Interpreting Canada's Productivity Performance in the Past Decade: Lessons from Recent Research

Richard Dion, Research Department

- *Trend productivity growth in Canada has remained modest in the past 10 years. This contrasts with a sustained productivity resurgence observed in the United States. The rise and fall of Canadian productivity growth centred around the year 2000 largely reflect business cycle developments and the boom and bust in the demand for information and communications technologies (ICT).*
- *Canada has taken less advantage of ICT than the United States and has realized fewer efficiency gains in the production of goods and services. Comparatively moderate wages relative to the price of investment in machinery and equipment (M&E) likely exacerbated the gaps in M&E and technology intensities relative to the United States until at least the early 2000s.*
- *Adjustment costs associated with the reallocation of resources between industries in response to large relative price movements have probably slowed aggregate productivity growth in Canada in recent years. As well, high resources prices would have induced the exploitation of marginal reserves, with significant negative effects on aggregate productivity growth in 2005 and 2006. These phenomena would have intensified the more persistent drag exerted by impediments to innovation.*
- *Canada's lagging performance with respect to innovative activity, the adoption of new technologies, and investment in organizational capital seem to mostly reflect a relatively weak demand for innovation. The latter could partly stem from less competition and fewer rewards from risk taking and, until recently, a slower decline in the price of M&E-embodied technologies relative to labour compensation.*

The past decade in Canada has seen a rise and fall in productivity growth centred around the year 2000, but no shift in the growth of trend productivity from its moderate pace of the previous 20 years. The United States, in contrast, throughout the same period has witnessed a resurgence of the strong productivity growth of the 1960s and early 1970s. In this article, we attempt to shed light on the evolution of Canadian productivity since the mid-1990s, using the United States as a benchmark for comparison. We begin by looking at Canada's trend productivity growth over the past 30 years, alone, and in comparison with other advanced economies. We then examine the sources of productivity growth in Canada over the past decade using growth accounting and decomposition by industry to gain additional insights about differences from the United States. This is followed by an analysis of several factors that likely underpin these results, notably, adjustment costs, a lacklustre demand for innovation, and structural factors. The article concludes with suggestions for further research, particularly in areas where outstanding issues remain.

Canadian Productivity Growth in Perspective

There have been remarkably diverse patterns of labour productivity growth across advanced countries over the past 10 years or so. Labour productivity growth in Canada picked up over the late 1990s, only to fall back in the next five years to the sluggish pace of the 1974–96 period (Table 1). The same profile was observed in Australia and New Zealand, but with much less amplitude. In contrast, average productivity growth in 11 European Union countries has fallen markedly compared with the previous 20 years, while in the United States it has shifted to persistently higher levels. These patterns reflect, to varying degrees, changes in trend productivity growth, business cycle influences, lags in the impact of macroeconomic policies, and the effects of transitory sector-specific developments.

An increase in trend productivity growth has occurred in the United States . . . but not so far in Canada.

By isolating the trend component in labour productivity growth, we can gauge the importance of structural factors and make better judgments about future growth prospects. Methods of detecting changes in trend productivity growth include techniques based on the notion of slow and continuous change in the evolution of equilibrium productivity as well as statistical methods to identify structural breaks or abrupt shifts in the profile of productivity growth. One particularly rich version of the latter uses corroborating evidence from wages per hour worked and consumption per hour worked to estimate a common underlying growth trend (Kahn and Rich 2003).[1] As Chart 1 shows, the profiles of real output, wages, and consumption per hour are similar over the past 30 years.[2] Application of the Kahn and Rich approach to Canada reveals a shift in trend productivity growth in the late 1970s from a high-growth regime of about 2.5 per cent to a low-growth regime of a little over 1 per cent for the total economy, but no shift back to a high-growth regime in the late 1990s (Dolega 2007; Table 2). In contrast, the same technique applied to the United States signals a shift to a low-growth regime in the early 1970s and a switch back to a high-growth regime in the late 1990s. Skoczylas and Tissot (2005) report similar results for Canada and the United States, using a statistical procedure designed to detect structural inflection points. They also find that trend productivity growth shifted down in the euro area in the mid-1990s and in Australia in the early 2000s and has been very low in New Zealand since the early 1990s. Thus, an increase in trend productivity growth has occurred in

Table 1

Gross Domestic Product per Hour Worked: Total Economy

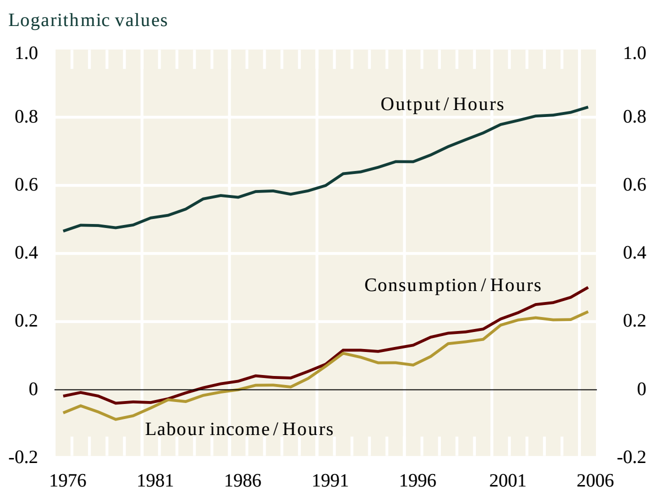
Annual average growth rates (%)

	1974–96	1997–2005	1997–2000	2001–05
Canada	1.2	1.9	2.9	1.1
United States	1.3	2.4	2.1	2.5
European Union (EU-11)*	2.7	1.5	1.9	1.2
(United Kingdom)	(2.2)	(2.1)	(2.5)	(1.9)
Australia	1.7	1.9	2.1	1.7
New Zealand	0.8	1.3	1.6	1.0

* EU-15 excluding Austria, Greece, Luxembourg, and Portugal.
Source: OECD Productivity Database, September 2006

Chart 1

Trends in Real Output, Consumption, and Labour Income per Hour Worked: Total Canadian Economy



Sources: National Accounts and Labour Force Survey. Nominal output and labour income are deflated by the GDP price deflator. Nominal consumption is deflated by the price index for personal consumption.

1. Kahn and Rich (2003) show that, under assumptions consistent with the neoclassical growth model, output per hour, real wages per hour, and real consumption per hour will share a common trend over the long run.

2. Tests reveal that the variables are indeed cointegrated.

Table 2

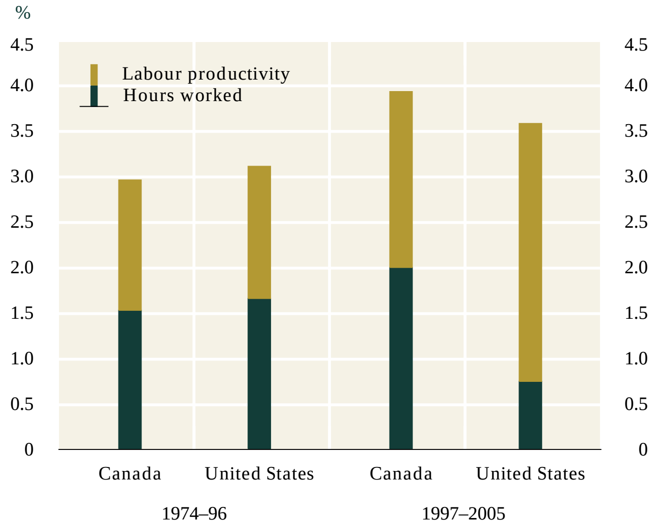
Most Recent Trends in Labour Productivity Growth Rates (%)

	Previous trend		Most recent trend		Sector
	Start	Average	Start	Average	
Canada					
S&T (2005)*	mid-1960s	4.00	mid-1970s	1.25	Business
Dolega (2007)	1966	2.40	1979	1.10	Total economy
United States					
S&T (2005)*	mid-1970s	1.25	late 1990s	3.00	Business
Kahn & Rich (2003)	1974	1.40	1997	2.90	Non-farm business
Euro area					
S&T (2005)*	late 1970s	2.50	mid-1990s	1.50	Business
Australia					
S&T (2005)*	early 1990s	2.50	early 2000s	1.50	Business
New Zealand					
S&T (2005)*	early 1970s	1.25	early 1990s	0.75	Business

* S&T = Skoczylas and Tissot (2005)
Note: Productivity is defined as gross domestic product per hour worked.

Chart 2

Contributions to Real GDP Growth in the Business Sector



Sources: Statistics Canada and the U.S. Bureau of Labour Statistics (data for the non-farm business sector)

the United States in the past decade or so, but not so far in Canada or in most other advanced countries.

This failure did not prevent Canada from achieving a higher rate of output growth in the business sector than the United States over the 1997–2005 period. It did this by relying more on additional workers to increase production (Chart 2). Whereas in Canada productivity growth accounted for nearly half of the gross domestic product (GDP) advance, as it did in the 1974–96 period, in the United States it accounted for 80 per cent of the output gain, a much higher proportion than before.

Examining the sources of the broad movements in Canadian productivity in terms of growth accounting and decomposition by industry provides additional clues about trend productivity growth.

Sources of Productivity Growth in Canada

Growth accounting is an empirical methodology that, in its most common version, decomposes labour productivity growth into three elements:[3] growth in the services of physical capital per hour worked, or *capital deepening*;[4] changes in human capital per job, or *labour quality*, as a result of variations in the levels of education and experience of the workforce; and growth of *total factor productivity* (TFP). TFP is the residual component usually associated with technological change but can also reflect a host of other factors, including variations in capacity utilization and capital adjustment costs;[5] changes in returns to scale

3. Growth accounting based on a "gross output" measure of output also includes the contribution of intermediate inputs.

4. Capital service flows reflect both the growth of capital stocks and capital quality. Such service flows are derived by weighting the growth of the stock of each asset by its respective rental price or user cost. An increase in the share of information and communications technology (ICT) in total capital stock would lead to a rise in capital services per unit of capital stock because the rental price of ICT services is relatively high.

5. These costs may originate from substantial but unrecorded complementary investments in learning and reorganization, especially with ICT, which has attributes of a general-purpose technology. They would cause TFP first to slow down and then to accelerate as they run off. Estimates of the lag before TFP accelerates vary considerably. Using aggregate data, Leung (2004) estimates a lag of three years for computer hardware in Canada, while Basu and Fernald (2006), using industry data, estimate lags of five to 15 years for ICT in the United States. Bosworth and Triplett (2007), on the other hand, generally find no significant effect of ICT intensity on TFP growth in the United States.

Table 3

Canadian Business Sector: Labour Productivity Growth, 1974–2005 (%)

	1974–96	1997–2000	2001–05
Labour productivity	1.4	3.0	1.0
Capital deepening	1.1	1.0	0.7
Information and communications technology (ICT)	0.4	0.7	0.3
Non-ICT	0.7	0.4	0.4
Labour quality	0.4	0.4	0.4
Total factor productivity	0.0	1.6	-0.1

Source: Statistics Canada, Cansim Table 383-0021, 2007

and mark-ups of price over marginal cost; unrecorded investment in intangible assets;[6] and measurement errors in outputs and inputs.

Growth accounting reveals that the rise and fall of productivity growth in Canada centred around the year 2000 largely originated from variations in TFP growth, which strengthened markedly until 2000 before turning slightly negative in subsequent years (Table 3). Capital deepening in ICT assets accelerated in the 1997–2000 period but moderated considerably afterwards; with respect to non-ICT assets it settled down to a slower pace from the late 1990s onwards. Labour quality progressed in the past decade at the same rate as over the 1974–96 period.

The rise and fall of productivity growth in Canada centred around the year 2000 largely originated from variations in TFP growth.

Unlike Canada, the United States has experienced an upward shift in productivity growth that has persisted throughout the period (Table 4). Efficiency gains in the production of both information and communications technology (ICT) and services accelerated in the second half of the 1990s, while a steeper decline in ICT prices stimulated heavier investment and capital deepening in ICT assets during this period. In the first half of the 2000s, the direct contribution of ICT diminished, but capital deepening in non-ICT assets started to pick up, and efficiency gains in the production of services and non-ICT goods accelerated.

6. These would include, for the most part, research and development (R&D), brand equity, and employer-provided worker training.

Table 4

U.S. Non-Farm Business Sector: Labour Productivity Growth, 1987–2005 (%)

	1987–95	1995–2000	2000–05
Labour productivity	1.4	2.5	2.5
Capital deepening	0.5	0.9	0.8
Information and communications technology (ICT)	0.4	0.8	0.5
Non-ICT	0.1	0.1	0.3
Total factor productivity	0.9	1.6	1.7
Computers	0.3	0.7	0.3
Services	0.3	0.9	1.1
Others	0.3	–	0.3

Source: Bosworth and Triplett (2007)

The growth-accounting results just outlined reflect the boom and bust in the demand for ICT around the year 2000. These shocks had at least some transient effects, first positive then negative, on TFP growth in the ICT-producing sector in both countries. They also affected capital deepening in ICT assets: in Canada, for instance, the growth of ICT capital input intensified markedly in the late 1990s and slowed to a sub-par rate in subsequent years, particularly in 2001–03. The decline in ICT-capital deepening over the 2001–05 period cut productivity growth in the Canadian business sector by 0.4 percentage points per year.

Growth accounting also reveals that business cycle influences drove aggregate productivity growth in Canada but not in the United States. Productivity growth rates tend to be the highest in the immature phase of a business cycle expansion because firms can more fully use labour hoarded during the preceding slowdown. This factor underpinned the strong growth of TFP in the non-ICT-producing sectors in Canada in the late 1990s. As economic growth in Canada fell below its potential rate in the first half of the 2000s, the pace of productivity growth slowed markedly in cyclically sensitive sectors, especially manufacturing (Table 5). Early in the period, this dampening largely originated from the downswing in the U.S. economy, while closer to mid-decade, the appreciation of the Canadian dollar played an important role by slowing output growth. Meanwhile, wholesale trade and retail trade did well relative to other industries with respect to productivity growth, at least in part because they experienced a comparatively brisk expansion of demand and output. This provided support to aggregate TFP growth over the 2001–05 period.

Table 5

Average Growth in Output and Labour Productivity by Sector (%)

	1997–2000		2001–05	
	Output	Output per hour	Output	Output per hour
Business sector	5.7	3.0	2.5	1.0
Business sector, goods	5.0	3.6	1.3	0.6
Manufacturing	7.2	4.8	-0.2	0.6
Wholesale trade	7.8	5.1	4.7	3.3
Retail trade	5.7	4.4	4.7	2.4

Source: Statistics Canada, Cansim Table 383-0021, 2007

Table 6

Growth in Output and Labour Productivity in Retail Trade, 2001–05 (%)

	Labour productivity	Output	Hours
Canada[1]	2.4	4.7	2.3
United States[2]	4.2	4.1	-0.1

1. Statistics Canada, Cansim Table 383-0021, 2007
2. Output defined as real value-added from the U.S. Bureau of Economic Analysis, April 2007; hours worked from the U.S. Bureau of Labor Statistics

Business cycle influences drove aggregate productivity growth in Canada but not in the United States.

The absence of a cyclical slowdown in U.S. productivity growth in the early 2000s indicates an absence of labour hoarding that is unusual during an economic slowdown. This likely reflects structural adjustment conducive to faster efficiency gains. These could have arisen from increased competitive pressures in an environment of more flexible and efficient labour markets (Oliner, Sichel, and Stiroh 2007). Another possible source of efficiency gains is the earlier accumulation of ICT facilitating subsequent innovation and enabling organizational changes and other investments needed to fully translate technological adoption into productivity growth. This would go some way towards explaining the strong TFP gains in services, including such ICT-intensive industries as wholesale trade, retail trade, and financial services.[7] As shown in Table 6, hours worked in the retail trade sector were flat in the United States over the 2001–05 period, whereas in Canada they adjusted to the growth in output in a more or less typical fashion.[8]

Net labour reallocation into industries with lower productivity growth reduced aggregate productivity growth slightly over the 1997–2003 period.

The industry approach to growth accounting allows us to quantify the effect on aggregate productivity gains of labour reallocation between industries with different levels or growth rates of productivity. Shifts between industries with different levels of productivity are generally found to have only a small effect and therefore could not have contributed significantly to the patterns of productivity growth of the past decade. Faruqui et al. (2003) estimate that this type of labour reallocation within the Canadian business sector had no net effect over the 1996–2000 period. The second type of reallocation typically refers to long-run shifts of labour to industries with lower-than-average productivity growth, from manufacturing to business services, for example. Tang and Wang (2004) show that this reallocation did slow aggregate productivity growth in Canada over the 1987–98 period, but by less than 0.1 percentage point per year. More recent calculations[9] reveal that net reallocation into industries with lower productivity growth subtracted about 0.15 percentage points from the average annual

7. A cross-sectional analysis by Oliner, Sichel, and Stiroh (2007), however, failed to support the notion that the industries that invested heavily in ICT in the late 1990s reaped a large productivity payoff after 2000.

8. The Canadian and U.S. figures are not strictly comparable because of differences in measurement methodologies, but they are nevertheless indicative of qualitatively different adjustments in the two countries.

9. Net reallocation in this exercise is the difference between aggregate productivity growth and the weighted sum of industry productivity growth rates. The weights correspond to the two-period average industry shares in aggregate nominal value-added. These calculations combine data at the two-digit level for non-manufacturing industries and at the three-digit level for manufacturing industries.

Table 7

Impact of Reallocation and Industry Mix on Labour Productivity Growth in Canada (%)

	Aggregate productivity growth	Industry productivity growth			Net reallocation effect
		Canadian mix	U.S. mix	Difference	
Business sector					
1997–2003	2.11	2.26	2.35	-0.09	-0.15
1987–96	1.01	1.05	0.94	0.12	-0.05
1978–86	1.12	1.25	1.36	-0.10	-0.14
Manufacturing sector					
1997–2003	2.64	3.06	3.08	-0.02	-0.41
1987–96	2.21	2.25	2.47	-0.23	-0.04
1978–86	2.28	2.50	2.64	-0.13	-0.22

Source: Statistics Canada, Cansim Table 383-0021; U.S. Bureau of Economic Analysis, Annual Industry Accounts

growth rate of labour productivity in the business sector over the 1997–2003 period (Table 7).[10] It is worth noting that the gap in productivity growth between goods-producing and services-producing industries in the Canadian business sector has narrowed considerably over time, vanishing between 1996 and 2001, and turning negative in the first half of the 2000s.

To summarize, in the past 10 years, Canada, unlike the United States, has not moved to a higher trend productivity growth rate. Relative to the previous 20 years or so, capital deepening has moderated somewhat in Canada, and the stronger pace of TFP growth that underpins the higher average growth rate of labour productivity essentially reflects a cyclical upswing in the late 1990s. Net labour reallocation into industries with lower productivity growth reduced aggregate productivity growth slightly over the 1997–2003 period.

10. Bosworth and Triplett (2007) estimate that net labour reallocation into industries with lower productivity growth subtracted about 0.25 percentage points from the average annual growth rate of U.S. labour productivity over the 1995–2005 period. Taking into account the reallocation of intermediate inputs in addition to labour can make quite a difference. Bosworth and Triplett (2007) find that a more favourable shift of intermediate inputs into industries that have higher productivity growth provided considerable support to aggregate productivity growth in the United States over the 2000–05 period relative to the 1995–2000 period.

Explaining Canada's Weak Trend Productivity Growth

Growth accounting allows us to trace the sources of productivity growth, but it cannot explain how capital deepening and TFP growth relate to more fundamental factors. In this section, we explore these deeper questions by analyzing the potential role of three sets of factors: reallocation and adjustment costs, impediments to innovation, and structural elements of the Canadian economy. Impediments to innovation go a long way towards explaining low trend productivity growth in Canada.

Reallocation and adjustment costs

In recent years, large relative price movements associated with the surge in commodity prices in Canada and the appreciation of the Canadian dollar may have led to greater reallocation of labour and capital across industries, resulting in more resources being diverted from production to searching out, hiring, and training labour and setting up or adapting production systems. This may have caused an increase in adjustment costs that slowed aggregate productivity growth, but should, however, be a transitory phenomenon.

Aggregate adjustment costs would have increased either because the volume of reallocation has increased or because the average cost for a given volume of reallocation has risen. Since labour turnover at the industry level accounts for one-fifth of the total labour turnover at the firm level (Kavcic and Yuen 2005), even a substantial increase in this turnover component may have had only a moderate impact on total labour turnover. In fact, the extent to which total labour turnover would have intensified in recent years remains to be determined. Even if it had not increased, the average adjustment costs for a given volume of reallocation may have risen for two reasons. First, skills are less easily transferable between industries than within industries, so an increase in reallocation between industries relative to within industries would result in higher adjustment costs. Second, average adjustment costs may have risen if employers had to hire a larger proportion of workers with low skills and little experience in the face of more widespread labour shortages and generally firm labour market conditions. Overall, it seems reasonable to expect that increased adjustment costs would have slowed productivity growth in recent years, but measuring these costs is a challenge.

Increased adjustment costs would have slowed productivity growth in recent years.

Another channel through which large relative price movements have likely affected aggregate productivity growth is the impact of high resources prices on the resources sector itself. High prices for energy, metals, and minerals would have contributed to slow productivity growth in the mining and oil and gas extraction industries by encouraging the exploitation of marginal reserves. Industry productivity data show that TFP in these industries fell by 7.5 per cent in 2005, after having declined by 4.2 per cent in 2004 and 3.5 per cent in 2003, a pattern consistent with the jump of energy prices to very high levels in 2005. Quarterly productivity data reveal that labour productivity in the same industries fell slightly more in 2006 than in 2005, at a time when energy prices remained elevated and metals prices surged to exceptional levels. This points to a further substantial decrease in TFP in 2006. Assuming that this decrease was the same as in 2005 and taking 2003 as a benchmark, the 4-percentage-point fall of TFP growth in 2005–06 relative to the benchmark subtracts 0.4 percentage points from annual labour productivity growth in the business sector.[11] These calculations suggest that diminishing returns in extraction industries had a significant negative impact on aggregate productivity growth in 2005 and 2006.

Impediments to innovation

Innovation refers to the conception, acquisition, and adaptation of new ideas, technologies, and practices that enhance business processes or products. Innovation may be technological, organizational, or marketing in nature. It enhances productivity growth through two channels. The first is innovative activity, a key element of which is research and development (R&D). Models of endogenous innovation and growth predict that the intensity of R&D relative to GDP positively impacts TFP growth through higher rates of both invention and technology transfer, the latter reflecting a greater capacity to understand and assimilate the discoveries of others (Griffith, Redding, and Van Reenen 2004). The second channel is through the adoption of new ideas and technologies (Baldwin and Sabourin 2004), which are often embodied in capital goods and directly reflected in capital deepening.

Innovation can only be measured by relying on surveys of technology adoption by firms or on proxies for innovation activity, such as business R&D spending relative to GDP, patents granted per worker, or investment in M&E or ICT per worker. Although each of these proxies has drawbacks as a measure of innovation, they all confirm survey results in suggesting a sub-par innovation performance in Canada relative to many countries belonging to the Organisation for Economic Co-operation and Development (OECD), including the United States (Jaumotte and Pain 2005).[12]

Canada's relatively weak performance in terms of R&D and other indicators of innovation appears to arise less from deficient supply conditions than from a lower demand for innovation.

Because of the high concentration of research in a few industries, the smaller share of research-intensive industries in Canada significantly contributes to a relatively low aggregate R&D intensity (ab Iorwerth 2005).[13] Beyond that factor, Canada's relatively weak performance in terms of R&D and other indicators of innovation appears to arise less from deficient supply conditions than from a lower demand for innovation.

11. This estimate is based on the assumption that the weight of mining and oil and gas extraction in the business sector averages about 10 per cent in 2005–06, compared with 7.4 per cent in 2003, the last year for which information is available. The weight is based on the share of industry nominal value-added in business sector value-added (OECD 2001). A two-period average of this share is used as the weight to reflect the fact that real GDP for the business sector is a chained-dollar aggregate. The weight is expected to rise when the relative prices of energy and metals increase significantly.

12. Surveys reveal that Canadian manufacturing plants have tended to adopt fewer advanced technologies than their U.S. counterparts (Baldwin and Sabourin 1998). Moreover, manufacturing firms that introduce product innovations draw a lower proportion of their sales from these products than do their European counterparts (Mohnen and Therrien 2003).

13. In fact, Canada does proportionately more research than the United States in at least three research-intensive industries: office and computing machines; pharmaceuticals; and radio, television, and communications equipment (ab Iorwerth 2005).

On the supply side, Canada enjoys low bureaucratic barriers to entrepreneurship, high rates of firm entry and exit,[14] a relatively high proportion of university-educated workers, a relatively flexible labour market,[15] and an abundant supply of venture capital to finance innovative activity (OECD 2006; IMF 2005). In most of these dimensions, including continuing employee education and training, Canada does not fare quite as well as the United States, but this would explain only part of the innovation gap. Moreover, the Canadian economy is highly integrated with the U.S. economy through trade, capital flows, and a large stock of U.S. direct investment in Canada. This should facilitate access to foreign R&D, new technologies, and best management practices.[16] Since the size of the science and engineering workforce relative to total employment has evolved in much the same way in Canada and the United States over the 1980–2001 period and by 2001 was the same in both countries (Beckstead and Gellatly 2006), the human capital base for assimilating and adapting new foreign technologies and for doing R&D should have been comparable in the two countries. Yet the apparent productivity of this workforce in terms of innovative activity and technology adoption has been significantly lower in Canada. Perhaps among U.S. scientists and engineers there is a higher proportion of exceptionally talented individuals, drawn from all over the world by the opportunity of matching up with other very talented individuals.[17] This higher density of talent would provide a comparative advantage in inventing new products and processes. Another possibility, which might better explain the lower technology intensity in Canada, is that scientists and engineers are less effectively deployed in industries and their skills less fully used because the demand for innovation is lower.

One indication of weaker demand for innovation in Canada is the difference in the premium for university-educated employees relative to other workers. As shown in Chart 3, this premium is much smaller in Canada than in the United States even though the proportion of university-educated workers is somewhat lower in Canada (Kryvtsov and Ueberfeldt 2007).[18] These combined facts point to a relatively soft demand for highly skilled workers, reflecting a smaller productivity differential in favour of university-educated workers in Canada and / or a reduced demand for innovation, given that skills complement technology or capital quality in production.[19] To the extent that this complementarity is stronger for equipment than for structures, the lower skills premium in Canada would partly reflect a lower M&E-embodied technology intensity in production,[20] and, hence, a weaker demand for innovation. Broadly consistent with this conclusion is the finding by Rao, Tang, and Wang (2006) that, relative to the United States, a lower ratio of M&E capital to labour in Canada is a key determinant of the weaker Canadian TFP in the business sector over the 1987–2003 period. The reasons for the more sluggish demand for innovation in Canada are not entirely clear, and at this stage they are more in the realm of hypotheses requiring validation.

One reason may be a limited *initial* supply of skills. Beaudry, Doms, and Lewis (2006) find that the U.S. cities where college-educated labour was cheapest and most abundant in 1980 were those that adopted the personal computer most intensely between 1980 and 2000 and saw the returns to college education catch up the fastest. A similar phenomenon likely took place among Canadian cities. However, there is no study yet on the extent to which Canadian cities had, on average, a lower initial supply of skills than U.S. cities. The fact that the earnings premium of university-educated workers was higher in Canada than in the United States in the first half of the 1980s suggests that a lower initial supply of skills may have slowed the adoption of ICT in Canada. This would not have lasted long, however, because the skills premium in

14. This facilitates the experimentation and testing of new ideas and the adoption of best-practices technology.

15. The resulting moderate cost of adjusting labour makes it easier for firms to adopt new technologies and better work practices, and to innovate more generally.

16. Lileeva (2006), for example, finds relatively important productivity spillovers from foreign direct investment in science-based supplier industries to domestically controlled manufacturing plants.

17. For more details on this matching theory, see Easterly (2001).

18. Evaluated at a purchasing-power-parity rate of 0.84, real earnings per hour worked in Canada in 2000 were lower than in the United States by about 15 per cent for university-educated workers and by about 5 per cent for other workers.

19. As an example of the relationship between skills and innovation, Autor, Levy, and Murnane (2003) show that the shifts in tasks associated with computerization can explain 60 per cent of the estimated relative demand shift in favour of college-educated labour in the United States between 1970 and 1998.

20. Hornstein, Krusell, and Violante (2005) explain the linkages among the skills premium and the relative productivity of skilled workers, the relative supply of skilled workers, and M&E-embodied technology relative to hours worked by skilled labour.

Canada soon fell below that in the United States (Chart 3).

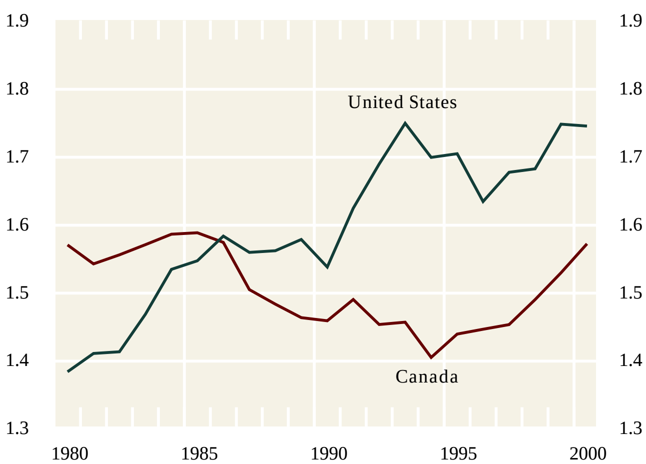
A second reason may be less competition, which blunts incentives for incumbent firms to innovate in order to protect or reinforce their market position (Aghion et al. 2005). More regulation would be one reason for less competition, but it is not the only one. Conway et al. (2006) estimate that product market regulation that restrains competition is more prevalent in Canada than in the United States and find that this type of regulation holds back productivity growth mainly by slowing the adoption of ICT. Thus, more regulation could go some way towards explaining why capital deepening in ICT assets has been lower in Canada.[21] In the retail trade sector, Wal-Mart and other big-box stores are less widespread in Canada than in the United States and as a result would have generated fewer competitive pressures in local markets, and fewer incentives to adopt new technologies and organizational innovations to boost productivity (Sharpe and Smith 2004).

A third reason may be fewer rewards and more aversion to risk taking. For Canadian firms, the smaller size of local markets in non-tradable product sectors would limit the returns to innovation and inhibit innovative activity. It could explain in part why R&D intensity in the services sector is lower in Canada than in the United States, which in turn contributes to the weaker aggregate R&D intensity in Canada (ab Iorwerth 2005). Fewer rewards for the relatively high risks associated with innovation might also result from higher marginal tax rates on personal income,[22] lower compensation for high-level managers, and larger bankruptcy costs or stigma facing Canadian entrepreneurs. Finally, a lower educational level of managers in Canada than in the United States (Institute for Competitiveness and Prosperity 2005) could make them less attuned to radically new technologies and business practices and less prone to undertake organizational change.

A final reason, which reflects cyclical rather than structural forces, relates to relative factor prices. Empirical work in Canada and New Zealand, for example, suggests that moderation in the price of labour relative to capital would lead to less capital/labour substitution (Leung and Yuen 2005; Hall and Scobie 2005) and, hence, less absorption of capital-embodied technologies. In this light, comparatively moderate wages relative to the price of M&E investment (Chart 4) would have contributed to the gap in

Chart 3

University-Education (Skills) Premium*



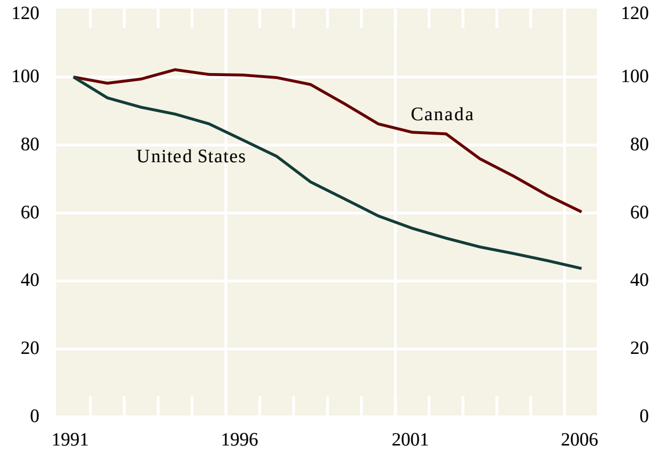
*Ratio of earnings per hour worked of university-educated to other workers

Source: Kryvtsov and Ueberfeldt (2007)

Chart 4

Price of Investment in Machinery and Equipment Compared with Labour Compensation per Hour*

1991 = 100



*Labour compensation per hour in the business sector in Canada and non-farm business sector in the United States

21. Part of the considerable impact in Canada relative to the United States found in the OECD study arises not just from more regulation in Canada but also from the much greater distance of Canada from the technological frontier, which, in the OECD approach, magnifies the negative impact of regulation.

22. The marginal fiscal burden for entrepreneurs of medium and large businesses was also considerably higher in Ontario than in five large U.S. states in 2004 (Chen and Mintz 2004).

technology intensity in Canada, compared with the United States, from the early 1990s to at least 2003, when the appreciation of the Canadian dollar started reducing the price of imported M&E.[23] Inasmuch as the substitution of M&E for labour is more sensitive to changes in wages than equipment costs, as work by Rao, Tang, and Wang (2007) and by Leung and Yuen (2005) suggests, the evolution of factor prices could have had an even more prolonged negative impact on M&E intensity in Canada relative to the United States.

The translation of technology adoption into productivity growth depends to some degree on complementary investments in the reorganization of business practices, particularly when ICT-based technologies are involved. Canadian firms probably lag behind U.S. firms in terms of organizational capital and management practices. Work by Bloom, Sadun, and Van Reenen (2005) suggests that, over the 1995–2003 period, U.S. firms would have adopted organizational forms that facilitated the adoption of ICT to a greater extent than their foreign competitors. On average, they are much better managed than European firms, and this has been strongly associated with a superior record in trend TFP (Bloom and Van Reenen 2006).

Structural aspects of the economy

Structural factors, such as industry mix, the size of local markets, average firm size, and the quality of public infrastructure, are likely to influence the evolution of productivity to the degree that they act as constraints on the adoption or effective use of new technologies, the achievement of scale economies, or the intensity of competition.

The industry mix in Canada, with its heavier weight on resource-based industries, transportation, construction, and utilities, and lower weight on ICT-using industries, had a slightly negative effect on labour productivity growth in the business sector as a whole over the 1997–2003 period (Table 7).[24] Within the much narrower manufacturing sector, the industry mix was also less conducive to productivity growth in Canada than in the United States, although to a lower degree than in previous periods. The less favourable manufacturing mix largely stems from the smaller size of the computer and electronic products industry, which usually registers above-average productivity growth rates.

The industry mix in Canada . . . had a slightly negative effect on labour productivity growth in the business sector as a whole over the 1997–2003 period.

The limited size and lower demand density of local markets in Canada compared with the United States likely reduce the potential for economies of scale and productivity gains by restraining the average size of establishments in industries in which geographic market segmentation operates. Such industries would include, for instance, the retail trade sector and the restaurant industry (Campbell and Hopenhayn 2002), and manufacturing industries with low value-to-weight products like ready-mix concrete (Syverson 2001). Size appears to matter as well in banking services. Allen, Engert, and Liu (2006) find that although Canadian banks are as productive as those in the United States, they are less efficient in terms of scale and have more to gain in terms of efficiency from becoming larger.

At the aggregate level, the average firm size is smaller in Canada than in the United States, reflecting 25–30 per cent fewer employees per firm in both the smallest (0 to 19 employees) and the largest (500+ employees) firm-size categories (Table 8). This would be associated with lower productivity in Canada because productivity varies positively with size at the firm or plant level in both Canada and the United States (Baldwin, Jarmin, and Tang 2004).[25] A shift in the distribution of firm size towards smaller (larger) firms, holding productivity differentials constant across firm sizes, would restrain (boost) aggregate productivity gains. In fact, the distribution of firm size shifted towards larger firms between 1998 and 2004, but more so in Canada than in the

23. It would be more appropriate to use a measure of wages for non-highly skilled workers than a measure for all workers, since skills and capital-embodied technology are complementary inputs in production. Data availability is a constraint.

24. This result is obtained by comparing the weighted sums of average productivity growth rates by industry over the 1997–2003 period, alternatively using as weights the two-period nominal value-added shares by industry for Canada and the United States.

25. Small firms use fewer advanced technologies and less capital per worker and provide less training to employees. One reason may be that investment is more adversely affected in small firms by profit uncertainty or a lower probability of survival.

Table 8

Average Number of Employees per Firm by Size, Canada and the United States, 2001

Firm size (employment)	Average number of employees	
	Canada	United States
0–19	3.1	4.1
20–99	40.3	39.3
100–499	190.8	192.4
500+	2372.6	3321.1
Total	13.3	23.2

Source: Canada: Statistics Canada, *Business Dynamics in Canada, 2001*, February 2005. United States: U.S. Small Business Administration

Table 9

Changes in Firm Size Distribution, 1998–2004

Percentage

Firm size (employment)	Canada	United States
0–19	-2.3	-0.4
20–99	-0.3	0.0
100–499	-1.3	0.3
500+	3.9	0.0

Source: Statistics Canada, Labour Force Survey; U.S. Small Business Administration

United States (Table 9).[26] As a result, ouput per employee would have increased by nearly 0.15 percentage points per year in Canada and 0.01 percentage point per year in the United States over this period, keeping the productivity levels by firm size at their 1997 values.

A final structural factor to be considered here is investment in public infrastructure, which appears to have positive effects on productivity growth in the business sector. Harchaoui and Tarkhani (2003) find that an increase in the services of public capital contributes to TFP growth in the Canadian business sector, especially in transportation, trade, and utilities. Capital stock data indicate that the average age of bridges, sewer systems, roads and highways, and wastewater treatment facilities rose markedly between the mid-1970s and the late 1990s before stabilizing in the early 2000s and edging down in 2003 (Gaudreault and Lemire 2006). This suggests a trend decline in services per unit of infrastructure until recently, with likely negative effects on efficiency gains in the economy. It remains to be seen how this evolution compares with that in the United States.[27]

Conclusion and Areas for Further Research

Much uncertainty surrounds the root causes of Canada's failure in the past decade to follow in the footsteps of the United States towards a higher growth rate in trend productivity. Canada appears to have taken less advantage of ICT and has also experienced fewer efficiency gains in the production of services and non-ICT goods. Capital deepening in non-ICT assets was stable in the past half-decade instead of intensifying as it did in the United States, possibly held back by a lower rise in wages relative to the price of M&E investment than in the United States, at least until 2003. Increased adjustment costs associated with reallocation of resources in response to large relative price movements have likely had negative effects on TFP growth in recent years. As well, high resources prices would have encouraged the exploitation of marginal reserves, with significant negative effects on productivity growth in 2005 and 2006. These phenomena would have exacerbated the drag exerted by a persistently lagging performance in Canada with respect to innovative activity, adoption of new technologies, and investment in organizational capital. This lagging performance seems to reflect less a deficiency in supply conditions than a lacklustre demand for innovation, which in turn could stem from less competition, fewer rewards for risk taking and, from the early 1990s to at least 2003, a slower decline in the price of M&E investment relative to labour compensation per hour. As well, the smaller size of local markets for non-tradable products could have limited the scope for economies of scale and the incentives for innovation.

In spite of the enormous volume of research on productivity in the past decade, many hypotheses still need to be tested and issues need to be better understood in a Canadian context. The preceding analysis points to several potentially fruitful avenues for further research, including the following topics:

26. Data for Canada are from the Labour Force Survey. This is not the best source of information on firm-size distribution, but it does provide a timely indication of changes in this distribution.

27. Calculations by Kamps (2006) for the OECD countries, based on the same assumptions across countries about depreciation rates, show that government net capital stock per capita at 1999 purchasing-power parities for gross fixed-capital formation was nearly 37 per cent lower in Canada than in the United States in 2000 and had grown slightly slower in Canada than in the United States between 1990 and 2000.

1) Quantifying the size and timing of adjustment costs and spillover effects for different assets and industries would help to interpret the dynamics of productivity growth and measure the contribution of changes in capital composition.

2) Estimating the effect of movements in relative factor prices on capital deepening would shed light on the robust rate of net job creation and the sluggish pace of innovation in the past decade relative to the United States.

3) Using longitudinal microdata to investigate the relationships between large relative price movements, labour turnover at the firm level and productivity growth and, more generally, how firms adjust to specific macroeconomic shocks.

4) Investigating the potential role of structural factors in holding back economies of scale and the demand for innovation in Canada.

Literature Cited

ab Iorwerth, A. 2005. "Canada's Low Business R&D Intensity: The Role of Industry Composition." Department of Finance Working Paper No. 2005–3.

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt. 2005. "Competition and Innovation: An Inverted-U Relationship." *Quarterly Journal of Economics* 120 (2): 701–28.

Allen, J., W. Engert, and Y. Liu. 2006. "Are Canadian Banks Efficient? A Canada-U.S. Comparison." Bank of Canada Working Paper No. 2006–33.

Autor, D., F. Levy, and R. Murnane. 2003. "The Skill Content of Recent Technological Change: An Empirical Exploration." *Quarterly Journal of Economics* 118 (4): 1279–1333.

Baldwin, J. and D. Sabourin. 1998. "Technology Adoption: A Comparison between Canada and the United States." Analytical Studies Research Paper Series No. 119. Statistics Canada Cat. No. 11 F0019M1E1998119.

———. 2004. "The Effect of Changing Technology Use on Plant Performance in the Canadian Manufacturing Sector." Economic Analysis Research Paper No. 20. Statistics Canada Cat. No. 11F0027M1E2004020.

Baldwin, J., R. Jarmin, and J. Tang. 2004. "Small North American Producers Give Ground in the 1990s." *Small Business Economics* 23 (4): 349–61.

Basu, S. and J. Fernald. 2006. "Information and Communications Technology as a General-Purpose Technology: Evidence from U.S. Industry Data." Federal Reserve Bank of San Francisco Working Paper No. 2006–29.

Beaudry, P., M. Doms, and E. Lewis. 2006. "Endogenous Skill Bias in Technology Adoption: City-Level Evidence from the IT Revolution." Federal Reserve Bank of San Francisco Working Paper No. 2006–24.

Beckstead, D. and G. Gellatly. 2006. "Innovation Capabilities: Science and Engineering Employment in Canada and the United States." The Canadian Economy in Transition Series. Statistics Canada Cat. No. 11–622–MIE2006011.

Bloom, N., R. Sadun, and J. Van Reenen. 2005. "It Ain't What You Do It's The Way That You Do I.T.—Testing Explanations of Productivity Growth Using U.S. Affiliates." Centre for Economic Performance, London School of Economics (September). Photocopy.

Bloom, N. and J. Van Reenen. 2006. "Measuring and Explaining Management Practices Across Firms and Countries." NBER Working Paper No. 12216.

Bosworth, B. and J. Triplett. 2007. "The Early 21st Century U.S. Productivity Expansion Is Still in Services." *International Productivity Monitor* 14: 3–19. Centre for the Study of Living Standards.

Campbell, J. and H. Hopenhayn. 2002. "Market Size Matters." NBER Working Paper No. 9113.

Chen, D. and J. Mintz. 2004. "Ontario's Fiscal Competitiveness in 2004." Prepared for the Institute for Competitiveness and Prosperity.

Conway, P., D. de Rosa, G. Nicoletti, and F. Steiner. 2006. "Regulation, Competition and Productivity Convergence." OECD Economics Department Working Paper No. 509.

Literature Cited (cont'd)

Dolega, M. 2007. "Tracking Trend Productivity: A Dynamic Factor Model with Regime-Switching." Bank of Canada. Photocopy.

Easterly, W. 2001. *The Elusive Quest for Growth*. Cambridge, MA: MIT Press.

Faruqui, U., W. Gu, M. Kaci, M. Laroche, and J.-P. Maynard. 2003. "Differences in Productivity Growth: Canadian-U.S. Business Sectors, 1987–2000." U.S. Bureau of Labor Statistics *Monthly Labor Review* 126 (4): 16–29.

Gaudreault, V. and P. Lemire. 2006. "The Age of Public Infrastructure in Canada." Analysis in Brief. Statistics Canada Cat. No. 11–621–MIE, No. 035.

Griffith, R., S. Redding, and J. Van Reenen. 2004. "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries." *Review of Economics and Statistics* 86 (4): 883–95.

Hall, J. and G. Scobie. 2005. "Capital Shallowness: A Problem for New Zealand?" New Zealand Treasury Working Paper No. 05/05.

Harchaoui, T. and F. Tarkhani. 2003. "Public Capital and Its Contribution to the Productivity Performance of the Canadian Business Sector." EA Research Paper Series. Statistics Canada Cat. No. 11F0027MIE, No. 017.

Hornstein, A., P. Krusell, and G. Violante. 2005. "The Effects of Technical Change on Labor Market Inequalities." In *Handbook of Economic Growth*, Vol. 1B, 1275–1370, edited by P. Aghion and S. Durlauf. Amsterdam: Elsevier/North-Holland.

International Monetary Fund (IMF). 2005. "How Flexible Is the Canadian Economy? An International Comparison." In *Canada*: *Selected Issues*, 92–100. IMF Country Report No. 05/116.

Institute for Competitiveness and Prosperity. 2005. "Realizing Canada's Prosperity Potential." Presented at the Annual Meeting 2005 of the World Economic Forum, Davos, Switzerland (January).

Jaumotte, F. and N. Pain. 2005. "Innovation in the Business Sector." OECD Economics Department Working Paper No. 459.

Kahn, J. and R. Rich. 2003. "Tracking the New Economy: Using Growth Theory to Detect Changes in Trend Productivity." Federal Reserve Board of New York Staff Reports No. 159.

Kamps, C. 2006. "New Estimates of Government Net Capital Stocks for 22 OECD Countries, 1960–2001." *IMF Staff Papers* 53 (1): 120–50.

Kavcic, R. and T. Yuen. 2005. "Employment Reallocation in Canada." Bank of Canada (August). Photocopy.

Kryvtsov, O. and A. Ueberfeldt. 2007. "Schooling, Inequality, and Government Policy: A Canada-U.S. Comparison." Bank of Canada. Forthcoming.

Leung, D. 2004. "The Effect of Adjustment Costs and Organizational Change on Productivity in Canada: Evidence from Aggregate Data." Bank of Canada Working Paper No. 2004–1.

Leung, D. and T. Yuen. 2005. "Do Exchange Rates Affect the Capital-Labour Ratio? Panel Evidence from Canadian Manufacturing Industries." Bank of Canada Working Paper No. 2005–12.

Lileeva, A. 2006. "Global Links: The Benefits to Domestically Controlled Plants from Inward Direct Investment—The Role of Vertical Linkages." Statistics Canada Cat. No. 11–622–MIE, No. 010.

Mohnen, P. and P. Therrien. 2003. "Comparing the Innovation Performance of Manufacturing Firms in Canada and in Selected European Countries: An Econometric Analysis." In *Understanding Innovation in Canadian Industry*, 313–39, edited by F. Gault. Kingston, ON: McGill-Queen's University Press for Queen's University School of Policy Studies.

Oliner, S., D. Sichel, and K. Stiroh. 2007. "Explaining a Productive Decade." *Brookings Papers on Economic Activity* (March 29–30). Preliminary version, available at http://www3.brookings.edu/es/commentary/journals/bpea_macro/forum/200703oliner.pdf.

Literature Cited (cont'd)

Organisation for Economic Co-operation and Development (OECD). 2001. *Measuring Productivity — OECD Manual*.

———. 2006. "2006 Economic Review—Canada." Economics Department (May).

Rao, S., J. Tang, and W. Wang. 2006. "What Explains the Canada-U.S. TFP Gap?" Industry Canada Working Paper No. 2006–08.

———. 2007. "What Explains the Canada-U.S. Capital Intensity Gap?" Industry Canada Working Paper No. 2007–02.

Sharpe, A. and J. Smith. 2004. "The Productivity Performance of the Retail Trade Sector in the United States and Canada." Paper prepared for the seminar "North American Incomes and Productivity in the Global Context: Industry Challenge." Organized by the Commission for Labor Cooperation and the Carnegie Endowment for International Peace, Washington, 22 October 2004. Centre for the Study of Living Standards. Photocopy.

Skoczylas, L. and B. Tissot. 2005. "Revisiting Recent Productivity Developments across OECD Countries." BIS Working Paper No. 182.

Syverson, C. 2001. "Market Structure and Productivity: A Concrete Example." U.S. Census: Center for Economic Studies Working Paper No. 01–06.

Tang, J. and W. Wang. 2004. "Sources of Aggregate Labour Productivity Growth in Canada and the United States." *Canadian Journal of Economics* 37 (2): 421–44.