration of immigrant PhDs in S&E fields is due to the fact that Canada produces proportionately fewer graduates in mathematics, sciences and engineering than other G-7 countries, with the exception of Italy according to 1997 OECD data. Indeed, Zhao, Drew and Murray (2000) has shown that in 1995 Canada produced 741 university graduates in science-related fields per 100,000 people aged 25 to 34 years in the labour market compared with 938 in the United States and an average of 831 across OECD countries.

The proportionately lower number of graduates in S&E has meant Canada is increasingly reliant on the rest of the world's supply of university graduates. Indeed, the employed immigrant and non-permanent residents PhDs were more concentrated in science and engineering fields whereas Canadian-born PhDs were predominantly in the Non-S&E fields. Of the nearly 23,000 immigrant PhDs between the 1991 to 2000 time period, about 18,000 (78%) were S&E PhDs. In fact, over 480,000 or approximately one third of the 1.5 million labour force immigrants age 15 and above that came during the 1991 to 2000 time period had some form of university education including degrees or certificates (Table 13). This is not surprising since Zhao, Drew and Murray, (2000: p.44) has shown that "for every one university graduate migrating from Canada to the United States, whether on a temporary or permanent basis, four university degree holders migrate from the rest of the world to Canada."

China followed by India and the United States were the top three places of birth of the immigrants with PhDs between the years 1991 to 2000. One quarter (25.2%) of the 23,000 immigrant PhDs were born in China, 6.4% were born in India and 5.9% were born in the United States. S&E PhDs represented 90% of China's total and 77% of India's total but only 37% of the U.S. total immigrants to Canada. The majority (63%) of U.S. born PhD immigrants between 1991 to 2000 were therefore Non-S&E PhDs. Of the 1991-2000 Chinese born PhDs, 70% were 35 to 44 years of age compared to 49% and 48% respectively for the U.S. and India. Over half (56%) of the total S&E immigrant PhDs from 1991 to 2000 were between 35 to 44 years of age.

Canada has had a relatively stable supply of doctorate degrees, well over 3,000 annually since 1992 (Figure 7). Indeed, the 12 year mean between 1992 and 2003 was 3,729 doctorate degrees. Therefore, the supply of doctorate degrees is not necessarily shrinking in Canada. The balance between immigrant and non-immigrant PhDs has remained around 50% when 1986 and 2001 Census data are compared. The domestic supply of Canadian-born PhDs in Non-S&E fields is therefore being balanced with the supply of immigrant PhDs in science and engineering fields.

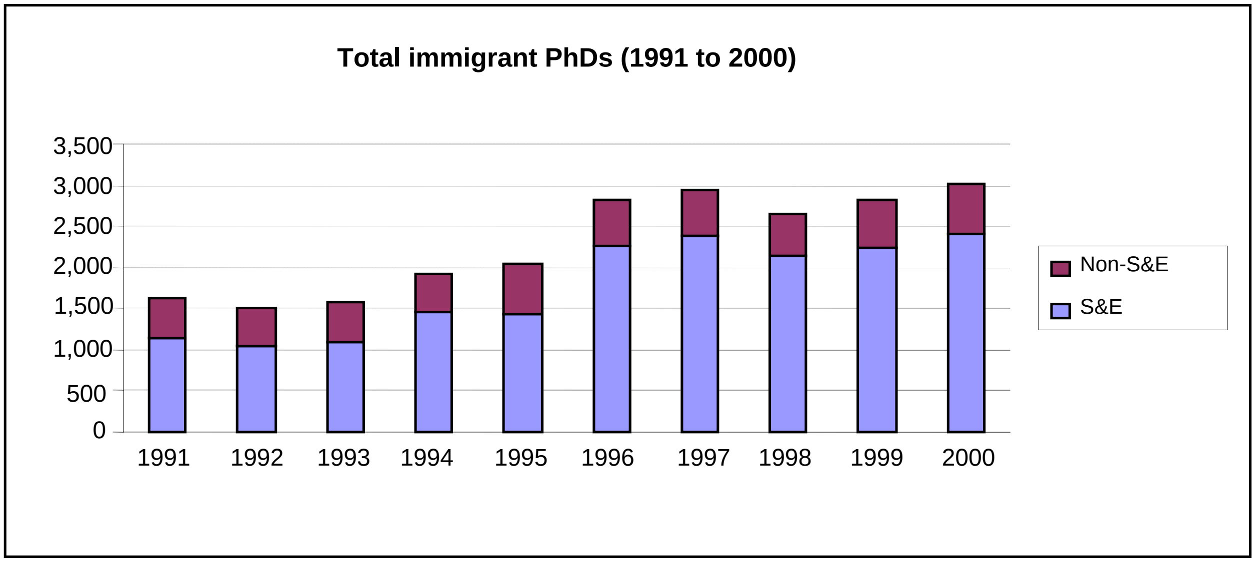
Figure 7



Source: Statistics Canada, CANSIM Table 477-0014.

Immigrants and non-permanent residents combined represented a 60% share of the 57,000 employed S&E doctorates in Canada in 2001, a much higher share than the 20% for the employed population at large. In fact, over the 5-year period between 1996 and 2000, over 2,000 immigrant S&E doctorates were added annually to the Canadian stock of PhDs compared with only 500 to 600 Non-S&E immigrant PhDs that were added annually to the stock over the same time frame (Figure 8).

Figure 8



Note: Immigrant doctorates include those who had a doctorate when they immigrated to Canada as well as those who earned their degree after they arrived.
Source: Statistics Canada, 2001 Census of Population.

In the total stock of earned doctorates in 2001, there were two employed immigrants with PhDs with S&E credentials for every one employed immigrant with PhD with Non-S&E qualifications. Canada has invested less heavily in university-level education than other advanced economies such as the United States according to Boothy and Rainville, (2004) consequently, the low levels of Canadian doctoral graduation in science and engineering may continue for some time. Canada's demands for S&E PhDs is further reflected in the fact that the ratio of two immigrant S&E PhDs for every one immigrant Non-S&E PhD in 1991 increased substantially to five to one by 2000 (Figure 8). Indeed, 18,000 or 79% of the 23,000 total immigrant PhDs from 1991 to 2000 were employed in 2001, and of the 18,000 employed 78% or 14,000 were S&E PhDs (see Appendix E).

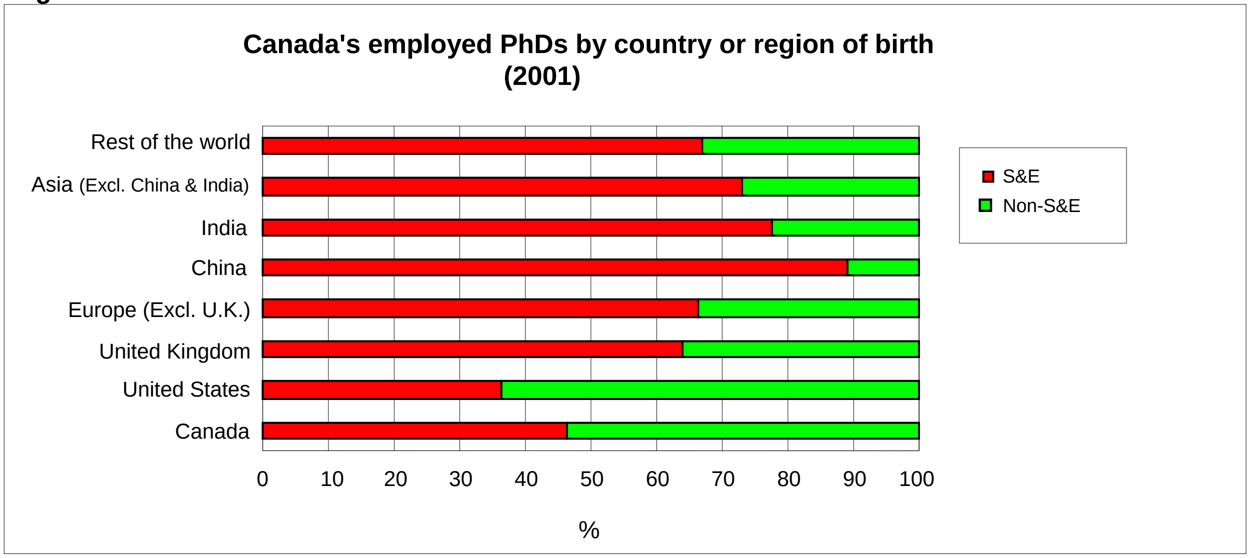
In terms of the percentage enrolment of foreign students in all PhD courses, for example, OECD (2003) data shows that in 2000, 17.3% of enrolled PhD students in Canada were born outside the country. When compared to other OECD countries, Canada was seventh (a relatively high ranking) behind countries such as Switzerland (36.8%), Belgium (36.1%), the United Kingdom (34.0%), the United States (26.9%), Australia (21.4%) and Denmark (18.2%). Italy and Mexico ranked the lowest, registering 1.1% and 0.9% respectively.[15]

The bulk of Canada's recent immigrants with PhDs are not directly as a result of foreign students remaining in Canada but rather from a combination of immigration policy changes in the early 1990s and market forces such as the high technology boom of the mid to late 1990s (Figure 8). In 1993, for instance, new immigration regulations changed the selection criteria in order to give more weight to education thus favouring highly educated and highly skilled immigrants. Indeed, the predominance of occupations related to the natural and applied sciences is a fairly recent phenomenon, as this group has become the dominant occupational category of recent immigrants during the 1990s according to Citizenship and Immigration Canada (CIC). Since 1993, arrivals with these occupations have steadily outpaced other occupations, and in 2000 alone professional occupations in the natural and applied sciences accounted for more than 13% of all immigrants landed in that year while no other occupational group accounted for more than 2% (CIC, 2003). Engineers were the largest occupational grouping although significant numbers of immigrants also intended to work in the information technology sector (Habtu, 2003).

15. OECD figures are for the year 2000 with the exception of Denmark where 1999 figures were used.

Asia, and in particular China and India, have become the major source of immigrants with PhDs since the beginning of the 1980s whereas the U.S. and U.K., the two dominant sources prior to 1981, have had declining shares of the total immigrants with PhDs from the beginning of the 1980s. The U.S. share, for example, went from a high of 24% over the 1971-1980 immigration period to a low of 6% over the 1991-2000 period while China's share went from a low of 2% to a high of 25% over the same immigration time periods (see Appendix C). The total employed PhDs by country or region of birth also reveal that S&E PhDs are proportionally greater than 50% for all countries or regions with the exception of Canadian and U.S. born PhDs. In fact, of the 100,000 employed PhDs in 2001, Canadian-born PhDs numbered 47,000 of which 46% (22,000) were S&E doctorates (Figure 9), further indication of Canada's reliance on other countries' S&E doctorates to fill our domestic demands for highly skilled and highly trained S&E workers (see Appendix E).

Figure 9



Source: Statistics Canada, 2001 Census of Population.

PhDs born in China tend to be much younger than the US born PhDs. For example, about 61% of the total Chinese born PhDs in Canada were between 35 to 44 years of age due to their recent entry whereas 61% of the US born PhDs was in the older age brackets between 45 to 64 years because the majority arrived during the earlier time periods. Indeed, 59% of the total US born PhDs came to Canada between the 1961 to 1980 time periods (Appendix C).

Emerging and critical problem in the U.S. S&E labour force according to U.S. National Science Board

In the United States, Canada's closest competitor, there is a similar pattern of foreign born individuals in the S&E labour force. Indeed, the U.S. National Science Board (2004) projected that some 2.2 million new jobs in science and engineering would be created in the 10 year period 2000-2010, especially in computer-related occupations. The problem for the U.S., however, is that jobs requiring S&E skills in the U.S. labour force is growing at almost 5% per year but the domestic supply of S&E graduates has not kept up with demand. Growth in the United States' S&E labour force has been maintained above the domestic supply of S&E graduates mainly because of the large number of foreign born S&E workers. Between 1990 and 2000, the share of U.S. S&E occupations filled by scientists and engineers who were born abroad increased from 14 to 22% for all university and college degree levels. At the doctorate level, the increase was from 24% to 38%, the highest increase of all university and college degree levels.

Immigration notes

Immigrant Population: Refers to people who are, or have been, landed immigrants in Canada.

Period of Immigration: Refers to ranges of years based on the year of immigration. Year of immigration refers to the year in which landed immigrant status was first obtained.

Non-Permanent Residents: Refers to people from another country who had an employment authorization, a student authorization, or a Minister's permit or who were refugee claimants at the time of the Census, and family members living here with them.

The 2001 figures for the first 5 months prior to the Census are included in the total labour force activity numbers shown in Table 13. The totals shown in Figure 8 and Appendix C are for total labour force activity as well.

Conclusion

Knowledge has always been a central element in the process of innovation and economic growth. Economic growth, in a knowledge-based economy, depends very much on the availability of talent and the stock of human capital (Easton, Harris and Schmitt, 2005). Canada's PhDs, the talented captains of the knowledge-based economy, have experienced unprecedented growth in numbers; an indication of Canada's potential for diffusing advanced knowledge and supplying the labour market with highly skilled workers.

Canada's PhDs are involved in a variety of occupational roles and functions across all industrial sectors. Beckstead and Gellatly (2004) showed that knowledge workers were not limited only to high technology industries and similarly Canada's science and engineering doctorates were found in all industrial sectors and not only in educational services or the natural and applied sciences occupational categories. In fact, the natural and applied sciences occupations represented only one third of the share of all employed S&E doctorates in 2001 and thus a study of scientists and engineers based solely on the natural and applied sciences occupations would be quite limited in scope and coverage in explaining where our scientists and engineers are.

It is reasonable to conclude that there is lesser risk of shortages in the natural and applied sciences occupation at the doctorate degree level since there were three younger replacements for each one nearing retirement age, a figure that is comparably higher than the two younger replacements for the total occupations with S&E doctorates. This particular finding is also consistent with Boothby and Rainville's (2004: p.24) conclusion that "the labour market position of scientists and engineers is somewhat better than that of university graduates as a whole [and that there is no indication of] a persistent and growing shortage of scientists and engineers." There were over 2,000 unemployed S&E doctorates in 2001. The shortage issue therefore is often a tightening of the labour market and not a sudden aggregate shortage of scientists and engineers. Economies are subject to cycles characterized by under and over utilization of available human resources and, as Gingras and Roy (1998) point out, it is important not to confuse a shortage of skilled labour with a labour shortage, especially during periods of economic growth where demand is quite strong.

In 2000/2001, the demand for PhDs was quite strong. The relative unemployment rates in the five key industrial sectors were equal to or lower than the total PhDs and total S&E PhDs unemployment rates with the exception of manufacturing. The lower PhD unemployment rates are signals of strong demand in those sectors. S&E doctorates in healthcare and public administration, for example, respectively had 1.3% and 1.8% unemployment rates in 2001, well below the 3.8% S&E PhDs unemployment rate for all Canadian industries.

The total number of PhDs in Canada grew by 93% between 1986 and 2001 whereas the number of university professors only increased by 35% over the same time frame due to a proportionate reduction in their share of all PhDs. Industry and academia compete for the nation's supply of PhDs and the 2001 findings reveal that 44% of all employed PhDs were in educational services while the remaining 56% were employed in other industrial sectors. PhD holders in educational services had a 2.8% unemployment rate in 2001, the second highest of the five key industrial sectors behind manufacturing. PhDs in the manufacturing sector, however, had four younger replacements compared to only one younger replacement in educational services where university professors are located. What may well be taking place is perhaps mismatches between what the market needs and is willing to pay in terms of the skill sets, interests and salary expectations. Skills mobility is an important aspect of the doctoral qualifications as revealed in Table 4.

University professors and many PhDs in educational services are also in a public sector marketplace under different provincial employment policies and guidelines. The 2001 Census data reveal that educational services had the lowest median employment income among 35 to 44 year old PhDs for total major field of study working FY-FT in 2000, and educational services were at or near the bottom when comparisons are made between S&E and Non-S&E PhDs' median FY-FT employment income among the five key industrial sectors (McKenzie, 2006).

Almost a third (29%) of the employed university professors were in the 55 to 64 years age bracket. With the industrial competition for PhDs both nationally and internationally, the low replacement numbers may be a future cause for concern. For instance, the Association of Universities and Colleges of Canada projects university enrolment to increase between 20 to 25 percent from 575,000 students in 2000 to about 700,000 students in 2010 due to demographic and participation rate increases while at the same time universities combined hiring needs are projected to be between 2,500 to 3,000 new faculty per year over the same ten year period (Elliott, 2000). Indeed, countries such as Australia and Italy are now concerned with replacing large numbers of professors when they retire. In Italy, for example, 70% of full professors are over age 50 (Cervantes, 2004).

Canada's percentage of graduates with doctorates in S&E is much lower than many other OECD countries including the United States. The principal source of the S&E gap at the doctorate level, according to Boothby and Rainville (2004), "is low levels of overall doctoral output in Canada, since a high percentage (around 40%) of Canadian doctoral output is in science and engineering fields." The proportionately lower number of PhDs in S&E has meant Canada is increasingly reliant on the rest of the world's supply of university graduates in S&E fields (Figure 9). From 1991 to 2000 for example, the ratio of two immigrant S&E PhDs for every one immigrant Non-S&E PhD increased substantially to five to one, reflecting Canada's increasing demands for S&E PhDs. More than half (56%) of the S&E immigrant PhDs from 1991 to 2000 were between 35 to 44 years of age. The foreign born supply of S&E PhDs will therefore continue to be vital in filling Canada's industrial S&E demands in an increasingly competitive global market for PhDs.

This study is based on 2001 Census data and looks back from that year. The event on September 11, 2001 had an impact on human resources mobility worldwide and should also be the subject of future study based on 2006 Census data. If, for example, governments set targets for research and development and innovation activities new research scientists and engineers are going to be required (NSERC, 2005). Global competition for highly qualified personnel, including PhDs adds to the policy relevance of the indicators describing them.

Appendix A

Total labour force activity by major field of study and highest degree, certificate or diploma (2001)

	Total highest degree, certificate or diploma	Earned doctorate degree	University with BA and above (excl PhD)	University certificate or diploma below bachelor	Non-university certificate or diploma (college)	Trades certificate or diploma	Secondary (high) school graduation certificate	No degree, certificate or diploma
Total major field of study	**23,901,360**	**0.5%**	**14.9%**	**2.5%**	**15.0%**	**10.9%**	**23.0%**	**33.2%**
Total Science and Engineering	**4,779,930**	**1.5%**	**24.6%**	**3.9%**	**33.6%**	**36.3%**	**0.0%**	**0.0%**
Total agricultural, biological and veterinary sciences	497,505	3.0%	33.3%	4.6%	26.3%	32.7%	0.0%	0.0%
Total engineering and applied sciences	2,739,830	0.6%	14.9%	2.0%	31.9%	50.7%	0.0%	0.0%
Total health sciences	1,164,105	1.3%	27.7%	6.7%	48.4%	15.8%	0.0%	0.0%
Total math, computer and physical sciences	378,495	6.8%	74.0%	8.5%	10.7%	0.0%	0.0%	0.0%
Total Non-S&E	**5,686,465**	**1.0%**	**41.9%**	**7.3%**	**34.7%**	**15.2%**	**0.0%**	**0.0%**
Social sciences	1,038,225	2.3%	62.4%	5.6%	23.4%	6.3%	0.0%	0.0%
Education	1,083,695	0.8%	59.3%	10.1%	24.4%	5.4%	0.0%	0.0%
Commerce, management and business administration	2,287,220	0.2%	24.9%	7.6%	48.4%	18.9%	0.0%	0.0%
Humanities	674,560	2.6%	61.9%	7.6%	24.7%	3.2%	0.0%	0.0%
Fine and applied arts	576,925	0.3%	16.6%	3.4%	31.0%	48.6%	0.0%	0.0%
No specialization	25,840	0.2%	33.5%	9.0%	38.1%	19.3%	0.0%	0.0%

Note: These figures are for the Census Reference Week prior to May 15, 2001 for age 15 and above including employed, unemployed, and those not in the labour force at the time of the Census. The employed labour force by university degrees are shown below.

Source: Statistics Canada, 2001 Census of Population.

Employed labour force by major field of study and university degrees (2001)

	Total highest degree, certificate or diploma	Total university degrees (BA and above)	Earned doctorate degree(s)	Bachelor's degree(s)	University certificate or diploma above bachelor	Degree in medicine, dentistry, veterinary medicine, or optometry	Master's degree(s)
Total major field of study	**14,695,135**	**2,880,345**	**100,040**	**1,892,850**	**290,780**	**97,385**	**499,290**
Total science and engineering	**24.6%**	**33.7%**	**57.1%**	**31.9%**	**21.9%**	**94.7%**	**31.1%**
Total agricultural, biological and veterinary sciences	2.5%	4.8%	11.4%	4.8%	2.9%	7.7%	3.9%
Total engineering and applied sciences	14.3%	11.4%	13.3%	11.8%	9.1%	1.2%	12.9%
Total health sciences	5.8%	9.3%	12.2%	6.7%	4.5%	85.2%	6.3%
Total math, computer and physical sciences	2.0%	8.3%	20.2%	8.6%	5.3%	0.6%	7.9%
Total Non-S&E	**28.8%**	**66.3%**	**42.9%**	**68.1%**	**78.1%**	**5.3%**	**68.9%**
Social sciences	5.6%	18.7%	19.0%	20.2%	15.7%	2.0%	18.1%
Education	5.2%	17.2%	6.5%	16.4%	32.9%	1.1%	16.4%
Commerce, management and business administration	11.7%	16.6%	3.0%	17.2%	18.1%	1.4%	19.0%
Humanities	3.3%	11.0%	13.0%	11.2%	9.0%	0.6%	13.0%
Fine and applied arts	2.8%	2.6%	1.4%	2.9%	2.3%	0.2%	2.3%
No specialization	0.1%	0.2%	0.0%	0.3%	0.1%	0.0%	0.0%

Source: Statistics Canada, 2001 Census of Population.

Appendix B

Employed PhDs by Frascati occupational classification and major field of study (2001)	Total MFS	Total S&E	Total Non-S&E
Total occupations (Frascati classification derived from NOCS-2001)	**99,975**	**57,060**	**42,915**
Researchers	**75.5%**	**79.2%**	**70.5%**
Physical, mathematical and engineering science professionals	15.6%	25.8%	2.0%
Physicists, chemists and related professionals	6.4%	10.9%	0.3%
Mathematicians, statisticians and related professionals	0.4%	0.5%	0.3%
Computing professionals	3.8%	5.9%	1.1%
Architects, engineers and related professionals	5.0%	8.5%	0.3%
Life science professionals (including nurses)	9.3%	15.3%	1.4%
Life science professionals (excluding nurses)	9.1%	15.1%	1.1%
Life science professionals only	3.2%	5.3%	0.4%
Health professionals (except nurses)	5.9%	9.8%	0.7%
Nurses	0.2%	0.2%	0.3%
University and College teaching professionals	36.2%	29.3%	45.3%
University Professors and Assistants	32.6%	26.7%	40.5%
University professors	28.4%	21.1%	38.1%
Post-secondary teaching and research assistants	4.2%	5.6%	2.4%
College and other vocational instructors	3.6%	2.6%	4.9%
Other professionals	12.4%	5.7%	21.3%
Business professionals	1.9%	1.2%	2.8%
Legal professionals	0.8%	0.2%	1.7%
Archivists, librarians and related information professionals	0.2%	0.1%	0.4%
Social science and related professionals	9.5%	4.3%	16.5%
Natural and applied science policy researchers and analysts	1.1%	1.6%	0.4%
Social science policy researchers and analysts	3.3%	2.0%	5.0%
Other policy researchers and analysts	0.5%	0.4%	0.6%
Other social counsellors	4.7%	0.3%	10.5%
Specialist managers including R&D managers	1.9%	3.0%	0.5%
Technicians and equivalent staff	**3.0%**	**4.3%**	**1.3%**
Physical and engineering science associate professionals	1.6%	2.2%	0.7%
Physical and engineering science technicians	0.9%	1.3%	0.3%
Computer associate professionals	0.3%	0.5%	0.1%
Photographers, Graphic Arts Technicians and Technical and Co-ordinating Occupations in Motion Pictures, Broadcasting and Performing Arts	0.0%	0.0%	0.0%
Transportation Officers and Controllers	0.0%	0.0%	0.0%
Safety and quality inspectors	0.3%	0.4%	0.2%
Life safety and quality inspectors science and health associate professionals	1.1%	1.8%	0.2%
Life science technicians and related associate professionals	0.4%	0.7%	0.0%
Modern health associate professionals (except nursing)	0.7%	1.1%	0.2%
Midwives and practical nurses	0.1%	0.2%	0.0%
Technical Occupations in Libraries, Archives, Museums and Art Galleries	0.1%	0.0%	0.1%
Survey Interviewers and Statistics Clerks	0.1%	0.1%	0.2%
Other supporting staff	**21.5%**	**16.5%**	**28.2%**
Clerks	1.1%	0.9%	1.3%
Occupations Unique to Primary Industry	0.5%	0.7%	0.2%
Occupations Unique to Processing, Manufacturing and Utilities	0.3%	0.4%	0.2%
Administrative associate professionals	1.0%	0.7%	1.3%
Legislators, senior officials and managers, n.e.c	9.5%	8.8%	10.4%
Other n.e.c	9.2%	5.0%	14.8%

Note: Total occupations are less because military occupations are excluded.
Source: Statistics Canada, 2001 Census of Population.

Appendix C

Total immigrant PhDs by selected country or region of birth and by period of immigration (1961 to 2000)				
	1961 to 1970	**1971 to 1980**	**1981 to 1990**	**1991 to 2000**
Total	**12,750**	**11,190**	**10,255**	**22,905**
United States	22.1%	24.1%	10.5%	5.9%
Central and South America (Incl. the Caribbean)	5.0%	6.0%	4.4%	3.1%
United Kingdom	22.2%	14.4%	9.6%	3.3%
Northern and Western Europe	11.9%	9.8%	9.1%	5.7%
Eastern and Southern Europe	10.2%	9.4%	13.8%	18.9%
China	3.6%	2.4%	11.0%	25.2%
India	7.6%	8.3%	7.0%	6.4%
Asia (Excluding China and India)	9.1%	16.2%	23.9%	18.5%
Australia and New Zealand	2.0%	1.3%	0.9%	0.5%
Rest of the world	6.4%	7.9%	9.7%	12.4%

Source: Statistics Canada, 2001 Census of Population.

Chinese born and U.S. born PhDs age group comparisons (1961 to 2000)						
	Age group	**Total**	**1961 to 1970**	**1971 to 1980**	**1981 to 1990**	**1991 to 2000**
United States	**Total ages**	**9,385**	**2,820**	**2,700**	**1,075**	**1,340**
	25 to 34	5.3%	1.1%	2.6%	2.3%	9.7%
	35 to 44	15.9%	8.5%	4.4%	18.6%	48.5%
	45 to 54	26.1%	11.3%	36.9%	46.0%	25.4%
	55 to 64	34.9%	47.5%	47.8%	24.2%	9.7%
China	**Total ages**	**8,305**	**455**	**265**	**1,135**	**5,765**
	25 to 34	11.3%	0.0%	3.8%	0.9%	12.0%
	35 to 44	60.9%	2.2%	5.7%	59.5%	70.3%
	45 to 54	15.7%	15.4%	26.4%	26.9%	14.1%
	55 to 64	7.5%	46.2%	52.8%	7.0%	2.4%

Source: Statistics Canada, 2001 Census of Population.

Appendix D

2001 CMA rankings based on PhDs per 100,000					
CMA	**Total PhDs per 100,000**	**Total PhDs rank**	**Total S&E PhDs rank**	**Total Non-S&E PhDs rank**	**Total labour force activity (age 15 and over)**
Kingston	1,718	1	1	1	116,730
Ottawa-Hull	1,397	2	2	3	845,050
Victoria	1,119	3	4	2	259,275
Saskatoon	1,091	4	3	6	175,970
London	845	5	7	5	342,995
Sherbrooke	842	6	5	8	122,965
Halifax	812	7	6	7	289,855
Edmonton	803	8	8	10	741,160
St. John’s	797	9	13	4	140,450
Kitchener	781	10	12	9	324,615
Québec City	761	11	9	11	562,750
Vancouver	732	12	10	12	1,620,920
Toronto	687	13	14	13	3,728,980
Calgary	682	14	11	18	756,130
Montréal	647	15	15	16	2,761,215
Winnipeg	594	16	17	14	533,360
Hamilton	559	17	16	20	527,545
Windsor	510	18	18	19	243,200
Regina	461	19	21	15	151,700
Greater Sudbury	447	20	19	22	125,325
Thunder Bay	397	21	22	17	98,135
Trois-Rivières	382	22	20	21	112,455
St. Catharines-Niagara	313	23	23	23	303,635
Chicoutimi-Jonquière	280	24	24	25	126,680
Abbotsford	267	25	26	24	112,335
Saint John	235	26	25	26	97,905
Oshawa	130	27	27	27	226,840

Note: CMAs are ranked by Total PhDs per 100,000. The average value for total PhDs is 677.
Source: Statistics Canada, 2001 Census of Population.

Appendix E

Employed Scientists and Engineers (S&E) PhDs occupational comparisons of Canadian born and Recent Immigrants (2001)	Total employed S&E	Total Canadian Born employed S&E	Total Recent Immigrants employed S&E
Total occupations (Frascati classification derived from NOCS-2001)	**57,060**	**22,175**	**14,115**
Researchers	**79.2%**	**81.1%**	**77.9%**
Physical, mathematical and engineering science professionals	25.8%	20.2%	40.6%
Physicists, chemists and related professionals	10.9%	11.2%	11.8%
Mathematicians, statisticians and related professionals	0.5%	0.4%	0.4%
Computing professionals	5.9%	3.0%	14.5%
Architects, engineers and related professionals	8.5%	5.5%	13.9%
Life science professionals (including nurses)	15.3%	20.7%	8.2%
Life science professionals (excluding nurses)	15.1%	20.4%	8.0%
Life science professionals only	5.3%	6.1%	4.3%
Health professionals (except nurses)	9.8%	14.3%	3.8%
Nurses	0.2%	0.2%	0.2%
University and College teaching professionals	29.3%	32.0%	20.2%
University Professors and Assistants	26.7%	29.0%	18.3%
University professors	21.1%	25.5%	10.5%
Post-secondary teaching and research assistants	5.6%	3.5%	7.8%
College and other vocational instructors	2.6%	3.0%	1.8%
Other professionals	5.7%	5.7%	5.0%
Business professionals	1.2%	1.1%	1.1%
Legal professionals	0.2%	0.2%	0.0%
Archivists, librarians and related information professionals	0.1%	0.2%	0.1%
Social science and related professionals	4.3%	4.2%	3.8%
Natural and applied science policy researchers and analysts	1.6%	1.6%	1.1%
Social science policy researchers and analysts	2.0%	1.7%	2.2%
Other policy researchers and analysts	0.4%	0.4%	0.2%
Other social counsellors	0.3%	0.4%	0.3%
Specialist managers including R&D managers	3.0%	2.6%	3.9%
Technicians and equivalent staff	**4.3%**	**3.3%**	**6.8%**
Physical and engineering science associate professionals	2.2%	1.5%	4.0%
Physical and engineering science technicians	1.3%	1.0%	2.2%
Computer associate professionals	0.5%	0.2%	0.9%
Photographers, Graphic Arts Technicians and Technical and Co-ordinating Occupations in Motion Pictures, Broadcasting and Performing Arts	0.0%	0.0%	0.1%
Transportation Officers and Controllers	0.0%	0.0%	0.1%
Safety and quality inspectors	0.4%	0.2%	0.9%
Life safety and quality inspectors science and health associate professionals	1.8%	1.6%	2.3%
Life science technicians and related associate professionals	0.7%	0.7%	0.8%
Modern health associate professionals (except nursing)	1.1%	0.8%	1.6%
Midwives and practical nurses	0.2%	0.1%	0.2%
Technical Occupations in Libraries, Archives, Museums and Art Galleries	0.0%	0.0%	0.1%
Survey Interviewers and Statistics Clerks	0.1%	0.0%	0.1%
Other supporting staff	**16.5%**	**15.6%**	**15.4%**
Clerks	0.9%	0.8%	1.7%
Occupations Unique to Primary Industry	0.7%	0.8%	0.4%
Occupations Unique to Processing, Manufacturing and Utilities	0.4%	0.2%	1.0%
Administrative associate professionals	0.7%	0.8%	0.6%
Legislators, senior officials and managers, n.e.c	8.8%	8.9%	6.6%
Other n.e.c	5.0%	4.1%	5.1%

Note: Recent Immigrants are the 1991 to 2000 immigrants.
Source: Statistics Canada, 2001 Census of Population.

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