Canada's Recent Productivity Record and Capital Accumulation

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Canada's relatively good economic performance and the stellar record on the trade front in the second half of the 1990s seriously mask its underlying competitiveness problem.[1] Canada's labour productivity growth lagged behind that of the United States in the last 15 years and this situation is generally pervasive across industries and provinces (Rao, 2002). In a world of increased globalization of production and innovation activity, and fierce international competition for productive resources, physical capital, skilled workers and intellectual capital (innovation activities) have become highly mobile across countries and among regions and industries within a given country. Hence, Canada's ability to attract and retain internationally mobile resources, and create a virtuous cycle of strong economic growth and improvements in quality of life for its citizens will critically depend on its success in making progress in closing the productivity and living standards gaps vis-à-vis the United States, its largest trading partner and one of the most prosperous and dynamic economies in the world.

The causes of the widening productivity and living standards gaps between the two countries have been studied extensively. In a number of recent studies, we examined the role of differences in innovation, human capital and the production and use of Information and Communication Technologies (ICTs) in the widening of the Canada-U.S. labour productivity gap.[2] The objective of this article is to analyse in some detail the contribution of capital accumulation to labour productivity growth in Canada and the widening of the Canada-U.S. labour productivity gap in the 1990s, especially in the latter half of the decade.[3] The following are some of the key research questions we hope to address:

- Did the pace of increase in capital intensity (the capital-labour ratio) slow in Canada in the 1990s? Was the slowdown pervasive across industries or concentrated in a few large industries?
- How much of the inter-industry variation in labour productivity levels across Canadian industries can be explained by the variation in capital intensity levels?
- Is the impact of machinery and equipment (M&E) capital on productivity significantly larger than the impact of structures capital?
- How much of the Canada-U.S. labour productivity gap can be accounted for by the capital intensity gap between the two countries?
- What role has capital intensity played in the widening of the Canada-U.S. productivity gap?

- What role did the differences in trends in the relative rental price of capital to labour cost in the two countries play in the widening of the capital intensity gap?
- What were some of the key drivers of different trends in the relative rental price of capital to labour in the two countries?

Our empirical results indicate that the slowdown in capital intensity growth in the 1990s was pervasive across all Canadian industries. Inter-industry variation in capital intensity explains a large part of the productivity level differences across Canadian industries. In addition, the slowdown in capital intensity growth was a major drag on labour productivity growth in the second half of the 1990s. Our regression results suggest that M&E capital exerts a much bigger impact on productivity than structures capital. Furthermore, the widening of the capital intensity gap also contributed significantly to the widening of the Canada-U.S. labour productivity gap. After controlling for industry specific effects, the differences in trends in the relative rental price of capital (the ratio of the rental price of capital to the wage rate) in Canada and the United States played a significant role in the widening of the capital intensity gap between the two countries. The depreciation of the Canadian dollar and the unemployment rate gap seem to have mainly contributed to the faster increase in the relative rental price of capital in Canada in the 1990s, hence to the widening of the capital intensity and the labour productivity level gaps between the two countries.

The article is organized in the following way. In the next section we examine recent trends in labour productivity in Canadian and U.S. industries. In the third section we discuss changes in the two types of capital intensities: M&E and structures. In this section, we also examine the role of the two types of capital intensities in inter-industry differences in Canadian labour productivity levels and the Canada-U.S. labour productivity gap. Using the growth accounting framework, we also assess the role of capital intensity in Canada's labour productivity growth as well as in Canada-U.S. labour productivity growth differentials in the 1990s. In the fourth section we examine the sources of the widening of the capital intensity gap between the two countries. In this section, we also discuss possible reasons for the faster growth in the relative rental price of capital in Canada. In the last section we summarize the key findings of our paper and explore their research and policy implications.

Canada's Productivity Record: An Industry Analysis

Based on data from the July 2003 issue of the *OECD Economic Outlook*, in the second half of the 1990s (1995-2000) real GDP per worker for the total economy increased at an annual rate of 1.7 per cent, compared to 1.0 per cent per year during the 1987-1995 period.[4] But, despite the large acceleration, Canada's productivity growth lagged behind the United States and a number of OECD countries in the second half of the last decade. Indeed, labour productivity growth in the United States averaged 2.4 per cent per year resulting in a significant widening of the Canada-U.S. labour productivity gap.

Nevertheless, productivity growth in Canada varied greatly across industries. For instance, during the 1987-2000 period, labour productivity (real GDP per worker) increased at a healthy pace (above 2.5 per cent per year) in a number of Canadian industries: primary industries, rubber and plastic products, furniture and fixtures, primary metals, fabricated metals, machinery and electrical and electronic equipment, refined petroleum and wholesale trade (Table 1). On the other hand, in many other industries, labour productivity either declined or remained stagnant. These industries included construction, leather, textiles, lumber and wood, printing and publishing, other manufacturing and retail trade.

Table 1
Labour Productivity Growth by Industry
(Average annual rate of change)

Industry	Canada			United States		
	1987-1995	1995-2000	1987-2000	1987-1995	1995-2000	1987-2000
Primary industries	3.1	3.8	3.4	0.9	2.4	1.5
Construction	-1.4	2.0	-0.1	0.2	-0.3	0.0
Manufacturing sector	3.2	1.5	2.5	2.9	4.5	3.5
Food & kindred products	1.8	0.9	1.4	1.6	-5.2	-1.0
Rubber & plastic	3.1	2.4	2.9	4.2	4.2	4.2
Leather	1.9	-1.1	0.7	4.2	-0.6	2.3
Textiles	-0.3	2.5	0.8	2.9	3.4	3.1
Lumber & wood	-2.1	1.3	-0.8	-3.2	-1.1	-2.4
Furniture and fixture	2.9	4.1	3.4	0.8	1.1	0.9
Paper & allied	0.9	2.6	1.5	0.0	1.1	0.4
Printing and publishing	-1.8	-1.0	-1.5	-2.6	0.0	-1.6
Primary metals	2.8	3.8	3.2	2.6	2.2	2.5
Fabricated metal	2.6	3.0	2.8	1.6	0.8	1.3
Machinery, electrical and electronics	6.7	2.1	4.9	9.4	16.1	12.0
Transportation equipment	5.4	-0.6	3.0	0.8	1.9	1.2
Non-metallic	-1.8	6.0	1.1	3.0	0.9	2.2
Refined petroleum & coal	6.9	2.0	5.0	0.6	4.4	2.0
Chemicals & allied	3.4	-2.7	1.0	2.3	1.6	2.0
Other manufacturing	-1.3	1.4	-0.2	0.3	1.0	0.6
Transportation & warehousing	1.9	0.2	1.3	1.8	1.4	1.7
Communications & utilities	1.5	5.7	3.1	3.9	1.5	3.0
Wholesale trade	3.4	2.6	3.1	2.9	7.1	4.5
Retail trade	-0.1	1.8	0.6	1.2	4.8	2.6
Business sector	1.0	2.1	1.4	1.4	2.6	1.8
Total economy	1.0	2.0	1.4	1.1	2.0	1.5

Note: Labour productivity is defined as real GDP per worker.

Sources: Statistics Canada (Cansim Table 379-0017 for real GDP and Table 282-0008 for employment) and U.S. Bureau of Economic Analysis.

Like Canada, productivity growth also varied considerably across industries in the United States during the 1987-2000 period. Canada's labour productivity growth lagged behind that of the United States in machinery and electrical and electronic equipment, communication and utilities, wholesale trade, and retail trade (Table 1). On the other hand, Canada performed better than the United States in primary industries, food and kindred products, furniture and fixtures, primary metals, fabricated metals, transportation equipment, and refined petroleum products.

The large widening of the Canada-U.S. manufacturing labour productivity gap in the second half of the 1990s was largely due to Canada's relatively lower productivity growth in the machinery and electrical and electronic equipment industry. In this industry, labour productivity increased by 16.1 per cent per year in the United States, compared to a mere 2.1 per cent in Canada (Table 1). However, Canada's performance in other manufacturing industries, on average, was better than that in the United States.

There is also a great deal of variation in labour productivity levels across Canadian industries. For instance, real GDP per worker varies from a low of $27 thousand ($1997) in retail trade to a high of over $120 thousand in the chemicals and allied products industry in 1998.[5] The top five industries in terms of labour productivity levels are: chemicals and allied products, communications and utilities, wholesale

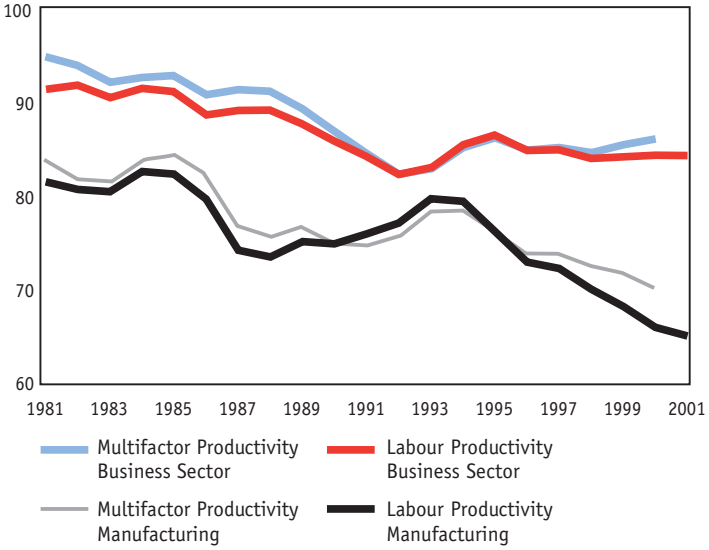
trade, primary metals and refined petroleum. The bottom five industries are retail trade, other manufacturing, leather, textiles, and furniture and fixtures. In general, labour-intensive industries have low productivity levels. On the other hand, resource-based and high-tech industries display high productivity levels.

Canada's labour productivity in the business sector was about 16 per cent below the U.S. level in 2001, compared to 14 per cent in 1990 (Chart 1).[6] A similar picture emerges from the multifactor productivity level gap in the business sector. More importantly, in the manufacturing sector, the battle ground of fierce international competition, the Canada-U.S. labour productivity gap increased from about 25 per cent in 1990 to around 35 per cent in 2001. Canada's productivity challenge is not confined to a few large industries. Instead, the problem is generally pervasive across Canadian industries (Chart 2). But, Canada performs well or exceeds the U.S. productivity levels in mining, construction, paper and allied products, primary metals, lumber and wood, furniture and fixtures and transportation equipment. On the other hand, in electrical and electronic equipment and machinery industries, Canadian productivity levels are only about 30 per cent of the U.S. levels.[7]

Capital Accumulation and Labour Productivity

Capital accumulation is a key driver of living standards, because it contributes directly towards an increase in labour productivity by providing more capital per unit of labour input. Capital formation, especially M&E capital, also raises the productivity of all other inputs, in other words increases total factor productivity (TFP), by facilitating an effective utilization of new and state of the art technologies.[8] Hence, capital accumulation contributes both directly and indirectly towards raising labour productivity.

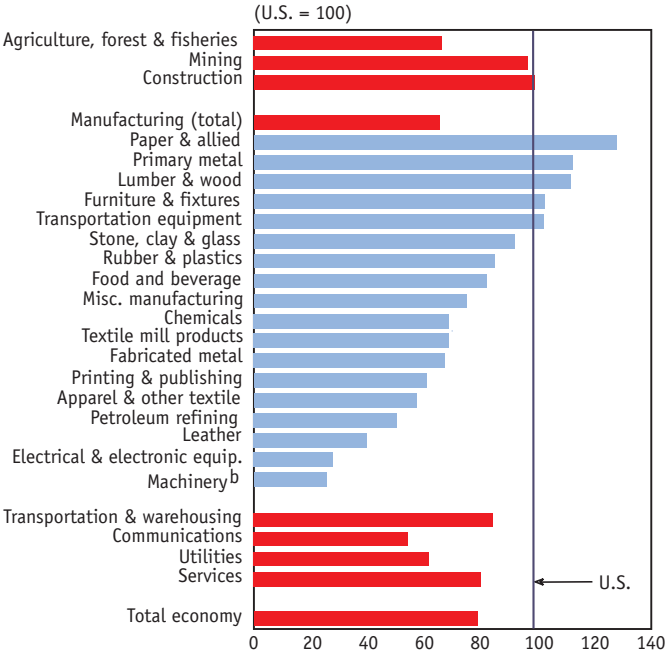
Chart 1
Relative Productivity Levels in Canada
(U.S.=100)



Notes: Labour productivity is defined as real GDP per worker, PPP based. Multifactor productivity is the residual of labour productivity minus the contribution from capital stock intensity.

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

Chart 2
Relative Labour Productivity Levels[a] of Canadian Industries, 2000

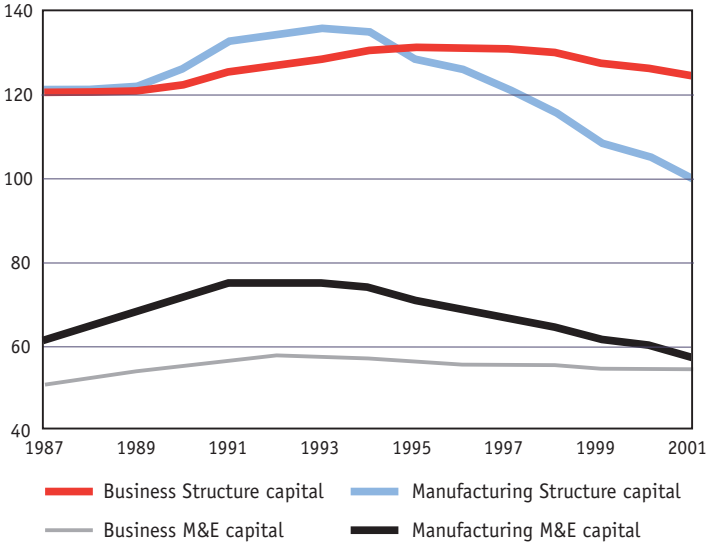


Notes: a GDP per worker in 1990 dollars.

b Machinery includes computer and office equipment industry.

Source: Industry Canada computations based on data from Statistics Canada, U.S. Bureau of Economic Analysis, and OECD STAN (98).

Chart 3
Relative Canadian Capital Intensity in the Business and the Manufacturing Sectors, 1987-2001
(U.S.=100)



Notes: Capital intensity is defined as capital stock per worker. Canadian capital stock in 1997 dollars are converted into U.S. dollars using the investment PPP from Statistics Canada (2002) (0.69 for M&E and 0.94 for structures).

Sources: Statistics Canada and U.S. Bureau of Labor Statistics.

In this section, we first examine the recent trends in capital intensity, measured as capital stock per worker, in Canadian and U.S. industries, disaggregated by two types of capital: M&E and structures. Next, we analyse the impact of the two capital intensities on labour productivity. Finally, we discuss the role of capital accumulation in inter-industry variation in labour productivity levels in Canada and the Canada-U.S. labour productivity gap.

Recent Trends in Capital Intensity

The capital stock consists of machinery and equipment and structures. Capital intensity is defined as capital stock per worker.[9] Aggregate capital intensity in the Canadian business sector increased at a slower pace in the latter half of the 1990s, compared to the 1987-95 period (Appendix Table 1). This slowdown was mainly due to an absolute decline in structures capital intensity in the manufacturing sector. In addition, the M&E capital intensity in this crucial sector more or less remained constant between 1995 and 2000. The following manufacturing industries registered an absolute decline in total capital intensity during this period: lumber and wood, fabricated metals, machinery and electrical and electronics equipment, transportation equipment, petroleum and coal products and chemicals. On the other hand, total capital intensity increased at a healthy pace in primary industries, primary metals, communications and utilities and wholesale trade. These industries also registered a significant increase in M&E intensity.

As expected, there is a considerable variation in capital intensity across Canadian industries. The top five capital intensity industries in 2000 were: communications and utilities, petroleum and coal products, paper and allied products, primary metals and chemicals. They were also the top five in terms of M&E intensity. On the other hand, furniture and fixtures, textiles, retail trade, construction and printing and publishing were at the bottom end of the spectrum. It is very surprising that the machinery and electrical and electronics industry has one of the lowest intensities for both M&E and structures.

The M&E capital intensity in the business sector in 2000, on average, was only 55 per cent of the U.S. level, and the gap widened between 1995 and 2000 (Chart 3).[10] In the manufacturing sector, the M&E intensity gap increased from about 30 per cent in 1995 to 40 per cent in 2000. Furthermore, the Canadian advantage in structures intensity in this sector declined from 29 per cent in 1995 to just 5 per cent in 2000. In all two-digit manufacturing industries, with the exception of lumber and wood and paper and allied products, M&E capital intensity is considerably below the U.S. level (Appendix Table 2). More importantly, in the machinery and electrical and electronics equipment industry, it is only 30 per cent of the U.S. intensity. Similarly, there is also

a large M&E intensity gap in primary industries and service industries. However, Canada's structures intensity exceeds by a large margin the U.S. levels in many industries: primary industries, construction, leather, lumber and wood, paper and allied products, primary metals, petroleum products, chemicals, transportation and warehousing and communications and utilities.

Contribution of Capital Intensity to Productivity Growth

Since M&E capital is the carrier of new and state of the art technologies, its impact on labour productivity is expected to be significantly larger than structures capital. In an effort to obtain an empirical estimate of the relative importance of the two types of capital intensities, using pooled industry and time-series data, we estimated an equation for labour productivity for Canada as well as the United States:[11]

$$(1) \quad \Delta \ln LP_t = \alpha + \beta_1 \Delta \ln k_{ME,t} + \beta_2 \Delta \ln k_{ST,t} + \varepsilon_t ,$$

where $\Delta \ln LP_t$ is the change in log of real value added per worker in year *t* from *t-1*; and $\Delta \ln k_{ME,t}$ and $\Delta \ln k_{ST,t}$ are the change in log of M&E capital intensity and log of structures capital intensity. Capital intensity is defined as capital stock per worker.

As expected, the coefficient on the M&E capital intensity is positive and statistically significant in both countries.[12] On the other hand, the coefficient on the structures intensity, while positive, is either statistically insignificant or weakly significant. More importantly, in all equations, the estimated elasticity of labour productivity with respect to the M&E capital intensity is close to or more than three times that of the structures elasticity. For instance, in the manufacturing sector, the M&E elasticity is 0.54, compared to the structures elasticity of 0.19. These results imply that without taking into consideration the differences in elasticities of the two capital intensities and changes in the composition of the capital stock, we will obtain an inaccurate estimate for the contribution of capital accumulation to labour productivity.

How much of the variation in labour productivity levels across Canadian industries can be explained by inter-industry differences in capital intensities? Our regression results imply that the differences in capital intensity, especially M&E intensity, explain very well the large inter-industry differences in labour productivity levels in Canada. For instance, the top five industries in terms of M&E intensity are also the top industries in labour productivity levels — communications and utilities, paper and allied products, primary metals, petroleum and coal products and chemicals. Similarly, the bottom five industries in M&E capital intensity, with the exception of wholesale trade, also have the lowest levels of labour productivity — retail trade, furniture and fixtures, leather and textiles. The simple correlation between M&E capital intensity and labour productivity levels across Canadian industries in 2000 is 0.65, while with structures it is only 0.47.

Can differences in M&E intensity between Canadian and U.S. industries also explain the large inter-industry variation in the Canada-U.S. labour productivity gaps? The answer is again yes. For example, in construction, lumber and wood, and paper and allied products, the M&E intensity in Canada is either equal to or higher than in the United States (Appendix Table 2). In these industries, Canada's productivity levels are either comparable to or higher than in the United States (Chart 2). Similarly, in industries where the M&E intensity gap is large, the Canada-U.S. labour productivity level gap is also large: machinery and electrical and electronic equipment, petroleum and coal products, textiles and fabricated metals. Moreover, in the manufacturing sector, the M&E intensity gap is about 40 per cent, while the labour productivity gap is about 35 per cent. There is a strong

Table 2
Sources of Labour Productivity Growth in Canada and the United States

	Canada		U.S.		U.S. minus Canada	
	1987-95	1995-00	1987-95	1995-00	1987-95	1995-00
Business Sector						
Growth: (per cent per year)						
Labour Productivity	1.0	2.1	1.4	2.6	0.4	0.5
Contribution: (percentage points per year)						
Multifactor Productivity	0.4	1.9	1.1	2.0	0.8	0.1
Total Capital Intensity	0.6	0.2	0.2	0.6	-0.4	0.4
Manufacturing Sector						
Growth: (per cent per year)						
Labour Productivity	3.2	1.5	2.9	4.5	-0.3	3.0
Contribution: (percentage points per year)						
Multifactor Productivity	2.1	1.7	2.3	3.5	0.2	1.8
Total Capital Intensity	1.1	-0.2	0.5	0.9	-0.5	1.1

Note: Labour productivity is defined as real GDP per worker

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

positive correlation (0.66) between the M&E intensity gap and the Canada-U.S. labour productivity gap across industries in 2000. More importantly, the widening of the M&E intensity gap seems to have played an important role in the widening of the manufacturing labour productivity gap between 1995 and 2000.

Sources of the Canada-U.S. Labour Productivity Gap: Growth Accounting[13]

In this section, we examine the Canada-U.S. labour productivity growth differentials as well as level gaps. We first deal with the growth differentials.

Canada-U.S. labour productivity growth differentials

Using the growth accounting framework, we estimate the contribution of capital intensity growth to labour productivity growth in the business sector as well as the manufacturing sector. Following Jorgenson, Gollop and Fraumeni (1987), we express labour productivity growth in each country as a function of growth in TFP and capital intensity:[14]

(2) $$\Delta \ln LP_t = \Delta \ln MFP_t + \bar{v}_{K,t} \Delta \ln k_t ,$$

where $\Delta \ln LP_t$ is the change in log of real value added per worker in year *t* from *t-1*; $\Delta \ln MFP_t$ is the change in log of the level of multifactor productivity (MFP) in year *t* from *t-1*;[15] $\Delta \ln k_t$ is the change in log of capital intensity, defined as capital stock per worker, in year *t* from *t-1*; and $\bar{v}_{K,t}$ is the two-year average income share of capital in year *t* and *t-1*.

Using equation (2), we analyse the contribution of capital accumulation to labour productivity growth. In the business sector, labour productivity (real GDP per worker) in Canada increased from 1.0 per cent per year during the period 1987-95 to 2.1 per cent per year during the second half of the 1990s. U.S. labour productivity growth exceeded Canadian growth in both periods by 0.4-0.5 percentage points per year. All of the increase in labour productivity growth in Canada was due to the acceleration in MFP growth (Table 2). As a matter of fact, the contribution of capital intensity to labour productivity growth declined in Canada by 0.4 percentage points per year between the two

periods. On the other hand, in the United States, the capital contribution increased by 0.4 percentage points per year during this period. Hence, the widening of the labour productivity growth differential in the business sector during the latter half of the 1990s was largely (80 per cent) due to the widening of the capital intensity gap.

Developments were different in the manufacturing sector. Labour productivity in the U.S. manufacturing sector increased by 4.5 per cent per year during the second half of the 1990s from 2.9 per cent in the period 1987-1995, compared to a deceleration in Canada from 3.2 to 1.5 per cent per year. The widening of the capital intensity gap explains about 37 per cent of the labour productivity growth differential in the latter half of the 1990s (Table 2).

Canada-U.S. labour productivity level gap

Using the growth accounting framework, we can also estimate the contribution of the capital intensity gap to the Canada-U.S. labour productivity gap in the business sector as well as the manufacturing sector. As in Lee and Tang (2001), the theoretical framework for productivity gap and source comparisons between Canada and the United States is based on a translog production function:

$$(3) \quad \Delta \ln LP_{CA/US} = \Delta \ln MFP_{CA/US} + \bar{v}_{K,CA/US} \Delta \ln k_{CA/US},$$

where $\Delta \ln LP_{CA/US}$ is the log of real value added per worker in Canada (PPP-based) relative to the United States; $\Delta \ln MFP_{CA/US}$ is the log of the level of multifactor productivity in Canada relative to the United States; $\Delta \ln k_{CA/US}$ is the log of capital intensity in Canada (PPP-based) relative to the United States; and $\bar{v}_{K,CA/US}$ is the two-country average income share of capital.

Using equation (3), we estimate the contribution of the capital intensity gap to the Canada-U.S. labour productivity gap in the business sector as well as the manufacturing sector. These results are reported in Table 3.

In the business sector, the labour productivity gap is estimated to be about 16 per cent in 2000. The capital intensity gap accounted for 12 per cent of this gap (Table 3). In the manufacturing sector, the labour productivity gap was 34 per cent in 2000. The growth accounting framework suggests that about 16 per cent of this gap was due to the capital intensity gap. However, as pointed out earlier, these are lower bound estimates because M&E capital affects labour productivity more than structures capital.

In summary, capital intensity played a major role in the widening of the labour productivity gap in the latter half of the 1990s in both the business and the manufacturing sectors. In addition, the capital intensity gap accounted for between 12 to 16 per cent of the Canada-U.S. labour productivity gap in 2000. But, the actual contribution of capital intensity could be significantly higher because the M&E intensity gap is considerably bigger than the total capital intensity gap and its impact on labour productivity is also considerably larger than structures capital.[16]

Causes of the Canada-U.S. Capital Intensity Gap

Why is Canada significantly less capital intensive than the United States, especially in M&E capital? Why did the capital intensity gap increase in the second half of the 1990s? What explains the large inter-industry differences in the capital intensity gap? Did depreciation of the Canadian dollar play a role in the widening of the capital intensity gap in the 1990s by raising the relative cost of capital in Canada relative to the United States? These are some of the important questions we address in this section.

Firms minimize their costs of production of goods and services or maximize their profits sub-

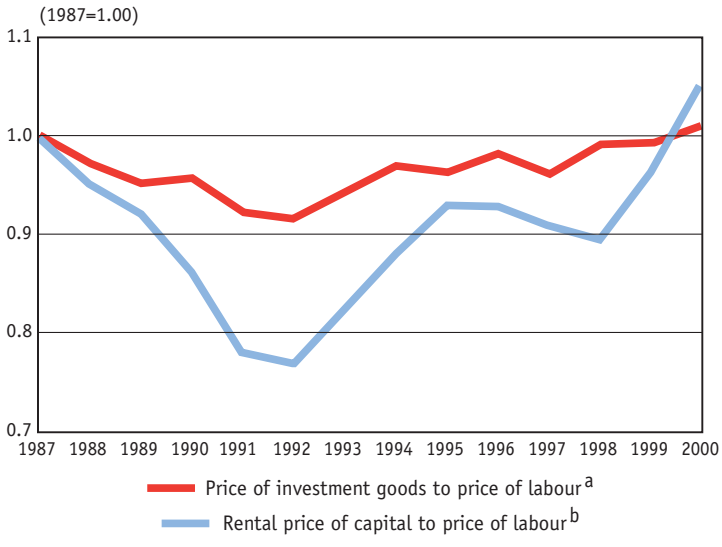
Table 3
Sources of the Canada-U.S. Labour Productivity Gap in 2000

Business Sector	
Relative labour productivity in Canada (U.S.=100)	84.4
Relative MFP in Canada (U.S.=100)	86.2
Relative total capital intensity (U.S. =100)	94.5
Canada-U.S. labour productivity gap	15.6
Contribution (%):	
Multifactor Productivity	87.9
Total Capital Intensity	12.1
Manufacturing Sector	
Relative labour productivity in Canada (U.S.=100)	65.8
Relative MFP in Canada (U.S.=100)	70.3
Relative total capital intensity (U.S. =100)	84.5
Canada-U.S. labour productivity gap	34.2
Contribution (%):	
Multifactor Productivity	84.0
Total Capital Intensity	16.0

Note: Labour productivity is defined as real GDP per worker. The percentage contribution is calculated based on equation (3).

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

Chart 4
Trends in Factor Prices in the Business Sector in Canada Relative to the United States
(US=100)



Notes: a Ratio of investment goods price to the price of labour.
b Ratio of the rental price of capital to the price of labour.

Sources: Statistics Canada and U.S. Bureau of Labor Statistics.

ject to their production function constraints. Under these assumptions, each firm will choose the mix of capital and labour based on relative input prices. Hence, the optimal level of capital intensity, defined as capital stock per unit of labour, is a function of the ratio of the rental price of capital to the wage rate:

$$k = f\left(\frac{r}{w}\right), \quad (4)$$

where k is capital intensity, r is the rental price or user cost of capital services, and w is the wage rate of labour. According to this model, capital intensity will be negatively correlated with the ratio of the rental price of capital to the wage rate. For simplicity, in this paper we refer to the price ratio as the relative rental price of capital.

According to equation (4), the inter-industry differences in capital intensity in Canada depend on the differences in the relative rental price of capital. In addition, the capital intensity gap between Canada and the United States will be determined by the gap in the relative rental price of capital between the two countries. Furthermore, trends in the capital intensity gap between Canada and the United States will be influenced by trends in the relative rental price of capital in the two countries.

As shown in Chart 4, the aggregate relative rental price of capital in Canada rose significantly faster than in the United States during the 1990s, a dramatic reversal of the steady decline between 1987 and 1991, suggesting that it might be an important factor in the widening of the capital intensity gap between the two countries. To examine empirically its role in the capital intensity gap, and hence the labour productivity gap, we regress capital intensity in Canada relative to the United States on the relative rental price of capital in Canada relative to that in the United States. The regression model is:

$$k_{i,t}^{R} = \beta\left(\frac{r}{w}\right)_{i,t}^{R} + \sum_{i=1}^{21} a_i I_{i,t} + \varepsilon_i, \quad (5)$$

where $k_{i,t}^{R}$ denotes the capital intensity in Canada relative to the United States in industry

i in year t; $\left(\frac{r}{w}\right)^{R}_{i,t}$ is the relative rental price of capital in Canada relative to the United States in industry i in year t; and $I_{i,t}$ is the industry dummy for industry i in year t.

We ran two separate regressions based on this model, using pooled industry and time series data between 1987 and 1998.[17] In the first regression, capital intensity is regressed on the relative rental price of capital in Canada relative to the United States. However, we do not have data on industry-specific relative rental prices of capital. Therefore, we used the aggregate data for the business sector. Consequently, the relative rental price of capital does not vary across industries in any given year, but varies over time.

In the second regression, to overcome this data problem, we used industry specific relative prices of investment goods (prices of investment goods relative to the wage rate) in Canada relative to the United States. They vary across industries and over time.

Like the aggregate relative rental price of capital, the aggregate relative price of investment goods also increased steadily in Canada relative to the United States in the 1990s (Chart 4). Nevertheless, the rate of decline prior to 1992 and the pace of increase thereafter was significantly lower than that of the relative rental price of capital. This is because trends in the latter, in addition to being affected by the price of investment goods, are also influenced by trends in real interest rates, corporate tax rates and tax credits in the two countries. For instance, the gap between the Canadian and U.S. real interest rates narrowed dramatically between 1987 and 1992. This trend seems to explain a large part of the divergence between the trends in the relative rental price of capital and the relative price of investment goods during this period.

After controlling for industry-specific effects, the coefficients on the relative rental price of capital and the relative price of investment goods gaps are negative and statistically significant in the two regression equation.[18] In addition, the long-run impact is more than three times that of the short-run impact.[19] These results imply that differences in the relative rental price of capital and the relative price of investment goods in Canadian industries relative to their American counterparts contributed significantly to the capital intensity gap between Canada and the United States. The widening of the relative rental price of capital and relative price of investment goods gaps also played an important role in the widening of the capital intensity gap between Canada and the United States.

Reasons for the Widening of the Relative Rental Price of Capital Gap between Canada and the United States

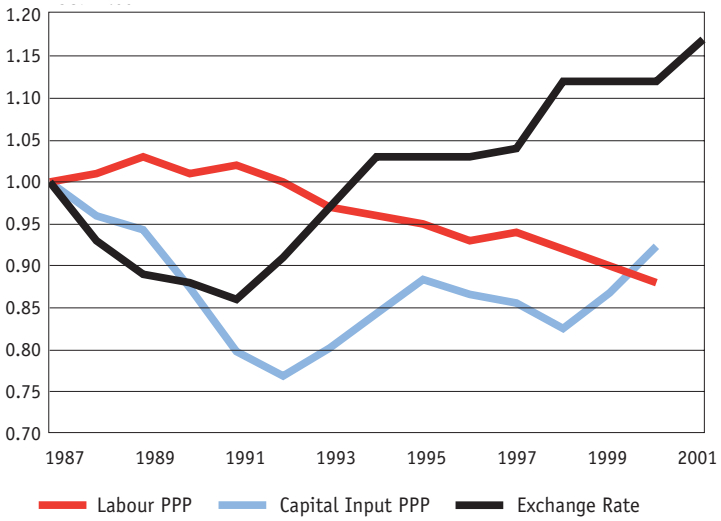
The next question is what were the factors behind the widening of the relative rental price of capital gap. A change in the relative rental price of capital in Canada relative to the United States could be due to either a change in the capital cost in Canada relative to the United States or a change in the Canadian wage rate relative to the United States or a combination of the two. We examine these alternative sources, based on purchasing power parity (PPP) prices for the two inputs. The PPP price for the capital input is defined as the ratio of the Canadian dollars required by Canadian firms to purchase the standard service of capital input in Canada to the U.S. dollars required by U.S. firms to use the same standard capital service in the United States. Similarly, the PPP price for labour is the ratio of Canadian dollars paid by Canadian firms for a standard hour worked in Canada to U.S. dollars paid by U.S. firms for the same standard hour worked in the United States (Lee and Tang, 2001).

The PPPs for capital and labour inputs followed very different trends in the 1990s. The PPP for the labour input trended downwards

Chart 5

Exchange Rate and Purchasing Power Parities for Capital and Labour Inputs

(1987=1.00)



Note: Labour input PPP is simply defined as the ratio of average hourly wage rate in Canada in Canadian dollars to that in the United States in U.S. dollars. Similarly, capital input PPP is defined here as the ratio of capital income per unit of capital stock in Canada to that in the United States.

Sources: Statistics Canada and U.S. Bureau of Labor Statistics.

gradually (Chart 5), implying that labour cost in Canada grew at a slower pace than that in the United States during this period. On the other hand, the PPP for the capital input declined sharply over the 1987-92 period but increased steadily from 1992.[20] It followed closely the movements in the value of the Canadian dollar relative to the U.S. dollar. These different trends for labour and capital input prices in the two countries were mainly responsible for the widening of the relative rental price of capital gap and hence the widening of the capital intensity gap between Canada and the United States.

Trends in capital and labour PPPs can be due to many factors such as trends in real interest rates, the price of investment goods, corporate tax rates and tax credits, the exchange rate and labour market conditions in the two countries.[21] Here, we examine two important factors: trends in the Canada-U.S. exchange rate and the unemployment rate gap between Canada and the United States. We think that these two factors were largely responsible for the widening of the gaps in the relative rental price of capital and relative price of investment goods in Canada relative to the United States in the second half of the 1990s.

A large portion of capital, especially machinery and equipment, is imported from the United States. Therefore, the prices of investment goods are heavily influenced by the movements in the market value of the Canadian dollar relative to the American currency. In other words, the large increase in the PPP for the capital input since 1992 was largely due to the depreciation of the Canadian dollar vis-à-vis the U.S. dollar.[22] On the other hand, a large part of wages and salaries in Canada is paid in Canadian dollars. Consequently, the labour PPP is largely immune from movements in the market value of the Canadian dollar. In addition, the labour market in the United States in the 1990s was much tighter than in Canada, as evidenced by the large unemployment rate gap between the two countries. The tighter labour market in the United States contributed to the faster growth in the U.S. wage rate, hence a declining PPP for the labour input. The stronger economic growth and the tighter labour market in the United States were largely due to greater dynamism of ICT producing industries in the United States and a bigger share of these industries in the U.S. economy, and more efficient use of ICTs in U.S. service industries.

Conclusions

The main objective of this paper has been to analyse the role of capital accumulation in the Canada-U.S. labour productivity gap in the 1990s. The following are some of the key findings:

- M&E capital intensity is more important for labour productivity than structures capital intensity;

- The inter-industry variation in labour productivity levels in Canada is highly positively correlated with the inter-industry differences in M&E capital intensity;
- Similarly, the inter-industry variation in the Canada-U.S. labour productivity gap and the differences in the M&E capital intensity gap are also highly positively correlated:
- The capital intensity gap accounted for at least 12 per cent of the Canada-U.S. business sector labour productivity gap in 2000;
- More importantly, the widening of the labour productivity gap in the latter half of the 1990s was largely due to the widening of the capital intensity gap between the two countries;
- After controlling for industry-specific effects, the capital-to-labour cost in Canada relative to the United States has a significantly positive impact on the Canada-U.S. capital intensity gap;
- The depreciation of the Canadian dollar vis-à-vis the U.S. dollar and the unemployment rate gap between the two countries seem to have contributed significantly to the faster rate of increase in the relative price of capital in Canada in the 1990s, hence to the widening of the capital intensity gap between the two countries.

These findings point to an optimistic outlook for the Canada-U.S. labour productivity and real income gaps. The market value of the Canadian dollar vis-à-vis the American currency, despite the recent appreciation, is still somewhat below the purchasing power parity level, estimated to be around $0.85 U.S. by both Statistics Canada and the OECD. Therefore, there is potential for a further appreciation of the Canadian dollar over the medium term. The recent appreciation of the Canadian dollar in combination with a potential for further appreciation, and the possibility of closing some of the unemployment rate gap between the two countries would lower the relative price of investment in Canada compared to the U.S., a reversal of the trend in the last decade. These positive developments, other things being equal, would narrow the capital intensity and the labour productivity gaps over the next five years or so. Nevertheless, capital is highly footloose across countries, especially in North America. Hence, to attract and retain investments in machinery and equipment and structures, Canada needs to maintain highly competitive and flexible corporate tax and investment incentive systems vis-à-vis the United States.

Future research should analyse in some detail the reasons behind the considerable M&E capital intensity gap between Canada and the United States in many industries, especially in high-tech industries. We also need to do more in-depth research about the causes of the higher relative price of investment goods in Canada.

Notes

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1 The competitiveness of a country can be formally defined as the degree to which a country can, under free and fair market conditions, produce goods and services that meet the test of international markets while simultaneously maintaining and expanding the real incomes of its citizens (President's Commission on Industrial Competitiveness, 1985).

2 See Rao et al. (2001) for innovation, Rao, Tang and Wang (2002) for human capital, and Rao and Tang (2001) for the production and use of ICTs.

3 Lower investment intensity in Canada has been identified as one of the key factors responsible for the Canada-U.S. labour productivity gap by many studies, e.g. Lee and Tang (2001), Bernstein, Harris and Sharpe (2002), Nadeau and Rao (2002), Rao, Tang and Wang (2002), and Sharpe (2003).

4 The *OECD Economic Outlook* does not provide data on hours worked for productivity analysis and U.S. statistical agencies do not publish hours worked for detailed industries. To be consistent, the number of employed persons is used to define labour productivity (i.e. GDP per worker) and capital intensity (i.e. capital stock per worker) throughout the paper.

5 Labour productivity levels are defined as real GDP per worker at market prices in 1997 dollars (real GDP at basic prices is adjusted to real GDP at market prices).

6 Note that Canada's productivity decline relative to the United States started in the early 1980s.

7 It should be noted that differences in commodity composition between the two countries may partly explain the lower relative productivity levels in the Canadian electrical and electronic equipment and machinery industries.

8 For instance, Greenwood, Hercowitz and Krusell (1997) suggest that technical change is "embodied" in new M&E investment. Therefore, M&E is needed to realize fully the benefits of technological progress. According to Stiroh (2002), the investment-specific technical change is conceptually distinct from capital accumulation and disembodied technical change.

9 Preferably, one could measure capital in such a way that it is consistent with the concept of "constant quality" as used by Jorgenson and his associates, e.g. Jorgenson (1995), Jorgenson and Griliches (1995) and Jorgenson and Stiroh (2000). Under this framework, capital input is derived as quantity indices of capital stocks of different types of assets, using capital rental prices as weights. However, we do not have data for undertaking such an exercise.

10 Note, however, that total capital intensity in Canada was equal to or slightly higher than that in the United States briefly in the mid-1990s (Appendix Table 2).

11 For both countries, there are 15 manufacturing and 6 non-manufacturing industries. Each industry has 11 observations for Canada and 13 observations for the United States.

12 The estimates are White-heteroskedasticity consistent, which corrects for the presence of any heteroskedasticity across industries. These results are found in Table 4 of the unabridged version of this article posted under the *International Productivity Monitor* at www.csls.ca.

13 The growth accounting framework has been widely used by Jorgenson and his associates in economic growth and productivity studies, e.g. Jorgenson, Gollop and Fraumeni (1987), Jorgenson (1995), Jorgenson and Griliches (1995), Jorgenson and Stiroh (2000), Jorgenson and Lee (2001) and Jorgenson and Yun (2001).

14 This growth accounting framework is based on the assumptions of constant returns to scale and competitive product and factor markets.

15 Under this framework, MFP growth is calculated as a residual, equal to labour productivity growth minus the contribution of capital intensity growth. MFP growth is often referred to as technical progress. Nevertheless, it captures the influence of a variety of other factors, including innovation of all sorts, economies of scale and scope, market imperfections, worker management relations, resource re-allocation, measurement errors in both output and inputs, etc.

16 For instance, if total capital stock is replaced by M&E capital stock and 0.543 used as the capital income share in equation (2) for the Canadian manufacturing sector, as per the regression results in Table 4 of the unabridged version of this article, then the M&E capital intensity level gap will explain about 64 per cent of the Canada-U.S. manufacturing labour productivity gap in 2000.

17 We have data for 15 manufacturing and 6 non-manufacturing industries for 1987-1998 and thus have a pooled sample of 252 observations.

18 The estimates are White-heteroskedasticity consistent, which corrects for the presence of any heteroskedasticity across industries.

19 These results are found in Tables 7 and 8 of the unabridged version of this article posted under the *International Productivity Monitor* at www.csls.ca.

20 The relative rental price of capital in Canada relative to the United States dropped sharply over the 1987-92 period. One possible explanation for the significant decline is the reduction in the real interest rate spread in the two countries. The real interest rate in Canada was significantly above that in the United States in the late 1980s and early 1990s, and the spread reached 5.8 percentage points in 1990. The spread is the risk premium that Canadian firms paid for obtaining capital, and it affects the user cost of capital by influencing the rate of return on each asset. The spread gradually declined after 1990, and virtually disappeared after 1995. The reduction in the spread coincided with the sharp decline in the user cost of capital in Canada relative to the United States. This phenomenon has also been studied by McKenzie and Thompson (1997).

21 Besides the price of investment goods, the user cost of capital is also influenced by many tax related parameters such as the statutory tax rate, property taxes, and personal taxes. Many studies have documented that these taxes discourage investment (e.g. Mintz, 1995 and Jorgenson and Yun, 2001). McKenzie and Thompson (1997) provide excellent comparisons of the two tax systems and their impact on the cost of capital, also done more recently by Chen and Mintz (2003). They show that despite the tax reforms in both Canada and the United States in the mid-1980s, the overall impact of the tax system on the cost of capital has been higher in Canada than in the United States. However, the tax disadvantage more or less stabilized after 1989 (McKenzie and Thompson, 1997 and Jog and Tang, 2001).

22 Note, however, that the rental cost of capital increased at a slower pace than the exchange rate in the 1990s. This may be explained by the fact that prices of some assets such as structures are less affected by the exchange rate changes.

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Appendix Table 1
Capital Intensity[a] in Canadian Industries

Industry[b]	M&E			Structures			Total		
	1987	1995	2000	1987	1995	2000	1987	1995	2000
Primary industries	42.2	31.5	42.4	238.7	281.8	365.6	280.2	313.4	408.0
Construction	10.3	15.0	16.8	5.7	7.4	7.2	16.0	22.4	24.0
Manufacturing (total)	35.8	49.2	49.1	39.3	44.9	39.5	75.0	94.2	88.7
Food and beverage and tobacco	24.1	33.3	37.7	34.1	37.8	37.3	58.6	71.7	75.6
Rubber & plastics	21.3	30.4	34.9	19.8	19.8	17.2	41.2	50.2	52.1
Leather	5.6	12.1	13.1	12.9	22.8	25.7	18.5	34.9	38.8
Textiles[c]	9.6	12.2	14.5	13.4	14.4	14.7	22.9	26.6	29.2
Lumber & wood	33.7	45.7	42.5	27.1	29.1	25.7	60.8	74.7	68.1
Furniture & fixtures	3.5	5.8	7.9	9.4	11.3	9.5	12.8	17.1	17.4
Paper & allied	133.1	197.0	200.8	68.7	91.1	95.3	202.1	288.1	296.1
Printing & publishing	12.4	16.7	18.8	8.5	10.1	9.4	20.8	26.8	28.2
Primary metal	104.3	123.8	148.6	85.3	106.5	107.9	189.6	230.3	256.6
Fabricated metal	14.0	15.9	18.8	18.0	20.5	17.4	31.9	36.3	36.2
Machinery, electrical and electronics	11.7	18.6	22.7	18.7	23.7	18.8	30.2	42.3	41.2
Transportation equipment	36.6	56.9	52.1	30.2	33.8	28.9	66.8	90.7	81.0
Stone, clay & glass	44.5	52.4	60.6	44.9	46.9	41.7	89.6	99.3	102.3
Petroleum and coal prod.	67.3	115.4	132.5	561.6	743.7	641.3	625.8	859.0	773.7
Chemicals	85.7	95.7	95.7	103.0	109.4	102.6	188.6	205.1	198.2
Transportation & warehousing	30.7	38.5	47.5	143.3	149.6	141.6	173.5	188.0	189.1
Communications & utilities	155.2	211.9	276.9	543.1	642.8	709.6	695.5	854.7	985.0
Wholesale trade	4.5	10.3	17.3	17.6	21.0	19.9	21.1	31.1	37.0
Retail trade	2.4	4.7	6.7	11.2	13.5	15.0	13.3	18.2	21.6
Business Sector	20.7	26.1	30.9	67.7	74.7	72.1	88.1	100.8	102.9

Notes:

a Real net non-residential capital stock (machinery & equipment, and structures, in 1997 Canadian dollars) per worker.

b Industrial classifications for Canada are based on North American Industry Classification.

c Including primary textile mills, apparel and other textile products.

Sources: Statistics Canada.

Appendix Table 2
Relative Capital Intensity[a] in Canadian Industries
(U.S. =100)

Industry[b]	M&E			Structures			Total		
	1987	1995	2000	1987	1995	2000	1987	1995	2000
Primary industries	0.43	0.34	0.40	0.90	1.22	1.52	0.78	0.96	1.16
Construction	0.82	1.08	1.01	0.93	1.17	1.39	0.95	1.23	1.25
Manufacturing (total)	0.62	0.71	0.60	1.21	1.29	1.05	0.91	1.00	0.83
Food and beverage and tobacco	0.37	0.44	0.43	0.79	0.85	0.80	0.58	0.65	0.61
Rubber & plastics	0.53	0.60	0.53	0.97	0.94	0.72	0.74	0.77	0.65
Leather	0.49	0.95	0.61	0.87	1.28	1.08	0.72	1.16	0.89
Textiles[c]	0.45	0.48	0.40	0.88	0.87	0.68	0.67	0.68	0.55
Lumber & wood	1.26	1.85	1.57	1.32	1.53	1.41	1.37	1.82	1.62
Furniture & fixtures	0.27	0.38	0.43	0.60	0.68	0.60	0.46	0.56	0.54
Paper & allied	1.01	1.26	1.15	1.84	2.25	2.20	1.36	1.67	1.56
Printing & publishing	0.43	0.54	0.47	0.51	0.55	0.50	0.50	0.59	0.53
Primary metal	0.62	0.72	0.85	1.11	1.49	1.57	0.86	1.06	1.17
Fabricated metal	0.26	0.29	0.33	0.83	0.97	0.85	0.48	0.53	0.52
Machinery, electrical and electronics	0.24	0.31	0.30	0.79	0.87	0.56	0.46	0.53	0.42
Transportation equipment	0.66	0.82	0.66	1.08	0.96	0.85	0.88	0.95	0.80
Stone, clay & glass	0.64	0.76	0.66	1.15	1.25	1.08	0.90	1.02	0.88
Petroleum and coal prod.	0.23	0.25	0.28	1.45	1.91	1.51	0.95	1.07	0.90
Chemicals	0.62	0.54	0.47	1.45	1.34	1.11	0.99	0.88	0.74
Transportation & warehousing	0.27	0.37	0.42	1.02	1.32	1.40	0.70	0.90	0.93
Communications & utilities	0.52	0.58	0.62	1.16	1.24	1.34	0.93	1.00	1.05
Wholesale trade	0.16	0.27	0.29	0.56	0.62	0.56	0.39	0.45	0.43
Retail trade	0.26	0.44	0.51	0.59	0.63	0.66	0.47	0.56	0.61
Business sector	0.51	0.57	0.55	1.20	1.31	1.26	0.93	1.01	0.95

Notes:

a Real net non-residential capital stock (machinery & equipment, and structures, in 1997 U.S. dollars) per worker. Canadian net capital stock is converted into U.S. dollars using purchasing power parity exchange rate for M&E and structure (Statistics Canada, 2002).

b Industrial classifications for Canada are based on North American Industry Classification System and those for the U.S. are based on U.S. 1987 Standard Industrial Classification.

c Including primary textile mills, apparel and other textile products.

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