Trends in R&D, Patents and Other Measures of Innovation

Micro-Economic Policy Analysis Branch

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Introduction

Innovation, defined as the process of generating and applying new ideas to the creation and upgrading of products, processes, and services, is a key driver of productivity and economic growth, and thus a fundamental determinant of a country's standard of living.

There are various indicators for assessing a nation's innovation performance, including research & development (R&D) spending, patents and innovation counts based on innovation surveys.

> Canada's Innovation Strategy was launched on February 12, 2002, with the release of two companion documents: Achieving Excellence: Investing in People, Knowledge and Opportunity and Knowledge Matters: Skills and Learning for Canadians. The papers highlights goals, milestones and targets that will improve innovation, skills and learning in Canada.

The purpose of this special report is to review a comprehensive set of indicators, measuring innovation performance of Canadian private and public sectors, industry and provinces. The report also provides an analysis of Canada's innovation performance compared to other major economies.

Assessing innovation activity through research expenditures alone does not provide a comprehensive measure of innovation. R&D (research & development) is an input of the innovation process. Since inputs can be used more or less efficiently, one would like to have indicators of the output side of the innovation process.

Patents are a more direct measure of innovation output than R&D spending. Many innovations are not protected by patents, with the propensity to patent being likely to vary across sectors and classes of firms. Moreover, many patents are never translated into commercially viable products and the economic impact of individual patents may differ considerably.

Besides R&D and patents, there is another possible approach to measuring innovation. This approach is based on innovation surveys that attempt to measure more aspects of the innovation process.

The overview section highlights some of the findings in the report.

- R&D

  - Canada's R&D intensity -- R&D spending as a share of GDP -- is considerably below the OECD average. However, Canada experienced the fastest growth in R&D intensity among the industrialized countries over the 1981-2000 period.

  - The government's share of gross expenditure on R&D decreased substantially in the past twenty years but is still higher than the OECD average.

  - Industries and universities account for almost 90% of all R&D spending in Canada. Almost 70% of business expenditures on R&D is concentrated in the goods producing sector with most of it in the Electrical and Electronic industry.

  - In 1999, Quebec, Ontario and Nova Scotia had the highest R&D expenditures as a percentage of GDP.

  - Two-thirds of R&D expenditure in the business sector is performed by large firms (with 500 or more employees). However, small firms (with 1 to 99 employees) devote a much greater share of their revenues to R&D than large firms.

- One-fifth of Canada's business expenditure on R&D (BERD) is concentrated in the Telecommunication industry, while the Aircraft & Parts and Engineering & Scientific industries, each contributes to about one-tenth of Canada's BERD.

- R&D financing by the private sector in Canada has been rising steadily in the 1990's, but remains considerably below that of the U.S. and of other major industrialized countries.

- The share of R&D funding by Canada's government sector has fallen in recent years, but it remains above other OECD countries.

- Foreign financing of R&D grew by 13% per year over the 1981-2000 period, raising the share of Canada's R&D funded by foreign sources from 4% in 1981 to 16% in 2000.

- Canada has a highly educated work force, but ranks low in the number of R&D personnel, defined in terms of full-time equivalent of persons who work on R&D projects, vis-a-vis other industrial countries.

- Ontario and Quebec have by far the largest shares of industrial R&D personnel in their labour force.

- Patents

Patents are one of the major means of protecting intellectual property rights and patent data are considered to be the most available, objective, and quantitative measure of innovation output. Thus, a country's patenting activity is an indicator of the strength of its research enterprise and of its technological strengths, both overall and in particular fields of technology. Individual inventors or corporations can apply for patents, both domestically or externally.

There are a number of reasons for inventors to apply for patents in other countries: (1) over the past few years the number of U.S. patents obtained by a country has become a norm against which to evaluate its innovative capabilities; (2) patents are first sought in the U.S. in order to evaluate and learn about the legal quality of a technology; and (3) if returns from innovations have to be quickly appropriated, it is the intellectual property in some target countries, such as the U.S., that have to be protected.

- In recent years Canada has experienced an increase in patenting activity. Non-resident patent applications have increased at a faster rate than domestic patent applications.

- Canadians file a much lower number of domestic patent applications per capita relative to other G-7 countries.

Overview (continued)

- Patent applications in Biotechnology and Computer-Related fields have increased at a faster pace than other fields in the 1990s. Nonetheless, Mechanical/Civil patents have continued to account for the largest share of applications filed in the 1990's.

- In 2000, Alberta, Ontario and Quebec accounted for the largest share of domestic patents per capita.

- Canada achieved the fastest rate of growth (20% annually over the 1981-1998 period) in the G-7 in external patent applications.

- In 1999, the number of U.S. patents issued to Canadian inventors was more than twice the number of Canadian patents issued to Canadians. During the same period, the largest number of U.S. patents of Canadian origin were in the Computer & Communications field.

- Over the 1994-1998 period, Nortel and Xerox were the top Canadian corporation with U.S. patents while the National Research Council of Canada was the Canadian research institution with the most U.S. patents.

- Quality of Patents

  - Quality of inventions, as measured by the number of citations of a patented invention, is significantly higher in Canada than other G-7 countries with the exception of the U.S. A similar pattern is observed in all technology fields, namely Chemical, Computer & Communications, Mechanical, Electrical & Electronic except for Drugs & Medicines where Canada has outperformed even the U.S. in 1999.

Overview (continued)

- Innovation counts based on survey results

  - Manufacturing firms in Canada are largely innovative. More than 80% of firms introduced a new and/or improved product or process between 1997 and 1999.

  - Almost 15% of innovative firms who introduced new products during the 1997-1999 period reported that new products accounted for more than 25% of their total sales.

  - The growth in the use of advanced technologies has picked up considerably since 1993. However, technology adoption was more concentrated in the larger firms.

  - Overall, foreign-controlled firms in Canada use more advanced technologies than domestic-controlled firms.

  - Establishments in Beverages, Primary Textiles, Paper & Allied Products, Primary Metals, and Electrical & Electronic Products industries tend to have the highest adoption rates of advanced technologies.

  - Although Canadian firms benefit from technology adoption, financial factors, the lack of skill workers and the small market are important obstacles to technology adoption in Canadian establishments.

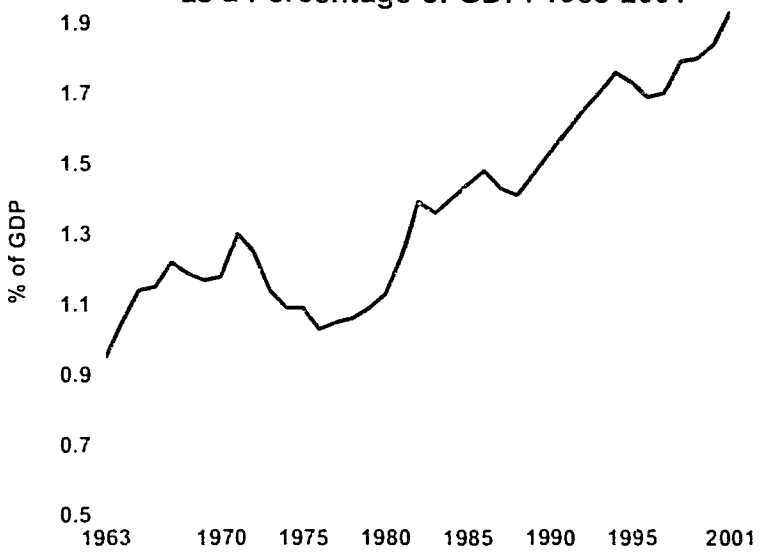
Input Innovation Indicator: R&D

Canada's R&D spending is rising...

- R&D investment in Canada hit a record $20.9 billion in 2001. R&D intensity has risen from less than 1% in the early 1960s to 1.9% in 2001.

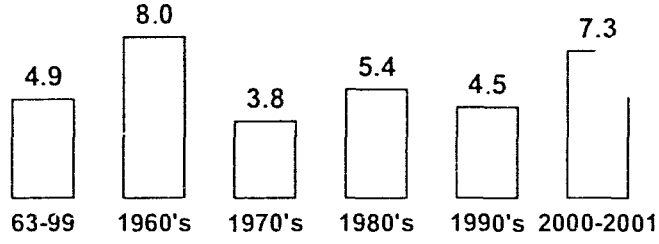
- In real terms, total R&D expenditures grew at an average rate of 4.5% during the 1990s, a slightly lower rate than in the 1980s. However, over the 2000-2001 period our R&D spending accelerated, growing at an impressive rate of 7.3% per year.

Canada's Gross Expenditure on R&D (GERD) as a Percentage of GDP: 1963-2001



Source OECD. Main Science and Technology Indicators 2002-1 and Statistics Canada. series V13682131 V3840593 V646937

Canada's Average Growth Rates for Real R&D Expenditure: 1963-2001 (% per year)

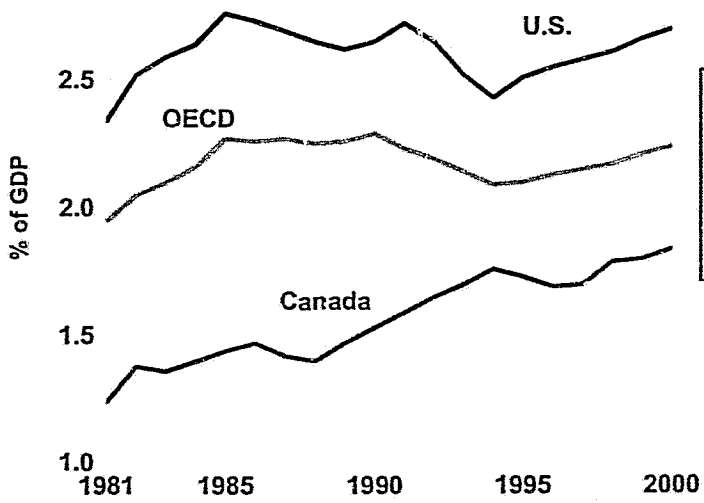


Source Statistics Canada. series V13682131 V3840593 V646937

...but its R&D intensity remains well below the OECD average

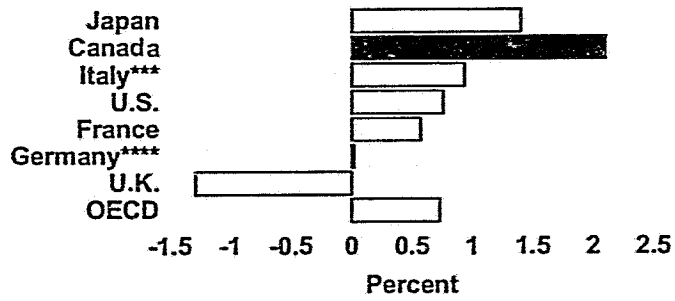
- Despite Canada's upward trend in R&D intensity, as measured by R&D expenditure as a percentage of gross domestic product (GDP), it has remained below the OECD average and ranked 14th among the OECD member countries in 1999, suggesting that Canada has a R&D gap.
- Canada experienced the fastest growth in R&D intensity over the 1981-2000 period among the G-7 countries, but still had the lowest R&D intensity after Italy.

Gross Expenditure on R&D (GERD) as a Percentage of GDP: 1981-2000*



Average Annual Growth Rates of GERD**: (1981-2000)	
Canada:	4.9
U.S.:	4.0

Average Annual Growth of R&D Intensity: 1981-2000



*For most countries except Canada data for 2001 were not available.
**Calculated on a 1995$ basis using purchasing power parities.
***1999 for Italy.
****Unified Germany from 1991 and western Germany until 1990.
Source: OECD, Main Science and Technology Indicators, 2002-1.

Canada ranks low in R&D personnel

- R&D personnel is crucial for innovation and productivity growth.
- Canada had the strongest growth among the G-7 countries in the numbers of research scientists & engineers as well as R&D personnel over the 1981-1999 period.
- Nonetheless, research scientists & engineers and R&D personnel still constitute a smaller part of Canada's labour force relative to most other G-7 countries.

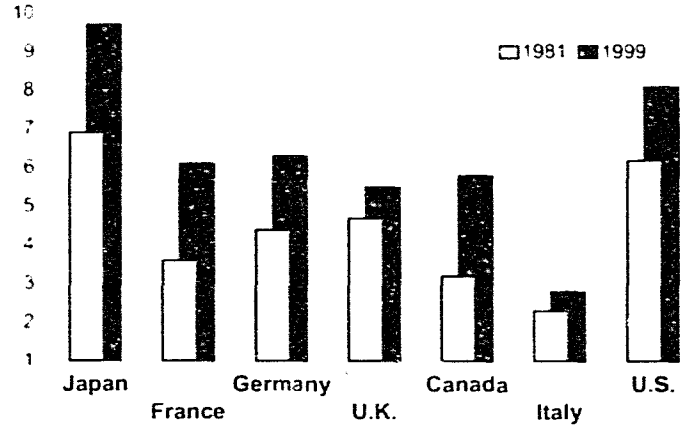
Changes (%) in R&D Personnel
Between 1981 and 1999

	A	B
Japan	67.8	41.6
France	87.6	26.3
Germany	104.7	33.7
U.K.	24.9	-17.6
Canad	132.5	79.6
Italy	24.6	38.3
U.S.	63.0	n.a.

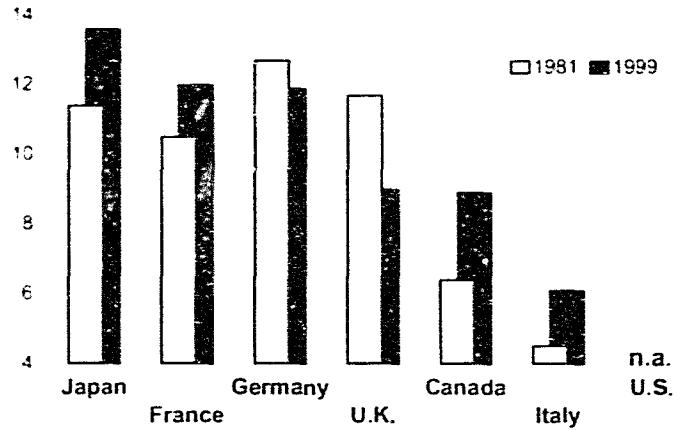
Note: A represents changes in scientists & engineers
B represents changes in total R&D personnel

*Number of full-time equivalent researchers performing R&D 1998 for the U K 1997 for the U S
**Total R&D personnel includes scientists engineers technicians and other related personnel 1993 for the U K
Source OECD Main Science & Technology Indicators 2002-1

Total Research Scientists & Engineers*
Per 1,000 Labour Force



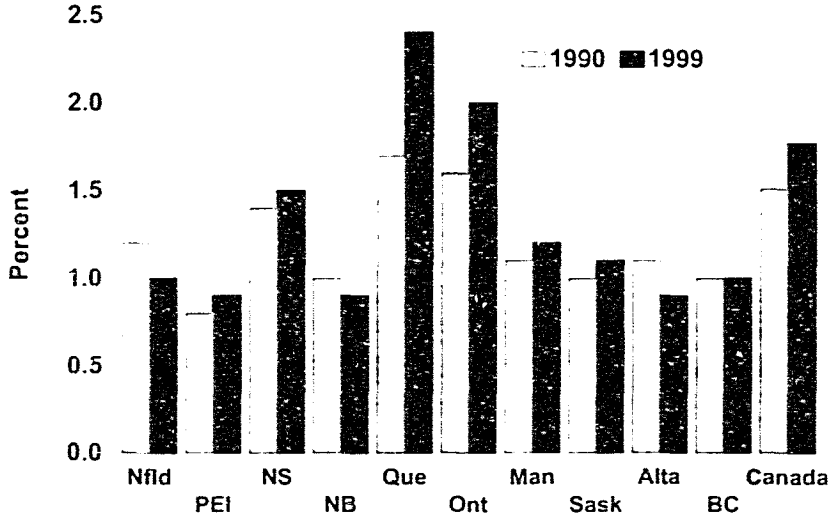
Total R&D Personnel**
Per 1,000 Labour Force



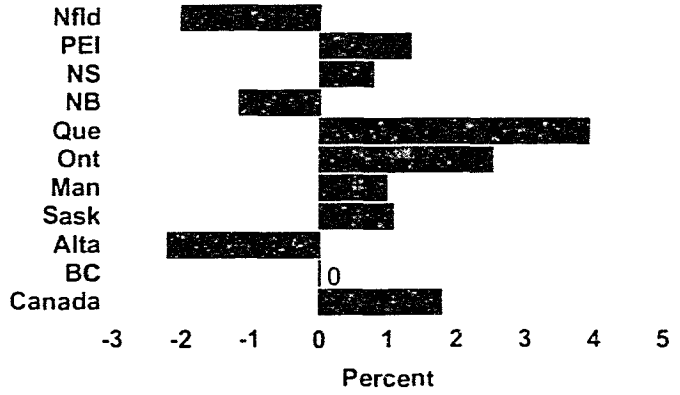
R&D is concentrated in larger provinces...

- Among all provinces, Quebec, Ontario, and Nova Scotia had the highest R&D intensity.
- From 1990 to 1999, Quebec enjoyed the highest growth rate in R&D intensity, followed by Ontario and Prince Edward Island.

Gross Expenditure on R&D (GERD) as a Percentage of GDP by Province



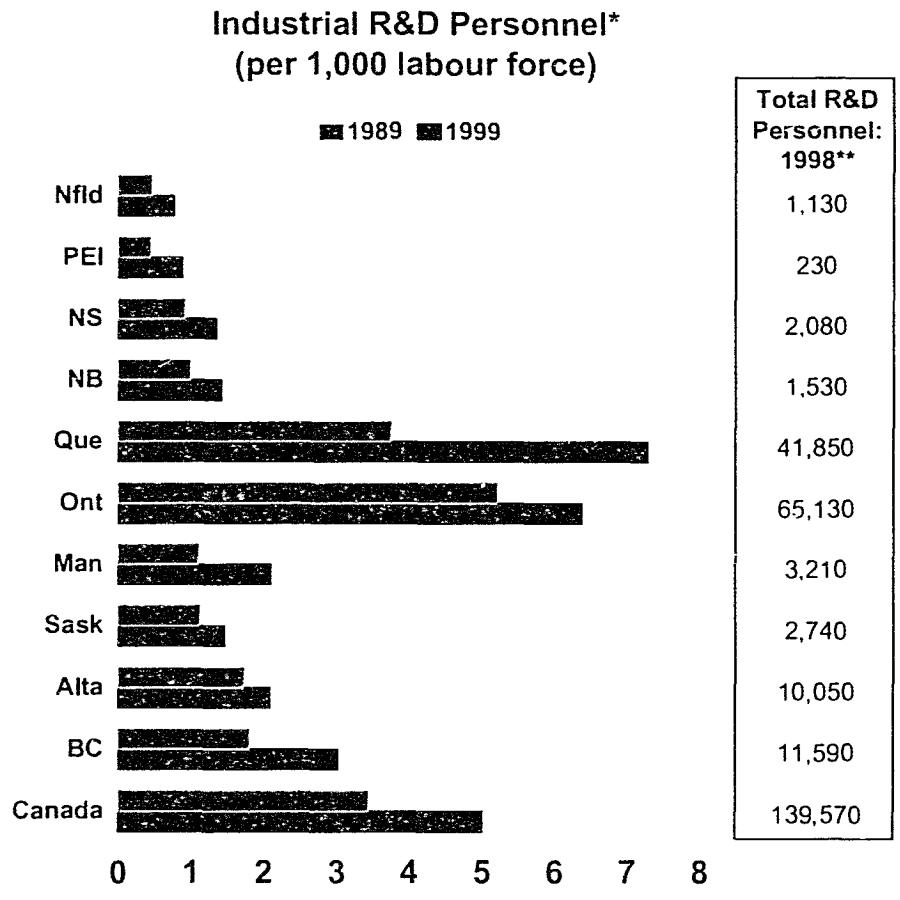
Average Annual Growth of R&D Intensity by Province: 1990-1999



Source: Statistics Canada, Science Statistics 2001

...as is R&D personnel

- Ontario and Quebec have by far the largest shares of industrial R&D personnel in their labour forces.
- However, the share of industrial R&D personnel has risen in every province.

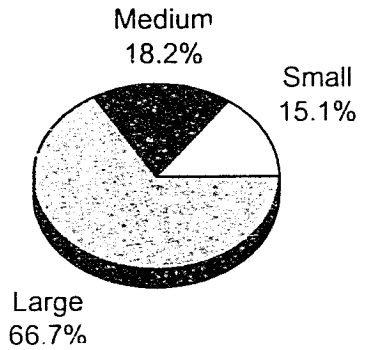


*Full-time equivalent of persons who work on R&D projects
**Source: Estimate of Research and Development Personnel in Canada, 1979 to 1999, Statistics Canada
Source: Industrial Research and Development - 2001 Intentions & Labour Force Survey, Statistics Canada

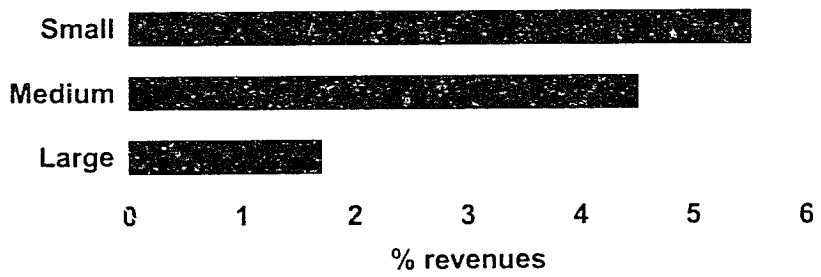
Large firms account for a large share of R&D...

- Roughly two-thirds of R&D expenditure in Canada is performed by large firms.
- However, small firms devote a much greater share of their revenues to R&D than large firms.

Canada's Concentration of R&D Expenditures by Firm Size*: 1999



Canada's R&D Expenditures as a Share of Revenues by Firm Size: 1999



Note: Firm size can be defined in several ways. However, the most commonly applied proxies of firm size are: sales and the number of employees.

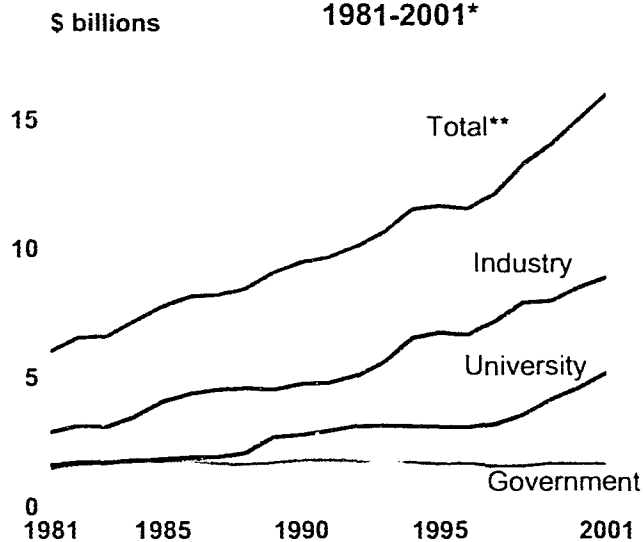
*Firm size: small 1-99 employees, medium 100-499 employees and large more than 499 employees

Source: Statistics Canada, Industrial Research and Development - 2001 Intentions

Industry and university expenditures on R&D have increased...

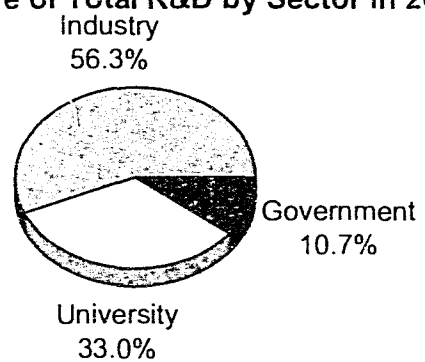
- Industries account for more than half of all R&D spending in Canada.
- Government spending on R&D (in real terms) has been flat over the past two decades and its share in R&D spending has continuously declined.

Canada's Real Gross Domestic Expenditure on R&D (GERD) by performing sectors: 1981-2001*



Average Annual Growth Rates: (1981-2001)	
Total:	5.0
Industry:	5.8
University:	6.1
Government:	0.7

Canada's Share of Total R&D by Sector in 2001***

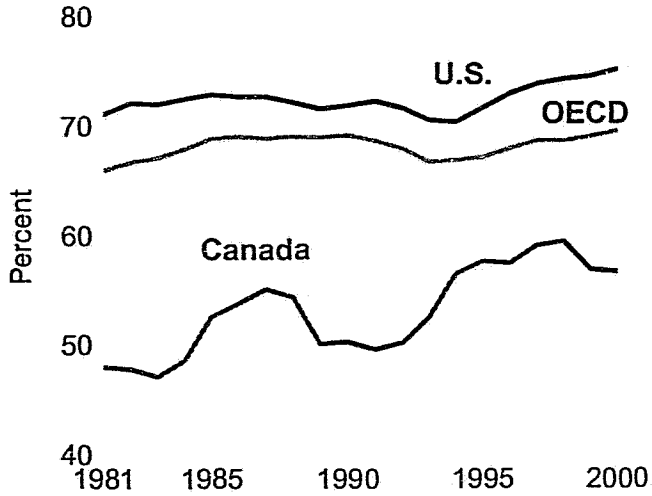


* Calculated on a 1995$ basis using purchasing power parities.
**Total also includes the private non-profit sector.
***Private non-profit sector distributed across sectors.
Source: OECD, Main Science and Technology Indicators, 2002-1.

...helping narrow the industrial R&D intensity gap

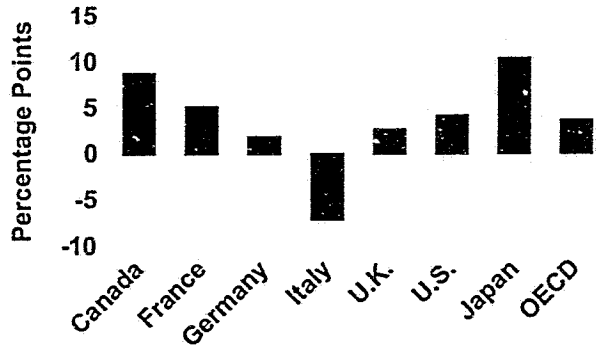
- Spending on R&D by Canadian industries has been lower than the OECD average through the 1980s and 1990s.
- However, the gap has narrowed substantially over time, and Canada, after Japan, experienced the highest increase among the G-7 countries in its share of gross expenditure on R&D by the industry sector.
- Industries expenditure on R&D increased by 5.8% per year during the 1981-2000 period compared to 4.3% in the U.S.

Industry's Share of Gross Expenditure on R&D (GERD): 1981-2000



Average Growth of BERD: (1981-2000)	
Canada:	5.8
U.S.:	4.3

Change in Share in the Industry Sector: 1981-2000*



*1999 for Italy.
Source: OECD, Main Science and Technology Indicators 2002-1.

But industrial R&D intensity still remains low internationally

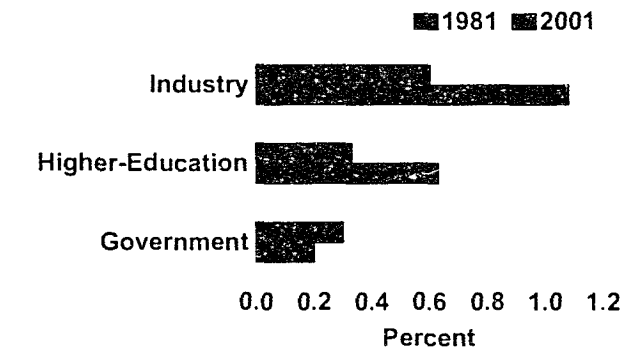
- The industry sector R&D intensity has been rising over time, reflecting strong growth in R&D expenditure.
- Still, in 2000, the U.S. industrial R&D intensity was nearly double that of Canada.

R&D Intensity Across Performing Sectors by Country: 1981 and 2000

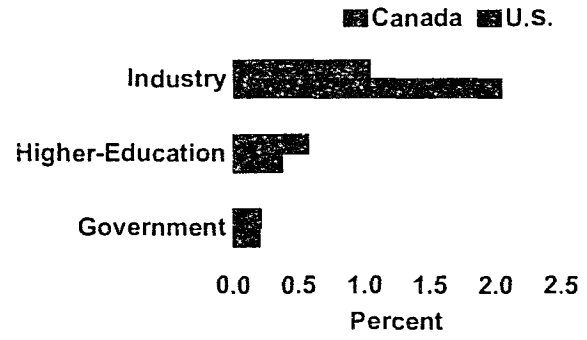
	1981		
	Canada	U.S.	OECD
Industry	0.60	1.67	1.29
Government	0.30	0.29	0.30
Higher-Ed.	0.33	0.31	0.31
Other	0.01	0.07	0.05
	2000		
	Canada	U.S.	OECD
Industry	1.04	2.04	1.56
Government	0.21	0.20	0.23
Higher-Ed.	0.57	0.37	0.38
Other	0.02	0.09	0.07

Source: OECD, Main Science and Technology Indicators, 2002-1.

Canada's R&D Intensity by Performing Sector



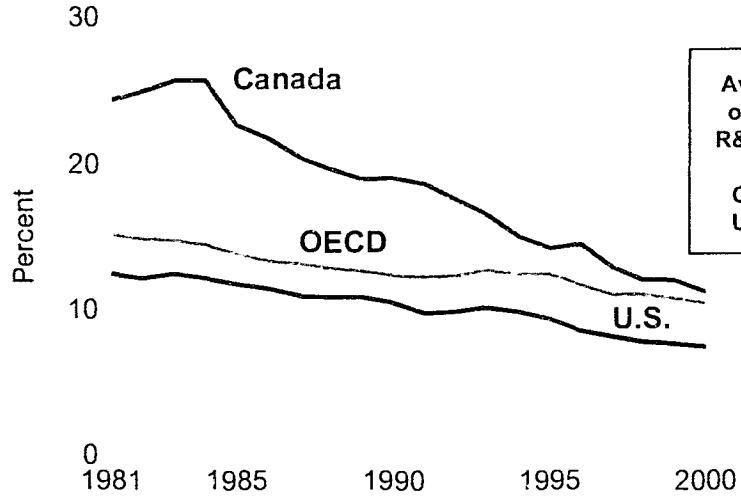
R&D Intensity, Canada vs. U.S.: 2000



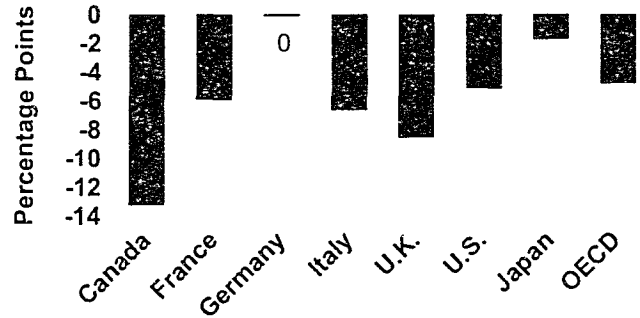
Government's share of R&D has fallen steadily...

- Government's share of total R&D spending has declined in most industrial countries since 1981.
- In Canada, government R&D expenditure grew by 0.7% per year over the past two decades. Nonetheless, its share in total R&D spending dropped from 24% in 1981 to 11% in 2000. This is the steepest drop among the G-7 countries.

Government's Share of Gross Expenditure on R&D (GERD): 1981-2000



Change in Share in GERD in the Government Sector: 1981-2000*

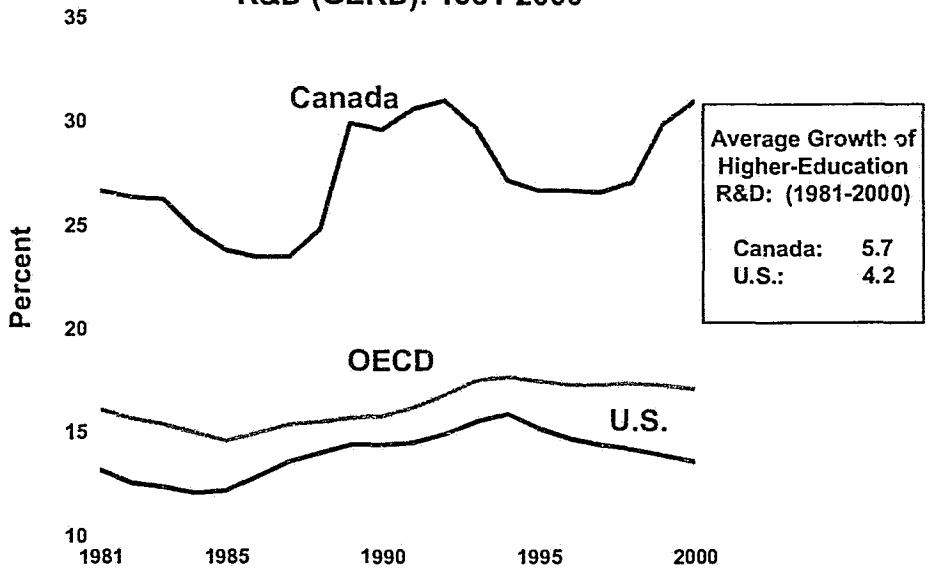


*1999 for Italy and 1995 for Japan.
Source: OECD, Main Science and Technology Indicators 2002-1.

...but it has risen in the Higher-Education sector and remains well-above the OECD average

- The share of total R&D spending by the Higher-Education sector in Canada is significantly above the OECD average.
  - Approximately one-third of the gross expenditure on R&D is concentrated in this sector.
- The Higher-Education sector's share of R&D spending in Canada increased from 27% in 1981 to 31% in 2000.

Higher-Education's Share of Gross Expenditure on R&D (GERD): 1981-2000



Change in Share in GERD in the Higher-Education Sector: 1981-2000*

*1999 for Italy and 1995 for Japan.
Source: OECD, Main Science and Technology Indicators 2002-1.

Growth of R&D Expenditures: High-Tech vs Low-Tech Industries

- Over the 1995-2001 period, Canadian High-Tech industries experienced the highest growth in R&D spending. While Medium-Low and Low-Tech industries decreased R&D spending.

- The High-Tech sector is also characterized by the highest R&D intensity, as defined by the ratio of R&D expenditures to revenues.

Canada's R&D Intensity and Growth of Gross R&D Expenditures by Industry*

	Annual Growth of Gross R&D Expenditures 1995-2001	Intensity 1999
High-Tech	10.8	8.8
Medium-High-Tech	2.9	0.7
Medium-Low-Tech	-0.6	1.0
Low-Tech	-1.2	0.4

*High-Tech includes: Business Machines, Pharmaceuticals, Telecommunication, Electronic Parts & Other Electronic Products, and Aircraft.

Medium-High-Tech includes: Scientific & Professional Products, Electrical Products, Motor Vehicles & Other Transportation Equipment, Chemical Products, and Machinery.

Medium-Low-Tech includes: Rubber Products, Plastic Products, Primary Metals (ferrous and non-ferrous), Refined Petroleum & Coal Products, Fabricated Metals, and Other Manufacturing.

Low-Tech includes: Food, Beverages & Tobacco, Textiles, Wood, Furniture & Fixture, Paper, Non-Metallic Mineral Products, and Printing & Publishing.

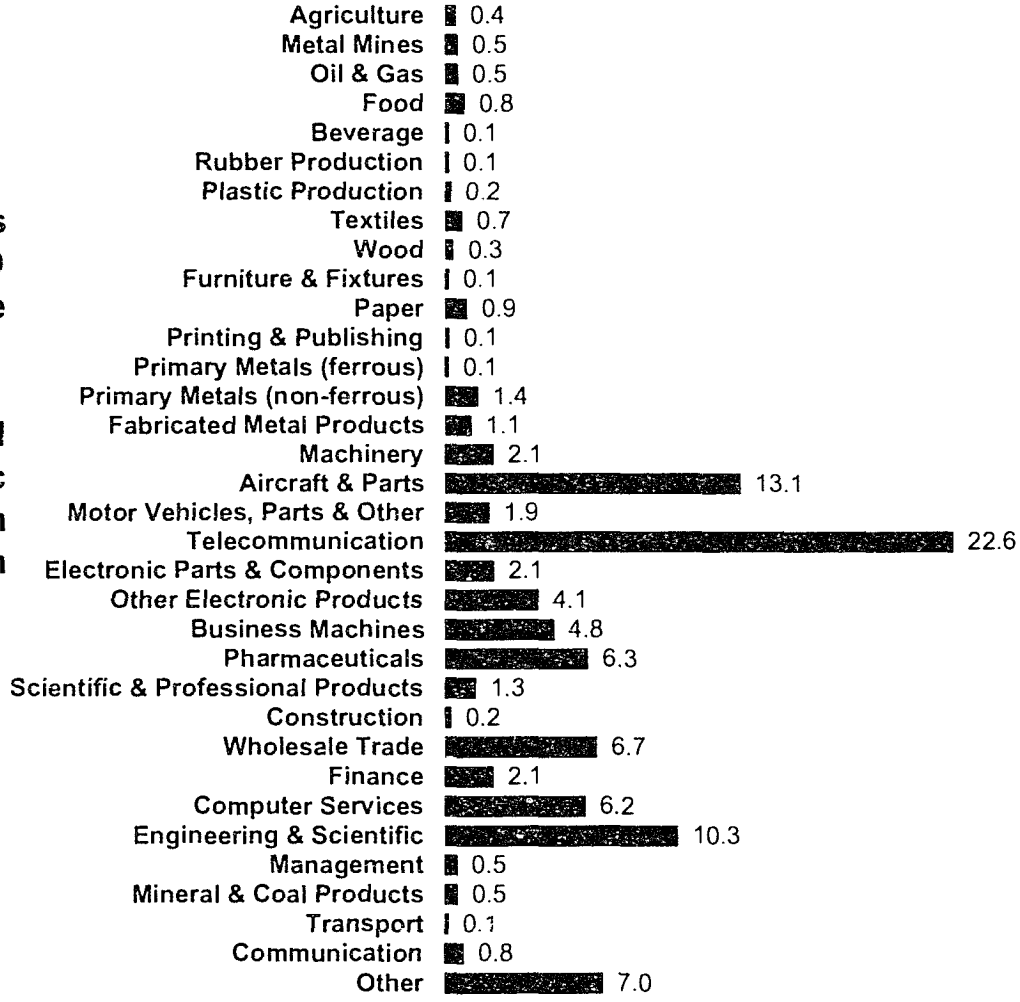
Source: OECD, *Revision of the High-Technology Sector and Product Classification*, 1997

Source: Statistics Canada, Industrial Research & Development, 2001 Intentions.

Telecommunication firms perform the most R&D...

- One-fifth of Canada's business expenditure on R&D (BERD) is concentrated in the Telecommunication industry.
- Aircraft & Parts and Engineering & Scientific Services industries, each contribute to about one-tenth of Canada's BERD.

Canada's Relative Share of R&D Spending by Industry Sector: 2001

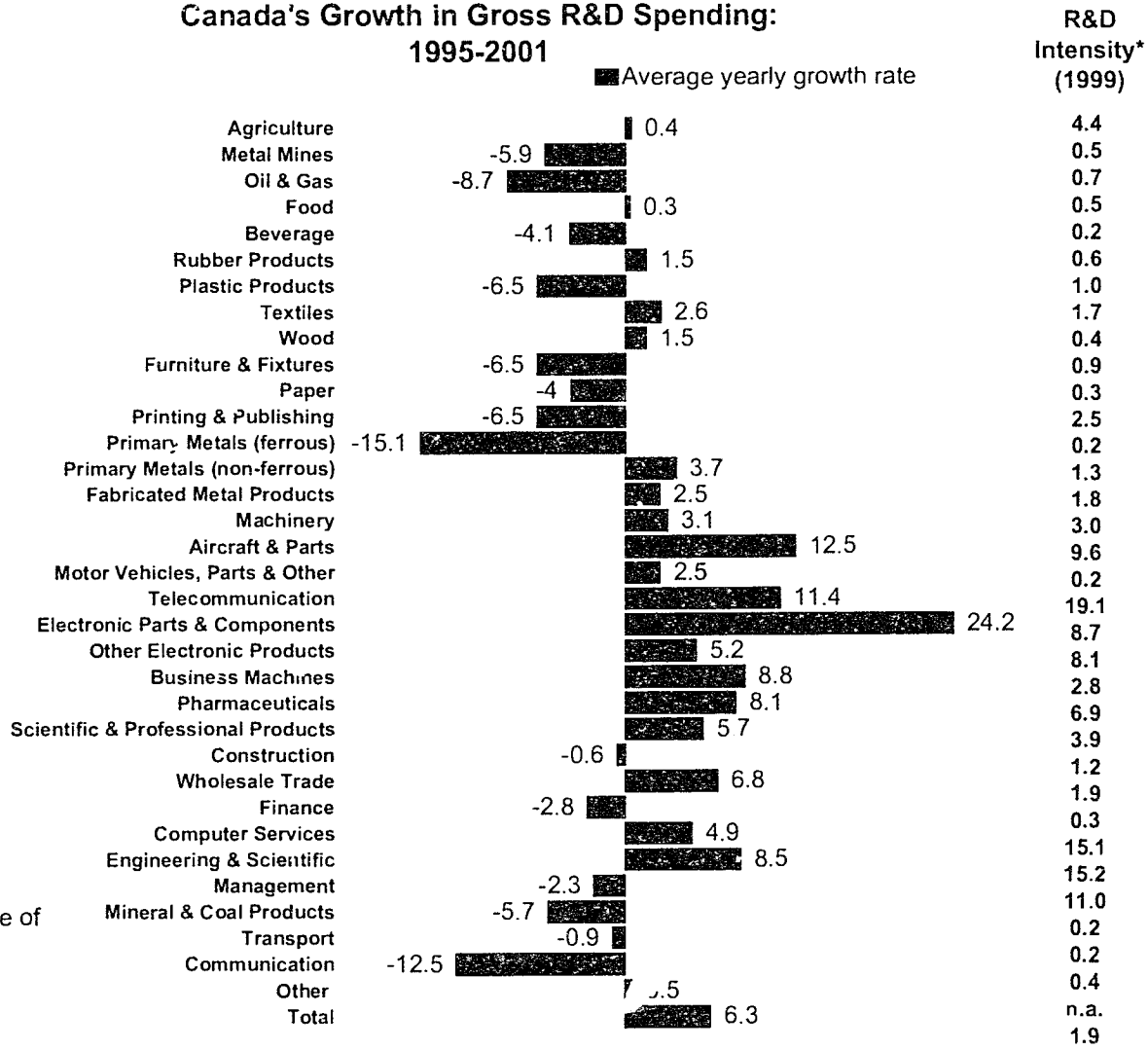


Source: Statistics Canada, Industrial Research & Development, 2001 Intentions

...and has the highest R&D intensity

- R&D gross spending growth was fastest in the Electronic Parts & Components industry, with annual growth of 24% during the 1995-2001 period.
- During the same period R&D in the Telecommunication industry grew by 11% annually. This industry had the highest R&D intensity level at 19% in 1999.

*Intensity is defined as the share of R&D expenditures relative to revenues.

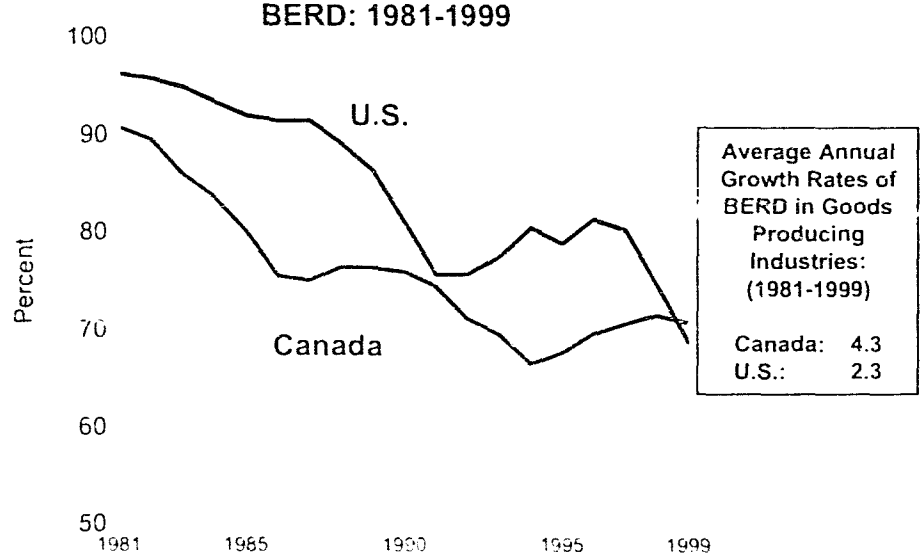


Source: Statistics Canada, Industrial Research & Development, 2001 Intentions.

Goods Producing industries' share of business R&D spending is dropping...

- The goods producing sector accounts for roughly two-thirds of business expenditure on R&D (BERD).
- Between 1981 and 1999, R&D expenditures by Canadian goods producing industries grew at a rate of 4.3% per year, but its share of BERD declined by 20 percentage points.

Share of Goods Producing Industries in BERD: 1981-1999



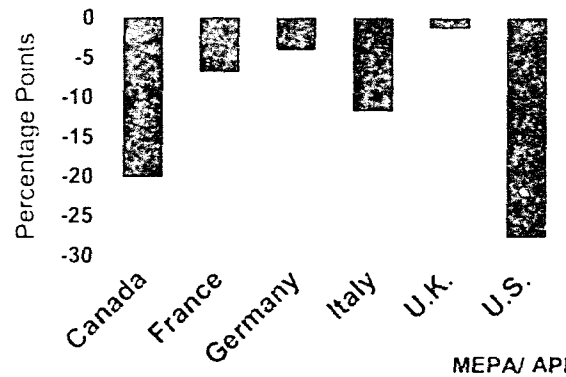
Share and Changes in Share of BERD in Selected Industries: 1981, 1999

	Share in percent				Difference	
	1981		1999			
	Canada	U.S.	Canada	U.S.	Canada	U.S.
Goods	90.8	96.3	70.8	68.8	-20.0	-27.5
Pharma.	2.4	4.0	6.4	6.7	4.0	2.7
Comp. & Off.	4.0	8.5	4.8	5.1	0.8	-3.4
Aerospace	12.1	23.1	11.6	7.9	-0.5	-15.2
Electro./Electri.	18.0	13.?	27.1	9.7	9.1	-3.5

*1986-1999 for the U.K

Source: OECD, Main Science and Technology Indicators, 2002-1.

Change in Share of Goods Producing Industries in BERD: 1981-1999*



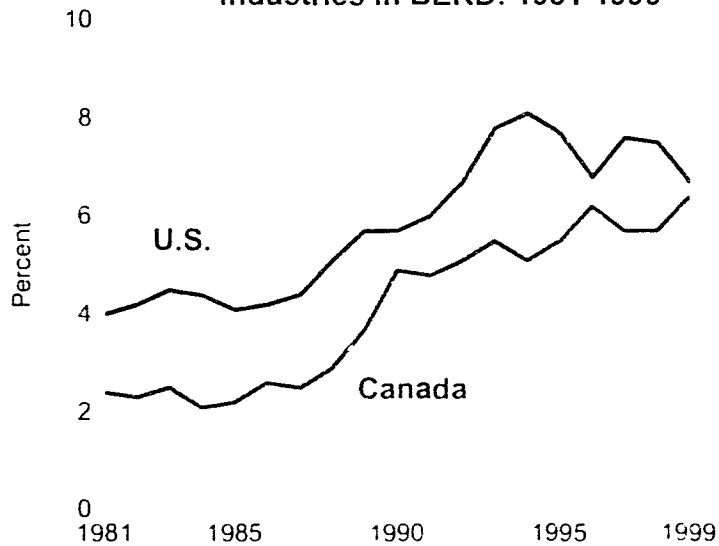
...but it is rising in Pharmaceutical industries

- R&D in Pharmaceutical industries in Canada increased 12% per year over the 1981-1999 period, outpacing growth in all other sectors.
- As a result, the share of the Canadian Pharmaceutical industries' R&D expenditure as a percentage of BERD rose from 2.4% in 1981 to 6.4% in 1999.

Average Annual Growth Rates of BERD by Industry: 1981-1999

	Canada	U.S.
Pharmaceutical	11.7	7.2
Computer & Office Equip.	6.9	1.3
Aerospace	5.5	-1.8
Electronic/Electrical	8.2	2.4

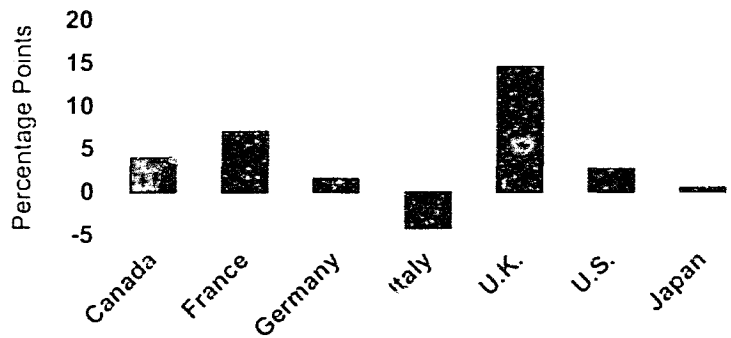
Share of Pharmaceutical Industries in BERD: 1981-1999



Average Annual Growth Rates of BERD in Pharmaceutical Industries: (1981-1999)

Canada: 11.7
U.S.: 7.2

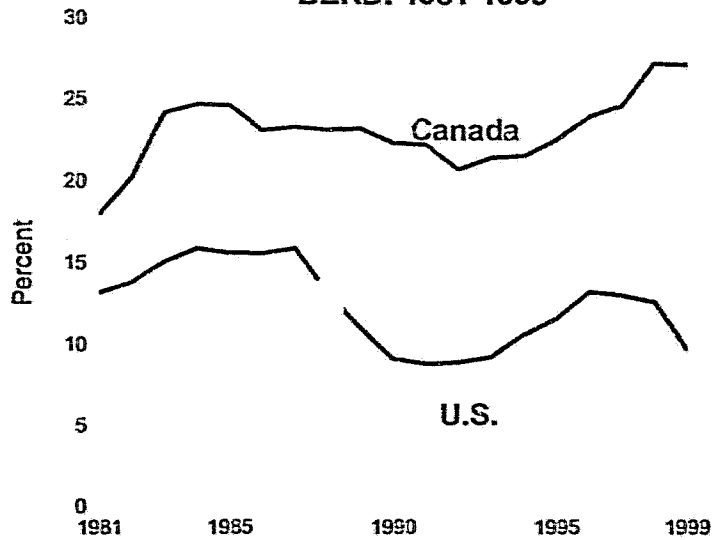
Change in Share of Pharmaceutical Industries in BERD: 1981-1999



Source: OECD, Main Science and Technology Indicators, 2002-1

- The Electronic/Electrical sector accounts for about one-third of BERD in Canada.
- During the 1981-1999 period, R&D expenditures in this sector grew at a rate of 8.2% per year in Canada compared to 2.4% annually in the U.S.
- Over the same period, the share of BERD in these industries rose by 9 percentage points in Canada.

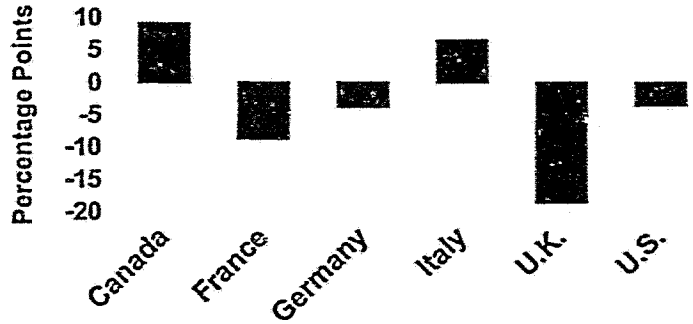
Share of Electrical/Electronic Industries in BERD: 1981-1999



Average Annual Growth Rates of BERD in Electrical/Electronic Industries: (1981-1999)

Canada:	8.2
U.S.:	2.4

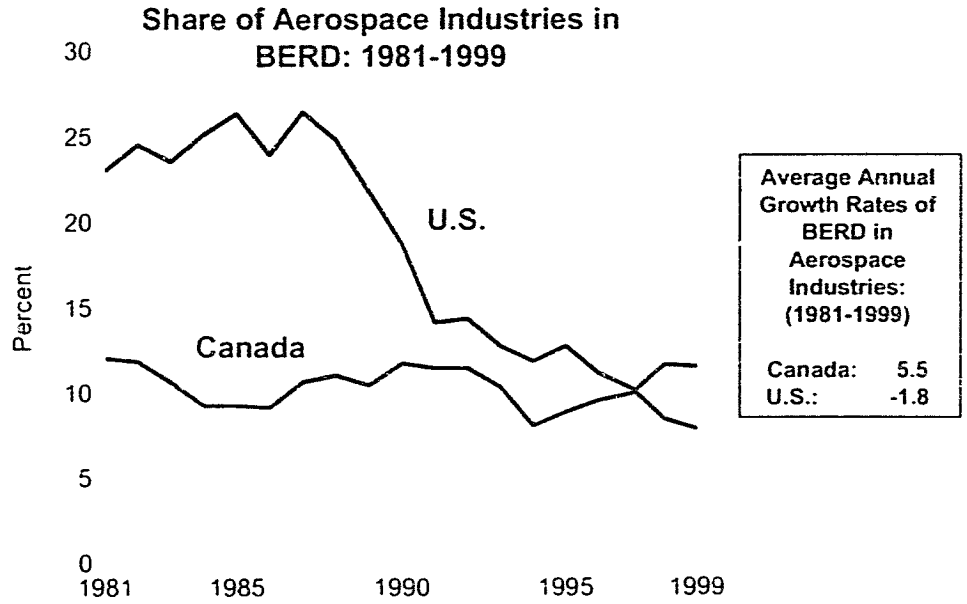
Change in Share of Electrical/Electronic Industries in BERD: 1981-1999

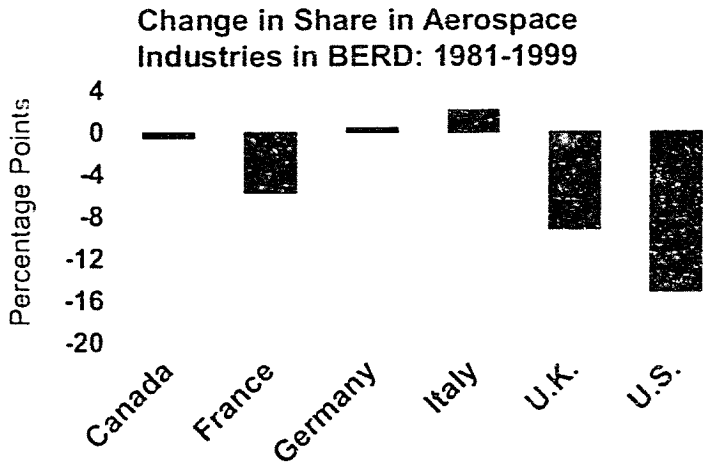


Source: OECD, Main Science and Technology Indicators, 2002-1.

...while falling in the Aerospace industry...

- Aerospace industries' R&D expenditure rose by an average yearly rate of 5.5% in Canada over the 1981-1999 period, while it declined in the U.S.
- Over the same period, the Aerospace sector's share of total BERD has declined in most of the G-7 countries, with the exception of Germany and Italy which experienced a very small increase.
- Between 1981 and 1999, the largest decline in the Aerospace industry's share of industrial R&D occurred in the U.S. (15 percentage points). Over the same period, Canada suffered a small decline of half a percentage point.



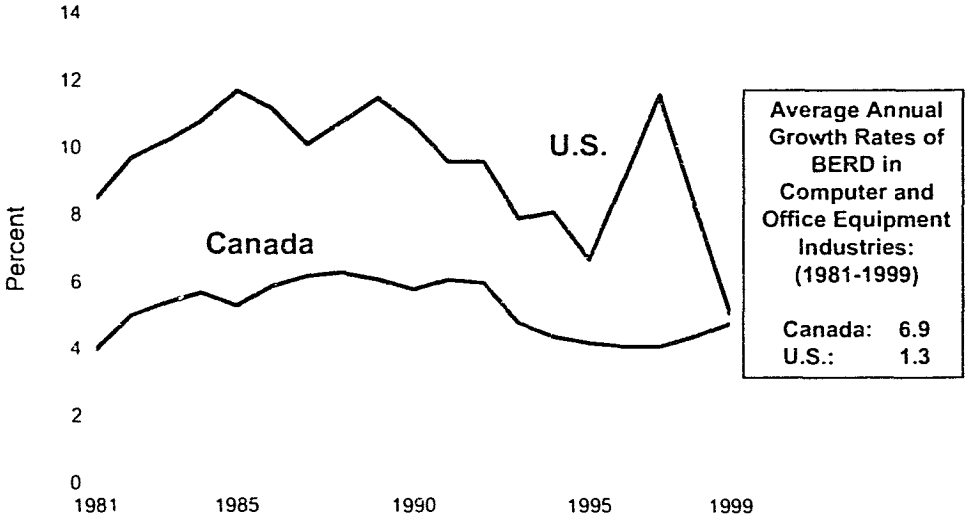


Source: OECD, Main Science and Technology Indicators, 2002-1.

...and increasing in the Computer and Office Equipment industries

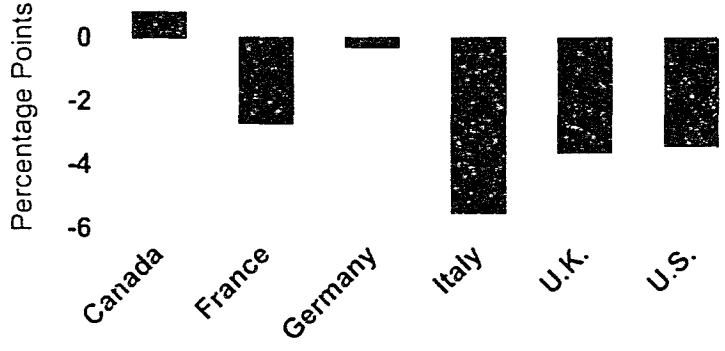
- R&D spending in the Computer and Office Equipment sector in Canada increased by 6.9% per year from 1981 to 1999, compared to 1.3% in the U.S.
- Over the same period, the sector's share of BERD rose by 0.8 percentage point.

Share of Computer and Office Equipment Industries in BERD: 1981-1999



Average Annual Growth Rates of BERD in Computer and Office Equipment Industries: (1981-1999)	
Canada:	6.9
U.S.:	1.3

Change in Share of the Computer and Office Equipment Industries in BERD: 1981-1999

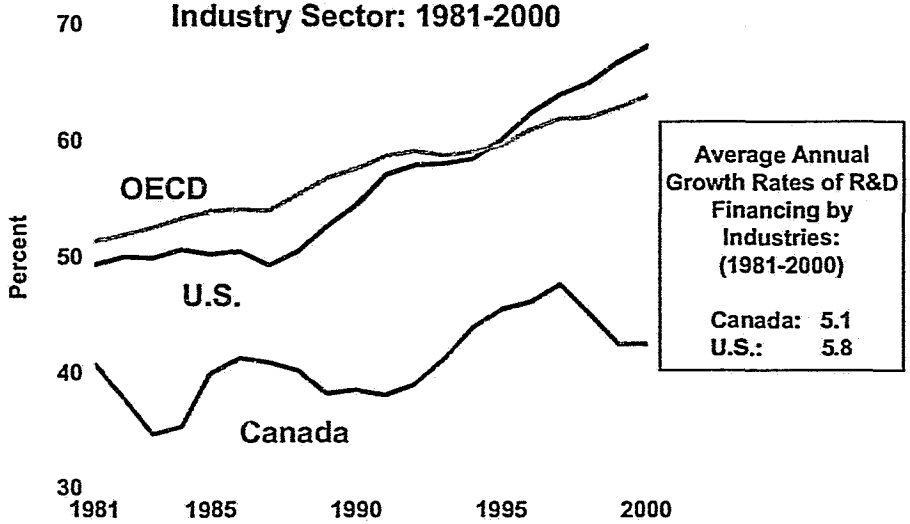


Source: OECD, Main Science and Technology Indicators, 2002-1.

The share of R&D funded by the industry sector is trending up

- The private sector share of R&D financing in Canada has been rising, but it remains considerably below that of the U.S. and of the OECD average.
- Over the 1981-2000 period, business R&D financing in Canada and the U.S. grew at an average yearly rate of 5% and 6% respectively.

Share of R&D Financed by the Industry Sector: 1981-2000



Share of GERD by Sources of Funds and by Country: 1981 and 2000

	1981		
	Canada	U.S.*	OECD
Industry	40.8	49.4	51.1
Government	50.6	47.8	44.4
Foreign	3.8	-	-
Other	4.8	2.8	2.9

	2000		
	Canada	U.S.	OECD
Industry	42.6	68.2	63.9
Government	31.8	27.3	28.9
Foreign	15.8	-	-
Other	9.8	4.4	4.5

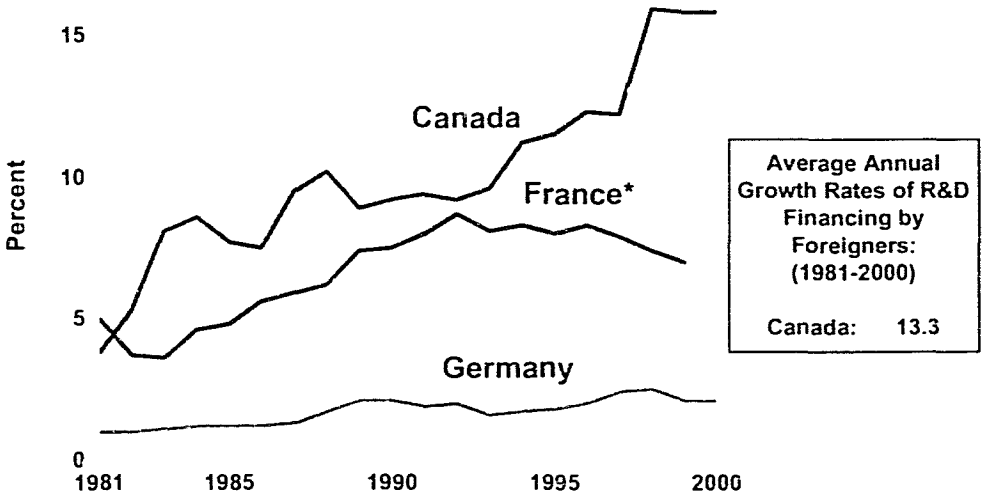
Change in Share of R&D Financed by the Industry Sector: 1981-2000**

*Data for the foreign sector not isolated.
**1995 for Japan, 1996 for Italy, and 1999 for France.
Source: OECD, Main Science and Technology Indicators, 2002-1.

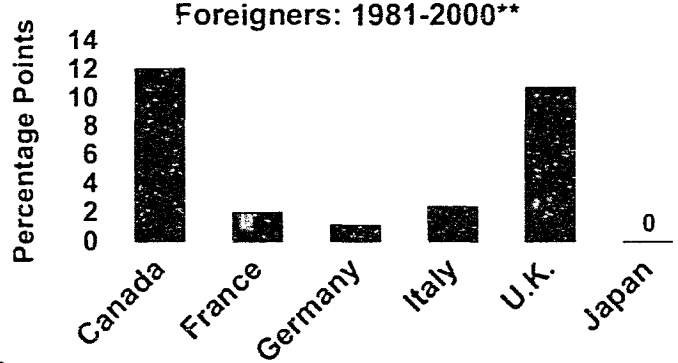
Share of foreign funding is also rising...

- Foreign financing of R&D grew by 13% per year over the 1981-2000 period, raising the share of Canada's R&D funded by foreign sources from 4% in 1981 to 16% in 2000.
- Over the 1981-2000 period, financing of R&D by foreign sources grew at a faster pace in Canada than other G-7 countries.

Share of GERD Financed by Foreigners: 1981-2000



Change in the Share of GERD Financed by Foreigners: 1981-2000**

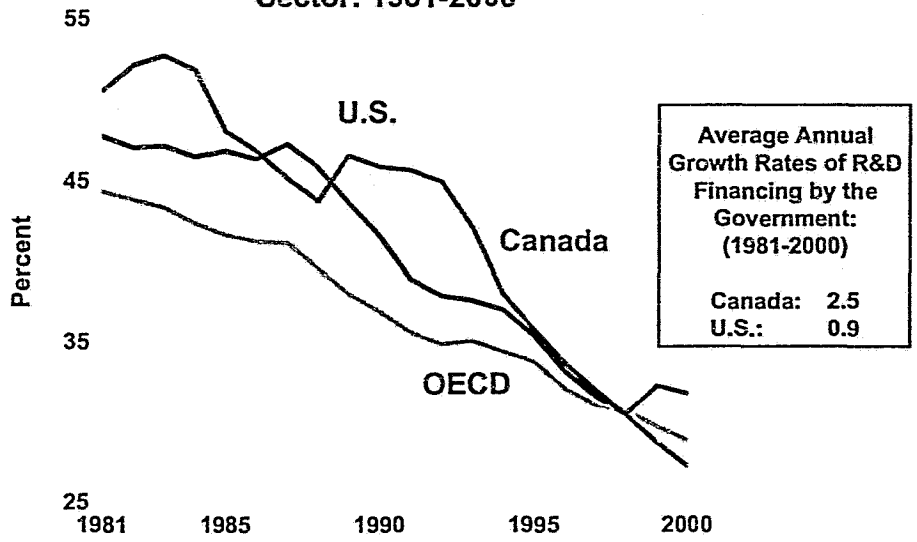


*1999 for France.
**1995 for Japan, 1996 for Italy, and 1999 for France; data for the U.S. were not available.
Source: OECD, Main Science and Technology Indicators, 2002-1.

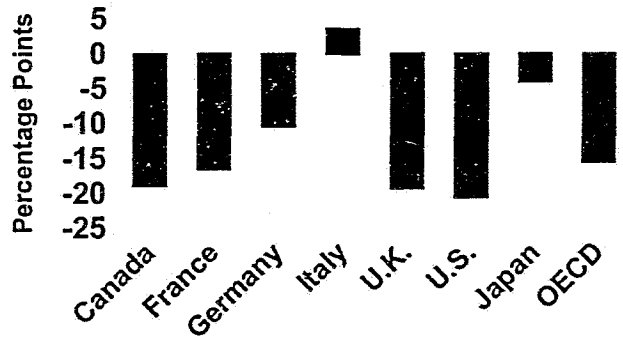
...but Government share of funding is falling

- Government financing of R&D in Canada grew by 3% per year on average during the 1981-2000 period.
- Given faster growth in other sectors, the share of R&D funding by Canada's government sector fell from 51% in 1981 to 32% in 2000.
- In the early 1980s, the government share of R&D funding was higher in Canada than the OECD average. But Canada's share is now close to the OECD average.
  - Over the 1981-2000 period, all OECD countries except Italy experienced a declining trend in the government's share of financing of R&D.

Share of R&D Financed by the Government Sector: 1981-2000



Change in Share of R&D Financed by the Government Sector: 1981-2000*



*1995 for Japan, 1996 for Italy, and 1999 for France.
Source: OECD, Main Science and Technology Indicators, 2002-1.

Output Innovation Indicator: Patents

Inventive activity in Canada has been increasing

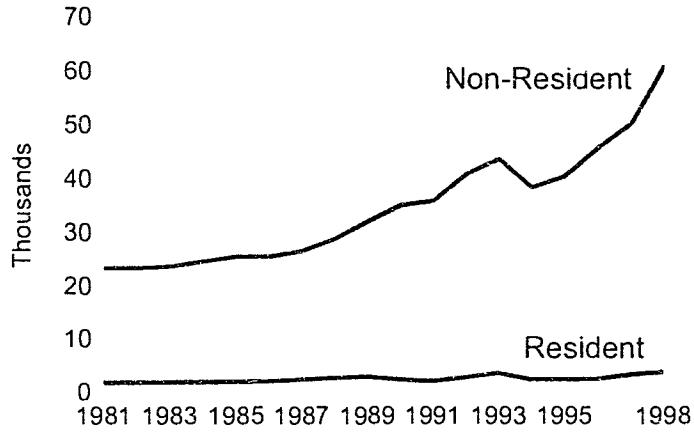
- In recent years Canada has experienced an increase in inventive activity, as measured by patenting activity.
- Non-residents accounted for 94% of all Canadian patent applications in 1998.
- The U.S. accounts for the largest share of non-resident patent applications in Canada. However, the U.S. share of Canadian patent applications is declining.

Share of Patent Applications in Canada Filed by Country of Residence

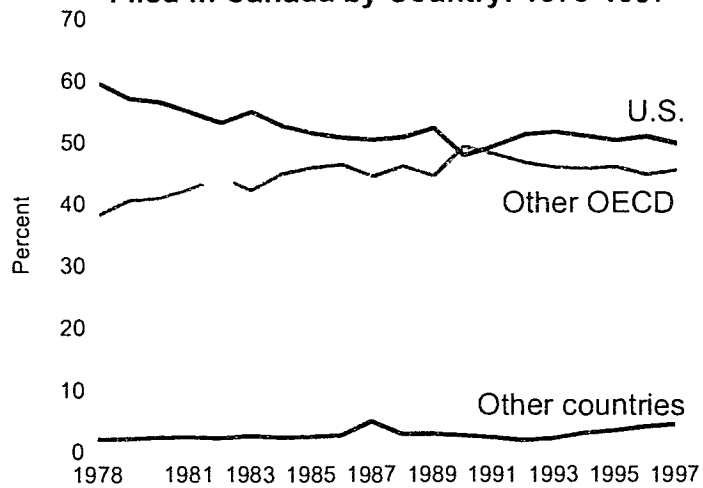
Country	1978	1997	Difference
Canada	7.6	6.3	-1.3
U.S.	59.6	49.9	-9.7
Other OECD	38.3	45.6	7.3
Other Countries	2.1	4.5	2.4

Note: Domestic or resident patent applications are applications that are filed by residents of the country. Non-resident or foreign applications in the country are applications that are made by foreigners.

Inventive Activity in Canada by Types of Patent Applications: 1981-1998



Share of Non-Resident Patent Applications Filed in Canada by Country: 1978-1997

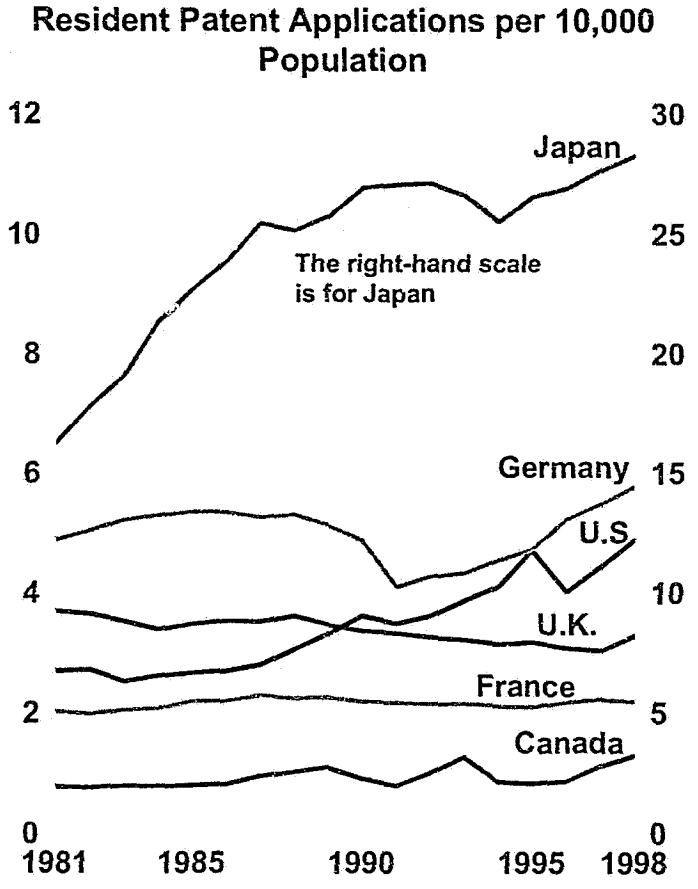


Source: OECD

Canada suffers from a substantial innovation gap vis-a-vis its competitors

- Patenting activities in most industrial countries are growing faster than ever before.
- Canada's filing of domestic patent applications per capita is the lowest among the G-7 countries, suggestive of an innovation gap relative to the other G-7 countries.

Note: The number of resident patent applications per 10,000 population is a proxy for the "inventiveness" of the country.

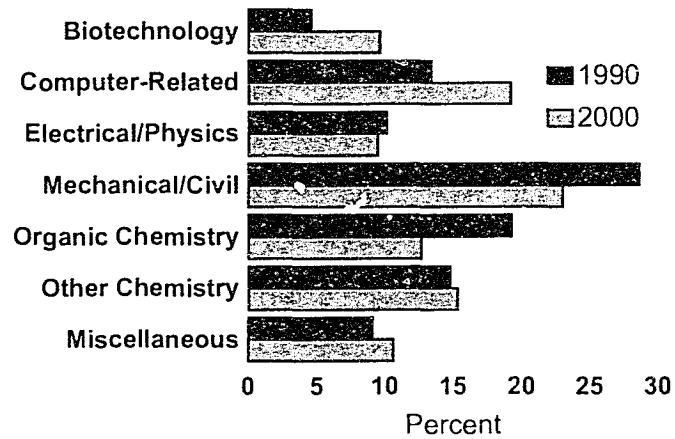


Source: OECD.

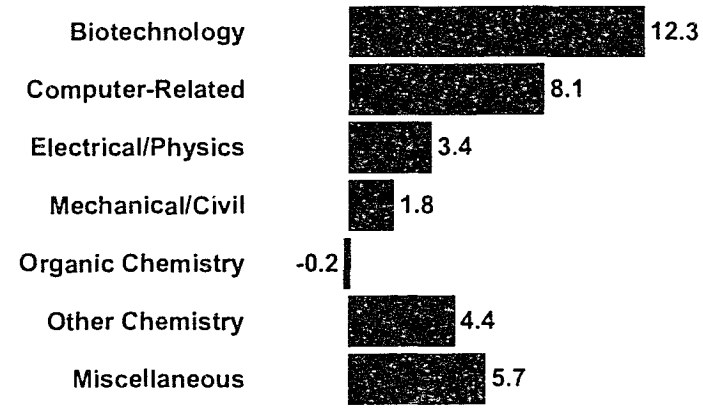
Growth in patenting activity in Canada is strongest in Biotechnology and Computer-Related fields...

- By major field, Mechanical/Civil patents accounted for the largest share of applications filed in Canada.
- However, the annual growth rate of patent applications in this field was relatively low compared to other fields.
- Patent applications in Biotechnology and Computer-Related fields have increased at a faster pace than other fields in the 1990-2000 period.
- As a result, the share of Biotechnology patents increased from 4.7% of the total in 1990 to 9.6% in 2000. Computer-Related patents accounted for 19.2% of the total in 2000, up from 13.4% in 1990.

Share of Patent Applications by Technology Fields*



Annual Growth in Patenting Activity by Technological Field: 1990-2000



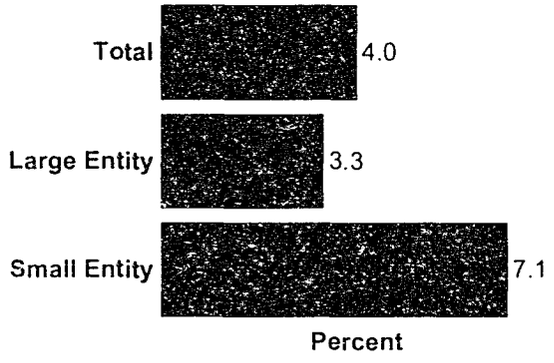
*Includes both domestic and foreign applications.
Source: CIPO.

...and is most evident among smaller entities

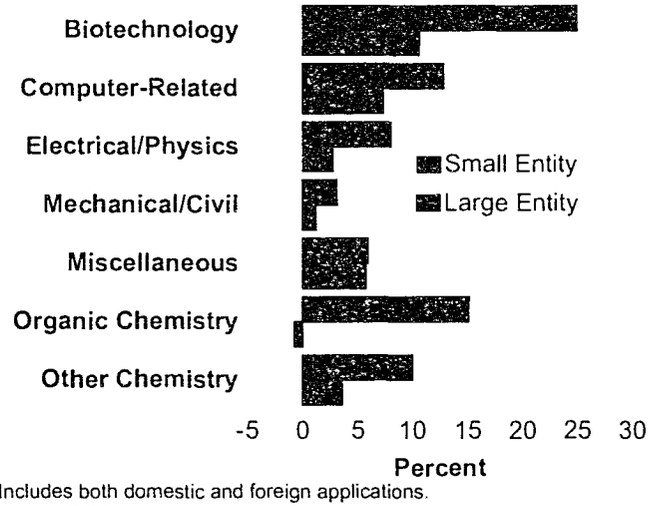
- Large entities accounted for just over three-quarters of all patent applications in 2000.
- However, the growth of patent applications has been faster for smaller entities across all major fields.

Canadian Intellectual Property Office (CIPO) defines "Small Entity" in respect of an invention as an entity that employs 50 or fewer employees or that is a university. (http://strategis.ic.gc.ca/sc_mrksv/cipo/help/glos-e.html)

Growth in Patenting Activity: Large vs. Small Entities: 1990-2000*



Growth in Patenting Activity by Entity Size and Technology Fields: 1990-2000*

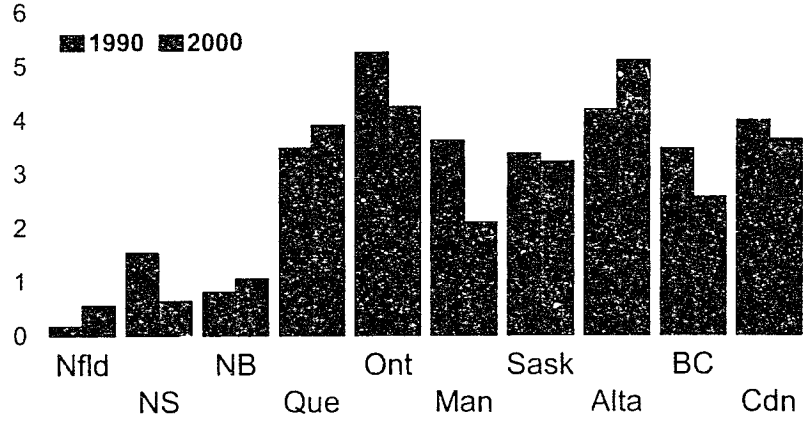


*Includes both domestic and foreign applications.
Source: CIPO

Alberta and Ontario patent more intensely than other provinces

- Canadian provinces differ significantly in patenting activities.
- In 2000, Alberta accounted for the largest amount of domestic patents per capita, followed by Ontario and Quebec.
- Overall, patents issued to Canadian provinces declined between 1990 and 2000.

Patents Issued per 100,000 Population by Canadian Province*



*Data for Prince Edward Island not available.
Source: CIPO.

Canada's Patenting Activity Abroad

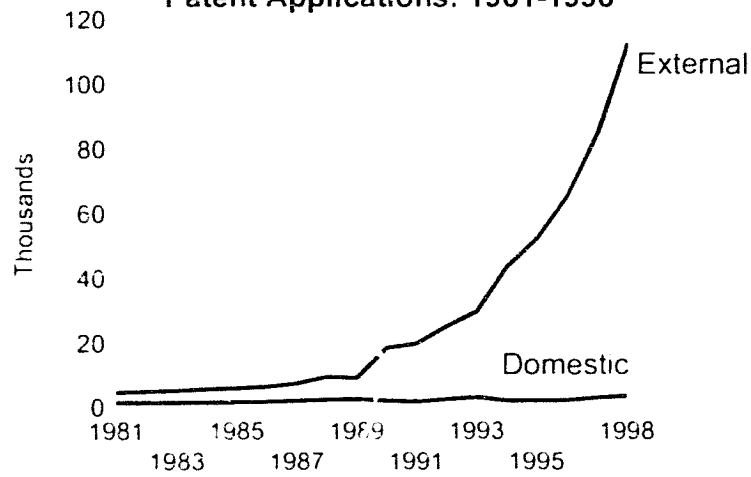
Canadians are increasingly patenting abroad...

- The composition of patent applications by Canadians has shifted dramatically.
- External patent applications by Canadian inventors have grown at a much faster rate than domestic applications. Over the 1981-1998 period, external applications increased at a rate of 20% per year, compared to 4% domestically.
- The share of Canada's external patent applications in the U.S. has declined sharply since 1978. Other OECD countries (all OECD excluding the U.S.) also experienced a steady decline in share, while non-OECD countries experienced an increase.

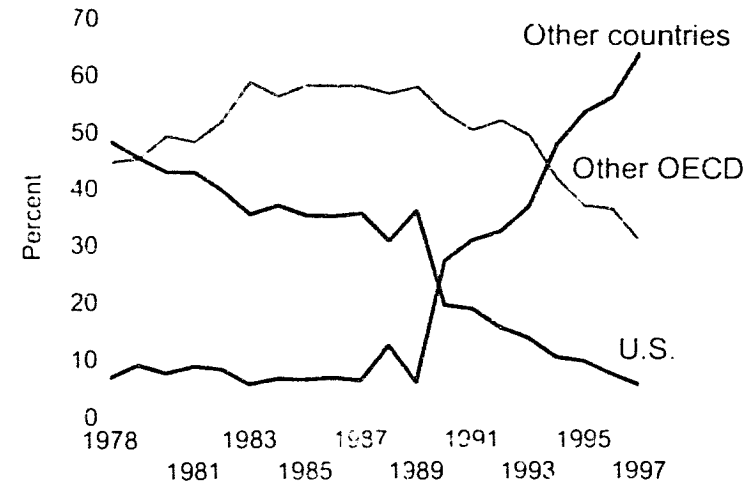
Foreign Country's Share of Total Patent Applications Filed by Canadians Abroad: 1978 and 1997 (in percent)

Country	1978	1997	Difference
U.S.	48.4	5.5	-42.9
Other OECD	44.7	30.7	-14
Other Countries	6.9	63.8	56.9

Patenting Activity by Canadians by Types of Patent Applications: 1981-1998



Share of Canada's External Patent Applications by Destination Country: 1978-1997

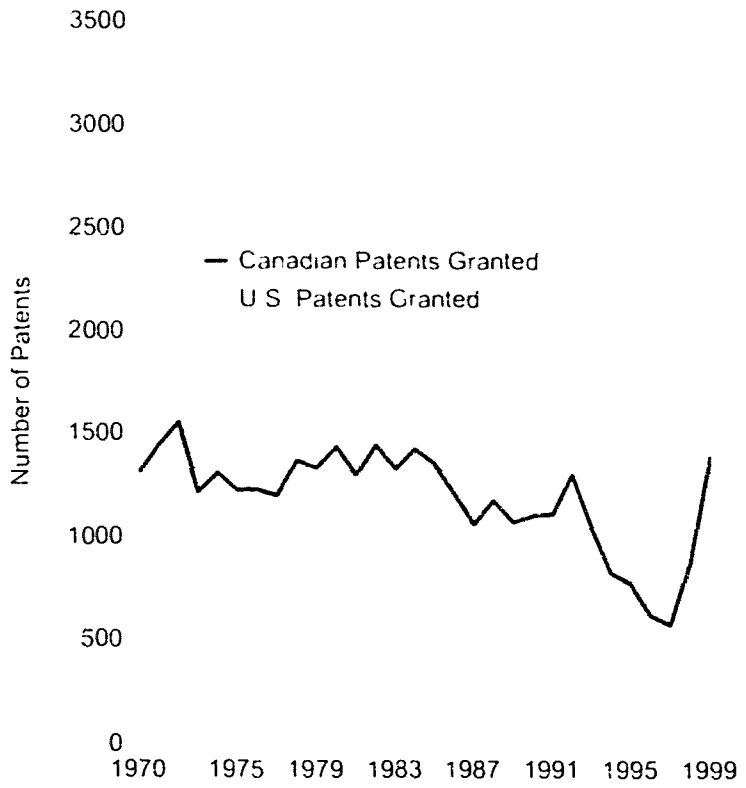


Source: OECD.

...including in the U.S.

- U.S. patents granted to Canadians are rising at a much faster rate than domestic patents.
- This suggests that U.S. patent data provide a more credible window into Canadian innovation performance than Canadian patent data.
- Between 1990 and 1999, the number of U.S. patents issued to Canadian inventors increased by 74% to 3,226. The number of Canadian patents issued to Canadian inventors over the same period increased by 26% to 1,389.

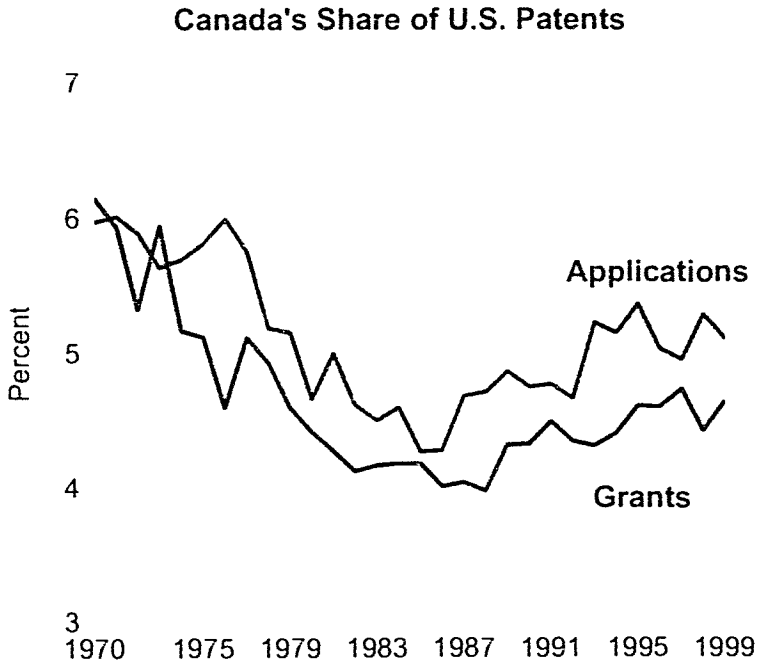
Comparison of Trends for U.S. and Canadian Patents Granted to Canadian Resident Inventors: 1970-1999



Source: USPTO and CIPO.

But Canada's share of U.S. patents has tended to decline...

- Canada's share of both applications and grants of U.S. patents of foreign origin has declined since 1970 despite a slight upward trend in the late 1980s.
- In 1999, Canadian inventors obtained about 4.6% of all U.S. patents issued to foreigners, and accounted for about 5.1% of all applications made by foreigners for U.S. patents.



Source: USPTO .

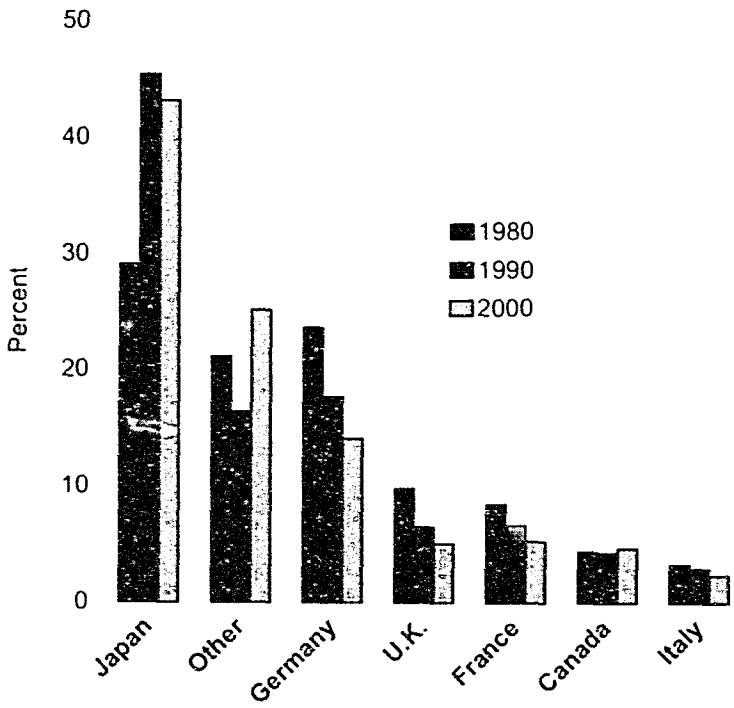
...like other G-7 countries

- Foreign patenting in the U.S. is highly concentrated by country of origin. In 2000, two countries -- Japan and Germany -- accounted for over 57% of U.S. patents granted to foreign inventors.
- Canada's share was 4.7% in 2000, a slight increase of 0.4% between 1990 and 2000.
- The lower share of European patenting in the U.S. may be attributable to the common European market, which has encouraged wider patenting within Europe.

Change in Foreign Inventor Share of U.S. Patents (in percentage points)

Country	1980-1990	1990-2000
Japan	16.3	-2.2
Others	-4.7	8.8
Germany	-5.9	-3.6
U.K.	-3.3	-1.4
France	-1.9	-1.4
Canada	-0.1	0.4
Italy	-0.4	-0.6

Share of U.S. Patents Granted to Foreign Inventors, by Nationality of Inventors

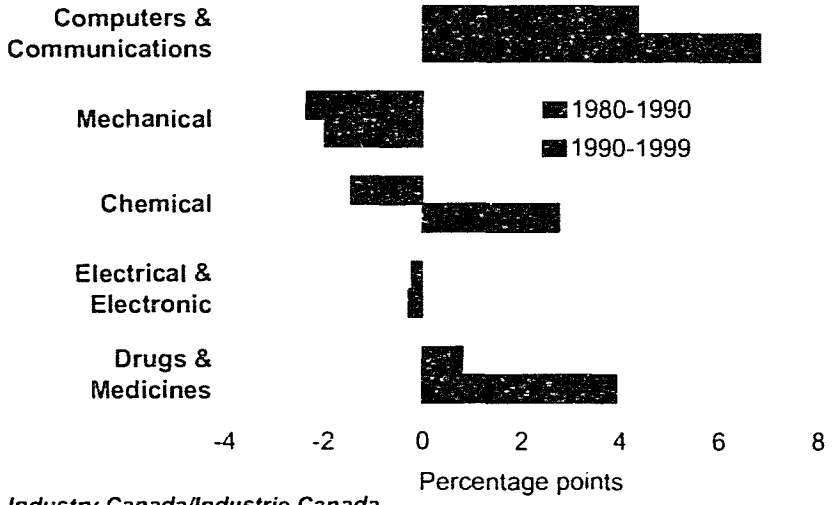


Source: USPTO.

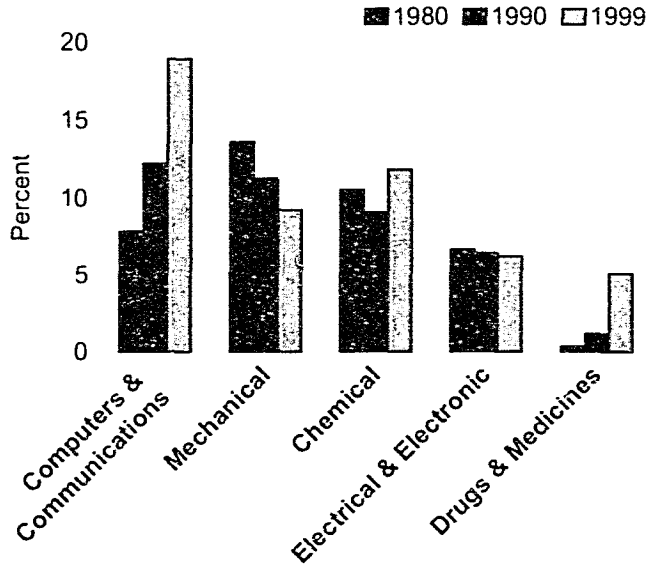
U.S. patents granted to Canadians in Computers & Communications technology are increasing...

- In the U.S., Canadian inventors are increasingly patenting in cutting-edge technologies that are expected to play an important role in future economic growth.
- Over the 1980-1999 period, the largest number of U.S. patents of Canadian origin were awarded to Computers & Communications technology. Over the same period, the traditionally strong Mechanical field lost ground.
- Over the last two decades, the largest increases in the share of U.S. patents of Canadian origin occurred in the Computers & Communications field, followed by Drugs & Medicines (albeit from a low base).

Change in Share of U.S. Patents in Selected Technology Fields



Share of U.S. Patents by Canadian Inventors in Selected Technology Fields

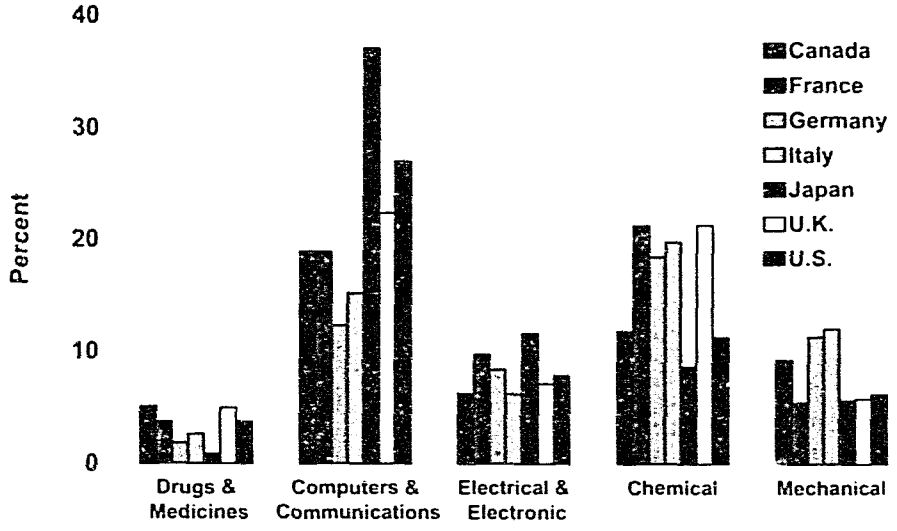


Source USPTO

...but we still lag behind other countries in this area

- Though Canada is strong in Computers & Communications technologies, our patenting activity in this field is still below all G-7 countries except Germany and Italy.
- Japan and the U.S., in particular, have significantly increased their shares of all U.S. patents in Computers & Communications over the 1990s.

Share of U.S. Patents by Country and Technology Field - 1999



Source: USPTO

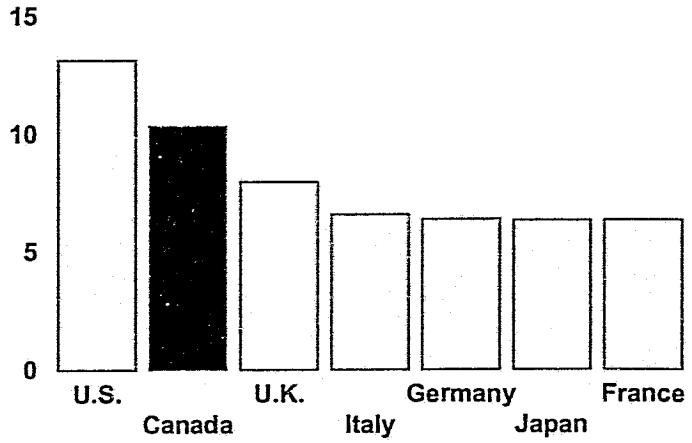
Changes in Share of U.S. Patents in Selected Technology Field by Country: 1990-1999 (percentage points)

	Canada	France	Germany	Italy	Japan	U.K.	U.S.
Drugs & Medicines	3.9	2.6	1.1	1.5	0.3	3.6	2.5
Computers & Communications	6.8	2.6	3.3	5.1	11.5	7.4	11.1
Electrical & Electronic	-0.3	0.6	0.7	-0.9	0.0	-1.3	-0.4
Chemical	2.8	2.9	-2.6	-1.4	-3.1	1.5	-1.5
Mechanical	-2.0	-4.4	-0.7	0.8	-1.7	-3.2	-2.4

Canadian inventions tend to be of high quality

- Citation per patent, a measure of the quality of inventions, is significantly higher in Canada than other G-7 countries with the exception of the U.S.
- Canada has a "quality gap" in patents, as measured by the "citation gap", relative to the U.S., though it leads all other countries in the number of citations per patent granted.
- In 1995, Canadian patents were "better" than Japanese patents by about 163%**. In that same year, U.S. patents were about 127% "better" than Canadian patents.

Citations per U.S. Patents Granted to G-7 Countries, 1995*



Source: USPTO.

An often-used quality indicator is the number of times a patent document is cited in other patent documents. Given the importance of the U.S. in the global market place, U.S. patent data offer a credible comparison of a country's performance with that of other nations.

*The calculation is based on the number of citations, cumulated over five years, to patents issued in 1995.
**If the average number of citations per patent of country A is C_a and that of country B is C_b, then the country A patents are $(C_a/C_b) \times 100$ percent better than country B patents.

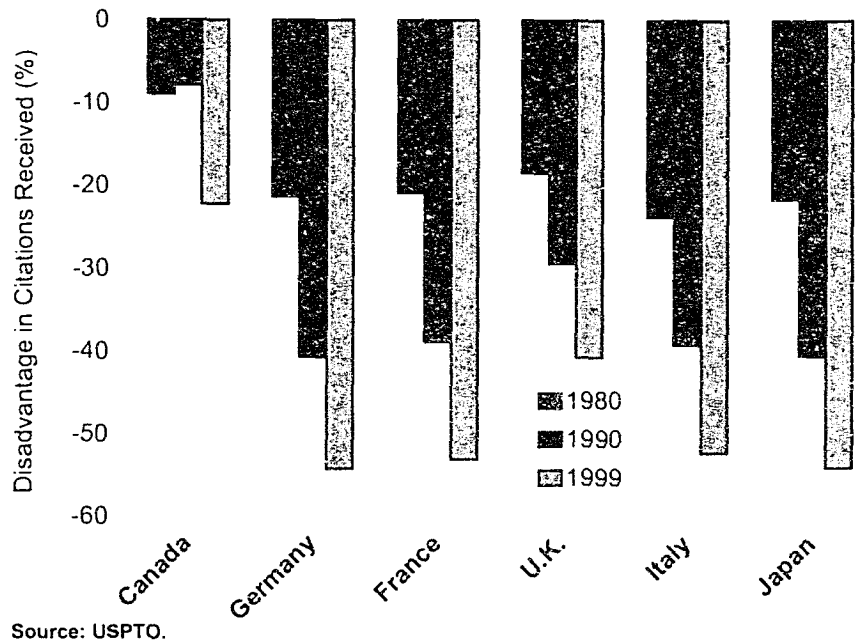
Relative to the U.S., the "quality" of Canadian patents is greater than other G-7 countries

- U.S. patents awarded to foreigners are generally cited less frequently than those awarded to U.S. inventors.
- As measured by citations, the "quality gap" between U.S. patents and all others is increasing over time. However, this "disadvantage" has increased at a slower pace for Canadian patents than for other countries.

Disadvantage of G-7 Patents Relative to U.S. Patents (%)

Country	1980	1990	1999
Canada	-9.0	-7.8	-22.2
Germany	-21.3	-40.7	-54.2
France	-20.9	-38.8	-53.0
U.K.	-18.5	-29.4	-40.7
Italy	-23.7	-39.1	-52.2
Japan	-21.6	-40.5	-54.0

Relative Importance of G-7 vs. U.S. Patents



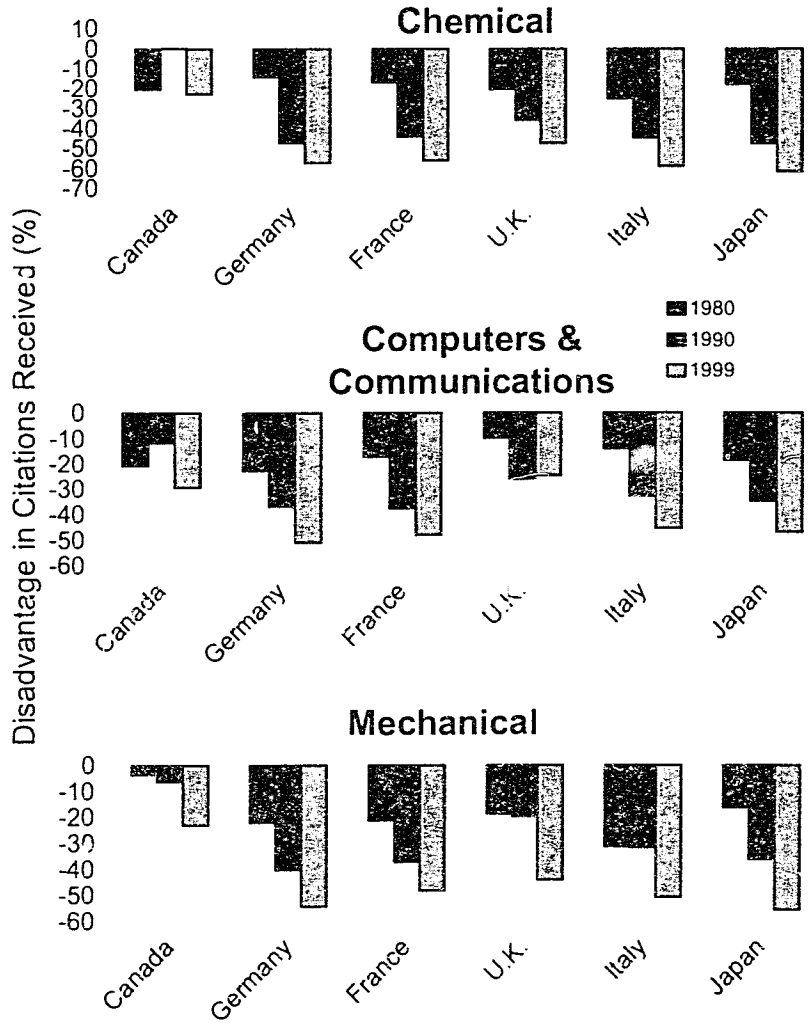
Source: USPTO.

Data on patent citations can be used to assess the "quality" of Canadian patents. The extent to which Canadian patents received lower citation rates than U.S. patents determines the disadvantage of Canadian patents relative to U.S. patents. Thus the "disadvantage" of Canadian patents vis-a-vis U.S. patents is defined as the ratio of the number of citations per U.S. patent of Canadian origin to the number of citations per U.S. patents of U.S. origin minus one expressed in percentage terms (e.g., Trajtenberg, M (2000). "Is Canada Missing the "Technology Boat"? Evidence From Patent Data, Discussion Paper Number 9, Industry Canada.

The quality of patents by technology fields

- U.S. patents awarded to U.S. residents are more frequently cited than patents from other countries across all technologies.
- Over time, the "quality" gap for Canada relative to the U.S. in all technologies increased in all fields except for the Drugs & Medicine and the Electrical & Electronic fields.
- Canada's quality gap vis-a-vis the U.S. has narrowed during the 1990s in the Drugs & Medicines and Electrical & Electronic fields.
- For other countries, the "quality" gap relative to the U.S. has widened over time across all technologies.

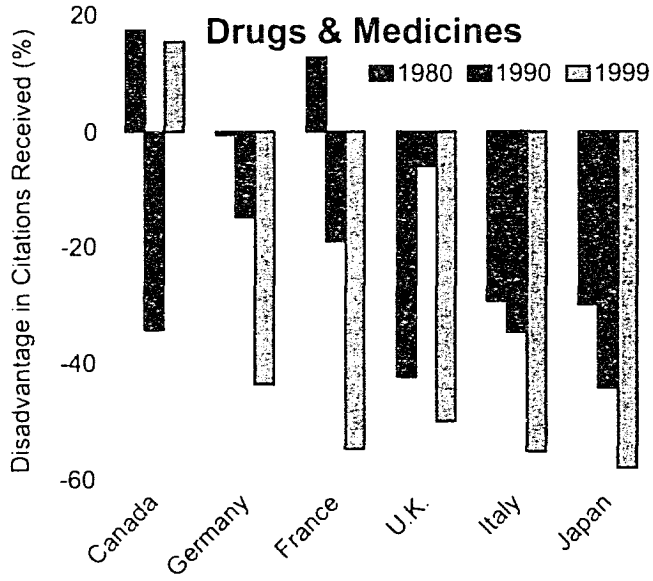
The Quality of Patents in Cutting-Edge Technologies
Relative to the U.S. by Country



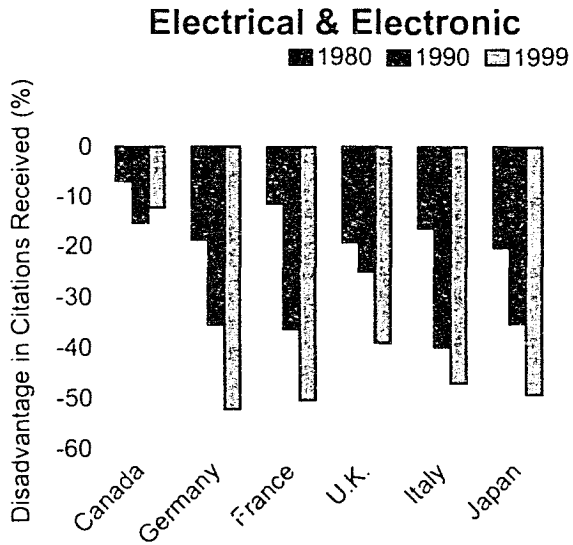
Source: USPTO.

The quality of patents by technology fields (continued)

The Quality of Patents in Cutting-Edge Technologies Relative to the U.S. by Country



The Quality of Patents in Cutting-Edge Technologies Relative to the U.S. by Country



Source: USPTO.

Patenting activity of Canadian companies and research labs in the U.S.

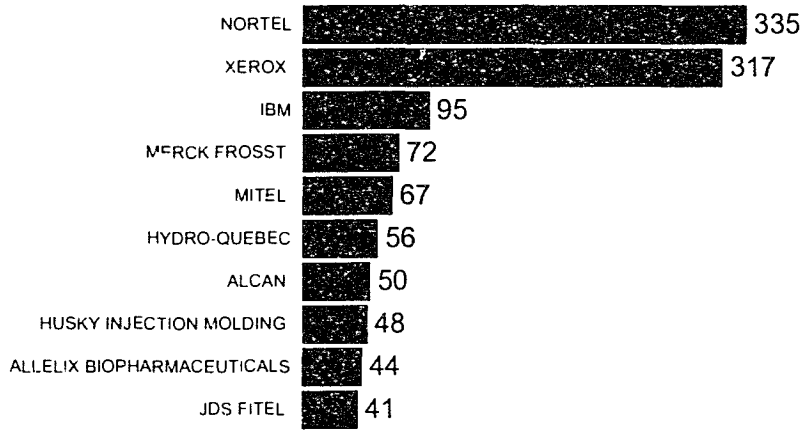
- Over the 1994-1998 period, 65% of Canadian-invented U.S. patents were issued to corporations with the rest issued to individual inventors. Just over one-third of all Canadian corporations with U.S. patents were issued at least 5 U.S. patents.

- Among those Canadian enterprises who were issued at least 5 U.S. patents over the 1994-1998 period, 10 corporations enjoyed the lion's share of the patent. These are large firms, typically in the high technology sector, with revenue ranging from $30 million to $26 billion in 1998.

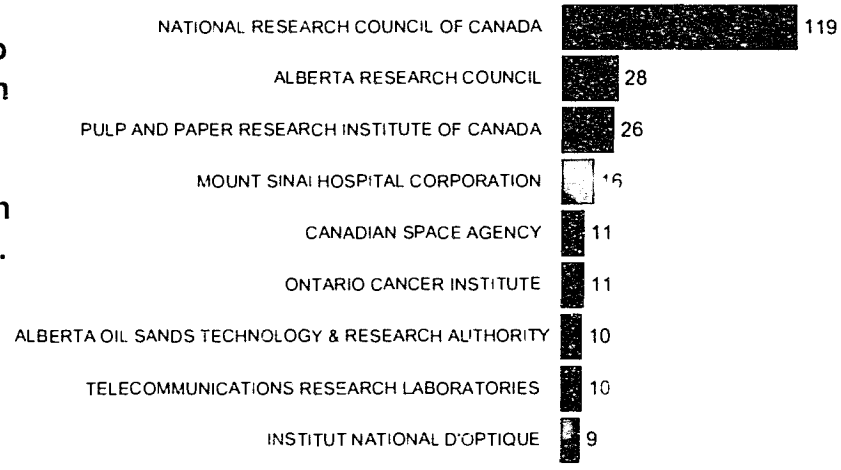
- Canadian research institutions also seek to commercialize their research results through the protection of intellectual property.

- Of these institutions, the National Research Council was the largest recipient of U.S. patents.

U.S. Patents Issued to Top-10 Canadian Corporations: 1994-1998



U.S. Patents Issued to Top-9 Canadian Research Institutions: 1994-1998



Source: USPTO

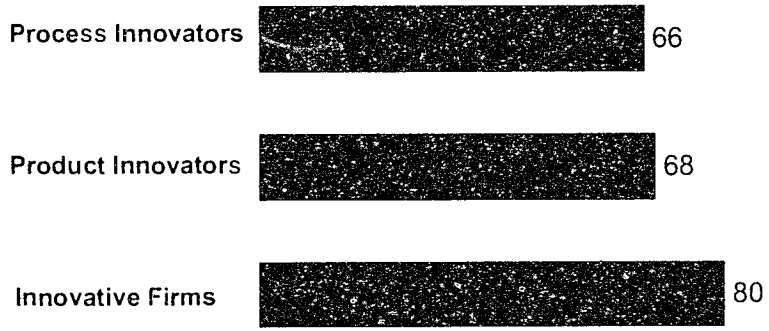
Innovation Counts Based on Innovation Surveys

Innovation by manufacturing firms

- Manufacturing firms in Canada are largely innovative. More than 80% of firms introduced a new and/or improved product or process between 1997 and 1999.
- 68% of manufacturing firms were product innovators in the 1997-1999 period.
  - Moreover, from 1997 to 1999, 43% of innovative manufacturers introduced six or more new or improved products.
- Over the same period, 66% of manufacturing firms were process innovators.

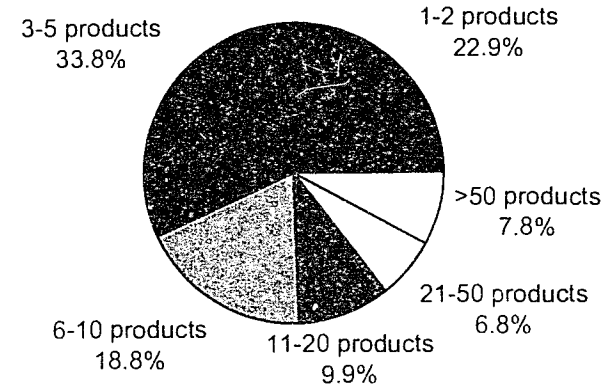
Note: The Oslo Manual (OECD/Eurostat, 1997) identifies two types of innovation to investigate a country's innovation in the manufacturing sector - product and process innovation. In the case of product innovation, the product must be introduced to the market. A process innovation must have been used within the production process. An innovative firm is one that has implemented a new or significantly improved product or process during the period under review.

Innovation by Firms: 1997-1999



Innovation rate (% of firms that innovate)

Distribution of the Introduction of New or Improved Products by Product Innovators: 1997-1999



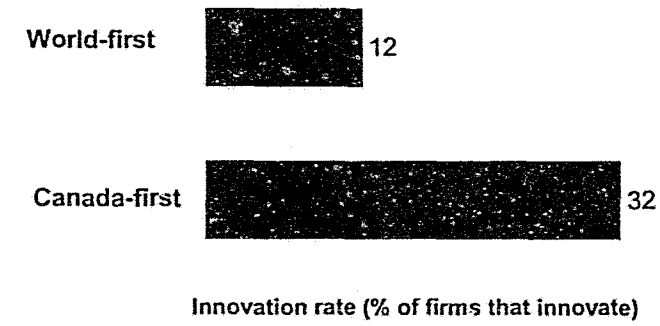
Source: Survey of Innovation: 1999, Statistics Canada.

A significant part of innovations of manufacturing firms are "world-first"

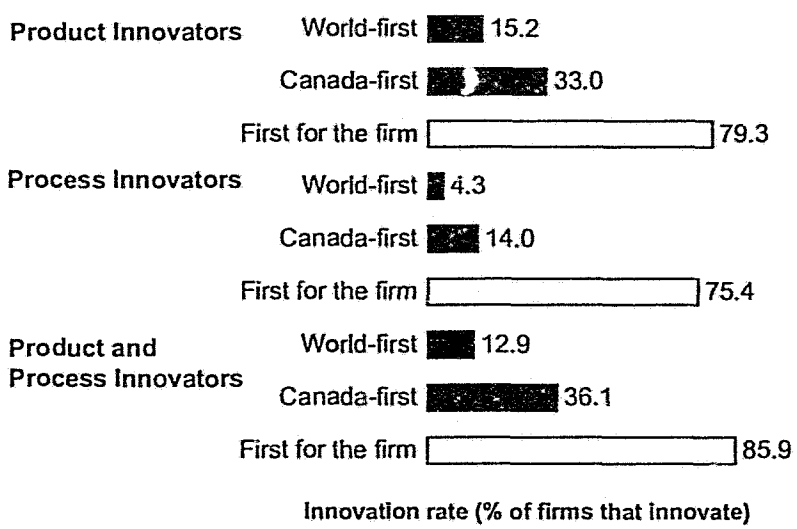
- 12% of innovations were "world-first" during the 1997-1999 period.
- Substantial differences in the degree of innovation exist between product and process innovators.
  - Product innovators introduced both "world-first" and "Canada-first" innovations at a higher rate than process innovators.

Note: If the most important new or significantly improved product or process (innovation) is a "world-first", it is also first in Canada and a first for the firm. If the most important innovation is not a "world-first", but still a first in Canada, then it is also a first for the firm.

Type of Innovations: 1997-1999



Innovation by Types of Innovators: 1997-1999



Source: Survey of Innovation: 1999, Statistics Canada.

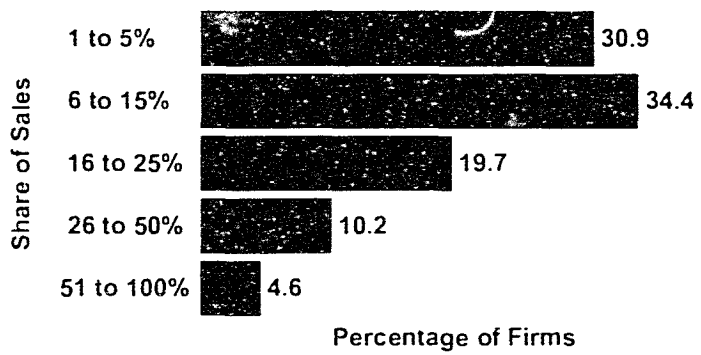
Share of sales from new products for innovative firms

- More innovative firms can be expected to have higher proportion of total sales due to new and improved products.

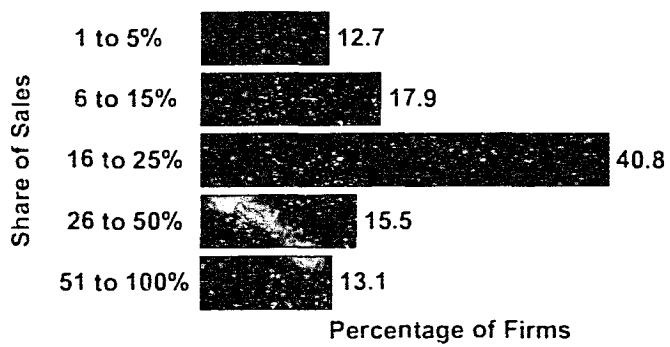
- Almost 15% of innovative firms who introduced new products during the 1997-1999 period reported that new products accounted for more than 25% of their total sales. Only 5% of firms reported that new products contributed more than half of their total sales.

- The proportion of sales arising from new products differs significantly across industries. For example, in 3 out of 10 firms in the Semiconductor and Electronic sector, revenues from new products account for more than one-quarter of their total sales. This is double the figure for the manufacturing sector as a whole.

Percentage of Firms by Share of Sales Attributable to New Products



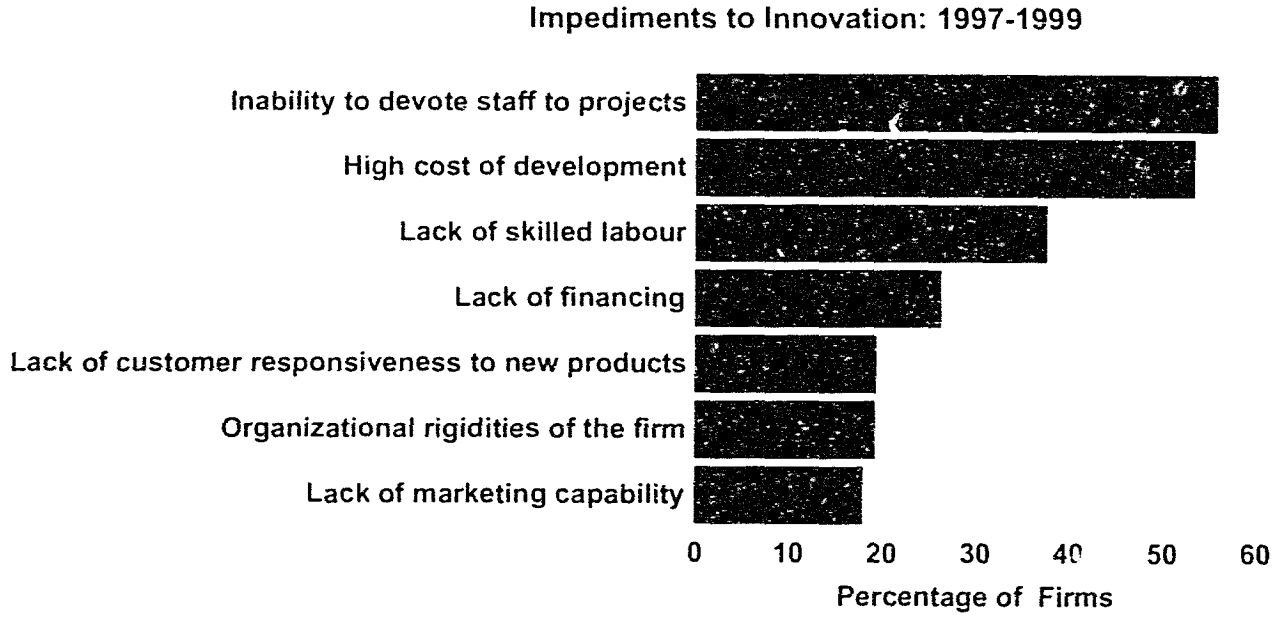
Percentage of Firms by Share of Sales Attributable to New Products in the Semiconductor and Electronic Sector



Source: Statistics Canada, Survey of Innovation, 1999.

"Inability to devote staff to projects" is regarded as the most important barrier to innovation for innovative manufacturing firms

- Innovation can be hindered by many factors, such as the inability to devote staff to projects on an on-going basis because of production requirements, high cost of development, lack of skilled labour, and lack of financing.
- The inability to devote staff to projects is cited as the most important barrier to innovation by Canadian manufacturing firms.
- In the 1997-1999 period, 56% of the firms claimed that the largest impediment to innovation was the "inability to devote staff to projects".



Source: Statistics Canada, Innovation in Canadian Manufacturing: National Estimates.

Adoption and Diffusion of Advanced Technologies

Technological capability is key to the firm's competitiveness and growth

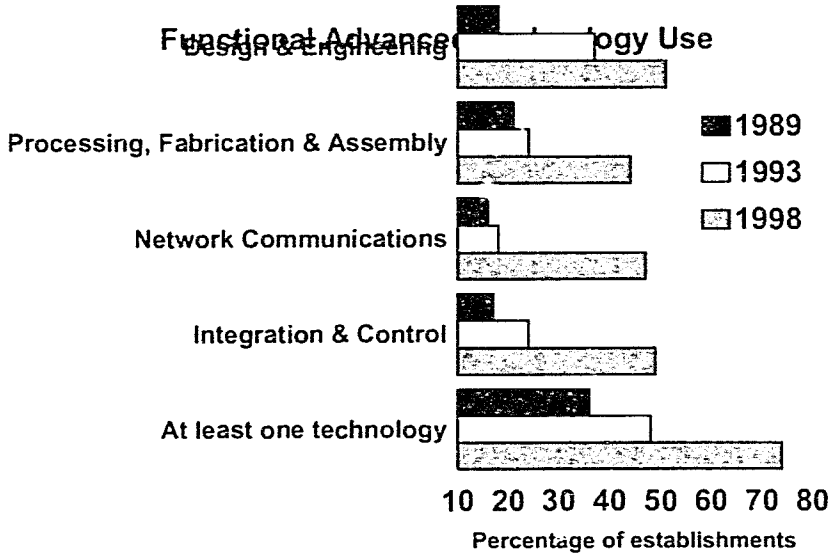
Technological advancement is essential for the economic growth of both firms and nations. It is also a key factor in determining the 'competitiveness' of a firm. With increasing global markets, firms are expected to produce 'high-quality', customized goods quickly and at a reasonable cost. To do so, they must rely on the use of advanced manufacturing technologies.

"Firms that have better routines -- production technologies, procedures for choosing alternative mixes of inputs and outputs, pricing rules, investment-project screening rules, mechanisms for allocating the attention of management and the operations research staff, R&D policies, etc. -- will tend to prosper and to grow relative to those firms whose capabilities and behavior are less-suited in the current situation."

Nelson, R., "Evolutionary Modelling of Economic Change"
in J.E. Stiglitz and G. F. Mathewson (eds.)
New Developments in the Analysis of Market Structure
The MIT Press, 1986, p. 453

Manufacturing firms are increasingly adopting advanced technology...

- Increasing global competition is forcing Canadian firms to significantly increase their rate of technology adoption.
- In 1998, three-quarters of manufacturing establishments adopted at least one advanced technology. This compares to about one-half in 1993, and about one-third in 1989 (see the Annex for a list of the 26 advanced technologies).
  - These gains in technology use have occurred in all four functional areas.
- Growth in the use of advanced technologies -- particularly communications technologies -- has picked up considerably since 1993.



Source: Baldwin & Sabourin "Advanced Technology Use in Manufacturing during the 90's", Canadian Economic Observer, March 2000 No. 1:9, Statistics Canada and communications with David Sabourin of Statistics Canada

Advanced manufacturing technologies rely on the integration of computers into the production process. They are employed either individually or in clusters at various stages of the production process to perform different functions. These technologies can be assigned to four functional groups: design and engineering; processing, fabrication and assembly; network communications; and integration and control.

...but small plants face a technology adoption gap...

- The rate of technology adoption increases with firm size.
- Over the 1989 to 1998 period, large plants had substantially higher adoption rates than medium and small-sized plants for each of the four functional areas of advanced technologies. This points to a technology gap between small and large plants.

Some reasons why large firms tend to have higher technology adoption rates than smaller firms:

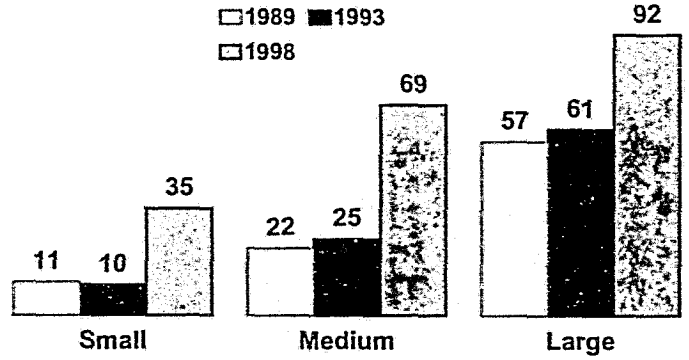
- Asymmetry of information: large firms may be generally more informed about new technologies than small firms.
- Resources: large firms tend to have more financial and technical resources to acquire advanced technologies than small firms.
- Production process: production processes of large firms tend to facilitate the implementation of advanced technologies compared to small firms.

Note: Plant size is measured according to the number of employees in the plant. Large plants are defined as establishments with 250 or more employees, medium-sized plants as establishments between 50 and 249 employees and small plants as establishments with fewer than 49 employees.
Source: Baldwin and Sabourin, 2000.

Functional Technology Use by Size of Firm

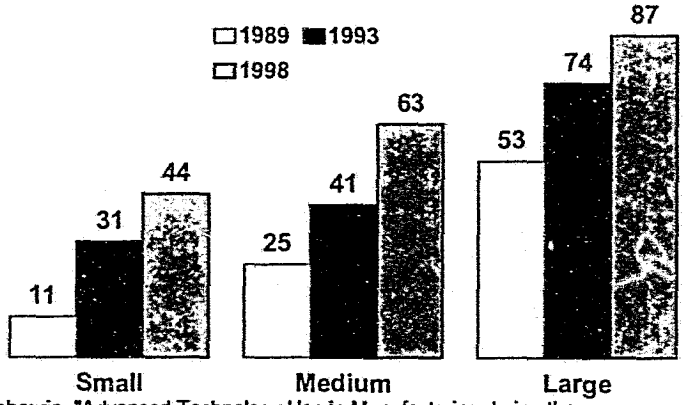
Network Communications

Percentage of Establishments



Design & Engineering

Percentage of Establishments



Source: Baldwin & Sabourin, "Advanced Technology Use in Manufacturing during the 90's", Canadian Economic Observer, March 2000 No. 119, Statistics Canada.

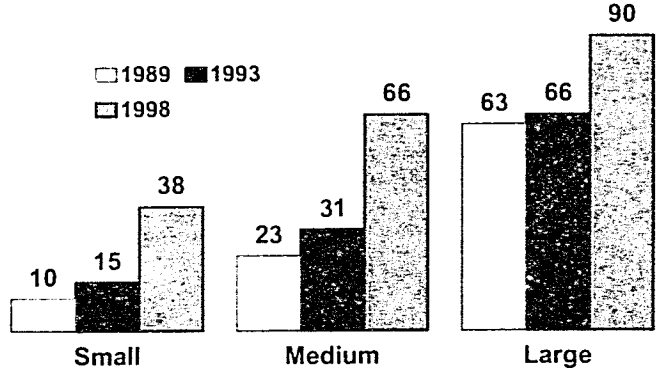
...that has not closed over time

- While technology use increased significantly for all firms over the 1989-1998 period, small plants did not catch up in any significant fashion with large plants.
- Changes in technology use over the 1993-1998 period for large and small plants were about the same, except in the case of *communications,* where the gap between small and large firms has widened.
- By contrast, medium sized plants narrowed the gap with large plants in all of the functional groups.

Functional Technology Use by Size

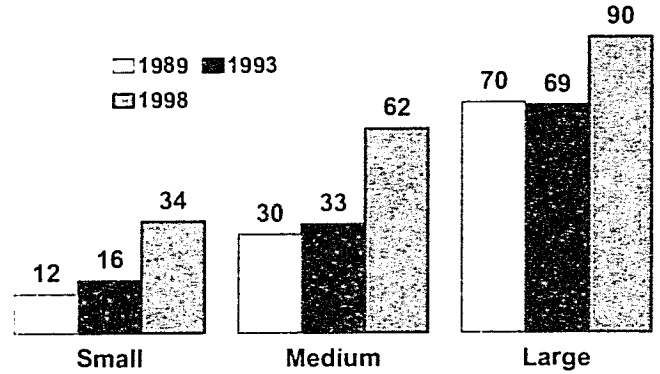
Integration & Control

Percentage of Establishments



Processing, Fabrication & Assembly

Percentage of Establishments



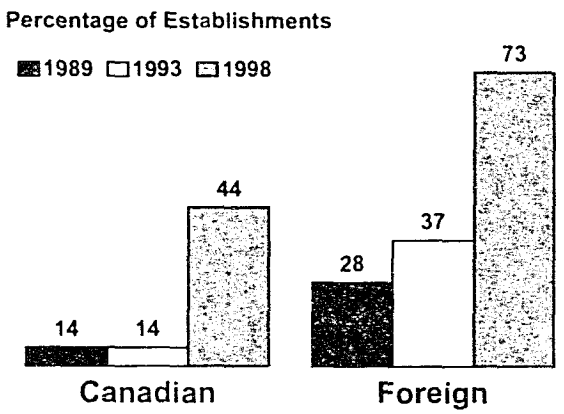
Source Baldwin & Sabourin, "Advanced Technology Use in Manufacturing during the 90's", Canadian Economic Observer, March 2000 No 119, Statistics Canada

Canadian-owned firms persistently suffer from a technology gap...

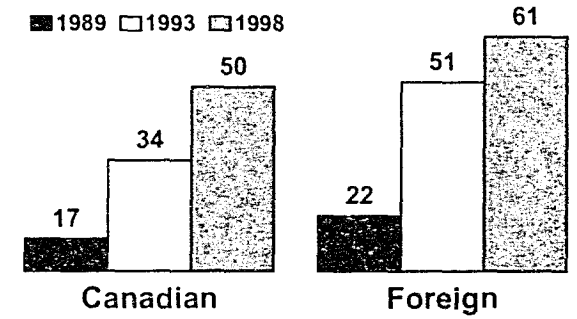
- Canadian-owned plants have a much weaker record of using advanced technologies than foreign-owned plants. This persistent technology adoption gap occurs at all types of technologies.

Functional Technology Use by Ownership

Network Communications



Design & Engineering



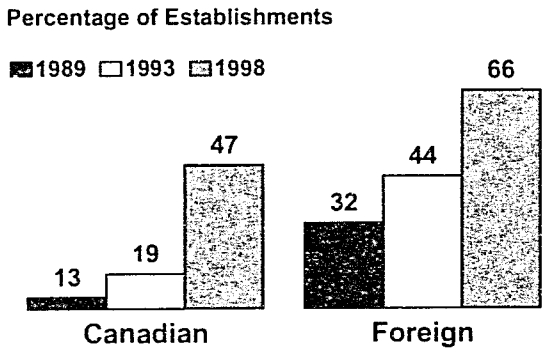
Source: Baldwin & Sabourin, "Advanced Technology Use in Manufacturing during the 90's", Canadian Economic Observer, March 2000 No. 119, Statistics Canada.

...that has not narrowed over the years

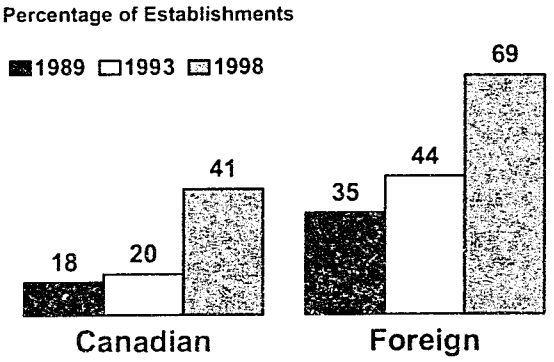
- Overall, foreign-controlled firms use more advanced technologies than domestic-controlled firms.
- In 1989, the differences in the rates of technology adoption between Canadian and fore*ign-owned* plants were largest in the areas of *integration and control* as well as *processing, fabrication and assembly technologies.*
- Foreign-owned plants increased their use of technologies at a faster rate than domestically owned firms from 1989 to 1993. As a result, the technology gap between foreign and domestically owned plants widened substantially in this period across almost all functional technology groups.
- Although the adoption rates in domestically-owned plants grew more rapidly than in foreign-owned plants between 1993 and 1998, technology use in domestic plants still lagged behind that of foreign-owned plants in 1998.

Functional Technology Use by Ownership

Integration & Control



Processing, Fabrication & Assembly



Source: Baldwin & Sabourin, "Advanced Technology Use in Manufacturing during the 90's", Canadian Economic Observer, March 2000 No. 119, Statistics Canada

Advanced technology adoption differs widely across industries

- Establishments in beverage, primary textiles, paper and allied products, primary metals, and electric and electronic products industries tend to have the highest adoption rates across most of the functional technology groups.
- Establishments in clothing, wood, furniture and fixture, refined petroleum and coal products, textile products, leather and allied products, and printing and publishing industries tend to have the lowest adoption rates across most functional technology groups.
- T some extent, the relative size of plants in these industries may affect results.

Functional Use of Advanced Technologies:

A:	Design & Engineering
B:	Network Communications
C:	Integration & Control
D:	Processing, Fabrication & Assembly
E:	Automated Material Handling
F:	Inspection

Ranking of Advanced Technology Use by Industry

	A	B	C	D	E	F
Beverage	13	1	1	3	3	2
Rubber Products	8	10	12	4	6	8
Plastic Products	7	8	7	1	6	6
Leather & Allied Products	11	13	15	16	8	14
Primary Textiles	8	3	3	9	1	1
Textile Products	15	11	11	14	9	9
Clothing	14	15	17	18	10	13
Wood	11	15	14	10	9	9
Furniture & Fixture	9	14	16	15	12	13
Paper & Allied Products	6	4	4	5	2	3
Printing & Publishing	12	7	13	17	11	10
Primary Metal	1	6	5	2	4	4
Fabricated Metal Products	3	9	9	7	14	9
Machinery	4	6	6	6	8	7
Transportation Equipment	5	7	8	8	3	3
Electric & Electronic	2	2	2	6	5	5
Non-Metallic Mineral Products	11	12	10	11	13	11
Refined Petroleum & Coal	10	15	12	16	11	6
Chemical & Chemical Products	12	5	8	12	7	5
Other Manufacturing	7	10	14	13	13	12

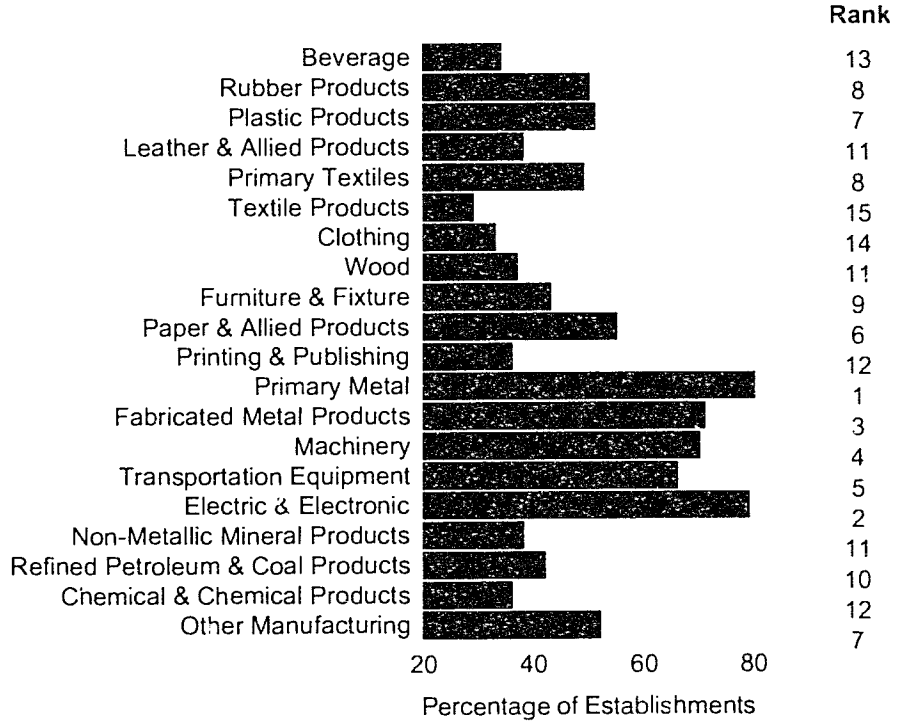
Source: D. Sabourin and D. Beckstead. "Technology Adoption in Canadian Manufacturing: Survey of Advanced Technology in Canadian Manufacturing 1998," Statistics Canada, 1999.

Adoption of advanced technologies by industry: Design & Engineering

- Establishments in primary metals, electrical & electronic products, fabricated metals, machinery, and transportation equipment were the largest users of design and engineering technologies in 1998.

Rate of Technology Adoption by Industries: 1998

Design & Engineering



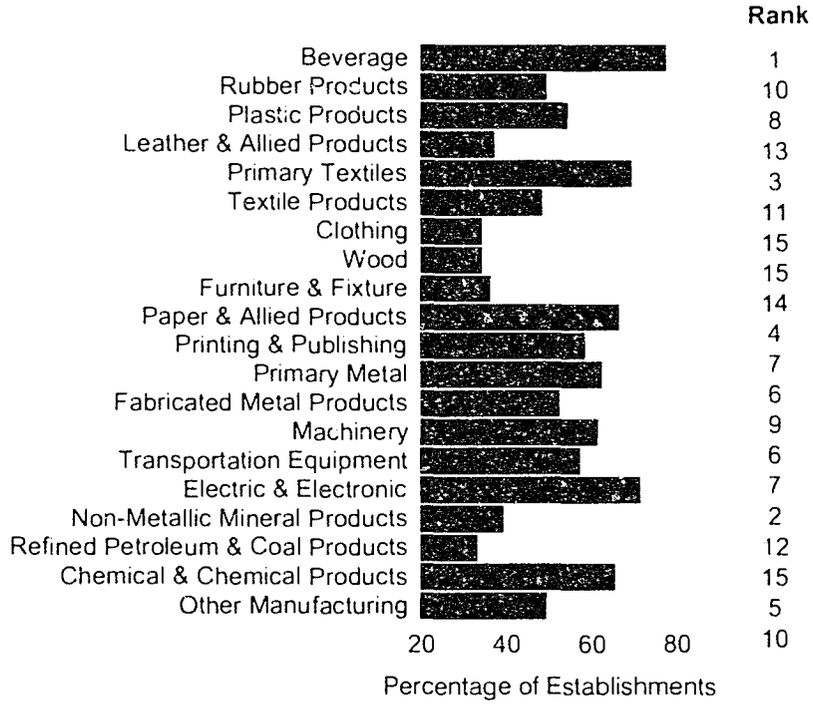
Source: D. Sabourin and D. Beckstead. "Technology Adoption in Canadian Manufacturing: Survey of Advanced Technology in Canadian Manufacturing 1998," Statistics Canada, 1999.

Adoption of advanced technologies by industry: Network Communications

- Establishments in beverage, electrical and electronic products, primary textiles, paper and allied products, and primary metal were the largest users of network and communications technologies in 1998.
- Roughly two-thirds to three-quarters of establishments in these industries used network and communications technologies in their production process.

Rate of Technology Adoption by Industries: 1998

Network Communications



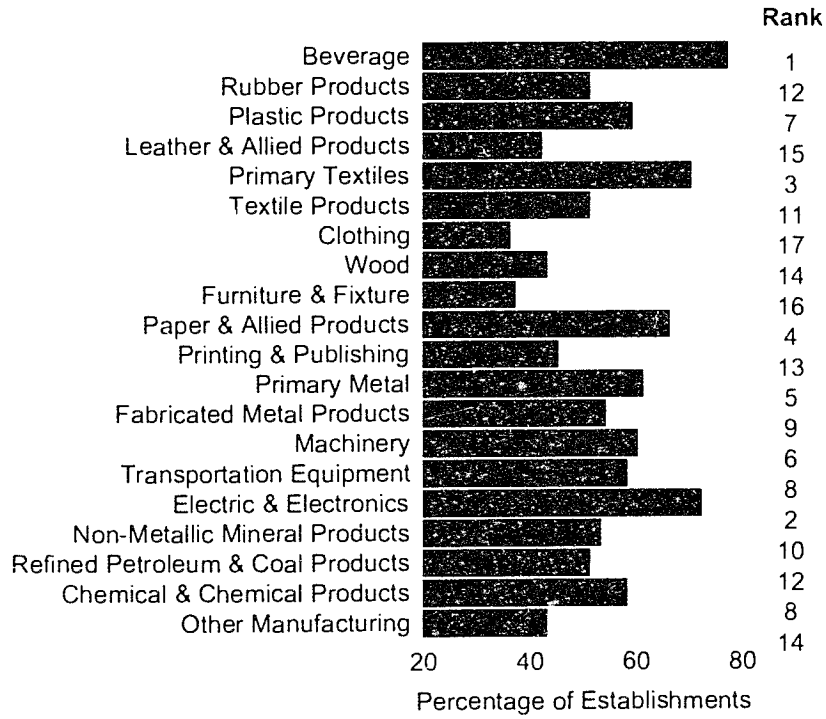
Source: D. Sabourin and D. Beckstead. "Technology Adoption in Canadian Manufacturing: Survey of Advanced Technology in Canadian Manufacturing 1998," Statistics Canada, 1999.

Adoption of advanced technologies by industry: Integration & Control

- In 1998, establishments in beverage, electrical & electronic products, primary textiles, and paper & allied products were the largest users of integration and control technologies.
- More than two-thirds of establishments in these industries used integration and control technologies in their production process.

Rate of Technology Adoption by Industries: 1998

Integration & Control



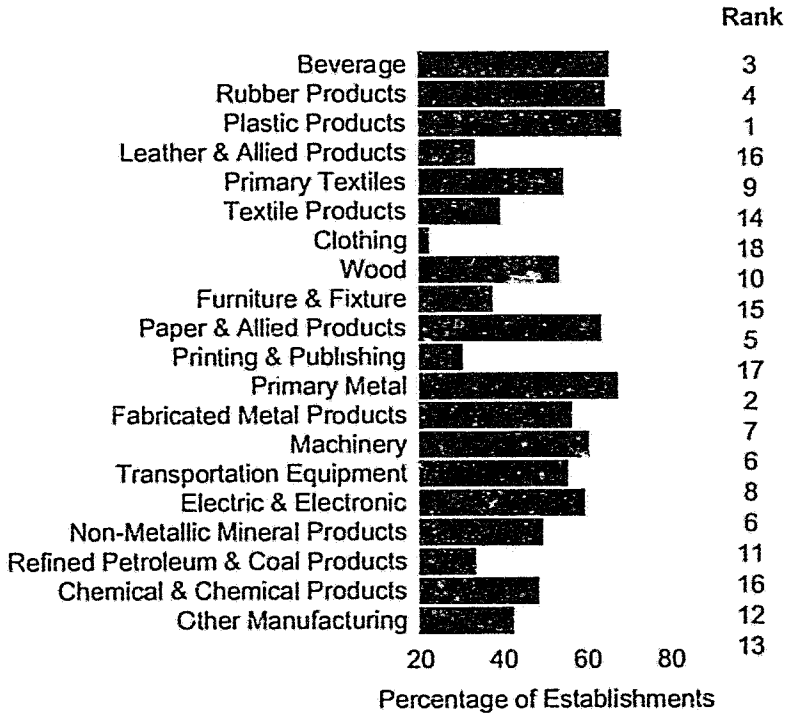
Source: D. Sabourin and D. Beckstead. "Technology Adoption in Canadian Manufacturing: Survey of Advanced Technology in Canadian Manufacturing 1998," Statistics Canada, 1999.

Adoption of advanced technologies by industry: Processing, Fabrication & Assembly

- In 1998, establishments in plastic products, primary metal, beverage, rubber products, and paper & allied products industries were the largest users of processing and fabrication technologies.
- Approximately two-thirds of establishments in these industries used processing and fabrication technologies in their production process.

Rate of Technology Adoption by Industries: 1998

Processing, Fabrication & Assembly

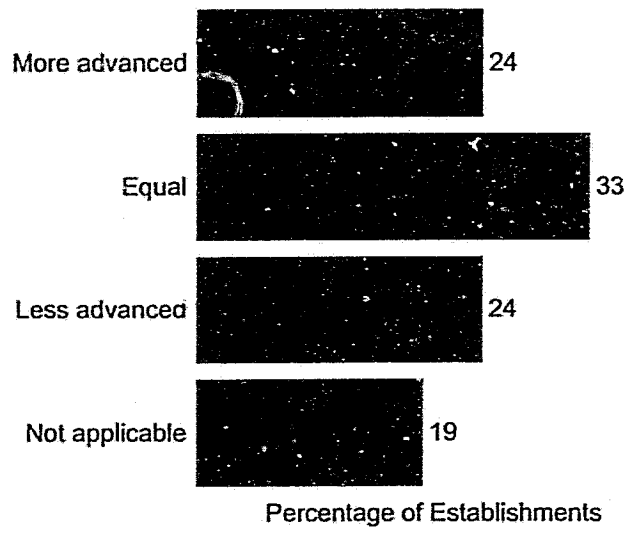


Source: D. Sabourin and D. Beckstead. "Technology Adoption in Canadian Manufacturing: Survey of Advanced Technology in Canadian Manufacturing 1998," Statistics Canada, 1999.

Technological competitiveness of Canadian plants relative to the U.S.

- In 1998, about 55% of Canadian domestic competitors felt that their production technologies were as advanced or more advanced than their U.S. counterparts.
- Roughly one-quarter of Canadian plants are believed to be behind their U.S. counterparts in technology competition.

Technology Competitiveness of Canadian Establishments Relative to their U.S. Counterparts: 1998



Source: D. Sabourin and D. Beckstead. "Technology Adoption in Canadian Manufacturing: Survey of Advanced Technology in Canadian Manufacturing 1998," Statistics Canada, 1999.

The technological competitiveness of domestic manufacturing establishments relative to their foreign competitors may be measured by the domestic establishment's self evaluation of its production technologies relative to its competitors.

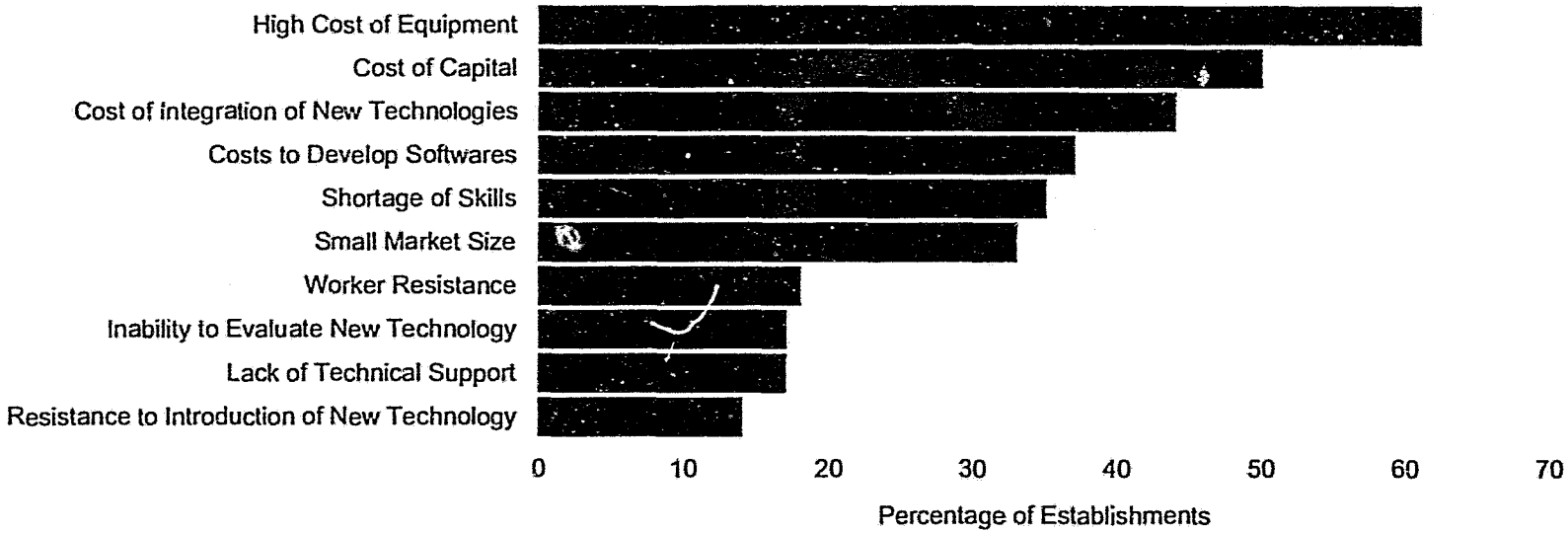
Costs and skill shortages are perceived as the major obstacles to technology adoption

- Adoption of advanced technologies can generate a stream of benefits, including increased productivity, reduced labour requirements, improved product quality, tighter control over the production process and reduced production costs.

- But while Canadian establishments appreciate the benefits from technology adoption, there are a large number of perceived barriers to technology adoption.

- Financial factors including high equipment costs, software development costs, the cost of capital, and cost of integrating new technologies are cited as important barriers. A lack of skilled workers and small market size are also considered to be important obstacles to technology adoption in Canadian plants.

Importance of Obstacles to Advanced Technology Adoption: 1998



Source: D. Sabourin and D. Beckstead. "Technology Adoption in Canadian Manufacturing: Survey of Advanced Technology in Canadian Manufacturing 1998," Statistics Canada, 1999.

Annex

Advanced Technologies by Functional Group

- Design & Engineering:
  - *Computer-aided design (CAD) and engineering*
  - *CAD output to control manufacturing machines*
  - *Modeling or simulation technologies*
  - *Electronic exchange of CAD files*
- Processing, Fabrication & Assembly
  - *Flexible manufacturing systems*
  - *Programmable logic controllers*
  - *Robots with sensing*
  - *Robots without sensing*
  - *Rapid Prototyping systems*
  - *High speed machining*
  - *Near net shape technologies*
- Automated Material Handling
  - *Part identification for manufacturing automation*
  - *Automated storage/retrieval system*
- Inspection
  - *Automated vision-based systems used for inspection/testing*
  - *Other automated sensor-based systems used for inspection/testing*
- Network Communications
  - *Local area network for engineering or production*
  - *Company-wide computer networks*
  - *Inter-company computer networks*
- Integration & Control
  - *Manufacturing resource planning*
  - *Computer used for control on the factory floor*
  - *Computer integrated manufacturing*
  - *Supervisory control and data acquisition*
  - *Use of inspection data for manufacturing control*
  - *Digital, remote controlled process plant control*
  - *Knowledge-based software*

Source: Sabourin and Beckstead (1998), Statistics Canada.