The Importance of Skills for Innovation and Productivity

Someshwar Rao, Jianmin Tang and Weimin Wang*
Micro-Economic Policy Analysis Branch
Industry Canada

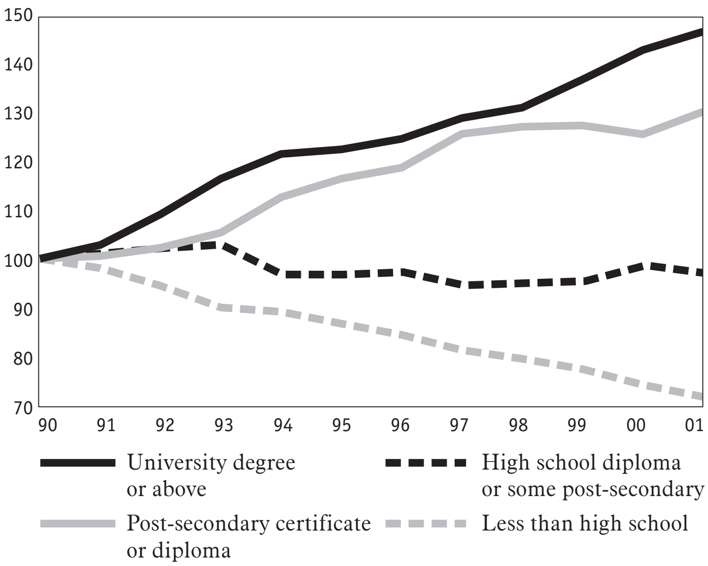
Productivity is the fundamental longer-term driver of differences in living standards across nations and across regions within a country. Similarly, real incomes and productivity trends tend to move together over time in all countries. Therefore, improvements in productivity are critical for raising living standards and the 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 also improve a country's cost competitiveness vis-à-vis the country's trading partners, but also slows growth in living standards.

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 gaps widened. In the crucial manufacturing sector, the battle ground for fierce international competition, the Canada-U.S. labour productivity gap increased from 21 per cent in 1990 to 34 per cent in 2000.

Canada's relatively lackluster 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 analysts have identified the innovation gap as the main reason for Canada's productivity problems.[1] According to these studies, Canada is lagging behind the United States and many other OECD countries in both product and process innovation, as well as in the commercialization of innovations.

The main objective of this article is to highlight the linkages between skills and innovation and productivity in Canada. Using firm-level data for the manufacturing sector, the article examines the impact of different types of skills and of government financial support for innovation activities for product and process innovation

Chart 1
Employment Growth by Educational Attainment in Canada
(Index: 1990=100)



Source: Statistics Canada.

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 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 workers with 1-3 years of non-university post-secondary education; and the percentage of workers with a university degree.

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

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 interpersonal 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 1). Indeed, employment for those with less than a high school diploma declined significantly. Similarly, the share of employment in knowledge and management occupations in total employment more than doubled in Canada between 1971 and 1996 (Chart 2). Similar trends are also observed in other OECD countries.

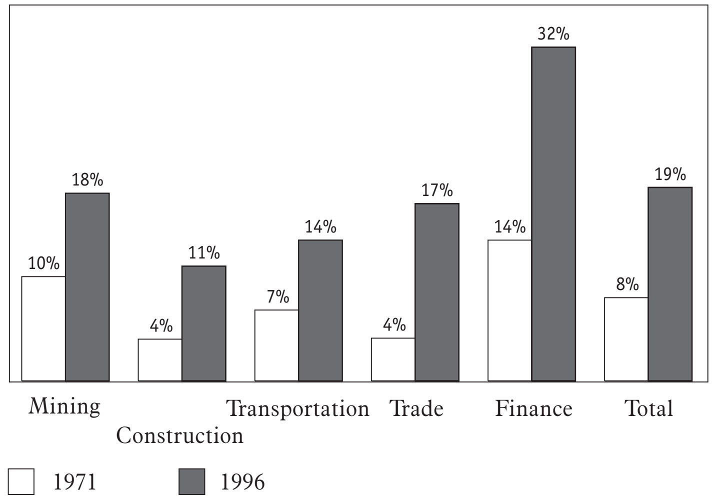
Characteristics of Firms in the Innovation Survey

Using firm-level data from the Statistics Canada 1999 Innovation Survey,[2] 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).

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 between 20 and 49 employees, 54 per cent medium-sized firms, defined as firms with between 50 and 249 employees, 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 3). 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.

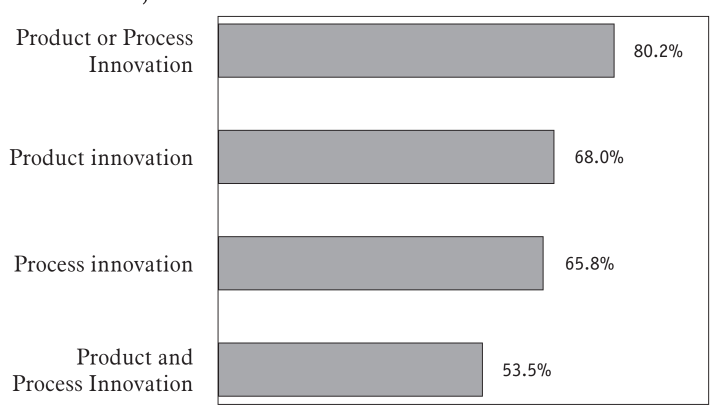
Sixty-six per cent of firms report some type of process innovation. Like product innovation, it varies significantly across industries and is positively correlated with firm size. Eighty per cent of firms in the sample undertake either product or process innovation. But only slightly more than half (54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

Chart 2
Employment in Knowledge and Management Occupations as a Share of Total Employment



Source: Based on Lavoie, Roy and Therrien (2000).

Chart 3
Percentage of Manufacturing Firms Undertaking Innovation, 1997-99

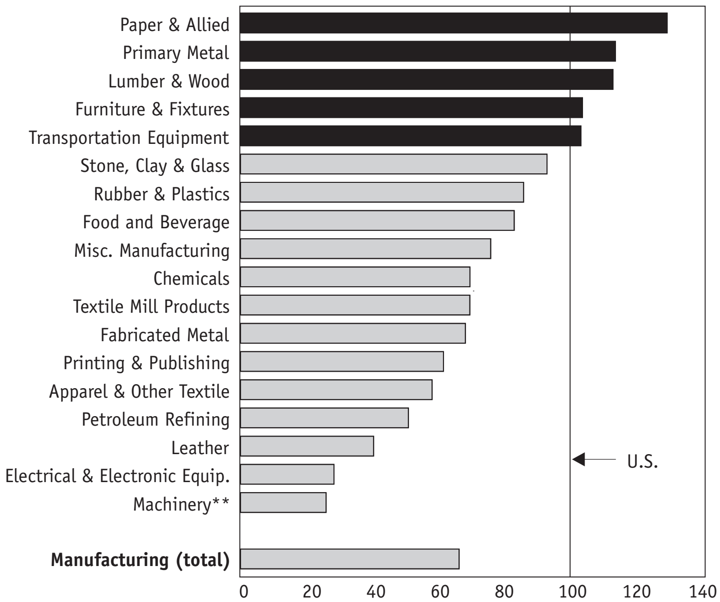


Source: Statistics Canada 1999 Innovation Survey.

Empirical Results

For purposes of empirical analysis, we organize the firms in the sample into four separate groups: firms which report *either* product *or* process innovation are compared with non-innovators; firms which do *both* types of innovation are compared with non-innovators; firms which report only product innovation are compared with non-innovators; and firms which report

Chart 4
Relative Labour Productivity* of Canadian Manufacturing Industries, 2000
(Per cent of United States)



* 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.

only process innovation are compared with non-innovators.[3]

The innovation behaviour of the four sets of firms is examined separately by using a logit model. However, the same set of explanatory variables is used in all four regression equations. These variables are: the hiring of skilled persons from outside Canada, experienced employees, and recent university graduates; cooperation with other firms;[4] product market competition;[5] government support through R&D tax credits and grants, venture capital, technical assistance, information and internet service, and training;[6] firm size;[7] and industry characteristics.[8]

The empirical results suggest (columns 1-2 of Table A1 in the Appendix) 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 engage in such hiring to a lesser extent. Cooperation with other firms and product market competition are also strongly associated for innovation. Similarly, government R&D credits, 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 for the variable 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 conditions in the labour market. As a result, their net contribution to innovation during the transition period might be limited, but greater over the longer term.

For firms that undertake product innovation only, the regression results suggest that firm size is not a significant explanatory variable (column 3 of Table A1 in the Appendix). The hiring of experienced employees, product market competition, cooperation with other firms, government support for R&D, and government technical support and assistance programs are the important drivers of product innovation (column 3 of Table A1 in the Appendix).

Unlike product innovation, process innovation is positively significantly correlated with firm size (column 4 of Table A1 in the Appendix). 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.

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.

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

Labour productivity varies a great deal across Canadian manufacturing industries. For instance, in 1996, output per person employed varied from a high of $116,760 (1992$) in the refined petroleum and coal industry to a low of $33,090 in the clothing industry (Table 1). Similarly, there are even greater differences in capital intensity, R&D intensity and educational attainment across Canadian manufacturing industries (Tables A2-A4 in the Appendix).

In addition, as mentioned in the introduction, the Canada-U.S. manufacturing labour productivity gap increased from 21 per cent in 1990 to 34 per cent in 2000. The gap is pervasive across many manufacturing industries and is especially large in machinery and electrical and electronic equipment industries (Chart 4). This happened despite both a substantial increase in Canada's trade and investment linkages with the United States and other countries, and an advantage in the proportion of Canada's work force with 1-3 years of non-university post-secondary education. Canada, however, generally lags the United States in university education, capital intensity and R&D intensity (Tables 2-4).

Table 1
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.

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 explaining differences in productivity levels among Canadian manufacturing industries. We proxy skills by two education variables: the proportion of workers with 1-3 years of non-university post-secondary education; and the percentage of workers with a university degree. In the knowledge-based economy, we expect a university education to have a larger positive impact on productivity and on innovation, especially fundamental innovation, that is the innovation of new products and processes, than a non-university post-secondary education. University education provides the generic skills 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 (cap-

Table 2
Educational Attainment, Per Thousand of Employed Persons
Relative Position of Canadian Manufacturing Industries, U.S.=100

Industry	1-3 Years non-university 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 Labor Statistics and U.S. Bureau of Economic Analysis.

ital 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.

After controlling for the influence of industry characteristics, all other explanatory variables have a positive impact on labour productivity (Table A4 in the Appendix). 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.[9]

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 their impact on R&D spending.

Canada leads the United States in terms of the proportion of the workforce with some post-secondary education, but it lags significantly behind the United States in terms of the proportion with a university education (Table 2). This gap is greater in manufacturing than at the economy-wide level as Canada in 1998 had only 60 per cent of the U.S. proportion of manufacturing workers with a university degree, compared to 68 per cent for all industries. 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 5).

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 the skills gap in the Canada-U.S. manufacturing productivity gap. Towards these goals, first, using 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 suggests that experienced employees and new university graduates, cooperation with other firms, product market competition, and government support for R&D, training, and technical assistance are the 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 determinants 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, in capital intensity, and in R&D intensity. Our empirical results suggest that Canada could make significant progress in closing the Canada-U.S. productivity and real income gaps by narrowing the gaps in the proportion of the workforce with a university education, that is highly qualified persons (HQP), R&D expenditures, 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).

Table 3
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. Besides M&E and structures, the capital stock includes land and inventories (Jorgenson and Lee, 2001).

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

Table 4
Real R&D Expenditures* Per Employed Person

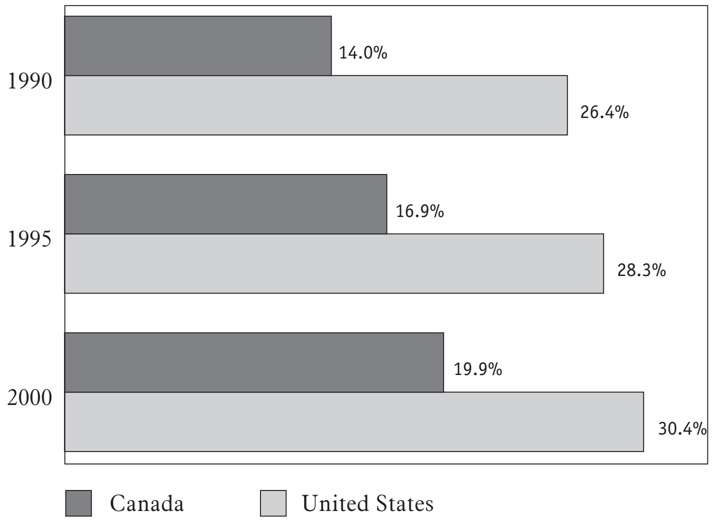
Relative Position of Canadian Manufacturing Industries, U.S.=100

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, Statistics Canada, and U.S. Bureau of Economic Analysis.

Chart 5
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.

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 the 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 manufacturing and equipment, 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 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.

Notes

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

2 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 hereafter) includes all its establishments in the same province and industry at the 4-digit North American Industrial Classification System (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.

3 The sample size was 5451 for the first group, 3994 for the second group, 1851 for the third group and 1688 for the fourth group. The number of non-innovating firms was 1041.

4 The four hiring variables and the cooperation variable are based on the following question: "Please rate the importance of each of the following factors for the success of your firm." Firms were asked to indicate their opinions by using numbers from 0 to 5, with 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.

5 The product market competition variable is a composite latent variable, measured as the weighted sum of four indicators of product market competition (for details, see Tang (2002)). These four indicators are easy substitution of products, constant threat of the arrival of new competitors, constant threat of the arrival of competing products, and quick obsolescence of products. For the four indicators, firms were asked to indicate their opinion on a six-point scale with 0 for not relevant, 1 for strongly disagree and 5 for strongly agree.

6 The five government-related variables are binary and are based on the 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?"

7 For firm size, the reference group in the regression model is the small-sized group in which the number of employees is between 20 and 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.

8 Finally, industries are grouped at the 3-digit NAICS level. There is a total of 20 industries (due to confidentiality, apparel and leather industries are combined). The reference industry is Miscellaneous Manufacturing (NAICS 339).

9 The coefficient on the lagged dependant variable in the productivity equation is 0.53 and statistically significant, implying that the longer-term impacts of the explanatory variables are almost double those of their shorter-term impacts.

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Appendix

Table A1
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*	-1.61*	-2.01*	-2.64*
	(3.4)	(-5.8)	(-5.6)	(-6.0)
Medium-sized firms	0.32*	0.44*	-0.09	0.46*
	(3.9)	(4.8)	(-0.8)	(3.8)
Large-sized firms	0.43*	0.55*	0.03	0.55*
	(3.3)	(4.0)	(0.2)	(2.9)
Hiring new graduates from Univ.	0.17*	0.18*	0.16*	0.15*
	(5.2)	(5.1)	(3.4)	(3.2)
Hiring experienced employees	0.13*	0.13*	0.11*	0.15*
	(3.7)	(3.5)	(2.3)	(3.0)
Hiring skilled people from	-0.02	-0.00	-0.04	-0.06
outside of Canada	(-0.5)	(-0.0)	(-0.8)	(-1.2)
Cooperation with other firms	0.22*	0.27*	0.15*	0.14*
	(8.0)	(8.7)	(3.8)	(3.5)
Product market competition	0.15*	0.21*	0.16*	0.00
	(5.3)	(6.2)	(3.9)	(0.1)
R&D tax credits	1.00*	1.15*	0.94*	0.37*
	(9.9)	(10.9)	(7.3)	(2.6)
Gov. R&D grants	0.83*	0.91*	0.54*	0.54**
	(3.9)	(4.1)	(2.0)	(1.9)
Gov. venture capital support	0.10	0.06	-0.32	0.06
	(0.4)	(0.2)	(-0.8)	(0.2)
Gov. tech. support and assistance	0.70*	0.81*	0.62*	0.53*
programs	(3.5)	(3.8)	(2.5)	(2.0)
Gov. info. and internet service	-0.06	0.02	-0.16	-0.32
	(-0.4)	(0.2)	(-0.8)	(-1.6)
Gov. support for training	0.24*	0.25*	0.06	0.28**
	(2.3)	(2.2)	(0.4)	(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 A2
Capital Intensity* and R&D Expenditure in Canadian Manufacturing Industries**
(Thousands of 1993 dollars per employed person for capital intensity and thousands of 1990 dollars per employed person for R&D expenditures)

	Capital intensity		R&D expenditure	
Industry	**1987**	**1996**	**1987**	**1996**
Food & Kindred Products	82.5	96.7	0.3	0.3
Rubber & Plastic	53.6	57.5	0.3	0.4
Textile Mill	70.4	85.6	0.3	0.4
Primary Metals	191.4	243.7	1.0	1.3
Fabricated Metal	50.1	45.6	0.3	0.5
Machinery, Except Electrical	78.0	90.2	5.3	7.4
Transportation Equipment	82.4	104.3	2.6	2.8
Electrical & Electronic	44.9	86.1	7.0	12.0
Non-metallic	116.7	129.7	0.3	0.2
Refined Petroleum & Coal	783.2	1060.6	3.5	4.2
Chemicals & Allied	228.1	244.8	3.1	6.7
Clothing, Hosiery Industries	24.6	36.4	0.2	0.2
Lumber & Wood	64.7	57.7	0.1	0.1
Furniture and Fixture	32.7	37.6	0.1	0.1
Paper	209.3	293.0	0.3	0.4
Printing	27.0	34.0	0.3	0.3
Total Manufacturing			1.5	2.2

* Capital intensity is defined as net capital stock based on geometric depreciation per employed person. In addition to M&E and structures, the capital stock includes land and inventories.

** R&D expenditure deflated by GDP deflator.

Sources: Jorgenson and Lee (2001) based on Statistics Canada data for capital intensity; OECD and Statistics Canada for R&D expenditure.

Table A3
Educational Attainment in Canadian Manufacturing Industries
(Per cent of employed persons)

Industry	1-3 Years non-university post-secondary education		University degree	
	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 A4
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.

Note: Productivity is defined as GDP per worker. University education denotes the percentage of employees with university education or above. 1-3 years non-university post-secondary education denotes the percentage of employees with 1-3 years post-secondary school. R&D is the real R&D spending per employed person. The capital intensity is defined as capital stock per employed person. Besides M&E and structures, the capital includes land and inventories (Jorgenson and Lee, 2001). The analysis is for thirteen 2-digit (SIC) manufacturing industries, over the period 1987-96, as shown in Table 1.