An Analysis of Productivity Trends in the Canadian Forest Products Sector, 2000-2012

Ricardo de Avillez[1]

Abstract

The 2000-2012 period was a difficult time for the Canadian forest products sector. Yet despite an unfavourable environment the sector experienced an above-average productivity performance, driven in particular by the wood product manufacturing subsector. While the forestry and logging subsector has also benefited from strong productivity gains, the productivity performance of the paper manufacturing subsector has been far from impressive, especially in the post-2008 period. This article provides a detailed analysis of output, input and productivity trends in the Canadian forest products sector. It also looks at the key drivers of productivity in the sector, investigating potential barriers to productivity growth and discussing policies that could enable faster growth. Given the increasing role of countries with low-labour costs in several forest product markets, maintaining robust productivity growth is an imperative for the Canadian forest products sector if it wants to remain competitive internationally. In this sense, the article recommends renewed focus on human and physical capital investment, as well as on R&D spending.

Productivity improvements allow firms to produce the same quantity of output by using fewer inputs, which reduces costs.[2] However, the sector's competitiveness depends not only on productivity but also on other factors, such as exchange rates and input costs. The competitiveness of Canada's forest products sector has suffered greatly due to a strong Canadian dollar and high labour costs, which make it harder for the sector to compete internationally with low-wage countries such as Russia, China, and Brazil. In fact, even when compared to other developed countries, Canada's labour costs are quite high.

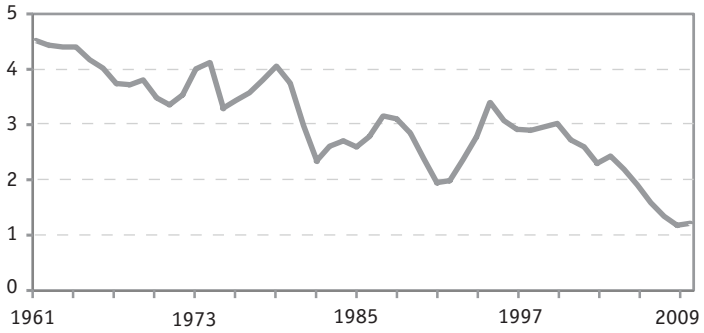
It is unlikely that labour costs in the Canadian forest products sector will experience a significant fall. Aside from nominal (downward) wage rigidities, which are observed in most sectors of the economy, it seems to be a consensus among forest product firms that the sector faces problems related to skill shortages.

Productivity gains can help by reducing the sector's need for labour input, thus reducing

1 Ricardo de Avillez was a senior economist at the Centre for the Study of Living Standards (CSLS) when the research for this project was undertaken. The author would like to thank CSLS Executive Director Andrew Sharpe and Jean-Francois Larue, Chief Economist at the Forest Products Association of Canada (FPAC) for comments. The CSLS would like to thank FPAC for financial support for this research. This article is an abridged version of de Avillez (2014). Email: csls@csls.ca.

2 This article discusses two productivity measures: value-added labour productivity and value-added multifactor productivity.

Chart 1
Nominal GDP in the Forest Products Sector as a Share of Total Economy GDP, 1961-2010
(per cent)



Source: CSLS calculations based on Statistics Canada data.

Exhibit 1
The Forest Products Sector
(subsectors and industry groups breakdown by NAICS codes)

113 Forestry and Logging
- 1131 Timber Tract Operations
- 1132 Forest Nurseries and Gathering of Forest Products
- 1133 Logging

321 Wood Product Manufacturing
- 3211 Sawmills and Wood Preservation
- 3212 Veneer, Plywood and Engineered Wood Product Manufacturing
- 3219 Other Wood Product Manufacturing

322 Paper Manufacturing
- 3221 Pulp, Paper and Paperboard Mills
- 3222 Converted Paper Product Manufacturing

Source: Statistics Canada (2012).

production costs. By lowering production costs, productivity gains can help Canadian firms to better compete with international firms, and thus regain some of their lost market share.

Much more effectively than other manufacturing industries, the Canadian forest products sector has managed to soften the blow of rapidly rising unit labour costs with major productivity gains. In order to increase competitiveness, the Canadian forest products sector must maintain high rates of productivity growth.

The objective of this article is to understand these productivity trends in the Canadian forest products sector, emphasizing recent developments in labour and multifactor productivity. The article builds on and expands previous CSLS research on the subject, in particular Harrison and Sharpe (2009) and Sharpe and Long (2012).

This article is organized into four sections. The first section defines the forest products sector and discusses the output and input trends experienced by that sector. The second section details recent productivity developments in the forest products sector. The third section examines the drivers of productivity growth in the forest products sector. The fourth (and final) section concludes.

An Overview of the Canadian Forest Products Sector[3]

The Forest Products Sector

The forest products sector, as it is defined in this article, is not identified by a single two-digit NAICS sector or by a single three-digit NAICS subsector; rather, it encompasses three NAICS subsectors, each of which includes different activities related to forest products: forestry and logging; wood product manufacturing; and paper manufacturing. A more detailed breakdown of all the activities included in the forest products sector can be seen in Exhibit 1.

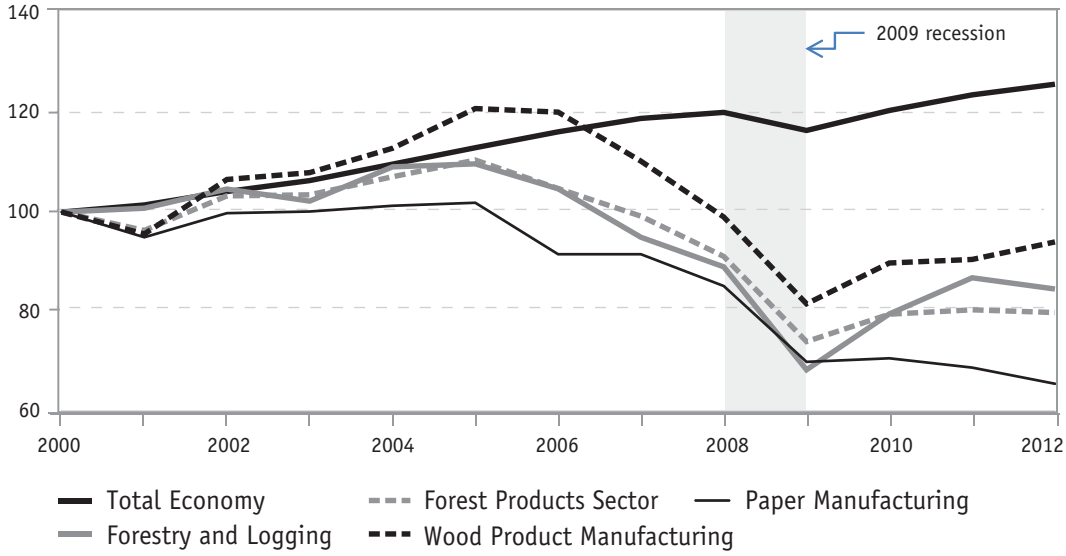
Output

Nominal GDP

The Canadian forest products sector generated $18,752 million in nominal value added in 2010, accounting for 1.2 per cent of Canada's GDP. Of its three subsectors, paper manufacturing was the largest, responsible for $8,519 million or 45.4 per cent of the value added of the forest products sector. The subsector with the

3 This article makes extensive use of official productivity estimates from Statistics Canada's Canadian Productivity Accounts (CPA). The CSLS has made small adjustments to the official data, which are highlighted in the unabridged version of the article. A database containing the underlying data used in this article is posted at www.csls.ca/res_reports.asp

Chart 2
Real GDP in the Forest Products Sector, 2000-2012
(index, 2000=100)



Source: CSLS calculations based on Statistics Canada data.

second largest value-added share was wood product manufacturing ($6,809 million or 36.3 per cent), followed by forestry and logging ($3,424 million or 18.3 per cent).

Three provinces accounted for 80 per cent of the nominal value added generated by the forest products sector in 2009: Quebec (31.2 per cent), British Columbia (25.5 per cent), and Ontario (24.1 per cent). In addition, the province of Alberta was responsible for 9.3 per cent of the forest products sector's nominal value added.

During the 2000-2008 period, while Canada's economy grew 5.3 per cent per year in nominal terms, nominal value added in the forest products sector fell 4.8 per cent per year. This fall was largely caused by wood products and paper manufacturing, both of which saw a decline of 5.4 per cent per year in nominal output.

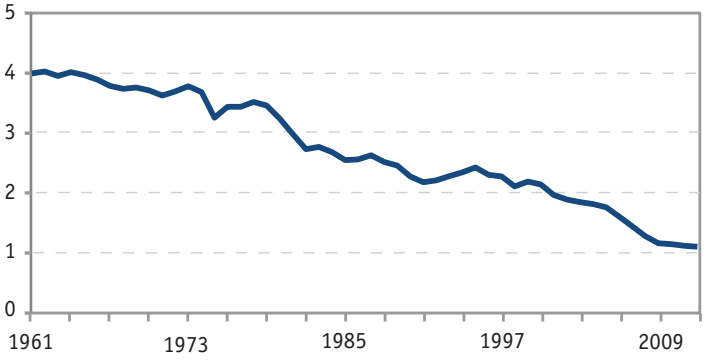
As Chart 1 dramatically illustrates, the nominal value-added share of the forest products sector in Canada's economy has reached its lowest value in 50 years, 1.1 per cent in 2009, down 3.2 percentage points from 4.4 per cent in 1961.

Real GDP

Real GDP in the forest products sector declined during the 2000-2008 period at a rate of 1.2 per cent per year. During this period, real output in forestry and logging and paper manufacturing fell by 1.4 and 2.0 per cent per year, respectively, while real output in wood product manufacturing remained practically constant. Comparing the sector's real growth with its nominal growth, it becomes clear that, with the exception of the forestry and logging subsector – where prices remained relatively stable – most of the nominal GDP decline in the two other subsectors and in the forest products sector as a whole came from a fall in prices.[4]

4 Prices fell by 3.2 per cent per year in the total forest products sector between 2000 and 2008. In forestry and logging, they fell 0.2 per cent per year. In wood product manufacturing, the declines were much more substantial, at 4.6 per cent per year. Total paper manufacturing also saw siginifcant declines at 3.2 per cent per year.

Chart 3
Number of Jobs in the Forest Products Sector as a Share of All Industries, 1961-2012
(per cent)



Note: From 1961 to 1997, employment growth in the forest products sector is assumed to be equal to hours growth. Also, total economy employment growth is assumed to be the same as business sector hours growth.

Source: CSLS calculations based on Statistics Canada data.

Real value added of the forest products sector fell significantly during the 2009 recession and, by 2012, the sector's real output level was still well below its 2008 level (Chart 2). For the forest products sector as a whole, real GDP declined 3.0 per cent per year during the 2008-2012 period, with most of this decline acconted for by the paper manufacturing subsector. Chart 2 clearly shows, however, that real output in the forest products sector peaked in 2005 – which is not surprising, given that this was the peak of the U.S. housing market – and started falling well before the 2009 recession.

As the above analysis shows, the last decade has not been kind to the forest products sector. The difficulties in the sector stem from multiple causes, including (but not limited to):

- Decreased U.S. demand for forest products due to the recent housing crisis and the lacklustre economic recovery in the United States;
- The strong Canadian dollar;
- The ongoing migration of readers from newsprint to electronic media; and
- Increased international competition from countries with lower labour costs.

This list, while not comprehensive, highlights the fact that adverse conditions faced by the forest products sector are a reflection not only of transitory factors – such as the strong Canadian dollar or the weak post-2009 economic recovery in the United States – but also of structural changes in the demand for forest products.

Labour Input

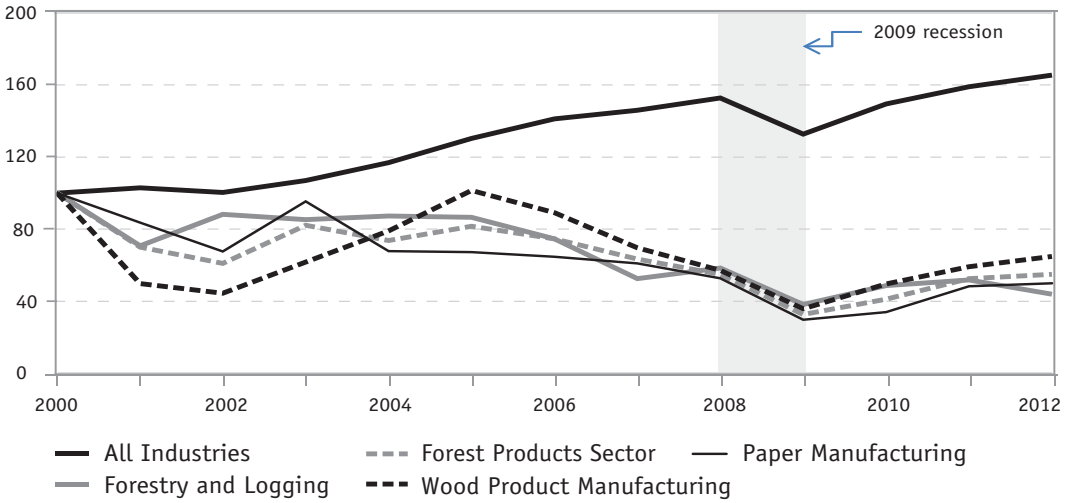
According to Statistics Canada's Canadian Productivity Accounts (CPA) data, there were 199 thousand jobs in the forest products sector in 2012. Wood product manufacturing was the most important subsector in terms of employment, responsible for 97 thousand jobs (or 49 per cent of the total jobs in the forest products sector), followed by paper manufacturing with 68 thousand jobs (34 per cent of the total) and forestry and logging with 35 thousand jobs (17 per cent of the total).

During the 1961-2012 period, the relative importance of the sector in terms of employment fell by three-quarters: it accounted for 4.0 per cent of all jobs in the Canadian economy in 1961, but by 2012 this proportion had fallen to 1.1 per cent (Chart 3).

Employment in the forest products sector declined at a rapid pace of 4.5 per cent per year during the 2000-2008 period, totalling a loss of 101 thousand jobs. In the 2008-2012 period, the rate of job loss fell to 3.0 per cent per year and the sector lost only 26 thousand jobs. Wood product manufacturing and forestry and logging lost jobs at approximately the same rate during the 2000-2012 period, with employment in both subsectors falling by 4.5-4.6 per cent per year, while employment in paper manufacturing fell at a much lower rate of 2.9 per cent per year.

Another point worth highlighting is that the bulk of the job losses observed in the forest

Chart 4
Real Investment in the Forest Products Sector, 2000-2012
(index, 2000=100)



Source: CSLS calculations based on Statistics Canada.

products sector happened prior to the recession, in the 2005-2008 period. Although employment in the sector lost more ground during the 2009 recession, it became considerably more stable afterwards.

For the purposes of calculating labour productivity, employment is not the best labour input measure available because of changes in average annual hours worked. Table 1 details trends in hours worked in the Canadian forest products sector during the 2000-2012 period. However, over the period, there are few significant differences between the trend industry growth rates for employment and hours worked.

Table 1
Hours Worked in the Forest Products Sector, Detailed Breakdown, 2000-2012

	2000-2012	2000-2008	2008-2012
	(CAGR, per cent)		
All Industries	1.1	1.5	0.4
Forest Products Sector	-4.2	-4.6	-3.3
Forestry and Logging	-4.5	-4.8	-3.8
Wood Product Manufacturing	-4.6	-5.7	-2.5
Paper Manufacturing	-3.2	-2.8	-4.2

Source: CSLS calculations based on Statistics Canada data.

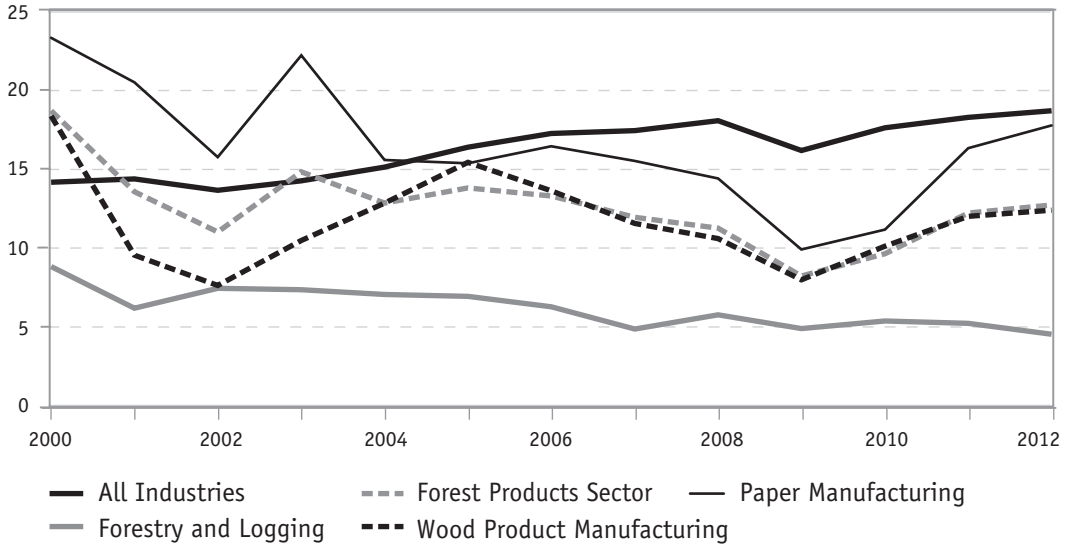
Capital Input

Non-Residential Fixed Investment

According to data from Canada's Fixed Capital Flows and Stocks (FCFS) program, real investment (measured in chained 2007 dollars) in the Canadian forest products sector reached $2,395 million in 2012, down 45 per cent from $4,359 million in 2000. The low point of investment in the sector happened in 2009, as a consequence of the recession, with real investment at $1,430 million. By 2012, real investment had already bounced back to its 2008 level (Chart 4). However, real investment only surpassed its pre-recession level in wood product manufacturing. The "sustained" part of the decline in the sector's real investment happened during the 2000-2008 period, a time when total economy investment was growing at a fairly robust pace. In fact, all three subsectors experienced large declines in real investment in the 2000-2008 period.

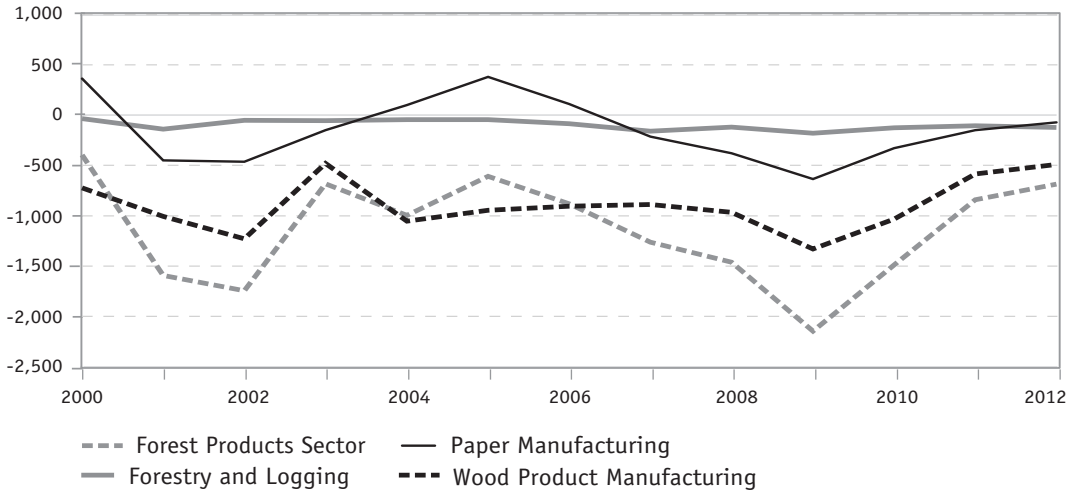
Since GDP in the sector experienced a decline in absolute terms, a fall in real invest-

Chart 5
Real Investment as a Share of GDP in the Forest Products Sector, 2000-2012
(per cent)



Source: CSLS calculations based on Statistics Canada data.

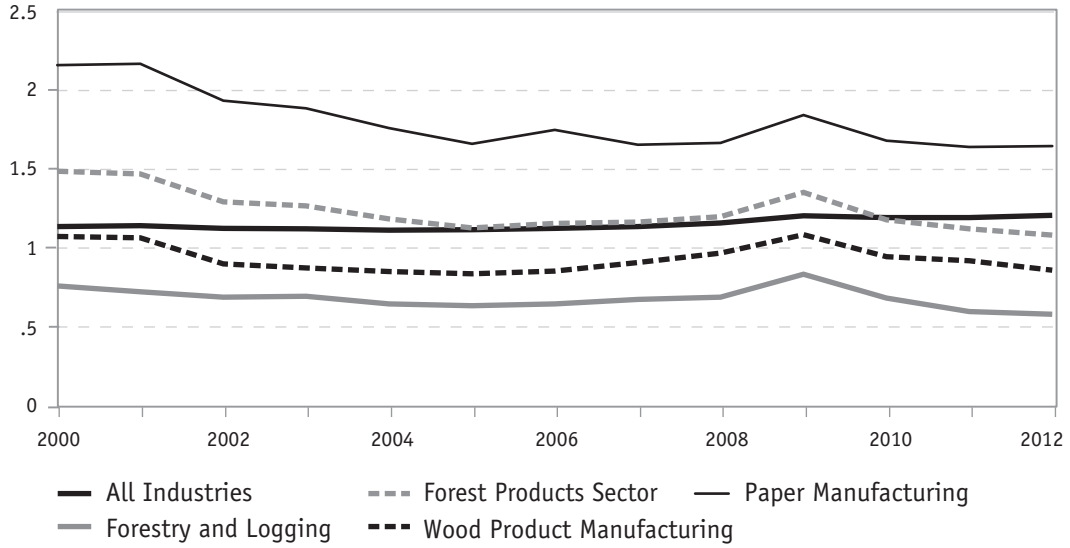
Chart 6
Real Net Investment in the Forest Products Sector, 2000-2012
(chained 2007 dollars, millions)



Source: CSLS calculations based on Statistics Canada data.

ment would not be unexpected – especially if that fall was approximately proportional to the decline in GDP. The problem, however, is that investment in the forest products sector has fallen considerably more than GDP. As Chart 5 shows, real investment as a share of real GDP in the forest products sector fell 5.9 percentage points during the period, from 18.7 per cent in 2000 to 12.8 per cent in 2012. During the same period, the non-residential

Chart 7
Real Capital Stock-to-GDP Ratio in the Forest Products Sector, 2000-2012



Source: Statistics Canada.

fixed investment share of GDP for the total economy actually increased from 14.2 per cent to 18.7 per cent, which highlights the very weak investment performance of the forest products sector in the past decade. These low levels of investment are worrisome, as they suggest that a significant number of firms in the Canadian forest products sector are using outdated capital assets that do not embody the latest technological innovations.

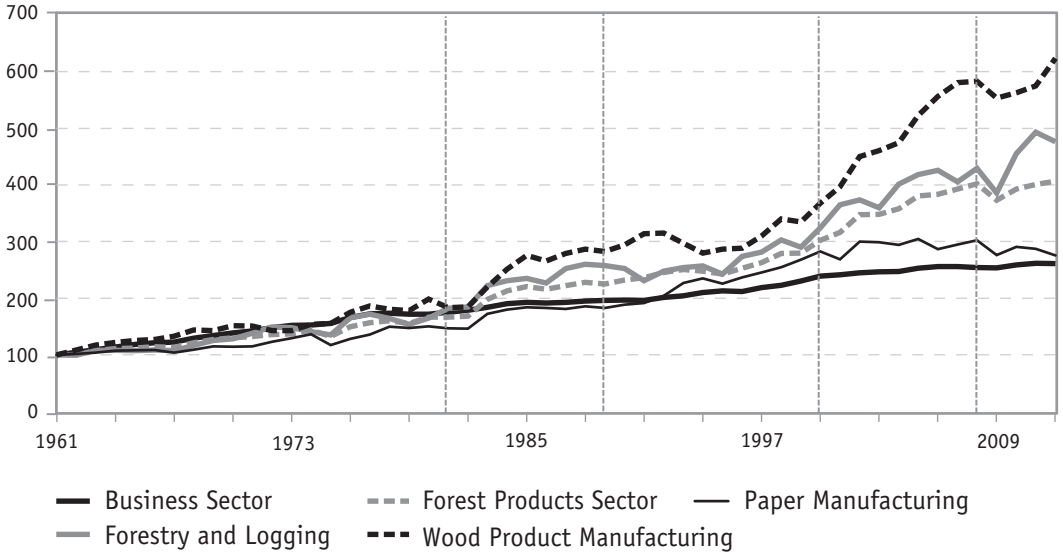
The investment figures discussed so far refer to gross investment. By subtracting depreciation from gross investment, we obtain a measure of net investment, which is investment that increases the overall capital stock. In the case of the Canadian forest products sector, real net investment was negative throughout the 2000-2012 period (Chart 6). In fact, forestry and logging and paper manufacturing had negative net investment during the entire 2000-2012 period, while wood product manufacturing only had positive levels of net investment briefly in 2000 and then in the 2004-2006 period.

Non-Residential Fixed Capital Stock

The negative net investment in the forest products sector during the 2000-2012 period led to a marked fall in real capital stock (measured in chained 2007 dollars), which declined at an average rate of 4.4 per cent per year, from $34,685 million in 2000 to $20,299 million in 2012. In recent years, real capital stock in the sector has started to fall at a faster pace (5.5 per cent per year for the 2008-2012 period vs. 3.8 per cent per year for the 2000-2008 period). All three subsectors followed roughly the same trends observed for the forest products sector as a whole, with real capital stock falling during the entire 2000-2012 period, but falling at a faster pace during the 2008-2012 period.

The real capital stock-to-GDP ratio of the forest products sector fell from 1.5 to 1.1 between 2000 and 2012, a period during which the total economy ratio remained fairly stable (Chart 7). Declines in this ratio were observed for all three subsectors: in paper manufacturing, it fell from 2.2 in 2000 to 1.7 in 2012; from 1.1 to 0.9 in wood product manufacturing; and from 0.8 to 0.6 in forestry and logging.

Chart 8
Labour Productivity in the Forest Products Sector, 1961-2012
(index, 1961=100)



Source: CSLS calculations based on Statistics Canada data.

Productivity in the Canadian Forest Products Sector

Labour Productivity[5]

Long-Run Labour Productivity Trends

The Canadian forest products sector has had an excellent productivity performance in the last 50 years, outperforming the business sector by far. The sector's labour productivity quadrupled during the 1961-2012 period, while business sector productivity had a much more modest (albeit still significant) 2.5-fold increase (Chart 8).

Between 1961 and 2012, wood product manufacturing saw faster labour productivity growth (3.7 per cent per year) than both forestry and logging (3.1 per cent per year) and paper manufacturing (2.0 per cent per year). During this period, labour productivity in wood product manufacturing and forestry and logging increased (approximately) 6.0 fold and 5.0 fold, respectively. Paper manufacturing, on the other hand, experienced roughly the same labour productivity growth as the business sector, increasing 2.8 fold.

Recent Labour Productivity Trends

During the more recent 2000-2008 period, labour productivity increased at an average annual rate of 3.6 per cent per year in the Canadian forest products sector, significantly faster than business sector growth (0.8 per cent) (Table 2).

Labour productivity growth in the forest products sector between 2000 and 2008 was largely driven by wood product manufacturing (5.9 per cent per year), although forestry and logging also benefited from strong productivity gains (3.6 per cent per year). The productivity performance of paper manufacturing, on the other hand, was far from impressive, in line with business sector growth (0.8 per cent per year).

Labour productivity gains in the Canadian forest product sector were negligible in the 2008-2012 period (0.3 vs. 0.7 per cent per year in the

5 Unless noted otherwise, labour productivity is defined here as real GDP (in chained 2007 dollars) per hour worked.

business sector), due largely to productivity losses in paper manufacturing (-2.3 per cent per year). During the period, productivity in wood product manufacturing and forestry and logging continued to improve (1.7 and 2.6 per cent per year, respectively), albeit at a slower pace.

Despite its weak post-2008 labour productivity growth, the Canadian forest products sector had the second highest growth rate for the 2000-2012 period when compared to two-digit NAICS sectors (2.5 per cent per year), only behind agriculture, forestry, fishing and hunting, which experienced an increase of 3.1 per cent per year in labour productivity.

Provincial and International Comparisons

Driven by its important wood product manufacturing subsector, British Columbia's forest products sector experienced the fastest labour productivity growth among all the provinces for which data were available, at 4.7 per cent per year during the 2000-2012 period, almost double the productivity increase observed by the Canadian forest products sector as a whole. In contrast, Ontario's forest products sector had no labour productivity growth in the period.

The Canadian forest products sector also fared well in international comparisons. Between 2000 and 2007, labour productivity in the forest products sector grew most rapidly in Canada, Finland, Germany and France, at approximately the same rate of 3.8-3.9 per cent per year, in a sample of eight OECD countries (Table 3).

Out of the eight OECD countries, Canada had by far the fastest labour productivity growth in the wood product manufacturing subsector during the 2000-2007 period. The performance of Canada's forestry and logging and paper manufacturing, however, was far from stellar. In the case of forestry and logging, Canada had at most a middling productivity performance, with an average annual growth of 3.2 per cent, well below the growth rates experienced in Germany, Finland, and France. In the case of paper manufacturing, Canada had a subpar productivity performance, experiencing the lowest productivity increases among the eight countries in our sample (0.6 per cent per year).

Table 2
Labour Productivity in the Forest Products Sector, Detailed Breakdown, 2000-2012

	2000-2012	2000-2008	2008-2012
	(CAGR, per cent)		
Business Sector	0.7	0.8	0.7
Forest Products Sector	2.5	3.6	0.3
Forestry and Logging	3.3	3.6	2.6
Wood Product Manufacturing	4.5	5.9	1.7
Paper Manufacturing	-0.2	0.8	-2.3

Source: CSLS calculations based on Statistics Canada data.

Multifactor Productivity[6]

Long-Run Multifactor Productivity Trends

Multifactor productivity (MFP) in the forest products sector grew at an average annual rate of 1.4 per cent between 1961 and 2012, seven times the growth rate observed at the business sector level (0.2 per cent per year). In 50 years, MFP in the sector roughly doubled, while business sector MFP increased only around 12 per cent (Chart 9).

Looking at the 1961-2012 period as a whole, MFP in forestry and logging and wood product manufacturing increased practically at the same

6 There are no official MFP estimates for the three forest products subsectors – and, hence, for the forest products sector as a whole – after 2008. Using Statistics Canada data, the CSLS has constructed MFP estimates for the forest products sector and its subsectors for the 2009-2012 period. The CSLS estimates should be seen as preliminary estimates, and therefore interpreted with caution. More information about of these MFP estimates can be found in the unabridged version of this article.

Table 3

Labour Productivity Growth in the Forest Products Sector, Selected OECD Countries, 1989-2007

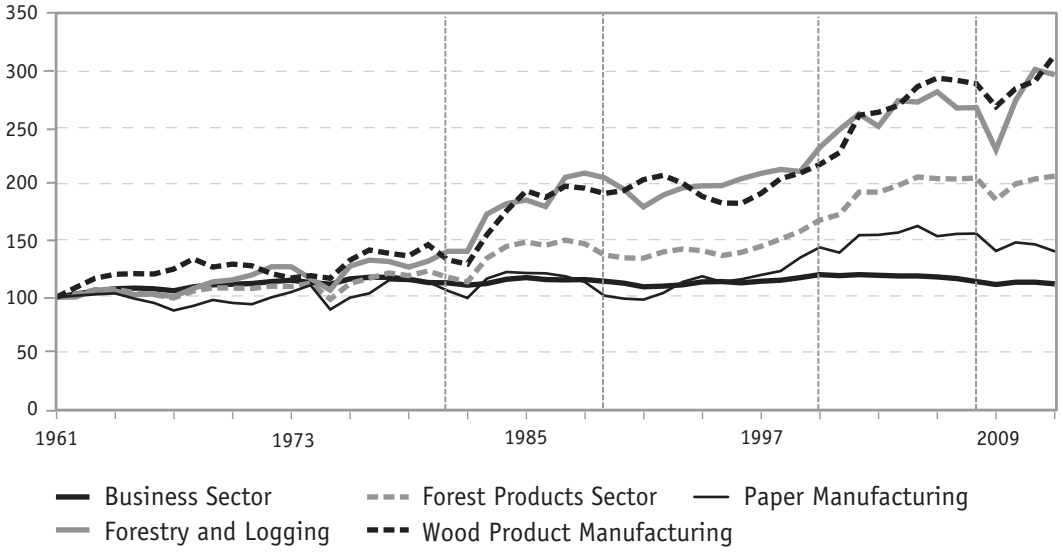
	Canada	Finland	France	Germany	Italy	Sweden	United Kingdom	United States
	(compound annual growth rates, per cent)							
Forest Products Sector								
1989-2007	3.0	5.4	1.2	4.3	3.1	1.6	1.4	..
1989-2000	2.8	6.3	-0.6	4.6	4.5	2.6	2.1	..
2000-2007	3.8	3.9	4.1	3.8	1.0	0.2	0.3	..
Forestry and Logging								
1989-2007	3.2	5.4	-4.9	4.6	5.2	0.3	5.4	..
1989-2000	3.1	4.4	-11.6	1.1	6.0	1.3	12.0	..
2000-2007	3.2	7.1	6.8	10.2	3.8	-1.3	-4.2	..
Wood Product Manufacturing								
1989-2007	3.7	3.6	5.3	3.5	2.5	3.3	0.7	1.7
1989-2000	3.0	5.1	5.6	3.9	3.6	2.8	-0.2	0.8
2000-2007	6.8	1.3	4.7	2.8	0.8	4.0	2.0	3.1
Paper Manufacturing								
1989-2007	2.6	7.1	2.9	4.2	3.2	2.5	2.0	2.2
1989-2000	3.1	7.7	2.2	5.1	4.7	1.8	2.6	1.8
2000-2007	0.6	6.1	4.0	2.8	0.7	3.5	1.0	2.9

Source: Canada data from Statistics Canada; U.S. data from the BLS; for all other countries, data from EU KLEMS.

Chart 9

Multifactor Productivity in the Forest Products Sector, 1961-2012

(index, 1961=100)



Source: CSLS calculations based on Statistics Canada data.

rate (2.2 and 2.3 per cent per year, respectively). MFP growth in paper manufacturing was much more modest (0.7 per cent per year), although still significantly above business sector growth.

Recent Multifactor Productivity Trends

During the 2000-2008 period, MFP in the forest products sector increased 2.5 per cent per year, by far outperforming the business sector, which experienced negative growth of 0.6 per cent per year (Table 4). Of the three forest products subsectors, wood product manufacturing had the fastest MFP growth (3.6 per cent per year), followed by forestry and logging (1.8 per cent), and paper manufacturing (1.0 per cent).

According to CSLS estimates, MFP growth in the forest products sector suffered a significant slowdown in the 2008-2012 period (0.2 per cent per year), even though the sector still outperformed the business sector (-0.5 per cent per year). This slowdown was not caused by an "across the board" fall in MFP growth; rather, it reflects productivity losses in paper manufacturing (-2.6 per cent per year).

Compared to two-digit NAICS sectors, the Canadian forest products sector ranked second highest in terms of MFP growth during the 2000-2008 period, only behind agriculture, fishing, forestry and hunting, which experienced an increase of 2.6 per cent per year in MFP.

Table 4
Multifactor Productivity Growth in the Forest Products Sector, 2000-2012

	2000-2012	2000-2008	2008-2012
	(CAGR, per cent)		
Business Sector	-0.6	-0.6	-0.5
Forest Products Sector	1.7	2.5	0.2
Forestry and logging	2.0	1.8	2.6
Wood product manufacturing	3.1	3.6	2.1
Paper manufacturing	-0.2	1.0	-2.6

Source: CSLS calculations based on Statistics Canada data.

International Comparisons[7]

The Canadian forest products sector fared well in international MFP comparisons. Looking specifically at the 2000-2007 period, Canada's wood product manufacturing subsector had the highest MFP growth among the eight countries in our sample, 3.6 per cent per year, but only marginally higher than the MFP growth experienced by France's or Sweden's wood product manufacturing subsectors (3.4-3.5 per cent per year). Canada's paper

Table 5
Multifactor Productivity Growth in the Forest Products Sector, Selected OECD Countries, 1989-2007

	Canada	Finland	France	Germany	Italy	Sweden	United Kingdom	United States
	(compound annual growth rates, per cent)							
Wood Product Manufacturing								
1989-2007	2.4	2.3	3.5	2.5	2.1	3.4	-0.6	-1.0
1989-2000	1.6	3.5	3.5	3.2	3.1	3.4	-1.7	-2.8
2000-2007	3.6	0.5	3.5	1.4	0.5	3.4	1.3	2.0
Paper Manufacturing, Printing and Publishing								
1989-2007	0.9	3.8	0.7	0.3	-0.2	-0.1	0.1	-1.1
1989-2000	1.0	4.2	0.1	0.9	0.3	-0.7	-0.5	-2.0
2000-2007	0.6	3.3	1.6	-0.5	-0.9	0.8	1.0	0.3

Source: Canada and U.S. data from World KLEMS; for all other countries, data from EU KLEMS.

7 Multifactor productivity estimates were unavailable for forestry and logging in particular. As a consequence, we cannot calculate MFP growth for the forest products sector as a whole. This part of the article thus focuses on international MFP growth comparisons only for the wood product and paper manufacturing subsectors.

manufacturing subsector, however, had MFP growth of 0.6 per cent per year, making it only the 5th highest of the eight countries studied.

Productivity Drivers in the Canadian Forest Products Sector

This section seeks to understand the reasons behind the productivity performance of the Canadian forest products sector and its subsectors.

Growth Accounting

The starting point for any discussion on the dynamics of productivity growth is the standard growth accounting framework used to determine the sources of labour productivity growth in a sector.

During the 1961-2012 period, labour productivity in the Canadian forest products sector grew at a rate of 2.8 per cent per year, almost one percentage point faster than the business sector average of 1.9 per cent per year. The labour productivity differential between the forest products sector and the business sector can be entirely attributed to differences in MFP growth (1.4 vs. 0.2 percentage points, respectively). Overall, the above story is true not only for the forest products sector as a whole, but also for its subsectors.

The labour productivity growth differential between the forest products sector and the business sector has widened in recent years. Between 2000 and 2008, while business sector productivity increased at a rate of only 0.8 per cent per year, labour productivity in the forest products sector grew 3.6 per cent per year. Looking at the forest products sector as a whole, the picture seems very similar to the one we have seen for the overall 1961-2012 period, with MFP growth explaining the lion's share of the labour productivity differential (Table 6, Panel A). However, there were significant differences at the subsector level, particularly between paper manufacturing and the other two forest product subsectors.

In the more recent 2008-2012 period, labour productivity growth in the forest products sector suffered a significant slowdown (falling to 0.3 per cent per year), due largely to the paper manufacturing subsector, while business sector productivity growth remained stable (at 0.7 per cent per year). For the business sector, the sources of labour productivity growth remained largely unchanged from the previous period. For the forest products subsectors, however, there were important changes (Table 6, Panel B). First, capital intensity was either stagnant or fell in all three forest products subsectors. Second, the contribution of MFP growth to labour productivity growth fell in wood product manufacturing and paper manufacturing, while it increased in forestry and logging.

Human Capital

This subsection looks at human capital indicators in the Canadian forest products sector, and seeks to understand the role of education and training in driving productivity growth in the sector.

Average Years of Schooling

Over the past 22 years, the education level of Canadian workers has risen consistently, and workers in the forest products sector are no exception. Average years of schooling increased by almost one full year in the forest products sector, from 12.2 years in 1990 to 13.1 years in 2012, only slightly below the increase of 1.1 years observed for the average Canadian worker (from 12.9 years to 14.0 years). Overall, the education gap (in terms of average years of schooling) between the average Canadian worker and the average worker in the forest products sector remained stable in the 1990-2012 period.

Table 6

Sources of Labour Productivity Growth in the Forest Products Sector, 2000-2012

A) 2000-2008

	Business Sector	Forest Products Sector	Forestry and Logging	Wood Product Manufacturing	Paper Manufacturing
	(percentage point contributions to labour productivity growth)				
Labour Productivity	0.8	3.6	3.6	5.9	0.8
Contribution of Capital Intensity	1.1	1.0	1.9	2.3	-0.7
Capital Stock	0.7	1.8	7.3	2.0	-1.0
Capital Composition	0.4	-0.8	-5.4	0.3	0.3
Contribution of Labour Composition	0.3	0.2	0.0	0.1	0.5
MFP	-0.6	2.5	1.8	3.6	1.0
	(per cent contributions to labour productivity growth)				
Labour Productivity	100.0	100.0	100.0	100.0	100.0
Contribution of Capital Intensity	145.2	26.6	53.7	39.4	-85.3
Capital Stock	95.6	48.8	205.0	34.5	-117.0
Capital Composition	49.6	-22.1	-151.4	4.8	31.6
Contribution of Labour Composition	38.4	5.2	-0.4	0.9	62.9
MFP	-81.9	68.8	49.9	60.9	121.6

B) 2008-2012

	Business Sector	Forest Products Sector	Forestry and Logging	Wood Product Manufacturing	Paper Manufacturing
	(percentage point contribution to labour productivity growth)				
Labour Productivity	0.7	0.3	2.6	1.7	-2.3
Contribution of Capital Intensity	0.9	-0.2	0.1	-0.4	-0.3
Capital Stock	0.5	-0.2	0.2	-0.4	-0.4
Capital Composition	0.4	0.1	-0.1	0.0	0.1
Contribution of Labour Composition	0.3	0.2	0.0	0.1	0.6
MFP	-0.5	0.2	2.6	2.1	-2.6
	(per cent contribution to labour productivity growth)				
Labour Productivity	100.0	100.0	100.0	100.0	100.0
Contribution of Capital Intensity	130.6	-62.5	4.0	-26.1	12.0
Capital Stock	68.1	-92.8	6.2	-25.6	15.9
Capital Composition	62.5	30.3	-2.1	-0.5	-3.8
Contribution of Labour Composition	41.7	83.9	-0.5	3.9	-26.9
MFP	-69.9	86.4	98.3	125.0	114.1

Note: Percentage point contributions may not sum up to labour productivity growth due to rounding.
Source: CSLS calculations based on Statistics Canada data.

Breakdown of Workforce by Highest Level of Educational Attainment

In 2012, only 9.3 per cent of workers in the forest products sector had a university degree (vs. 26.9 per cent for the Canadian economy as a whole); 38.6 per cent had a non-university post-secondary diploma as their highest educational credential (vs. 35.8 per cent for the Canadian economy); 5.9 per cent had incomplete post-secondary education (vs. 7.3 per cent); 25.4 per cent had only a high-school education (vs. 19.7 per cent); and 20.8 per cent had less than a high-school education (vs. 10.3 per cent).

In a sense, the lower educational attainment levels of workers in the forest products sector are expected. The sector has very specific skill needs that, more often than not, require on-the-job training or non-university post-secondary education (such as a trade certificate) instead of

a university education. The (still) high proportion of workers without a high-school diploma – especially in forestry and logging – however, raises legitimate concerns regarding basic literacy and numeracy skills, the lack of which can negatively impact worker productivity.

Innovation

This subsection looks at innovation indicators in the Canadian forest products sector, and seeks to understand the role of innovation in driving productivity growth in the sector.

Defining Innovation

Innovation does not result from one particular factor; rather, it is brought about by many different elements, including research and development (R&D), learning-by-doing, monitoring of best practices, etc. As a consequence, there is no single indicator that can summarize the state of innovation in an industry. To deal with the complex nature of innovative activity, a systems approach is recommended. Sharpe and Long (2012) developed an analytical framework for assessing the state of the innovation system in Canada's natural resource industries, which we have adapted for the particularities of the forest products sector (Exhibit 2).

Unique Characteristics of the Forest Products Sector Affect Innovation

Certain characteristics of an industry can influence its ability, as well as its incentives, to innovate. The Canadian forest products sector has a number of characteristics that distinguish it from other sectors in the economy, influencing its innovative performance. Below, we highlight some of these characteristics: [8]

- Homogenous products;
- Highly competitive international markets;
- Price volatility;
- Environmental effects of production;
- The degree of regulation; and
- The degree of vertical linkages in production.

Exhibit 3 summarizes the above discussion by highlighting the general effects each of these unique characteristics of the Canadian forest products sector are expected to have on innovative activities.

Innovation Indicators

This subsection analyses several different indicators of innovation in the forest products sector, each of which provides a partial picture of the sector's overall innovative capacity.

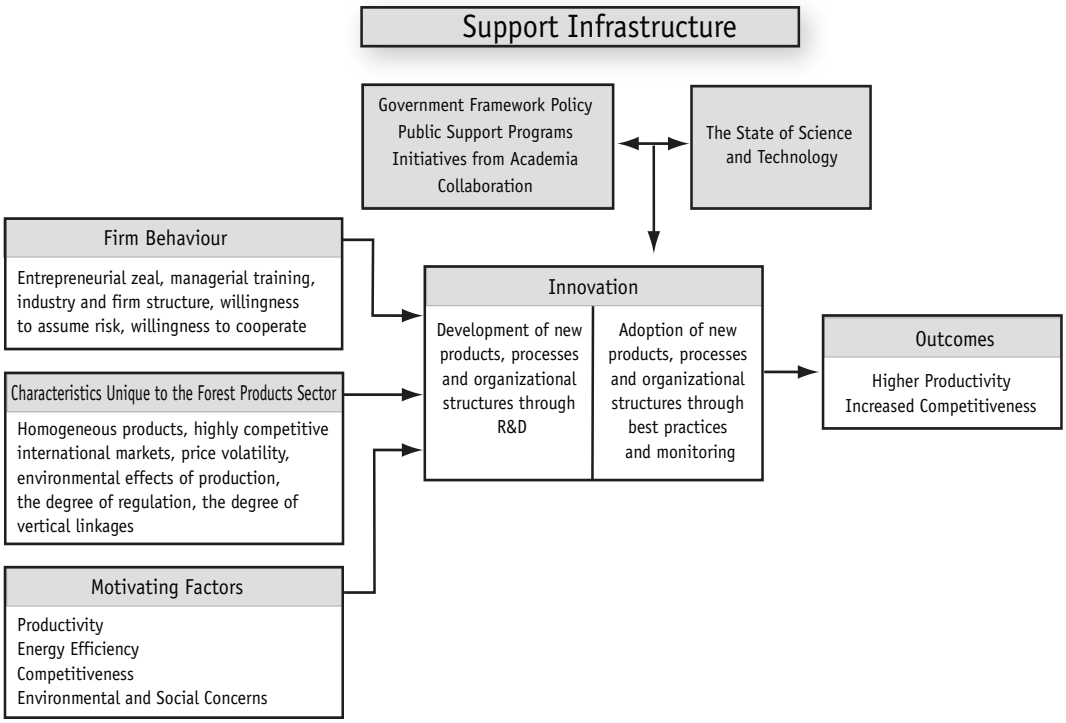
Technological Prowess and Academic Research

In its 2006 report on the state of science and technology (S&T) in Canada, the Council of Canadian Academies conducted a large-scale online survey of the opinion of Canadian experts, asking them about the overall direction and trend of S&T in a number of different areas. The report rated 16 broad areas of science and technology and 197 more specific sub-areas in terms of their technological standing.

Of the 16 broad areas, energy, mining and forest technologies were deemed to be in a strong technological position relative to other countries by the highest proportion of respondents, at 71 per cent (vs. 55 per cent for all areas). Drilling down to a greater level of detail, two forest products-related S&T sub-areas were within the top-50, with forestry engineering ranked at 35th place (out of 197) and pulp and paper technologies at 50th place. Timber harvesting technologies were also well ranked, coming at 51st place. Despite their high ranking,

8 The unabridged version of the article provides a detailed discussion of the characteristics that distinguish the forest products sector from other sectors in the economy.

Exhibit 2
The Innovation System in the Canadian Forest Products Sector



Source: Adapted from Sharpe and Long (2012).

a significant number of experts expected the relative strength of forest products S&T sub-areas to either stay stable or decline in coming years.

The Council of Canadian Academies updated and expanded its assessment of the state of S&T in Canada in 2012. The report notes that there has been a decline in the output and impact of Canadian forestry research between the 1999-2004 period and the more recent 2005-2010 period when compared to the rest of the world. It also notes, however, that "Canada's Forestry research was ranked second in the world by top-cited researchers, and Canada accounts for over 10 per cent of the world's papers in this subfield" (Council of Canadian Academies, 2012:164).

Business Enterprise R&D Expenditures

Economists have found a robust, positive relationship between R&D and productivity growth (see, for instance, Khan, Luintel, and Theodoridis, 2010). Below, we analyze the evolution of business enterprise R&D (BERD) expenditures in the forest products sector and its subsectors during the 2000-2012 period.

During the 2000-2008 period, BERD spending in the forest products sector grew at the same rate as total economy BERD spending (3.8 per cent per year). There were, however, important differences at the subsector level, with wood product manufacturing BERD increasing at a very rapid pace of 22.9 per cent per year, forestry and logging BERD increasing at half the total economy rate (1.9 per cent per year), and paper manufacturing BERD actually declining (-5.1 per cent per year).

With the 2009 recession, BERD spending plummeted in all three forest products subsectors. In the 2009-2012 period, BERD spending

Exhibit 3
The Effect of Unique Characteristics of the Forest Products Sector on Innovation

	How Does it Affect Innovation in the Forest Products Sector?	Expected Effect
Homogeneous Products	• Homogeneous products leave little (or no) room for competition via product differentiation. Since forest-product firms are generally price takers, they must constantly strive for cost effectiveness, which provides an important incentive to engage in process innovation.	+
Highly Competitive International Markets	• Canadian forest product industries are more exposed to international competition than the average Canadian firm. Hence, they must innovate if they want to stay in business.	+
Price Volatility	• Commodity prices tend to be volatile. As a consequence, forest-product firms have difficulty planning ahead, and tend to be biased towards producing (as opposed to innovating) in periods where prices are high, and hesitant to do anything when prices are low (for fear the trend continues).	-
Environmental Effects of Production	• The increasingly competitive international market will reward clusters that enhance energy efficiency and reduce emissions intensity with substantial cost-savings.	+
The Degree of Regulation	• In general, regulation is seen as a factor that inhibits innovation; • However, in the forest products sector, regulation can potentially force firms to improve their production processes (Porter hypothesis).	Ambiguous
The Degree of Vertical Linkages in Production Processes	• Higher levels of vertical integration can foster innovation since the innovative needs of the sector as a whole are known amongst firms; • Conversely, low vertical integration can hinder innovation because downstream industries will share the benefits, but not the costs, of innovation.	Ambiguous

Source: Adapted from Sharpe and Long (2012).

started to increase again in forestry and logging and paper manufacturing, growing at rates of 6.9 and 18.1 per cent per year (respectively), but not in the wood product manufacturing subsector, where it declined 5.3 per cent per year. This recovery has been quite timid, however, and BERD expenditures are still well below their pre-recession levels for all three forest products subsectors.

R&D Intensity

An important indicator of innovation performance is R&D intensity, defined here as BERD expenditures as a share of nominal GDP. Before 2000, R&D intensity in the forest products sector was remarkably stable (0.7-0.8 per cent), slightly below total economy R&D intensity. In the 2000s, however, R&D intensity in the forest products sector rose to above-average levels, peaking at 2.8 per cent in 2006; this increase was caused entirely by the paper manufacturing subsector. In 2009, R&D intensity in the forest products sector had fallen back to the total economy average of 1.1 per cent.

Compared to a group of eleven other OECD countries, Canada had the second highest R&D intensity in wood product manufacturing during the 2000-2008 period (0.9 per cent), only below Norway (1.3 per cent).[9] In the case of paper manufacturing, Canada had the third highest

9 International comparisons are based on data from the OECD's STAN database, which has detailed industry-level R&D intensity estimates for a number of countries for both wood product and paper manufacturing.

Table 7
Business Enterprise Expenditures in Research and Development in the Canadian Forest Products Sector, 2000-2012

	2000	2008	2012	2000-2012	2000-2008	2008-2012
	(millions, current dollars)			(CAGR, per cent)		
All Industries	12,395	16,644	15,493	1.9	3.8	-1.8
Forest Products Sector	290	391	221	-2.2	3.8	-13.3
Forestry and logging	18	21	14	-2.1	1.9	-9.6
Wood product manufacturing	42	219	85	6.1	22.9	-21.1
Paper manufacturing	230	151	122	-5.1	-5.1	-5.2

Source: Statistics Canada, Research and Development in Canadian Industry, CANSIM Table 358-0024.

R&D intensity (3.4 per cent) out of the 11 countries in our sample. Norway had the highest R&D intensity (4.4 per cent), followed by Sweden (3.7 per cent).

R&D Personnel Intensity

R&D personnel intensity, defined here as the number of R&D personnel per 1,000 workers is an important indicator of an industry's ability to innovate. In 2010, there were 8.5 R&D personnel per 1,000 workers in the Canadian forest products sector, up almost 50 per cent from 5.7 in 2000, and well above the all-industries average (7.8 R&D personnel per 1,000 workers in 2010). At the subsector level, paper manufacturing accounted for most of the rise in the R&D intensity of the forest products sector during the early 2000s.

Using OECD data, Sharpe and Long (2012:47) calculated R&D personnel intensity for wood product and paper manufacturing in 2008 for 10 OECD countries. In wood product manufacturing, Canada had the second highest R&D personnel intensity among the countries in our sample (8.4 R&D personnel per 1,000 workers), only behind France (16.4 R&D personnel per 1,000). In paper manufacturing, however, Canada's R&D personnel intensity (17.7 R&D personnel per 1,000 workers) was well below Norway's, Finland's, and Sweden's – all of which are countries with well developed forest products sectors.

M&E Investment Intensity

Although the relatively high levels of R&D investment in the Canadian forest products sector are good news, these indicators represent only one aspect of innovation. In general, a great deal of innovation is related to adopting state-of-the-art capital goods that improve the efficiency of the production process (as innovation tends to be embodied in physical capital).

The low levels of investment in physical capital, especially in the paper manufacturing subsector, suggest that a number of firms in the Canadian forest products sector are using outdated capital assets that do not embody the latest technological innovations. Rheaume and Roberts (2007:20) remark, for instance, that "Canadian pulp and paper mills are significantly smaller and older than those operated by their international competitors". Similarly, Woodbridge Associates (2009:53) support this view, stating that B.C.'s "pulp and paper mills generally are aging, and are not cutting edge."[10]

M&E investment intensity, defined here as real investment in machinery and equipment (M&E) per hour worked, is an important indica-

Table 8
M&E Investment Intensity Growth in the Forest Products Sector, 2000-2012

	2000-2012	2000-2008	2008-2012
	(CAGR, per cent)		
All Industries	2.7	4.0	0.2
Forest Products Sector	-0.1	-2.6	5.1
Forestry and Logging	0.4	2.7	-4.2
Wood Product Manufacturing	1.4	-2.4	9.6
Paper Manufacturing	-2.0	-4.5	3.3

Source: CSLS calculations based on Statistics Canada data.

tor of embodied technological change. Between 2000 and 2012, while M&E investment intensity for the Canadian economy as a whole was increasing at an average annual rate of 4.0 per cent, M&E investment intensity in the forest products sector was actually declining 2.6 per cent per year (Table 8).

In the 2008-2012 period, M&E investment intensity in the forest products sector picked up pace, increasing at a rate of 5.1 per cent per year, significantly faster than total economy growth (0.2 per cent per year). Growth in M&E investment intensity was fueled by the wood product manufacturing subsector, which saw M&E investment intensity increase at an average annual rate of 9.6 per cent.

Foreign Direct Investment

Both foreign investment in the domestic economy and investment of Canadian firms abroad can foster technology diffusion, with firms creating new production processes or adapting established production processes to new realities. According to Statistics Canada estimates, between 2000 and 2012, inward FDI flows declined 48 per cent in the wood product manufacturing subsector and 23 per cent in the paper manufacturing subsector.

Incidence of Innovation

Innovation at the firm and plant level is also an important indicator. Three occasional Statistics Canada surveys related to innovation provide a variety of insights into what constitutes innovation and how innovation is measured:

- Survey of Innovation;
- Survey of Advanced Technologies, and
- Survey of Innovation and Business Strategy (SIBS).

The Survey of Innovation shows the per cent of innovative plants in the three forest products subsectors during the 2002-2004 period. Compared to total manufacturing (65.0 per cent), the performance of the forest products sector was quite poor, with logging and wood product manufacturing being 47.5 and 7.3 percentage points below the manufacturing total.

According to SIBS, which provides data with additional detail on the type of innovative activity conducted, process innovation clearly plays a larger role in the forest products sector than it does in other industries. More than half of wood product and paper manufacturing firms introduced new methods of manufacturing during the 2007-2009 period (vs. only 17.3 per cent of all firms). In terms of product innovation, wood product and paper manufacturing firms were, in general, more innovative than the average Canadian firm, although they still trailed behind the manufacturing total by a significant margin.

Finally, the Survey of Advanced Technology provides an additional indicator of innovation, inquiring about the percentage of firms in the manufacturing sector that adopted advanced technologies. In fact, 96.9 per cent of wood product manufacturing plants were using at least

10 In general, however, Woodbridge Associates (2009:53) praise the B.C. forest products sector, stating that the "industry is well known for its rapid adoption of state-of-the-art processing technologies," which is consistent with its superior productivity performance. Not surprisingly, B.C. has had by far the best productivity performance in the forest products sector of any province in the 2000-2012 period.

one advanced technology by 2007, above the manufacturing total of 91.5 per cent. Although the proportion of paper manufacturing plants using at least one advanced technology was lower than the manufacturing total (86.0 per cent), paper manufacturing had a higher proportion of plants that used at least five advanced technologies (76.2 vs. 67.7 per cent for the manufacturing total).

Business Cycle, Returns to Scale, and Other Factors

The standard theoretical framework used to calculate MFP growth relies on some important assumptions, three of which are particularly relevant to us:

- Efficiency;
- Constant returns to scale; and
- Perfect competition.

Needless to say, these can be strong assumptions. In situations where they do not hold, MFP growth – and, as a consequence, sources of labour productivity growth – will be affected. In this subsection, we explore the possibility that part of the MFP growth experienced by the Canadian forest products sector is linked to the factors listed above.

Business Cycle

In general, productivity exhibits procyclical behaviour, that is, it increases during economic booms and decreases during recessions (Basu and Fernald, 2001). There are many potential reasons for this, but two stand out:

Capacity utilization: During recessions, a significant part of firms' capital stock is idle, causing productivity to fall; inversely, during booms, capital can be over-utilized, causing productivity to rise; and

Labour hoarding: During recessions, firms have a tendency to keep more workers than it would be optimal for a given level of production, driving down productivity.

In forestry and logging, capacity utilization remained relatively high in the 2000-2008 period, ranging from a low of 81.6 per cent in 2001 to a high of 93.6 per cent in 2008. With the recession, capacity utilization dropped 16.3 percentage points to 77.3 per cent, but quickly recovered.

Chart 10 looks at what happens to MFP growth in the forest products sector when we use the capacity-utilization adjusted measure (vs. the baseline measure). During the overall 2000-2012 period, average MFP growth was practically the same, regardless of the measure used (1.6 per cent per year using the capacity utilization-adjusted measure vs. 1.7 per cent per year using the baseline measure). The capacity utilization-adjusted measure (CU-MFP), however, reduced the volatility of MFP growth, making the series more stable.

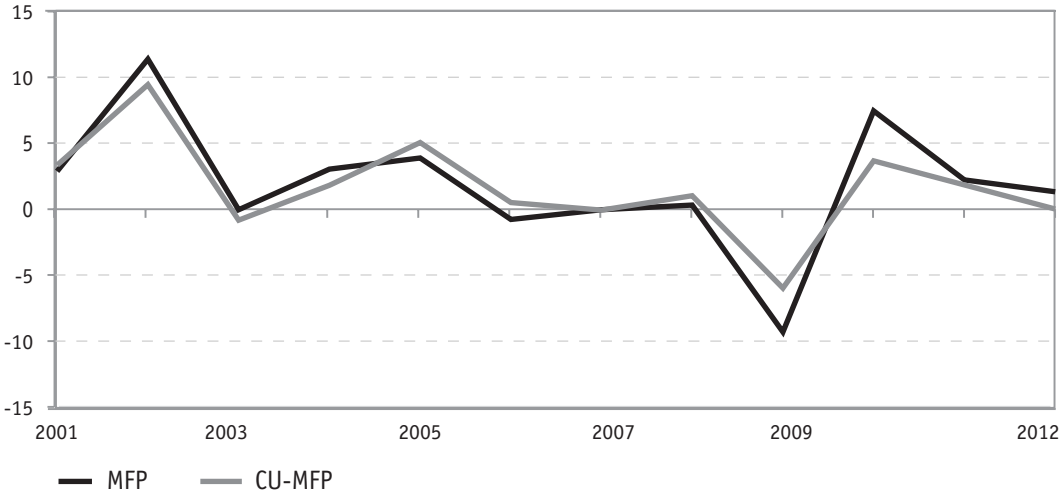
The effect of labour hoarding on productivity growth is harder to quantify. The unabridged version of this article provides a detailed discussion of this issue.

Returns to Scale and Firm Size

The standard theoretical framework used to compute MFP growth assumes constant returns to scale, that is, a doubling of inputs leads to a doubling of output. Whenever this assumption is violated, productivity gains created by increasing returns to scale (IRS) appear as part of MFP growth.[11] The existing literature highlights the importance of returns to scale in the forest products sector, but does not provide actual estimates of its impact on productivity. Although the econometric estimation of returns to scale is beyond the scope of this article, such estimates can be constructed using the methodology delin-

11 It is interesting to note that the benefits associated with IRS are also linked to the business cycle. In the presence of IRS, economic booms can yield significant productivity gains, since production has to increase to meet the strong demand; conversely, economic downturns lead to productivity losses.

Chart 10
MFP Growth in the Forest Products Sector Adjusted by Changes in Capacity Utilization, 2000-2012
(per cent)



Source: CSLS calculations based on Statistics Canada data.

eated in Diewert and Fox (2005). It is interesting to note, furthermore, that Diewert and Fox find evidence of the existence of IRS in the U.S. wood product and paper manufacturing subsectors.

Other Factors

Other factors have influenced productivity growth in the Canadian forest products sector, namely: profits; industrial structure and intersectoral shifts; and the quality and size of Canada's natural resource base.

Profits

Chart 11 shows operating profits in the Canadian forest products sector during the 2000-2011 period. The level of profits in paper manufacturing peaked in 2000 at $5,080 million and then quickly declined, reaching $848 million in 2011.

Profits can influence productivity growth through three main channels:

Composition Effect: Low (or negative) profit levels can force low-productivity establishments out of business, raising the average productivity of the sector.

Survival Effect: Falling profits may serve as an incentive for firms to innovate, as they look for ways to cut costs and improve the overall efficiency of their production processes.

Investment Effect: Conversely, falling profits can make it harder for firms to invest in R&D or new capital, slowing down productivity growth.

Although the exact effect profits may have had on productivity growth in the forest products sector is unknown, it is more than likely that falling profits have helped shape a leaner, more efficient sector, despite the falls in investment.

Chart 11
Operating Profits in the Forest Products Sector, 2000-2011
(current dollars, millions)

Source: Statistics Canada, Financial and Taxation Statistics for Enterprises, CANSIM Table 180-0003.

Industrial Structure and Intersectoral Shifts

Productivity growth in the forest products sector is a combination of productivity growth in forestry and logging, wood product manufacturing, and paper manufacturing. For each subsector, in turn, productivity growth is the aggregation of productivity growth in more specific activities. Aggregate productivity growth depends not only on how much productivity growth each of these activities experience (pure productivity effect), but also on how important each activity is relative to the total. Shifts towards higher-productivity activities can also cause the overall productivity in the sector to increase (reallocation effect). The reallocation effect in the Canadian forest products sector was quite small during the 2000-2012 period, explaining only 4.6 per cent of average labour productivity growth in the period, with the pure productivity effect accounting for the remaining 95.4 per cent.

Quality and Size of Canada's Natural Resource Base

The overall quality of the natural resource base can have an important effect on productivity. Ceteris paribus, easily accessible and high-quality natural resources will lead to lower costs and higher productivity than hard-to-reach and low-quality natural resources. There is no evidence that this fact played a significant role in influencing productivity in the 2000-2012 period, either positively or negatively.

Conclusion

Even though global demand for forest products has risen in the past decade, largely reflecting growth in emerging markets, increased international competition has taken its toll on the Canadian forest products sector. Canada's share in world production of all major forest products has fallen, and its share in total world exports of forest products has halved.

The competitiveness of Canada's forest products sector has suffered greatly due to a strong

Canadian dollar and high labour costs, which make it harder for the sector to compete internationally with low-wage countries. By lowering production costs, productivity gains can help Canadian firms to better compete with international firms, and thus regain some of the lost market share.

In fact, much more effectively than other manufacturing subsectors, the Canadian forest products sector has managed to soften the blow of rapidly rising unit labour costs by posting major productivity gains, driven in particular by the wood product manufacturing subsector. In order to regain some of the lost ground and remain competitive, however, Canada's forest products sector must maintain (or even improve) high rates of productivity growth.

Public policies can have a significant impact on productivity growth by affecting the behaviour of firms. Well designed policies can help align incentives, leading to more (and better) investment in human capital, physical capital, and innovation, which usually translates into faster productivity growth. Conversely, poorly designed policies can create perverse incentives, thus hindering productivity growth.[12]

Policies must address two key issues in order to promote productivity growth in the forest products sector. First, the falling levels of investment in physical capital, especially in paper manufacturing, suggest that a number of firms in the sector are using outdated capital assets that do not embody the latest technological innovations. Second, human capital deficiencies in forest products firms can significantly hinder productivity growth if not dealt with properly. In this sense, the article recommends renewed focus on both human and physical capital investment, as well as on R&D spending.

References

Basu, Susanto and John Fernald (2001) "Why is productivity procyclical? Why do we care?" in New developments in productivity analysis, Charles R. Hulten, Edwin R. Dean and Michael J. Harper (eds.), National Bureau of Economic Analysis (Chicago: University of Chicago Press).

de Avillez, Ricardo (2014) "A Detailed Analysis of Productivity Trends in the Canadian Forest Products Sector" CSLS Research Report 2014-01 (Ottawa: Centre for the Study of Living Standards), May. www.csls.ca/reports/csls2014-01.pdf

Diewert, Erwin and Kevin J. Fox (2005) "On the estimation of returns to scale, technical progress and monopolistic markups," Journal of Econometrics, Vol. 145, No. 1-2, pp. 174-193.

Forest Products Association of Canada (2014) "2014 – Productivity Report Card: Canada's Forest Products Industry Gets Top Grade."

Harrison, Peter and Andrew Sharpe (2009) "A Detailed Analysis of the Productivity Performance of the Canadian Forest Products Sector Since 2000," CSLS Research Report 2009-09 (Ottawa: Centre for the Study of Living Standards).

Haskel, Jonathan and Christopher Martin (1993) "Do skill shortages reduce productivity? Theory and evidence from the United Kingdom," The Economic Journal, Vol. 103, No. 417, pp. 386-94

Rheaume, Gilles and John Roberts (2007) "Mission possible: a Canadian resources strategy for the boom and beyond," The Canada Project Final Report, Volume II, Conference Board of Canada.

Sharpe, Andrew and Blair Long (2012) "Innovation in Canadian natural resource industries: a system-based analysis of performance, policy and emerging challenges," CSLS Research Report 2012-06 (Ottawa: Centre for the Study of Living Standards).

Wood Manufacturing Council (WMC) (2007) "A survey of the educational needs of the advanced wood products processing sector."

Woodbridge Associates (2009) "Opportunity BC 2020, BC's forest industry – Moving from a volume focus to a value perspective," report prepared for the business council of BC.

12 Refer to the unabridged version of the article for a detailed discussion of the effect of various human capital, innovation, taxation and regulation policies on productivity growth in the forest products sector. In addition, refer to FPAC (2014) for a discussion of policies that they recommend to promote productivity growth.