Role of Skills and Government Support in Stimulating Innovation

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Rapid progress in skill-biased technologies has increased the demand for skilled workers in all countries. Lack of skilled workers could become a serious impediment to innovation. In this study, we first examine the importance of skills and government support for innovation using firm-level data from Statistics Canada's Survey of Innovation 1999. We then investigate the role of differences in skills in explaining the differences in productivity levels among Canadian manufacturing industries. After controlling for other factors, we find that firms' practices of hiring new graduates from universities and hiring experienced employees have positive and significant impacts on innovation outcomes, and that they are equally important for both product and process innovation. In addition, after controlling for industries characteristics, inter-industry differences in labour productivity levels among Canadian two-digit manufacturing industries are positively related to differences in capital intensity, R&D intensity and skills intensity, proxied by two variables: the proportion of employees with 1-3 years post-secondary education; and the percentage of employees with a university degree and more.

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1. Introduction

Innovation is a key driver of economic growth. As stated in Freeman and Soete (1997), innovation is an essential condition of economic progress and a critical element in the competitive struggle of enterprises and of nation states. Council of Economic Advisors (2001) points out that innovation in the ICT sector and throughout the whole economy has been the leading factor for the strong growth in the U.S. since the mid-1990s.

Skill is one of key factors influencing innovation. There is abundant evidence, from studies of both consumer and producer behavior, that more-educated individuals tend to adopt innovation sooner than less-educated individuals.[1] Also, more-educated individuals have a comparative advantage with respect to the implementation of innovations.[2] This observation is also consistent with the fact that information and communication technology industries, the most innovative industries, maintain a considerably higher percentage of workers with a university degree or above than the average for all industries (Chart 1).

Lack of skills is often considered to be one of main barriers to innovation. After investigating small firms in U.K., Freel (2000) claims that skilled labour is a main barrier to product innovation. Recently, the relative demand for skilled labour has increased dramatically, mainly due to skill-biased technical change.[3] As a result, skill shortages continue to persist despite increases in training and the skill levels of the workforce. Haskel and Martin (2001) provide evidence from the U.K. micro data that technical progress raised the demand for skilled labour to match the observed increase in supply. They also find that skill shortages are higher for establishments that use advanced technology in the production process.

The main objective of this article is to highlight the linkages between skills and innovation and productivity in Canada. Using firm level data, the article examines the impact of different types of skills and government financial support for innovation activities for product and process innovation in Canada. The article also uses panel data on two-digit manufacturing industries to analyse the role of skills in accounting for the inter-industry differences in labour productivity levels among Canadian manufacturing industries during the 1987-96 period.

Our firm level analysis suggests that firm size and product innovation are not significantly related to each other, after controlling for the influence of other factors. On the other hand, both medium size and large firms do significantly more process innovation than small firms. Our results also indicate that companies, which hire experienced employees and new graduates from universities, outperform in terms of both product and process innovation the firms, which do not. In addition, cooperation with other firms, product market competition and government financial support (R&D tax credits, R&D grants and support for training) are also important for innovation. The industry level results indicate that, after controlling for the influence of industry

[1] See Wells (1972), and Nelson and Phelps (1966).
[2] See Bartel and Lichtenberg (1987).
[3] See Bresnahan, Brynjolfsson and Hitt (1999) for evidence from the U.S. firm-level data, Machin and Van Reenen (1998) for evidence in the U.S., the U.K., Denmark, France, Germany, Japan and Sweden, Murphy, Riddell and Romer (1998) for evidence in the U.S. and Canada.

characteristics, inter-industry differences in labour productivity levels among Canadian two-digit manufacturing industries are positively related to differences in capital intensity, R&D intensity and skills intensity, proxied by two variables: the proportion of employees with 1-3 years post-secondary education; and the percentage of employees with a university degree and more.

The paper is organized in the following manner. In section 2, we briefly describe the characteristics of the firms in the sample, followed by an analysis of the determinants of product and process innovation. We discuss the industry results on the key drivers of differences in labour productivity levels among two-digit Canadian manufacturing industries in the next section. In the final section, section 4, we summarize the key findings and examine their policy implications for narrowing the Canada-U.S. labour productivity and real income level gaps.

2. The Dynamics of Innovation in Canada: A Firm Level Analysis

The global economy is becoming increasingly knowledge-based. Acquisition, application and use of information and knowledge are very important for creating and adding value. The importance of human capital and skills, especially problem solving, communication and inter-personal skills, has increased in all economies. For instance, on a net basis, all jobs created in Canada during the 1990s were filled by persons with at least a high school diploma. Employment growth was much faster for persons with a post-secondary diploma or a university degree than those without such qualifications (Chart 2). Indeed, employment for those with less than high school diploma declined significantly. Similarly, the share of knowledge and management positions in total employment more than doubled across in Canada between 1971 and 1996 (Chart 3). Similar trends are also observed in other OECD countries.

Data from the Innovation Survey

Using firm-level data from the Statistics Canada 1999 Innovation Survey,[4] we examine the importance of skills and government support for innovation in Canadian manufacturing industries. Two types of innovation outcomes are analysed: product innovation (introduction of new or significantly improved products); and process innovation (introduction of new or significantly improved processes). Innovation outcomes are measured by firms' answers to either the question 3a or the question 4 in the 1999 SI. The question 3a is: "*During the last three years, 1997 to 1999, did your firm offer new or significantly improved products (goods and services) to your clients?*"[5] The question 4 is: "*During the last three years, 1997 to 1999, did*

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[4] The Statistics Canada 1999 Survey of Innovation (SI), which was linked to the 1997 Annual Survey of Manufacturing (ASM), was conducted in 1999 for the Canadian manufacturing and selected natural resources industries, on the basis of provincial enterprises. A provincial enterprise (firm thereafter) includes all its establishments in the same province and industry at the 4-digit NAICS level. The SI only surveyed firms with at least $250,000 gross business income and 20 or more employees. All information in the SI concerns firms' innovation activities during the 1997-99 period. The linked SI contains additional information on firms' operational activities such as employment in 1997.

[5] **A new product (good and service)** to a firm, as defined in the 1999 SI, is a product whose characteristics or intended uses differ significantly from those of the firm's previously produced products. **A significantly improved product (good and service)** to a firm is defined in the 1999 SI as an existing product whose performance has been

your firm introduce new or significantly improved production/manufacturing processes?"[6] The corresponding variables are listed below with the corresponding SI number in curly brackets.

(Y_1) Introduction of new or significantly improved products {3a},
(Y_2) Introduction of new or significantly improved processes {4}.

Both Y_1 and Y_2 are binary variables, one for "yes" and zero otherwise. For example, $Y_1^j = 1$ implies that firm j is a product innovator. For better understanding of the impacts of skills on innovation, we first divide firms into four groups: (1) firms that had product innovation only; (2) firms that had process innovation only; (3) firms that had both product innovation and process innovation; and (4) firms that had neither product innovation nor process innovation. Firms in the first three groups are called innovators.[7] We then create four new binary variables, representing different combinations of the four groups. The definitions of these variables are listed below, with corresponding sample size in brackets.

$$y_1 = \begin{cases} 1, \text{if a firm is a product innovator or process innovator, i.e., } Y_1 = 1 \text{ or } Y_2 = 1 \, (4410) \\ 0, \text{if a firm is not an innovator, i.e., } Y_1 = 0 \text{ and } Y_2 = 0 \, (1041) \end{cases}$$
$$y_2 = \begin{cases} 1, \text{if a firm is a product and process innovator, i.e., } Y_1 = 1 \text{ and } Y_2 = 1 \, (2953) \\ 0, \text{if a firm is not an innovator, i.e., } Y_1 = 0 \text{ and } Y_2 = 0 \, (1041) \end{cases}$$
$$y_3 = \begin{cases} 1, \text{if a firm is a product innovator only, i.e., } Y_1 = 1 \text{ and } Y_2 = 0 \, (810) \\ 0, \text{if a firm is not an innovator, i.e., } Y_1 = 0 \text{ and } Y_2 = 0 \, (1041) \end{cases}$$
$$y_4 = \begin{cases} 1, \text{if a firm is a process innovator only, i.e., } Y_1 = 0 \text{ and } Y_2 = 1 \, (647) \\ 0, \text{if a firm is not an innovator, i.e., } Y_1 = 0 \text{ and } Y_2 = 0 \, (1041) \end{cases}$$

The variables y_1 to y_4 are used to examine if skills are playing an important role in the likelihood of a firm being an innovator (product innovator or process innovator), a both product and process innovator, a product innovator only or a process innovator only.

All explanatory variables used in this paper are listed below with the SI number in curly brackets.

(x_1): Hiring new graduates from universities {2g},

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significantly enhanced or upgraded. A complex product that consists of a number of components or integrated subsystems may be improved by partial changes to one of the components or subsystems. Changes to a firm's existing products which are purely aesthetic or which only involve minor modifications are not to be included.

[6] **New production/manufacturing processes**, as described in the 1999 SI, involve the introduction into a firm of new production/manufacturing methods, procedures, systems, machinery or equipment that differs significantly from the firm's previous production/manufacturing processes. **Significantly improved production/manufacturing processes** involve significant changes to a firm's existing processes that may be intended to produce new or significantly improved products (goods and services) or production/manufacturing processes. Minor or routine changes to processes are not to be included.

[7] As defined in OECD OSLO manual (1996)

(x_2): Hiring experienced employees {2i},

(x_3): Recruiting skilled people from outside of Canada {2j},

(x_4): Involvement in collaboration and cooperation with other firms {2n},

(x_5): Research and development (R&D) tax credits {29a};

(x_6): Government research and development (R&D) grants {29b},

(x_7): Government venture capital support {29c},

(x_8): Government technology and assistance programs {29d},

(x_9): Government information or Internet services {29e},

(x_{10}): Government support for training {29f}, and

(ξ_p): Product market competition.

The variables x_1 to x_4 are based on the survey question regarding success factors for firms. The question is: "*Please rate the importance of each of the following factors for the success of your firm.*" Firms are asked to indicate their opinions by using numbers from 0 to 5, where 0 for irrelevant, 1 for low importance and 5 for high importance. As a crucial assumption of this paper, we assume that a firm acts on its perception of the importance of those factors.

The variables x_5 to x_{10} are binary variables, based on firms' answer to the survey question regarding government support programs, one for "yes" and zero otherwise. The question is: "*Has your firm used any of the following types of programs sponsored by the federal government or a provincial government during the last three years, 1997 to 1999?*"

Finally, the variable ξ_p is a composite latent variable, measured as the weighted sum of four indicators of product market competition. These four indicators are *easy substitution of products* (1b), *constant threat of the arrival of new competitors* (1d), *constant threat of the arrival of competing products* (1e) and *quick obsolescence of products* (1i), based on firms' answers to the first question of the SI regarding to competitive environment.[8] The corresponding weights are 0.021, 0.100, 0.857 and 0.021, which are determined using the same latent model as in Tang and Wang (2001).[9]

Regression Models

As all of the variables representing innovation outcomes and innovation activities are binary variables, we set up a logit model, which links skill related variables to innovation outcomes and innovation activities. For innovation outcomes,

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[8] The question is: "For your firm, how strongly do you agree or disagree with each of the following statement?" Firms are asked to indicate their opinions by using six scales where 0 for not relevant, 1 for strongly disagree and 5 for strongly agree. There are 11 statements given in the survey, and we choose firms' answers to four of them to form our measure of product market competition. See Tang (2001) or Tang and Wang (2001) for details.

[9] Similar results are obtained if only the indicator *constant threat of the arrival of competing products* (1e) is used as an indicator of product market competition.

(1) Prob$[y_i = 1] = [1 + \exp(-\mathbf{X\beta})]^{-1}$, with

$$\mathbf{X\beta} = \beta_0 + \sum_{m=1}^{10} \beta_m x_m + \beta_{11}\xi_p + \beta_{12}SM + \beta_{13}SL + \sum_{n=1}^{19} \alpha_n I_n + \varepsilon_i, \quad i = 1, 2, \cdots, 5.$$

In the above equations, *y*-variables denote innovation outcomes, *x*-variables are the explanatory variables as defined in Section 2.2, ξ_p denotes product market competition, and ε_i is an error term. Size and industry dummies are defined as follows:

> SM is a size dummy for medium-sized firms, 1 for a firm being medium-sized and 0 otherwise;
> SL is a size dummy for large-sized firms, 1 for a firm being large-sized and 0 otherwise; and
> I_n is a dummy for industry n, 1 for a firm belonging to industry n and 0 otherwise.

We introduce firm size dummies and industry dummies into the regression models to capture size-related and industry-related residuals that are not captured by other variables. To capture the size effect, we divide firms into three groups according to their size. The reference group in the regression model is the small-sized group in which a firm's number of employees is not greater than 49. In the medium-sized group, the number of employees of a firm falls between 49 and 249. The large-sized group contains firms with more than 249 employees. Industries are grouped at the 3-digit NAICS level. There are total of 20 industries.[10] The reference industry is Miscellaneous Manufacturing (NAICS 339).

Characteristics of Firms in the Innovation Survey

Before discussing the empirical results, we provide a brief description of the characteristics of the firms captured by the innovation survey. The sample consists of 5,451 manufacturing firms of which 30 per cent are small firms, defined as firms with 20 and 49 employees, 54 per cent medium-size firms, defined as firms with employees between 50 and 249, and 16 per cent large firms, defined as firms with 250 or more employees. All 20 three-digit (NAICS) manufacturing industries are represented. Of the total sample, 68 per cent of firms reported undertaking product innovation (Chart 4). However, as expected, the percentage of firms, which do product innovation, varies significantly across industries, from a high of 86 per cent in computers and electronics to a low of 55 per cent in the wood industry. Similarly, before controlling for other factors, product innovation varies with firm size, with small firms doing less than medium-sized and large firms.

Almost 65 per cent of all firms report some type of process innovation. Like product innovation, it too varies significantly across industries and is positively correlated with firm size. About 80 per cent of all firms in the sample undertake either product or process innovation. But only slightly more than half (54 per cent) of all firms report the two types of innovation.

[10] Due to confidentiality, apparel and leather industries are combined.

Empirical Results

The empirical results suggest (column 1-2 of Table 1) that medium-sized and large-firms undertake significantly more innovation than small firms. Firms which hire experienced employees and recent university graduates are significantly more innovative than firms which do not engage in such hiring. Cooperation with other firms and product market competition are also strongly associated for innovation. Similarly, government R&D credits, government R&D grants, government technical support and assistance programs, and government support for training of employees are significantly positively correlated with innovation. On the other hand, hiring of skilled persons from outside of Canada, government venture capital support, and government information or Internet services do not seem to be related significantly with the innovation activities of Canadian manufacturing firms.

The statistically insignificant coefficient on the hiring of skilled persons from outside of Canada is surprising. Perhaps, it simply reflects the fact that new immigrants take time to adjust to the conditions in labour market. As a result, their net contribution to innovation during the transition period might be limited. However, in the longer term, their contribution could be much greater.

As per product innovation, the regression results suggest that firm size is not a significant explanatory variable. The hiring of experienced employees, product market competition, and cooperation with other firms and government support for R&D, and government technical support and assistance programs are the important drivers of product innovation (column 3 of Table 1).

Unlike product innovation, process innovation is positively significantly correlated with firm size. On the other hand, as expected, it is not related to product market competition. In addition, as expected, R&D tax credits are significantly less important for process innovation than product innovation. On the other hand, government support for training is an important determinant of process innovation. Like product innovation, process innovation is positively related to the hiring of experienced employees, cooperation with other firms and government R&D grants (see column 4 of Table 1).

In summary, hiring of experienced employees and new university graduates, co-operation with other firms, product market competition and government support for R&D, training and technical support and assistance programs are the important drivers of product and process innovation. After controlling for the influence of other factors, large and medium-sized firms do more process innovation than small firms.

3. Importance of Skills for Innovation and Labour Productivity in the Canadian Manufacturing Sector

Productivity is the fundamental longer-term driver of differences in living standards across nations and across regions within a country. Similarly, real incomes and productivity trends tend to move together over time in all countries. Therefore improvements in productivity are critical for raising living standards and quality of life because they provide the economic base for investments in education, health, environmental improvements, infrastructure, poverty reduction and social security. In addition, productivity growth is the key determinant of international competitiveness in the longer term. Improving relative productivity growth is the only way to improve a country's competitive position while raising the real incomes of its citizens. Slower growth in real wages and a real depreciation of the currency will improve a country's cost competitiveness vis-à-vis the country's trading partners, but lower real incomes.

Labour productivity varies a great deal across Canadian manufacturing industries. For instance, in 1996, output per person employed varied from a high of $116,760 in refined petroleum and coal industry to a low of $33,090 in clothing industry (Table 2). Similarly, there are substantial differences in capital intensity, R&D intensity and education attainment across Canadian manufacturing industries (Table 3-5).

Canada's labour productivity growth lagged behind that of the United States, its largest trading partner, in the second half of the 1990s. As a result, the aggregate Canada-U.S labour productivity and real income level gaps widened. In the crucial manufacturing sector, the battle ground for fierce international competition, the Canada-U.S. labour productivity level gap increased from about 21 percent in 1990 to over 34 percent in 2000. And, the gap is pervasive across many manufacturing industries, especially large in machinery and electrical and electronic equipment industries (Chart 5). This happened despite a substantial increase in Canada's trade and investment linkages with the United States and other countries, and Canada's advantage in 1-3 years post-secondary education. Canada, however, generally lags the U.S. in university education, capital intensity and R&D intensity (Table 6-8).

Canada's relatively poor productivity record has been blamed on a number of factors, including relatively weak machinery and equipment investment, a high regulatory and tax burden, non-innovative management strategies and practices, a depreciating currency, low levels of domestic competition, and an innovation gap relative to the United States. All these factors are highly interrelated and interact in complex and dynamic ways. Nevertheless, recently many researchers have identified the innovation gap as the main reason for Canada's productivity problems.[11] According to these studies, Canada is lagging behind the United States and many other OECD countries in both product and process innovation, especially in the high-tech sectors, as well as in the commercialisation of innovations.

In this section, using the panel data on two-digit Canadian manufacturing industries, we examine the role of differences in skills and other variables in the differences in productivity levels among Canadian manufacturing industries. The regression model is

$$\textbf{(4)} \quad \ln(LP_{it}) = \alpha_1 \ln(LP_{it-1}) + \alpha_2 \ln(KI_{it}) + \alpha_3 \ln(UE_{it}) + \alpha_4 \ln(PE_{it}) + \alpha_5 \ln(RI_{it}) + \sum_{k=1}^{16} \theta_k I_{kt} + \varepsilon_{it},$$

where LP denotes value added per employee; KI is capital intensity, defined as capital stock per employed person;[12] UE is university education, denoting the percentage of employees with

[11] See, for example, OECD (2001), Conference Board of Canada (2001), and Rao, Ahmad, Horsman and Kaptein-Russell (2001), and Government of Canada (2002a).

[12] Besides M&E and structures, the capital stock includes land and inventories (Jorgenson and Lee, 2001).

university education or above; PE is 1-3 years non-university post-secondary education, denoting the percentage of employees with 1-3 years post-secondary school; RI is the real R&D spending per employed person.[13] The analysis is for sixteen 2-digit (SIC) manufacturing industries, over the period 1987-96, as shown in Table 2.

We proxy skills by two education variables: the proportion of workers with 1-3 years post-secondary education; and the percentage of employees with a university degree. In the knowledge-based economy, we expect that a university education to have a bigger positive impact on innovation, especially fundamental innovation and productivity than a non-university post-secondary education, because it provides much more the generic skills which are essential to succeed in a fiercely competitive and fast changing global knowledge-based economy. In addition to the two skills variables, we include capital intensity (capital stock per worker), R&D intensity (R&D per worker) and industry characteristics as the drivers of productivity levels. Skills are hypothesised to influence productivity directly as well as indirectly by stimulating fundamental innovation via increased R&D spending.

Canada leads the United States in terms of the proportion of the employees with some post-secondary education, but it lags significantly behind the United States in terms of the proportion of the employees with a university education (Table 6). For instance, in 2000, the share of the population aged 25-64 with a university degree in the labour force was 20 per cent in Canada compared to 30 per cent in the United States (Chart 6). This gap is greater in manufacturing than at the economy-wide level as Canada in 1998 had only 60 per cent of the US proportion of workers with a university degree, compared to 68 per cent for all industries.

After controlling for the influence of industry characteristics, all other explanatory variables have a positive impact on labour productivity (Table 9). As expected, differences in university education have a much larger impact on inter-industry differences in productivity levels than differences in 1-3 years post-secondary education. The regression results imply that the longer-term impacts of the two types of skills, capital intensity and R&D intensity are considerably larger (almost double) than the shorter-term effects.

The two skill variables have a positive impact on R&D spending, the key driver of fundamental innovation. Not surprisingly, once again, university education has a bigger impact on R&D spending than some post-secondary education.

In short, the empirical results suggest that inter-industry differences in Canadian manufacturing labour productivity levels are shaped by differences in skills, especially university education, capital intensity, R&D intensity and industry characteristics. In addition, skills also influence productivity via its impact on R&D spending.

4. Conclusions

The main objectives of this paper have been to examine empirically the importance of skills and government support for innovation in the Canadian manufacturing sector, and analyse the role of skills gap in the Canada-U.S. manufacturing productivity gap. Towards these goals, first, using

[13] Nominal R&D is deflated by GDP deflator.

firm level data from the 1999 Innovation Survey, we studied the innovation dynamics of Canadian manufacturing firms. Next, using the panel data on two-digit Canadian manufacturing industries, we analysed the impact of the skills on innovation and labour productivity performance.

The firm level analysis strongly suggests that experienced employees and new university graduates, cooperation with other firms, product market competition, and government support for R&D and training, and technical assistance are the important drivers of innovation. After controlling for the influence of other factors, firm size and product innovation are not correlated. The findings from the industry level analysis are generally consistent with the results from the firm level analysis. The two skill variables are important drivers of inter-industry differences in productivity levels among Canadian manufacturing industries.

As mentioned before, Canada’s manufacturing sector lags behind its U.S. counterpart in the proportion of workers with university education, capital intensity, and R&D intensity. Our empirical results suggest that Canada could make a significant progress in closing the Canada-U.S. productivity and real income gaps by narrowing the gaps in university education, R&D, and capital intensity. These findings provide strong support for the conclusions of the two recently released Government of Canada policy documents on innovation and skills (Government of Canada, 2002a,b).

All economies are becoming increasingly knowledge-based. In addition, all industrialised countries are currently facing a shortage of highly qualified people and these pressures are expected to increase in the future because of low birth rates and the ageing of population. Consequently, competition for skilled people among countries is going to intensify. Given that human capital is a strong complement to R&D and physical capital, especially M&E, improving the economic climate for attracting and retaining skilled people is critical for stimulating innovation and increasing the trend productivity growth in Canada. In addition, Canada also needs to close the capital intensity gap and the gap in university education vis-à-vis the United States, our largest trading partner as well as the major competitor, because it would set in motion a virtuous circle of narrowing of the capital deficit and the innovation, productivity and real income gaps vis-à-vis the U.S.

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Table 1
Determinants of Innovation Outcomes in the Canadian Manufacturing Sector, 1999

	Product or Process Innovation y_1	Product and Process Innovation y_2	Product Innovation Only y_3	Process Innovation Only y_4
Intercept	-0.85* (3.4)	-1.61* (-5.8)	-2.01* (-5.6)	-2.64* (-6.0)
Medium-sized firms	0.32* (3.9)	0.44* (4.8)	-0.09 (-0.8)	0.46* (3.8)
Large-sized firms	0.43* (3.3)	0.55* (4.0)	0.03 (0.2)	0.55* (2.9)
Hiring new graduates from Univ.	0.17* (5.2)	0.18* (5.1)	0.16* (3.4)	0.15* (3.2)
Hiring experienced employees	0.13* (3.7)	0.13* (3.5)	0.11* (2.3)	0.15* (3.0)
Hiring skilled people from outside of Canada	-0.02 (-0.5)	-0.00 (-0.0)	-0.04 (-0.8)	-0.06 (-1.2)
Cooperation with other firms	0.22* (8.0)	0.27* (8.7)	0.15* (3.8)	0.14* (3.5)
Product market competition	0.15* (5.3)	0.21* (6.2)	0.16* (3.9)	0.00 (0.1)
R&D tax credits	1.00* (9.9)	1.15* (10.9)	0.94* (7.3)	0.37* (2.6)
Gov. R&D grants	0.83* (3.9)	0.91* (4.1)	0.54* (2.0)	0.54** (1.9)
Gov. venture capital support	0.10 (0.4)	0.06 (0.2)	-0.32 (-0.8)	0.06 (0.2)
Gov. tech. Support & assistance programs	0.70* (3.5)	0.81* (3.8)	0.62* (2.5)	0.53* (2.0)
Gov. info. or internet service	-0.06 (-0.4)	0.02 (0.2)	-0.16 (-0.8)	-0.32 (-1.6)
Gov. support for training	0.24* (2.3)	0.25* (2.2)	0.06 (0.4)	0.28** (1.9)

* Significant at 5% level. ** Significant at 10% level.

Note: y_1: firms, which report either product or process innovation, are compared with non-innovators;

y_2 Firms, which do both types of innovation, are compared with non-innovators;

y_3 firms which report only product innovation are compared with non-innovators; and

y_4 Firms, which report only process innovation, are compared with non-innovators.

All variables are binary, zero for non-innovators and one otherwise.

Table 2
Labour Productivity* in Canadian Manufacturing Industries (1992$, thousand)

Industry	1987	1996
Food & Kindred Products	64.8	73.0
Rubber & Plastic	51.0	61.9
Textile Mill	43.0	51.4
Primary Metals	50.2	71.7
Fabricated Metal	46.9	49.8
Machinery, Except Electrical	49.7	67.8
Transportation Equipment	54.8	83.4
Electrical & Electronic	47.2	71.0
Non-metallic	61.1	63.3
Refined Petroleum & Coal	58.5	116.8
Chemicals & Allied	87.1	116.5
Clothing, Hosiery Industries	27.8	33.1
Lumber & Wood	52.9	48.9
Furniture and Fixture	32.5	42.5
Paper	51.2	66.1
Printing	59.8	49.3
Total Manufacturing	52.1	64.3
All Industries	52.4	56.9

*GDP per worker
Source: Statistics Canada

Table 3
Capital intensity* in Canadian Manufacturing Industries (1993$, thousand)

Industry	1987	1996
Food & Kindred Products	82.5	96.7
Rubber & Plastic	53.6	57.5
Textile Mill	70.4	85.6
Primary Metals	191.4	243.7
Fabricated Metal	50.1	45.6
Machinery, Except Electrical	78.0	90.2
Transportation Equipment	82.4	104.3
Electrical & Electronic	44.9	86.1
Non-metallic	116.7	129.7
Refined Petroleum & Coal	783.2	1060.6
Chemicals & Allied	228.1	244.8
Clothing, Hosiery Industries	24.6	36.4
Lumber & Wood	64.7	57.7
Furniture and Fixture	32.7	37.6
Paper	209.3	293.0
Printing	27.0	34.0

*Capital intensity is defined as capital stock per employed person.
Source: Statistics Canada

Table 4
Real R&D expenditure* per employed person in Canadian Manufacturing Industries (1990$, thousand)

Industry	1987	1996
Food & Kindred Products	0.3	0.3
Rubber & Plastic	0.3	0.4
Textile Mill	0.3	0.4
Primary Metals	1.0	1.3
Fabricated Metal	0.3	0.5
Machinery, Except Electrical	5.3	7.4
Transportation Equipment	2.6	2.8
Electrical & Electronic	7.0	12.0
Non-metallic	0.3	0.2
Refined Petroleum & Coal	3.5	4.2
Chemicals & Allied	3.1	6.7
Clothing, Hosiery Industries	0.2	0.2
Lumber & Wood	0.1	0.1
Furniture and Fixture	0.1	0.1
Paper	0.3	0.4
Printing	0.3	0.3
Total Manufacturing	1.5	2.2

*Deflated by GDP deflator.
Sources: OECD ANBERD and Statistics Canada

Table 5
Educational Attainment
in Canadian Manufacturing Industries, Per Thousand of Employed Persons

Industry	**1-3 Years post-secondary education**		**University degree or above**	
	1987	**1998**	**1987**	**1998**
Food & Kindred Products	164.6	340.1	57.8	88.1
Rubber & Plastic	176.5	404.8	51.6	69.2
Textile Mill	66.4	321.3	73.3	50.5
Primary Metals	204.8	447.8	67.2	79.0
Fabricated Metal	238.6	474.5	50.6	68.7
Machinery, Except Electrical	278.4	479.1	107.5	136.2
Transportation Equipment	225.6	437.1	73.4	109.0
Electrical & Electronic	343.7	450.1	134.4	237.1
Non-metallic	155.1	383.3	45.3	51.4
Refined Petroleum & Coal	379.9	469.6	161.6	149.2
Chemicals & Allied	248.1	370.2	214.0	302.2
Clothing, Hosiery Industries	103.0	232.5	19.3	41.0
Lumber & Wood	159.1	361.2	40.2	37.7
Furniture and Fixture	167.7	319.7	39.9	58.7
Paper	208.2	481.3	78.4	91.9
Printing	243.4	412.9	126.2	138.9
Total Manufacturing	213.2	403.8	81.9	113.0
All Industries	267.4	435.1	146.3	183.4

Source: Statistics Canada

Table 6
Educational Attainment, Per Thousand of Employed Persons
Relative Position of Canadian Manufacturing Industries, U.S.=100

Industry	1-3 Years post-secondary education		University degree or above	
	1987	1998	1987	1998
Food & Kindred Products	105.9	153.3	49.6	60.4
Rubber & Plastic	109.0	175.3	47.4	50.3
Textile Mill	62.0	204.7	106.7	53.6
Primary Metals	129.5	189.7	63.5	54.8
Fabricated Metal	144.0	195.0	49.4	50.3
Machinery, Except Electrical	136.0	161.7	59.9	61.3
Transportation Equipment	108.9	148.5	36.5	49.1
Electrical & Electronic	167.9	151.2	64.3	93.0
Non-metallic	102.9	175.1	40.6	36.7
Refined Petroleum & Coal	169.2	150.6	64.0	52.1
Chemicals & Allied	134.6	143.9	77.5	95.5
Clothing, Hosiery Industries	97.5	146.1	30.3	44.6
Lumber & Wood	119.2	184.9	56.0	38.2
Furniture and Fixture	123.9	162.0	49.5	53.7
Paper	132.4	213.4	63.6	59.0
Printing	114.2	140.8	54.8	51.1
Total Manufacturing	117.6	152.9	53.7	59.8
All Industries	130.7	153.3	65.2	67.5

Sources: Statistics Canada, U.S. Bureau of Labour Statistics and U.S. Bureau of Economic Analysis

Table 7
Capital intensity*
Relative Position of Canadian Manufacturing Industries, U.S.=100

Industry	1987	1996
Food & Kindred Products	63.0	66.6
Rubber & Plastic	61.4	55.8
Textile Mill	74.2	74.3
Primary Metals	66.6	86.1
Fabricated Metal	52.8	46.3
Machinery, Except Electrical	72.8	71.5
Transportation Equipment	59.7	61.8
Electrical & Electronic	41.0	56.0
Non-metallic	86.2	97.4
Refined Petroleum & Coal	85.0	97.4
Chemicals & Allied	82.5	70.7
Clothing, Hosiery Industries	69.7	69.9
Lumber & Wood	81.8	77.4
Furniture and Fixture	62.7	61.0
Paper	106.0	122.8
Printing	49.5	52.5

*Capital intensity is defined as capital stock per employed person, and the Canada-U.S. relatives are based on the PPP rate for M&E.
Sources: Statistics Canada, U.S. Labour Statistics and U.S. Bureau of Economic Analysis

Table 8
Real R&D Expenditures* Per Employed Person
Relative Position of Canadian Manufacturing Industries, U.S.=100

Industry	**1987**	**1996**
Food & Kindred Products	38.5	40.2
Rubber & Plastic	32.0	20.5
Textile Mill	176.9	102.6
Primary Metals	72.3	101.6
Fabricated Metal	32.3	44.5
Machinery, Except Electrical	78.3	57.1
Transportation Equipment	11.6	17.2
Electrical & Electronic	66.6	48.9
Non-metallic	13.9	22.8
Refined Petroleum & Coal	16.4	23.3
Chemicals & Allied	24.1	49.6
Clothing, Hosiery Industries	132.9	78.2
Lumber & Wood	57.4	15.0
Furniture and Fixture	61.4	18.1
Paper	76.4	36.6
Printing	89.9	43.3
Total Manufacturing	30.8	38.1

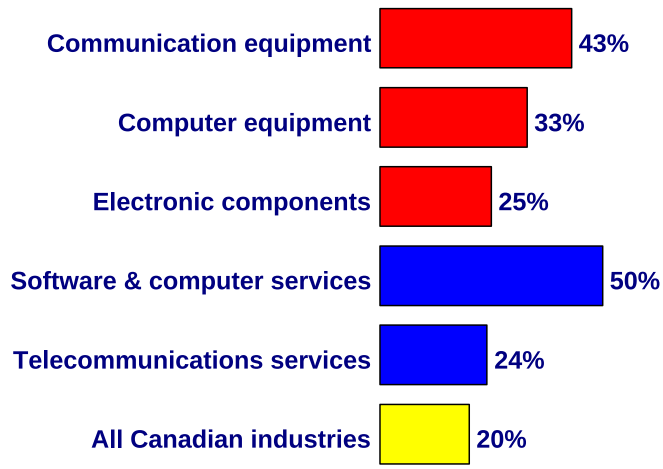
* Nominal R&D expenditures are deflated by GDP deflator, and the Canada-U.S. relatives are based on the PPP rate for aggregate GDP.
Sources: OECD ANBERD, Statistics Canada, and U.S. Bureau of Economic Analysis

Table 9
The Impact of Skills on Productivity and R&D Spending in Canadian manufacturing

	Productivity		R&D	
	Coeff.	t-value	Coeff.	t-value
Productivity (lag one year)	0.5279	9.5*	--	--
Capital intensity	0.0471	6.1*	--	--
University education	0.0659	2.8*	24.7433	5.3*
1-3 years post-secondary education	0.0089	1.6	1.4055	1.6
R&D intensity	0.0005	1.0	--	--
Industry Dummies	Yes		Yes	
Durbin-Watson	1.8		1.7	
Adjusted R-Square	0.97		0.92	

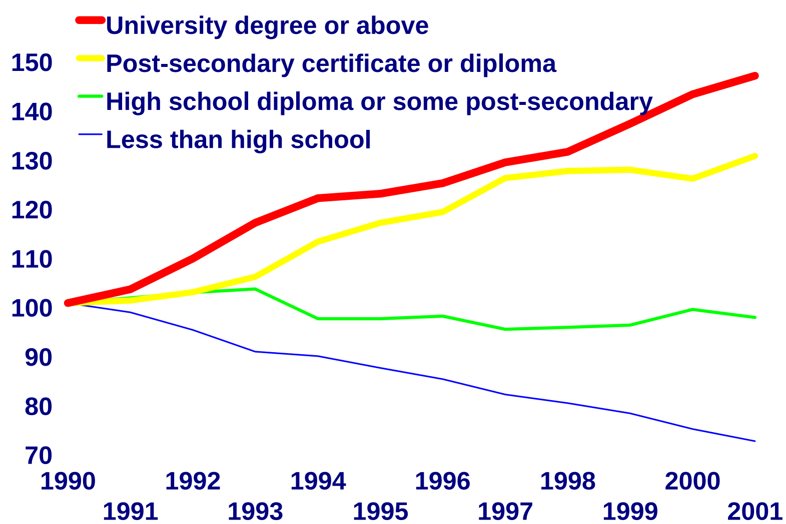
* Significant at 5% level.

Chart 1
Percentage of Workers with a University Degree or Above in Canadian Information and Communication Technology Industries, 2000



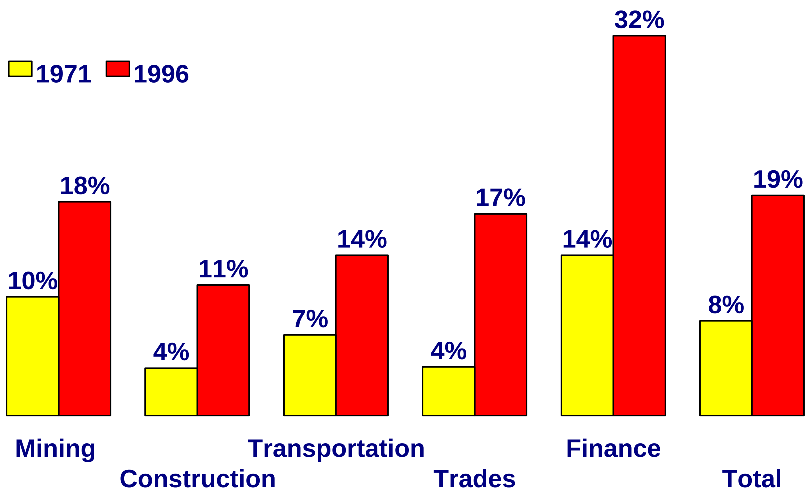
Source: Industry Canada compilations based on data from Statistics Canada

Chart 2
Employment Growth by Educational Attainment in Canada (Index: 1990=100)



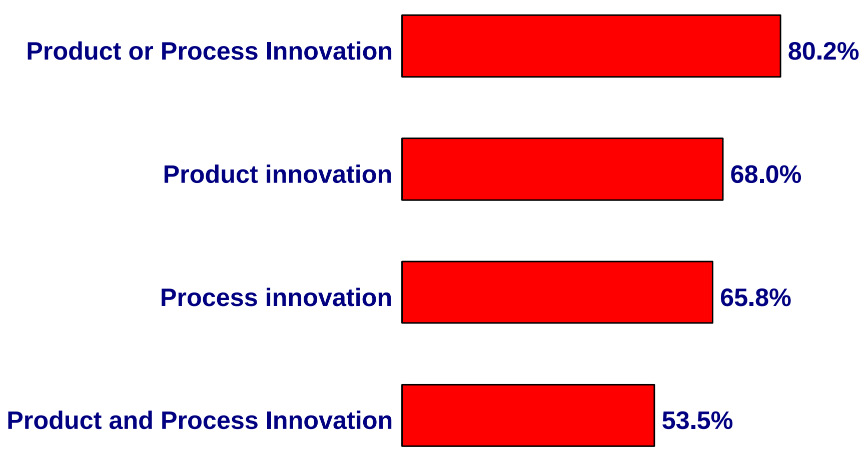
Source: Statistics Canada

Chart 3
Knowledge and Management Jobs as a Share of Total Employment



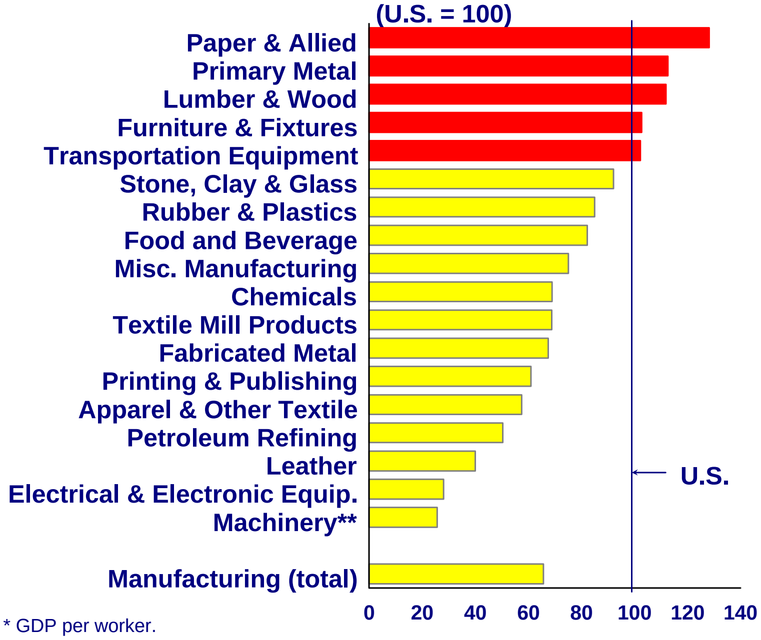
Source: Based on Lavoie, Roy and Therrier (2000)

Chart 4
Percentage of Manufacturing Firms Doing Innovation, 1997-99



Source: Statistics Canada 1999 Innovation Survey

Char 5
Relative Labour Productivity* of Canadian Industries, 2000

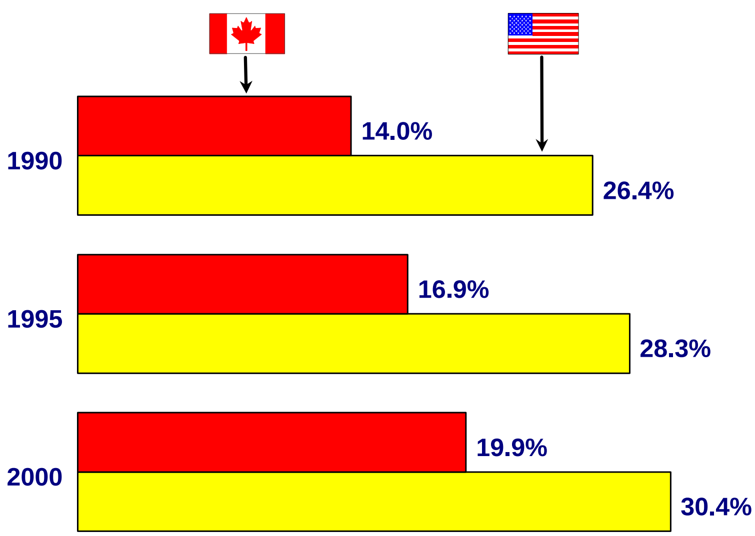


* GDP per worker.

** Machinery includes computer and office equimpment industry.

Source: Industry Canada computations based on data from Statistics Canada, U.S. Bureau of Economic Analysis, and OECD STAN.

Chart 6
Percentage of Labour Force (Aged 25-64) with a University Degree or Above in Canada and the U.S.



Source: Statistics Canada and U.S. Bureau of Labour Statistics