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UNIVERSITY RESEARCH AND THE COMMERCIALIZATION OF INTELLECTUAL PROPERTY IN CANADA

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UNIVERSITY RESEARCH AND THE COMMERCIALIZATION OF INTELLECTUAL PROPERTY IN CANADA

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1. INTRODUCTION

The importance of knowledge in stimulating economic growth and driving higher productivity is increasingly being emphasized by government, academia and private industry in Canada and around the world. The goal of increasing the creation of knowledge, as well as the successful diffusion and adoption of new technologies throughout the economy, has become a global pursuit. This is especially important for Canada in light of our well-documented "innovation gap" (OECD, 1996) relative to the other major industrialized countries.

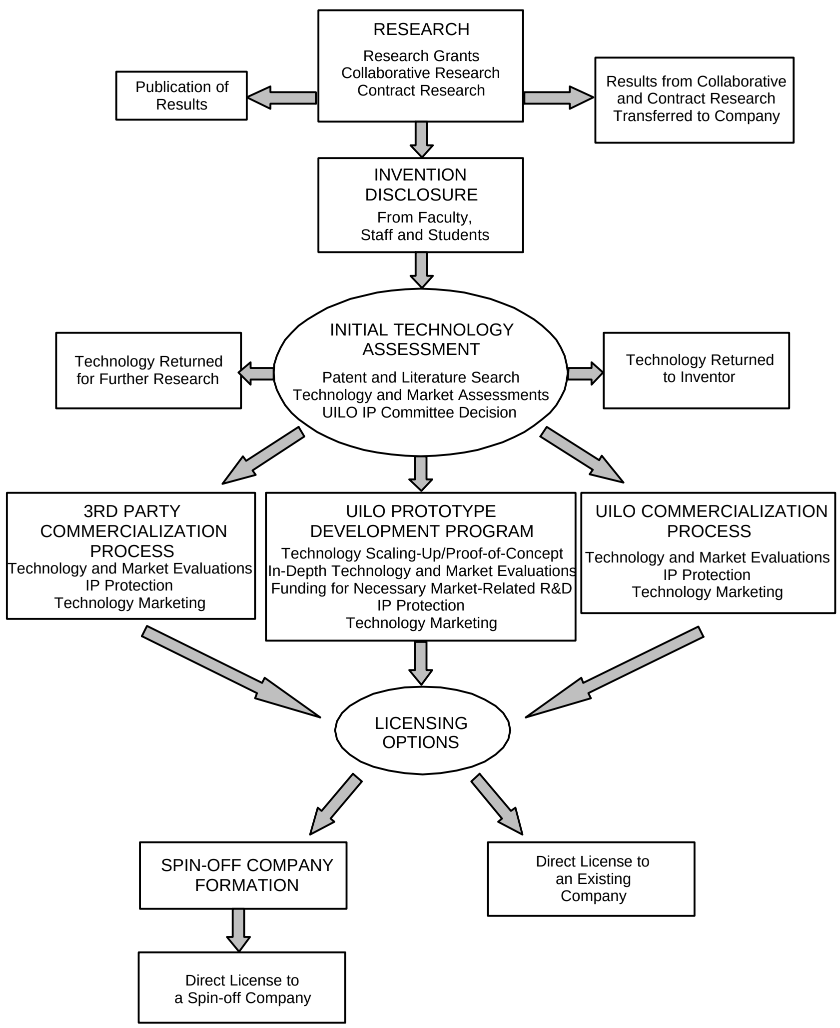
There is growing recognition that universities can play an effective role in promoting technical advance, not just through traditional mechanisms like the advancement of knowledge and education of a skilled labour force, but by actively engaging in commercialization activities. Furthermore, there has been growing attention paid to the quantity and quality of university-industry partnerships. Strong links between university and industry facilitate the transfer of technology from research laboratories to commercial markets.

The objective of this paper is to provide a statistical overview of Canadian universities' R&D activities and commercialization undertakings for the consideration of the Expert Panel on the Commercialization of University Research. The existing data suggest that Canadian universities play a major role in creating knowledge and promoting the diffusion of new technologies. Although Canada lags other countries in terms of R&D per unit of output, the share of national R&D that is conducted by universities is among the highest in the G7 countries. In addition, Canada has the highest share of industry-financed research in the academic sector among the G7 countries, suggesting strong linkages between industry and universities.

Figure 1 illustrates the different paths that universities may take in diffusing the results of their research. Intellectual property created through university research may be transferred to the economy as a public good (through publication in an academic journal) or it may be transferred to industry through collaborative research effort. Alternatively, intellectual property is disclosed to the university, initiating the commercialization process (seeking intellectual property protection, and further development if necessary). The research is then brought to market by licensing the technology to an existing firm or creating a spin-off firm to further develop and commercialize the new technology.

To investigate the characteristics of university commercialization activities, the study draws heavily on the results of two surveys. The first is the annual licensing survey conducted by the Association of University Technology Managers (AUTM). This U.S.-based organization has surveyed major Canadian and U.S. institutions since 1991. Between 12 and 16 major Canadian universities have regularly responded to the AUTM survey which focuses on licensing, but also includes questions on technology transfer, personnel and patents.

Figure 1 Example of the University Technology Transfer Process



Source: Adapted from UILO Technology Transfer Process at the University of British Columbia, Livingstone (1998).

The second survey was conducted by Statistics Canada — the *Survey of Intellectual Property Commercialization in the Higher Education Sector*. The pilot survey was issued to the 90 members of the Association of Universities and Colleges of Canada (AUCC) and responses from 81 universities from across Canada were received. Since this is a new survey, the data are only available for 1997-98. While we also consider evidence from other sources, these two surveys are the most relevant background documents with respect to the commercialization of university research in Canada.

The outline of this paper largely follows the schematic presented in Figure 1. First, Section 2 discusses the role of universities in Canada's national R&D effort, including a depiction of trends in R&D investment by universities and other R&D performers in Canada and in other countries, an examination of the sources of funds for university research, and the identification of fields of research in universities compared to other R&D-performing sectors of the economy. Section 3 describes the output or economic benefits of university R&D. These include the contribution to the stock of scientific and technical knowledge; the training of skilled personnel; and the commercialization of intellectual property. Section 4 discusses the choice between licensing to an existing firm or starting a new company. In Section 5, we provide a brief discussion of the nature and profile of university-industry partnerships which help facilitate the effective transfer of technology. Our conclusions are presented in Section 6.

2. THE ROLE OF UNIVERSITY RESEARCH IN CANADA'S R&D EFFORT

In this section, we present an overview of the aggregate and sectoral trends in research and development (R&D) in Canada over the past few decades. First, we look at the overall growth in national R&D and its distribution among the various R&D performers (industry, universities, government, nonprofit organizations) over time. In doing so, it becomes apparent that universities play an important role in terms of their contribution to R&D in Canada, especially in comparison to other countries. We then focus on the university sector and identify trends in the sources of funds for university research and the fields in which universities are investing their R&D dollars. Data permitting, we make international comparisons as well as identify regional differences in Canada. This overview of R&D activities will set the stage for the next section, which investigates the economic benefits of university research.

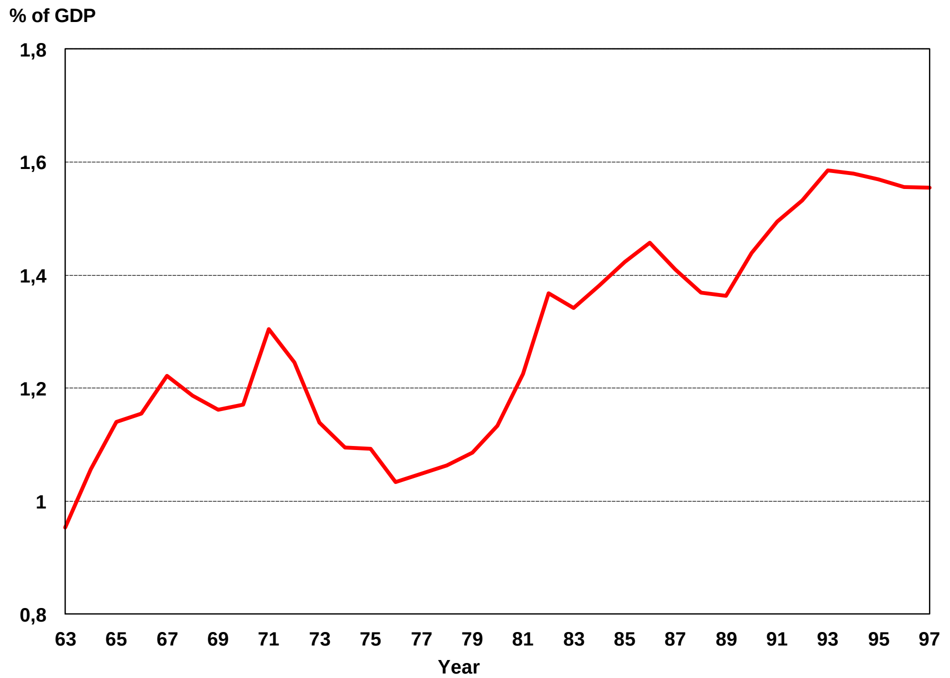
National Trends in R&D Expenditures

Statistics Canada estimates that total R&D investment in Canada reached $13.5 billion in 1997. In real terms, the gross domestic expenditure on R&D (GERD) has been growing at an average annual rate of 5 percent since 1963.[1] There has been a slight slowdown in recent years; total R&D expenditures climbed at an average rate of 4.6 percent between 1990 and 1993, while the rate of growth slowed to an average of 2.0 percent between 1994 and 1997.

Figure 2 illustrates the trend in R&D expenditures as a percentage of GDP since 1963. The chart shows that after hitting a low of 1.0 percent in 1976, the share of output spent on R&D (also known as the R&D intensity rate) in Canada has been trending upward over the past two decades. The ratio increased more rapidly in the late 1970s and early 1980s, and more recently over the 1989-93 period. However, growth in Canada's R&D intensity has slowed down since 1993. It is estimated to be only 1.56 percent in 1997.

R&D expenditures in Canada represent a much smaller component of GDP than in other industrialized countries. In fact, Canada's R&D intensity rate is among the lowest in the OECD area (Table 1). Although the R&D expenditure-to-GDP ratio has increased over the 1981-97 period, Canada's relative position has remained unchanged. The countries which devote the largest share of their output to R&D are Japan and the United States — according to the most recent data available, these countries have R&D intensities of 2.83 and 2.62, respectively.

Figure 2 National R&D Spending as a Share of GDP, 1963-97



Source: Statistics Canada (1997, 1998a) and CANSIM.

Table 1 National R&D Spending as a Share of GDP among the G7 Countries, Selected Years

Country	1981	1986	1991	1997†
United States	2.32	2.71	2.81	2.62
Japan	2.13	2.55	3	2.83
Germany	2.43	2.73	2.61	2.26
France	1.97	2.23	2.41	2.32
United Kingdom	2.37	2.25	2.11	1.94
Italy	0.88	1.13	1.24	1.06
Canada	1.22	1.46	1.49	1.56

† Estimates for 1997 or latest year available: 1996 for Japan, France and the United Kingdom.
Source: Statistics Canada (1997, 1998a) and CANSIM; National Science Foundation, *Science and Engineering Indicators, 1998*; OECD, *Main Science and Technology Indicators, 1998*.

By Performing Sector

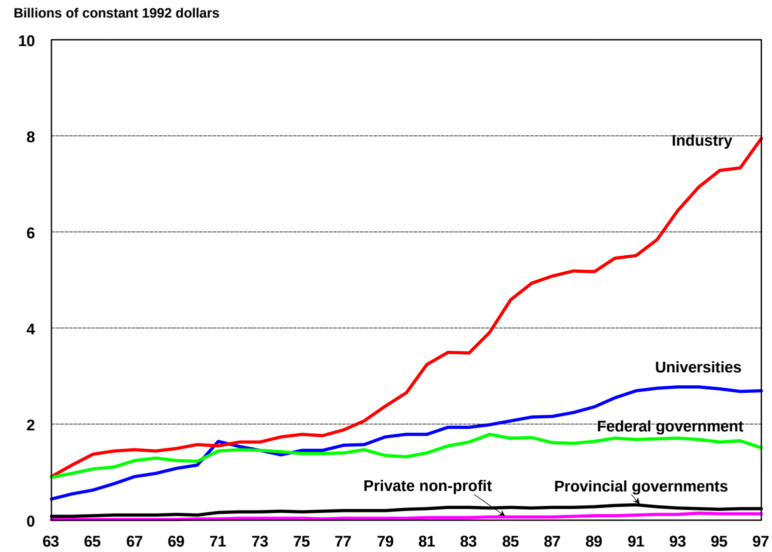
In this section, we present the trends in R&D spending by major sector, in real dollars and as a percentage of total R&D expenditures. We find that the relative contributions of R&D performers in Canada to total R&D investment have changed over the last three decades. The most striking change is observed in the shares of industry and government; the academic sector has remained strong and relatively constant.

The following summarizes the changes that have emerged over the 1963-97 period in Canadian R&D performance (see Figures 3 and 4). We focus on the three main performers of R&D: industry, universities, and government.

- **Industry** has been the fastest growing sector in terms of R&D spending, with annual expenditure increases estimated at 6.6 percent in inflation-adjusted dollars between 1963 and 1997. In the 1990s, the largest annual increase occurred in 1993 (over 10 percent). On average, the annual growth rate in the 1990s has been 6.6 percent. By 1997, business expenditures on R&D were estimated to have reached $8.5 billion in current dollars. Figure 4 shows that in the early 1960s, industry accounted for only 38.4 percent of total R&D; by 1997, its share had increased dramatically to reach 63.4 percent.

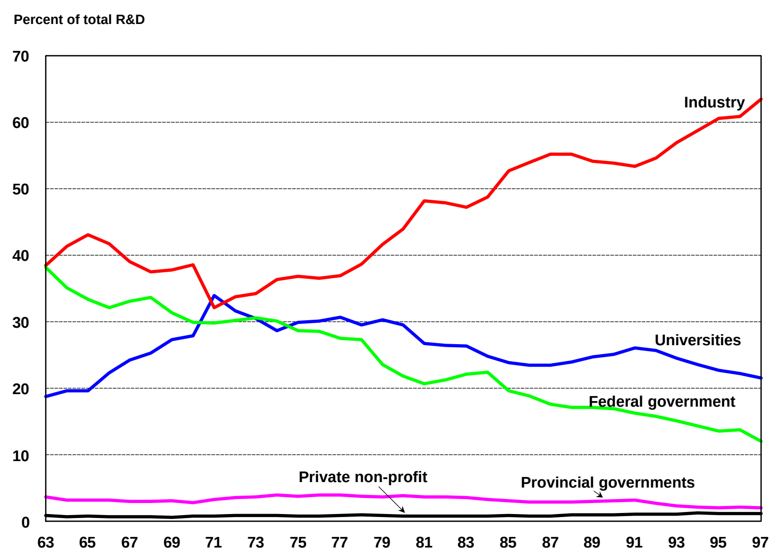
- **Universities** are a distant second to industry in terms of R&D performance, with total expenditures amounting to an estimated $2.9 billion in 1997 (see Box 1 for a description of Statistics Canada's estimation of university R&D expenditures).[2] Since 1963, the academic sector has been increasing its R&D at a real rate of about 5.4 percent per year. However, increases in R&D spending have slowed down markedly in the 1990s, growing by only 0.5 percent between 1990 and 1997. In 1995, R&D spending in the academic sector started to decline. Universities accounted for 20 percent of total R&D in 1963, and after reaching a high of 30.7 percent in 1977, the ratio has declined and returned to just over 20 percent.

Figure 3 National R&D Spending, by Performing Sector, 1963-97



Source: Statistics Canada (1997, 1998a).

Figure 4 Distribution of National R&D Spending by Performing Sector, 1963-97



Source: Statistics Canada (1997, 1998a).

- **Government** investment in R&D has increased at a much slower rate than industry and university R&D investment. Since 1963, federal expenditures on R&D have grown at an annual average rate of only 1.5 percent. Provincial governments have increased their spending by an average rate of 3.1 percent per year since 1963. However, we have seen small to negative growth in R&D spending by the government sector in the 1990s. Federal R&D spending has been declining since 1994, and provincial governments started spending less in 1992. By 1997, government spending on R&D was estimated to be $1.9 billion. This is only about 2 times higher than in 1963 (in real terms), whereas industry spending is 9 times higher and university R&D spending is 6 times higher than in 1963. The lack of increase is largely the result of stagnant federal spending. Figure 4 shows that the proportion of total R&D performed by the federal government in 1963 was 38.2 percent (approximately equal to industry's share); by 1997, the federal government's share had fallen to only 12.0 percent. As mentioned above, industry is accounting for more and more of Canada's total R&D effort.

Box 1 Statistics Canada's Method of Estimating R&D Expenditures in the Higher Education Sector

The higher education sector is composed of all universities, colleges of technology and other institutes of post-secondary education, whatever their source of financing or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of, or administered by, or associated with higher education establishments (Thompson, 1998). Statistics Canada identifies the institutions in this sector that perform R&D through the Canadian Association of University Business Officers (CAUBO) annual survey. According to the 1996-97 survey, there were 48 R&D-performing academic institutions in Canada (see Appendix 1 for a list of these institutions).

Using the CAUBO data, Statistics Canada determines the "relevant" total costs for each institution (total university expenditures excluding costs of ancillary enterprises). These costs are then distributed among the major fields of study according to the weighted number of full-time teachers in each field. That is, the actual number of full-time teachers in each field is weighted to reflect the different use of part-time teachers, different consumption patterns of university resources, and different requirements for capital equipment. For example, teachers in the Agricultural and Biological Sciences, Engineering and Applied Sciences, and Mathematics and Physical Sciences are given a weight of 2 to allow for the higher costs per teacher caused by the need for more equipment and facilities, as well as a slightly different rank and age structure. Full-time teachers in the Health Professions are given a weight of 2.5 because of the extensive use of part-time teachers, as well as the cost of equipment and facilities required for instruction and research in the health sciences. The resulting percentage distribution of the weighted number of full-time teachers by teaching field is then applied to the total costs of each institution to provide total expenditures by teaching field.

In order to estimate the R&D portion of total expenditures by teaching field for each institution, Statistics Canada postulates plausible R&D ratios (as measured by the percentage of researchers' time spent performing R&D) since there are no "time budget" surveys in Canada. To allow for a reasonable estimation of total R&D expenditures at the aggregate level, the institutions (universities) are classified into three categories (small, medium, and large) according to the following criteria: 1) the amount of expenditures on sponsored research (reported by CAUBO); 2) the proportion of sponsored R&D expenditures as a percentage of general operating expenditures; and 3) the number of doctoral programs. See Appendix 1 for a list of universities by size.

The R&D ratios for each size of R&D performer are applied to the "relevant" total costs of the university by teaching field (costs estimated according to the weighted number of teachers) to calculate the total R&D expenditures by the university sector in Canada. See Thompson (1998) for more details.

Box 1 (cont'd)

Weights and Ratios for Estimating R&D Costs in Academic Institutions

Teaching field	Weight for full-time teachers	R&D ratios by size of R&D performing university		
		Small	Medium	Large
Education	1.0	0.10	0.20	0.30
Fine and applied arts	1.0	-	0.10	0.20
Humanities	1.0	-	0.20	0.30
Social sciences	1.0	0.10	0.20	0.30
Agricultural and biological sc.	2.0	0.10	0.25	0.35
Engineering and applied sc.	2.0	0.10	0.25	0.35
Health professions	2.5	0.10	0.25	0.35
Math and physical sciences	2.0	0.10	0.25	0.35

International Comparison

How do the different sectors fare on an international basis? Tables 2 and 3 present the distribution of national R&D by performing sector and each sector's R&D intensity among G7 countries.[3] Table 4 shows the share of national R&D performed by universities at various points in time. We focus again on the three main sectors:

- **Industry:** As we mentioned in the previous section, industry performed over 63 percent of total R&D in Canada in 1997. As shown in Figure 3, industry's share of total R&D has been increasing since the 1960s at a faster rate than in any other sector. Despite this increase, however, Canada ranks fifth among the G7 countries in terms of industry's share of R&D (Table 2). In addition, it has been well documented that Canada's R&D intensity rate in the business sector compares poorly with other G7 countries (Table 3). In 1997, estimated R&D spending by industry (BERD) accounted for just under one percent of GDP in Canada. In the United States, the percentage was almost two times higher (1.96 percent), putting the United States in second place among the G7 countries and Canada in second last place. The last row in Table 3 shows that industry is responsible for almost 90 percent of the overall Canada-United States R&D intensity gap.

- **Universities:** Table 2 shows that the academic sector in Canada accounts for a higher share of national R&D investment than in other countries, according to the OECD. In fact, the proportion of total R&D spending performed by Canadian universities is among the highest in the G7. In the United States, for example, only 14.3 percent of national R&D is performed by universities.[4] However, despite the high share of national R&D accounted for by the academic sector, R&D spending by universities as a share of GDP in Canada is among the lowest in the G7 countries (only 0.33 percent of GDP in 1997).

- **Governments:** The federal and provincial governments account for 14 percent of total R&D spending in Canada. This is relatively low in comparison to other G7 countries. However, it is higher than in the United States where the government performs only 8.3 percent of total R&D.

Table 2 Gross Expenditure on R&D in the G7, by Performing Sector, 1997

Country	Industry	Government	Higher education	Non-profit institutions
		(Percent, 1997 †)		
United States	74.4	8.3	14.3	2.3
Japan	71.1	9.4	14.8	4.5
Germany	67	15.2	17.8	0
France	61.5	20.4	16.8	1.3
United Kingdom	64.9	14.4	19.5	1.2
Italy	54.5	21.6	23.8	0
Canada	63.4	14	21.5	1.2

† Estimates for 1997 or latest year available: 1996 for Japan, France and the United Kingdom.
Note: The procedure for estimating R&D expenditures in the higher education sector may differ among countries.
Source: Statistics Canada (1998a); OECD, *Main Science and Technology Indicators (1998)*.

Table 3 R&D as a Percentage of GDP in the G7, by Performing Sector, 1997

Country	Industry (BERD/GDP)	University (HERD/GDP)	Government (GOVERD/GDP)	Total R&D (GERD/GDP)
		(Percent, 1997 †)		
Canada	0.99	0.33	0.22	1.56
France	1.43	0.39	0.47	2.32
Germany	1.52	0.40	0.34	2.26
Italy	0.58	0.25	0.23	1.06
Japan	2.01	0.42	0.27	2.83
United Kingdom	1.26	0.38	0.28	1.94
United States	1.96	0.38	0.22	2.64
Can.-U.S. gap	0.97	0.05	0.00	1.08
(% of gap)	*(89.8)*	*(4.23)*	--	*(100.0)*

† Estimates for 1997 or latest year available: 1996 for Japan, France and the United Kingdom.
Notes: The missing sector includes private non-profit organizations. The procedure for estimating R&D expenditures in the higher education sector may differ among countries.
Source: Statistics Canada (1998a) and CANSIM; OECD, *Main Science and Technology Indicators (1998)*.

Table 4 University R&D as a Percentage of GERD, Selected Years

Country	Percentage of gross expenditure on R&D (GERD)			
	1981	1986	1991	1997†
United States	14.0	14.0	16.4	14.3
Japan	24.0	20.0	17.5	14.8
Germany	15.5	14.0	15.9	17.8
France	16.5	15.0	14.5	16.8
United Kingdom	13.2	14.5	14.7	19.5
Italy	25.5	20.0	19.8	23.8
Canada	23.0	22.5	26.0	21.5

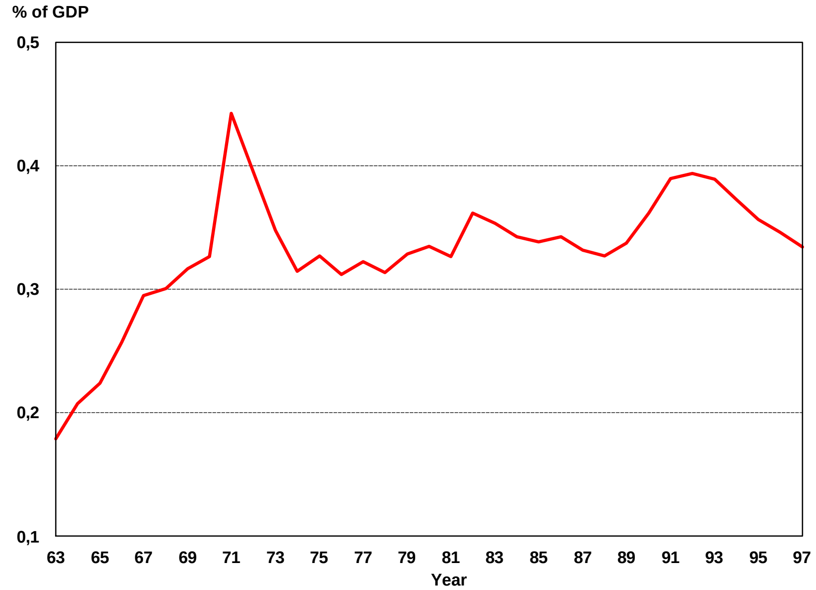
† Estimates for 1997 or latest year available: 1996 for Japan, France and the United Kingdom.
Source: Statistics Canada (1998a); National Science Foundation, *Science and Engineering Indicators, 1998*; OECD, *Main Science and Technology Indicators (1998)*.

Focus on University R&D

As noted in the previous section, Statistics Canada estimates that $2.9 billion was spent on R&D at Canadian academic institutions in 1997. Since 1980, university R&D expenditures have grown at an average real rate of 5.4 percent a year. In Table 3, we can see that the ratio of university R&D spending to GDP was estimated to be 0.33 percent in 1997; Figure 5 shows that there has been little variation in this statistic since the early 1970s. After hitting a record high of 0.44 percent in 1971, the trend in universities' R&D intensity has fluctuated between 0.3 percent and 0.4 percent. However, since 1993, this ratio has been steadily declining.

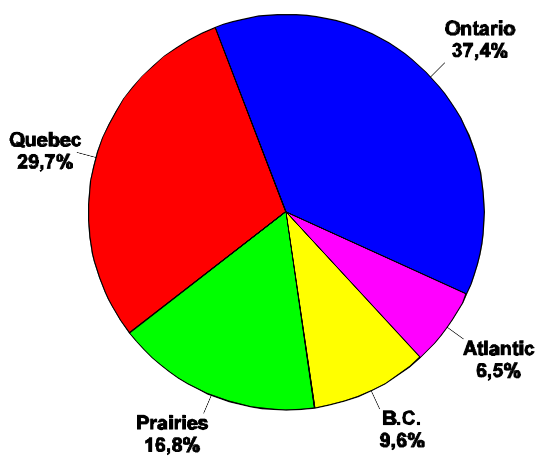
On a regional basis, most of the university research in Canada is conducted in Ontario and Quebec — a combined total of just over 67 percent in 1996 (see Figure 6). This largely reflects the high concentration of R&D-performing universities in these two provinces (see Appendix 1). Figure 7 shows university R&D expenditures as a proportion of provincial GDP. Relative to the Canadian average, provinces such as Nova Scotia and Quebec have a higher university R&D-to-GDP ratio (almost 0.5 percent). While Ontario has the largest share of university R&D expenditures in Canada, R&D expenditures account for only 0.32 percent of its GDP.

Figure 5 University R&D Spending as a Percentage of GDP, 1963-97



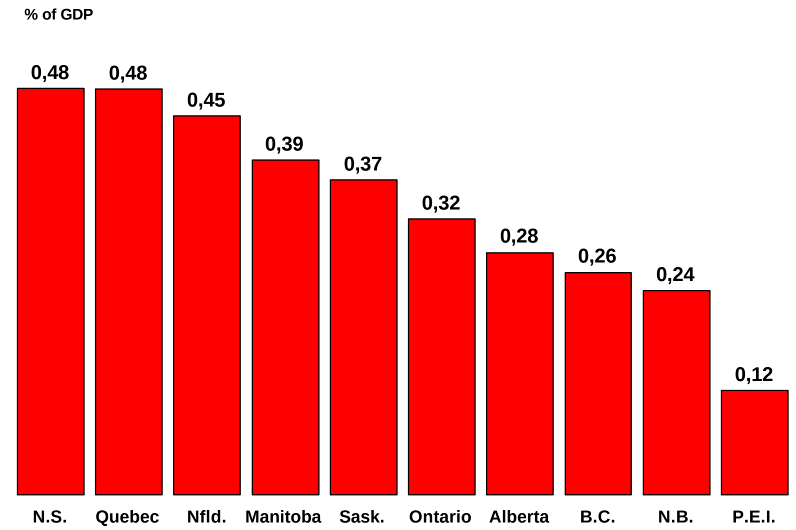
Source: Statistics Canada (1997, 1998a) and CANSIM.

Figure 6 Regional Distribution of University R&D in Canada, 1996



Source: Thompson (1998).

Figure 7 University R&D as a Percentage of GDP, by Province, 1996



Source: Based on data from Thompson (1998) and Statistics Canada.

In the remainder of this section, we look at the characteristics of university R&D in terms of the sources of funds and the fields of research into which universities are investing their R&D dollars.

Sources of Funds for University Research

Funds for university R&D expenditures come from five main sources: business enterprises; governments; private non-profit organizations; foreign sources; and the university itself (see Box 2 for a description of Statistics Canada's method of allocating expenditures among these sources). University sector funding includes the universities' own resources as well as general university funds which are government transfers, and therefore represent indirect federal/provincial government funding.[5] The distribution of R&D funding in Canada in 1996 is shown in Figure 8.

BOX 2 Statistics Canada's Method of Estimating the Sources of Funds for University R&D Expenditures

Once the total R&D expenditures performed in the higher education sector have been estimated (see Box 1), Statistics Canada determines the sources of funds for the R&D expenditures. Allocating the funds by source is complicated by the fact that data exist only for sponsored research. R&D carried out at universities without external funding often has no official accounting record. In addition, even when funding is received, R&D grants do not necessarily cover the full cost to the university of carrying out R&D activities.

The CAUBO survey provides data on sponsored research for participating institutions. The CAUBO data can be assigned to four of the six standard sectors (federal government; provincial governments; funding from abroad; and higher education, to which miscellaneous funds are assigned).

Statistics Canada uses a ratio based on data supplied by the MRC, SSHRC and NSERC to assign the remaining sponsored research funds from the category "bequests, donations, and non-government grants" to the two remaining external sources: business enterprises and private non-profit organizations.

The sponsored research is then deducted from the estimated total R&D expenditures and this residual is attributed to the higher education sector (in addition to the miscellaneous funds that are assigned to the higher education sector). Lack of data requires the eight major fields of study used to construct the total R&D expenditures to be consolidated into three fields of research.

For further details, see Thompson (1998).

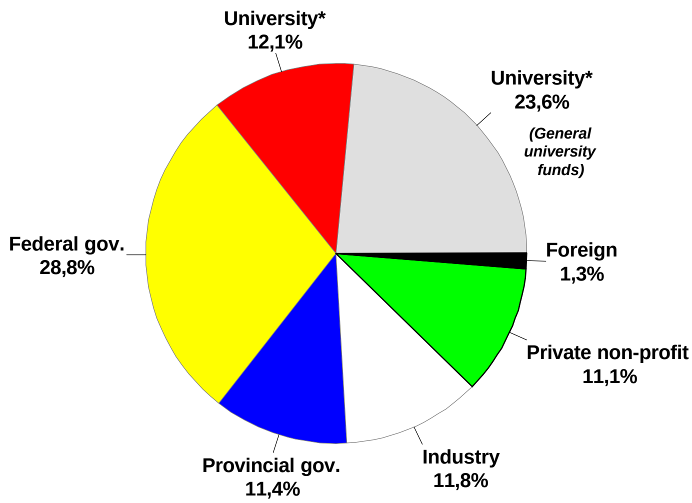
BOX 2 (cont'd)

Distribution of Sources of Funds Among Consolidated Fields of Research

Type	Source	Social sciences and humanities	Health sciences	Natural sciences and engineering
Sponsored research	Federal government	SSHRC + 30% of remainder	H&WC, MRC + 10% of remainder	NSERC, + 60% of remainder
	Provincial governments	20%	30%	50%
	Business enterprises	-3	-3	-3
	Private non-profit org.	-3	-3	-3
	Foreign	-4	-4	-4
Other	Higher education	Residual	Residual	Residual
Total		-5	-5	-5

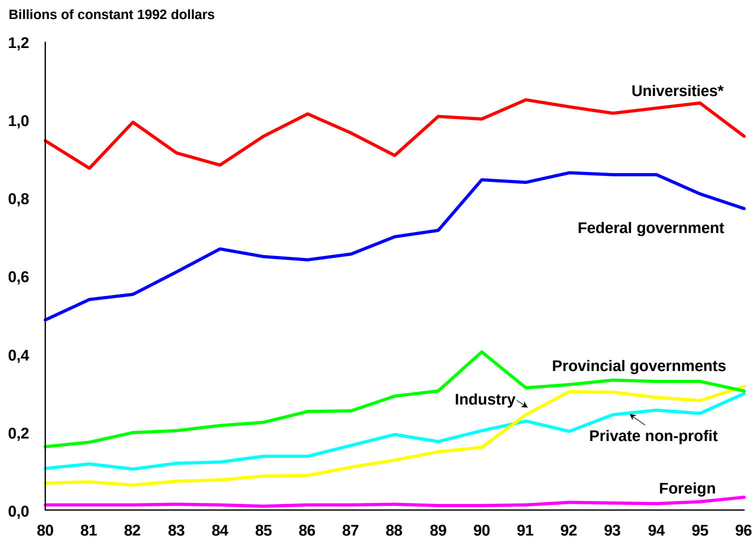
Notes:
1) The "remainder" is the difference between the Federal government total for university and the amounts attributed to SSHRC, H&WC, MRC and NSERC, based on the survey of federal expenditures.
2) The distribution is based on that reported by provincial governments.
3) The sponsored research funds ("bequests, donations and non-government grants plus miscellaneous") are assigned to business enterprises and private non-profit organizations using data from CAUBO, MRC, SSHRC and NSERC.
4) 60 percent of foreign funding is allocated to health sciences and 40 percent to other natural sciences, based on federal obligations for basic research to Canadian performers, as reported in *Federal Funds for Research and Development, Fiscal Years 1992, 1993, and 1994*, NSF 94-328, National Science Foundation, Washington, D.C., 1995.
5) Estimated total R&D expenditures, as described in the text of Box 1 .

Figure 8 Distribution of University R&D, by Source of Funds, 1996



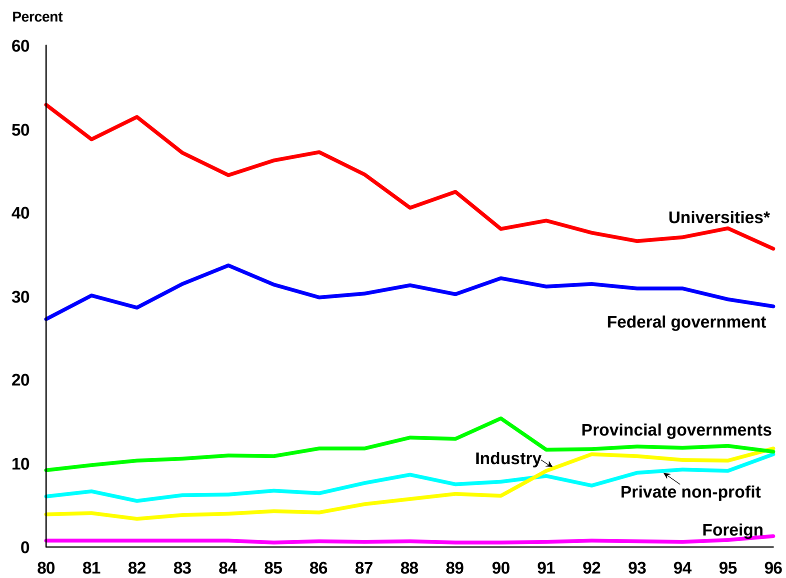
* The authors' estimate for 1996 are based on the preliminary data provided to the OECD by Statistics Canada.
Source: Thompson (1998) and OECD (1998a).

Figure 9 Sources of Funds for University R&D, 1980-96



* Includes general university funds received from government transfers.
Source: Thompson (1998).

Figure 10 Distribution of Funding for University R&D, 1980-96



* Includes general university funds received from government transfers.
Source: Thompson (1998).

The following summarizes the trends that have emerged over the 1980-96 period with respect to the funding of university research:

- **Industry:** In 1996, industry sponsored an estimated $338.7 million worth of university research in Canada—accounting for 11.8 percent of university R&D in 1996.[6] Industry was the fastest growing source of funds over the 1980-96 period, with an average real rate of growth of 14.1 percent per year. Figure 9 shows that industry-financed university R&D stopped growing after 1992 and began a slow decline until it increased again by 13 percent in 1996. Figure 10 shows that industry's contribution to academic R&D has been climbing steadily over time, reaching an estimated 11.8 percent in 1996.

- **Universities:** Over $1 billion dollars of the R&D performed by universities in 1996 was financed with university funds, in the form of the federal and provincial government transfers (or general university funds, 66 percent) and universities' own resources (34 percent). In 1996, general research funds accounted for 23.8 percent of university R&D funding and universities's own resources funded 13.1 percent of university R&D. Figure 9 shows that the real value of the combined university-related funds has not been growing over time. Indeed, Figure 10 shows that university funding accounted for over 50 percent of academic R&D in 1980, versus only 38.7 percent in 1996. This is partially a result of industry's growing share of university R&D financing.

- **Federal government:** The federal governments is the second largest source of R&D funds for Canadian universities, spending $825.2 million on university R&D in 1996 (direct funding). Figure 9 shows that federally-funded university R&D has generally been on an upward trend over the 1980-96 period (growing at an average annual real rate of 2.9 percent), but since 1994 it has been declining. Still, the federal government has financed a fairly steady share of university R&D over the 1980-96 period—about 28 percent.

- **Provincial governments:** The provincial governments directly financed $326 million worth of university R&D in 1996, accounting for 11.4 percent of total R&D investment by universities. Over the entire 1980-96 period, provincial funding increased by an average real rate of almost 4 percent per year. However, throughout the 1990s, direct funding by provincial governments has been declining at an annual rate of about 5 percent. The provinces have consistently funded around 10 percent of university R&D.

- **Private non-profit organizations:** In 1996, $318.6 million dollars was provided by non-profit organizations to fund university research—similar to the contribution made by industry and provincial governments. In real terms, this sector has been the second fastest growing over the 1980-96 period (second to industry-funded R&D), growing at an average real rate of 6.6 percent per year. This sector has increased its share of funded university research by over 5 percentage points since 1980, when it supplied only 6 percent of the universities' R&D funding.

- **Foreign sources:** University R&D funded abroad constitutes the smallest amount of funding at $36.5 million in 1996. However, while this sector is the smallest, it has outpaced the other sectors in the 1990s, growing at an average real rate of 17.3 percent between 1990 and 1996. In 1996 alone, university research funded by foreign sources increased by almost 56 percent.

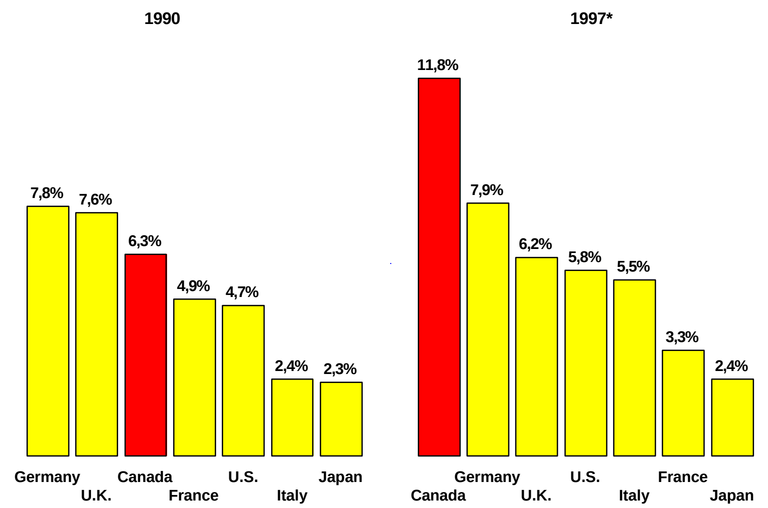
To summarize, the federal and provincial governments finance the largest portion of university R&D activities, with a combination of direct government sponsored research and indirect government research funding through general university funds. Industry funds a small portion of university research, but its role in sponsoring university research is increasing. Foreign sources are increasingly being utilized to conduct R&D at Canadian universities.

International Comparison

In this section we provide an international comparison of university R&D financing across the G7 based on OECD data. Table 5 presents the share of R&D financed by each major sector (industry, governments, universities, private non-profit organizations, and foreign sources) in Canada and in other G7 countries.[7] Note the following international differences in the distribution of university R&D financing:

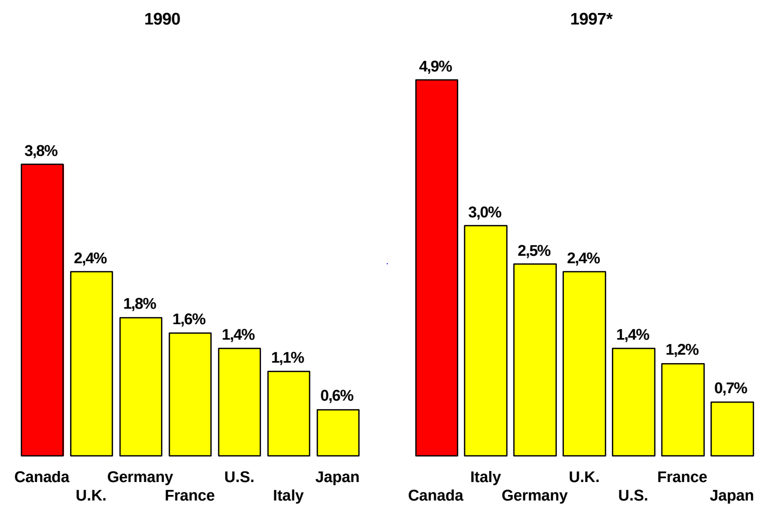
- **Industry:** The funds provided for academic R&D by the industrial sector in Canada are higher than in any other G7 country.[8] In fact, the share of academic R&D that is financed by firms in Canada is over two times higher than in the United States. Figure 11 shows that this has not always been the case. Even as recently as 1990, Canada ranked only third in terms of industry involvement in university R&D financing, with firms contributing only 6.3 percent of university R&D funds. Still, universities account for a relatively small proportion of the total R&D that industry supports—only 4.9 percent of industry-funded R&D is conducted in universities (Figure 12). Although this share is up from 3.8 percent in 1990, most business financing is still used towards the firm's own R&D activities.
- **Universities:** According to the OECD data, the share of university R&D that is funded with university resources (excluding general university funds from government transfers) is lower in Canada than in the United States. Japan allocates the largest share of funding to the academic sector among the G7 countries (45.1 percent). On the other hand, countries such as Germany and Italy rely entirely on non-university funds to conduct R&D.
- **Governments:** The share of R&D funding provided by federal and provincial governments in Canada is lower than government contributions in the other G7 countries, with the exception of Japan. This includes both direct funding of specific R&D endeavours at universities, and federal/provincial transfers. The low share of government financing is largely the result of relatively higher industry and university financing in Canada. In Italy and Germany, the government's share of university R&D funding is much higher at 91.9 and 90.8 percent, respectively.

Figure 11 Share of University R&D Financed by Industry, 1990 and 1997



* Data shown for most recent year available: 1997 for Canada; 1996 for Germany, Italy, and the United States; 1995 for France, Japan and the United Kingdom.
Source: OECD (1998a); Statistics Canada (1998a).

Figure 12 Share of Industry-Funded R&D Performed in Universities, 1990 and 1995



* Data shown for most recent year available: 1997 for Canada; 1996 for Germany, Italy, and the United States; 1995 for France, Japan and the United Kingdom.
Source: OECD (1998a); Statistics Canada (1998a).

Table 5 Source of Funds for University R&D Expenditures in the G7, 1996

	Canada	France	Germany	Italy	Japan	United Kingdom	United States
				Percent			
Industry	10.4	3.3	7.9	5.5	2.4	6.2	5.8
Governments	66.4	90.6	90.8	91.9	52.3	67.7	73.4
Direct gov.	40.6	46	n.a	n.a	10.4	29.9	73.4
GUF*	25.8	44.6	n.a	n.a	42.0	37.8	0
Universities	13.3	4	0	0	45.1	4.2	15.1
Private non-profit organizations	9.2	0.5	0	0	0.1	14.1	5.8
Foreign sources	0.7	1.6	1.3	2.6	0	7.8	0

Note: Data are for 1996 or latest year available (1995 for France, Japan and the United Kingdom).
* General university funds. In Canada's national statistics, these funds are grouped together with the university sector since they reflect government transfers that are difficult to classify as either federal or provincial.
Source: OECD (1998a).

- **Private non-profit organizations and foreign sources:** With the exception of the United Kingdom, private non-profit organizations play a stronger role in supporting university R&D in Canada than in other countries. For example, non-profit organizations contributed only 5.8 percent of university R&D funding in the United States, compared to 11.1 percent in Canada in 1997. As we noted earlier, foreign R&D support plays a role in Canada, growing to 1.3 percent of all funding by 1997. While there is no foreign funding of academic research in the United States, the European countries receive a larger proportion of their funding from abroad than Canadian universities do.

Regional Comparison

There is some regional variation in the sources of funds for university R&D. Table 6 presents data on the value and percentage distribution of R&D funding at universities for each province.[9] The most notable regional difference is with respect to industry financing of university R&D. The financing of university R&D by industry was considerably higher than the national average in Ontario (14.4 percent) and Alberta (13.8 percent) in 1996. Provinces in which industry support was weak include Manitoba (3.2 percent), Saskatchewan (8.6 percent) and Prince Edward Island (8.6 percent).

Fields of University Research

Figure 13 shows university R&D expenditures by broad fields of research: social sciences and humanities; health sciences; and other natural sciences and engineering (as described earlier in Box 1 and Box 2). In 1996, 25.9 percent of the R&D performed in the university sector was in social sciences and humanities, compared to 33.6 percent in health sciences and 40.5 percent in natural sciences and engineering. In comparison with other R&D performers, universities spend a relatively large portion of R&D in social sciences and humanities (Table 7). However, as mentioned in Box 1, R&D estimates by Statistics Canada include faculty salaries. Given that the faculty in social sciences and humanities is generally quite large in Canadian universities, the estimated R&D costs attributed to this field are similarly large.

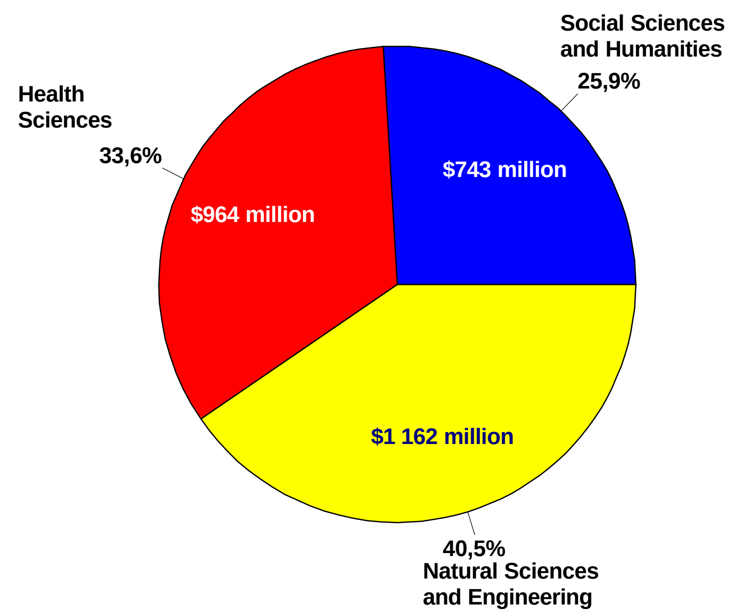
Table 6 University R&D by Source of Funds and Province, 1996

Province	Total university R&D	Source of funds *(percent distribution)*					
			Government				
		Industry	Federal	Provincial	University*	Private non-profit	Foreign sources
	($ millions)	*(Percent)*					
Newfoundland	47.5	10.9	33.3	1.9	50.3	3.6	0.0
P.E.I.	3.5	8.6	25.7	5.7	48.6	11.4	0.0
N.S.	93.8	11.2	34.5	3.2	41.0	2.9	7.1
N.B.	40.0	10.5	29.3	9.0	38.5	11.8	1.0
Quebec	853.3	9.9	25.7	15.1	39.3	8.8	1.2
Ontario	1,072.4	14.4	29.1	10.6	29.8	14.8	1.3
Manitoba	111.3	3.2	23.4	4.7	55.2	11.5	2.1
Saskatchewan	103.8	8.6	24.3	12.2	47.3	6.9	0.7
Alberta	266.3	13.8	33.4	13.7	29.4	9.4	0.3
B.C.	276.4	11.1	33.7	7.6	36.2	10.9	0.5
Canada	2,868.3	11.8	28.8	11.4	35.7	11.1	1.3

* Includes general university funds.

Source: Thompson (1998).

Figure 13 R&D in the Higher Education Sector, by Field of Research, 1996



Source: Thompson (1998).

Table 7 Field of R&D Research by Performing Sector, 1987 and 1996

Sector	% in natural sciences*		% in social sciences	
	1987	1996	1987	1996
Federal government	95.8	96.8	4.2	3.2
Provincial governments	89.9	94	10.1	6
Industry	100	100	0	0
Universities	71.4	74.1	28.6	25.9
Private non-profit org.	95.3	92.9	4.7	7.1
Total	92.2	93.6	7.8	6.4

* Includes health sciences and natural sciences and engineering.
Source: Statistics Canada, Working Paper ST-98-11 (1998a).

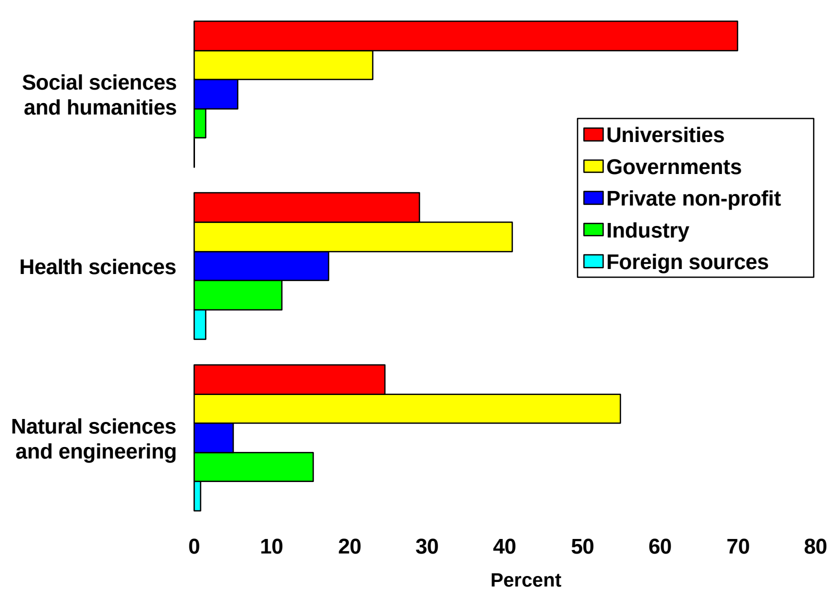
By Source of Funds

Figure 14 illustrates the sources of funds for university R&D by field of research. The following characteristics can be noted:

- **Social sciences and humanities:** Most R&D in social sciences and humanities is funded by universities through general university funds (or government transfers) and universities' own resources. That is, a smaller proportion of social sciences and humanities research is sponsored research by industry or government, and therefore the residual funding that is attributed to universities is quite large. About 23 percent of social science research is attributed to direct government funding (i.e., SSHRC), and to a lesser extent, private non-profit organizations and industry. (Note that although industry doesn't actually perform R&D in the social sciences, industry finances 1.5 percent of the R&D that universities perform in this field.)

- **Health sciences:** Most R&D conducted by universities in the health sciences is sponsored by the government (i.e., Health Canada and the Medical Research Council).

Figure 14 University R&D by Field of Research and Source of Funds, 1996



Source: Statistics Canada (1998a).

Table 8 University R&D Expenditures by Area of Research and Source of Funds, 1996

Financing sector	Millions of dollars			Percent			
	Social sciences and humanities	Health sciences	Natural sciences and engineering	Total	Social sciences and humanities	Health sciences	Natural sciences and engineering
Federal gov.	103.6	260.3	461.3	100	12.6	31.5	55.9
Provincial gov.	65.6	91.4	169	100	20.1	28	51.8
Industry	14.7	121.1	202.9	100	4.3	35.8	59.9
Universities	504.8	265.6	252.9	100	49.3	26	24.7
Private non-profit org.	54	203.6	61	100	16.9	63.9	19.1
Foreign sources	---	21.9	14.6	100	0	60	40
Total	**742.7**	**963.9**	**1161.7**	**100**	**25.9**	**33.6**	**40.5**

Source: Statistics Canada (1998a).

About 29 percent of the research in this field is attributed to university funds, while private non-profit organizations also play a strong role, financing 17.3 percent of the university research. Firms provide funds for 11.3 percent of the research and foreign sources account for 1.5 percent.

- **Other natural sciences and engineering:** The largest source of funds for university research in the natural sciences and engineering disciplines is the government sector (i.e., NSERC), providing almost 55 percent of the funds (39.2 percent by the federal government and 15.6 percent from the provincial governments). The remaining 45 percent of university R&D in this field of research is attributed to university-related sources (24.5 percent) and industry (15.3 percent).

Table 8 presents the same data from the perspective of the financing sector rather than the field of research. The same message emerges: the federal government, provincial governments, and industry are most likely to finance university R&D in the natural sciences and engineering; universities are most likely to support social science research; and private non-profit organizations and foreign sources are most likely to support research in the health sciences.

Summary

Overall, Canadian universities play a strong role in Canada's national R&D effort. Statistics Canada estimates that universities have performed between 20 to 30 percent of total R&D over the past few decades. In comparison to the other G7 countries, this share is among the highest. Furthermore, there is evidence to suggest that university-industry links are well-established in Canada compared to other countries. The share of university R&D sponsored by business enterprises was estimated to be almost 12 percent in 1997. This share is higher than in any other G7 country. This strong presence of industry in university R&D may reflect Canada's favourable R&D tax treatment, in which firms receive a tax credit for R&D spending.

There are, however, areas of concern with respect to R&D spending in Canada. The major concern is that total R&D expenditures are extremely low in Canada relative to other countries. As a share of output, both total R&D and university R&D comprise a small amount. Canada ranks second last in the G7 on these two measures. This implies that although universities in Canada are estimated to perform a large share of R&D, and university-industry linkages appear strong, there is still too little R&D investment in Canada.

In the next section we identify the reasons why university R&D is so important to the economy. We identify the economic benefits of university R&D in terms of its contribution to the stock of scientific and technical knowledge, the training of skilled personnel, and the commercialization of knowledge.

3. THE ECONOMIC BENEFITS OF UNIVERSITY R&D

Academia performs more than 20 percent of total R&D in Canada and is second to the industrial sector in terms of R&D performance, according to estimates by Statistics Canada. As the second largest R&D performer, universities contribute significantly to economic growth and rising living standards in the following three ways:

- University R&D contributes to the general stock of scientific and technical knowledge;

- University R&D provides training for skilled personnel; and

- University R&D contributes to economic development through its direct technology transfer and commercialization activities.

There are a number of difficulties in measuring the overall impact of university R&D on economic growth and employment. First, the economic impact of university R&D can only be determined after a long period of time. It is very difficult to measure such effects in detail and forecast the impact on economic development in the future. Second, academic research activities are often concentrated in basic research.[10] These fundamental advances take time to emerge in industrial productivity.

Despite these difficulties, a number of researchers have attempted to measure the overall impact of university R&D on economic development. Martin and Trudeau (1996) and Martin (1998) found that university R&D in Canada is a powerful stimulus for economic development, leading to measurable increases in both GDP and employment. Through its contribution to increased productivity, the total impact of university R&D amounts to $15.5 billion or around 2 percent of GDP each year. This corresponds to approximately 150,000 to 200,000 jobs, or around 1 percent of total employment.

However, as suggested by Doutriaux and Baker (1996), the results on the overall impact of university R&D are subject to a high degree of uncertainty and measurement difficulties. A more useful approach is to separately assess the contribution of university R&D in each of the three areas mentioned above. We will discuss each of these contributions in turn.

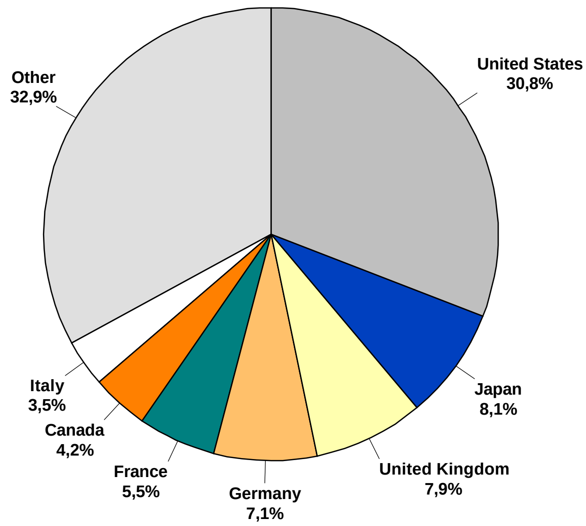
Contribution to the Stock of Scientific and Technical Knowledge

The vast majority of knowledge generated by university research is disseminated through traditional academic vehicles. It largely becomes freely available through the published literature (i.e., a public good).

Godin et al. (1998) examine knowledge flows in Canada as measured by bibliometrics in the science and technology fields. Their research shows that in 1995 Canada produced 25,882 publications, or 4.2 percent of the world's scientific production (see Figure 15). In the 15 years from 1980 to 1995, Canadian scientific production has increased by 61.3 percent. Indeed, the number of publications per 100 researchers is among the highest in the G7 countries (Figure 16). The university sector is the leading source of scientific production and it accounts for 65 percent of these publications. This is slightly lower than in the United States where the university sector accounts for 71 percent of all scientific publications (Table 9).

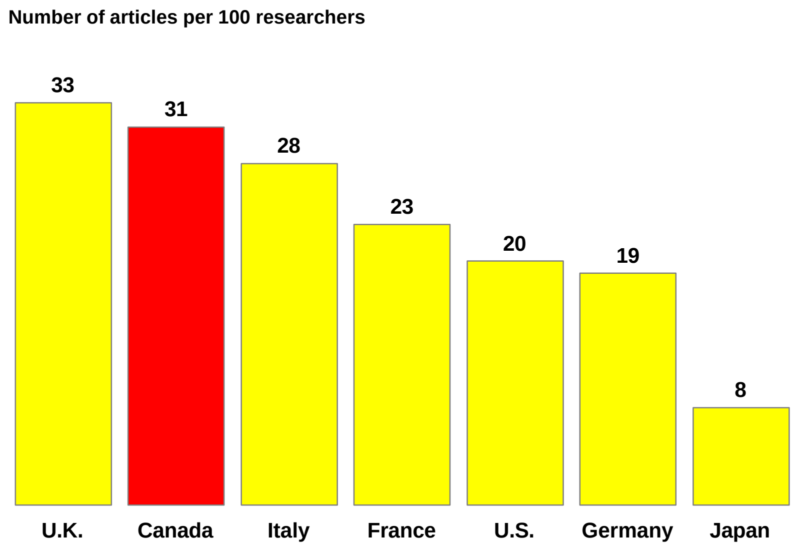
As an indicator of Canada's relative presence in each discipline, Godin et al. (1998) calculate a Specialization Index — the ratio between the percentage of Canadian publications in a particular subject area and the percentage of world publications in the same subject area. A ratio of greater than one indicates that Canada produces more than the world average in the area. The resulting specialization index, shown in Table 10, indicates that Canada specializes most in earth sciences (1.7), followed by biology (1.6); mathematics (1.2); and applied sciences and engineering (1.1). Canada publishes relatively less than the rest of world in physics and chemistry, and only slightly less in clinical medicine and biomedical research. The table shows that the United States and the United Kingdom also specialize in the earth sciences, but unlike Canada they exceed the world average in clinical medicine and biomedical research.

Figure 15 Distribution of Publications by Country, 1995



Source: Godin et al. (1998).

Figure 16 Number of Publications per 100 Researchers, 1995



Note: For the U.S., the latest data available on the number of researchers are for 1993.
Source: Godin et al. (1998); OECD, *Main Science and Technology Indicators*, 1998.

Table 9 Production of Publications by Sector, Canada and the United States

Sector	Canada		United States
	1974	1995	1995
		Percentage	
University	71.7	65	71
Non-university	28.3	35	29
Hospital	9.9	14.9	---
Federal government	13.6	10.8	---
Provincial government	1.3	2.4	---
Corporate	2.2	4	---
Other	1.3	2.9	---

Source: Godin et al. (1998) and NSF (1998).

Table 10 Specialization Indexes in the G7, 1995

Field	Canada	United States	Japan	United Kingdom	Germany	France	Italy
Physics	0.7	0.8	1.29	0.84	1.43	1.27	1.26
Chemistry	0.72	0.66	1.25	0.77	1.19	1.16	0.95
Clinical medicine	0.95	1.12	0.95	1.06	0.98	1.03	0.86
Biomedical research	1.03	1.21	0.95	1.06	0.98	1.03	0.86
Applied sc. and eng.	1.11	0.93	1.17	0.85	0.83	0.76	0.75
Mathematics	1.22	1.11	0.41	0.83	1.03	1.87	1.15
Biology	1.62	0.96	0.81	0.97	0.75	0.73	0.58
Earth sc.	1.7	1.24	0.47	1.24	0.95	1.12	0.99

Source: Godin et al. (1998).

What is the specialization pattern of universities relative to other R&D performing sectors in Canada? To what extent do the specialization indices of various sectors explain the overall specialization index of Canada? These questions are addressed in Table 11:

- Canadian universities specialize in mathematics, followed by physics, chemistry, applied sciences and engineering, and biomedical research. The university sector is largely responsible for Canada's overall specialization in mathematics, and partially accounts for Canada's specialization in applied sciences and engineering and biomedical research. See Figure 17 for a graphical depiction of the areas of specialization for university publications.

- The government sector accounts for Canada's overall specialization in earth sciences and biology and Canada's emphasis on clinical medicine research is largely due to hospitals and provincial governments.

Godin et al. (1998) also find that there is a high percentage of Canadian publications produced with scientific collaboration — 90.2 percent of Canada's publications were co-authored by two or more researchers in 1995, which is slightly above the world average of 86.5 percent. Further, like many other small countries, Canada has a much higher international collaboration rate than the world average, in every subject area. The United States is the leading collaborator for total Canadian publications and across all provinces.

In addition, the research on knowledge flows in Canada shows that every sector produces a portion of its publications in collaboration with other sectors. Almost 32 percent of all publications in Canada involve some form of collaboration between universities, hospitals, federal government, provincial governments, businesses, and other organizations. As noted by Godin et al. (1998), "the centrality of the university sector importance in the flow of scientific knowledge is evident in the fact that every other sector collaborates with universities" (p. 16). Table 12 shows that the university sector is the leading partner of all sectors in Canada.

Table 11 Specialization Indexes by Sector, 1995

Field	Clinical medicine	Bio-medical research	Biology	Physics	Applied sciences and eng.	Earth sciences	Chemistry	Mathe-matics.
University	0.84	1.04	0.93	1.25	1.08	0.96	1.24	1.50
Hospital	2.29	1.25	0.04	0.02	0.02	0.01	0.04	0.04
Federal gov.	0.26	0.68	2.56	1.10	0.89	2.51	1.08	0.07
Provincial gov.	1.30	0.85	2.07	0.09	0.50	1.23	0.20	0.08
Corporate	0.55	0.56	0.71	0.95	3.60	1.06	1.23	0.09
Other	1.12	0.59	1.11	0.95	1.82	1.24	0.49	0.35

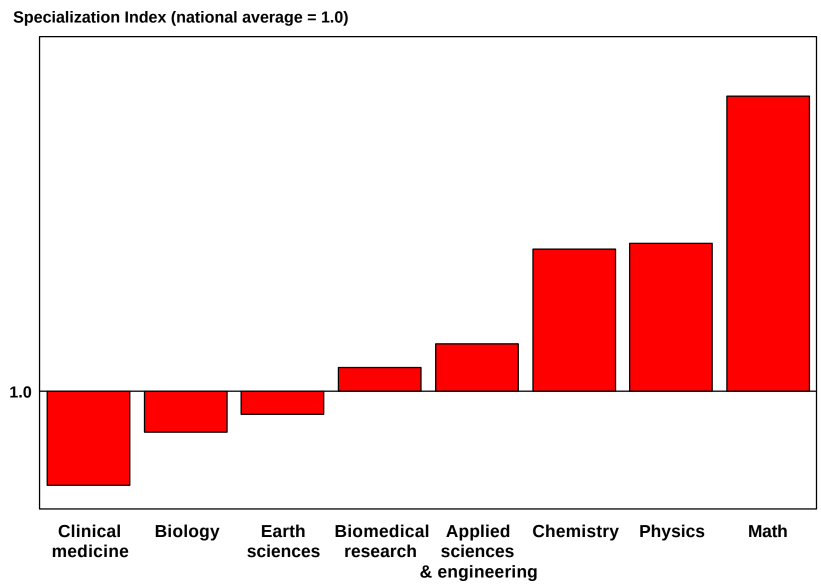
Source: Godin et al. (1998).

Table 12 Rate of Collaboration in Publications between Sectors in Canada, 1995

	University	Hospital	Federal gov.	Industry	Provincial gov.	Other	Unknown	Total
University	--	2,410 *48.7%*	1,164 *23.5%*	553 *11.2%*	371 *7.5%*	365 *7.4%*	88 *1.8%*	4951
Hospital	2,410 *86.7%*	--	61 *2.2%*	81 *2.9%*	93 *3.3%*	86 *3.1%*	50 *1.8%*	2781
Fed. gov.	1,164 *76.2%*	61 *4.0%*	--	128 *8.4%*	98 *6.4%*	51 *3.3%*	25 *1.6%*	1527
Industry	553 *65.4%*	81 *9.6%*	128 *15.1%*	--	39 *4.6%*	34 *4.0%*	11 *1.3%*	846
Prov. gov.	371 *56.3%*	93 *14.1%*	98 *14.9%*	39 *5.9%*	--	37 *5.6%*	21 *3.2%*	659
Other	365 *62.0%*	86 *14.6%*	51 *8.7%*	34 *5.8%*	37 *6.3%*	--	16 *2.7%*	589
Unknown	88 *41.7%*	50 *23.7%*	25 *11.8%*	11 *5.2%*	21 *10.0%*	16 *7.6%*	--	211
Total	4,951 *42.8%*	2,781 *24.0%*	1,527 *13.2%*	846 *7.3%*	659 *5.7%*	589 *5.1%*	211 *1.8%*	11564

Source: Godin et al. (1998).

Figure 17 Specialization Index for Canadian University Research, by Field, 1995



Source: Godin et al. (1998).

Impact of Academic Research on Industrial Technology

Largely through publication, academic research often forms the basis for further applied research and development efforts in the industry sector. Most of the evidence on the importance of academic research for industrial technical progress comes from various surveys of firms or industrial R&D managers in the United States. For example, a survey of industrial R&D managers undertaken by Nelson and his colleagues in the mid-1980s provides us with information on how university research contributes to industrial technology and on the industrial fields where this role is most important (Rosenberg and Nelson, 1993). The respondents to the questionnaire were asked to rate the importance of research done at universities to technical advance in their lines of business. Not surprisingly, the results differ significantly across industries. The industries that rated university research as “important” or “very important” include agriculture and forestry; drugs and surgical instruments; and electronic industries.

Table 13 shows the fields of university R&D that are important to U.S. industries. Fields of university research that were rated as important by a number of industries were concentrated in applied sciences and engineering disciplines. Very few of the more basic sciences are mentioned. The fact that university research in fields such as physics and mathematics were not rated as important should not be interpreted as indicating that academic research in these fields makes little contribution to industrial technology. Rather, the results in Table 13 should be interpreted as evidence that it takes a long time before fundamental advances in physics, mathematics and other basic sciences have an impact on industrial technology.

A more recent study by Mansfield (1998) provides another picture of the role of university research in industrial technology (Table 14). Mansfield asked 80 large American firms to provide the percentage of new products and processes introduced and commercialized over the periods 1975-1985 and 1986-1994 that could not have been developed without substantial delay in the absence of recent academic research. Then he asked about the percentage of products and processes whose development was substantially aided by recent academic research. The degree of reliance on university research varies considerably across industries. Firms in the pharmaceutical industry reported strong dependence on academic research, followed by information processing and instruments. Overall, the evidence for both periods shows that over 10 percent of new products and processes introduced in these industries could not have been developed without substantial delay in the absence of recent academic research.

A recent study by Baldwin and Da Pont (1996) provides some insight into the impact of university research in Canada. Using data from the Innovation and Advanced Technology Survey of manufacturing firms conducted in late 1992 and early 1993, the authors found that university laboratories were one of the most frequently used external sources for developing new technologies (Figure 18). Over 26 percent of world-first innovators (employment weighted) made use of university laboratories as external sources of ideas for new technology.

Mansfield (1998) provides information on the time interval between academic research results and the first commercial introduction of new products and processes. For new products and processes introduced in the period 1975-1985, which could not have been developed in the absence of recent academic research, the mean time interval between the relevant academic research and the first commercial introduction of the product or process was about 7 years. For the period 1986-1994, this time interval decreased to about 6 years (Table 15).

Table 13 Relevance of University Science to Industrial Technology

Science	Number of industries with scores:		Selected industries in which the relevance of university science was important
	≥5	≥ 6	
Biology	12	3	Animal feed, drugs, processed fruits/vegetables
Chemistry	19	3	Animal feed, meat products; drugs
Geology	0	0	None
Mathematics	5	1	Optical instruments
Physics	4	2	Optical instruments, electron tubes
Agriculture science	17	7	Pesticides, animal feed, fertilizers, food products
Applied math/operations research	16	2	Meat products, logging/sawmills
Computer science	34	10	Optical instruments, logging/sawmills, paper machinery
Materials science	29	8	Synthetic rubber, nonferrous metals
Medical science	7	3	Surgical/medical instruments, drugs, coffee
Metallurgy	21	6	Nonferrous metals, fabricated metal products
Chemical engineering	19	6	Canned foods, fertilizers, malt beverages
Electrical engineering	22	2	Semiconductors, scientific instruments
Mechanical engineering	28	9	Hand tools, specialized industrial machinery

Source: Rosenberg and Nelson, 1993.

Table 14 New Products and Processes Based on Recent Academic Research, Seven U.S. Industries, 1986-1994 and 1975-1985

Industry	Percentage that could not have been developed without substantial delay in the absence of recent academic research		Percentage that were developed with very substantial aid from recent academic research	
	1986-94	1975-85	1986-94	1975-85
Product Innovation				
Drugs and medical products	31	27	13	17
Information processing	19	11	14	17
Chemical	9	4	11	4
Electrical	5	6	3	3
Instruments	22	16	5	5
Machinery	8	n.a.	8	n.a.
Metals	8	13	4	9
Industry mean	15	13	8	9
Process Innovation				
Drugs and medical products	11	29	6	8
Information processing	16	11	11	16
Chemical	8	2	11	4
Electrical	3	3	2	4
Instruments	20	2	4	1
Machinery	5	n.a.	3	n.a.
Metals	15	12	11	9
Industry Mean	11	10	7	7

Source: Mansfield (1998).

Table 15 Average Time Interval between the First Commercial Introduction of a New Product/Process and the Relevant Academic Research Finding

Industry	Innovations that could not have been developed without substantial delay in the absence of recent academic research		Innovations that were developed with very substantial aid from recent academic research	
	1986-1994	1975-1985	1986-1994	1975-1985
	Mean number of years			
Drugs and medical products	8.5	8.8	6.2	10.3
Information processing	5.2	7.0	2.4	6.2
Chemical	5.4	6.8	4.8	7.3
Electrical	5.9	5.3	5	4.9
Instruments and metals	6.5	7.0	6.6	4.9
Machinery	5.6	n.a.	5.8	n.a.
Industry mean	6.2	7.0	5.1	6.7

Source: Mansfield (1998).

Adams (1990) used regression analysis to estimate the effects of academic research on productivity and the lags associated with these effects among U.S. two-digit manufacturing industries. He found the effects of academic R&D to be important and pervasive. Adams estimated that the time required for academic research in basic sciences to affect industrial productivity is about twenty years, but for applied sciences and engineering the lag is between zero and ten years.

A number of studies also estimated the social rate of return to academic research. The most well-known work in this area is Mansfield (1991, 1992). In his 1991 paper, he estimated that the social rate of return to academic R&D in the United States was 28 percent. In a subsequent paper (1992), the estimate was updated to 40 percent.

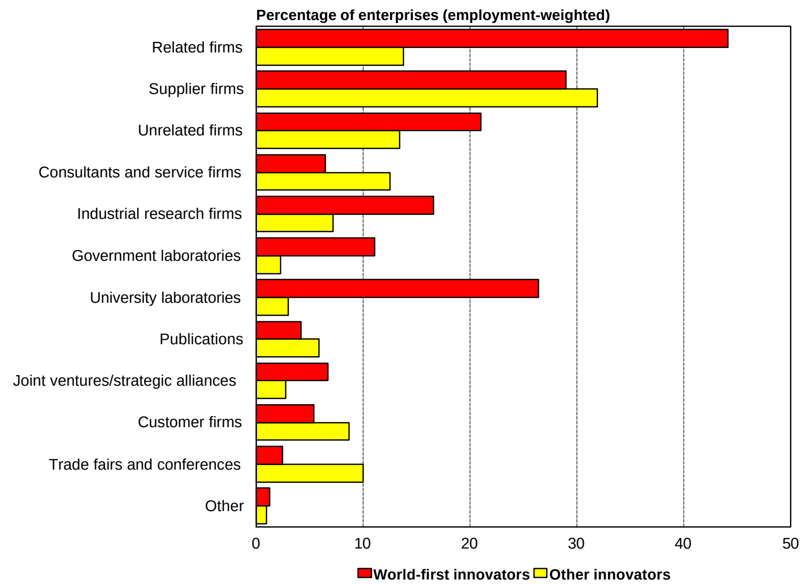
In sum, several recent studies provide a broad picture of the role presently played by academic research in contributing to scientific and technical knowledge. Although most of the empirical evidence is based on the United States, it is suggestive of the effect of university research on industrial technology in Canada.

Contribution to the Training of Skilled Personnel

Many studies on technology transfer have argued that technology is more effectively transferred through people than through the publication of research. One of the biggest contributions that universities make to the economy is producing graduates through whom technology is effectively transferred from university to industry. Thus one major benefit industry receives from university R&D, particularly through collaborative university-industry research, is access to students who have been trained at the cutting edge of technology.

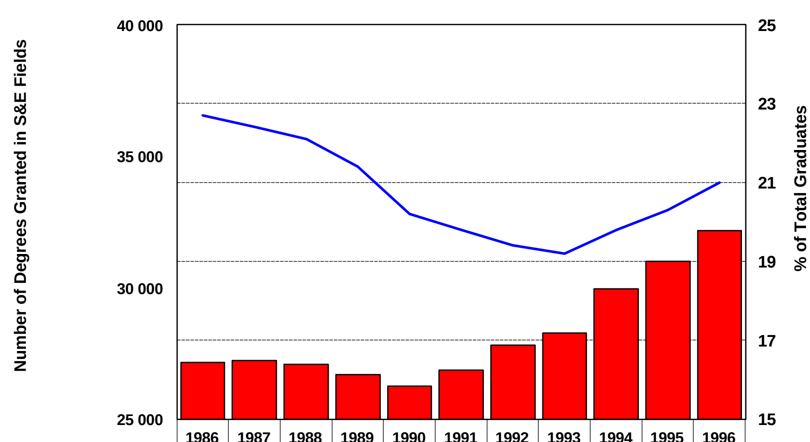
Most countries have been emphasizing that education in science and technology is essential to economic growth and competitiveness. University research is particularly important for Master's and Ph.D education in the science and engineering fields. Figure 19 shows that the number of science and engineering graduates from Canadian universities has generally been increasing throughout the 1990s.[11] The share of university degrees granted in the science and engineering fields has recently started to rise again, breaking the steady downward trend it had been on since 1986. However, science and engineering graduates still comprise a small share of total university graduates compared to other G7 countries (Figure 20). Therefore, Canada may not be reaping as many economic benefits from university research as other countries, given the relatively small flow of these graduates into the labour market.

Figure 18 External Sources of Technology Ideas in Canadian Manufacturing Firms, 1993



Source: Baldwin and Da Pont (1996).

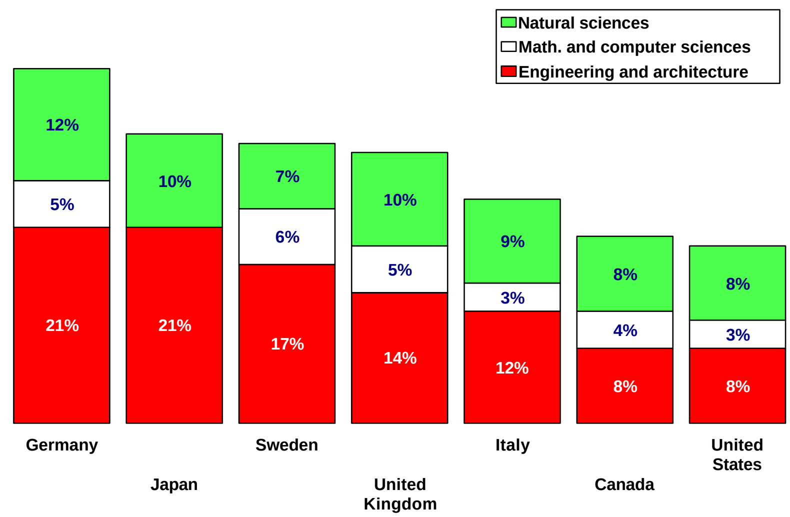
Figure 19 University Degrees Granted in Science and Engineering, 1986-96



	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Agr. & Bio. Sciences	7 122	7 507	8 324	8 427	8 386	8 507	8 749	9 067	9 479	9 841	10 734
Eng. & Appl. Sciences	10 283	10 463	9 911	9 806	9 829	10 248	10 732	10 846	11 688	12 013	12 282
Math & Phys. Sciences	9 739	9 269	8 854	8 469	8 044	8 105	8 328	8 362	8 784	9 148	9 151
Science & Eng. total	27 144	27 239	27 089	26 702	26 259	26 860	27 809	28 275	29 951	31 002	32 167
As % of total graduates	22,7	22,4	22,1	21,4	20,2	19,8	19,4	19,2	19,8	20,3	21

* Includes Bachelor's and First Professional degrees; Master's degrees; and Doctoral degrees. The data exclude undergraduate and graduate diplomas and certificates in the science and engineering fields.
Source: NSERC (1998).

Figure 20 University Degrees Granted in Science and Engineering in the G7, 1995



Source: OECD, *Education at a Glance,* 1997.

Contribution to the Commercialization of Intellectual Property

There is a growing recognition that R&D conducted in the higher education sector makes an important contribution to the economy and society, not just through traditional mechanisms like the advancement of knowledge and the education of researchers and skilled personnel, but also by further developing intellectual property or inventions into commercially viable products or processes.

Invention Disclosure

The first step towards the commercialization of university research is the disclosure of the researchers' inventions and the decision about whether to seek protection of the intellectual property (IP). However, universities across Canada differ in terms of their intellectual property policies and reporting requirements. Statistics Canada's recent *Survey of Intellectual Property Commercialization* in 1997-98 asked universities whether there is a requirement to report the creation of various forms of intellectual property to the institution. Table 16 shows that for most types of intellectual property, researchers in most universities are not required to report the creation of intellectual property. The notable exception is the reporting requirements for inventions created at the university. In 26 of 81 universities, researchers are required to disclose all inventions to the institution. Researchers in 18 of 81 universities are sometimes required to disclose inventions. Only 29 universities do not have specific reporting requirements for university inventions. The survey also shows that in 60 percent of universities, the discoverer (researcher) is responsible for reporting the discovery to the institution and requesting consideration for protection and/or commercialization. In only 2 percent of universities the institution monitors the activities of the researchers to identify the discoveries for which protection/commercialization should be sought. For details on specific university policies, see Appendix 2.

Regarding ownership of the intellectual property, universities that required reporting of the creation of certain types of intellectual property do not always claim ownership of it. In many cases, the university or researcher retains ownership of the intellectual property but the royalties are shared. Table 17 shows intellectual property ownership in Canadian universities by type. In the case of inventions, ownership is shared between the university and the researcher in 35 of 81 universities.

The Canadian universities covered in the Association of University Technology Managers' annual *AUTM Licensing Survey* received 690 invention disclosures in 1997 (see Table 18). Given that 16 universities were included in the survey in 1997, this corresponds to an average of 43 inventions per university. In 1991, only 250 inventions were disclosed, or an average of 25 per university. Still, Canada is far behind the United States which had almost 70 disclosures received per university. However, both total disclosures and invention disclosures per university increased faster from 1991 to 1997 in Canada than in the United States. The ratio of inventions per $10 million research has changed little in both Canada and the United States over the period 1991-97.[12]

Table 16 Reporting Requirements for All Types of Intellectual Property Created within the Institution

Type of intellectual property	Researcher always required to report	Researcher sometimes required to report	Researcher never required to report	IP type not applicable	Total
			Number of universities		
Inventions	26	18	29	8	81
Software or databases	12	29	40	0	81
Literary, artistic works, etc.	10	16	55	0	81
Educational materials	8	21	52	0	81
Industrial designs	13	11	45	12	81
Trademarks	12	10	47	12	81
Integrated circuit topographies	11	12	46	12	81
New plant varieties	13	12	38	18	81
Know-how	1	0	0	80	81

Source: Statistics Canada, *Survey of Intellectual Property Commercialization in the Canadian Higher Education Sector*, 1998.

Table 17 Policies on Intellectual Property Created within the Institution

	Institution owns both IP and all royalties	Researcher owns both IP and all royalties	Research contract sponsor owns both IP and all royalties	Shared ownership and /or shared royalties	IP type not applicable	Total
			Number of Universities			
Inventions	10	28	0	35	8	81
Software or databases	8	40	0	33	0	81
Literary, artistic works, etc.	1	70	0	10	0	81
Educational materials	5	60	0	16	0	81
Industrial designs	7	45	0	17	12	81
Trademarks	11	40	1	17	12	81
Integrated circuit topographies	8	46	0	15	12	81
New plant varieties	10	42	0	11	18	81
Know-how	0	0	0	1	80	81

Source: Statistics Canada, *Survey of Intellectual Property Commercialization in the Canadian Higher Education* Sector, 1998.

Table 18 Inventions Disclosed per $10 million Research Expenditures, Canada and the United States, 1997

Year	Invention disclosures received	Average disclosures per university	Total sponsored research expenditures	Inventions disclosed per $10 million research
Canada			US$	
1991 (N=10)	250	25	484,021,929	5
1992 (N=10)	284	28	472,420,978	6
1993 (N=12)	393	33	687,047338	6
1994 (N=12)	445	37	684,158438	7
1995 (N=16)	578	36	943,247,718	6
1996 (N=14)	509	36	855,217,872	6
1997 (N=16)	690	43	1,046,898,769	7
United States			US$	
1991 (N=98)	4,880	50	11,479,381,778	4
1992 (N=98)	5,700	58	12,799,045,236	5
1993 (N=117)	6,598	56	14,875,677,330	4
1994 (N=120)	6,697	56	16,058,644,323	4
1995 (N=127)	7,427	58	17,211,913,185	4
1996 (N=131)	8,119	62	18,688,253,796	4
1997 (N=132)	9,051	69	19,858,137,581	5
% Change 91-97				
Canada	**18.4**	**9.4**	**13.7**	**---**
United States	**10.8**	**5.5**	**9.5**	**---**

Note: "N" denotes the number of universities in each annual survey.
Source: AUTM (1997).

Seeking Intellectual Property Protection

Not all inventions are patentable, either because they have limited market potential or because they require further R&D. Table 19 shows the percentage of disclosures for which U.S. patent applications were filed over the past 6 years. Since 1995, more than 1 in 4 invention disclosures result in an application seeking patent protection. However, the AUTM survey only considers patents applied for in the United States by Canadian universities.

Information on total patent protection (regardless of destination country) is available from Statistics Canada's survey. According to the survey, Canadian universities sought patent protection for 57 percent of disclosures (Table 20).[13]

According to the AUTM survey, the number of patent applications and patents issued to Canadian universities in the United States have been increasing in recent years (Figure 21).[14] While no historical data is available for total patent applications, there is no reason to expect that the trend for total patent applications would be different from the trend for patent applications filed in the United States. Figure 21 also shows that only a portion of patent applications are subsequently granted.

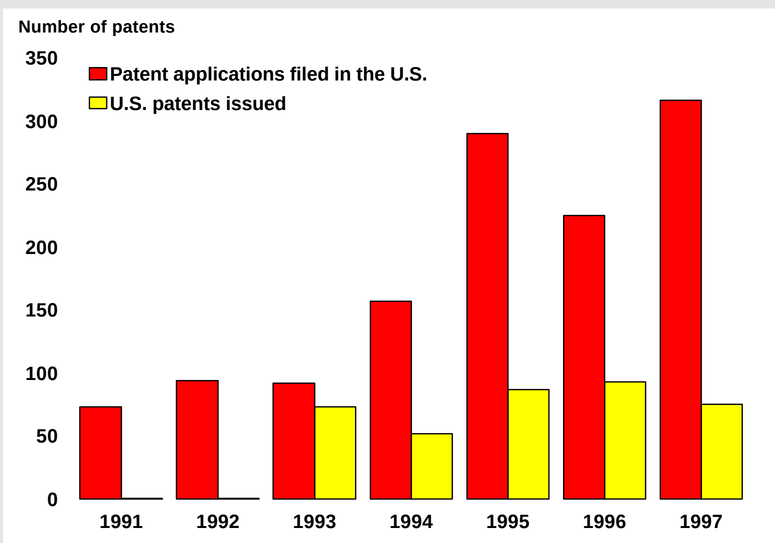
Detailed information on Canadian university patent applications by field of study and patents issued by country is provided in Tables 21 and 22. Table 21 shows that most patents applied for or issued are in health sciences and biological sciences. Tables 21 and 22 show that universities are more likely to be granted patents from countries other than Canada (the United States and "other"). Of a total of 143 new patents issued during the year 1997-98, 35 patents (24 percent) were in Canada, 82 in the United States (57 percent) and 25 in other countries (18 percent). In terms of cumulative total number of patents issued, Canadian universities hold 264 patents in Canada, 635 in the United States, and 353 in other countries.

Table 19 Relationship between Invention Disclosures and Patents Filed in Canada, 1991-97

Year		New patents filed (in the United States only)	
1991	250	59	23.6
1992	284	80	28.2
1993	393	65	16.5
1994	445	98	22.0
1995	578	157	27.2
1996	509	137	26.9
1997	690	190	27.5

Source: AUTM (1997).

Figure 21 Patent Applications Filed by Canadian Universities in the United States



Source: AUTM (1997).

Table 20 Summary of Intellectual Property at Canadian Universities

IP type	Application IP protection activity	No. and % of universities reporting intellectual property protection activity in the last 5 years	No. universities with disclosures in 1997/8	No. disclosures (reports) in 1997/8	No. universities engaging in protection activities	No. protection activities in 1997/8
Inventions	Patent application	35/81 or 43%	24	661	30	379
Computer software or databases	Copyright registration	23/81 or 28%	18	66	4	6
Literary, artistic, dramatic or musical works, books, paper	Copyright registration	20/81 or 25%	8	293	5	26
Educational materials	Copyright registration	19/81 or 23%	3	X	3	X
Industrial designs	Registration	2/81 or 2%	2	X	2	X
Trademarks	Registration	27/81 or 33%	9	24	14	41
Integrated circuit topographies	Registration	1/81 or 1%	0	0	0	0
New plant varieties	Registration (Canada) Patent (US)	5/81 or 6%	4	X	2	X
Various	Trade secret agreement	12/81 or 15%	n.a.	n.a.	4	X
Other intellectual property: know-how		1/81 or 1%	1	X	0	0
Other intellectual property: biological materials	Registration	1/81 or 1%	0	0	0	0

Note: “X” denotes figures that are suppressed to maintain confidentiality of individual respondents.
Source: Statistics Canada, preliminary results of the 1998 *Survey of Intellectual Property Commercialization in the Canadian Higher Education Sector,* 1998.

Table 21 Patenting Activities by Field of Study, 1998

Field of study	New patent apps.	Patents issued in:			
		Canada	United States	Other	Total
Education, rec. and counselling	X	X	0	0	X
Commerce, business	X	X	0	0	X
Agri./bio. sciences	66	5	7	X	X
Eng. and appl. sc.	40	8	10	X	X
Eng. and appl. sc. tech./trades	X	X	0	X	X
Health sciences	91	10	34	17	61
Math and physical sciences	12	X	X	0	5
All other n.e.c.	0	X	X	X	X
Total	**379**	**35**	**82**	**25**	**143**

Note: "X" denotes figures that are suppressed to maintain confidentiality.
Source: Statistics Canada, preliminary results of the *Survey of Intellectual Property Commercialization in the Canadian Higher Education* Sector, 1998.

Table 22 Total Patents Held by Canadian Universities, 1997-98

Country of destination	Total patents held
Canada	264
United States	635
Other countries	353
Total	1,252

Source: Statistics Canada, preliminary results of the *Survey of Intellectual Property Commercialization in the Canadian Higher Education* Sector, 1998.

Commercializing University Research through Licensing

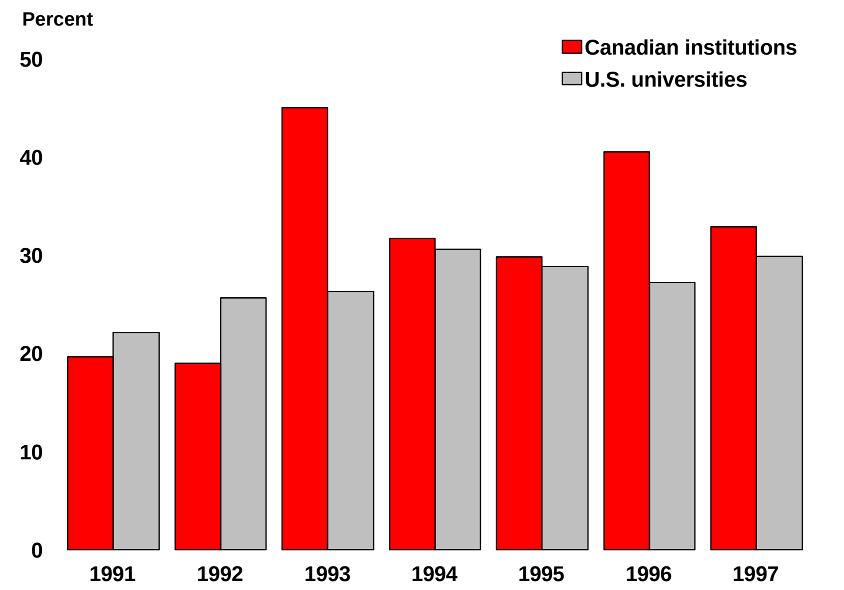
The final step in the commercialization of university research is licensing the new technology that has (or has not) received intellectual property protection. Only a portion of inventions will be successfully licensed to existing firms or new start-up firms. With the exception of 1993 in Canada, the number of licenses have generally been less than 40 percent of total invention disclosures for both Canadian and U.S. universities (see Figure 22). The actual share of inventions that were successfully licensed is likely to be even lower since licenses and options can be executed on a non-exclusive as well as exclusive basis (non-exclusive licenses may be executed with more than one firm). Table 23 shows 70 percent of all licenses executed by Canadian universities were identified as exclusive licenses and 30 percent as non-exclusive licenses.

Two hundred and twenty seven (227) new licenses and options were executed by Canadian institutions in the AUTM survey in 1997, up 363 percent from 49 in 1991 (Figure 23). For U.S. institutions, new licenses and options executed increased by 151 percent from 1079 in 1991 to 2707 in 1997. Figure 24 shows that the number of licenses and options executed per $1 million changed very little in recent years for both Canadian and U.S. universities in the AUTM survey.[15]

Table 24 provides detailed data by field of research for 750 active licenses and options held by Canadian institutions in 1997. Canadian and U.S. universities hold a similar portion of active licenses and options in the physical sciences (36 percent versus 34 percent).

Canadian institutions in the AUTM survey received US $11.3 million in gross income from licenses and options in 1997, up 242 percent from US $3.3 million in 1991. In contrast, total gross income received from licenses and options by U.S. universities was US $482.8 million in 1997, up 271 percent from US $130.0 million in 1991 (Figure 25). Gross license income per $1 million research (often referred to as the return on research expenditure) showed a slight increase in recent years for both Canadian and U.S. universities in the AUTM survey (Figure 26).

Figure 22 Ratio of Licenses and Options Executed to Invention Disclosures, Canada and the United States



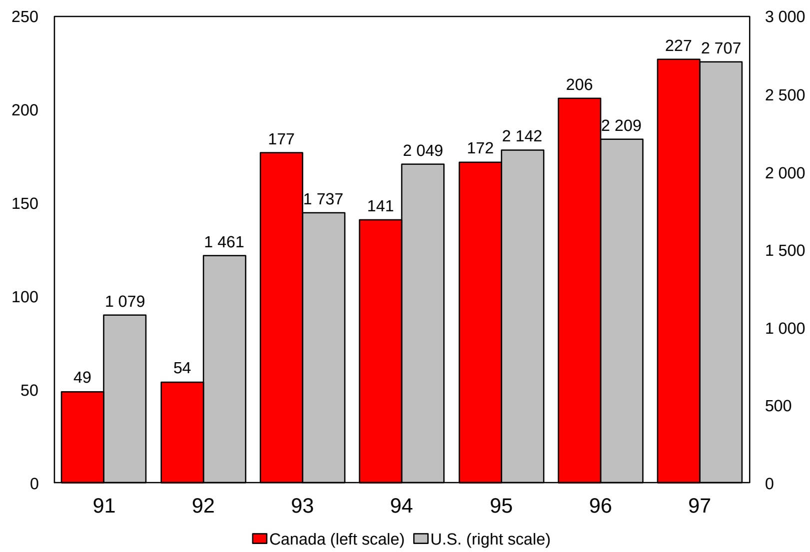
Source: AUTM (1997).

Table 23 Licenses and Options Executed: Exclusive vs. Non-Exclusive, 1997

	Total	Exclusive		Non-exclusive	
		Number	%	Number	%
Canadian institutions	198	139	70	59	30
U.S. universities	265	1,377	52	1,288	48
U.S. hospitals and research institutes	361	208	58	153	42

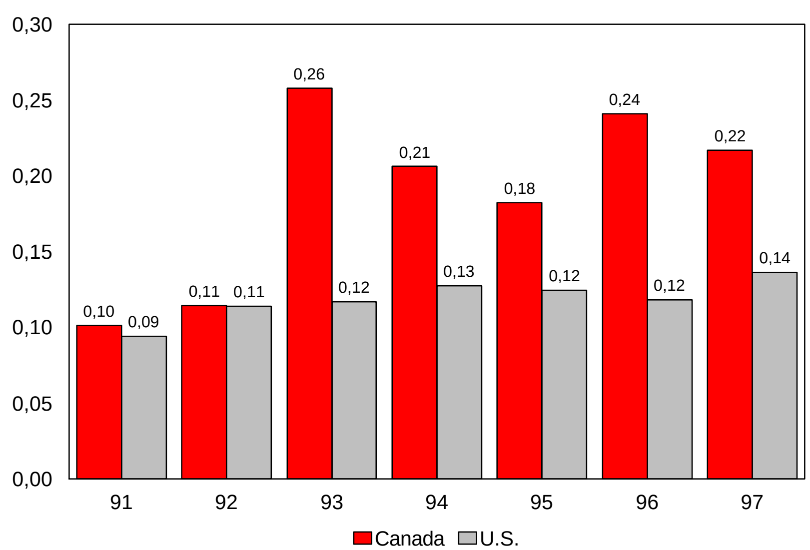
Source: *AUTM Licensing Survey* (1997).

Figure 23 Licenses and Options Executed by Canadian and U.S. Institutions



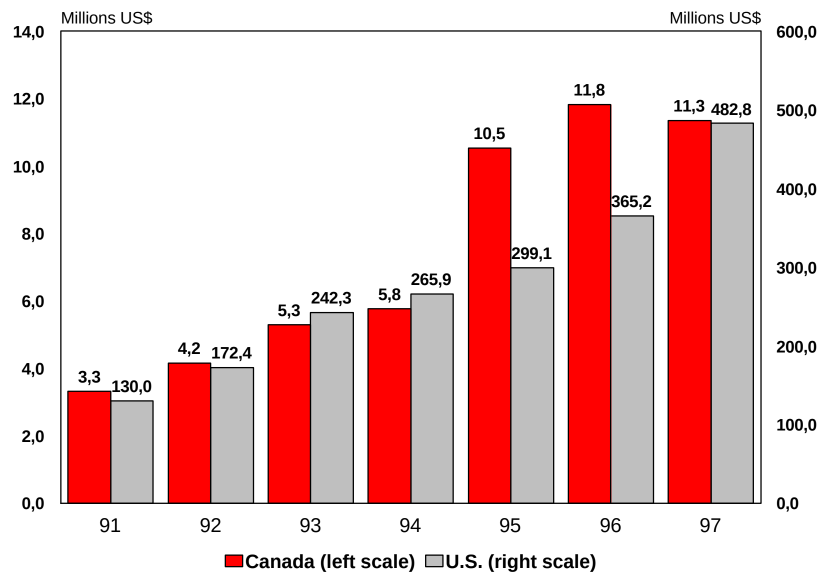
Source: AUTM Survey (1997).

Figure 24 Licenses and Options Executed per $1 Million Research, Canada and the United States



Source: AUTM Survey (1997).

Figure 25 Gross License Income Received, Canada and the United States



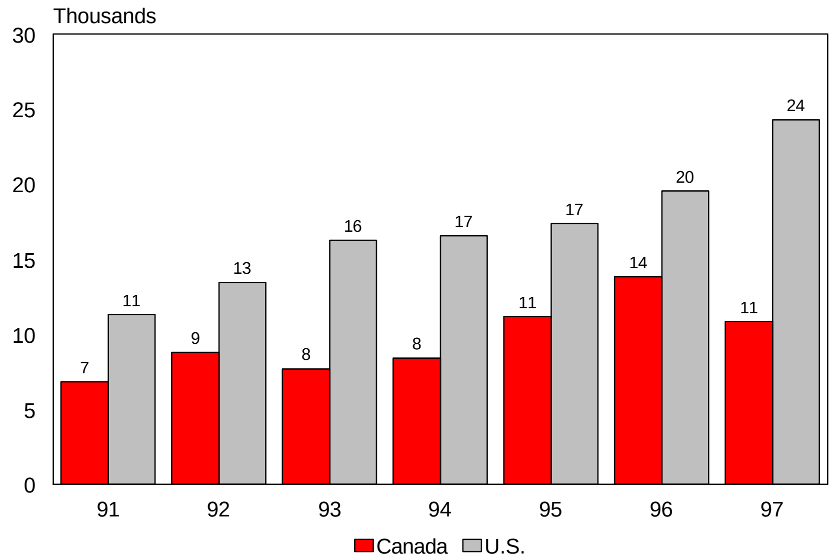
Source: AUTM Survey (1997).
Licence income not adjusted for royalties paid for other institutions.

Table 24 Cumulative Active Licenses and Options, Life Sciences vs. Physical Sciences

Year: 1997	Total active licenses and options		
	Life sciences	Physical sciences	Total
U.S. universities	6,153 (66%)	3,153 (34%)	9,306
U.S. hospitals and research institutes	1,550 (95%)	80 (5%)	1,630
Canadian institutes	483 (64%)	267 (36%)	750
Patent management firms	163 (75%)	54 (25%)	217
All respondents	8,349 (70%)	3,554 (30%)	11,903

Source: *AUTM Licensing Survey* (1997).

Figure 26 Gross Income per $1 Million Research, Canada and the United States



Source: AUTM Survey (1997).

Estimates of the Economic Impact of Commercialization

Finally, what are the economic benefits of the technology transfer process? Pressman et al. (1995) argue that the economic impact of the licensing activities include both pre-production investment and the economic impact after product introduction. University technology is typically forward-looking, and requires very large investments to bring products to market. The pre-production investment refers to money spent developing new products and efficient ways to produce and market these products. Based on royalty income, the AUTM economic impact committee estimates that licensing activities by U.S. and Canadian institutions in the AUTM survey generated a total of US $20.6 billion in product sales in 1996. A secondary finding based on the Pressman model shows that induced, pre-production investment yielded approximately US $4.2 billion in 1996. Adding these number together brings the total economic impact of technology transfer by academic institutions to US $24.8 billion, supporting an estimated 212,500 jobs per year.

Table 25 Spin-off Companies Related to NSERC-Funded Research, by Province, 1995 and 1998

	No. of companies		No. of employees		Annual sales/ revenue[1](000s)	
Province	1995	1998	1995	1998	1995	1998
British Columbia	22	26	1,331	1,563	117,310.0	144,646.8
Alberta	8	10	517	610	31,900.0	47,521.0
Saskatchewan	7	7	432	507	43,345.0	62,030.0
Manitoba	1	2	16	6	2000.0	150.0
Ontario	26	36	1,136	2,077	185,365.0	368,000.0
Quebec	14	15	558	707	130,440.0	253,300.0
New Brunswick	–	2	–	98	–	5,000.0
Nova Scotia	3	7	41	187	3,750.0	14,080.0
Newfoundland	1	2	13	25	1,000.0	1,000.0
Total	**82**	**107**	**4,044**	**5,780**	**515,110.0**	**895,727.8**

Source: NSERC (1995, 1998).

A separate estimate of the economic impact of licensing activities is not available for Canadian universities. When we allocate the above estimate of total economic impact in proportion to gross license income between Canadian and U.S. institutions, US$ 500 million and 4,000 jobs can be attributed to the results of licensing activities by Canadian universities. Implicit in this estimate is the assumption that the ratio of GDP to gross license income and the ratio of jobs created to gross license income are the same for Canadian and U.S. institutions.

For an indication of the economic impact of spin-offs in particular, NSERC (1995, 1998) provides some evidence by tracking the Canadian companies created based on the university research it has funded. It estimates that the total number of spin-offs companies in existence increased from 82 in 1995 to 107 in 1998. Together, the 107 spin-off companies employ more than 5,000 Canadians and generate nearly $900 million in annual sales/revenue (Table 25). The latter figure reaches $1 billion when an estimate for companies reporting this data as “confidential” is included.

Summary

In summary, there are numerous economic benefits to academic R&D. Universities contribute to economic growth and rising living standards through advancement of scientific and technical knowledge, training of skilled personnel, and increasingly, through commercialization of intellectual property.

Universities are the leading source of scientific dissemination and they account for 65 percent of scientific publications in Canada. Compared to other countries, Canada specializes most in earth sciences, followed by biology, mathematics, and applied sciences and engineering. A number of recent empirical studies show that academic research is central to technical advances in a small number of industries such as pharmaceuticals, and information processing and instruments. Academic research is found to have an important and pervasive impact on industrial productivity. The social rate of return to academic research is estimated to be quite high (30-40 percent according to Mansfield, 1991, 1992).

One of the most important forms of influence that universities have on the economy is the training of graduates, through whom technology is effectively transferred from university to industry. Thus, one major benefit industry receives from university R&D is access to students who have been trained at the cutting edge of technology, especially in the science and technology fields. However, science and engineering graduates still comprise a small share of total university graduates in Canada compared to other G7 countries.

Over the last two decades, Canadian universities have been increasingly involved in the commercialization of intellectual property. While there is no evidence to suggest that Canadian universities lag U.S. universities in commercialization activities, there are areas of concern. Most importantly, there are important differences in internal university policies regarding intellectual property commercialization such as inventions disclosure and intellectual property ownership. The lack of adequate or explicit government and university intellectual property policies may hamper future commercialization activities of Canadian universities.

4. SPIN-OFFS VERSUS LICENSING TO EXISTING FIRMS

There are two main mechanisms to commercialize university inventions: spin off new companies to develop and commercialize the institution's technology or license to existing companies. Until recently, the standard practice in North America has been to license university technology to existing companies, especially to companies who are in a business related to that which the university technology should apply.

Does the creation of a spin-off generate greater economic benefits than licensing the new technology to an existing firm? This question cannot be answered empirically; instead, there are many technology-specific factors that need to be carefully weighed in deciding which route to take. Factors conducive to a start-up include the lack of industrial receptor capacity, the local government's interest in nurturing knowledge-based industries and the presence of a champion who will drive the formation of the new venture. Factors conducive to a licensing agreement with an existing firm include the lack of financing for a start-up company, and the relatively large effort and high risk involved in creating a start-up.

In this section, we discuss each of these factors and provide some details on the profile of university spin-offs in Canada.

Creation of a Spin-off

One of the main reasons why universities may want to set up their own spin-off company is the lack of industrial receptor capacity, especially in the local economy. The absence of potential local receptors plays a critical role in starting up a company to license an institution's technology.

A growing number of large national and multi-national companies have realized that their internal means are not well suited by to generate new products and new lines of business to respond to changing opportunities. For them, it is very difficult and time consuming to create a new division to develop university inventions when their existing policies and structures are resistant. Instead, they are turning to mergers and acquisitions to meet these objectives. They are now willing to pay a significant amount for smaller operating companies which have potential and synergy with their business mission (Livingstone, 1998).[16]

University start-ups contribute to the ability of a local economy to expand its knowledge-based industries. They also contribute to nurturing industrial receptor capability for new technology that may pave the way for the formation of similar enterprises and the critical mass that seems essential to the technological advancement of the region. For example, research and technology transfer activities by the University of British Columbia have supported the emergence of the Vancouver region as a high technology hub for young companies in the biotechnology, software and advanced manufacturing sectors (Livingstone, 1998). Similarly, large ventures generated by the faculty of the University of Calgary compete in such fields as biotechnology, health care, computer services and software, specialty chemicals, and analytical instruments in Alberta's natural resources-based economy (Chrisman et al., 1998).

A recent study on UBC spin-off companies identified the presence of a champion as a critical factor when creating a new company. This individual may be an inventor, entrepreneur, or graduate student, and should possess characteristics such as being a self-starter, self motivated, and a sensible risk taker, to name a few (Livingstone, 1998).

University Spin-offs: Trends and Profile

University spin-offs are companies established to either: (1) license the institution's technology; (2) fund research at the institution in order to develop technology that will be licensed by the company; or (3) provide a service which was originally offered through a institution's department or unit. A subset of these spinoffs, those dependent upon initially licensing the institution's technology, are called start-up companies. Our interest lies in these start-up companies, where the institution's licensed technology is the primary motivation behind the formation of the company.

The composition of the various types of university spin-offs is provided in Statistics Canada's *Survey of Intellectual Property Commercialization in the Canadian Higher Education Sector*, as shown in Table 26. Canadian universities have created a total of 366 spin-off companies, mostly over the last two decades. The majority of these are start-up companies formed solely or partly to license an institution's technology. Of the 251 spin-off companies which provided detailed information on their institutional linkages, 202 firms (80 percent) are start-up companies.

Table 26 Institutional Linkage with Spin-off Companies, 1998

	Licences	R&D	Services	Licenses and R&D	Licenses and services	Unknown	Total
Number	177	43	6	24	1	115	366
%	48	12	2	6	0	32	100

Source: *Survey of Intellectual Property Commercialization in the Canadian Higher Education Sector*, Statistics Canada (1998).

Share of Total Licenses and Options Executed with Start-up and Existing Firms

Licenses and options executed by start-up, existing small companies (less than 500 employees) and existing large companies (more than 500 employees) are shown in Table 27. Thirty-one percent of licenses and options executed in Canadian institutions were negotiated with start-up companies. This is significantly higher than the share of licenses and options negotiated with start-up companies by U.S. universities (11 percent). Of particular interest is that in Canada, only 38 percent of the licenses and options executed were signed with existing small companies — significantly less than in the United States (48 percent). This is especially striking considering the relatively larger share of small companies in Canada. One interpretation may be that the lack of industrial receptor capability is more of a problem among existing small firms in Canada than in the United States. The emphasis on licensing to small firms in the United States may also be related to the U.S. Patent and Trademark Laws Amendments of 1980 (commonly known as the Bayh-Dole Act) which specified that for federally-funded research, universities must generally give priority to small businesses in granting licenses to use an invention.

Table 27 Licenses and Options Executed to Start-Up, SME, or Large Companies in Canada and the United States

	Licenses and options executed to:	FY 1996		FY 1997	
		Number	%	Number	%
Canadian institutions	Start-ups	53	28	62	31
	Existing SMEs	74	38	70	36
	Existing large companies	54	34	66	33
	Total	192	100	198	100
U.S. universities	Start-ups	219	11	255	11
	Existing SMEs	1,109	55	1,135	48
	Existing large companies	691	34	976	41
	Total	2,009	100	2,366	100
U.S. hospitals and research institutes	Start-ups	21	9	23	7
	Existing SMEs	111	46	163	53
	Existing large companies	107	45	122	40
	Total	239	100	308	100

Source: *AUTM Licensing Surveys* (1996, 1997).

Trend in the Number of Spin-off Companies Created

The creation of spin-off companies has been increasing over time. About 67 percent of spin-off companies for which we have data on the year of incorporation were created after 1990 (Table 28).

The *AUTM Licensing Survey* provides a comparison of the growth of start-up activities by Canadian and U.S. universities. The number of start-up companies created by Canadian universities doubled over the 1994-97 period, while the number of start-up companies created by U.S. universities increased by only about 50 percent over that period (Table 29).

Table 29 Start-Up Companies Created by Canadian and U.S. Institutions

	1980-1993	1994	1995	1996	1997	Change: 1994-97
U.S. universities	916	175	169	184	258	13.81%
U.S. hospitals and research institutes	79	22	18	15	16	-10.07%
Canadian universities	156	29	31	46	58	25.99%
Patent management firms	18	15	5	3	1	-59.45%
All respondents	1,169	241	223	248	333	11.38%

Source: *AUTM Licensing Survey* (1991-97).

Equity Consideration

University involvement in starting new companies and taking equity has become more prevalent among both Canadian and U.S. universities according to the AUTM survey. Table 30 shows that Canadian universities hold equity in roughly one quarter of the 278 spin-off companies which have provided information on equity holdings. For many companies, university involvement may be the only way to support the development and commercialization of ideas that do not attract interest from existing firms.

Spin-off Companies by Technological Fields

Table 28 Year of Incorporation of Spin-off Companies

Incorp. Year	Before 1980	1980 to 1984	1985 to 1989	1990 to 1994	1995 to 1998	Unknown	Total
Number	22	38	54	115	115	22	366
%	6	10	15	31	31	7	100

Source: *Survey of Intellectual Property Commercialization in the Canadian Higher Education*

Twenty-five percent of spin-off companies are in the combined fields of biotechnology and biology, followed by mathematics and physical sciences (20 percent), health sciences (18 percent), engineering and applied sciences (16 percent), and information technology (15 percent) (Table 31).

Status of Spin-off Companies

Table 32 shows that the majority of university spin-off companies were active in 1998 and have moved out of the conceptual or early development stage. According to the survey, 69 percent of all spin-off companies were active in 1997 and only 14 percent were still in the conceptual or early development stage. In addition, only 6 out of the 133 spin-off companies had merged with other companies.[17]

Table 30 Equity Held in Spin-off Companies, 1998

Spin-offs	Equity held by university	No equity held by university	Unknown	Total
Number	73	205	88	366
Percentage	20	56	24	100

Source: *Survey of Intellectual Property Commercialization in the Canadian Higher Education Sector*, Statistics Canada, 1998.

Table 31 Technological Field of Spin-off Companies

Tech. field	Biotech./ biology	Health sciences	Engineering/ applied sc.	Information	Math./ physical sc.	Business/ management	Other/ unknown	Total
Number	90	66	58	55	73	5	19	366
%	25	18	16	15	20	1	5	100

Source: *Survey of Intellectual Property Commercialization in the Canadian Higher Education Sector*, Statistics Canada, 1998.

Table 32 Status of Spin-off Companies

Tech. field	Conceptual stage	Early stage	Active	Merged	Inactive	Closed	Unknown	Total
Number	7	44	253	6	17	23	16	366
%	2	12	69	2	5	6	4	100

Source: *Survey of Intellectual Property Commercialization in the Canadian Higher Education Sector*, Statistics Canada,1998.

Growth of University Start-ups and Characteristics of Successful Start-ups

The evidence is sparse on the survival rate and growth of university start-ups due to limited data availability. Existing evidence seems to suggest that university start-ups are "fairly typical", similar to other non-university high-technology start-ups in terms of growth and rate of survival. An analysis of 58 spin-offs created between 1971 and 1990 by science and engineering professors shows that they behave just like the rest of high-tech spin-offs in terms of sales and rate of growth (Doutriaux and Dew, 1992). A study by the National Research Council of Canada found that, contrary to popular belief, the survival rate for university start-ups is no higher than the industry average (Cooper, 1997).

Livingstone (1998) identified the following characteristics of successful start-ups:

- A champion who lives and breathes to see the company succeed;
- Management with proven experience in the particular high technology sector;
- An understanding of the market opportunity;
- A business plan;
- Access to financing at all stages (technology development, seed capital, venture capital, and public markets);
- An experienced board of directors;
- The ability to access experienced R&D personnel and facilities; and
- A solid, well-understood and protected technology.

Licensing to an Existing Company

Lack of established sources of financing is a major obstacle to the creation and growth of university start-ups. As they lack concrete assets or even fully identifiable markets, start-ups are often viewed by investors as highly risky ventures. The vast majority of inventions licensed are so embryonic that commercialization requires a significant investment in developing and marketing the invention. The most critical funding shortage occurs at this development stage of the research, and at the initial seed and early stage of a company. Governments (both local and federal) and universities may well have a role to play in providing funding for these fledgling start-ups.

Participation in new company creation and growth is a time-consuming activity. It is estimated that up to 10 times more effort is required to participate in the formation, licensing, and ongoing relationship with a start-up as with an existing company. Activities such as management of equity, management of conflict of interest, access to university space and facilities, and dealing with the expectations of all parties all contribute to the additional time demand on technology transfer office (TTO) staff (Livingstone, 1998).

Summary

In a university's attempt to commercialize a new technology, there is little empirical evidence to suggest which route the university should take. The decision whether to license to an existing firm or create a spin-off company is complicated and most often depends on the technology under consideration. That is, it depends on factors such as the existence of sufficient receptor capacity in the local economy for the new technology, access to adequate financing, the degree of risk involved, and the presence of a champion who will spearhead the formation of the new venture.

The available data suggests that Canadian universities are active in the creation of new companies to license their technologies, having created a total of 366 spin-offs mostly over the past two decades. Of the licenses and options executed by Canadian universities in 1997, almost one-third were to start-up companies. This is much higher than in the United States, where only about one in ten licenses and options were executed to start-ups. Instead, academic institutions in the United States are more likely than Canadian institutions to license to existing SMEs. This may be a result of stronger industrial receptor capability in the United States and/or the U.S. Bayh-Dole Act which ensures that universities give priority to small businesses in granting licenses to use inventions based on federally-funded research.

5. UNIVERSITY-INDUSTRY RESEARCH PARTNERSHIPS

University-industry research partnerships have been an effective means of improving technology transfers and the commercialization of university research. Collaborative research between different business enterprises and universities have been found to contribute to a better exploitation of limited research capabilities by pooling resources, speeding the transfer of technology between science and industry, and generating synergies (OECD, 1998b). University-industry collaboration on specific projects promotes enhanced cooperation beyond the specific projects themselves.

University-Industry Partnerships

University-industry partnerships take many forms, including industrial research contracts, long-term R&D co-operative agreements, funding of graduate students' research, training and recruitment of staff, and joint R&D projects. A study by Link and Rees (1990) found that the rate of return on industrial R&D is enhanced by university-industry partnerships. They estimate a rate of return of 34.5 percent for firms with university links compared with 13.2 percent for firms without such links.

A picture of the various forms of university-industry partnerships was provided by a 1995 survey co-sponsored by NSERC and the Conference Board. The survey asked large and small technology-intensive firms and Canadian universities about the nature of university-industry research collaboration. By far, the major form of university-industry partnerships is research contracted out to a university. Close to 60 percent of industry respondents and 88 percent of university respondents agreed that contracting-out remains the most common form of research collaboration between universities and industry (Tables 33 and 34). Joint R&D projects are the next most commonly used form of collaboration between universities and industry, followed by long term cooperative research agreements between universities and industry. The survey also reveals that large firms in Canada are more likely than small firms to form partnerships with universities (Figure 27).

Table 33 What has been the primary involvement of your company with universities to date?

(N=51)	Responses	Percentage
Research contracted out to university faculty	52	56.5
Long-term R&D co-operative agreement	32	34.8
Funding graduate student's research	31	33.7
Training and recruitment of staff	18	19.6
Company bought and commercialized university technology	10	10.9
Joint R&D	37	40.2
Other	16	17.4

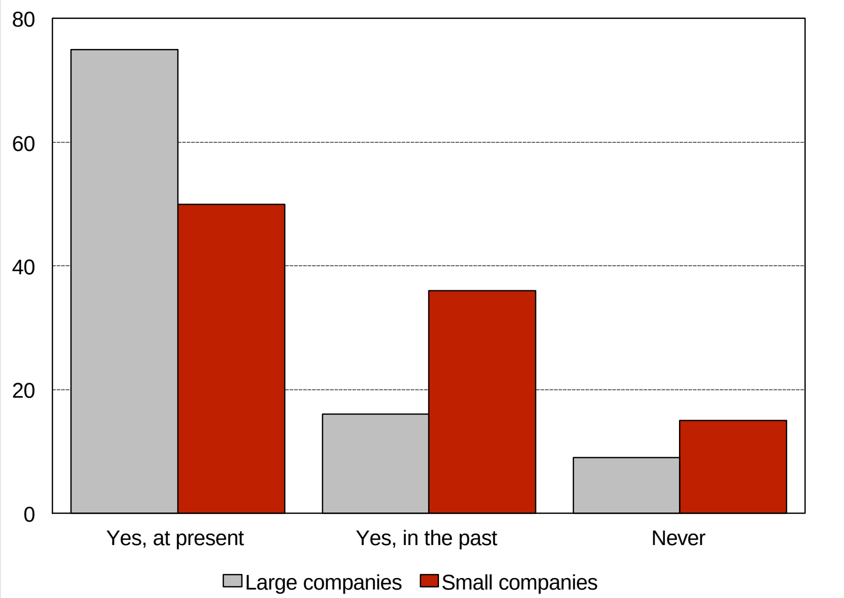
Source: Warda (1995).

Table 34 What has been your university's involvement with industry to date?

(N=92)	Responses	Percentage
Research contracted out to university faculty	45	88.2
Long-term R&D co-operative agreement	27	51.9
Funding graduate student's research	19	37.3
Training and recruitment of staff	7	13.7
Company bought and commercialized university technology	1	2.0
Joint R&D	33	64.7
Other	12	23.5

Source: Warda (1995).

Figure 27 Collaboration with Universities



Warda (1995).

Industrial Research Contracts

Research contracts generally constitute only a small part of a university's total research funding; most university research funding comes in the form of grants from governments and granting councils. According to Statistics Canada's intellectual property commercialization survey, universities were engaged in 5,081 research contracts in 1997-98, with an average value of $57,000 per contract (see Table 35). Almost half of these contracts (48.6 percent) are with industry, either Canadian businesses or foreign firms (see Table 36). Still, industrial contract funding comprises a relatively small share of total university research. Of the $2.1 billion in sponsored research during fiscal year 1997-98, only $115 million (6 percent) represented research contracts with private Canadian and foreign companies.

Table 35 Research Funding Summary

Total sponsored research (grants and contracts) (1997-98)	$2.1 billion
Research contracts - value (1997-98)	$289 million
Research contracts - number (1997-98)	5081
Average value of research contract	$57,000

Source: CAUBO, 1998; Statistics Canada, *Survey of Intellectual Property Commercialization in the Canadian Higher Education* Sector, 1998.

Table 36 Number and Value of Research Contracts by Category of Sponsor

Sponsor	Number	Value $`000
Federal government	862	56,947
Provincial and other levels of gov’t	786	70,610
Private business (Canadian)	2,072	91,801
Non-governmental organizations	291	7,607
Foreign firms	397	23,367
Foreign governments	56	5,456
International organizations	40	4,690
Other	50	8,050
Total research contracts	**5,081**	**288,600**

(1) The parts in this table do not equal the sum, as not all respondents were able to provide the breakdown by category of sponsor.
Source: Statistics Canada, *Survey of Intellectual Property Commercialization in the Canadian Higher Education* Sector, 1998.

Large firms are more likely than small firms to have R&D contractual agreements with universities. A Canadian Research Management Association (CRMA, 1991) survey found that, in the case of large firms (over 100 employees), 63 percent carried out some of their research and development by means of research contracts with universities or government laboratories. Only 15 percent of the small firms included in the survey reported that they had made such arrangements for R&D with universities.

Table 37 University Policy on Ownership and First Rights to License Intellectual Property from Research Contracts

Code	Response	Number
0	No response	15
1	Sponsor (owns intellectual property and has first rights to license)	8
2	University	3
21	University owns, sponsor has first rights	7
3	Researcher	10
31	Researcher owns, sponsor has first rights	1
4	Shared	3
42	University/researcher jointly owned, university has first rights	1
5	Not applicable/no policy	8
6	Varies/negotiable/per contract	25
	Total	**81**

Source: Statistics Canada, *Survey of Intellectual Property Commercialization in the Canadian Higher Education* Sector, 1998.

University policies on ownership and first rights to intellectual property from research contracts are extremely varied (Table 37). They range from the sponsor retaining the sole ownership of the invention, to the inventor owning the invention, and to the university having the sole ownership, with considerable variations within. As might be expected, the predominant response from universities was “Varies/negotiable/per contract.”

Impediments to University-Industry Partnerships

The 1995 Conference Board survey discussed above asked both universities and companies to list the impediments to university-industry partnerships. The results of the survey confirmed that the most significant barrier to university-industry collaboration is the culture gap between the two communities (Tables 38 and 39). The culture of university research has a long-term, generic perspective about research that is important. The culture of industry fosters a shorter term view about knowledge, focussing on solving a particular technical problem in the near future. Indeed, one objective of university-industry partnerships is to act as a bridging mechanism between university and industry with quite different research cultures.

Table 38 Impediments to University-Industry Collaboration According to Industry

Variables	Average score
Within university	
Faculty culture not geared to business collaboration	5.22
Rigid intellectual property enforcement	4.91
Industry-specific technical expertise not available	4.81
High administrative costs	4.68
Lack of active support in co-ordinating faculty programs and resources for business research	4.65
Theoretical orientation of faculty	4.62
Lack of rewards for work with industry	4.57
Conservative approach to change	4.42
Long-term research focus	4.35
Low return on investment in university research	4.34
Within industry	
Compressed product development cycle	5.28
Strategic research performed internally	4.9
Declining R&D budgets	4.28
Low awareness of university capabilities	4.16
Focus on ad hoc ventures and contracts	4.06
Lack of skilled people to communicate with university faculty	3.32
Little involvement of CEO or CTO	3.06
Lack of technical knowledge within the company	3.01
Little experience in any R&D collaboration	2.91
R&D not a priority for the company	2.57

Scale: 1 not at all significant; 2 not significant; 3 little significance; 4 neutral; 5 some significance; 6 significant; 7 extremely significant.
Source: Warda (1995).

Table 39 Barriers to University-Industry Collaboration According to Universities

Variables	**Average score**
Within university	
Poor knowledge of industry-relevant needs	5.45
Insufficient experience in product development and commercialization	5.18
Time pressures not in sync with industry	5.1
Low capacity to share risk	4.82
Few rewards for faculty’s work with industry	4.48
Concerns about intellectual property rights	4.34
Strong focus on theory	4.3
Administrative burden	3.82
Within Industry	
Lack of awareness of university research capabilities	5.9
Declining R&D funds	5.84
Compressed product development cycles	5.72
Little understanding of university culture	5.63
Lack of technology planning	5.23
Emphasis on product development	5.12
Focus on ad hoc ventures and one-way contracts	4.98
Most critical research performed internally	4.71
Lack of cutting-edge technical knowledge	4.62
Shortage of skilled people	4.57
Little involvement of CEO and CTO	4.35

Scale: 1 not at all significant; 2 not significant; 3 little significance; 4 neutral; 5 some significance; 6 significant; 7 extremely significant.
Source: Warda (1995).

Summary

Increasing attention has been paid to university-industry research partnerships as an effective means of improving technology transfer and commercialization of university research. University-industry partnerships have been found to contribute to better exploitation of limited research capabilities, faster transfer of technology between science and industry, and the generation of synergies. Empirical evidence shows that small and medium-sized firms are less likely than large firms to form partnerships with universities. Indeed, several countries have adopted policies to encourage SMEs to be more active in forming partnerships with universities.

Industrial research contracts in Canada account for a small share of total sponsored research (6 percent in 1996-97, according to the intellectual property commercialization survey conducted by Statistics Canada). However, as the amount of industrial research contracted out increases, the following issues need to be addressed:

- First, what is the impact of deepening ties with industry on academic research, specially on its composition (basic versus applied research)?
- Second, what is the impact on public dissemination of university research as industry support brings greater restrictions on the disclosure of university research?
- Third, does the lack of uniform university policies on ownership and first rights to contract research hamper the establishment of university-industry partnerships?

8. CONCLUSIONS

The objective of this background paper was to provide a statistical overview of university R&D activities and the commercialization of intellectual property in Canadian universities as an information tool for the consideration of the Expert Panel on the Commercialization of University Research. The paper is a compilation of available statistics, empirical evidence and general issues relating to university research and its role in promoting technical advance. We focus on the commercialization of university research, which has been increasingly recognized as an important contribution of universities to economic growth.

From this study, we draw the following main conclusions with respect to the role of Canadian universities in the national R&D effort:

- Canadian universities play a strong role in Canada's national R&D effort. National statistics show that universities have performed between 20 to 30 percent of total R&D over the past few decades. In comparison to other G7 countries, this share is among the highest (21.5 percent in 1997).

- The share of university R&D that is sponsored by business enterprise was estimated at almost 12 percent in 1997. This share is higher than in any other G7 country. The strong presence of Canadian industry in university R&D may reflect the favourable R&D tax treatment, by which firms receive a tax credit for R&D expenditures.

- However, despite Canada's international standing with respect to the share of R&D performed by the university sector, or the share financed by industry, the level of R&D expenditures is extremely low in Canada relative to other countries. As a share of output, both total R&D and university R&D comprise a small and decreasing amount. Canada ranks second last in the G7 on these two measures.

There are three main reasons why university R&D is so important to the economy. It provides economic benefits through its contribution to the stock of scientific and technical knowledge, the training of skilled personnel, and through the commercialization of knowledge. Several interesting findings emerge from the study about the economic benefits of university R&D.

- Universities are the leading source of scientific publications and they account for 65 percent of these publications in Canada. Compared with other countries, Canada specializes most in earth sciences, biology, mathematics, and applied sciences and engineering.

- A number of recent empirical studies show that academic research is central to technical advance in a small number of industries such as pharmaceuticals, and information processing, and instruments. Academic research is found to have an important and pervasive impact on industrial productivity. The social rate of return to academic research is estimated to be quite high — 30-40 percent according to Mansfield (1991, 1992).

- A major benefit industry receives from university R&D is access to students who have been trained at the cutting edge of technology, especially in the science and technology field. While the number of science and engineering graduates in Canada has been rising in recent years, they still represent a small share of total university graduates compared to other G7 countries.

- Over the last two decades, Canadian universities have been increasingly involved in the commercialization of intellectual property. However, a major area of concern is the large variation in internal university policies on intellectual property commercialization, such as inventions disclosure and intellectual property ownership. Inadequate or lack of explicit government and university intellectual property policies may hamper future commercialization efforts of Canadian universities.

New technologies are commercialized through licenses to existing companies or the creation of spin-off firms. Our main findings are:

- The factors conducive to a start-up include the lack of industrial receptor capacity, the local government's interest in nurturing knowledge-based industries and the presence of a champion who will spearhead the formation of the new venture. Factors conducive to a licensing agreement with an existing firm include the lack of financing for a start-up company, and the relatively large effort and high risk involved in creating a start-up.

- The available data suggests that Canadian universities are active in the creation of new companies to license their technologies, having created a total of 366 spin-off firms mostly over the past two decades. Universities in Canada are more likely to choose the spin-off option over licensing to an existing company than universities in the United States.

Finally, the formation of university-industry research partnerships is a way to improve technology transfer and the commercialization of university research. Collaborative research between different firms and universities have been found to contribute to the better exploitation of limited research capabilities by pooling resources and generating synergies which speed the commercialization process.

- The empirical evidence shows that small and medium-sized firms are less likely than large firms to form partnerships with universities.

- We find that industrial research contracts in Canada account for a small share of total sponsored research. However, as the number of industrial research contracts increases, issues will arise regarding their impact on the university's mix of basic and applied research and on the public disclosure of university research.

NOTES

1 To estimate real growth rates, R&D expenditures have been converted into constant 1992 dollars using the GDP implicit price index.

2 It has been argued that Statistics Canada may overstate the amount of social science R&D performed in Canada, thereby inflating the contribution of universities in the national R&D accounting. As described in Box 1, the allocation of total university expenditures is based on the weighted number of full-time teachers. Given the large size of the social science faculty in many universities, there may be more R&D costs allocated to the social sciences than are actually incurred. See *Fields of University Research* in Section 2 for further discussion of the fields of research for university R&D.

3 We make international comparisons using data published by the OECD, based on the national statistics of each reporting country. Thus, it should be kept in mind that different countries may have different procedures for estimating R&D in the various sectors and the resulting figures may not be directly comparable. However, the OECD (1998c) notes that any country differences "are generally too small to affect the general indicators" (p. 60).

4 The reader should note that the United States calculates academic R&D expenditures slightly differently than Canada. First, R&D spending in the U.S. academic sector does not include departmental research, and thus excludes faculty salaries in cases where research activities are not separately budgeted (National Science Foundation, 1998). On the other hand, as described in Box 1, R&D expenditures in Canada are estimated from total university expenditures and therefore include departmental research and faculty salaries even when research activities are not separately budgeted. Second, in the United States, academic R&D in the humanities and capital expenditures on R&D are excluded, whereas they are included in Canada's estimate of university R&D. Therefore, university R&D expenditures in the United States may be understated relative to the Canadian figures.

5 General university funds are essentially indirect government spending, rather than university funding *per se*. However, in the official Canadian statistics these funds are included in the university sector due to the difficulty of categorizing the funds as federal or provincial.

6 It should be noted that a proportion of industry-sponsored university research is refunded to firms as an R&D tax credit of 20 percent in most provinces (for details see the CCH, *Canadian Master Tax Guide*, 1997). Thus, to some extent, it reflects indirect government funding. However, since firms receive the tax credit whether they fund R&D within the firm or outside the firm at a university, the fact remains that they finance a considerable share of university R&D.

7 The data presented for Canada in Table 8 differ slightly from the data shown in Figure 8. While both are for 1996, the OECD data are based on preliminary data submitted by Statistics Canada, which have subsequently been updated in the national statistics. However, we use the OECD data here to maximize international comparability with respect to the university sector (to differentiate between government-funded general university funds and other university financing).

8 As noted earlier, this may reflect the favourable tax treatment of R&D spending in Canada.

9 Note that the data on provincial funding can be quite volatile; the amount of funding from any particular source may vary considerably from year to year.

10 The OECD (1998b) notes that in the United States and other major scientific powers, more than 60 percent of university research is in basic research. Unfortunately, there is no data available for Canada on the distribution of research between basic and applied research.

11 Science and engineering graduates include Bachelor's and First Professional degrees, Master's degrees, and Doctoral degrees granted in the following fields: agricultural and biological sciences; engineering and applied sciences; and mathematics and physical sciences.

12 This statistic is provided to compare the *trend* in the ratio between Canada and the United States over the period. Due to differences in measuring sponsored research expenditures between Canadian and U.S. universities, the actual ratio is not directly comparable between the two countries. According to the AUTM, total sponsored research expenditures provided by Canadian universities in the survey do not include researchers' salaries.

13 Table 20 also shows other types of intellectual property in addition to inventions. While we are focussing primarily on inventions and their commercialization, universities produce many other types of intellectual property that require different protection activities. See Brochu (1998) for a discussion on how the type of intellectual property protection sought differs according to field of research.

14 The large increase in patent applications in 1995 may be attributable to new U.S. patent application procedures that reduced application fees.

15 As noted earlier, there are differences in the measurement of sponsored research expenditures between Canadian and U.S. universities, thus this statistic is provided only to compare the trend in the two ratios over the period.

16 The lack of resources to develop university inventions for many small and medium-sized enterprises (SMEs), especially those in low technology areas, exacerbates the problem of receptor capacity.

17 Some have voiced concerns that foreign-owned multinationals buying spin-off companies that have been created by Canadian universities, as a result of publicly funded research, and that the economic benefits may be lost. However, the small share of spin-off companies that have merged with other firms suggests that foreign acquisition of start-ups is not prevalent.

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APPENDIX 1

R&D-Performing Universities in National R&D Figures, by Size, 1996-97

Province	Institution	Size
Newfoundland	Memorial University of Newfoundland	Medium
Prince Edward Island	University of Prince Edward Island	Small
Nova Scotia	Acadia University	Small
	University College of Cape Breton	Small
	Dalhousie University	Large
	Mount Saint Vincent University	Small
	Nova Scotia Agricultural College	Medium
	St. Francis Xavier University	Small
	Saint Mary's University	Small
	Technical University of Nova Scotia	Medium
New Brunswick	Université de Moncton	Small
	Mount Allison University	Small
	University of New Brunswick	Medium
Quebec	Bishop's University	Small
	Concordia University	Medium
	Université Laval	Large
	McGill University	Large
	Université de Montréal	Large
	Université du Québec - I.N.R.S.[1]	Medium
	Université de Sherbrooke	Large
Ontario	Brock University	Small
	Carleton University	Medium
	University of Guelph	Large
	Lakehead University	Small
	Laurentian University of Sudbury	Small
	McMaster University	Large
	University of Ottawa	Large
	Queen's University at Kingston	Large
	Ryerson Polytechnical Institute	Small
	University of Toronto	Large
	Trent University	Small
	University of Waterloo	Large
	The University of Western Ontario	Large
	Wilfrid Laurier University	Small
	University of Windsor	Small
	York University	Medium
Manitoba	Brandon University	Small
	University of Manitoba	Large
	University of Winnipeg	Small

Province	Institution	Size
Saskatchewan	The University of Regina	Small
	University of Saskatchewan	Large
Alberta	University of Alberta	Large
	University of Calgary	Large
	University of Lethbridge	Small
British Columbia	The University of British Columbia	Large
	Simon Fraser University	Medium
	University of Victoria	Medium

[1] Special calculations are made for the Institut national de la recherche scientique.
Source: Thompson (1998).

APPENDIX 2

University Intellectual Property Policies/Guidelines

Questions	Brock	Carleton	Guelph	Lakehead	*Laurentian	McMaster
#1. What does the policy cover?						
Patents (for inventions)	✔	✔	✔	✔	✔	✔
Copyright (may include all original literary, dramatic, musical and artistic works, including among others, books, writings, musical works, sculptures, paintings, photographs, films, audio and video tapes, computer programs, dictionaries, encyclopedia)	✔	✔	✔	✔	✔	✔
Private Research						
Other			Separate policy for computer software			
#2. Who owns the intellectual property at the inception - creator and/or university?	Creator	Joint ownership	University	Creator		University
#3. Is there an obligation to disclose?	Yes	Yes	Yes	No		Yes
#4. When intellectual property is commercialized, who is owner - creator and/or university and how are the revenues to be divided?						
a) <u>Patents</u>: If university commercializes:						
University Owns	✔	50%			✔	✔

Questions		Brock	Carleton	Guelph	Lakehead	*Laurentian	McMaster
	% <u>net</u> revenues	50%	50%	25% of first $100,000, 75% of income over $100,000	Where creation involved ordinary support of board 25%, where extraordinary support 75%	50%	50%
Creator	Owns		50%		✔		
	% <u>net</u> revenues	50%	50%	See above	See above	50%	50%
b) <u>Patents</u>: If creator commercializes:							
University	Owns		50%				
	% <u>net</u> revenues		To be negotiated				25%
Creator	Owns		50%				✔
	% <u>net</u> revenues		To be negotiated				75%

Questions	*Nipissing	Ottawa	Queen's	Ryerson	Toronto	Trent
#1. What does the policy cover?						
Patents (for inventions)	✔	✔	✔	✔	✔	✔
Copyright (may include all original literary, dramatic, musical and artistic works, including among others, books, writings, musical works, sculptures, paintings, photographs, films, audio and video tapes, computer programs, dictionaries, encyclopedia)	✔	✔	✔	✔	✔	✔
Private Research		✔		✔		

Questions		*Nipissing	Ottawa	Queen's	Ryerson	Toronto	Trent
Other				Trademarks	Industrial designs, trademarks, trade secrets	Separate policy for computer software	
#2. Who owns the intellectual property at the inception - creator and/or university?			-Patents/ inventions - university owns -Copyright - creator owns	Creator	Ownership varies according to nature of intellectual property	Shared ownership; assigned to creator(s) upon their request	Patents - shared ownership; copyright - creator owns
#3. Is there an obligation to disclose?			Yes, if inventor wishes to have invention exploited	Yes	Yes	Yes	✔
#4. When intellectual property is commercialized, who is owner - creator and/or university and how are the revenues to be divided?							
a) <u>Patents</u>: If university commercializes:							
University	Owns	✔	✔	✔	✔	✔	
	% <u>net</u> revenues	50%	20% of first $100,000, 50% of remainder	Revenue sharing in accordance with PARTEQ (usually 40-60%)	To be negotiated	75%	50%
Creator	Owns						
	% <u>net</u> revenues	50%	80% of first $100,000, 50% of remainder	See above	To be negotiated (normally min. 10% to creator)	25%	50%
b) <u>Patents</u>: If creator commercializes:							
University	Owns		100% unless university declines to apply for patent. Creator must obtain license.				

Questions		*Nipissing	Ottawa	Queen's	Ryerson	Toronto	Trent
	% net revenues		20% of first $100,000, 50% of remainder or equivalent equity	Usually 50%	Sum in keeping with industry norms (but to exceed 1%)	25%	
Creator	Owns		Creator owns only if university declines invention	✔		✔	✔
	% net revenues		100% unless otherwise negotiated	If PARTEQ a suitable vehicle for commercializ. but not used, 25% exceeding $500,000		75%	100%

Questions	Waterloo	*Western	Wilfrid Laurier	Windsor	York
#1. What does the policy cover?					
Patents (for inventions)	✔	✔	✔	✔	✔
Copyright (may include all original literary, dramatic, musical and artistic works, including among others, books, writings, musical works, sculptures, paintings, photographs, films, audio and video tapes, computer programs, dictionaries, encyclopedia)	✔	✔	✔	✔	✔
Private Research					
Other	-Trademarks -Teaching materials -original data	-Computer software -Trademarks -Industrial design			

Questions		Waterloo	*Western	Wilfrid Laurier	Windsor	York
#2. Who owns the intellectual property at the inception - creator and/or university?		Creator (for sponsored research subject to contract)	Shared ownership	Negotiable	Creator	Creator unless commissioned by or developed with direct support of university
#3. Is there an obligation to disclose?		Yes, if owner intends to pursue commerciali-zation	Yes	Yes	Yes	Yes, if patent sought
#4. When intellectual property is commercialized, who is owner - creator and/or university and how are the revenues to be divided?						
a) Patents: If university commercializes:						
University	Owns	✔	✔	✔	✔	
	% net revenues	50%	50%	50%	50%	To be negotiated
Creator	Owns					✔
	% net revenues	50%	50%	50%	50%	To be negotiated
b) Patents: If creator commercializes:						
University	Owns					
	% net revenues		25%	To be negotiated		To be negotiated
Creator	Owns	✔	✔	✔	✔	✔
	% net revenues	100%	75%	To be negotiated	100%	To be negotiated

Source: Adapted from materials distributed at “Capturing the Benefits: An AUCC Symposium on Intellectual Property”, November 26-27, 1998, Ottawa, Ontario.

APPENDIX 3

Source of Funds for Sponsored University R&D, by University, 1996-97

University	Total Sponsored R&D ($000)	Share (%) Fed.	Prov.	Ind.	Oth.
MEMORIAL UNIVERSITY OF NFLD	23580.00	67	3	18	13
UNIV. OF PRINCE EDWARD ISLAND	1863.00	51	10	15	24
ACADIA DIVINITY COLLEGE	0.00	0	0	0	100
ACADIA UNIVERSITY	1209.00	90	1	7	2
UNIVERSITY COLLEGE OF CAPE BRETON	2512.00	52	4	0	45
DALHOUSIE UNIVERSITY	36772.00	52	1	23	24
UNIVERSITY OF KING'S COLLEGE	8.00	25	0	0	75
MOUNT SAINT VINCENT UNIVERSITY	240.00	98	1	1	-0
N.S. AGRICULTURAL COLLEGE	4783.00	77	23	0	0
N.S. COLLEGE OF ART and DESIGN	0.00	0	0	0	100
UNIVERSITE SAINTE ANNE	10.00	100	0	0	0
ST. FRANCIS XAVIER UNIVERSITY	1270.00	95	4	0	1
SAINT MARY'S UNIVERSITY	2160.00	96	1	0	3
TECHNICAL UNIVERSITY OF N.S.	6461.00	56	17	17	10
UNIVERSITE DE MONCTON	4501.00	61	23	0	17
MOUNT ALLISON UNIVERSITY	2007.00	40	45	0	15
UNIVERSITY OF NEW BRUNSWICK	18167.00	45	9	19	27
ST. THOMAS UNIVERSITY	32.00	84	0	0	16
INSTITUT ARMAND-FRAPPIER	4775.00	32	17	11	40
INST. NAT. DE LA RECH. SCIENTIFIQUE	24273.00	24	13	0	63
BISHOP'S UNIVERSITY	300.00	56	6	25	13
CONCORDIA UNIVESITY	13095.00	64	19	8	9
HAUTES ETUDES COMMERCIALES	4077.00	26	10	37	27
ECOLE NATIONALE D'ADMIN. PUBLIQUE	2641.00	64	19	15	2
ECOLE POLYTECHNIQUE	28671.00	48	17	0	35
ECOLE DE TECHNOLOGIE SUPERIEURE	1733.00	49	9	42	0
UNIVERSITE LAVAL	80093.00	42	27	13	18
MCGILL UNIVERSITY	115158.00	58	10	9	24
UNIVERSITE DE MONTREAL	149163.00	35	26	19	19
UNIV. DU QUE. ABITIBI-TEMISCA.	2122.00	23	38	0	38
UNIV. DU QUEBEC A CHICOUTIMI	7521.00	28	28	37	7
UNIV. DU QUEBEC A HULL	1117.00	67	32	2	0
UNIV. DU QUEBEC A MONTREAL	29653.00	39	25	25	10
UNIV. DU QUEBEC A RIMOUSKI	3173.00	35	13	0	52
UNIV. DU QUEBEC A STE-FOY	115.00	0	0	0	100
UNIV. DU QUEBEC A TROIS-RIVIERES	10121.00	29	31	38	2
UNIVERSITE DE SHERBROOKE	29168.00	50	20	12	17
ALGOMA UNIVERSITY	0.00	0	0	0	100
BRESCIA COLLEGE	0.00	0	0	0	100

University	Total Sponsored R&D ($000)	Share (%) Fed.	Prov.	Ind.	Oth.
BROCK UNIVERSITY	2593.00	72	13	7	8
CONRAD GREBEL COLLEGE	0.00	0	0	0	100
CARLETON UNIVERSITY	25486.00	54	10	20	16
UNIVERSITY OF GUELPH	64019.00	32	50	9	9
COLLEGE UNIVERSITAIRE DE HEARST	0.00	0	0	0	100
HUNTINGTON UNIVERSITY	0.00	0	0	0	100
HURON COLLEGE	0.00	0	0	0	100
KING'S COLLEGE	11.00	100	0	0	0
LAKEHEAD UNIVERSITY	4035.00	36	26	20	18
LAURENTIAN UNIVERSITY	6769.00	42	23	26	9
MCMASTER UNIVERSITY	90488.00	34	11	21	34
NIPISSING UNIVERSITY COLLEGE	229.00	52	8	0	40
UNIVERSITY OF OTTAWA	59495.00	40	7	21	32
QUEEN'S UNIVERSITY	63200.00	53	6	22	19
REDEEMER COLLEGE	96.00	19	0	17	65
RENISON COLLEGE	0.00	0	0	0	100
ROYAL MILITARY COLLEGE	0.00	0	0	0	100
RYERSON POLYTECHNICAL INSTITUTE	2864.00	38	51	11	-0
UNIV. OF ST. JEROME'S COLLEGE	0.00	0	0	0	100
UNIVERSITY OF ST. MICHAEL'S COLLEGE	127.00	100	0	0	0
UNIVERSITE SAINT PAUL	91.00	59	0	0	41
ST. PETER'S SEMINARY	0.00	0	0	0	100
UNIVERSITY OF SUDBURY	50.00	4	80	4	12
UNIVERSITY OF TORONTO	281221.00	40	15	17	28
UNIVERSITY OF TORONTO NET	281221.00	40	15	17	28
TRENT UNIVERSITY	3536.00	56	23	10	11
UNIVERSITY OF TRINITY COLLEGE	14.00	100	0	0	0
VICTORIA UNIVERSITY	214.00	39	0	0	61
UNIVERSITY OF WATERLOO	44376.00	46	18	19	17
UNIVERSITY OF WESTERN ONTARIO	80982.00	35	4	24	38
WILFRID LAURIER UNIVERSITY	1833.00	57	18	11	15
UNIVERSITY OF WINDSOR	7770.00	62	13	17	7
YORK UNIVERSITY	18951.00	72	3	8	17
BRANDON UNIVERSITY	493.00	40	40	1	19
UNIVERSITY OF MANITOBA	48390.00	52	10	6	32
COLLEGE DE SAINT BONIFACE	0.00	0	0	0	100
ST. JOHN'S COLLEGE	0.00	0	0	0	100
ST. PAUL'S COLLEGE	0.00	0	0	0	100
UNIVERSITY OF WINNIPEG	1046.00	83	3	11	3
CAMPION COLLEGE	0.00	0	0	0	100
LUTHER COLLEGE	0.00	0	0	0	100
UNIVERSITY OF REGINA	5989.00	58	8	3	30
ST. THOMAS MORE COLLEGE	11.00	0	100	0	0

University	Total Sponsored R&D ($000)	Share (%) Fed.	Prov.	Ind.	Oth.
SASK. INDIAN FEDERATED COLLEGE	0.00	0	0	0	100
UNIVERSITY OF SASKATCHEWAN	48662.00	44	23	16	16
ST. PETER'S COLLEGE	0.00	0	0	0	100
UNIVERSITY OF ALBERTA	121281.00	49	17	12	22
ATHABASCA UNIVERSITY	319.00	100	0	0	0
UNIVERSITY OF CALGARY	79294.00	36	19	20	25
AUGUSTANA UNIVERSITY COLLEGE	0.00	0	0	0	100
CONCORDIA UNIV COLL OF ALBERTA	0.00	0	0	0	100
UNIVERSITY OF LETHBRIDGE	2232.00	60	11	1	28
THE KING'S COLLEGE	11.00	0	0	0	100
UNIVERSITY OF BRITISH COLUMBIA	128836.00	47	12	20	22
OPEN LEARNING AGENCY	0.00	0	0	0	100
SIMON FRASER UNIVERSITY	23227.00	67	11	12	10
TRINITY WESTERN UNIVERSITY	0.00	0	0	0	100
UNIVERSITY OF VICTORIA	24184.00	72	13	2	13
UNIVERSITY OF NORTHERN B.C.	3335.00	20	63	5	12
Total	2139525.00	44	16	16	24

Source: Canadian Association of University Business Officers (CAUBO), 1998.

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