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A DETAILED ANALYSIS OF PRODUCTIVITY TRENDS IN THE CANADIAN FOREST PRODUCTS SECTOR

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A Detailed Analysis of Productivity Trends in the Canadian Forest Products Sector

Abstract

The Canadian forest products sector has had an above-average productivity performance in the 2000-2012 period, 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 report 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 report recommends renewed focus on human and physical capital investment, as well as on R&D spending.

A Detailed Analysis of Productivity Trends in the Canadian Forest Products Sector

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Executive Summary

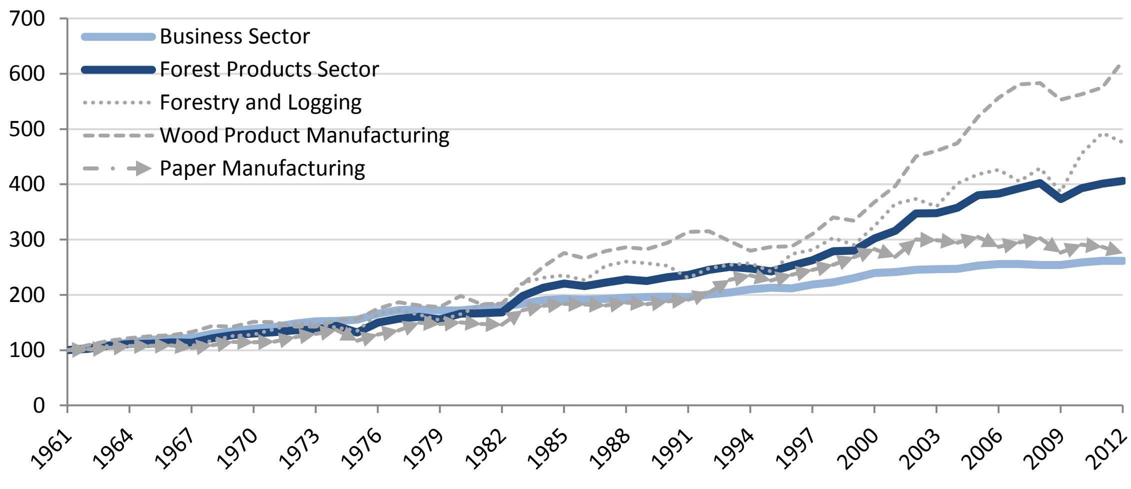
The Canadian forest products sector has had an above-average productivity performance in the 2000-2012 period, driven in particular by wood product manufacturing. Forestry and logging also benefited from strong productivity gains, but the productivity performance of paper manufacturing has been far from impressive, especially in the post-2008 period. The objective of this report is to shed light on these productivity trends in the Canadian forest products sector, emphasizing recent developments in labour and multifactor productivity. The report also seeks to explain how productivity can help the forest products sector achieve the output, employment, and environmental goals delineated in FPAC's *Vision 2020 Challenge*.

Highlights

- 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.

Labour Productivity in the Forest Products Sector, 1961-2012

(Index, 1961=100)



Source: CSLS calculations based on Statistics Canada data.

- In terms of multifactor productivity (MFP) growth, the performance of the forest products sector in the 1961-2012 period was also impressive, with MFP tripling in a period of stagnant business sector growth.

- Between 1961 and 2012, wood product manufacturing saw faster labour productivity growth (3.7 per cent per year) than forestry and logging (3.1 per cent per year) and paper manufacturing (2.0 per cent per year).

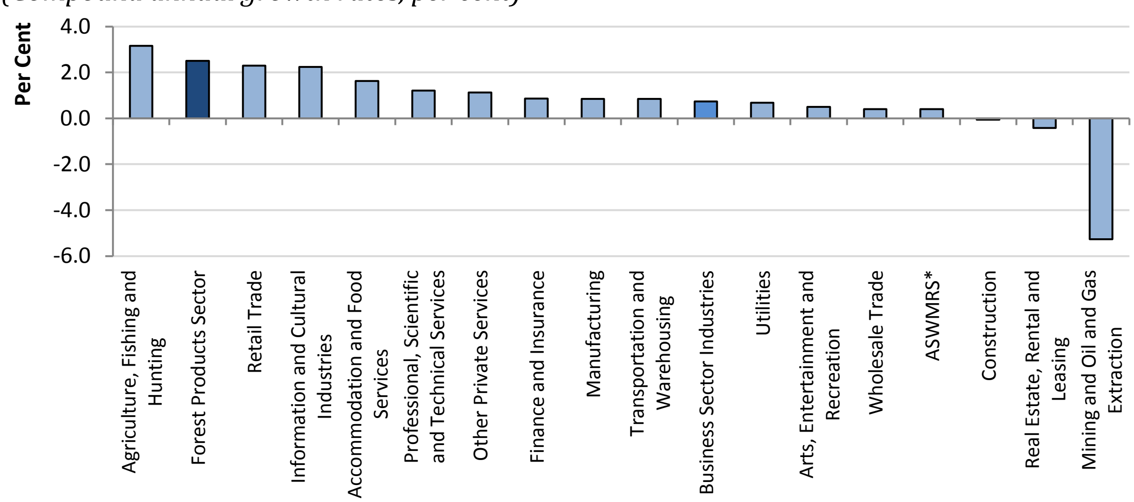
- During the more recent 2000-2008 period, labour productivity increased at an average annual rate of 3.6 per cent per year in the Canadian forest products sector, significantly faster than business sector growth (0.8 per cent).

- 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 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.

Labour Productivity Growth in the Forest Products Sector and Two-Digit NAICS Sectors, 2000-2012

(Compound annual growth rates, per cent)



* Administrative and Support and Waste Management and Remediation Services
Source: CSLS calculations based on Statistics Canada data.

- Despite its weak post-2008 labour productivity performance, the Canadian forest products sector had the second highest growth rate for the 2000-2012 period when compared to two-digit NAICS sectors, only behind agriculture, fishing and hunting, which experienced an increase of 3.2 per cent per year in labour productivity.

- 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.

- 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 of 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. In a sample of eight OECD countries, Canada had by far the fastest productivity growth in the wood product manufacturing subsector during the 2000-2007 period, both in terms of labour productivity and MFP. The productivity performance of Canada's paper manufacturing, however, was far from stellar.

Output and Input Trends

The 2009 recession had a large impact on the Canadian forest products sector, reducing real GDP and employment by 19 and 10 per cent (respectively), and leading to a 40 per cent drop in real investment. Despite experiencing a recovery in the 2009-2012 period, the sector's real GDP, employment and capital stock are still significantly below their pre-recession levels.

The reality, however, is that real GDP, employment and real investment in the forest products sector had been declining well before the recession. This decline is 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 deep structural changes in the demand for forest products – in particular the ongoing shift towards electronic media.

Below, we highlight some of the key findings of our analysis:

- Paper manufacturing was the most important subsector in terms of nominal value added, accounting for 45.0 per cent of the total value added in the Canadian forest products sector in 2009 (the last year for which nominal GDP estimates for the sector were available). The subsector with the second largest value-added share was wood product manufacturing (35.5 per cent), followed by forestry and logging (19.5 per cent);

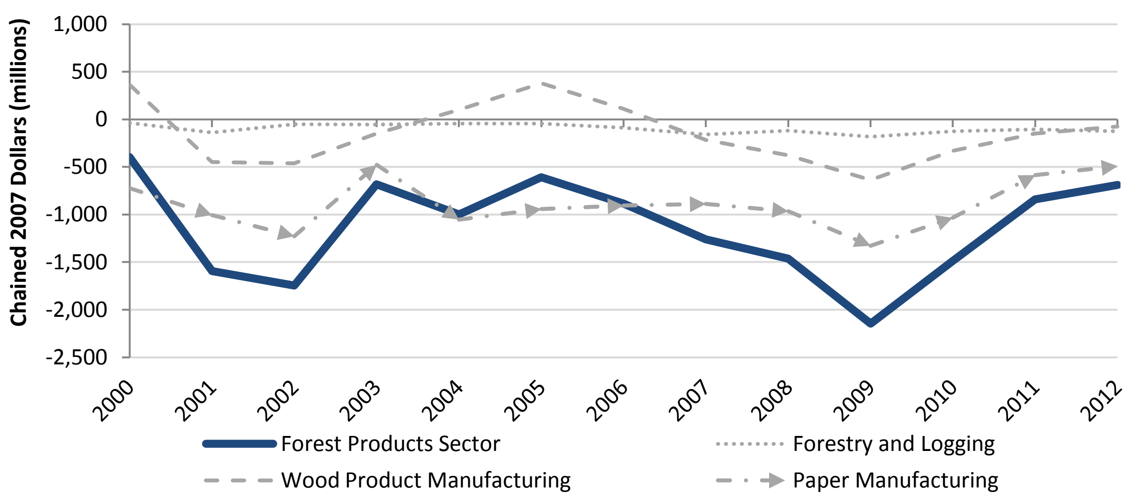
- Three provinces accounted for 80 per cent of the nominal value added generated by the forest products sector in 2009: Quebec (31.2 per cent), British Columbia (25.5 per cent), and Ontario (24.1 per cent). In addition, the province of Alberta was responsible for 9.3 per cent of the forest products sector's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

- In 2009, 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, down 3.2 percentage points from 4.3 per cent in 1961. In other words, the forest products sector now has only one-quarter of the economic importance it had 50 years ago.

- For the forest products sector as a whole, real GDP decreased at a pace of 1.2 per cent per year between 2000 and 2012, from $23,297 million to $18,753 million (in chained 2007 dollars). The sector lost 127 thousand jobs in the period, at a rate of 4.0 per cent per year. Furthermore, real capital stock declined by 4.4 per cent per year, from $34,685 million in 2000 to $20,299 million in 2012.

- Real investment in the Canadian forest products sector reached $2,395 million (measured in chained 2007 dollars) 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, however, real investment had already bounced back to its 2008 level.

Real Net Investment in the Forest Products Sector, 2000-2012



Source: CSLS calculations based on Statistics Canada data.

- These investment figures, however, refer to *gross* investment, i.e. they take into account not only spending on new capital goods, but also spending with the objective of *replacing* depreciated capital goods. Real *net* investment – that is, subtracting depreciation – in the Canadian forest products sector was *negative* throughout the 2000-2012 period.

- Paper manufacturing had, by and large, the worst performance among the three forest products subsectors, with real GDP falling 3.5 per cent per year during the 2000-2012 period. Unlike the other two subsectors, paper manufacturing did not experience a recovery in the 2009-2012 post-recession period, and real GDP continued to decline. Between 2000 and 2012, the subsector's real capital stock declined by half.

Productivity Drivers and Policies

MFP growth has been the main driving force behind the rapid labour productivity growth in the forest products sector, in particular MFP growth in forestry and logging and wood product manufacturing. By definition, MFP growth is a residual, representing output growth that is not accounted for by measured input growth. It is often seen as a proxy for disembodied technological change, but the reality is that it encompasses a number of very different factors, such as improvements in technology and organization, capacity utilization, increasing (or decreasing) returns to scale, etc. MFP growth also embeds errors due to the mismeasurement of inputs and outputs.

Overall, improvements in technology seem to have played a major role in driving MFP growth in the Canadian forest products sector. Canada conducts state-of-the-art research in several areas related to forest products. In forestry, for instance, "Canada's (…) 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). Furthermore, Canada had high R&D intensity in wood product and paper manufacturing, well above the international average and in line with the R&D intensity of countries such as Norway, Sweden and Finland, all of which have major forest products sectors.

It is important to keep in mind, however, that significant improvements can still be made. The falling levels of investment in physical capital, especially in paper manufacturing, are worrisome, as they 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. This point becomes all the more relevant given the looming possibility of a lumber supercycle. With the U.S. housing market heating up again and the strong demand for wood from China, Canadian forest-products firms will have to redouble their efforts in investing in state-of-the-art capital assets, particularly machinery and equipment, in order to reap the benefits from the growing demand.

In addition, despite noticeable gains in the education front over the past decades, workers in the forest products sector still have lower educational attainment levels than the average Canadian worker. In a sense, this is not surprising; the sector has very specific skill needs that, more often than not, require on-the-job training or a non-university post-secondary education (such as a trade certificate) instead of a university education. Nonetheless, the (still) high proportion of workers without a high-school diploma – especially in forestry and logging – raises legitimate concerns regarding basic literacy and numeracy skills, the lack of which can have a significant negative impact on worker productivity.

How Can Improved Productivity Help the Canadian Forest Products Sector?

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, declining from 18.8 per cent in 2000 to only 9.1 per cent in 2011.

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. 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 production costs. This means, however, that employment in the sector might *fall* in the short-run. In the medium- and long-run, however, productivity gains in the sector can prove to be an important boon, helping Canadian firms to better compete with international firms, and thus regain some of the lost market share. The increased demand for Canadian forest products may, in turn, lead to a rise in the sector's employment.

Finally, it is important to put the problems faced by the Canadian forest products sector into a broader perspective. High labour costs, a strong Canadian dollar, and increased international competition have affected not only the forest products sector, but the entire manufacturing sector in Canada. In fact, the past decade has not been kind to Canadian manufacturing. With few exceptions, manufacturing subsectors in Canada have seen real GDP decline during the 2000-2012 period. In addition to falling GDP, most manufacturing subsectors have experienced weak (or even negative) productivity growth in the period, further complicating their situation.

Much more effectively than other manufacturing subsectors, however, 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. In this sense, the report recommends renewed focus on human and physical capital investment, as well as on R&D spending.

Through a period of unprecedented restructuring, the Canadian forest products sector has demonstrated significant resilience despite stiffer competition and considerable terms of trade deterioration. This resilience will likely serve the sector well in the future. Further consolidation of the sector will work towards increasing its resilience, allowing it to improve its performance and continue posting strong productivity gains.

A Detailed Analysis of Productivity Trends in the Canadian Forest Products Sector[1]

I. Introduction

Despite its falling real output, the Canadian forest products sector has had an above-average labour productivity performance in the 2000-2012 period, 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.

The objective of this report is to understand these productivity trends in the Canadian forest products sector, emphasizing recent developments in labour and multifactor productivity. The report builds on and expands previous CSLS research on the subject, in particular Harrison and Sharpe (2009) and Sharpe and Long (2012). 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, identifying the main sources and drivers of productivity growth in the sector is an important step towards developing effective productivity-enhancing policies.

The report is organized as follows. Section two discusses definitions, concepts, and data sources used in this report. It also contains a short primer on some of the main issues related to productivity analysis. Section three analyzes output and input (labour and capital) trends in the Canadian forest products sector; section four looks at the evolution of labour, multifactor and energy productivity in the sector, using the overall business sector performance as a benchmark; section five identifies and discusses the main drivers of productivity growth in the forest products sector, highlighting potential areas where the sector might be lacking; section six discusses the importance of productivity growth in the Canadian forest products sector; section seven assesses the effect of the current policy environment on the sector's productivity growth, providing general policy suggestions aimed at improving its productivity performance; finally, section eight concludes.

[1] This report was written by Ricardo de Avillez under the supervision of Andrew Sharpe. We would like to thank Forest Products Association of Canada officials, especially Jean-Francois Larue, for detailed comments on earlier drafts of the report. Email: andrew.sharpe@csls.ca

II. Definitions, Concepts and Data Sources

This section discusses the main definitions, concepts and data sources used in this report. First, we define the forest products sector, which is composed of three NAICS subsectors. Next, we review some of the key issues related to productivity analysis and carefully define the productivity measures used in this report. Finally, we describe our main data sources.

A. The Forest Products Sector

Statistics Canada categorizes establishments according to the North American Industry Classification System (NAICS) based on the similarity of their production processes.[2] NAICS has a hierarchical structure that divides the economy into 20 sectors, which are identified by two-digit codes. Below the sector level, establishments are classified into three-digit subsectors, four-digit industry groups, and five-digit industries. At all levels, the first two digits always indicate the sector, the third digit the subsector, the fourth digit the industry group, and the fifth digit the industry.

The forest products sector, as it is defined in this report, 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;
- Paper manufacturing.

A more detailed breakdown of all the activities included in the forest products sector can be seen in Exhibit 1. Note that the forest products sector, as defined here, is very heterogeneous in terms of production processes. Both wood product and paper manufacturing are part of the manufacturing sector (NAICS codes 31-33) because they physically or chemically transform materials or substances into new products. Forestry and logging, on the other hand, is part of the agriculture, forestry, fishing and hunting sector (NAICS code 11) and involves completely different processes. Despite these differences, the activities included in these three subsectors share important commonalities in terms of inputs (from forests) and outputs (wood and paper products), which is why we refer to the aggregate as the forest products sector.

[2] "The establishment is defined as the smallest operating entity for which records provide information on the cost of inputs – capital, labour, energy, materials and services – employed to produce the units of output. The output may be sold to other establishments and receipts or sales recorded, or the output may be provided without explicit charge, that is, the good or service may be 'sold' within the company itself (…) The establishment in Canada is generally a single physical location, where business is conducted or where services or industrial operations are performed (for example, a factory, mill, store, hotel, movie theatre, mine, farm, airline terminal, sales office, warehouse, or central administrative office)." (Statistics Canada, 2012:15).

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).

Forestry and logging (NAICS code 113) is a subsector composed of establishments involved in growing and harvesting timber over a production cycle of 10 years or more. The length of the production cycle distinguishes the forestry and logging subsector from the crop production subsector, where output might be similar, but production cycles are shorter. The production of Christmas trees, for example, is classified as crop production, part of agriculture, because the production cycle is less than 10 years. Statistics Canada (2007) also notes that, except when undertaken on a very small scale, forestry and logging involves unique machinery and equipment, reflecting the unique production process of the subsector. The subsector also includes the gathering of forest products such as moss and bark.

Wood product manufacturing (NAICS code 321) is a subsector that includes establishments engaged in sawing logs into lumber, preserving wood products, and making products that improve the natural characteristics of wood (for instance, plywood, veneer, reconstituted wood panels, and engineered wood). Another industry in this subsector is millwork, wherein establishments use wood-working machinery like planers, jointers, lathers and routers to shape wood.

Paper manufacturing (NAICS code 322) includes the manufacture of pulp, paper and various paper products through cutting and shaping. Examples of products include boxes, stationery products, sanitary products, egg cartons, and paper bags.

Given the heterogeneity of activities and production processes included in the forest products sector, aggregate productivity measures should be interpreted with caution. Factors that influence the productivity of a particular subsector may have little or no effect on the productivity of other subsectors. New logging regulations, for instance, might have a significant impact on the productivity of the forestry and logging subsector, but no impact on the wood product and paper manufacturing subsectors. Thus, this report analyzes not only the performance of the Canadian forest products sector as a whole but also of each of its three constituent subsectors.

There are other activities that could have been, in principle, included in our definition of the forest products sector. First and foremost in this list is support activities for forestry (NAICS code 1153)[3], which includes forest conservation services, forest fire fighting services, log hauling in the forest, forestry pest control services, and timber cruising and valuation. Statistics Canada has nominal GDP, real GDP and employment estimates for this industry group, which would allow us to construct labour productivity estimates. Unfortunately, however, capital stock data for support activities for forestry are not publicly available, making it impossible for us to construct MFP estimates. Thus, taking into account support activities for forestry would have caused us to use *inconsistent* definitions of the forest products sector throughout this report, which could potentially make the report confusing and hard to follow. Moreover, it would make it impossible for us to decompose labour productivity growth into its sources at the aggregate level, since labour productivity estimates would include support activities for forestry, but MFP estimates would not.

It is important to keep in mind, however, that support activities for forestry represent only a small fraction of forest products-related activities. In 2008 (the last pre-recession year for which nominal GDP estimates were available), nominal GDP in support activities for forestry was close to $1.4 billion, only 6 per cent of the nominal GDP of forest products-related activities. In this sense, excluding support activities for forestry from the forest products sector aggregate does not have a major impact on our estimates or on our conclusions. Regardless, we have provided information on nominal GDP, real GDP and employment for this industry group in footnotes. Other activities that could have been considered part of forest products sector, but had little or no data available, were local forest product trucking (NAICS code 484223) and long-distance forest product trucking (NAICS code 484233).

B. A Brief Productivity Primer

Productivity can be broadly defined as a measure of how much output is produced per unit of input used. Despite this simple definition, several different productivity measures arise from the use of distinct concepts of output and input, with each of these measures serving different purposes. Here, we explain important topics related to productivity analysis, define the

[3] The Forestry Product Association of Canada defines the forest product sector to include forestry support services. This increases the total employment in the sector to 235 thousand in 2012 compared to 199 thousand when these services are excluded.

main productivity concepts used throughout the report, and discuss the reasons why productivity measurement is relevant to economic analysis.

i. Gross Output Productivity vs. Value Added Productivity

Since productivity is a ratio of output to input(s) used in the production process, different productivity measures can be constructed using: 1) different measures of output; 2) different measures of inputs. In this subsection, we discuss the two most used measures of output: gross output and value added. The next subsection focuses on the choice of one or more inputs when constructing a productivity measure.

Gross output consists of all goods and services produced by an economy, sector, industry or establishment during a certain period of time. Value added (or GDP at basic prices), on the other hand, measures the contribution of primary inputs (labour and capital) to the production process.

When dealing with the economy as a whole, the value-added approach is the natural choice, because it avoids double counting of intermediate inputs in the aggregate output. In practice, the value-added approach is also the standard choice of most sectoral productivity analysis. Trueblood and Ruttan (1992) argue, however, that when investigating the productivity performance of a particular sector, the focus should be on the total input-output relationship in order to evaluate the overall gains in both primary and intermediate input use. This is particularly true in the case of sectors that experienced significant shifts in the use of inputs through time, such as the primary agriculture sector, where intermediate inputs (feed, fertilizers, pesticides, etc.) play a much more prominent role nowadays than they did in the past.

ii. Partial Productivity Measures vs. Multifactor Productivity

Economists distinguish between partial and multifactor productivity (MFP) measures. Partial productivity measures are a ratio between output and a single input, such as labour or capital. Labour productivity, for example, is commonly defined as the ratio between output and hours worked in a certain activity, while capital productivity is the ratio of output to capital stock.

MFP, in turn, is the ratio between output and *combined* inputs used in the production process, e.g. value-added MFP is calculated as the ratio of value added to (an index of) *combined* labour and capital inputs. Therefore, MFP growth is a residual, reflecting output growth that is not accounted for by measured input growth. MFP growth can be explained by a number of very different factors, such as improvements in technology and organization, capacity utilization, returns to scale, etc. It also embeds errors due to the mismeasurement of inputs and outputs.

iii. Productivity Growth Rates vs. Productivity Levels

Productivity can be expressed either in growth rates or in levels. The economics literature largely centres on productivity *growth rates*, which refer to changes in *real* variables (as opposed to *nominal* variables), e.g. value-added labour productivity growth represents the increase of real GDP per hour worked over time; gross-output MFP growth measures the increase of real gross output per unit of aggregate labour, capital, and intermediate inputs.

In this report, we are also interested in making *level* comparisons. Labour productivity level comparisons are usually done in *nominal* terms, directly capturing the *value* generated by one hour of work (or one worker). Why use nominal labour productivity levels instead of real levels? The main limitation of real levels is that they are a function not only of real growth rates, but also of the nominal level in an *arbitrary* base or reference year. As a consequence, comparisons of real labour productivity levels across industries can lead to vastly different results depending on the state of relative prices in the chosen base or reference year. This issue is explored in more detail in Section IV-A-i. In order to avoid this problem, the report focuses on nominal labour productivity levels. It is important to keep in mind, however, that changes in nominal productivity levels incorporate not only actual productivity growth, but also price changes.

iv. Productivity Measures Used in this Report

This report discusses three main productivity measures:

- *Value-added labour productivity*, defined here as real GDP (at basic prices) per hour worked. Alternatively, value-added labour productivity could also have been defined as GDP per worker. However, the hours worked measure provides more accurate estimates of labour input, since it takes into account: 1) changes in the duration of the work week; 2) shifts from full-time employment to part-time employment.

- *Value-added multifactor productivity*, defined here as the ratio between real GDP (at basic prices) and an index of *combined* capital and labour input.

- *Energy productivity*, defined here as the ratio between real GDP (at basic prices) and an index of energy input use.

v. Why Measure Productivity?

The OECD (2001) highlights five objectives of productivity measurement:

- Measuring *technical change* – In economics, a production technique can be understood as a particular way of combining inputs (labour, capital and intermediate inputs) and transforming them into output. Technical change can be either disembodied (e.g. new organizational techniques) or embodied (e.g. better quality capital goods). Economists often try to capture the effects of technical change in the economy or in an industry by using some measure of MFP. It is important to keep in mind, however, that the relationship between technical change and MFP is *not* straightforward. First, not all of the effects of technical change are captured by MFP. If inputs are quality adjusted, for instance, MFP will not capture embodied technical change, only disembodied technical change. Second, MFP captures a variety of effects, not only technical change – thus, it is a mistake to attribute the entirety of MFP growth to technical change.

- Measuring *efficiency improvements* – From an engineering perspective, a production process is efficient if, for a given technology, it uses the least amount of inputs to produce one unit of output (or alternatively, if it produces the maximum amount of output for a given quantity of inputs). From an economist's perspective, however, allocative efficiency should also be taken into account, i.e. firms will only make changes to their production process if these changes are consistent with profit-maximizing behaviour. The OECD (2001:11) notes that: "(…) when productivity measurement concerns the industry level, efficiency gains can either be due to improved efficiency in individual establishments that make up the industry or to a shift of production towards more efficient establishments."

- Measuring *real cost savings* – Closely related to the two objectives discussed above, understanding productivity matters because it allows firms to produce a given amount of output using less input, which implies, *ceteris paribus*, lower costs. In other words, productivity improvements generate real cost savings.

- Measuring *improvements in living standards* – Productivity is linked to living standards via two fronts: 1) Value-added labour productivity has a direct link to GDP per capita, which is a commonly used measure of living standards; 2) Long-term value-added MFP growth can be used to evaluate the evolution of an economy's potential output.

- *Benchmarking* production processes – At the firm level, productivity measures can be used to identify distortions and inefficiencies across production units. Such measures are often expressed in physical units, e.g. a car company could compare the productivity of two (similar) factories by looking at the number of cars produced per day by each of the factories.

C. Data Sources

This report makes extensive use of official productivity estimates from Statistics Canada's Canadian Productivity Accounts (CPA). The CPA is composed of three programs:

- *Labour Productivity Measures – National (Quarterly)*: This program provides quarterly labour productivity estimates for Canada from 1981 to 2013. Estimates are available for the business sector[4] and two-digit NAICS sectors. In addition to labour productivity, this program also has data on real GDP, nominal GDP, implicit price deflators, number of jobs, average hours worked, hours worked, total compensation, total compensation per hour worked, unit labour costs, unit labour costs in U.S. dollars, non-labour payments, and unit non-labour payments. All estimates are provided in index number form. Data for this program are available in CANSIM tables 383-0008 and 383-0012.

- *Labour Productivity Measures – Provinces and Territories (Annual)*: This program provides annual labour productivity estimates for Canada, the provinces, and the territories from 2007 to 2012. Estimates are available for the total economy, business sector and two-digit NAICS sectors. In addition to labour productivity, the program has estimates for most of the variables described above, with the exception of non-labour payments and unit non-labour payments. CANSIM table 383-0029 provides the main estimates for this program, with CANSIM tables 383-0030 and 383-0031 providing more detailed labour data.

- *Productivity Measures and Related Variables – National and Provincial (Annual)*: This program provides annual labour, capital and multifactor productivity estimates for Canada and the provinces. Labour and multifactor productivity estimates are available both on a value-added basis and on a gross-output basis. Estimates for Canada are available from 1961 to 2011 (or 2008, for three-digit NAICS subsectors), while provincial estimates are available from 1997 to 2010. National estimates cover the business sector, two-digit NAICS sectors, and three-digit NAICS sectors, but provincial estimates cover only the business sector and two-digit NAICS sectors. In addition to productivity estimates, the program has estimates for real GDP, nominal GDP, labour input, hours worked, labour composition, capital input, combined labour and capital input, labour compensation, capital cost, and many other variables. Provincial productivity estimates are provided in CANSIM table 383-0026, while national productivity estimates are provided in CANSIM tables 383-0021 and 383-0022. Detailed

[4] A definition of the business sector can be found in Box 3 (p. 49).

data on labour and capital inputs are available in CANSIM tables 383-0024 and 383-0025, respectively.

Although estimates from all three programs are used in this report, our main data source is the last program, *Productivity Measures and Related Variables – National and Provincial (Annual)*, also known as Statistics Canada's *MFP program*. The long time span covered by this program, as well as its level of detail, makes it ideal for our analysis. Furthermore, this is the only program that has multifactor productivity estimates for the three forest products subsectors. The program has, however, two important limitations: 1) Estimates for three-digit NAICS sectors currently only go up to 2008; 2) Estimates do not currently incorporate the latest changes to the System of National Accounts (SNA), as well as the latest revisions to output, labour input and capital input figures.

In order to minimize these problems, the CSLS has made small adjustments to the official data. Highlighted below are the most important adjustments made:

- Chained real GDP estimates for the 1997-2012 period were taken from the *GDP by Industry – National (monthly)* program. Since data from the latest CANSIM table (379-0031) for this program only span the 2007-2012 period, a longer time series was generated by "back linking" the 2007-2012 estimates to growth rates obtained from the program's previous CANSIM table (379-0027), which was terminated after the most recent SNA revision. For longer time frames, growth rates from Statistics Canada's *MFP program* (383-0021/22) were back linked to the new series.

- The same back linking procedure was used to obtain up-to-date estimates of hours worked. The updated hours worked data from the *Labour Productivity Measures – Provinces and Territories (Annual)* program currently span only the 2007-2012 period (CANSIM tables 383-0030/31). Thus, growth rates from pre-SNA revision data (CANSIM tables 383-0010/11) were used to extend the series back to 1997. For longer time frames, growth rates from Statistics Canada's *MFP program* (383-0021/22) were back linked to the new series. This back linking operation was also used for other variables, such as nominal GDP and employment.

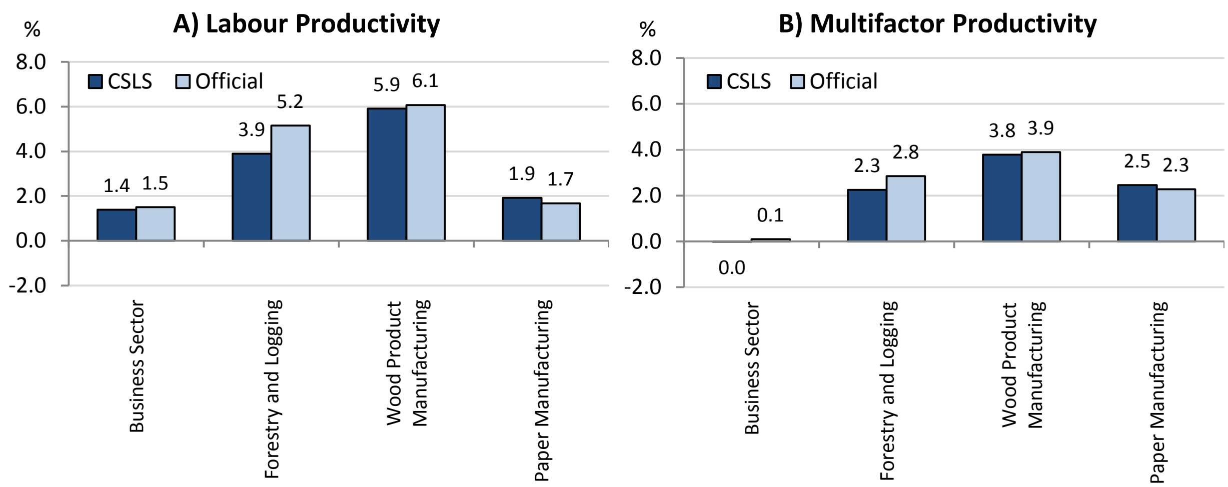
- Using the up-to-date real GDP and hours worked series, labour productivity estimates were calculated for the 1961-2012 period for the forest products sector and its three subsectors, as well as for the business sector.

- MFP growth for the three forest product subsectors and the business sector were recalculated by the CSLS with the updated real GDP and hours worked series for the 1961-2008 period, using labour composition, capital input, and compensation shares from

Statistics Canada's *MFP program*. MFP estimates were calculated as the ratio between real GDP and an index of joint labour-capital input. Following Statistics Canada methodology, this index was constructed using a Tornqvist index (for details, see Baldwin, Gu, and Yan, 2007).

Table 1 provides a summary of the main variables and data sources used in this report. Note that, by construction, labour and multifactor productivity growth in our series matches estimated growth rates from Statistics Canada's *MFP program* during the 1961-1997 period. For the 1997-2008 period, although there were differences, they tended to be quite small (Chart 1). In the business sector, for instance, CSLS growth rates for labour and multifactor productivity were 1.4 and 0.0 per cent per year during the 1997-2008 period, practically the same as the growth rates for the official estimates (1.5 and 0.1 per cent per year). The same can be said for wood product and paper manufacturing, where differences between the two series were relatively minor, averaging a difference of 0.2 percentage points in compound annual growth rates. In the case of forestry and logging, however, the differences between the CSLS estimates and the official estimates from Statistics Canada's *MFP program* were quite large.

Chart 1: Comparison of Labour and Multifactor Productivity Growth Rates Using the CSLS Series and Official Series, 1997-2008



Source: CSLS calculations based on Statistics Canada data.

Using the CSLS real GDP and hours worked estimates, labour productivity in the forestry and logging subsector increased at an average annual rate of 3.9 per cent, much less than the official estimate of 5.2 per cent; similarly, CSLS estimates point to an average annual MFP growth of 2.3 per cent vs. 2.8 per cent in the official estimates. The bulk of this difference can be traced back to a single outdated estimate in Statistics Canada's *MFP program*. According to this program, hours worked in forestry and logging declined almost 25 per cent in 2008, whereas the more up-to-date estimate from the *Labour Productivity Measures – Provinces and Territories (Annual)* program shows only an 11 per cent decline.

The report uses data from several other Statistics Canada's programs or surveys. In particular, it discusses estimates from Statistics Canada's Fixed Capital Flows and Stocks (FCFS) program, which (as the name implies) provides estimates for fixed, non-residential investment and capital stock broken down by asset type and industry. The data span the 1961-2012 period and are available for Canada, the provinces, and territories. A more detailed discussion of FCFS estimates can be found in Section III-C.

The report also relies on data from a variety of sources for international comparisons. These include the U.S. Bureau of Labor Statistics estimates of hourly compensation and unit labour costs; the OECD STAN database for R&D intensity estimates; the EU KLEMS and World KLEMS databases for estimates on nominal value-added shares, labour productivity and MFP in other countries.

The sources described above were used to construct the CSLS Forest Products Sector Database, an extensive database of more than 100 tables and charts that describes trends in output, labour input, capital input, productivity and many other variables in the Canadian forest products sector and its subsectors. The database will be posted with this report.

Table 1: Main Data Sources and Data Availability, Statistics Canada

Variable	Survey / Program	CANSIM Table	Index or Level	Total Economy	Business Sector	Forest Products Subsectors
GDP						
Nominal	Input-Output Structure of the Canadian Economy in Current Prices	379-0029	L	2007-2009	..	2007-2009
		379-0023/24 (terminated)	L	1961-2008	1961-2008	1961-2008
	Labour Productivity Measures - Provinces and Territories	383-0029	L	2007-2009	2007-2009	..
		383-0011 (terminated)	L	1997-2008	1997-2008	..
	Productivity Measures and Related Variables – National	383-0021/22	L	..	1961-2008	1961-2008
Real, Chained	GDP by Industry - National (monthly)	379-0031	L	2007-2013	2007-2013	2007-2013
		379-0027 (terminated)	L	1997-2012	1997-2012	1997-2012
	Labour Productivity Measures - Provinces and Territories	383-0029	L	2007-2009	2007-2009	..
		383-0011 (terminated)	L	1997-2008	1997-2008	..
	Productivity Measures and Related Variables – National	383-0021/22	I	..	1961-2011	1961-2008
Employment	Labour Force Survey	Special Order	L	1990-2012	..	1990-2012
	Survey of Employment, Payrolls and Hours	281-0024	L	..	..	1991-2012
	Labour Productivity Measures - Provinces and Territories	383-0029/30/31	L	2007-2012	2007-2012	2007-2012
		383-0009/10/11 (terminated)	L	1997-2011	1997-2011	1997-2011
Hours	Labour Productivity Measures - Provinces and Territories	383-0029/30/31	L	2007-2012	2007-2012	2007-2012
		383-0009/10/11 (terminated)	L	1997-2011	1997-2011	1997-2011
	Productivity Measures and Related Variables – National	383-0021/22	L	..	1961-2011	1961-2008
Labour Input and Composition	Productivity Measures and Related Variables – National	383-0021/22	I	..	1961-2011	1961-2008
Capital Stock						
Nominal	Fixed Capital Flows and Stocks	031-0002	L	1955-2012	*	1955-2012
Real, Chained	Fixed Capital Flows and Stocks	031-0002	L			
	Productivity Measures and Related Variables – National	383-0021/25	I / L	..	1961-2011	1961-2008
Capital Services and Composition	Productivity Measures and Related Variables – National	383-0021/22/25	I	..	1961-2011	1961-2008
Capital Compensation	Productivity Measures and Related Variables – National	383-0021/22	L	..	1961-2011	1961-2008
Labour Productivity	Labour Productivity Measures - Provinces and Territories	383-0029	L	2007-2012	2007-2012	..
		383-0011 (terminated)	L	1997-2011	1997-2011	..
	Productivity Measures and Related Variables – National	383-0021/22	I	..	1961-2011	1961-2008
MFP	Productivity Measures and Related Variables – National	383-0021/22	I	..	1961-2011	1961-2008

* The FCFS does have data for a business sector aggregate, but this aggregate does not correspond to Statistics Canada's official definition of the business sector. The FCFS's business sector aggregate represents the total economy minus health care and social assistance, educational services, and public administration. The official definition of the business sector is discussed in Box 2.

III. An Overview of the Canadian Forest Products Sector

This section provides an overview of the Canadian forest products sector, exploring recent output, labour input, and capital input trends in the sector and highlighting its place in the Canadian economy. The economic variables discussed here are key inputs of the productivity measures analyzed in Section IV.

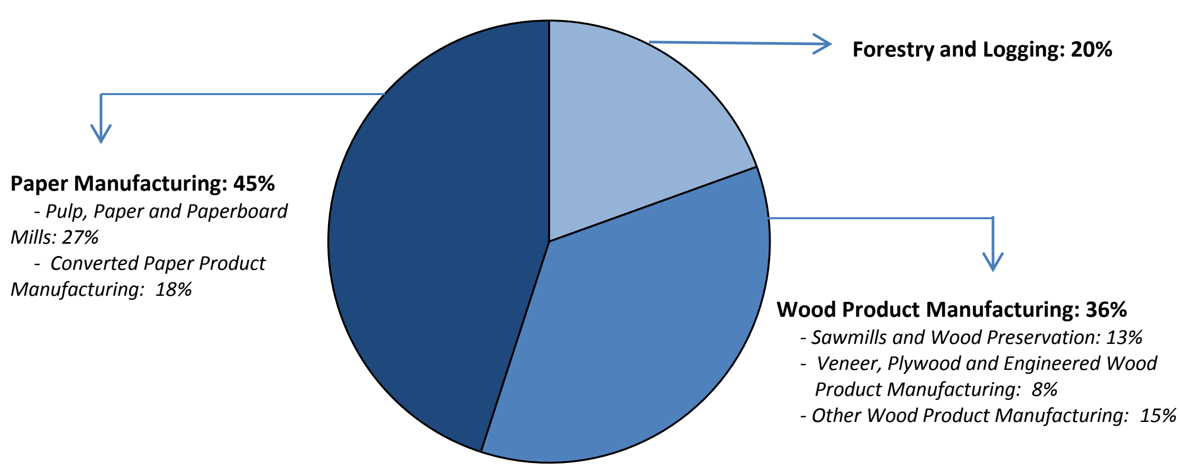
A. Output

This subsection analyzes nominal GDP, real GDP, and implicit price deflator trends in the Canadian forest products sector and its subsectors, using as a benchmark the performance of the Canadian economy as a whole. Although the subsection focuses on the 2000-2012 period, longer periods are also briefly discussed in order to place the sector's evolution in a broader historical perspective.

i. Nominal GDP

The Canadian forest products sector generated $16,762 million in nominal value added in 2009 (the last year for which data were available), accounting for 1.1 per cent of Canada's GDP. Of its three subsectors, paper manufacturing was the largest, responsible for $7,535 million or 45.0 per cent of the value added of the forest products sector (Chart 2). The subsector with the second largest value-added share was wood product manufacturing ($5,957 million or 36 per cent), followed by forestry and logging ($3,270 million or 20 per cent).

Chart 2: Breakdown of Nominal GDP in the Forest Products Sector, 2009



Source: Statistics Canada.

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) (Table 2). In addition, the province of Alberta was responsible for 9.3 per cent of the forest products sector's nominal value added. The exact value-added shares of the other provinces in the forest products sector could not be calculated because official data for paper manufacturing in those provinces were not available due to confidentiality reasons.

Table 2: Nominal GDP in the Forest Products Sector, Provincial Breakdown, 2009

	Forest Products Sector	Logging and Forestry	Wood Product Manufacturing	Paper Manufacturing
	(millions, current dollars)			
Canada	**16,762**	**3,270**	**5,957**	**7,535**
British Columbia	4,276	1,299	1,754	1,224
Alberta	1,558	286	872	400
Saskatchewan + Manitoba	..	61	237	..
Ontario	4,041	441	1,020	2,580
Quebec	5,224	808	1,687	2,728
Atlantic Canada	..	374	388	..
	(as a share of Canada, per cent)			
Canada	**100.0**	**100.0**	**100.0**	**100.0**
British Columbia	25.5	39.7	29.4	16.2
Alberta	9.3	8.7	14.6	5.3
Saskatchewan + Manitoba	..	1.9	4.0	..
Ontario	24.1	13.5	17.1	34.2
Quebec	31.2	24.7	28.3	36.2
Atlantic Canada	..	11.4	6.5	..

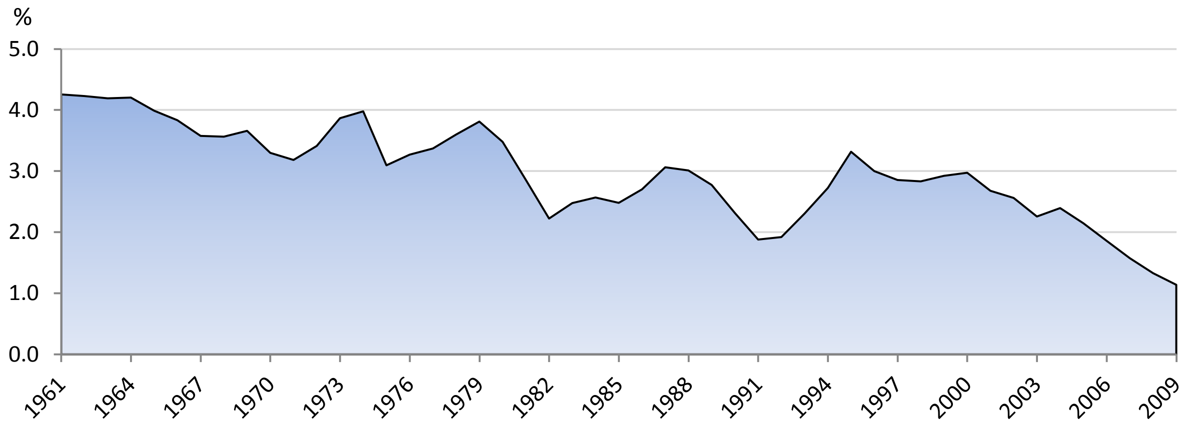
Source: Statistics Canada.

British Columbia was responsible for almost 40 per cent of the value-added in the logging and forestry subsector, followed by Quebec (24.7 per cent), Ontario (13.5 per cent), and Alberta (8.7 per cent). We see a similar picture in wood product manufacturing, with British Columbia generating close to 30 per cent of the subsector's value added, followed once more by Quebec (28.3 per cent), Ontario (17.1 per cent), and Alberta (14.6 per cent). The paper manufacturing subsector, however, was largely concentrated in Quebec and Ontario, which accounted for 36.2 per cent and 34.2 per cent (respectively) of the subsector's value added, while British Columbia was responsible for 16.2 per cent.

Historically, the forest products sector has grown (in nominal terms) at a somewhat slower pace than Canada as a whole, averaging a rate of 7.7 per cent per year during the 1961-2000 period (vs. 8.7 per cent for the total economy). In the past decade, however, the sector has faced a significant contraction, with nominal GDP in 2009 down by almost 50 per cent from its peak of $30,493 million in 2000. Of course, it is important to keep in mind that 2009 was a recession year, which accentuates the sector's declining GDP trend. Nonetheless, this phenomenon can also be observed in the cyclically-neutral period of 2000-2008.

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. Forestry and logging also experienced a fall in nominal value added during this period, albeit a much more modest one (1.6 per cent per year). As Chart 3 makes clear, 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, down 3.2 percentage points from 4.3 per cent in 1961. In other words, the forest products sector now has only one-quarter of the economic importance it had 50 years ago.

Chart 3: Nominal GDP in the Forest Products Sector as a Share of Total Economy GDP, 1961-2009



Source: CSLS calculations based on Statistics Canada data.

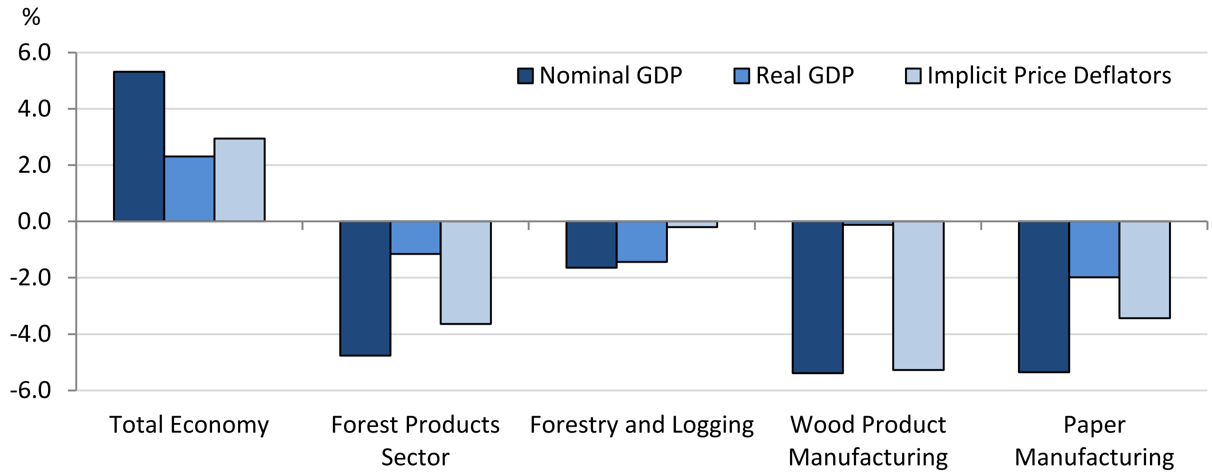
ii. Real GDP and Implicit Price Deflators

To better understand this trend of rapidly declining nominal value added in the Canadian forest products sector, we can look at how the sector's quantity and price indexes have changed over the past decade. Although official nominal value-added estimates currently only go up to 2009, real value-added estimates (as measured by quantity indices) are produced in a timely manner by Statistics Canada and are available up to 2012.

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 (Chart 4). 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 substantial fall in prices. In fact, the implicit price deflators for wood product manufacturing and paper manufacturing decreased by 5.3 and 3.4 per cent per year (respectively) during the period, with the overall deflator for the forest products sector falling by 3.8 per cent per year.[5]

Chart 4: Nominal GDP, Real GDP and Implicit Price Deflators Growth in the Forest Products Sector, 2000-2008

(Compound annual growth rates, per cent)



Source: CSLS calculations based on Statistics Canada data.

Real value added of the forest products sector fell significantly during the 2009 recession and, so far, the sector's real output level is still well below its 2008 level (Chart 5). For the forest products sector as a whole, real GDP declined 3.0 per cent per year during the 2008-2012 period. Chart 5 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.

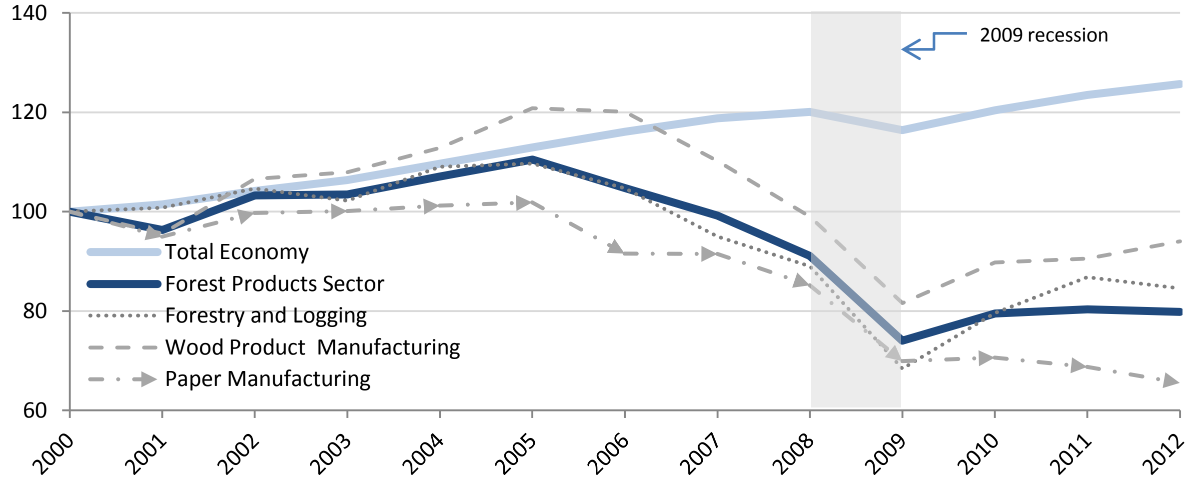
Table 3 provides a more detailed look at what happened to real GDP in the Canadian forest products sector during the 2008-2012 period. Although all three subsectors saw real output decline, the rate of decline in paper manufacturing (6.4 per cent per year) was much faster than in forestry and logging (1.3 per cent per year) and wood product manufacturing (0.8 per cent per year). In fact, paper manufacturing accounted for approximately 75 per cent of the real output drop in the forest products sector between 2008 and 2012. The slump in paper manufacturing, in turn, was caused by the drastic fall in the real output of pulp, paper and paperboard mills, which decreased by 9.5 per cent per year in the period, totaling a 33 per cent reduction in output. Although real output in both pulp and paperboard mills suffered a marked decline during the

[5] Other price indexes produced by Statistics Canada also point to this overall trend of falling prices in the forest products sector. According to the Raw Materials Price Indexes (RMPI), wood prices fell 1.6 per cent per year in the 2000-2008 period and 1.0 per cent per year in the 2008-2012 period (CANSIM Table 330-0007). The Industry Price Indexes (IPI) also capture a 1.6 per cent per year drop in lumber and other wood products for the 2000-2008 period, while registering a 1.0 per cent per year *increase* in prices during the 2008-2012 period. The IPI for pulp and paper products fell by 0.7 per cent per year in both the 2000-2008 period and the 2008-2012 period. These figures remain largely the same whether we look at the IPI by product (CANSIM Table 329-0061) or by NAICS code (CANSIM Table 329-0057).

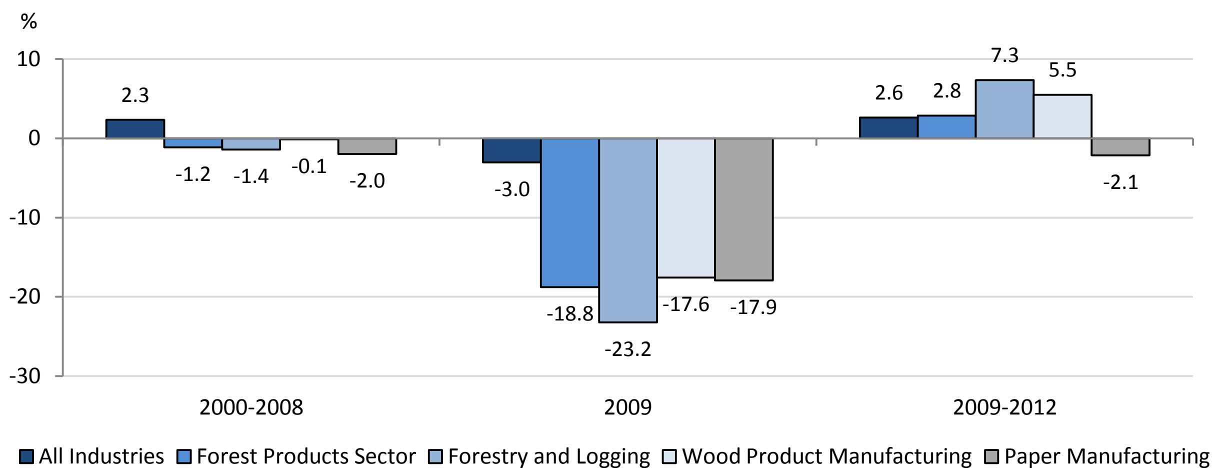
period, falling (4.3 and 4.4 per cent per year (respectively), paper mills were hit the hardest. Newsprint mills saw real output plummet by 8.9 per cent per year, while in other paper mills the rate of decline was slightly slower (7.7 per cent per year).[6]

Chart 5: Real GDP in the Forest Products Sector, 2000-2012

A) Index, 2000=100



B) Pre- and Post-Recession Comparison (CAGR for periods and annual change for 2009, per cent)



Source: CSLS calculations based on Statistics Canada data.

[6] After the latest revision of the System of National Accounts, Statistics Canada stopped publishing a five-digit NAICS breakdown of real GDP in the pulp, paper and paperboard mills industry. The growth rates discussed above were taken from the previous iteration of the industry accounts data (CANSIM Table 379-0027) and, consequently, are not entirely consistent with the growth rates presented in Table 3.

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):

- Increased international competition from countries with lower labour costs;
- 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; and
- The ongoing migration of readers from newsprint to electronic media, etc.

This list, while not comprehensive, highlights two important points.[7] First, the 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. Although paper manufacturing remains the largest of the three subsectors (in terms of nominal value added), its relative importance has fallen substantially due to the ongoing shift towards electronic media.

Second, given the harsh market conditions, the real output loss suffered by the other two forest products subsectors during the 2008-2012 period was actually quite moderate, pointing to the overall vitality of Canadian forestry and logging and wood product manufacturing industries. Furthermore, the different growth paths followed by paper manufacturing and the other two subsectors show the risks of focusing on the forest products sector aggregate instead of its subsectors.

Table 3: Real GDP in the Forest Products Sector, Detailed Breakdown, 2000-2012

	2000	2008	2012	2000-2012	2000-2008	2008-2012
	(millions, chained 2007 dollars)			(CAGR, per cent)		
All industries	**1,234,877**	**1,482,333**	**1,552,284**	**1.9**	**2.3**	**1.2**
Forest Products Sector	23,297	21,223	18,753	-1.8	-1.2	-3.0
Forestry and Logging	4,430	3,944	3,747	-1.4	-1.4	-1.3
Wood Product Manufacturing	8,736	8,649	8,370	-0.4	-0.1	-0.8
Sawmills and Wood Preservation	4,214	3,676	3,587	-1.3	-1.7	-0.6
Veneer, Plywood and Engineered Wood Product Manufacturing	1,649	1,831	1,896	1.2	1.3	0.9
Other Wood Product Manufacturing	2,892	3,138	2,917	0.1	1.0	-1.8
Paper Manufacturing	10,131	8,630	6,636	-3.5	-2.0	-6.4
Pulp, Paper and Paperboard Mills	6,362	5,354	3,584	-4.7	-2.1	-9.5
Converted Paper Product Manufacturing	3,529	3,276	3,120	-1.0	-0.9	-1.2

Source: CSLS calculations based on Statistics Canada data.

[7] For detailed analyses of the factors affecting the demand and supply of forest products in Canada and in the rest of the world, see, for instance, Tang (2008), Bogdanski (2011), and Deloitte (2011, 2012, 2013).

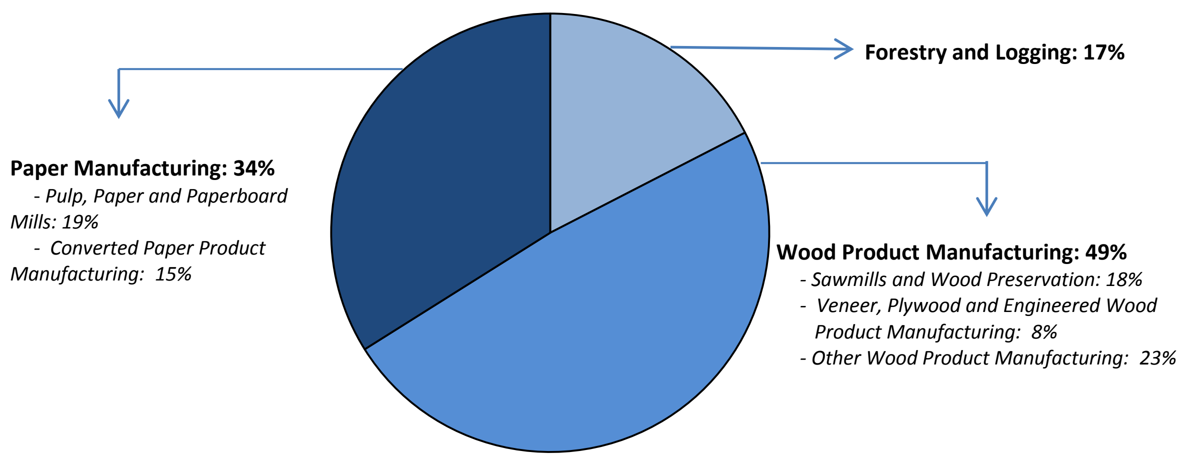
B. Labour Input

This subsection looks at labour input use in the forest products sector during the 2000-2012 period, emphasizing employment growth rates and levels. In addition, trends in hours worked and weekly hours worked are also analyzed. Again, longer time periods are briefly discussed in order to place the sector's employment trends in a broader historical perspective. Box 1 compares employment estimates from the Canadian Productivity Accounts to those from the Survey of Employment, Payrolls, and Hours (SEPH) and the Labour Force Survey (LFS).

i. Employment

According to Statistics Canada's Productivity Accounts 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) (Chart 6).

Chart 6: Breakdown of Employment in the Forest Products Sector, 2012

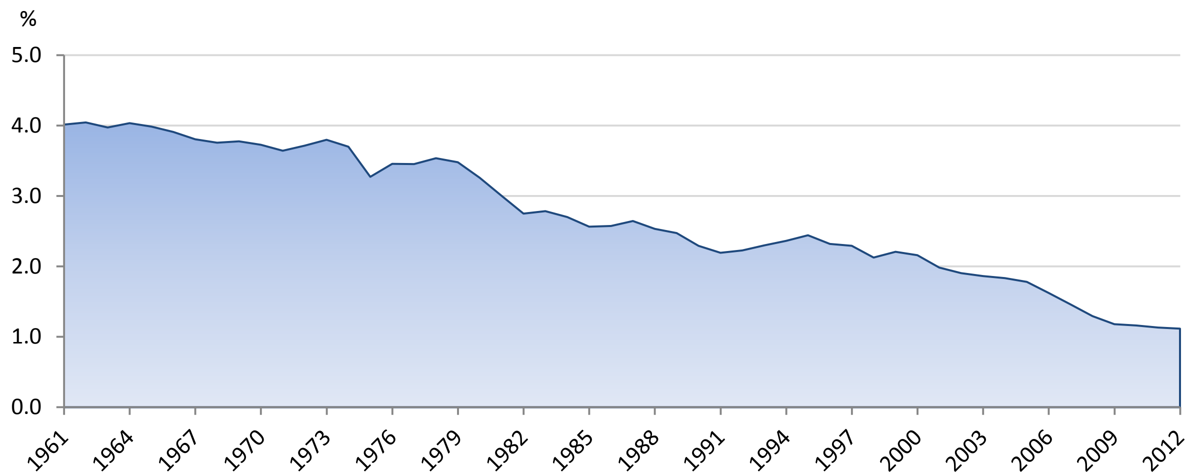


Source: Statistics Canada.

From 1961 to 2000, the number of jobs in the Canadian forest products sector fluctuated around 330 thousand, ranging from a high of 380 thousand in the late 1970s and early 1980s to a low of 280 thousand in the early 1990s. Since 2000, employment in the sector has fallen 39 per cent, from 326 thousand to 199 thousand, marking a significant break from historical trends. 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 7).

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 (Table 4). 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. While not good news *per se*, the fact that the rate of job loss in the sector saw a marked decrease in recent years – and during the aftermath of a recession, no less – points, once again, to the strength of the Canadian forest products sector.

Chart 7: Number of Jobs in the Forest Products Sector as a Share of All Industries, 1961-2012



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.

Table 4: Number of Jobs in the Forest Products Sector, Detailed Breakdown, 2000-2012

	2000	2008	2012	2000-2012	2000-2008	2008-2012
	(thousands, persons)			(CAGR, per cent)		
All industries	**15,096**	**17,382**	**17,864**	**1.4**	**1.8**	**0.7**
Forest Products Sector	326	225	199	-4.0	-4.5	-3.0
Forestry and logging	61	42	35	-4.6	-4.5	-4.8
Wood product manufacturing	169	105	97	-4.5	-5.8	-2.0
Sawmills and wood preservation	..	39	36	..	..	-2.3
Veneer, plywood and engineered wood product manufacturing	..	17	16	..	..	-1.3
Other wood product manufacturing	..	49	45	..	..	-2.1
Paper manufacturing	96	77	68	-2.9	-2.6	-3.3
Pulp, paper and paperboard mills	60	45	37	-4.0	-3.5	-4.8
Converted paper product manufacturing	36	33	31	-1.3	-1.3	-1.5

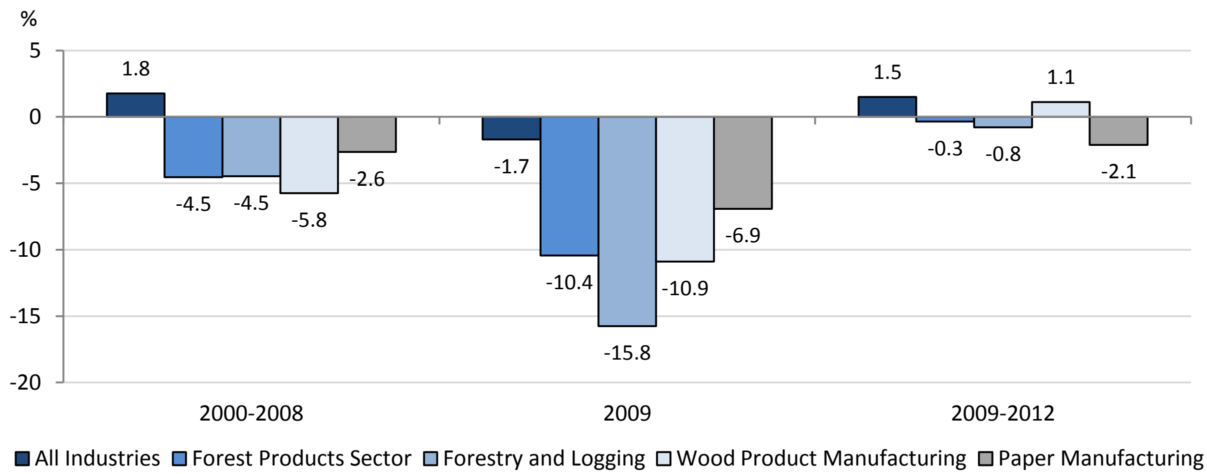
Source: CSLS calculations based on Statistics Canada data.

From the three forest products subsector, wood product manufacturing experienced the greatest job losses *in absolute terms*: 64 thousand jobs in the 2000-2008 period and 8 thousand jobs in the 2008-2012 period, for a total of 72 thousand jobs. In fact, the job losses in wood product manufacturing were more than the sum of the combined job losses in the other two subsectors (26 thousand jobs in forestry and logging and 29 thousand jobs in paper manufacturing for the 2000-2012 period as a whole). However, 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 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. Chart 8 provides a breakdown of employment growth in the forest products sector during the 2000-2012 period, highlighting how it fared before, during, and after the recession. Of the three forest products subsectors, wood product manufacturing was the only one in which employment actually increased during the 2009-2012 recovery period, albeit at a fairly modest pace of 1.1 per cent per year. However, the rate of job loss in paper manufacturing and in forestry and logging slowed down considerably after the recession.

Chart 8: Employment Growth in the Forest Products Sector, Pre- and Post-Recession Comparison

(Compound annual growth rates for periods and annual change for 2009, per cent)



Source: CSLS calculations based on Statistics Canada data.

ii. Hours Worked

For the purposes of calculating productivity, employment is not the best labour input measure available. In general, estimates of hours worked provide more accurate measures of labour input, since they take into consideration changes in the duration of the work week and shifts from part-time to full-time work. Table 5 details trends in hours worked in the Canadian forest products sector during the 2000-2012 period. Overall, there are few significant differences between the trends shown in Table 4 and those in Table 5, with industry growth rates for employment and hours worked usually moving together. Two points are worth highlighting, however:

- Employment and hours growth for all three subsectors of the Canadian forest products sector were practically the same during the 2000-2008 period;
- Some significant differences between the two measures appear in the 2008-2012 period. In forestry and logging, for instance, employment decreased 3.8 per cent per year, while hours worked fell at a faster pace (4.8 per cent per year). On the other hand, employment in paper manufacturing declined at a faster pace than hours worked (4.2 per cent per year vs. 3.3 per cent per year, respectively).

Table 5: 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
Sawmills and Wood Preservation	..	..	-2.3
Veneer, Plywood and Engineered Wood Product Manufacturing	..	..	-1.2
Other Wood Product Manufacturing	..	..	-3.0
Paper Manufacturing	-3.2	-2.8	-4.2
Pulp, Paper and Paperboard Mills	-4.4	-4.0	-5.3
Converted Paper Product Manufacturing	-1.5	-0.9	-2.7

Source: CSLS calculations based on Statistics Canada data.

iii. Weekly Hours Worked

Using employment and hours worked data, we can see how the duration of the work week in the Canadian forest products sector has changed over time. Given that there were few differences between the two labour input measures, it is not surprising to see that there was little variation in the average work week of a worker in the forest products sector, which fell slightly in the 2000-2012 period from 38.4 hours to 37.6 hours. All three forest products subsectors had longer work weeks than the Canadian average (32.9 hours in 2012), with workers in forestry and logging having by far the longest work week of the three subsectors (43.2 hours vs. 36.7 hours and 36.0 hours in wood product and paper manufacturing, respectively).

Table 6: Weekly Hours Worked in the Forest Products Sector, 2000-2012

	2000	2008	2012	2000-2012	2000-2008	2008-2012
	(weekly hours)			(CAGR, per cent)		
All industries	**34.2**	**33.3**	**32.9**	**-0.3**	**-0.3**	**-0.3**
Forest Products Sector	38.4	38.1	37.6	-0.2	-0.1	-0.3
Forestry and logging	42.8	41.6	43.2	0.1	-0.4	1.0
Wood product manufacturing	37.3	37.4	36.7	-0.1	0.0	-0.4
Paper manufacturing	37.6	37.2	36.0	-0.4	-0.1	-0.8

Source: CSLS calculations based on Statistics Canada data.

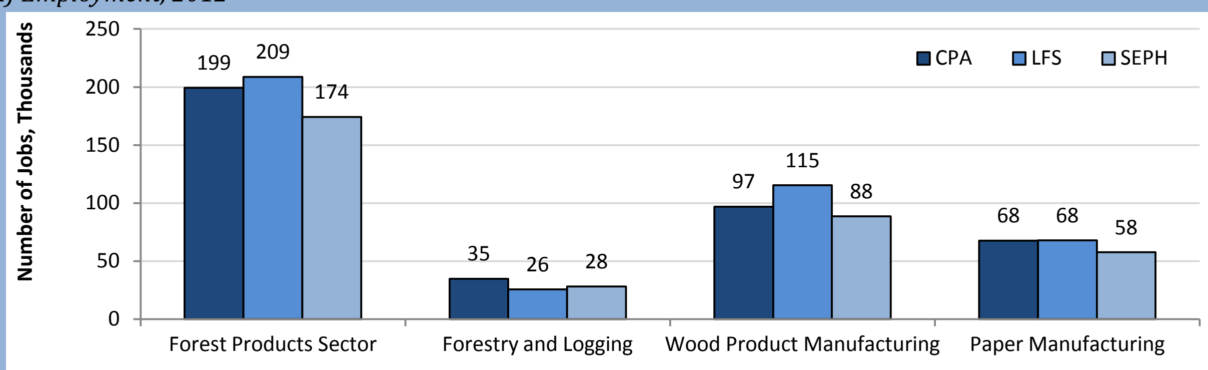
Box 1: Comparing Employment Estimates from the CPA, LFS and SEPH

On a more technical note, it is important to clarify why we chose the employment estimates from the Canadian Productivity Accounts (CPA) program as our benchmark instead of those from the Labour Force Survey (LFS) or those from the Survey of Employment, Payrolls and Hours (SEPH). The main difference between the LFS and the SEPH refers to their information source: while the LFS is a household survey, the SEPH is based on a census of administrative data from businesses. The CPA program integrates information from both surveys in an effort to produce more accurate estimates. The CPA assumes, for instance, that workers can provide better information than firms on the hours they actually worked, making the LFS a better source of data on hours worked. Firms, on the other hand, tend to allocate workers among NAICS industries more accurately, making the SEPH the preferred source of employment estimates by industry.

The chart below (Panel A) looks at how the CPA's employment estimate for the Canadian forest products sector in 2012 compares to estimates from the LFS and SEPH. For the forest products sector as a whole, the CPA figure (199 thousand jobs) stands between the SEPH figure (174 thousand jobs) and the LFS figure (209 thousand employees). Note that, with the exception of forestry and logging, the LFS numbers are higher than the SEPH numbers. The main reason for this is that SEPH estimates do not include the self-employed. In the case of forestry and logging, the lower LFS number is probably a consequence of the misallocation of labour between forestry and logging and support activities for forestry. In terms of growth rates for the 2000-2012 period, there are important differences between the CPA, LFS, and SEPH estimates at the subsector level, but these differences largely offset each other when we look at the forest products sector as a whole (Panel B).

Employment in the Forest Products Sector, Comparison between CPA, LFS and SEPH

A) Employment, 2012



B) Employment Growth, 2000-2012

Source: Statistics Canada, 1) CPA employment data from CANSIM tables 383-0010 and 383-0030; 2) SEPH employment data from CANSIM table 281-0024; 3) LFS employment data obtained through special order.

C. Capital Input

Like labour, capital is an essential input in the production of goods and services. Statistics Canada's Fixed Capital Flows and Stocks (FCFS) program uses data from the Capital and Repair Expenditures survey to produce timely estimates of non-residential investment and capital stock broken down by asset type and industry. As the name of the program implies, it focuses on fixed assets, i.e. *produced* durable assets that are used as inputs in a production process. Although most of the fixed assets covered by the FCFS are tangible goods – such as machinery and equipment (M&E) or structures – some of them are not. In particular, the FCFS has recently capitalized research and development (R&D) expenditures and created a new broad asset category called "intellectual property products", which includes not only the aforementioned R&D expenditures, but also outlays on software, as well as on oil and gas and mining exploration.

The Canadian Productivity Accounts (CPA) program also uses data from the FCFS on fixed, non-residential assets, but expands its estimates of capital assets to include inventories and land. Furthermore, the CPA benchmarks FCFS data on final demand input-output tables "in order to ensure consistency between capital input measures and output measures" (Baldwin, Gu, and Yan, 2007:24). This benchmarking procedure leads to (usually minor) differences between CPA and FCFS estimates.

Since this report relies on official MFP estimates from the CPA, it seems logical to give preference to the CPA's capital stock/investment estimates over those from the FCFS. Unfortunately, however, CPA data on capital stock and investment at the three-digit NAICS level are currently available only up to 2008.[8] Thus, in order to provide up-to-date investment and capital stock estimates for the Canadian forest products sector, this section focuses on FCFS data.

This subsection is divided into two parts. First, gross and net investment trends in the Canadian forest products sector during the 2000-2012 period are analyzed. Second, we turn our attention to capital stock trends and levels, providing detailed breakdowns of capital stock by asset type for all forest products subsectors. Additionally, Box 2 discusses significant differences between capital stock estimates from the CPA and the FCFS.

i. Non-Residential Fixed Investment

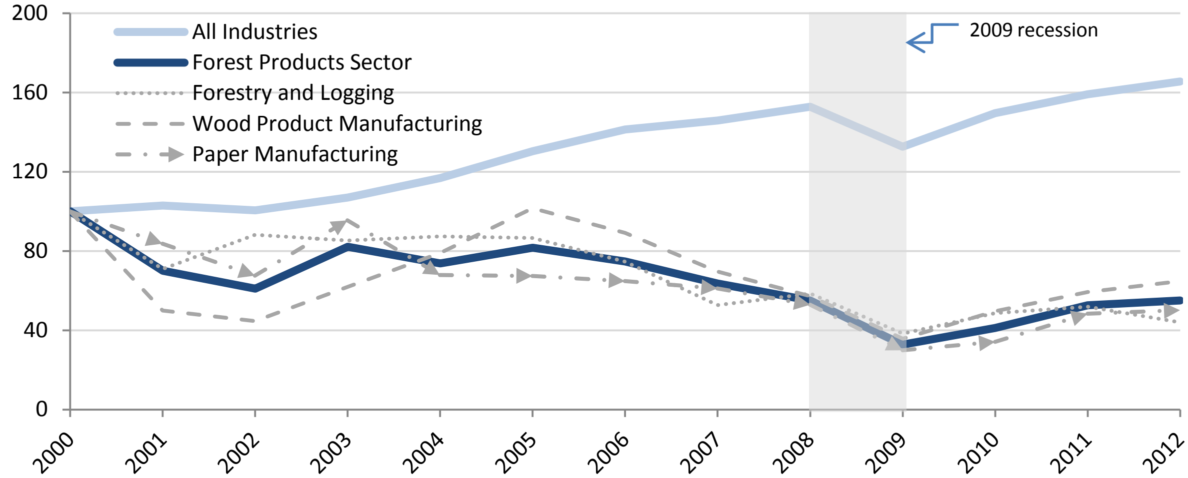
According to data from the FCFS, real investment (measured in chained 2007 dollars) in the Canadian forest products sector reached $2,395 million in 2012, down 45 per cent from

[8] A second limitation of the CPA capital stock data is that, currently, it does not include the recent updates to the System of National Accounts, such as the capitalization of R&D.

$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, however, real investment had already bounced back to its 2008 level (Chart 9). In this sense, 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.

Chart 9: Real Investment in the Forest Products Sector, 2000-2012

(Index, 2000=100)



Source: Statistics Canada.

Investment in the Canadian forest products sector is largely a reflection of investment in wood product and paper manufacturing, which accounted for over 90 per cent of the sector's investment over the 2000-2012 period. In general, paper manufacturing had the highest investment share among the three subsectors, followed by wood product manufacturing and forestry and logging. There were, however, significant year-to-year variations in the relative importance of each subsector, with the paper manufacturing share of total investment in the forest products sector ranging from 45 to 65 per cent, the wood product manufacturing share ranging from 27 to 45 per cent and the forestry and logging share ranging from 7 to 12 per cent. In 2012, paper and wood product manufacturing accounted for 49 and 44 per cent of total investment in the sector (respectively), with forestry and logging responsible for the remaining 7 per cent.

Table 7: Real Investment in the Forest Products Sector, 2000-2012

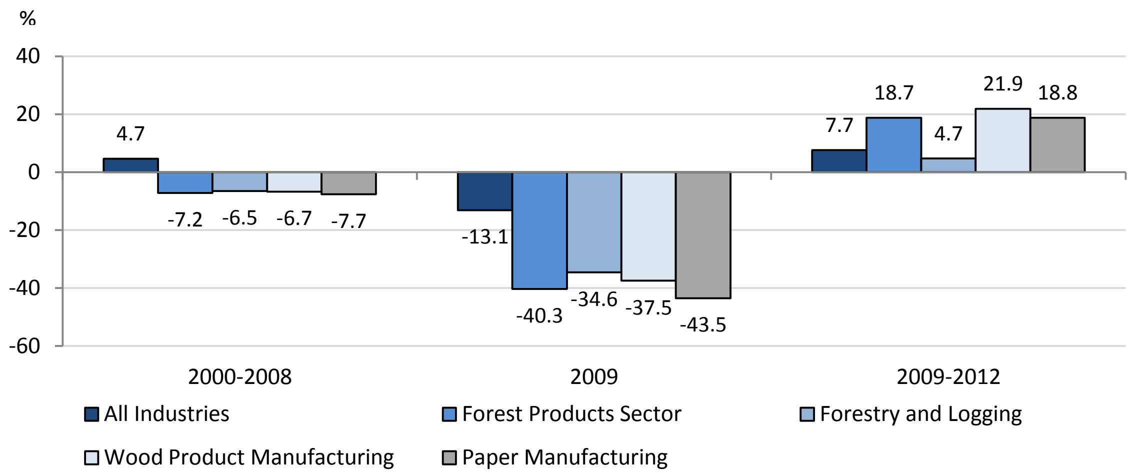
	2000	2008	2012	2000-2012	2000-2008	2008-2012
	(millions, chained 2007 dollars)			(total per cent change)		
All industries	**175,373**	**267,824**	**290,312**	**65.5**	**52.7**	**8.4**
Forest Products Sector	4,359	2,397	2,395	-45.1	-45.0	-0.1
Forestry and logging	394	231	173	-56.1	-41.5	-24.9
Wood product manufacturing	1,605	919	1,041	-35.2	-42.7	13.2
Paper manufacturing	2,359	1,247	1,181	-50.0	-47.2	-5.3

Source: Statistics Canada.

All three subsectors had declining levels of real investment in the 2000-2008 period: real investment fell 41.5 per cent in forestry and logging; 42.7 per cent in wood product manufacturing; and 47.2 per cent in paper manufacturing (Table 7). In 2009, as a consequence of the recession, the level of real investment fell dramatically for all forest products subsectors: 34.6 per cent in forestry and logging, 37.5 per cent in wood product manufacturing, and 43.5 per cent in paper manufacturing (Chart 10). The 2009-2012 period saw a strong recovery of real investment in wood product manufacturing, which rose 13 per cent above its pre-recession level (although still below its 2000 level). Paper manufacturing investment also saw an important recovery during the period, but remained 5 per cent below its pre-recession level. In the case of forestry and logging, real investment was still 25 per cent below its 2008 level in 2012.

Chart 10: Real Investment Growth in the Forest Products Sector, Pre- and Post-Recession Comparison

(Compound annual growth rates for periods and annual change for 2009, per cent)

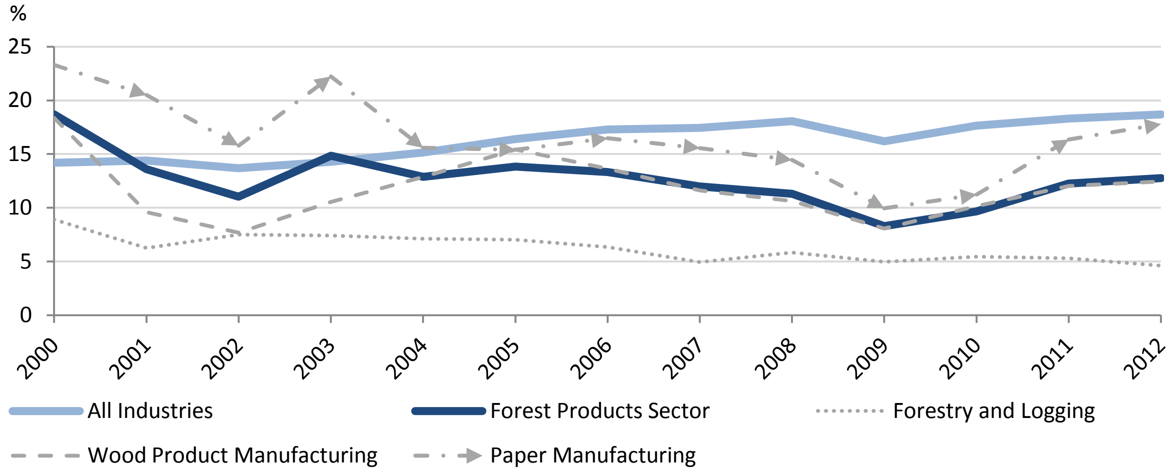


Source: Statistics Canada.

The above analysis, while informative, does not provide a complete picture of the investment performance of the Canadian forest products sector during the past decade. Since GDP in the sector experienced a decline in absolute terms, a fall in real investment 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 11 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 investment share of GDP for the total economy actually increased from 14.2 per cent to 18.7 per cent, which highlights the weak investment performance of the forest products sector in the past decade. On a positive note, the investment share of the forest products sector in 2012 was slightly above its level prior to the 2008-09 recession.[9]

[9] In nominal terms, the story is similar, despite some noteworthy differences. Nominal investment as a share of GDP in the total economy saw much less variation than it did in real terms, ranging from 15.5 per cent to 17.9 per cent between 2000 and 2009. In

Chart 11: Real Investment as a Share of GDP in the Forest Products Sector, 2000-2012



Source: CSLS calculations based on Statistics Canada data.

In 2000, two out of the three forest products subsectors had above-average investment shares of GDP (paper manufacturing at 23.3 per cent and wood product manufacturing at 18.4 per cent). Only forestry and logging had a below-average investment share (8.9 per cent). By 2012, all three forest products subsectors had below-average investment shares of GDP: 4.6 per cent in the case of forestry and logging; 12.4 per cent for wood product manufacturing; and 17.8 per cent for paper manufacturing. 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. Woodbridge Associates (2009:58) provide a concrete example of how low investment levels can hurt the productivity and competitiveness of the Canadian forest products sector:

> In BC's pulp and paper sector (bio-fuels expenditures excluded) there has been a long term downward trend in elective capital spending. Moreover, many observers consider the level of maintenance and repairs expenditures being made by pulp and paper mills to be unsustainably low. For example, many of the province's pulp mills require replacement of aging and deteriorating recovery boilers. These are 'large ticket' capital items, involving one-time spending of $100-130 million each – but with little or no benefit to the firm's profit margin. (…) The problem this creates is that, without the benefit of the highly productive state-of-the-art capital equipment in harvesting and manufacturing, it will be difficult for these sub-sectors of the industry to regain and maintain global competitiveness.

This point becomes all the more relevant given the looming possibility of a lumber supercycle. With the U.S. housing market heating up again and the strong demand for wood from

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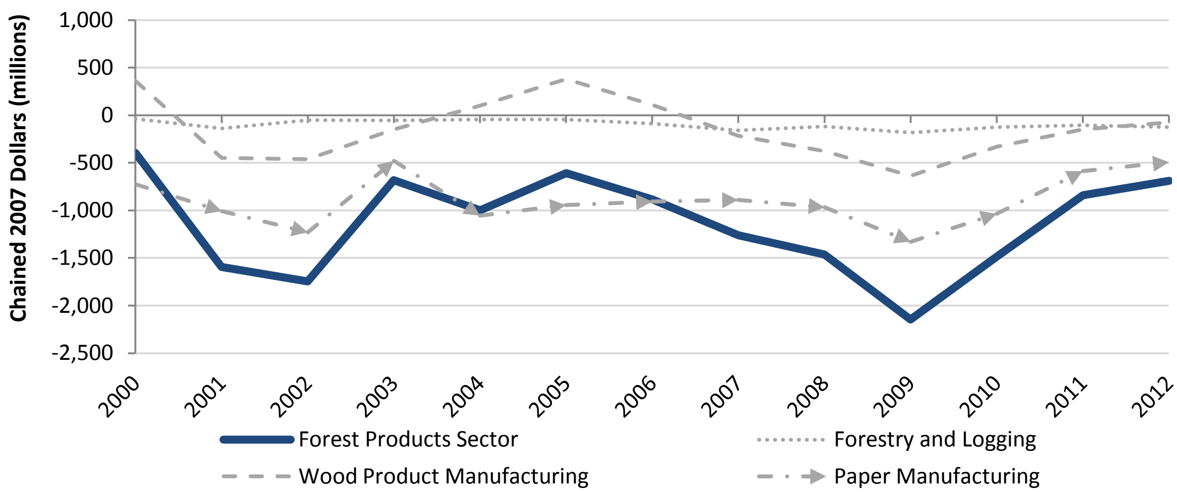
the end, it increased slightly, from 16.4 per cent in 2000 to 16.8 per cent in 2009. For the forest products sector, the nominal investment share of GDP also saw a drop of 6.0 percentage points during the period (roughly the same as the drop experienced in terms of real shares), but the investment share of the sector was never higher than that of the total economy, falling from 15.2 per cent in 2000 to 9.2 per cent in 2009.

China, Canadian forest-products firms will have to redouble their efforts in investing in state-of-the-art capital assets, particularly machinery and equipment, in order to reap the benefits from the growing demand.

The investment figures discussed so far refer to *gross* investment, i.e. they take into account not only spending on new capital goods, but also spending with the objective of *replacing* depreciated capital goods – that is, replacement 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 12). 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.

Chart 12: Real Net Investment in the Forest Products Sector, 2000-2012



Source: CSLS calculations based on Statistics Canada data.

ii. 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),[10] 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 (Table 8).[11] 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

[10] The capital stock estimates reported here are end-year net stock estimates constructed by Statistics Canada using geometric depreciation, which assumes that assets depreciate at a constant *rate* over time.

[11] Looking at a longer time span, we can see that, with the exception of a few years, real capital stock in the forest products sector has been consistently falling since 1991, after peaking at $38,269 million (chained 2007 dollars) in the previous year.

whole, with real capital stock falling during the entire 2000-2012 period, but falling at a faster pace during the 2008-2012 period.

Table 8: Real Capital Stock in the Forest Products Sector, Breakdown by Asset and Subsector, 2000-2012

	2000	2008	2012	2000-2012	2000-2008	2008-2012
	(millions, chained 2007 dollars)			(CAGR, per cent)		
All industries						
Total Capital Stock	*1,405,314*	*1,719,996*	*1,875,709*	*2.4*	*2.6*	*2.2*
Buildings	580,140	634,390	669,705	1.2	1.1	1.4
Engineering	483,348	592,141	684,413	2.9	2.6	3.7
M&E	237,973	313,170	328,728	2.7	3.5	1.2
Intellectual Property Products	110,397	180,605	190,591	4.7	6.3	1.4
Forest Products Sector						
Total Capital Stock	*34,685*	*25,485*	*20,299*	*-4.4*	*-3.8*	*-5.5*
Buildings	14,408	10,581	8,535	-4.3	-3.8	-5.2
Engineering	3,263	2,695	2,207	-3.2	-2.4	-4.9
M&E	15,292	10,030	7,835	-5.4	-5.1	-6.0
Intellectual Property Products	1,345	2,176	1,731	2.1	6.2	-5.6
Forestry and Logging						
Total Capital Stock	*3,360*	*2,705*	*2,161*	*-3.6*	*-2.7*	*-5.5*
Buildings	416	373	317	-2.2	-1.4	-3.9
Engineering	2,153	1,642	1,252	-4.4	-3.3	-6.6
M&E	722	607	537	-2.4	-2.2	-3.0
Intellectual Property Products	61	85	63	0.3	4.2	-7.2
Wood Product Manufacturing						
Total Capital Stock	*9,382*	*8,367*	*7,186*	*-2.2*	*-1.4*	*-3.7*
Buildings	4,509	3,734	3,106	-3.1	-2.3	-4.5
Engineering	329	416	376	1.1	2.9	-2.5
M&E	4,264	3,650	3,056	-2.7	-1.9	-4.3
Intellectual Property Products	250	567	659	8.4	10.8	3.8
Paper Manufacturing						
Total Capital Stock	*21,942*	*14,413*	*10,951*	*-5.6*	*-5.1*	*-6.6*
Buildings	9,483	6,475	5,112	-5.0	-4.7	-5.7
Engineering	781	638	580	-2.5	-2.5	-2.4
M&E	10,306	5,773	4,242	-7.1	-7.0	-7.4
Intellectual Property Products	1,033	1,524	1,009	-0.2	5.0	-9.8

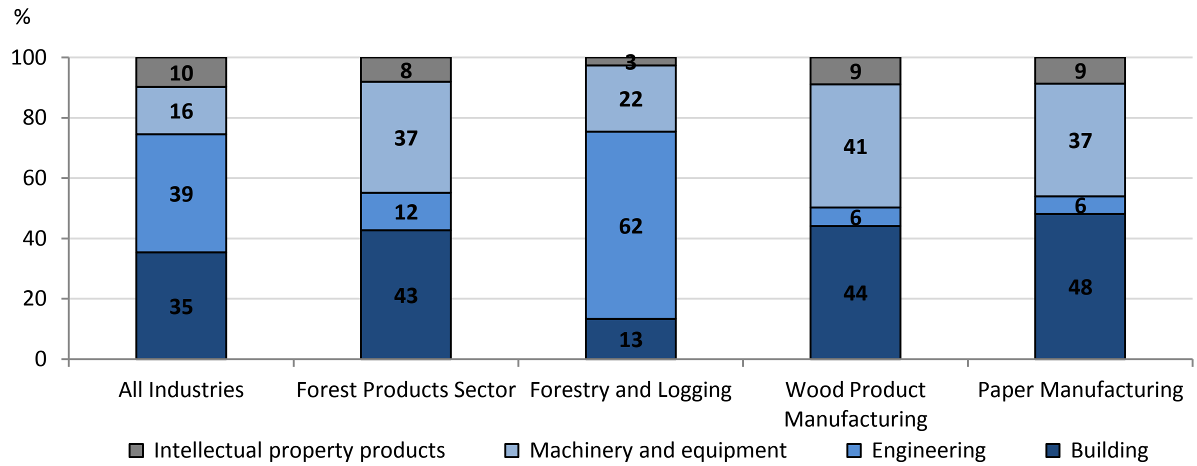
Source: Statistics Canada.

The shrinking of the sector's real capital stock can be traced back to the massive decline in paper manufacturing capital stock. The capital stock in this particular subsector accounted for almost 65 per cent of total capital stock in the forest products sector in 2000, with wood product manufacturing capital stock accounting for approximately 25 per cent of total stock and forestry and logging responsible for the remaining 10 per cent. By 2012, real capital stock in paper manufacturing had fallen by 50 per cent, even though the subsector still remained responsible for half of the forest sector's overall capital stock. The textile mill industry was the only other industry that experienced a fall of this magnitude in its real capital stock in such a short period.

Forestry and logging and wood products manufacturing also experienced declines in real capital stock, albeit of smaller magnitudes (35 per cent and 23 per cent, respectively).

It is interesting to note that the capital stock composition of the forest products sector is quite different from that of the total economy. In 2012, although buildings and engineering assets accounted for three-quarters of the total economy's capital stock, these assets represented only about half of the total capital stock in the forest products sector (Chart 13). On the other hand, machinery and equipment (M&E) assets were much more important for the forest products sector than for the total economy (37 per cent of total capital stock vs. only 16 per cent in the total economy).[12] Intellectual property products had a similar weight in both the total economy and the forest products sector.

Chart 13: Nominal Capital Stock in the Forest Products Sector, Asset Breakdown, 2012



Source: Statistics Canada.

There were also important differences in terms of capital stock composition *within* the forest products sector. While wood product manufacturing and paper manufacturing had basically the same capital stock profile as that of the forest products sector as a whole (which should come as no surprise since these two subsectors account for the bulk of the capital stock in the forest products sector), the capital stock composition of forestry and logging was quite unique. In this subsector, engineering alone accounted for 60 per cent of total capital stock, with M&E responsible for 20 per cent of capital stock and structures for slightly more than 10 per cent.

Table 8 details real capital stock growth rates and levels broken down by asset type for the forest products sector, its subsectors and the total economy. Between 2000 and 2008, real

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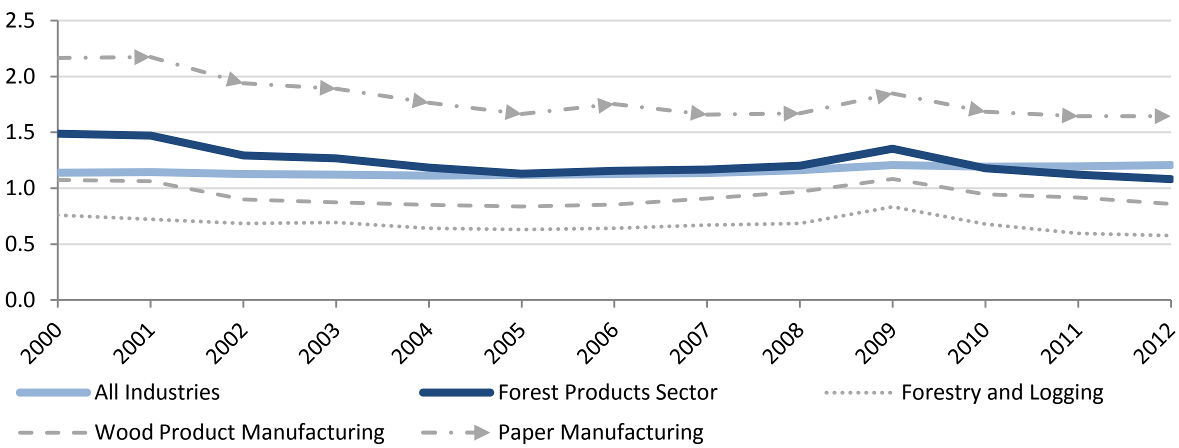
[12] The share of M&E assets in total capital stock has fell substantially between 2000 and 2012, not only for the forest products sector, but also for the total economy. In 2000, M&E assets represented approximately 55 per cent and 25 per cent of nominal capital stock in the forest products sector and the total economy, respectively.

capital stock in the Canadian forest products sector experienced losses in all major asset categories with the exception of intellectual property products, where capital stock grew 6.2 per cent per year, in line with total economy growth. M&E was the category that experienced the largest losses, with capital stock declining at a rate of 5.1 per cent per year, followed by buildings (3.8 per cent per year) and engineering (2.4 per cent per year). In the 2008-2012 period, the situation worsened considerably, and real capital stock in the sector declined at a fast pace for all four major asset categories.

Again, keeping in mind that the importance of the Canadian forest products sector in terms of its output share has also fallen substantially, analyzing the evolution of the sector's capital stock-to-GDP ratio can provide a better understanding of how the use of capital has changed over time in the sector (Chart 14). 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. 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.[13]

Chart 14: Real Capital Stock-to-GDP Ratio in the Forest Products Sector, 2000-2012



Source: CSLS calculations based on Statistics Canada data.

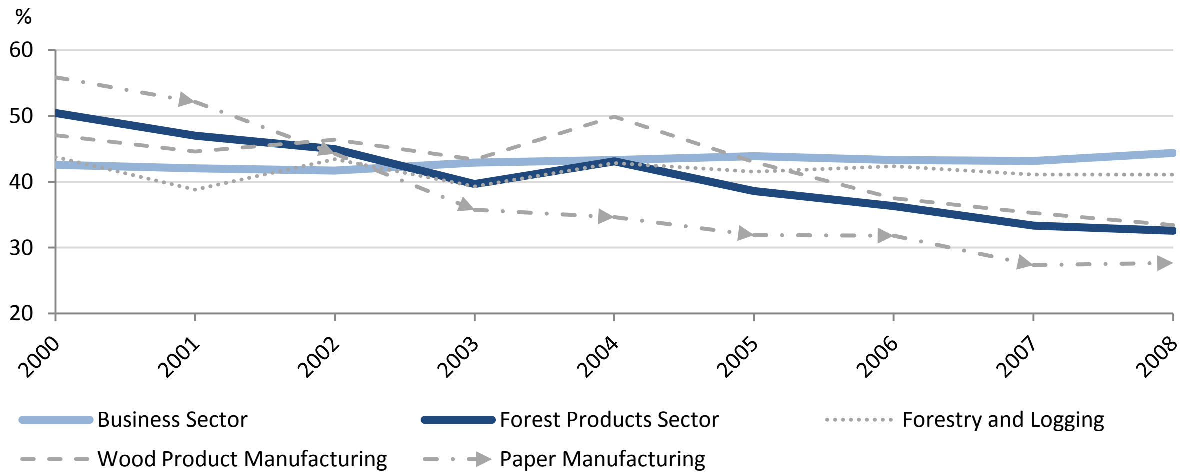
A fall in the capital stock-to-GDP ratio is not necessarily bad news, however. A smaller ratio means that capital is being used *more efficiently*, not less. In 2000, $1.00 of real GDP required $2.20 of real capital stock to be produced, but by 2012 it required only $1.70 of real capital stock. On the flip side, a fall in the capital stock-to-GDP ratio usually means that less

[13] Interestingly, the story is quite different in nominal terms. The nominal capital stock-to-GDP ratio for the forest products sector actually *increased* between 2000 and 2009 (the last year for which nominal GDP data were available for the forest products sector), from 1.0 in 2000 to 1.5 in 2012, surpassing the total economy ratio, which moved from 1.1 in 2000 to 1.3 in 2009. In the end, however, what matters is the real capital stock-to-GDP ratio, since it links real GDP to real capital stock. The increase in the nominal capital stock-to-GDP ratio in the forest products sector is caused by capital stock prices increasing, while GDP deflators were *falling*.

money is going to capital compensation – that is, the surplus (including profits, depreciation, rent, and net interest) intended to compensate owners of capital for their risk.

In fact, capital compensation as a share of GDP in the Canadian forest products sector fell 17.9 percentage points between 2000 and 2008 (the last year for which capital compensation data for the sector were available), from 50.5 per cent in 2000 to only 32.6 per cent in 2008 (Chart 15). At the subsector level, the most drastic decrease happened in paper manufacturing, with capital compensation accounting for only 27.7 per cent of nominal GDP in 2008, down from 55.9 per cent in 2000. Wood product manufacturing also saw a marked decline in its capital compensation share of GDP, from 47.1 per cent to 33.4 per cent, while in forestry and logging the decline was quite modest, from 43.8 per cent to 41.1 per cent. During this same period, capital compensation for the Canadian economy as a whole actually *increased* by 2 percentage points, from 42 per cent to 44 per cent.

Chart 15: Capital Compensation as a Share of Nominal GDP in the Forest Products Sector, 2000-2008



Source: Statistics Canada.

Box 2: Comparing Real Capital Stock Growth Estimates from the CPA and FCFS

There are two sources of capital stock data for the Canadian forest products sector: the Canadian Productivity Accounts (CPA) and the Fixed Capital Flows and Stocks (FCFS) program. Although this section focuses on FCFS estimates, the productivity estimates discussed in Section IV are constructed using the CPA capital stock estimates. Thus, it is useful to understand how estimates from these two Statistics Canada programs compare to each other.

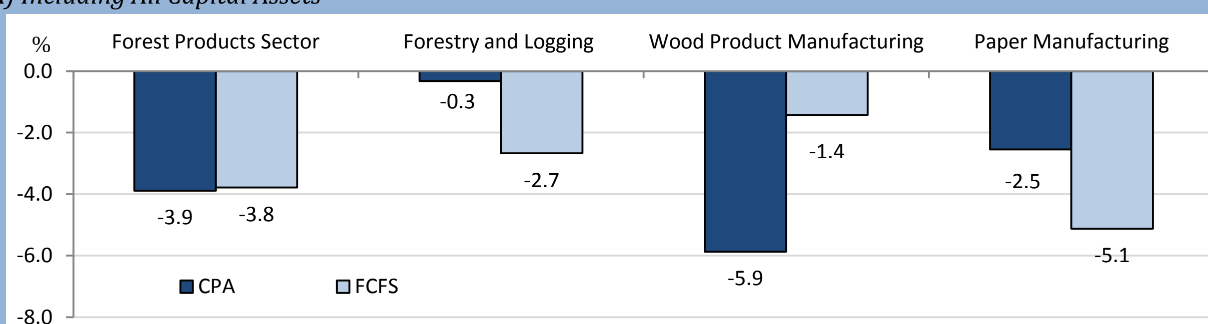
The chart below looks at the growth rates of real (net) capital stock in the Canadian forest products sector (and its constituent subsectors) from 2000 to 2008 according to both CPA and FCFS data. At the subsector level, there were notable differences between the estimates from the two programs: in forestry and logging, for instance, real capital stock declined only 0.3 per cent per year according to CPA estimates, but 2.7 per cent according to FCFS estimates (Panel A). Marked differences can also be seen in the cases of wood product manufacturing (-5.9 vs. -1.4 per cent per year according to the CPA and the FCFS, respectively) and paper manufacturing (-2.5 vs. -5.1 per cent per year). These differences, however, were largely offsetting, with real capital stock in the forest products sector as a whole falling at practically the same rate (3.8-3.9 per cent per year) regardless of whether CPA or FCFS estimates were used.

Most of the differences at the subsector level can be explained by the fact that the CPA uses a more comprehensive definition of capital stock. While the FCFS includes in its capital stock estimates only fixed, reproducible capital, such as machinery and equipment and structures, the CPA also includes land as part of its estimates. When land is removed from total capital stock (Panel B), CPA and FCFS estimates tell (mostly) the same story, not only for the forest products sector as a whole, but also for its subsectors.

Real Capital Stock Growth in the Forest Products Sector, Comparison between CPA and FCFS Estimates, 2000-2008

(Compound annual growth rates, per cent)

A) Including All Capital Assets



B) Excluding Land from the CPA

Source: Statistics Canada, 1) CPA data from CANSIM Table 383-0025; 2) FCFS data from CANSIM Table 031-0002.

D. Key Findings

The 2009 recession had a large impact on the Canadian forest products sector, reducing real GDP and employment by 19 and 10 per cent (respectively), and leading to a 40 per cent drop in real investment. Despite experiencing a recovery in the 2009-2012 period, the sector's real GDP, employment and capital stock are still significantly below their pre-recession levels.

The reality, however, is that real GDP, employment and real investment in the forest products sector had been declining well before the recession. This decline is 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 deep structural changes in the demand for forest products – in particular the ongoing shift towards electronic media.

Below, we highlight some of the key findings of our analysis:

- Paper manufacturing was the most important subsector in terms of nominal value added, accounting for 45.0 per cent of the total value added in the Canadian forest products sector in 2009 (the last year for which nominal GDP estimates for the sector were available). The subsector with the second largest value-added share was wood product manufacturing (35.5 per cent), followed by forestry and logging (19.5 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;

- 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 4.3 per cent in 1961. In other words, the forest products sector now has only one-quarter of the economic importance it had 50 years ago.

- For the forest products sector as a whole, real GDP decreased at a pace of 1.2 per cent per year between 2000 and 2012, from $23,297 million to $18,753 million (in chained 2007 dollars). The sector lost 127 thousand jobs in the period, at a rate of 4.0 per cent per year. Furthermore, real capital stock declined by 4.4 per cent per year, from $34,685 million in 2000 to $20,299 million in 2012.

- Real GDP in wood product manufacturing declined 0.4 per cent per year during the 2000-2012 period. From the three forest products subsectors, this is the one that employed the most people, responsible for approximately 50 per cent of total employment in the forest products sector in 2012; it was also the one that suffered the most job losses in absolute terms, shedding 72 thousand jobs between 2000 and 2012.

- Paper manufacturing had, by and large, the worst performance among the three forest products subsectors, with real GDP falling 3.5 per cent per year during the 2000-2012 period. Unlike the other two subsectors, paper manufacturing did not experience a recovery in the 2009-2012 post-recession period, and real GDP continued to decline. Between 2000 and 2012, the subsector's real capital stock declined by half.

IV. Productivity in the Canadian Forest Products Sector

This section of the report examines the productivity performance of the Canadian forest products sector. First, labour productivity trends and levels in the forest products sector and its subsectors are analyzed, both at national and provincial levels. Second, multifactor productivity trends are discussed. The productivity performance of the forest products sector in Canada is also compared to that of other countries. Next, energy input productivity trends in the sector are described, and key findings are summarized. As usual, although the focus of the section is on the 2000-2012 period, longer periods are also studied in order to place the sector's productivity growth in a broader historical perspective.

Box 3: The Business Sector

In the previous section, output and input trends in the Canadian forest products sector were compared to total economy trends. When it comes to productivity analysis, however, a better benchmark is the *business sector*. Broadly speaking, the business sector includes all activities in which goods and services are sold at a price intended to cover the cost of production. In this sense, the business sector excludes output of non-business establishments, such as public hospitals, public universities and government departments. Historically, the business sector has accounted for 80 to 85 per cent of the Canadian economy.

Statistics Canada's general definition of the business sector includes four main elements:

- The corporate sector (incorporated businesses);
- The unincorporated sector (self-employed and proprietorships);
- Government business enterprises; and
- Owners who occupy their own dwelling.

While business sector activities sell goods and services at market prices, most government services are either provided free of charge or at heavily subsidized prices. Due to the lack of market price data for those goods and services, output is valued based on the cost of inputs used in production, which implies that nominal output growth equals nominal input growth. In addition, in order to calculate real output and real input growth in non-business sector industries, output and input series are both deflated using the same (input) price index, which causes real output growth to equal real input growth. Thus, by construction, there is *no* (multifactor) productivity growth in non-business sector activities.

As a consequence, including non-business sector activities when calculating aggregate productivity growth tends to *dampen* actual productivity growth. To avoid this problem, Statistics Canada's Canadian Productivity Accounts (CPA) program estimates aggregate productivity growth only taking into account business sector activities. The CPA makes an additional adjustment to the "standard" business sector definition by excluding owner-occupied dwellings, since this is an imputed value that does not entail any actual production.

Taking all these points into consideration, this section compares the productivity performance of the forest products sector in Canada to that of the business sector, not the total economy. For more on measuring output and productivity of non-business sector industries, see Yu (2004) and Diewert (2008).

A. Labour Productivity

This subsection is divided into four parts: first, we look at *long-run* labour productivity trends in the Canadian forest products sector and its subsectors, comparing the sector's performance with that of the business sector; next, we analyze the forest products sector's *recent* labour productivity performance, focusing on the 2000-2012 period; we then discuss recent labour productivity trends and levels in the sector at the *provincial level*; finally, we show how the Canadian forest products sector has fared in terms of labour productivity growth when compared to other countries. Unless noted otherwise, labour productivity is defined here as *real* GDP (in chained 2007 dollars) per hour worked.

i. Long-Run Labour Productivity Trends

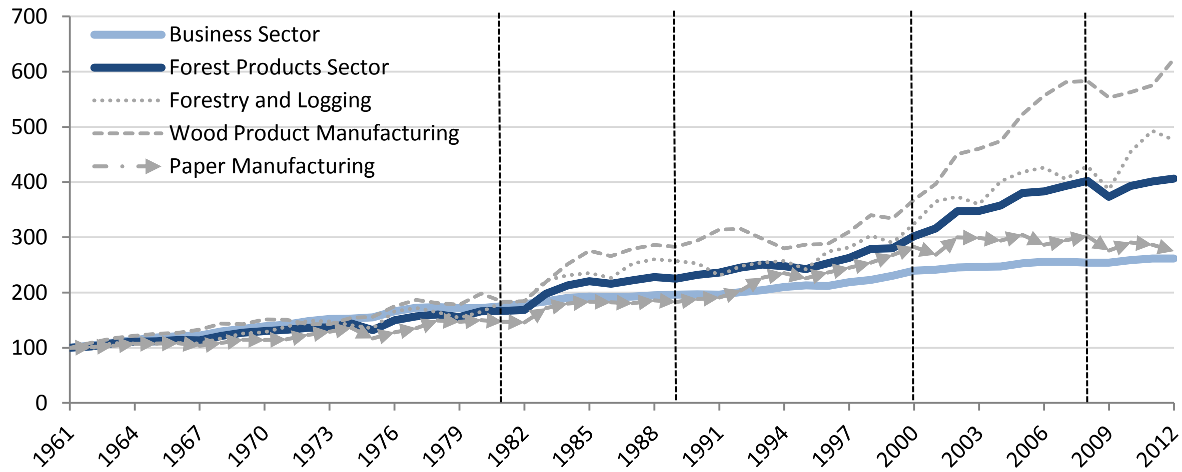
In the past 50 years, the performance of the Canadian forest products sector in terms of labour productivity growth has been quite impressive. During the 1961-2012 period, labour productivity in the sector increased at an average rate of 2.8 per cent per year, almost 1.0 percentage point faster than business sector labour productivity, which grew at a rate of 1.9 per cent per year. In half a century, labour productivity in the Canadian forest products sector quadrupled, while business sector labour productivity had a much more modest (albeit still very important) 2.5-fold increase (Chart 16, Panel A).

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.

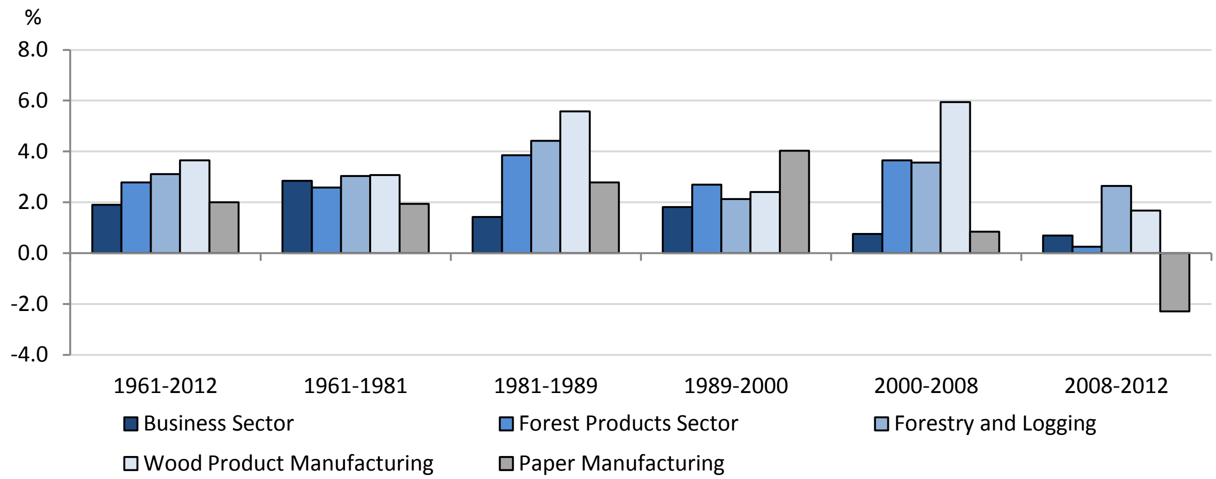
Chart 16 (Panel B) highlights how productivity gains in the Canadian forest products sector happened in bursts. Up until 1981, labour productivity had been growing at a slightly slower rate in the forest products sector than in the business sector (2.6 vs. 2.8 per cent per year during the 1961-1981 period). This changed in the 1981-1989 period, when labour productivity growth in the forest products sector accelerated (to 3.8 per cent per year) at the same time that business sector productivity growth suffered a slowdown (to 1.4 per cent per year). In the 1989-2000 period, despite an important deceleration, labour productivity in the forest products sector still grew at a faster pace than in the business sector (2.7 vs. 1.8 per cent per year). The 2000-2008 period marked yet another period of fast productivity growth in the forest products sector (3.6 per cent per year), well above the business sector average (0.7 per cent per year).

Chart 16: Labour Productivity in the Forest Products Sector, 1961-2012

A) Index, 1961=100



B) Compound annual growth rates by period, per cent



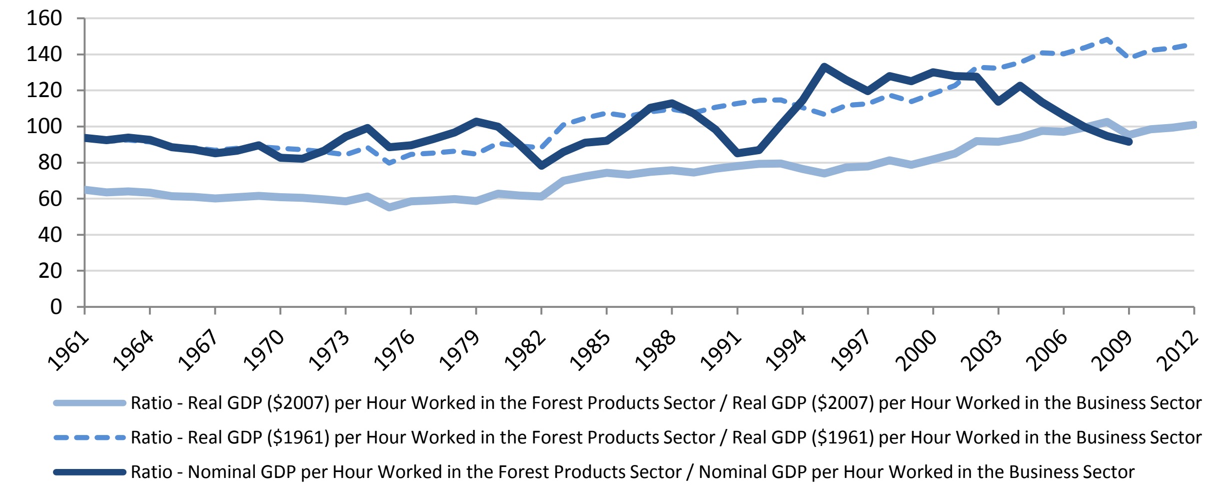
Source: CSLS calculations based on Statistics Canada data.

Given the above-average labour productivity growth rates in the forest products sector during a significant part of the 1961-2012 period, it should come as no surprise that, since 1981, the sector`s labour productivity level (in real terms) has been consistently increasing in comparison to the business sector level (Chart 17). In 1981, the labour productivity level of the forest products sector (in chained 2007 dollars) was only 61.7 per cent of the business sector level ($19.71 vs. $31.96); by 2012, it was 100.9 per cent of the business sector level ($48.08 vs. $47.74).

The problem with using labour productivity in real terms for *level* comparisons is that real labour productivity levels are a function of *nominal* levels in the reference year and *real* growth rates. Thus, while labour productivity growth will be the same,[14] relative labour productivity levels – that is, the labour productivity level of the forest products sector as a per cent of the business sector level – will change depending on the choice of the reference year. Chart 17 highlights this point by showing relative labour productivity levels calculated using both chained 1961 dollars and chained 2007 dollars. The relative labour productivity level of the forest sector is much higher in 1961 dollars than in 2007 dollars due to the higher relative prices of forest products back then. Note, however, that both series capture the same *change* in relative levels, with the sector's real relative labour productivity level increasing 55 per cent between 1961 and 2012.

Chart 17: Relative Labour Productivity Levels in the Forest Products Sector, 1961-2012

(Forest products sector as % of business sector, business sector = 100)



Source: CSLS calculations based on Statistics Canada data.

Looking at *nominal* labour productivity levels (nominal GDP per hour worked) instead of *real* labour productivity levels (real GDP per hour worked) solves this reference year problem. In nominal terms, however, relative levels reflect not only the real labour productivity growth differential between the forest products sector and the business sector, but also changes in relative prices. These changes in relative prices cause nominal relative levels to be much more volatile than real relative levels.

In nominal terms, the labour productivity level of the forest products sector oscillated around 90 per cent of the business sector level up until the early 1990s, when an increase in the relative price of forest products led to a sharp increase in the sector's relative labour productivity level. By 1995, the nominal labour productivity level of the forest products sector was 133 per cent of the business sector level. The forest products sector sustained a high relative labour productivity level up until 2004, when the decline in forest product prices led to a fall in the

[14] Note that this is strictly true only when real output is calculated using chained indexes; when it is calculated using fixed-base indexes, the choice of the base year can have a significant impact on real growth rates.

nominal labour productivity of the Canadian forest products sector vis-à-vis the business sector. In 2009 (the last year for which nominal GDP estimates for the forest products sector were available), the relative labour productivity level of the forest products sector was 91.6 per cent. Using this metric, the relative labour productivity level of the forest products sector actually *declined* 2 per cent in the last 50 years. In other words, the continuing fall in the relative prices of forest products has more than offset the sector's labour productivity gains.

ii. Recent Labour Productivity Trends

Labour productivity increased at an average annual rate of 2.5 per cent in the Canadian forest products sector during the 2000-2012 period, more than three times the business sector growth of 0.7 per cent (Table 9). Productivity gains in the sector happened almost completely in the 2000-2008 period (at a rate of 3.6 per cent per year), becoming negligible afterwards (0.3 per cent per year during the 2008-2012 period).

Table 9: 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
Sawmills and Wood Preservation	..	..	1.7
Veneer, Plywood and Engineered Wood Product Manufacturing	..	..	2.1
Other Wood Product Manufacturing	..	..	1.3
Paper Manufacturing	-0.2	0.8	-2.3
Pulp, Paper and Paperboard Mills	-0.2	1.9	-4.5
Converted Paper Product Manufacturing	0.5	0.0	1.5

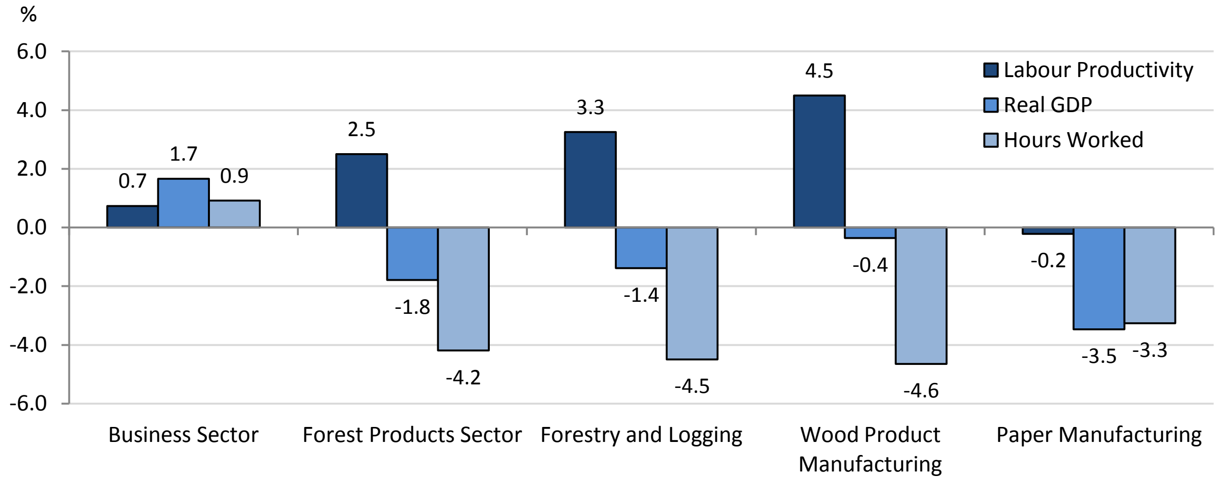
Source: CSLS calculations based on Statistics Canada data.

At first glance, it may seem puzzling that labour productivity in the forest products sector actually increased between 2000 and 2012, especially when we take into account that real GDP in the sector declined at an average rate of 1.8 per cent per year during the period. What is important to keep in mind, however, is that the magnitude of the decline in hours worked (at a rate of 4.2 per cent per year) was more than enough to offset the sector's negative real GDP growth (Chart 18). This is true not only for the forest products sector as a whole, but also for two of its subsectors. Both forestry and logging and wood product manufacturing experienced very rapid labour productivity growth during the period (at rates of 3.3 and 4.5 per cent per year, respectively) despite declining real GDP. Paper manufacturing was the only forest products subsector where real GDP fell at a slightly faster pace than hours worked, resulting in negative labour productivity growth (-0.2 per cent per year). It is interesting to note that paper manufacturing suffered a *larger* fall in real output than the other two forest products subsectors, but a *smaller* fall in hours worked. In other words, despite the sharp decline in the demand for

Canadian paper products, firms laid off a smaller proportion of their workers than in the other two forest products subsectors. The reasons for this "partial" adjustment of labour input use in the subsector are unclear.

Chart 18: Labour Productivity Growth in the Forest Products Sector, 2000-2012

(Compound annual growth rates, per cent)



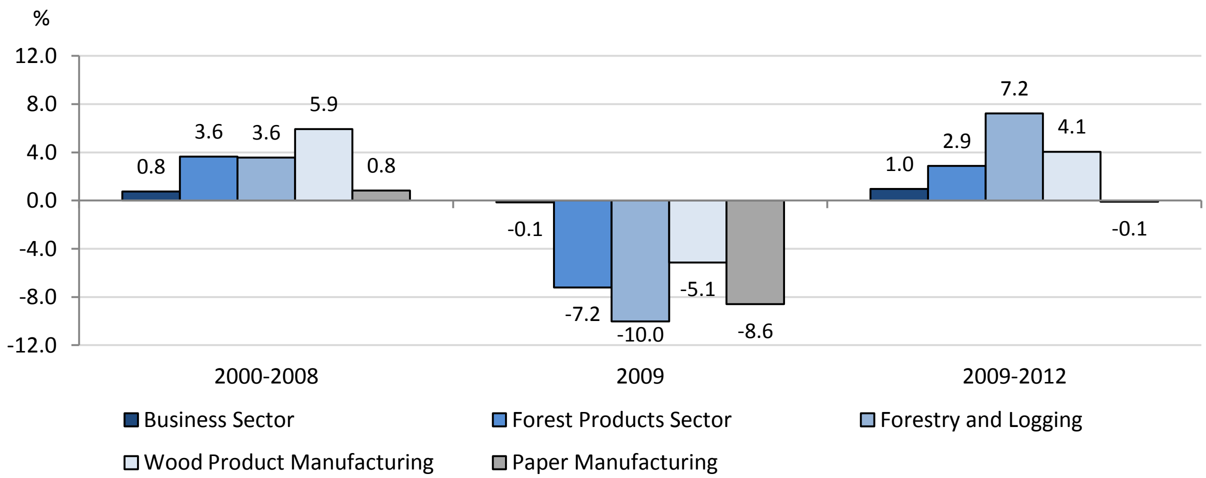
Source: CSLS calculations based on Statistics Canada data.

Forestry and logging and wood product manufacturing experienced exceptional labour productivity growth both before and after the recession (Chart 19). Productivity increased at a rate of 3.6 per cent per year in the case of forestry and logging and 5.9 per cent per year in the case of wood product manufacturing between 2000 and 2008. The recession caused productivity in the forest products sector to plummet, even though business sector productivity barely changed. Most of this drop in labour productivity can be explained by labour hoarding, i.e. firms let go less workers than what would be "optimal" for a given output fall. The forestry and logging subsector had the worst losses, experiencing a decline of 10.0 per cent in productivity, twice as much as the decline suffered in wood product manufacturing. The post-recession period of 2009-2012 saw strong productivity gains in both subsectors: 7.2 and 4.1 per cent per year for forestry and logging and wood product manufacturing, respectively.

The main culprit for the lacklustre productivity performance of the forest products sector in the 2008-2012 period was the paper manufacturing subsector. During the 2000-2008 period, despite having the weakest productivity performance among the three forest products subsectors (0.8 per cent per year), the subsector's productivity growth followed closely business sector growth. Much like the other two subsectors, paper manufacturing suffered significant losses during the recession, with a fall of 8.6 per cent in labour productivity. Unlike the other two subsectors, however, there was no "recovery" in the post-recession period. Between 2009 and 2012, labour productivity in paper manufacturing had close to zero growth. Drilling down even more, we can see that the subsector's poor performance can be attributed *entirely* to a decline in the productivity of pulp, paper and paperboard mills, which fell 14.4 per cent in 2009 and continued to fall in the post-recession period at a rate of 0.9 per cent per year. On the other hand, the productivity of converted paper product manufacturing actually improved in the period, growing 2.3 per cent in 2009 and 1.2 per cent per year during between 2009 and 2012.

Chart 19: Labour Productivity Growth in the Forest Products Sector, Pre- and Post-Recession Comparison

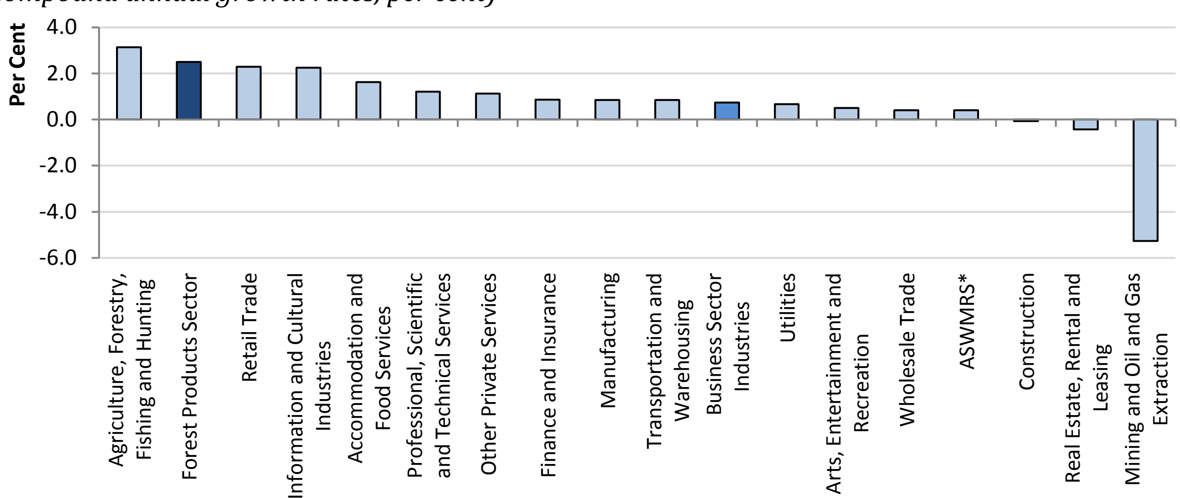
(Compound annual growth rates, per cent)



Source: CSLS calculations based on Statistics Canada data.

Chart 20: Labour Productivity Growth in the Forest Products Sector and Two-Digit NAICS Sectors, 2000-2012

(Compound annual growth rates, per cent)



* Administrative and Support and Waste Management and Remediation Services

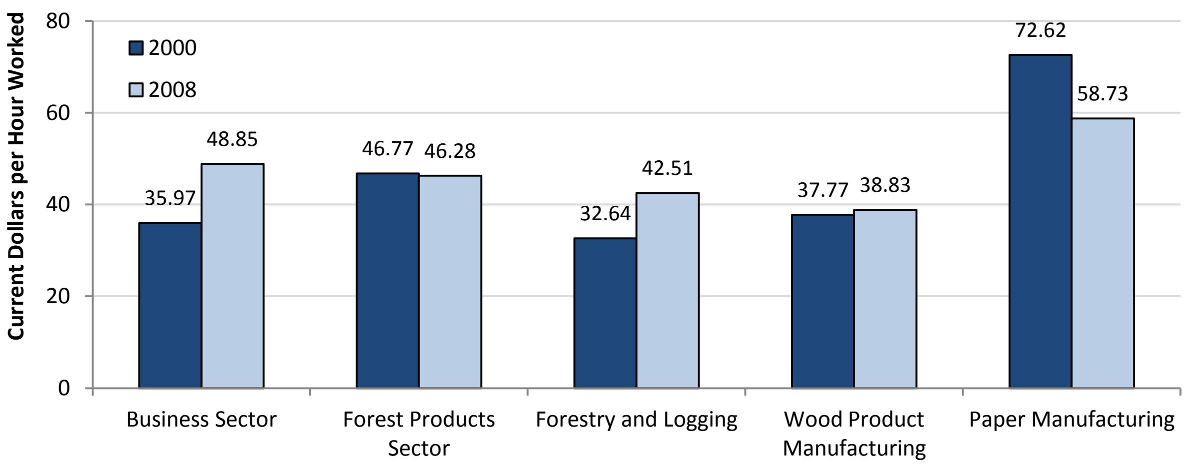
Source: CSLS calculations based on Statistics Canada data.

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 (Chart 20). Other sectors that saw strong labour productivity gains in the period were retail trade (2.3 per cent per year), information and cultural industries (2.2 per cent), and accommodation and food services (1.6 per cent). Mining and oil and gas extraction had by far the worst performance among two-digit NAICS sectors, with labour productivity declining at a rate of 5.3 per cent per year.

In the previous subsection, we discussed the risks of relying on *real* labour productivity level comparisons. While real levels can be useful in understanding how labour productivity has changed over time in a certain industry, they are not a good metric of comparison *across* industries since they are crucially dependent on the chosen reference year. Therefore, we focus here on *nominal* labour productivity levels, which reflect the economic value created by a person working in the sector. It is important to keep in mind, however, that these levels incorporate not only labour productivity growth, but also changes in prices.

Chart 21: Nominal Labour Productivity Levels in the Forest Products Sector, 2000 and 2008



Source: CSLS calculations based on Statistics Canada data.

Chart 21 presents nominal labour productivity level estimates for the forest products sector, its subsectors and the business sector in 2000 and 2008 (the last non-recession year for which nominal GDP estimates for the forest products sector were available). Between 2000 and 2008, while business sector nominal labour productivity increased from $35.97 to $48.85, nominal labour productivity in the forest products sector remained practically constant at the $46-47 range.[15] The sector's relative labour productivity level, however, experienced a large fall,

[15] In 2009, the nominal labour productivity level of the forest products sector was $42.93 (vs. $46.86 for the business sector), reflecting the large fall in both physical productivity and the relative price of forest products. In the case of the subsectors, nominal labour productivity levels were: $41.95 for forestry and logging, $33.51 for wood product manufacturing, and $55.92 for paper manufacturing.

from 130 per cent of the business sector level in 2000 to only 95 per cent in 2008. Recalling that real labour productivity in the sector grew 3.6 per cent per year in the period (vs. only 0.8 per cent in the business sector), the decline in the sector's relative labour productivity level can be attributed entirely to the fall in the relative price of forest products. In fact, as we have seen in Section III-A, while prices in the forest products sector decreased 3.6 per cent per year, the implicit price deflator for the Canadian economy as a whole *increased* 3.0 per cent per year.

Box 4: Labour Productivity Growth Using Different Employment Estimates

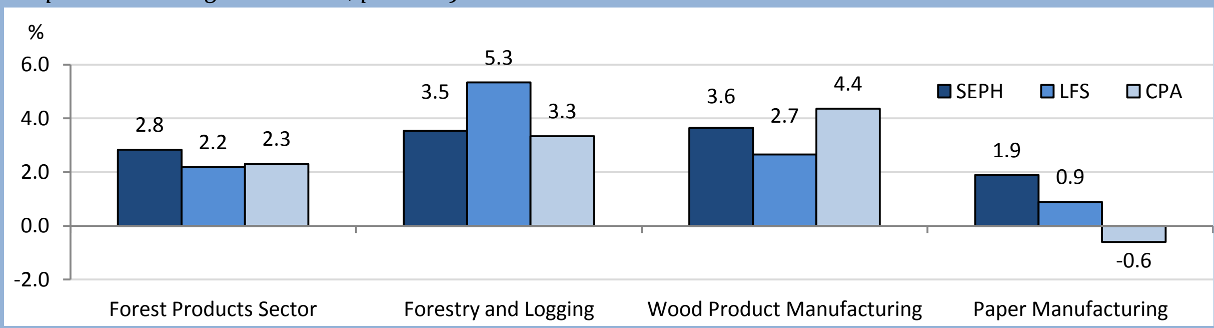
Box 1 compared employment estimates from the Canadian Productivity Accounts (CPA) to those from the Labour Force Survey (LFS) and the Survey of Employment, Payrolls, and Hours (SEPH). Using official real GDP estimates, these three series of employment estimates can be used to compute three different sets of labour productivity estimates for the Canadian forest products sector and its subsectors.

The chart below does exactly that, comparing labour productivity growth in the Canadian forest products sector during the 2000-2012 period according to the CPA, LFS and SEPH. For the forest products sector as a whole, measured labour productivity growth was the strongest using SEPH data, at an annual rate of 2.8 per cent per year. Using LFS and CPA estimates, growth was significantly slower, at 2.2 and 2.3 per cent per year (respectively).

At the subsector level, the differences were much more marked. Using LFS employment estimates, for instance, showed much stronger labour productivity gains in forestry and logging (5.3 per cent per year) than if we had used CPA or LFS data (3.3 and 3.5 per cent per year, respectively). On the other hand, LFS estimates produced weaker labour productivity growth in wood product manufacturing (2.7 per cent per year vs. 3.6 per cent using SEPH figures and 4.4 per cent using CPA figures). In paper manufacturing, estimated labour productivity growth was the highest when we used SEPH employment estimates (1.9 per cent per year), with LFS employment estimates yielding a much smaller growth rate (0.9 per cent per year), and CPA employment estimates actually pointing to a decline in productivity growth (-0.6 per cent per year). Note that, since these alternative labour productivity estimates are computed using the same real GDP data, the differences are caused entirely by differences in measured labour input,

Labour Productivity Growth in the Canadian Forest Products Sector, Comparison between CPA, LFS and SEPH-based Estimates, 2000-2012

(Compound annual growth rates, per cent)



Note: Growth rates for the CPA-based labour productivity estimates differ slightly from growth rates presented in the main text because labour productivity was calculated here as real GDP divided by *number of jobs*, instead of real GDP divided by *hours worked*.
Source: Statistics Canada, 1) CPA employment data from CANSIM tables 383-0010/30; 2) SEPH employment data from CANSIM table 281-0024; 3) LFS employment data obtained through special order; 4) Real GDP data from CANSIM tables 379-0023/29.

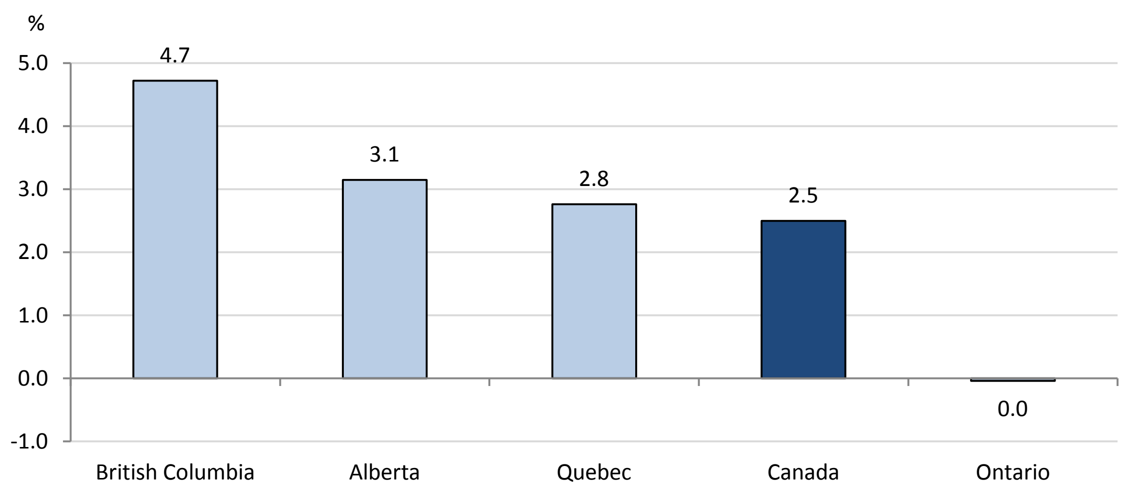
At the subsector level, nominal labour productivity in forestry and logging increased from $32.64 in 2000 to $42.51. This is a reflection mainly of real productivity gains (3.6 per cent per year), since the subsector's implicit price deflator did not change significantly during the period (-0.2 per cent per year). In the case of both wood product and paper manufacturing, however, prices suffered a marked downturn, falling 5.3 and 3.4 per cent per year, respectively. Despite the fall in prices, nominal labour productivity in wood product manufacturing managed to increase slightly during the period, from $37.77 to $38.83, due to strong real productivity gains. Paper manufacturing, on the other hand, saw a sharp decline in its nominal labour productivity, from $72.62 to $58.73, since its real productivity growth of 0.8 per cent per year was not enough to offset the rapid fall in prices. Even with a decline of this magnitude, paper manufacturing remained the forest products subsector with the highest nominal labour productivity level, followed by forestry and logging, and wood product manufacturing.

iii. Provincial Breakdown of Recent Labour Productivity Trends

At the provincial level, we have computed labour productivity growth rates and levels for the forest products sectors in British Columbia, Alberta, Ontario and Quebec. Estimates for the other provinces could not be calculated, since real GDP and/or hours data for paper manufacturing were not available due to confidentiality reasons. It is important to keep in mind, however, that British Columbia, Ontario and Quebec accounted for 80 per cent of the nominal value added generated by the Canadian forest products sector, with Alberta responsible for an additional 10 per cent.

Chart 22: Labour Productivity Growth in the Forest Products Sector, Provincial Breakdown, 2000-2012

(Compound annual growth rates, per cent)

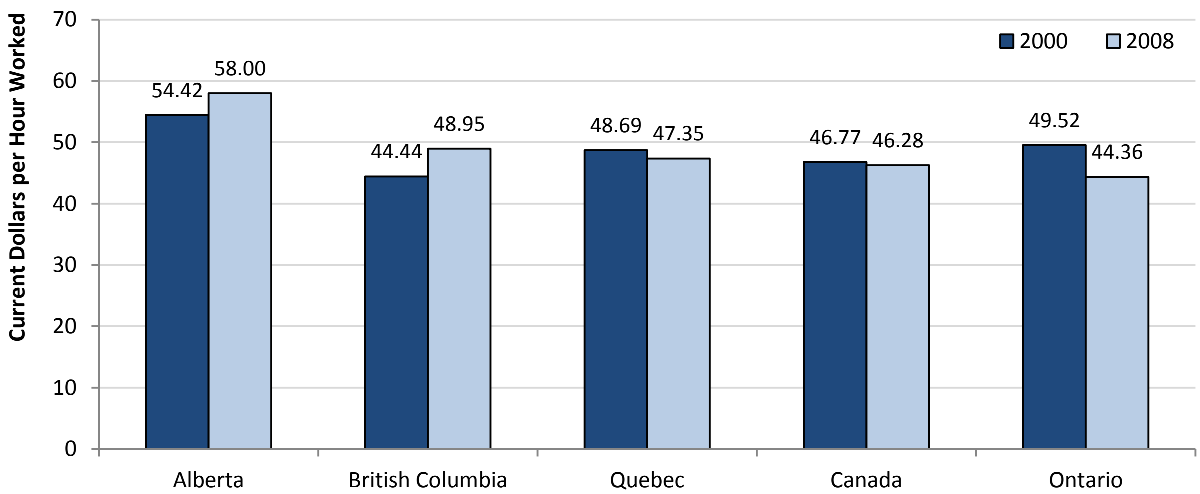


Source: CSLS calculations based on Statistics Canada data.

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 (Chart 22), almost double of the productivity increase observed by the Canadian forest products sector as a whole (2.5 per cent per year). While Alberta's and Quebec's forest products sectors also had above-average labour productivity growth during the period (at 3.1 and 2.8 per cent per year, respectively), there was no labour productivity growth in Ontario's forest products sector. Following national trends, the forest products sectors in B.C., Alberta, Quebec, and Ontario all experienced a post-2008 slowdown in labour productivity growth (Table 10).

In 2008 (the last non-recession year for which data were available), Alberta's forest products sector had the highest (nominal) labour productivity level among all the provinces, at $58.00. Labour productivity levels in the other provinces were significantly lower, ranging from $44.00 to $49.00. British Columbia's forest products sector had the second highest labour productivity level ($48.95), followed by Quebec's (47.35) and Ontario ($44.36), which was the only province with a major forest products sector that had below-average labour productivity levels. Although labour productivity data for the forest products sector as a whole were not available for Saskatchewan, Manitoba, and the Atlantic Provinces, the generally low labour productivity levels these provinces had in forestry and logging and wood product manufacturing (see Table 10) are indicative of low labour productivity levels in the forest products sector aggregate.

Chart 23: Labour Productivity Levels in the Forest Products Sector, Provincial Breakdown, 2008



Source: CSLS calculations based on Statistics Canada data.

Table 10 summarizes the above discussion by providing labour productivity levels (in nominal terms) and growth rates (in real terms) for the forest products sector and its subsectors during the 2000-2012 period, at both national and provincial levels. A few additional points are worth highlighting

- During the 2000-2012 period, labour productivity growth in forestry and logging was highest for the Atlantic Provinces (5.8 per cent per year), followed by Quebec (4.6 per cent per year), and British Columbia (4.5 per cent per year) – all of which had above-average labour productivity growth (with the national average at 3.3 per cent per year). Ontario's forestry and logging subsector experienced below-average, albeit still positive, productivity growth (0.4 per cent per year). In the case of the Prairie Provinces, however, growth was negative between 2000 and 2012 (-0.5 per cent per year for Alberta and -2.8 per cent per year for Saskatchewan and Manitoba).

- In the case of wood product manufacturing, the biggest productivity gains happened in British Columbia, which saw labour productivity increase at a rate of 6.4 per cent per year between 2000 and 2012 (vs. a national average of 4.5 per cent per year). A possible explanation for this exceptional performance is linked to returns to scale, since wood product manufacturing plants in British Columbia have, on average, greater productive capacity than plants in other provinces. Alberta's and Quebec's wood product manufacturing subsectors also had strong performances in terms of productivity growth (5.1 and 4.3 per cent per year). On the other hand, productivity increases in other provinces occurred at a much slower pace: 2.1 per cent per year in Saskatchewan and Manitoba; 2.0 per cent in the Atlantic Provinces; and 1.1 per cent in Ontario.

- Compared to the other two subsectors, paper manufacturing saw little to no productivity gains during the 2000-2012 period. At the national level, productivity in the subsector declined 0.2 per cent per year. At the provincial level, however, the subsector experienced positive productivity growth in Alberta (1.5 per cent per year), British Columbia (1.0 per cent), and Quebec (0.4 per cent). In Ontario, paper manufacturing labour productivity fell 1.2 per cent per year. Estimates were not available for the other provinces, since real GDP and/or hours data were not available due to confidentiality reasons.

- There were sizeable variations in terms of *nominal* labour productivity levels for provincial forest products subsectors. In 2008 (the last non-recession year for which data were available), British Columbia had the highest nominal labour productivity level in forestry and logging among all the provinces ($59.07), while Saskatchewan and Manitoba had the lowest ($30.41). Alberta had the highest labour productivity levels in the other two forest products subsectors: $45.65 in the case of wood product manufacturing (with the Atlantic Provinces having the lowest level, $26.97) and $120.16 in the case of paper manufacturing, well above the national average of $58.73. Nominal labour productivity levels experienced a sharp drop with the 2009 recession. In particular, Alberta's nominal labour productivity in paper manufacturing declined 40 per cent, from the aforementioned $120.16 to $72.00 (still significantly above the labour productivity level of other provinces).

Table 10: Labour Productivity in the Forest Products Sector, Provincial Breakdown, 2000-2012

	2000	2008	2009	2000-2012	2000-2008	2008-2012
	(current dollars per hour worked)			(CAGR, per cent)		
Forest Products Sector						
Canada	46.77	46.28	42.93	2.5	3.6	0.3
British Columbia	44.44	48.95	45.74	4.7	6.2	1.8
Alberta	54.42	58.00	49.81	3.1	5.0	-0.4
Saskatchewan + Manitoba	..	..	..	..	..	..
Ontario	49.52	44.36	44.27	0.0	0.9	-1.8
Quebec	48.69	47.35	44.11	2.8	3.5	1.4
Atlantic Canada	..	..	..	..	..	..
Forestry and Logging						
Canada	32.64	42.51	41.95	3.3	3.6	2.6
British Columbia	37.94	59.07	56.57	4.5	6.9	-0.3
Alberta	38.27	45.65	42.76	-0.5	1.4	-4.2
Saskatchewan + Manitoba	30.32	30.41	35.19	-2.8	-5.5	2.9
Ontario	37.53	37.81	41.57	0.4	-1.5	4.3
Quebec	26.80	30.68	32.56	4.6	1.4	11.5
Atlantic Canada	22.90	34.23	33.70	5.8	7.9	1.8
Wood Product Manufacturing						
Canada	37.77	38.83	33.51	4.5	5.9	1.7
British Columbia	42.67	43.73	38.02	6.4	7.1	5.0
Alberta	41.99	46.97	45.82	5.1	5.6	4.2
Saskatchewan + Manitoba	30.35	27.96	26.12	2.1	2.4	1.4
Ontario	36.29	32.37	28.54	1.1	4.2	-4.7
Quebec	35.77	41.48	33.22	4.3	7.0	-0.9
Atlantic Canada	28.49	26.97	22.75	2.0	3.3	-0.5
Paper Manufacturing						
Canada	72.62	58.73	55.92	-0.2	0.8	-2.3
British Columbia	58.57	48.65	50.13	1.0	3.4	-3.6
Alberta	115.01	120.16	72.00	1.5	6.7	-8.1
Saskatchewan + Manitoba	..	..	..	..	..	..
Ontario	66.93	55.81	57.43	-1.2	-0.9	-1.8
Quebec	83.43	63.85	63.73	0.4	0.4	0.5
Atlantic Canada	..	..	..	..	..	..

Note: Labour productivity levels are in nominal terms (nominal GDP per hour worked), while growth rates are in real terms (real GDP per hour worked).
Source: CSLS calculations based on Statistics Canada data.

iv. International Comparisons

The EU KLEMS Project provides output, input and productivity estimates at the industry level for a number of OECD countries, allowing us to compare the productivity performance of the forest products sector in Canada with that of other countries. The EU KLEMS ISIC Revision 3 dataset (ISIC-3) spans 72 industries and 30 countries up to 2007. This dataset was released on March 2011, and is no longer updated.

Unfortunately, ISIC-3 EU KLEMS data for Canada and the United States span a shorter time period, ending in 2004 and 2005, respectively. In addition, both the Canadian and the U.S. data lack the necessary level of detail, with forestry and logging included as part of the larger "agriculture, fishing, hunting, forestry and fishing" category and paper manufacturing lumped together with the printing and publishing industry. These issues were addressed using different approaches for each country:

- For Canada, we used official Statistics Canada estimates instead of the EU KLEMS estimates. Overall, the official estimates are largely consistent with EU KLEMS estimates, which should not come as a surprise since both sets of estimates were constructed by Statistics Canada.

- For the United States, nominal GDP shares were obtained from official nominal GDP estimates from the U.S. Bureau of Economic Analysis (BEA). The overall size of the U.S. forest products sector is overstated, however, given that only data for "forestry, fishing and related activities" were available. Productivity estimates for wood product and paper manufacturing were obtained from the U.S. Bureau of Labor Statistics (BLS), but estimates for forestry and logging were not available.

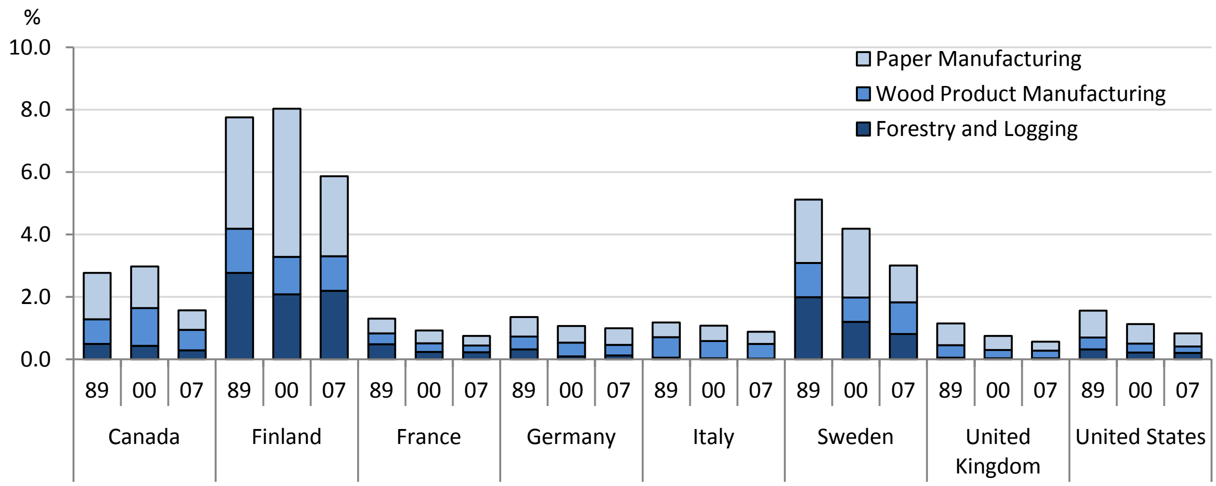
Before discussing international labour productivity trends in the forest products sector, it is necessary to assess the importance of the forest products sector in different countries. As a share of total economy GDP, Finland had by far the largest forest products sector in our selection of 8 OECD countries (Chart 24): in 2007, it accounted for almost 6 per cent of the Finnish economy; Sweden had the second largest forest products sector in our sample, even though it accounted for only 3 per cent of that country's economy, half of its importance in Finland; Canada came third, with its forest products sector responsible for 1.6 per cent of the Canadian economy. The forest products sectors of major European economies such as France, Germany, Italy, and the United Kingdom accounted in general for less than 1.0 per cent of total economy GDP. The same can be said for the United States, where the forest products sector was responsible for only 0.8 per cent of total economy GDP in 2007.

Regardless of its importance in different countries, a few observations can be made regarding the evolution of the forest products sector in the past 20 years:

- The declining importance of the forest products sector (in terms of nominal GDP shares) is not an isolated Canadian phenomenon, having occurred in other industrialized economies as well. In Finland, for instance, the sector's share of nominal GDP fell almost 2.0 percentage points between 1989 and 2007, from 7.8 per cent to 6.0 per cent; a similar fall can be seen in Sweden (from 5.1 per cent to 3.0 per cent). Even in countries were the forest products sector represents only a small part of total economic activity, its share has fallen.

- Of the three forest products subsectors, paper manufacturing was the largest one in terms of nominal value added,[16] accounting on average for almost half of the sector's GDP. It was also the subsector that lost more ground in recent years.

Chart 24: Nominal Value Added in the Forest Products Sector as a Share of the Total Economy, Selected OECD Countries, 1989, 2000 and 2007



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

During the overall 1989-2007 period, Finland's forest products sector had the fastest labour productivity growth in our sample (6.3 per cent per year), followed by Germany's (4.3 per cent per year) (Table 11). The Canadian forest products sector was tied with Italy's for third place, with labour productivity rising 3.0-3.1 per cent per year in both countries. Labour productivity in the forest products sectors in Sweden, the United Kingdom, and France increased at a much slower pace. Estimates of labour productivity growth for the U.S. forest products sector were not available due to missing data on the productivity of the U.S. forestry and logging subsector.

With the exception of Canada and France, labour productivity growth in the forest products sector of the countries in our sample suffered a slowdown after 2000. In Finland's

[16] The industry groupings in the ISIC classification, which is used by the EU KLEMS project, are not exactly the same as those in the NAICS. The NAICS *forestry and logging* subsector is equivalent to the ISIC *forestry* industry, while the NAICS *wood product manufacturing* subsector corresponds to ISIC's *wood & products of wood and cor*k industry. In the case of the NAICS *paper manufacturing* subsector, the closest ISIC code used by the EU KLEMS is *pulp, paper & paper products*. For simplicity, however, we continue to use the NAICS industry names in this section.

forest products sector, for instance, average annual growth declined from 6.3 per cent per year in the 1989-2000 period to 3.9 per cent per year in the 2000-2007 period; the same trend can be seen in Germany, Italy, Sweden and the United Kingdom. In Canada and France, however, labour productivity in the forest products sector gained momentum, increasing at a faster pace. In Canada's case, it rose from an average annual rate of 2.8 per cent to 3.8 per cent, while in France it jumped from -0.6 per cent to 4.1 per cent.

Table 11: 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

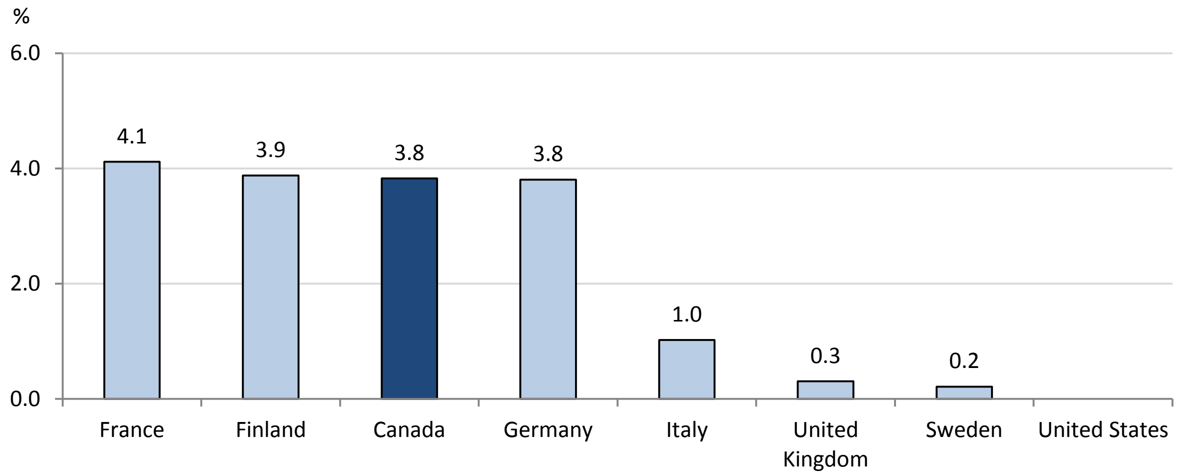
Source: Canada data from Statistics Canada; U.S. data from the BLS; for all other countries, data from EU KLEMS.

Between 2000 and 2007, labour productivity in the forest products sector grew rapidly in Canada, Finland, Germany and France, at approximately the same rate of 3.8-3.9 per cent per year (in France growth was slightly faster, 4.1 per cent per year) (Chart 25). On the other hand, labour productivity in the sector rose at a rather slow pace in Italy, Sweden and the United Kingdom.

Compared to other countries, Canada had a particularly impressive productivity performance in the wood product manufacturing subsector, which experienced large gains in the 2000-2007 period, with labour productivity increasing at an average rate of 6.8 per cent per year, more than double of the U.S. rate (3.1 per cent per year). No other country in our sample saw such large productivity gains in its wood product manufacturing subsector during the period. In the case of forestry and logging, however, 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 (10.2 per cent per year), Finland (7.1 per cent per year), and France (6.8 per cent per year). Finally, Canada's paper manufacturing subsector had a subpar performance in terms of labour productivity growth, experiencing the lowest productivity increases among the 8 countries in our sample, 0.6 per cent per year, 10 times less than the productivity growth experienced in Finland's paper manufacturing subsector (6.1 per cent per year).

Chart 25: Labour Productivity Growth in the Forest Products Sector, Selected OECD Countries, 2000-2007

(Compound annual growth rates, per cent)



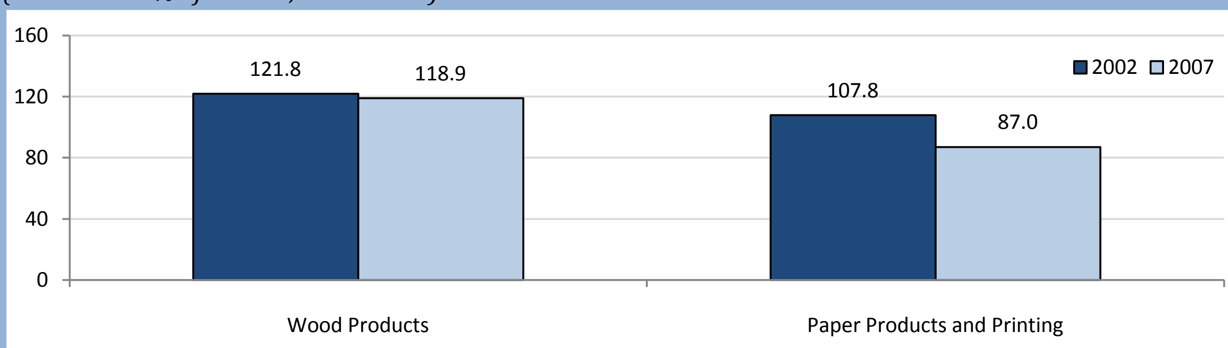
Source: Canada data from Statistic Canada; U.S. data from the BLS; for all other countries, data from EU KLEMS.

Box 5: Labour Productivity Levels in Canada and in the United States

Tang, Rao and Li (2010) compared labour productivity levels in Canada and in the United States for a variety of manufacturing industries, including wood product manufacturing and paper products and printing. The chart below shows Canada's labour productivity levels in these two industries relative to the U.S. levels in 2002 and 2007. In 2002, Canada's labour productivity levels were higher than U.S. levels in both industries, by 21.8 per cent in wood product manufacturing and by 7.8 per cent in paper manufacturing and printing. Five years later, however, both relative levels had fallen. In wood product manufacturing, the difference between levels fell to 18.9 per cent, with Canada maintaining the lead; in paper manufacturing and printing, however, Canada's level fell 13.0 per cent below the U.S. level.

Labour Productivity in Wood Product and Paper Manufacturing, Canada-U.S. Level Comparison, 2002 and 2007

(Canada as a % of the U.S., U.S. = 100.0)



Source: Tang, Rao and Li (2010).

B. Multifactor Productivity

This subsection is divided into three parts: first, we look at long-run multifactor productivity trends in the Canadian forest products sector and its subsectors; next, recent multifactor productivity growth trends in the sector are analyzed, focusing on the 2000-2008 period; finally, international comparisons are made. It should be noted that this subsection does not discuss provincial MFP trends for the forest products sector, given that Statistics Canada does not produce official MFP estimates for three-digit NAICS subsectors at the provincial level.

The reason we focus on the 2000-2008 period instead of the 2000-2012 period is that there are no official estimates for the three forest products subsectors – and, hence, for the forest products sector as a whole – after 2008. Statistics Canada produced MFP estimates for the Canadian business sector and two-digit NAICS sectors up to 2011. However, three-digit NAICS subsector estimates are produced with a considerable lag, and, as mentioned above, are currently available only up to 2008.

Using Statistics Canada data, the CSLS has constructed MFP estimates for the forest products sector and its subsectors for the 2009-2012 period. These estimates, however, were constructed under two main assumptions: 1) changes in labour and capital composition between 2009 and 2012 are assumed to be equal to the average growth rates for these variables observed in the 2000-2008 period; 2) real capital stock growth between 2009 and 2012 is assumed to be equal to the FCFS non-residential fixed capital stock growth. These assumptions, while likely quite accurate at the business sector level, might cause a loss of precision at the subsector level – particularly in the case of subsectors that experienced significant shifts in their labour and capital composition. In this sense, the CSLS estimates should be seen as preliminary estimates, and therefore interpreted with caution.[17]

i. Long-Run Multifactor Productivity Trends

MFP in the forest products sector grew at an average annual rate of 1.4 per cent between 1961 and 2012,[18] 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 26, Panel A). During the 1961-1981 period, MFP growth in the

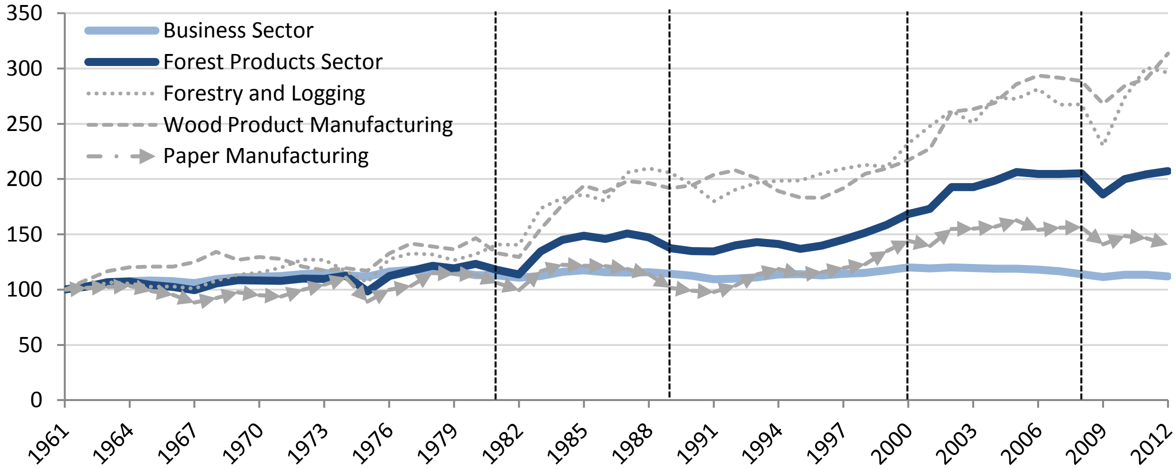
[17] It should be highlighted, also, that the MFP growth rates discussed in this subsection do not match *perfectly* the growth rates obtained from official Statistics Canada estimates, even for the 1961-2008 period or the 2000-2008 period. After the latest SNA revision, real GDP estimates have been updated. Unfortunately, these changes have not yet been incorporated by the CPA. To address this problem, the CSLS has produced "revised" MFP estimates using the new real GDP series in place of the old real GDP series from the CPA. Overall, the changes in MFP growth are minor, around 0.1-0.2 percentage points over a 50 year period. There were, however, significant differences in MFP growth for forestry and logging, given that the revised estimates are much higher than the old ones.

[18] Instead of focusing on the 1961-2008 period here, we chose to discuss the 1961-2012 period. The experimental nature of the CSLS MFP estimates for the 2009-2012 period does not matter that much in a longer time frame, given that the overall impact of four years of growth during a fifty-year period is quite small when determining compound annual growth rates.

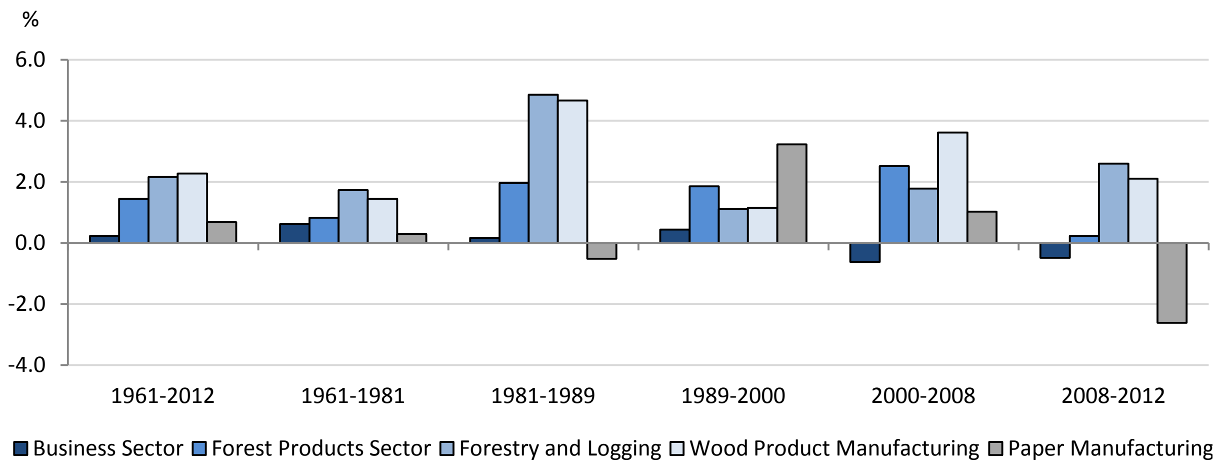
forest products sector was only marginally above business sector growth (0.8 vs. 0.6 per cent, respectively). Starting in the 1980s, however, the sector's MFP growth took off, leading to its impressive long-run performance.

Chart 26: Multifactor Productivity in the Forest Products Sector, 1961-2012

A) Index, 1961=100



B) Compound annual growth rates by period, per cent



Source: CSLS calculations based on Statistics Canada data.

Looking at the 1961-2012 period as a whole, MFP in forestry and logging and wood product manufacturing increased practically at the same 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. In the end, MFP in forestry and logging and wood product manufacturing experienced a 3-fold increase between 1961 and 2012, compared to a 1.5-fold increase in paper manufacturing.

Much like labour productivity, multifactor productivity gains also happened in bursts. In particular, there were large gains in forestry and logging and wood product manufacturing between 1981 and 1989, during which MFP grew 4.9 and 4.7 per cent per year (respectively); and between 2000 and 2008, during which MFP increased 1.8 and 3.6 per cent per year. It is interesting to note that paper manufacturing MFP growth was actually negative in the 1981-1989 period (-0.5 per cent per year), despite strong productivity gains in the other two forest products subsectors. The paper manufacturing subsector did, however, outperform the other two subsectors in terms of MFP growth during the 1989-2000 period, when MFP increased at an average annual rate of 3.2 per cent (vs. 1.1 per cent in both forestry and logging and wood product manufacturing).

ii. 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 12). 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).[19]

Table 12: 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

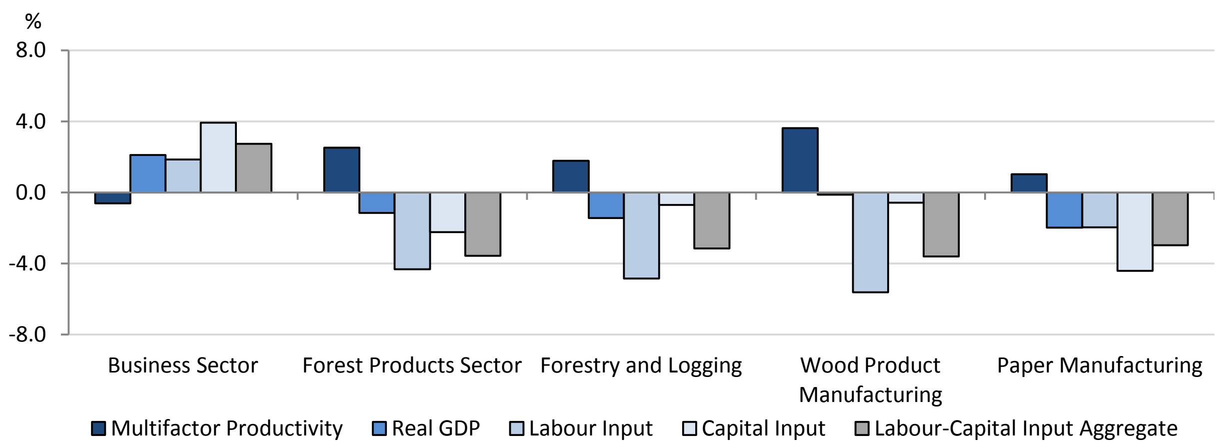
Source: CSLS calculations based on Statistics Canada data.

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). MFP growth in wood product manufacturing, despite falling to 2.1 per cent per year was still substantial, while productivity growth in forestry and logging actually accelerated to 2.6 per cent per year.

[19] Note that, even though the paper manufacturing subsector has been ailing in the past decade, its performance in terms of MFP growth during the 2000-2008 period was still significantly above the business sector average (1.0 per cent per year vs. -0.6 per cent per year). There are many possible reasons for this. This result might be driven by the healthy pulp manufacturing industry. Alternatively, the hardships faced by paper mills might have played a very significant role in increasing the industry's productivity through two main channels: 1) a composition effect caused by the closing of inefficient paper mills; 2) The Horndall effect, named after a mill in Sweden that managed to improve its productivity without additional investments simply by making due with less workers. In order to investigate this issue further, we would need access to detailed firm-level data.

Chart 27 compares real GDP growth to labour and capital input growth in the forest products sector, its subsectors and the business sector as a whole during the 2000-2008 period. In contrast to the business sector, where real GDP, labour input and capital input all had positive growth during the period, in the forest products sector (and all its subsectors) real GDP, labour input and capital input all had *negative* growth. Furthermore, while labour input experienced roughly half of the growth of capital input in the business sector, it grew almost twice as much as capital input in the forest products sector. Faster declines in labour input (compared to capital input) can be observed in two out of three forest products subsectors, namely: forestry and logging and wood product manufacturing; only paper manufacturing had capital input declining at a faster rate than labour input during the period.

Chart 27: Multifactor Productivity in the Forest Products Sector, 2000-2008



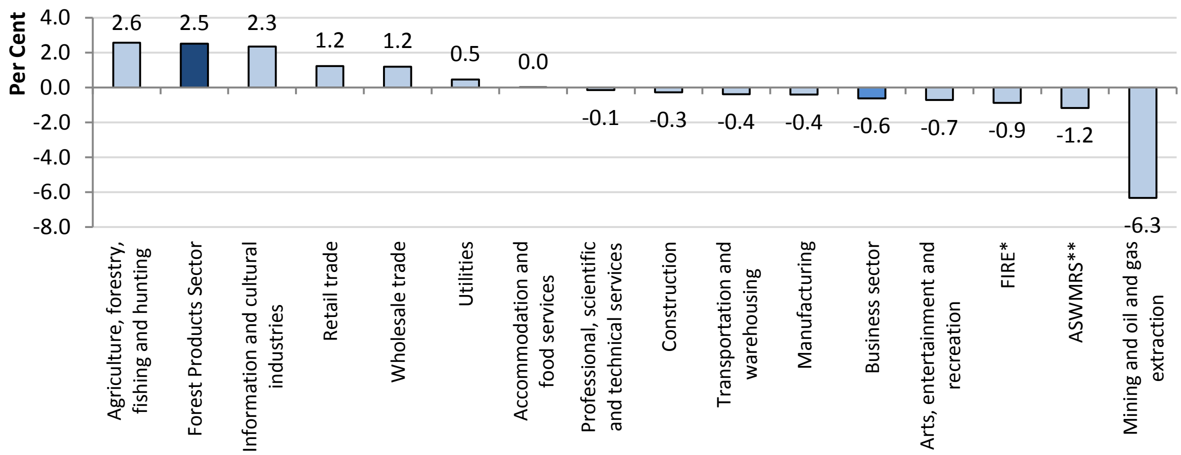
Source: CSLS calculations based on Statistics Canada data.

Growth in the labour-capital input aggregate is obtained by weighing labour and capital inputs by their (two-period average) compensation shares. Recall from Section III-C that the compensation share of capital had been falling in the forest products sector (from 50 per cent in 2000 to 33 per cent in 2008); coupled with the slower rate of decline of capital input, this means that labour input growth had a very large role in determining the growth of the labour-capital input aggregate (3.6 per cent per year). As mentioned in the previous paragraph, real GDP in the sector declined at a much slower pace than the labour-capital input aggregate (-1.2 per cent per year), which implies that the sector experienced robust MFP growth in the period (2.5 per cent per year). On the other hand, real GDP in the Canadian business sector grew at a slower pace than the labour-capital input aggregate, which increased by 2.7 per cent per year, indicating falling MFP (-0.6 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. Other sectors that had strong MFP gains in the period were: information and cultural industries (2.3 per cent per year), retail trade (1.2 per cent) and wholesale trade (1.2 per cent). Mining and gas extraction had the worst performance among two-digit NAICS sectors, with MFP declining at a rate of 6.3 per cent per year between 2000 and 2008.

Chart 28: Multifactor Productivity Growth in the Forest Products Sector and Two-Digit NAICS Sectors, 2000-2008

(Compound annual growth rates, per cent)



*Finance, Insurance, Real Estate, Rental and Leasing ** Administrative and Support, Waste Management and Remediation Services
Source: CSLS calculations based on Statistics Canada data.

iii. International Comparisons

The EU KLEMS does not have multifactor productivity estimates for forestry and logging in particular, only for agriculture, hunting and forestry. As a consequence, we cannot calculate MFP growth for the forest products sector as a whole. This part of the report thus focuses on international MFP growth comparisons only for the wood product and paper manufacturing subsectors. Another limitation of the EU KLEMS data is that, for MFP estimates, paper manufacturing is grouped with printing and publishing. Given that ISIC-3 EU KLEMS data for Canada and the United States only go up to 2004 and 2005 (respectively), World KLEMS estimates were used.

During the 1989-2007 period, France and Sweden had the highest MFP growth rates for wood product manufacturing (3.4-3.5 per cent per year), followed by Germany, Canada, Finland and Italy (all of which had growth rates between 2.1 and 2.5 per cent per year) (Table 13). In the U.K. and the U.S., the wood product manufacturing subsector actually experienced negative MFP growth (-0.6 and -1.0 per cent per year).

In general, MFP growth in paper manufacturing, printing and publishing industries was much more modest. Aside from Finland, where paper manufacturing, printing and publishing MFP grew at 3.8 per cent per year, the other countries included in our analysis saw either slow growth – the case of France, Germany and the U.K. – or a fall in productivity – the case of Sweden, Italy, and the U.S. MFP in the Canadian paper manufacturing, printing and publishing industries increased at a rate of 1.0 per cent per year during the 1989-2007 period, ranking second among the 8 OECD countries in our sample.

Table 13: Multifactor Productivity Growth in the Forest Products Sector, Selected OECD Countries, 1989-2007

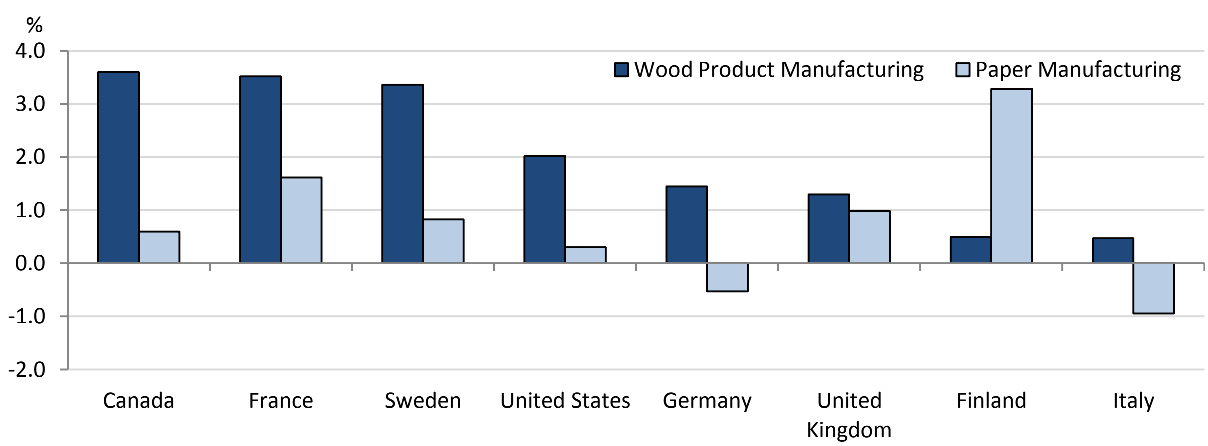
	Canada	Finland	France	Germany	Italy	Sweden	United Kingdom	United States
	(compound annual growth rates, per cent)							
	Wood Product Manufacturing							
1989-2007	2.4	2.3	3.5	2.5	2.1	3.4	-0.6	-1.0
1989-2000	1.6	3.5	3.5	3.2	3.1	3.4	-1.7	-2.8
2000-2007	3.6	0.5	3.5	1.4	0.5	3.4	1.3	2.0
	Paper Manufacturing, 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.

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 (Chart 29), 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 manufacturing subsector, however, had only slightly above-average MFP growth (1.1 per cent per year), below Finland's (3.3 per cent per year) and France's (1.6 per cent), and in line with that of the U.K. (1.0 per cent).

Chart 29: Multifactor Productivity Growth in the Forest Products Sector, Selected OECD Countries, 2000-2007

(Compound annual growth rates, per cent)



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

Box 6: MFP Levels in Canada and in the United States

MFP *level* comparisons across countries can be tricky, as they crucially depend on how capital input is estimated, and the estimation of capital input can differ significantly from country to country. Different depreciation assumptions, for instance, can lead to vastly different estimates of capital input (since depreciation rates influence the user cost of capital), therefore affecting MFP levels. Using three different depreciation assumptions, Tang, Rao, and Li (2010) calculated relative MFP levels for a variety of manufacturing industries in Canada and in the United States in 2007, including wood product manufacturing and paper products and printing.

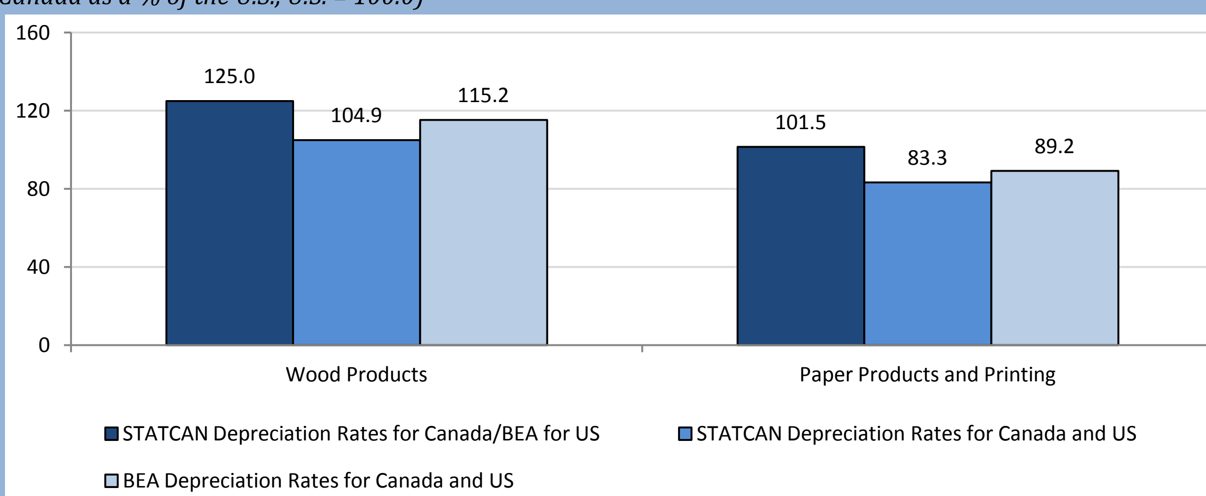
Below, we describe the three depreciation assumptions adopted by Tang, Rao and Li:

1) STC-BEA – For Canada, capital input is calculated using Statistics Canada`s depreciation rates, while for the United States it is calculated using the depreciation rates adopted by the U.S. Bureau of Economic Analysis (BEA).
2) STC-STC – Capital input for both countries is calculated using Statistics Canada's depreciation rates.
3) BEA-BEA – Capital input for both countries is calculated using the BEA's depreciation rates.

In 2007, Canada's MFP level in wood product manufacturing was higher than the U.S. level regardless of the depreciation assumption used. The magnitude by which it surpassed the U.S. level, however, differed considerably depending on the assumption. Under the STC-BEA assumption, Canada's level was 25.0 per cent higher than the U.S. level, while under the BEA-BEA assumption the difference fell to only 4.9 per cent. The STC-STC assumption led to a level difference of 15.2 per cent.

In the case of paper products and printing, the situation was not as rosy. Canada's paper manufacturing MFP level was higher than the U.S. level only under the STC-BEA assumption, and even then by only 1.5 per cent. Under the STC-STC and BEA-BEA assumptions, Canada's MFP level was significantly lower than the U.S. level (16.7 per cent and 10.8 per cent, respectively).

MFP in Wood Product and Paper Manufacturing, Canada-U.S. Level Comparison, 2007
(Canada as a % of the U.S., U.S. = 100.0)



Source: Tang, Rao and Li (2010).

C. Energy Productivity

So far, the focus of this report has been on value-added productivity measures – namely, labour and multifactor productivity –, which are arguably the most commonly used measures in productivity analysis. Looking at gross-output measures, however, can also provide important insights regarding the evolution of productivity in the Canadian forest products sector.[20] Given the growing concern with the sector's environmental footprint, one particularly useful gross-output measure is *energy productivity*.

Table 14: Breakdown of Intermediate Input Costs by Category in the Forest Products Sector, 1961-2008 Average

	Intermediate Inputs	Energy Input	Material Input	Services Input
	(share of intermediate input costs, per cent)			
Forest Products Sector	100.0	8.3	78.9	12.8
Forestry and Logging	100.0	6.8	67.0	26.1
Wood Product Manufacturing	100.0	3.8	86.6	9.6
Paper Manufacturing	100.0	11.9	76.9	11.3

Source: Statistics Canada, Productivity Measures and Related Variables – National and Provincial, CANSIM table 383-0022.

Energy input is one of the three broad categories of intermediate inputs used by Statistics Canada's CPA, the other two being materials and services inputs. Energy input captures the use of various fuels in the production process, including electricity, fuel oil, coal, natural gas, and other miscellaneous fuels. In all three forest products subsectors, energy represents the smallest fraction of total intermediate input costs (Table 14), ranging from an average of 3.8 per cent in wood product manufacturing to 11.9 per cent in paper manufacturing. Materials account for the lion's share of intermediate input costs in all three forest products subsectors, ranging from an average of 67.0 per cent in forestry and logging to 86.6 per cent in wood product manufacturing.

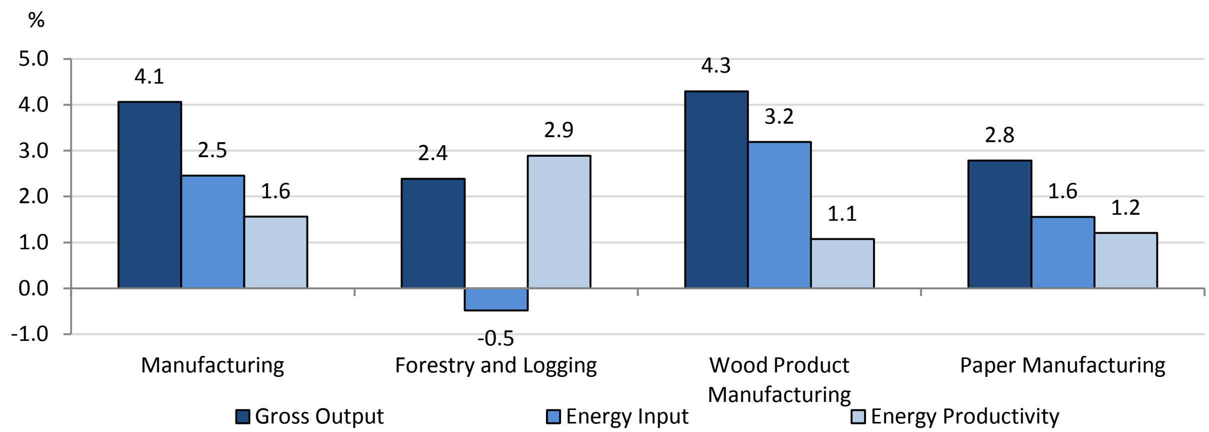
Energy productivity measures how much gross output is produced per unit of energy input used. It is calculated as the ratio between real gross output and an index of energy input use. This index is constructed by Statistics Canada's CPA, and is available for two-digit and

[20] Although this report does not emphasize gross-output labour and multifactor productivity measures in the forest products sector, it is still interesting to look at general trends for these variables, which can be obtained from Statistics Canada's CPA. During the 1961-2008 period, gross-output and value-added labour productivity increased at similar rates for all three forest products subsectors: 3.5 per cent per year in forestry and logging (vs. 3.1 per cent using the value-added measure); 3.5 per cent in wood product manufacturing (vs. 3.8 per cent); and 2.4 per cent in paper manufacturing (vs. 2.4 per cent). Gross-output MFP, on the other hand, increased at a significantly *slower* pace than value-added MFP for all three forest products subsectors: 1.1 per cent per year for forestry and logging (vs. 2.1 per cent using the value-added measure); 0.8 per cent for wood product manufacturing (vs. 2.3 per cent); and 0.3 per cent for paper manufacturing (vs. 1.0 per cent). The slower growth of gross-output MFP vis-à-vis its value-added counterpart points to a lacklustre performance in terms of intermediate input productivity. In fact, despite strong energy productivity gains, materials productivity was stagnant for all three forest products subsectors. Since materials represent a much larger share of intermediate input costs for all three subsectors, this translates into low (or even slightly negative) intermediate input productivity growth and slower gross-output MFP growth.

three-digit NAICS industries. Currently, official energy input estimates for the three forest products subsectors are available from 1961 to 2008.

Chart 30: Energy Productivity Growth in the Forest Products Sector, 1961-2000

(Compound annual growth rates, per cent)

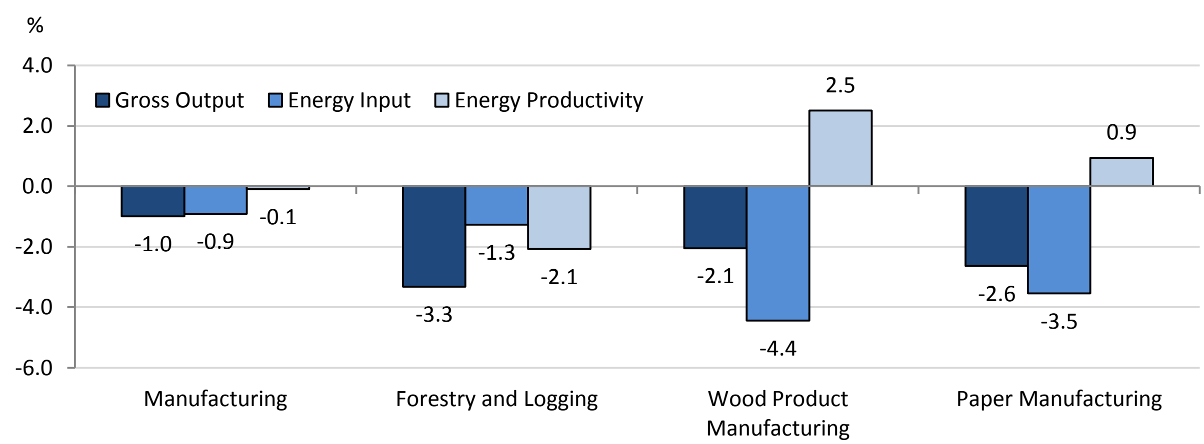


Source: Statistics Canada, Productivity Measures and Related Variables – National and Provincial, CANSIM table 383-0022.

During the 1961-2000 period, energy productivity increased in all three forest products subsectors (Chart 30). The increase was particularly important in forestry and logging, where it averaged 2.9 per cent per year. Energy productivity growth in the other two forest products subsectors averaged 1.1 and 1.2 per cent per year, respectively, slightly less than the energy productivity gains observed for the manufacturing sector as a whole (1.6 per cent per year). Forestry and logging differs from the other two forest products subsectors in that it actually *reduced* its energy input use in the period (-0.5 per cent per year), while increasing gross output. Energy input use in wood product and paper manufacturing, on the other hand, continued to grow throughout the period, albeit at a slower pace than gross output.

Chart 31: Energy Productivity Growth in the Forest Products Sector, 2000-2008

(Compound annual growth rates, per cent)



Source: Statistics Canada, Productivity Measures and Related Variables – National and Provincial, CANSIM table 383-0022.

In the 2000-2008 period, however, energy productivity in the forestry and logging subsector deteriorated, falling 2.1 per cent per year (Chart 31). In wood product and paper manufacturing, energy productivity increased, with energy input use declining at a faster pace than real gross output. Wood product manufacturing, in particular, saw marked improvements in its energy productivity, with average growth at 2.5 per cent per year. In paper manufacturing, energy productivity growth was far less impressive (0.9 per cent per year), although still significantly above the energy productivity performance of the manufacturing sector as a whole (-0.1 per cent per year).

D. Key Findings

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. In terms of multifactor productivity (MFP) growth, the performance of the forest products sector was also impressive, with MFP tripling in a period of stagnant business sector growth

In the past decade, the sector has continued to maintain 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.

Below, we highlight other key findings of our analysis:

- 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.

- In terms of multifactor productivity (MFP) growth, the performance of the forest products sector in the 1961-2012 period was also impressive, with MFP tripling in a period of stagnant business sector growth.

- Between 1961 and 2012, wood product manufacturing saw faster labour productivity growth (3.7 per cent per year) than forestry and logging (3.1 per cent per year) and paper manufacturing 2.0 per cent per year).

- 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).

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

- 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.

- 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 of 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. In a sample of eight OECD countries, Canada had by far the fastest productivity growth in the wood product manufacturing subsector during the 2000-2007 period, both in terms of labour productivity and MFP. The productivity performance of Canada's paper manufacturing, however, was far from stellar.

- During the 1961-2000 period, energy productivity increased in all three forest products subsectors. The increase was particularly important in forestry and logging, where it averaged 2.9 per cent per year. Energy productivity growth in the other two forest products subsectors averaged 1.1 and 1.2 per cent per year, respectively, slightly less than the energy productivity gains observed for the manufacturing sector as a whole (1.6 per cent per year

- In the 2000-2008 period, however, energy productivity in the forestry and logging subsector deteriorated, falling 2.1 per cent per year. In wood product and paper manufacturing, energy productivity increased (2.5 and 0.9 per cent per year, respectively), with energy input use declining at a faster pace than real gross output.

V. Productivity Drivers in the Canadian Forest Products Sector

Sections III and IV detailed the evolution of output, input and productivity in the Canadian forest products sector, looking at both long-term and recent trends. Despite its falling real output and declining share of total economy GDP, the Canadian forest products sector has had an exceptional productivity performance in the last 50 years, outperforming the business sector by far. This performance, however, was mainly driven by strong productivity gains in forestry and logging and wood product manufacturing. Paper manufacturing productivity, on the other hand, increased in line with business sector productivity over the long-run, and has been quite poor in recent years.

This section seeks to understand the reasons behind the productivity performance of the Canadian forest products sector and its subsectors. A good starting point for any discussion on the dynamics of productivity growth is the standard neo-classical growth accounting model. In this model, three key factors determine labour productivity growth:

- *Human capital*: investment in human capital determines the overall quality of the workforce, with better trained and better educated workers being, in general, more productive than the average worker.

- *Physical capital*: investment in capital goods determines the size of the capital stock and, hence, the amount of machinery and equipment and structures available to workers.

- *Technological progress and innovation*: Whether it comes through research and development (R&D), embodied in new capital, learning by doing or other means, innovation can help firms produce goods and services in more efficient ways.

The three factors highlighted above are often referred to as the *sources* of labour productivity growth. It is important to keep in mind, however, that they are (in general) only *proximate* causes of growth, and can be affected by several underlying factors, including (but not limited to): industrial structure shifts, changes in the resource base, the macroeconomic environment, as well as a wide range of policies.

In this section, we first use the standard growth accounting framework to determine the sources of labour productivity growth in the Canadian forest products sector and its subsectors; next, we discuss human capital and innovation indicators in the forest products sector in an effort to identify possible barriers to productivity growth; finally, other factors that can have an effect on labour productivity growth are discussed, and key findings are summarized.

A. Growth Accounting

Using a standard growth accounting framework (see Appendix), contributions to labour productivity growth can be broken down into three factors: 1) capital services intensity growth; 2) labour composition growth; and 3) multifactor productivity (MFP) growth. In this subsection, we first define these three factors, and then discuss their role in driving labour productivity growth in the Canadian forest products sector.

When used in a production process, capital stock generates a flow of *capital services* (also known as *capital input*). Different capital assets provide services at different rates. As Baldwin, Gu and Yan (2007:24) note:

> Short-lived assets, such as a car or computer, must provide all of their services in just the few years before they completely depreciate. Office buildings provide their services over decades. So, in a year, a dollar's worth of a car provides relatively more services than a dollar's worth of a building.

Thus, capital services *growth* is a function of two components: 1) capital stock growth; and 2) shifts in the composition of capital, caused by more investment in assets that provide relatively more services per dollar of capital stock (i.e. short-lived assets). What is relevant to labour productivity growth, however, is not the growth in capital services *per se*, but the growth in capital services per hour worked. In general, the more capital a worker has at his disposal, the more productive he is. The ratio between capital services and hours worked is called *capital services intensity*.

Labour composition captures (albeit very imperfectly) improvements in human capital. Statistics Canada defines labour composition as the ratio between labour input and hours worked. Labour input, in turn, is obtained by aggregating hours worked across different categories of workers using hourly compensation as weights. The variables used to categorize workers are: education (broken down into four levels), experience (proxied by seven age groups), and class of workers (paid employees vs. self-employed workers). Overall, there are 56 different categories of workers. Like capital services, labour input *growth* can be decomposed into two components: 1) hours growth; 2) labour composition growth.

Finally, multifactor productivity (MFP), as explained before, is the ratio between output and combined labour and capital inputs. 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. While capital intensity growth contributed only slightly less to labour productivity growth in the forest products sector than it did in the business sector (1.1 vs. 1.3 percentage points, respectively), the contribution of labour composition growth was the same in both sectors (0.4 percentage points) (Table 15). The labour productivity differential between the forest products sector and the business sector can thus be *entirely* attributed to differences in MFP growth (1.4 vs. 0.2 percentage points, respectively).

Table 15: Sources of Labour Productivity Growth in the Forest Products Sector, 1961-2012

	Business Sector	Forest Products Sector	Forestry and Logging	Wood Product Manufacturing	Paper Manufacturing
	(compound annual growth rates, per cent)				
Real GDP	3.5	1.8	1.1	3.2	1.1
Hours Worked	1.5	-1.0	-1.9	-0.4	-0.9
Capital Services	4.8	1.8	0.4	2.6	1.0
Capital Stock	3.1	1.0	0.0	2.6	0.5
Capital Composition	1.6	0.8	0.4	0.0	0.5
Capital Services Intensity	3.2	2.8	2.4	3.0	1.9
Labour Composition	0.7	0.5	0.3	0.5	0.8
	(average share of nominal GDP, per cent)				
Capital Compensation Share	40.1	34.6	34.2	29.8	36.5
Labour Compensation Share	59.9	65.4	65.8	70.2	63.5
	(percentage point contributions to labour productivity growth)				
Labour Productivity	1.9	2.8	3.1	3.7	2.0
Contribution of Capital Intensity	1.3	1.1	0.9	1.2	1.0
Capital Stock	0.8	0.6	0.1	1.2	0.5
Capital Composition	0.4	0.5	0.8	0.0	0.5
Contribution of Labour Composition	0.4	0.4	0.2	0.4	0.5
MFP	0.2	1.4	2.2	2.3	0.7
	(per cent contributions to labour productivity growth)				
Labour Productivity	100.0	100.0	100.0	100.0	100.0
Contribution of Capital Intensity	66.9	39.0	28.0	32.8	47.4
Capital Stock	43.8	21.0	2.7	32.9	22.8
Capital Composition	23.1	17.9	25.3	-0.1	24.6
Contribution of Labour Composition	22.0	13.2	5.9	10.6	26.1
MFP	11.7	51.6	69.3	62.1	33.5

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

Overall, the above story is true not only for the forest products sector as a whole, but also for its subsectors. A few differences, however, are worth highlighting:

- The contribution of capital intensity growth to labour productivity growth ranged from a low of 0.9 percentage points in the case of forestry and logging to a high of 1.2 percentage points in the case of wood manufacturing. It was 1.0 percentage point in the case of paper manufacturing.

- The contribution of labour composition growth to labour productivity growth was lowest in forestry and logging (0.2 percentage points) and highest in paper manufacturing (0.5 percentage points). It was 0.4 percentage points in the case of wood product manufacturing.

- MFP had the highest contribution to labour productivity growth in forestry and logging and wood product manufacturing (2.2 and 2.3 percentage points, respectively), but was less important than capital intensity growth in the case of paper manufacturing (0.7 percentage points), which explains why labour productivity growth in paper manufacturing was only slightly higher than business sector growth.

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 16, Panel A). However, this hides significant differences at the subsector level, particularly between paper manufacturing and the other two forest product subsectors.

Despite falling hours worked, the massive decline in the capital stock of the paper manufacturing subsector caused capital intensity to fall 1.7 per cent per year, leading to a negative contribution to labour productivity growth (0.7 percentage points). On the other hand, labour composition and MFP growth contributed 0.5 and 1.0 percentage points (respectively) to labour productivity growth, resulting in an average labour productivity growth of 0.8 per cent per year. Business sector labour productivity growth, in turn, was caused mainly by capital intensity growth (1.1 percentage points), with labour composition growth playing a small role (0.3 percentage points), and MFP growth actually having a negative contribution (-0.6 percentage points).

In forestry and logging and wood product manufacturing, while labour composition growth contributed very little to labour productivity growth (0.0-0.1 percentage points), both capital intensity and MFP growth played a large role in driving labour productivity growth. Both subsectors saw a fall in their capital stock, but hours worked declined at a faster pace, meaning that workers had, in general, more capital to work with. Capital intensity growth contributed 1.9 and 2.3 percentage points to labour productivity growth in forestry and logging and wood product manufacturing, respectively. Both subsectors also had substantial MFP gains, with MFP growth contributing 1.8 and 3.6 percentage points (respectively) to labour productivity growth. Summing up those three factors, labour productivity grew 3.6 per cent per year in forestry and logging and 5.9 per cent per year in wood product manufacturing during the 2000-2008 period.

Table 16: 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
	(compound annual growth rates, per cent)				
Real GDP	2.1	-1.2	-1.4	-0.1	-2.0
Hours Worked	1.3	-4.6	-4.8	-5.7	-2.8
Capital Services	3.9	-2.2	-0.7	-0.6	-4.4
Capital Stock	2.6	-4.0	-2.6	-0.5	-5.9
Capital Composition	1.3	1.8	1.9	-0.1	1.6
Capital Services Intensity	2.6	2.5	4.3	5.4	-1.7
Labour Composition	0.5	0.3	0.0	0.1	0.9
	(share of nominal GDP, per cent)				
Capital Compensation Share	43.1	39.4	41.3	41.7	35.7
Labour Compensation Share	56.9	60.6	58.7	58.3	64.3
	(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
	(compound annual growth rates, per cent)				
Real GDP	0.8	-3.0	-1.3	-0.8	-6.4
Hours Worked	0.1	-3.3	-3.8	-2.5	-4.2
Capital Services	2.1	-3.8	-3.7	-3.8	-5.1
Capital Stock	1.1	-5.5	-5.5	-3.7	-6.6
Capital Composition	1.0	1.8	1.9	-0.1	1.6
Capital Services Intensity	2.0	-0.5	0.1	-1.4	-1.0
Labour Composition	0.5	0.3	0.0	0.1	0.9
	(share of nominal GDP, per cent)				
Capital Compensation Share	43.9	..	..	..	..
Labour Compensation Share	56.1	..	..	..	..
	(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.

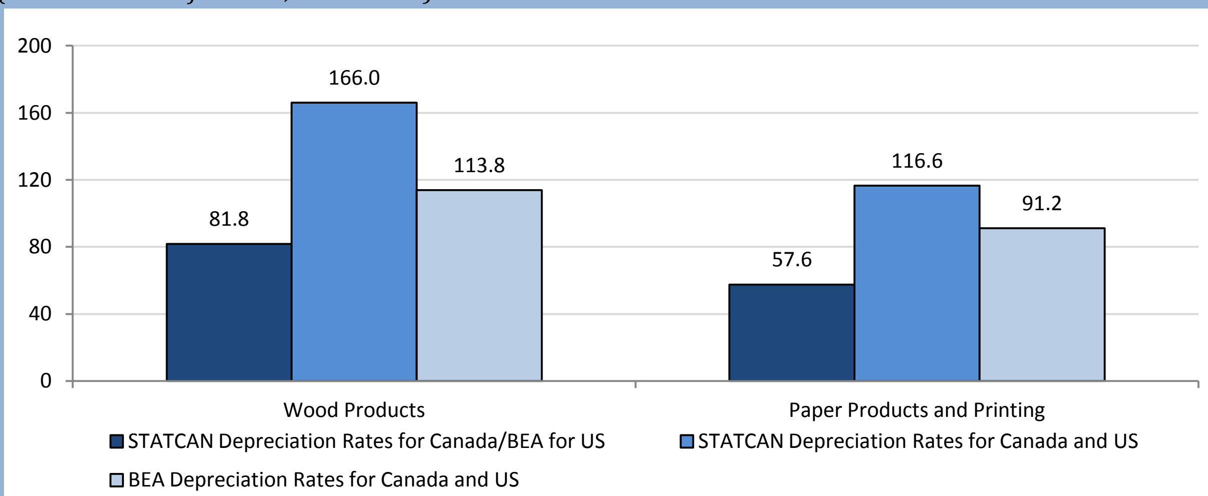
Source: CSLS calculations based on Statistics Canada data.

Box 7: Capital Intensity Levels in Canada and in the United States

Using three different depreciation assumptions (described in Box 6), Tang, Rao, and Li (2010) calculated relative capital intensity levels for a variety of manufacturing industries in Canada and in the United States in 2007, including wood product manufacturing and paper products and printing.

Using the STC-BEA assumption, Canada had lower capital intensity levels in both wood product manufacturing and paper products and printing (81.8 per cent of the U.S. level and 57.6 per cent, respectively). When depreciation rates were equalized across countries, however, Canada's relative capital intensity levels rose considerably. Under the STC-STC assumption, Canada had higher capital intensity levels in both industries (166.0 per cent of the U.S. level in wood product manufacturing and 116.6 per cent in paper products and printing), while under the BEA-BEA assumption Canada had a higher capital intensity level in wood product manufacturing (113.8 per cent of the U.S. level), but a lower capital intensity level in paper products and printing (91.2 per cent of the U.S. level).

Capital Intensity in Wood Product and Paper Manufacturing, Canada-U.S. Level Comparison, 2007
(Canada as a % of the U.S., U.S. = 100.0)



Source: Tang, Rao and Li (2010).

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 (in which labour productivity declined 2.3 per cent per year), 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 16, Panel B):[21]

[21] The reader should bear in mind that the contribution estimates for the 2008-2012 period are based on preliminary MFP estimates calculated by the CSLS, and thus should be interpreted with caution.

- Capital intensity was either stagnant or fell in all three forest products subsectors. In forestry and logging, the contribution of capital intensity growth to labour productivity growth fell from 1.9 percentage points in the 2000-2008 period to only 0.1 percentage points; in wood product manufacturing, it declined from 2.3 percentage points to -0.4 percentage points; in paper manufacturing, it remained negative at -0.4 percentage points (up from -0.7 percentage points in the previous period);

- The contribution of MFP growth to labour productivity growth fell in wood product manufacturing (from 3.6 to 2.1 percentage points) and paper manufacturing (from 1.0 to 2.6 percentage points); it increased in forestry and logging, however, from 1.8 to -2.6 percentage points.

It should be clear from the above discussion that MFP growth has been the main driving force behind the rapid labour productivity growth in the forest products sector. Labour composition growth, on the other hand, has had a below-average contribution to labour productivity growth in two out of three forest products subsectors, namely: forestry and logging and wood product manufacturing. The next two subsections investigate the reasons for these trends in more detail, looking at human capital and innovation indicators for the forest products sector and its subsectors. Note that capital intensity indicators will not be discussed in more detail here, given that capital input trends in the forest products sector were already covered extensively in Section III-C.

B. 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. First, we examine trends in average years of schooling; this is followed by a breakdown of the workforce of the forest products sector by educational attainment level; next, we investigate the risks of labour shortages in the sector.

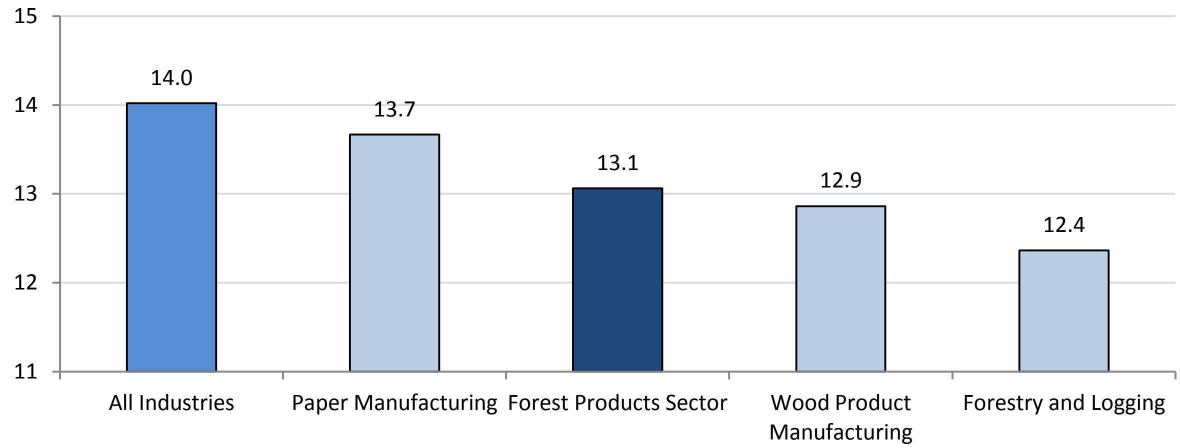
i. Average Years of Schooling

In 2012, workers in the Canadian forest products sector had, on average, 13.1 years of education,[22] almost one full year less than the average worker in the Canadian economy, which had 14.0 years of education (Chart 32). There were, however, important differences at the

[22] Average years of schooling were calculated by the CSLS using Labour Force Survey (LFS) estimates. The LFS breaks down workers into 6 main categories according to their highest level of educational attainment. The CSLS multiplied the proportion of workers in each category by the assumed years of schooling necessary to reach specific educational levels and summed up the total. Assumed years of schooling for each educational attainment level were as follows: 8 years for workers with 0 to 8 years of schooling; 10 years for workers with some high school; 12 years for high-school graduates; 13 years for workers with some post-secondary; 14 years for workers with non-university post-secondary (e.g. apprenticeship degrees, college programs etc.); 16.5 years for university graduates.

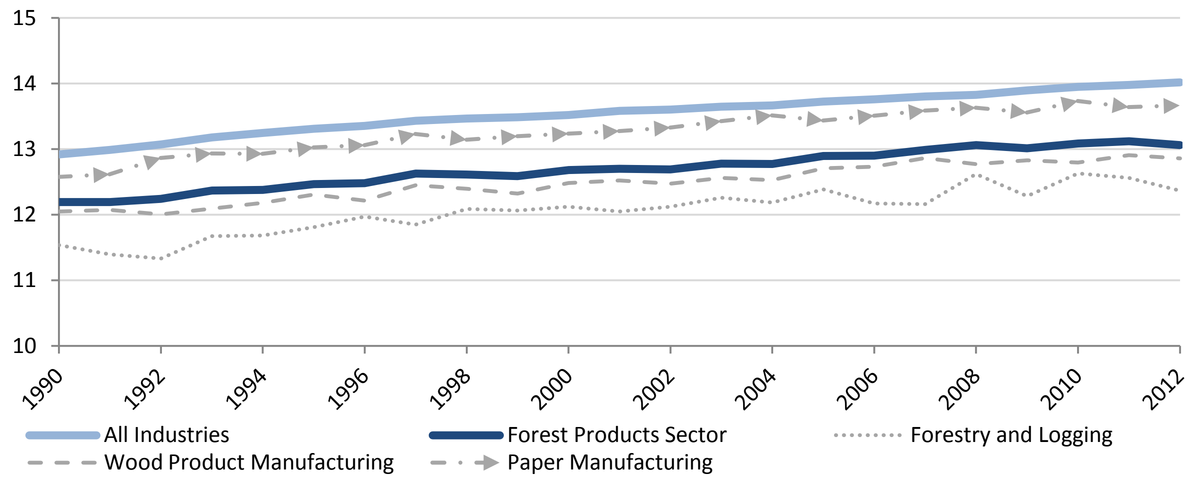
subsector level. While paper manufacturing workers had almost the same level of schooling than the average Canadian worker (13.7 years), forestry and logging workers had only 12.4 years of education, 1.6 years less than the national average. Workers engaged in wood product manufacturing had on average 12.9 years of schooling.

Chart 32: Average Years of Schooling for Workers in the Forest Products Sector, 2012



Source: Labour Force Survey, special data order.

Chart 33: Average Years of Schooling for Workers in the Forest Products Sector, 1990-2012



Source: CSLS calculations based on Statistics Canada data.

Over the past 22 years, the education level of Canadian workers has risen consistently, and workers in the forest products sector are no exception (Chart 33). 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). Average years of schooling increased 0.9 years for workers engaged in forestry and logging activities (from 11.5 years to 12.4 years) and wood product manufacturing (from 12.0 years to 12.9 years), but increased 1.1 years for paper manufacturing workers (12.6 years to 13.7 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.

ii. Breakdown of Workforce by Highest Level of Educational Attainment

Although average years of schooling estimates are useful indicators of educational attainment, they provide only a general idea of the education level of workers in the forest products sector and its subsectors. A breakdown of workers by their highest educational attainment level allows for a more detailed picture of the state of formal education in the sector, and the differences between workers in the forest products sector and the average Canadian worker.

Chart 34 looks at the proportion of workers in each of five educational categories for the forest products sector and its subsectors,[23] comparing those proportions to the Canadian averages. 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) (Panel C); 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).

At the subsector level, paper manufacturing workers were the most likely to have a university degree (12.4 per cent) – followed by workers in wood product manufacturing and forestry and logging (8.6 and 4.7 per cent, respectively) –, although they were still far less likely to have a university education than the average Canadian worker. Paper manufacturing workers were also the most likely to have a non-university post-secondary degree (47.7 per cent vs. 34.7 and 31.6 per cent for wood product manufacturing and forestry and logging, respectively).

The three forest products subsectors had similar proportions of workers with only a high-school education (between 22.3 and 27.7 per cent) or incomplete post-secondary studies (between 5.9 and 6.2 per cent). It should be noted, however, that more than a third of the workers engaged in forestry and logging activities had *less* than a high-school education (35.5 per cent). This is an extremely high number not only when compared to the Canadian economy as a whole (where only 10.3 per cent of the workers had less than a high-school education), but also compared to the other two forest products subsectors. The proportion of workers with less than a high-school education was 23.2 per cent for wood product manufacturing and 11.0 per cent for paper manufacturing.

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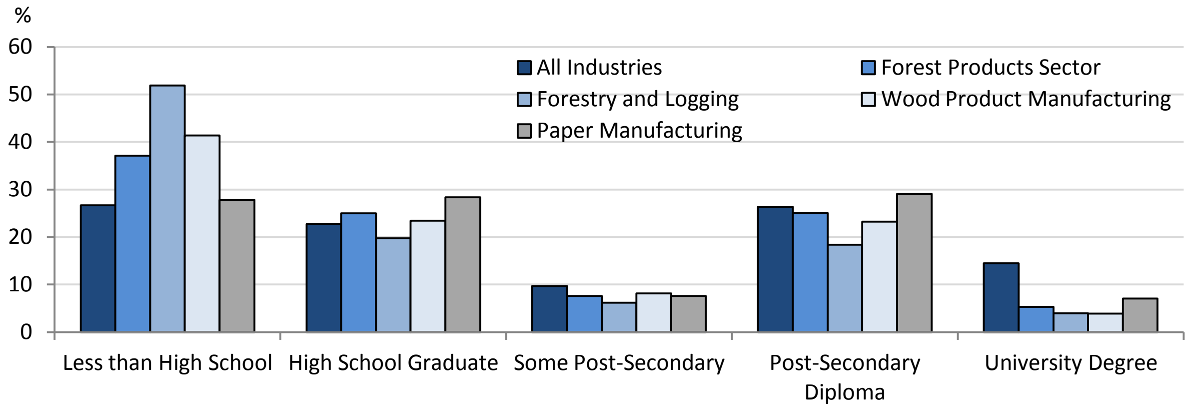
[23] Workers with 0 to 8 years of schooling and some high school were grouped together under the category "less than high school".

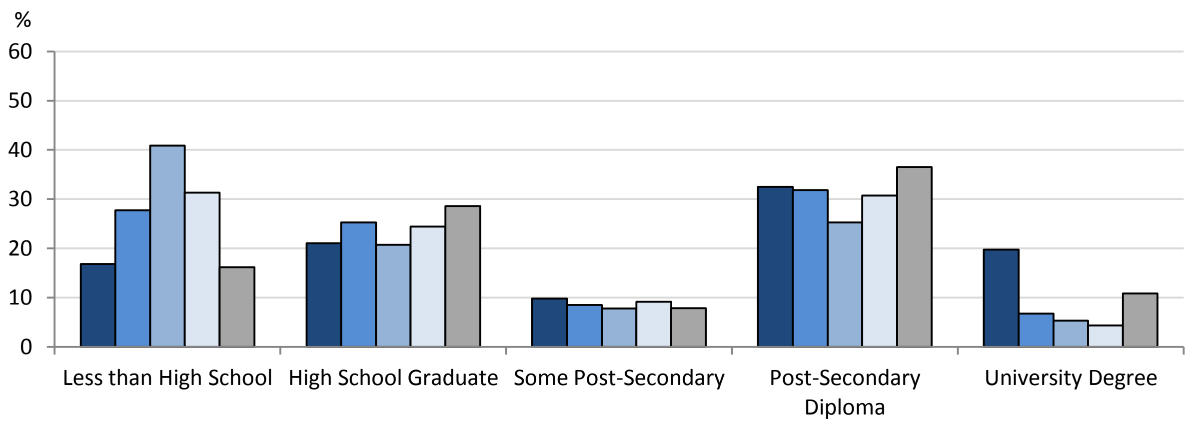
Chart 34: Highest Level of Educational Attainment for Workers in the Forest Products Sector, 1990, 2000, 2012

(Per cent of workforce)

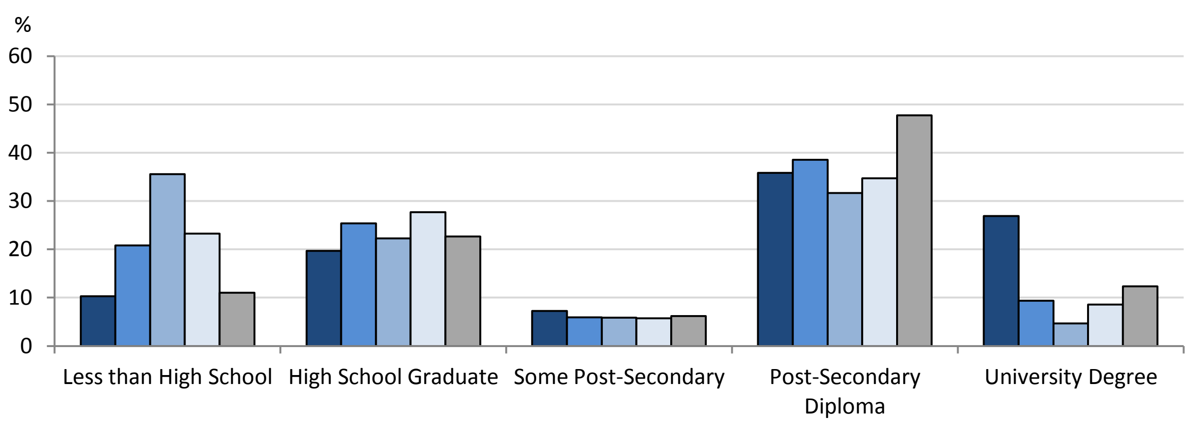
A) 1990



B) 2000



C) 2012



Source: Labour Force Survey, special data order.

Despite the high number of workers with less than a high-school education in the forest products sector, it is important to keep in mind that there have been noticeable improvements in this front over the past two decades. In 1990, almost 40 per cent of the workers in the sector had less than a high-school education, significantly more than the proportion for the Canadian economy as a whole (26.7 per cent) (Chart 34, Panel A). While the proportion of paper manufacturing workers without a high-school education was roughly the same as for the total economy, more than half of the forestry and logging workers and over 40 per cent of the wood product manufacturing workers did not have a high-school diploma.

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 have a significant negative impact on worker productivity.

iii. Skill Shortages

Skill shortages can have a negative impact on productivity by reducing the quality of labour market matching. When certain skills are in short supply, the bargaining power of workers who possess those skills increases, usually prompting a rise in hiring costs. According to Haskel and Martin (1993), this can cause firms to settle for less skilled, cheaper workers, who tend to have lower productivity. Another issue is that, due to the lack of skilled labour, firms may not be able to run at full capacity or, even worse, they may be "unable to staff specialized positions that could arguably drive technological or organization change and in turn boost productivity growth" (Arsenault and Shape, 2008:29).

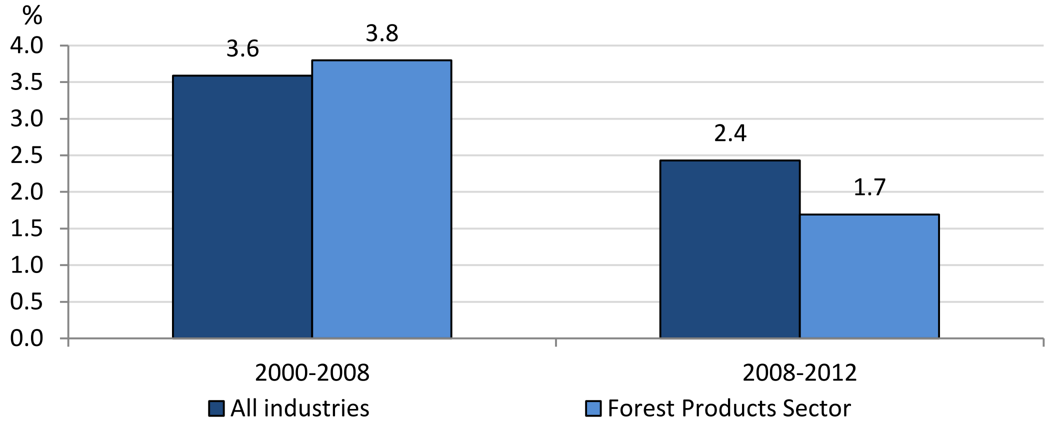
According to the Forest Products Sector Council (FPSC) (2011), the forest product sector will need to hire between 40,000 and 120,000 new workers between now and 2020, both for the replacement of retiring workers and for the creation of new jobs in the industry. Even if employment in the sector remains stable, 53,000 workers are expected to leave in the coming decade, creating an important demand for new workers. It is hard to define the type of occupations or the skill levels that will be needed, as the "affected occupations range from entry level positions – requiring lower levels of formal education and training – to highly skilled careers requiring post-secondary education" (FPSC, 2011:12).

The FPSC argues, however, that far from being only a future concern, skill shortages are already affecting several areas in the Canadian forest products sector. Specific positions identified by the FPSC as occupations where firms currently have difficulty hiring new workers include process operators; harvesting and logging machine operator; skilled tradespeople, including millwrights and stationary engineers; foresters; engineers; and sawmill and pulp mill managers.

In addition, when wood product manufacturing companies were asked in a survey by the Wood Manufacturing Council (WMC) (2007) which factor was most limiting to their growth, the most common answer was skilled staff shortages, at 29.7 per cent. An impressive 83.5 per cent of the companies surveyed claimed that there was a shortage of skilled tradespeople. Some firms also experienced more general labour shortages, with 37.5 per cent of the respondents saying that they were having difficulties hiring entry-level workers.

Chart 35: Hourly Compensation Growth in the Forest Products Sector, 2000-2008 and 2008-2012

(Compound annual growth rates, per cent)



Source: CSLS calculations based on Statistics Canada data (CANSIM Tables 383-0010/30).

Official data on hourly compensation provide additional evidence to the hypothesis that the Canadian forest products sector faces problems related to skill shortages. Upward pressure on wages can be seen in the forest products sector, especially during the 2000-2008 period. Despite falling employment, hourly compensation increased by 3.8 per cent per year (respectively) between 2000 and 2008, more than the average annual increase of 3.6 per cent observed at the total economy level. After 2008, with the recession, wage pressures in forestry and logging and wood product manufacturing seem to have subsided, though hourly compensation continued to rise at 1.7 per cent annually..

In light of these facts, it seems reasonable to assume the forest products sector is indeed facing skill shortage problems, especially in the paper manufacturing subsector. We have identified five reasons for the current skill shortage problems the sector has been facing:

- An aging workforce;
- The low enrollment and closure of forestry schools;
- The bad perception of the industry by potential workers;
- The fear of "poaching" by other industries (in particular oil and gas); and
- The inappropriate attitude of employers toward training activities.

The threat posed by the aging workforce is threefold. First, many older workers have jobs that require considerable physical effort, energy and dexterity. Needless to say, aging workers experience a decline in their non-cognitive abilities, which may cause their productivity to fall (Sharpe, 2011). Second, older workers may experience greater difficulties in learning new skills. Third, with the retirement age of workers in the forest products sector being under the national average, and more than half of the sector's workforce being 45 years old or older (FPAC, 2011:6), there might not be enough experienced journeypersons to train new apprentices. "Easy" solutions like the acceleration of apprenticeship training or increasing the ratio of apprentices to journeypersons could prove to be counterproductive, as they could lead to questionable results in terms of skill acquisition or skill portability.

Another concern related to the quality of labour supply in the forest product sector is the declining enrolment in forest products-related educational programs at the post-secondary level (CIF, 2006 and FPSC, 2012). Lower enrollment rates have vicious effects, as they force the closure of forestry schools and further reduce educational opportunities in forest products-related training. To cite a report by the FPSC (2012:13), "it appears the education and training systems are unsuccessful in recruiting and thus graduating sufficient numbers to meet industry demand". As an example, three of the 13 programs offering training in wood manufacturing in 2012 were suspended because of lack of applicants.

The low enrollment levels in educational programs and the general difficulty of forest-product firms to train and attract new workers may have common causes. Many argue, for instance, that the sector is poorly perceived by the Canadian population, with potential workers viewing the sector as a last resort, an industry in decline that does not have much to offer other than low-paying jobs (FPSC, 2012; APEC, 2008; CIF, 2006).

Another important barrier to skill development in the forest products sector is the fear of "poaching" by other sectors, i.e. the fear that workers being trained by forest-product firms will leave the sector for better paying opportunities in other industries (such as oil and gas) as soon as their training is completed. In the advanced wood products manufacturing industry, for example, the top reason for voluntary turnover (64 per cent) was that workers found another job outside the industry (WMC, 2012). This phenomenon can substantially reduce the incentive of firms to train their employees.

Finally, many argue that an important reason why the forest product sector experiences problems in meeting its demand for skilled workers is the inappropriate mentality of employers with respect to training activities. A report by Woodbridge Associates (2009:79) states, for instance, that:

> There still is a cultural attitude among industry managers that a "pool" of skilled workers – and an educated general labour force – should be made available freely to firms from the publicly-funded secondary and post-secondary education system. This 'historically trapped' cultural attitude emanates from the extractive nature of the industry, and the traditional 'hire and fire' approach to dealing with volatile industry cycles.

C. Innovation

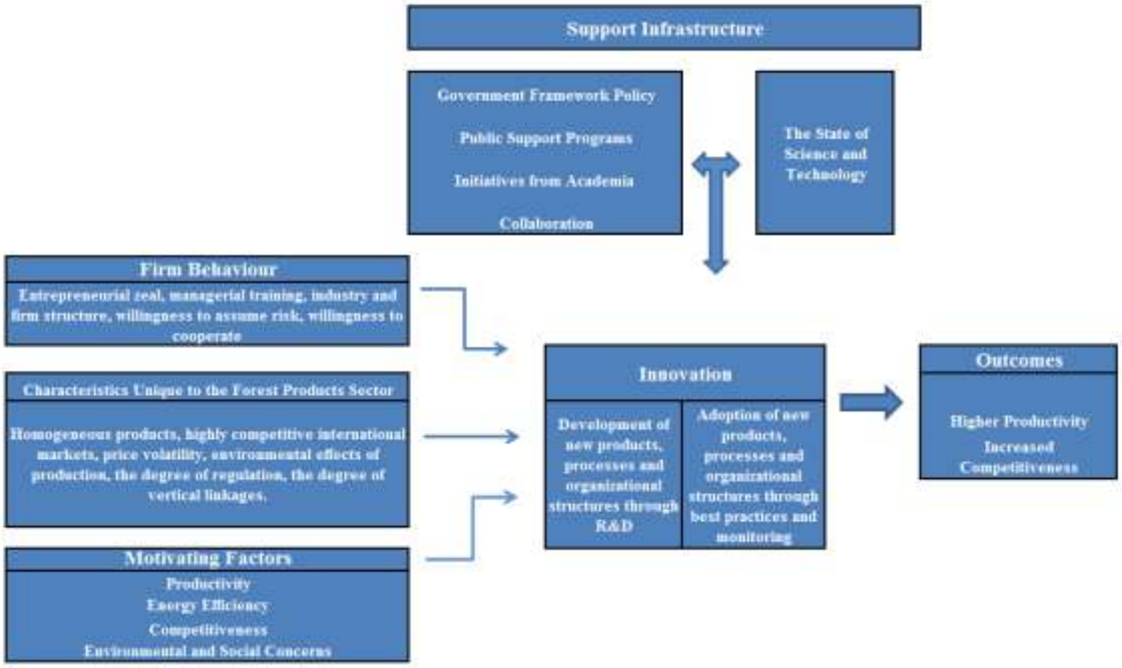
This subsection investigates the role of innovation in driving productivity growth in the Canadian forest products sector. It draws heavily from Sharpe and Long (2012), using a systems of innovation approach to understand the overall state of innovative activity in the forest products sector. First, we provide a general definition of innovation and discuss some important characteristics of the forest products sector that can affect innovative activity. Next, a number of innovation indicators in the sector are analyzed.

i. Defining Innovation

A standard definition of innovation, used by the OECD in the Oslo Manual (OECD/Eurostat, 2005:46), states that innovation is "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations". Similarly, Canada's Federal Science, Technology and Innovation Council (2011) defines innovation as: "the process by which individuals, companies and organizations develop, master and use new products, designs, processes and other business methods."

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).

Exhibit 2: The Innovation System in the Canadian Forest Products Sector



Source: Adapted from Sharpe and Long (2012).

Innovation in the Canadian forest products sector is influenced by the sector's general characteristics and by firm behaviour. The forest products sector has a number of unique characteristics, including: homogeneous products; highly competitive international markets; output price volatility; environmental effects of production; a complex regulatory environment; and a significant degree of inter-industry vertical linkages.

Firm behavior related to innovation is affected by the environment external to the firm and the characteristics of business leaders. The former include the state of aggregate demand, the exchange rate, environmental and social concerns, industry structure and competitive intensity, among others. The latter include ownership and control structures affecting decision making, entrepreneurial drive and willingness to assume risks, managerial training, business strategy, and willingness to cooperate with others. These factors influence innovation in all industries, not just natural resource industries.

The support infrastructure for innovation in the forest products sector includes the overall state of sciences and technology relevant to the sector in terms of basic and applied research, in both Canada and abroad. This infrastructure also encompasses government framework policies, including macroeconomic policies, such as fiscal policy, and microeconomic policies, such as tax policy, intellectual property policy. The universities represent an additional component of this support infrastructure for innovation in natural resource industries, undertaking basic and applied research and educating skilled personnel. Collaborative efforts related to innovation between government and business, universities and business, and among all three players represent a final element of this support infrastructure.

The outcomes arising from innovation are higher productivity levels and a higher degree of international competitiveness, which in turn ensure that the industry prospers. At the aggregate economy level, increased productivity generally translates into increased living standards and economic well-being.

ii. 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:

- *Homogenous products*: Outputs of the forest products sector are generally commodities, such as pulp and lumber, which are by definition homogenous goods. As a consequence, there is little room for firms in the sector to compete via product differentiation, making them highly sensitive to international market conditions. Generally, forest-product firms are price takers that must prioritize cost-effectiveness in order to remain competitive. This bias towards cost savings suggests that forest-product firms should tend to engage in process innovation more than manufacturing or service industries.

- *Highly competitive international markets*: In the past decade, the Canadian forest products sector has faced increased competitive pressure from the international marketplace. Competition from state-of-the-art paper mills in Europe, China and the tropics – coupled with falling demand for newsprint – has taken its toll on Canadian paper manufacturing (Wernerheim and Long, 2011). However, competition is also an important driver of innovation (Sharpe and Currie, 2008), and the Canadian forest products sector still shows a great deal of innovative potential.

- *Price volatility*: The volatility of commodity prices makes it difficult for forest-product firms to plan their future, biasing them towards production (as opposed to innovating) when prices are high, and making them hesitant to invest in innovative activities when prices are low. The desire to capitalize on high commodity prices without consideration for long-term development hinders innovation in the sector, diverting resources from R&D in favour of short-term production (Centre for Innovation Studies, 2008).

- *Environmental effects of production*: Issues surrounding sustainability and environmental considerations have generated additional pressure on forest-product firms to “clean up”.

Improving environmental outcomes is now a priority for the Canadian forest products sector. Not only can it improve the sector's public image, but it can also broaden its market access as the demand for eco-friendly forest products increase. The increasingly competitive international market will reward clusters that enhance energy efficiency and reduce emissions intensity with substantial cost-savings.

- *The degree of regulation*: Compared to other sectors in the economy, natural resource industries tend to be more regulated. This is also true for the Canadian forest products sector in particular, which is not surprising given that 93 per cent of all Canadian forests are owned by the government (Natural Resources Canada, 2011). Rheaume and Roberts (2007:110), for example, find that "the regulatory approval processes for new mills (…) are slow and cumbersome". Major projects may have to receive approval from federal, provincial and municipal governments, which implies three sets of regulations to comply with. Rheaume and Roberts (2007:110) note, furthermore, that "federal and provincial regulations are often overlapping and duplicative, making approval processes complex and costly". In general, economists argue that regulations tend to inhibit innovation. However, properly designed regulations can foster innovation by forcing firms to adopt or develop advanced technologies (Porter hypothesis).

- *The degree of vertical linkages in production*: The forest products sector is characterized by a high degree of vertical linkages between its component subsectors. The sector is composed of a main primary subsector (forestry and logging) and two downstream subsectors (wood product and paper manufacturing). The effect of vertical linkages on innovation is ambiguous. On the one hand, an upstream industry may be unwilling to engage in innovative efforts because downstream industries will share the benefits, but not the costs of innovation. On the other hand, if the production processes of several industries are integrated, then the innovative needs of the sector as a whole are known amongst firms, leading to collaborative efforts and co-innovation that benefit the sector as a whole.

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.

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).

iii. Innovation Indicators

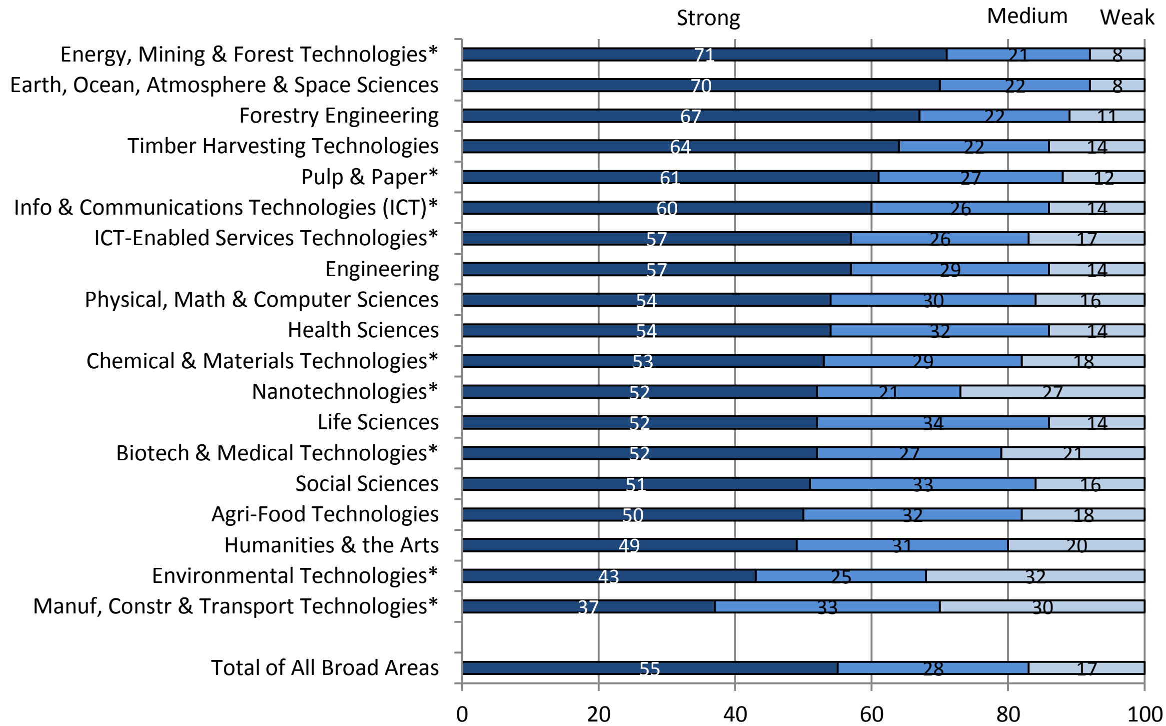
Given the inherent complexity of innovative activities, no single indicator can summarize the state of innovation in an industry. In this sense, we analyse several different indicators of innovation in the forest products sector, each of which provides a partial picture of the sector's overall innovative capacity. Indicators discussed here include: business enterprise R&D expenditures; R&D intensity; R&D personnel; M&E investment intensity; foreign direct investment; incidence of innovation, among others.

a. 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), while only 8 per cent considered the area weak (vs. 17 per cent for all areas) (Chart 36). Drilling down to a greater level of detail, two forest products-related S&T sub-areas were at 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.

Chart 36: Average Strength Rating of Broad S&T Areas
(Per cent of respondents)



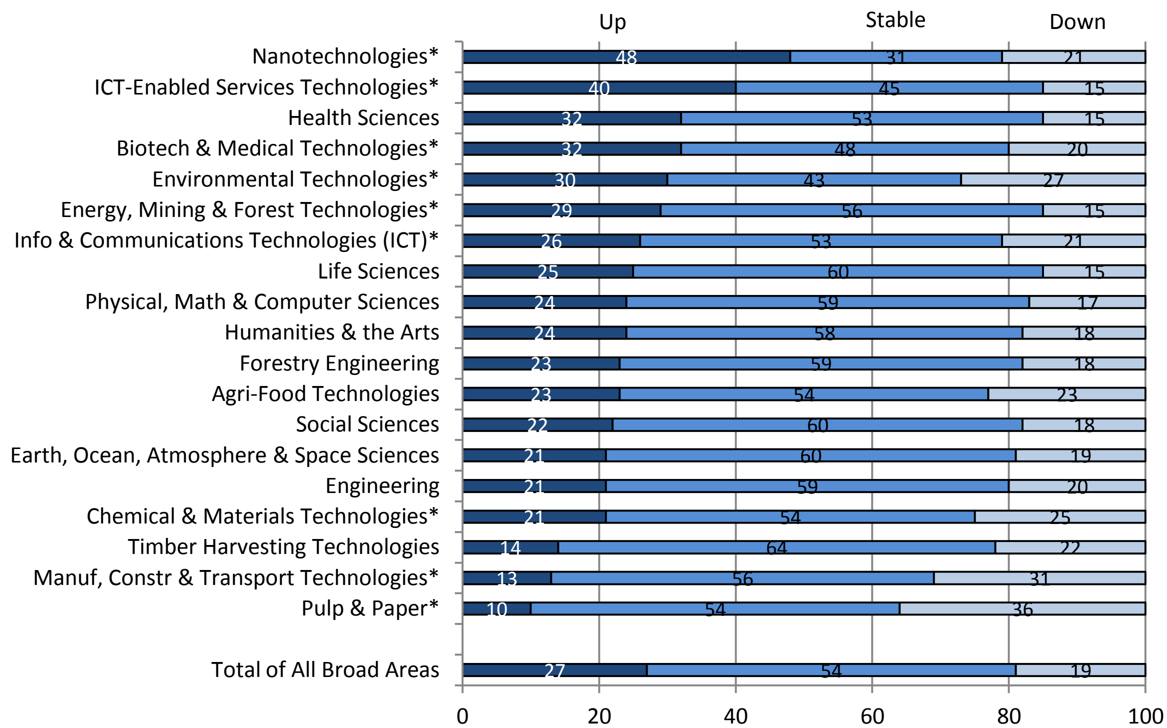
* Broad areas of technology application; others (no asterisk) are areas of scientific research.
Source: Council of Canadian Academies (2006), Figure 1 (p. 4) and Appendix 4.

Despite their high ranking, 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. In pulp and paper, for instance, only 10 per cent of the respondents perceived an upward movement (vs. 27 per cent for all areas) in terms of S&T strength, while 36 per cent expected a downward trend (vs. 19 per cent for all areas) (Chart 37). The trend for timber harvesting technologies was also far from positive, with only 14 per cent of the respondents expecting an improvement and 22 per cent projecting a decline in the relative strength of the sub-area. Of the three forest products-related sub-areas, forestry engineering was the only one that had a relatively positive expected trend, with 23 per cent of the respondents perceiving an upward movement in the near future and 18 per cent a downward movement.

The Council of Canadian Academies updated and expanded its assessment of the state of S&T in Canada in 2012. In addition to important methodology changes, the new report uses a different breakdown of S&T areas and sub-areas that does not provide as much detail on the state of S&T in the forest products sector as the 2006 report. Nonetheless, it seems to confirm many of the expected trends. 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).

Chart 37: Average Trend Rating of Broad S&T

(Per cent of respondents)



* Broad areas of technology application; others (no asterisk) are areas of scientific research.
Source: Council of Canadian Academies (2006), Figure 1 (p. 4) and Appendix 4.

b. 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). However, the relationship between these two variables is complex. R&D takes time, and its benefits often materialize only years down the road. In the short term, firms that invest more in R&D might not be able to invest as much as they would like in physical capital, leading to a temporary slowdown in productivity growth. To make matters even more complicated, the effect of R&D on productivity can manifest itself through both embodied technical change (better quality or innovative capital assets) and disembodied technical change (e.g. organizational change). In this sense, it is extremely hard to quantify the *exact* contribution of R&D to productivity growth. Nonetheless, we can confidently state that more R&D leads to faster MFP growth and, consequently, to faster labour productivity growth. 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.

In 2012, firms in the forest products sector spent 221 million in R&D (Table 17). Paper manufacturing R&D accounted for 55 per cent of total BERD in the forest products sector, with wood product manufacturing R&D responsible for 38 per cent and forestry and logging R&D accounting for the remaining 6 per cent.

Table 17: 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.

During the 2000-2008 period, BERD spending in the forest products sector grew in line with total economy BERD spending (3.8 per cent per year).[24] 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),[25] 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 (Chart 38), especially forestry and logging, where it fell by 66.7 per cent in a single year (in wood product and paper manufacturing it fell by 54.3 and 51.0 per cent, respectively). In the 2009-2012 period, BERD spending started to increase again in forestry and logging and paper manufacturing, growing at a rate 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, especially wood product manufacturing.[26]

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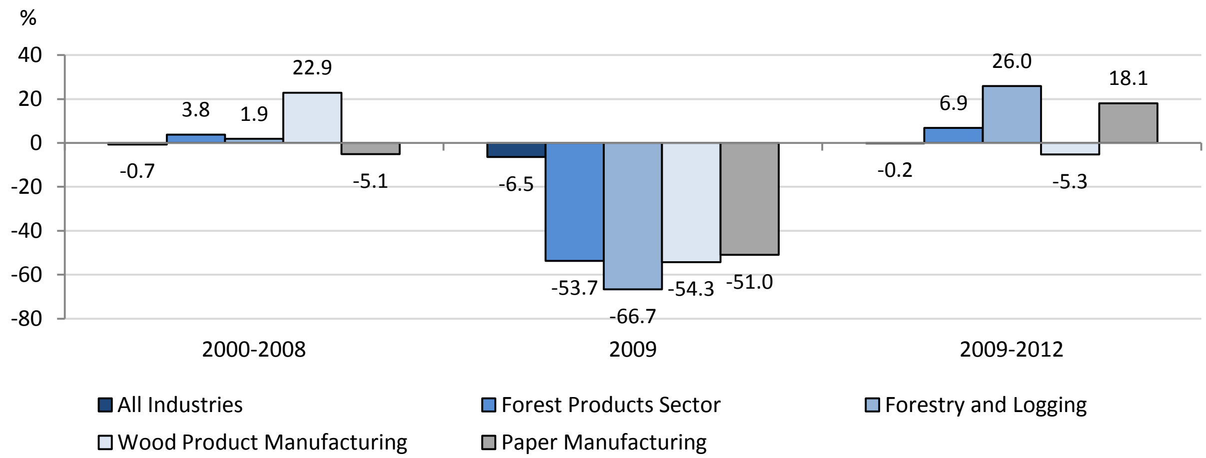
[24] For the 1994-2000 period, R&D expenditures in the forest products sector increased at an average annual rate of 11.7 per cent, well above the average for all industries (8.6 per cent). This was driven by the fast growth in paper manufacturing R&D expenditures (14.1 per cent per year), with both forestry and logging and wood product manufacturing growing at below-average rates (1.5 and 6.4 per cent per year).

[25] R&D expenditures in forestry and logging also include support activities for forestry.

[26] It would have been interesting to have a breakdown of BERD by source of funding, so that we could have a better understanding of how much of total business R&D spending could be attributed to government funding programs like the Pulp and Paper Green Transformation Program (PPGTP) from 2010 to 2012. Unfortunately, however, Statistics Canada offers very limited information on the sources of funds for business sector R&D expenditures (BERD) in the forest products sector. Table 5-16 of the publication *Industry Research and Development: Intentions* (Statistics Canada, 2013) has industry-level R&D expenditures estimates broken down by sources of funds. According to the table, of the $85 million R&D expenditures in wood product manufacturing in 2011, Canadian performing companies were the source of $83 million and the federal government and other Canadian sources were the source of the remaining $2 million. Estimates for forestry and logging and paper manufacturing were not available due to confidentiality reasons.

Chart 38: Pre- and Post-Recession Comparison of BERD Spending in the Forest Products Sector

(Compound annual growth rates, per cent)

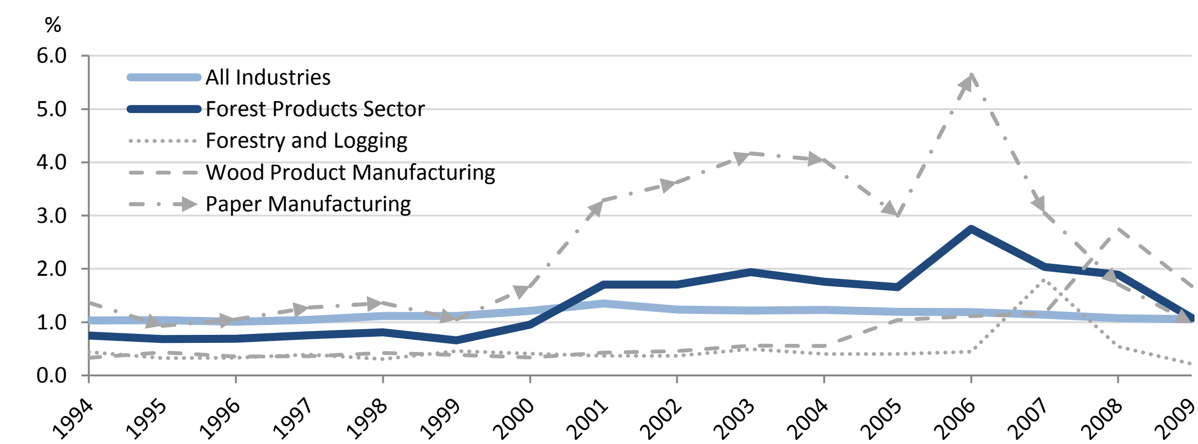


Source: Statistics Canada, Research and Development in Canadian Industry, CANSIM table 358-0024.

c. 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, which hovered around 1.0-1.1 per cent between 1994 and 2000 (Chart 39). 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. In 2009 (the last year for which nominal GDP estimates for the forest products sector were available), R&D intensity in the forest products sector had fallen back to the total economy average of 1.1 per cent.

Chart 39: R&D Intensity in the Forest Products Sector, 1994-2009



Source: CSLS calculations based on Statistics Canada data.

The increase in the forest products sector's R&D intensity during the early 2000s was caused entirely by the paper manufacturing subsector, which was experiencing not only rising R&D spending, but also falling nominal GDP. The subsector had above-average R&D intensity during most of the 2000s, peaking at 5.6 per cent in 2006. By 2009, however, R&D intensity in paper manufacturing had declined back to the total economy average. Throughout the entire period, except for brief increase in 2007, R&D intensity in forestry and logging remained at below-average levels, oscillating between 0.2 and 0.5 per cent. Wood product manufacturing also had below-average R&D intensity levels of 0.4-0.6 per cent until the mid-2000s, after which a boost in R&D spending (and, once again, falling nominal GDP) led to above-average levels. In 2009, wood product manufacturing was the only of the three forest products subsectors to have above-average R&D intensity, at 1.7 per cent.

d. International Comparisons of R&D Intensity

The OECD's STAN database has detailed industry-level R&D intensity estimates for a number of countries. Although there were no R&D estimates available for forestry and logging, estimates were available for both wood product and paper manufacturing. Given that R&D intensity estimates for these two forest products subsectors can change substantially in a very short period of time,[27] our focus here is on *average* R&D intensity during the 2000-2008 period.

Chart 40 (Panel A) shows that, compared to a group of 11 other OECD countries, Canada had the second highest R&D intensity in wood product manufacturing during the 2000-2008 period (0.9 per cent),[28] only below Norway (1.3 per cent). Unsurprisingly, wood product manufacturing R&D intensity was also quite high in Sweden and Finland (0.8 and 0.7 per cent, respectively), two countries with very well developed forest products sectors. The U.S. wood product manufacturing subsector had an average R&D intensity of 0.6 per cent during the period. Countries with low wood product manufacturing R&D intensity include Italy (0.1 per cent), Germany (0.3 per cent) and Iceland (0.3 per cent).

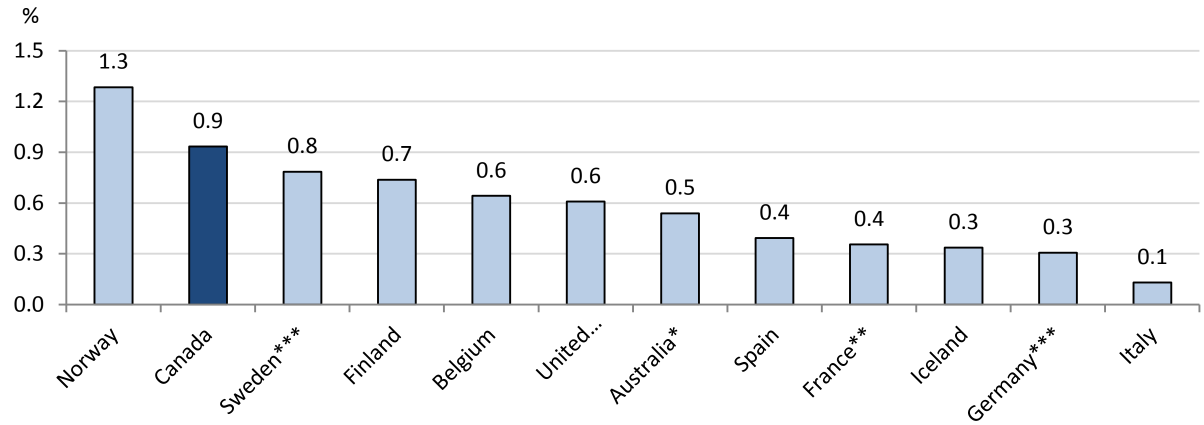
[27] Recall, for instance, that R&D intensity in the Canadian wood product manufacturing subsector increased from 1.2 per cent in 2007 to 2.8 per cent in 2008, dropping to 1.7 per cent in 2009

[28] Since R&D intensity estimates from the OECD STAN database only went up to 2006 for Canada, we used here the same R&D intensity estimates discussed in Section V-C-iii-c, which were constructed from Statistics Canada data and go up to 2009. For paper manufacturing, the two sets of estimates match almost perfectly. For wood product manufacturing, however, there were significant differences, with the OECD estimates being lower than the estimates constructed from Statistics Canada data. Surprisingly, these OECD estimates, do not appear to be consistent with the OECD's *own* value added and R&D expenditure figures, which are also provided separately. According to the OECD's "pre-constructed" R&D intensity estimates, average R&D intensity of Canadian wood product manufacturing during the 2000-2006 period was only 0.5 per cent. However, if we construct R&D intensity estimates using the OECD's figures for value added and R&D expenditures, we obtain an average R&D intensity of 0.7 per cent, in line with the R&D intensity we obtain from official Statistics Canada's estimates.

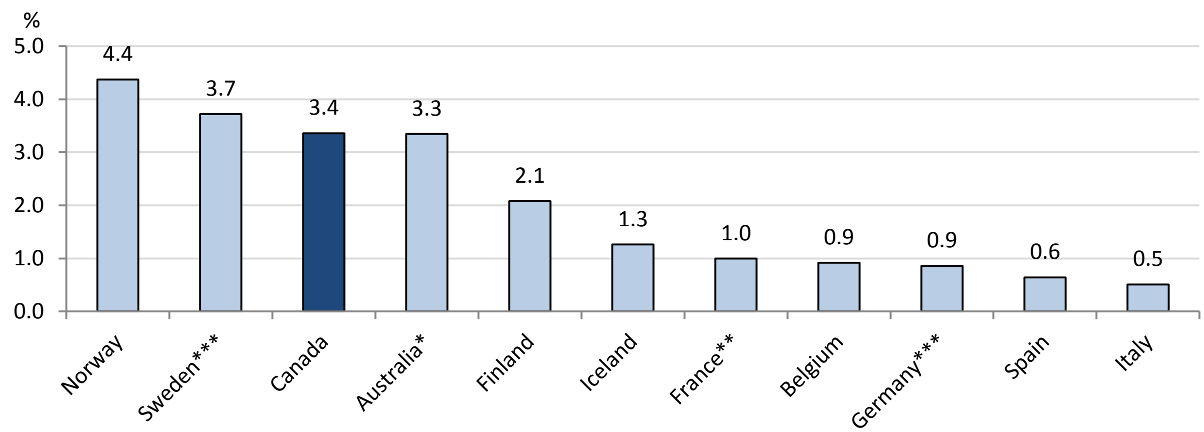
Chart 40: R&D Intensity in the Forest Products Sector, International Comparison, 2000-2008 Average

(Business enterprise R&D expenditures as a % of Nominal Value Added)

A) Wood Product Manufacturing



B) Paper Manufacturing



*Last data point in 2005 ** Last data point in 2006 *** Last data point in 2007

Source: For Canada, estimates were constructed by the CSLS using Statistics Canada data; for all other countries, data from the OECD STAN Database.

In the case of paper manufacturing, Canada had the third highest R&D intensity (3.4 per cent) out of the 11 countries in our sample (Chart 40, Panel B). Norway had the highest R&D intensity (4.4 per cent), followed by Sweden (3.7 per cent). Although Finland's paper manufacturing subsector had a relatively high R&D intensity (2.1 per cent), it was well below that of other countries with major forest products sectors. Unfortunately, no R&D intensity estimates were available for the U.S. paper manufacturing subsector. Finally, it is interesting to note that paper manufacturing R&D intensity was much higher than wood product manufacturing R&D intensity for all countries.

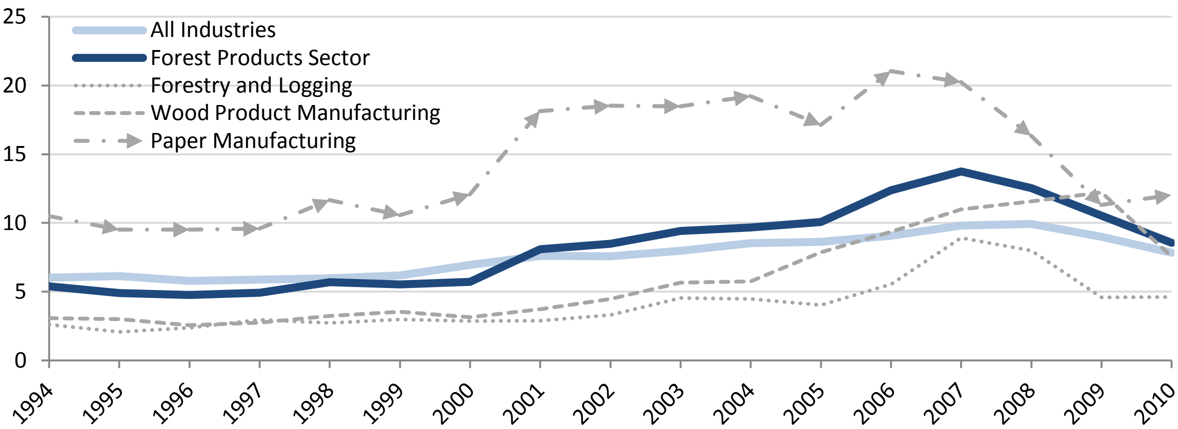
Overall, Canada's R&D intensity in wood product and paper manufacturing was quite high during the 2000-2008 period, well above average and in line with the R&D intensity of countries such as Norway, Sweden and Finland – all of which have major forest products sectors.

e. 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) (Chart 41). This increase in the forest products sector's R&D personnel intensity was *entirely* due to the sharp employment fall experienced by the sector during the period. In fact, the forest products sector employed slightly *less* R&D personnel in 2010 than it did in 2000 (1,863 vs. 1,726 R&D personnel, respectively). Note, also, that despite increasing significantly in the last ten years, R&D personnel intensity in the forest products sector has declined in recent years, after peaking at 13.7 R&D personnel per 1,000 workers in 2007.

Chart 41: R&D Personnel Intensity in the Forest Products Sector, 1994-2010

(R&D personnel per 1,000 workers)



Source: CSLS calculations based on Statistics Canada data (CANSIM Table 358-0024)

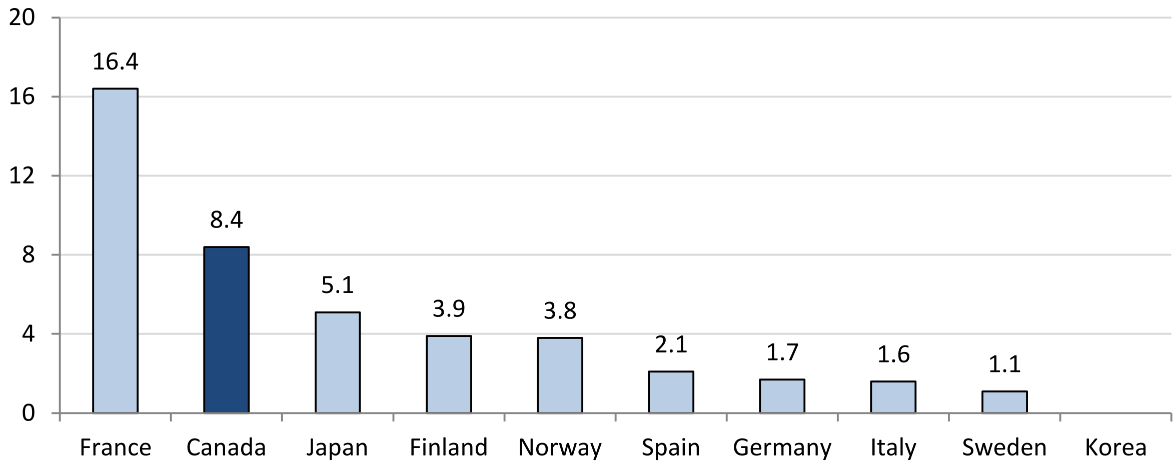
At the subsector level, the story is very similar to what we have seen in terms of BERD intensity, with paper manufacturing accounting for most of the rise in the R&D intensity of the forest products sector during the early 2000s. In the past decade, paper manufacturing was the only forest products subsector that consistently had above-average R&D personnel intensity. In 2010, R&D personnel intensity in paper manufacturing was 12.0 per 1,000 workers, considerably more than in forestry and logging (4.6 R&D personnel per 1,000 workers) or wood product manufacturing (7.6 R&D personnel per 1,000 workers).

f. International Comparisons of R&D Personnel Intensity

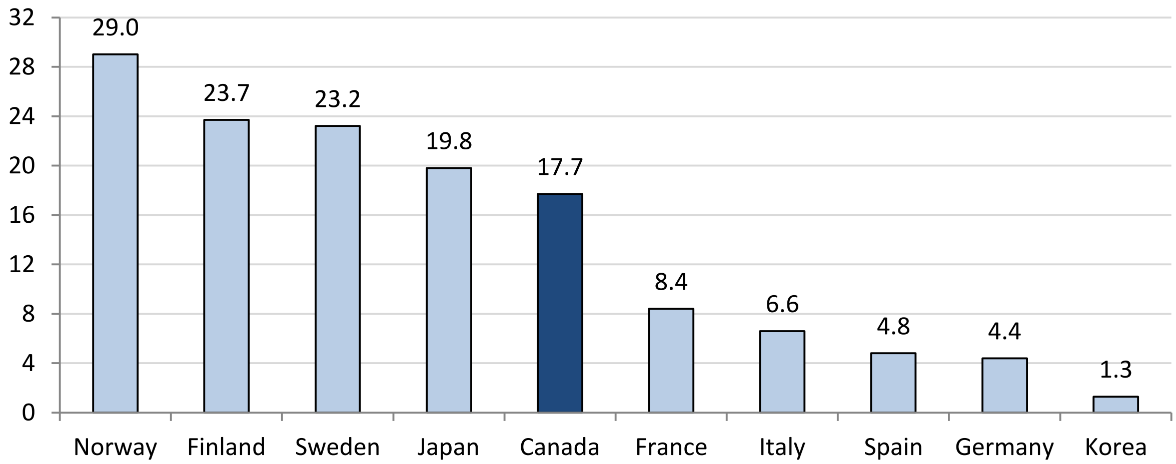
Chart 42: R&D Personnel Intensity in the Forest Products Sector, International Comparison, 2008

(R&D personnel per 1,000 workers)

A) Wood Product Manufacturing



B) Paper Manufacturing



Note: Estimates presented here are not directly comparable to those in the previous subsection.
Source: Sharpe and Long (2012), based on OECD data.

Using OECD data, Sharpe and Long (2012:47) calculate 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.

g. M&E Investment Intensity

Although the relatively high levels of R&D intensity and R&D personnel intensity 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. This is particularly true for the forest products sector, where innovation tends to be *embodied* in physical capital.

The low levels of investment in physical capital (see Section III-C), 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". Woodbridge Associates (2009:53) support this view, stating that B.C.'s "pulp and paper mills generally are aging, and are not cutting edge;" they further add that the sawmill sector in B.C.'s coast is "characterized by old-vintage mills," which despite being upgraded over time, cannot compete against U.S. supermills.[29]

M&E investment intensity, defined here as real investment in machinery and equipment (M&E) per hour worked, is an important indicator of embodied technological change, keeping track of the effort made by firms in a given industry to use "up-to-date" equipment. Between 2000 and 2008, 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 18). During the period, forestry and logging was the only forest products subsector that experienced an increase in M&E investment intensity (2.7 per cent per year). In wood product and paper manufacturing, M&E investment intensity fell 2.4 and 4.5 per cent per year, respectively.

Table 18: 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.

In the 2008-2012 period, after experiencing a large fall due to the 2009 recession, M&E investment intensity in the forest products sector picked up pace, increasing at a rate of 5.1 per

[29] 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.

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 and, to a smaller extent, paper manufacturing, where M&E investment intensity increased 3.3 per cent per year. In forestry and logging, M&E investment intensity fell at a rate of 4.2 per cent per year.

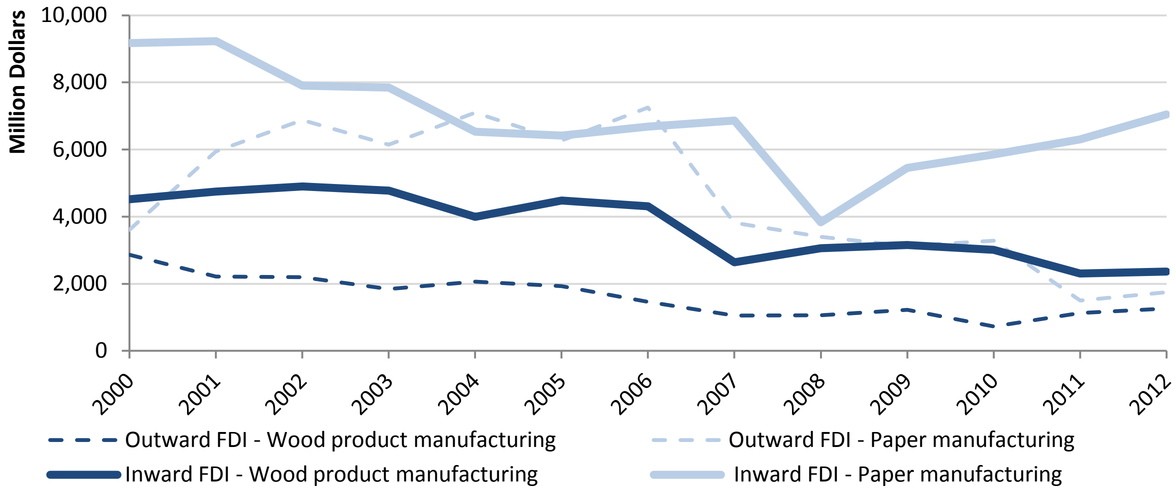
For the overall 2000-2012 period, M&E investment intensity in the forest products sector as a whole remained practically unchanged. While forestry and logging and wood product manufacturing M&E investment intensity did experience an increase, this increase was fairly timid compared to the national average. The situation in paper manufacturing is even more concerning, however, with a noticeable decline in paper manufacturing M&E investment intensity.

h. 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. In addition to generating positive technological externalities, FDI can also increase product market competition.

According to Statistics Canada estimates, between 2000 and 2012, inward FDI (foreign investment in Canada) declined 48 per cent in the wood product manufacturing subsector, from $4,516 million to $2,360 million, and 23 per cent in the paper manufacturing subsector, from $9,176 million to $7,047 million. Outward FDI (Canadian investment abroad), in turn, fell 56 per cent in wood product manufacturing, from $2,866 million to $1,259 million, and 52 per cent in paper manufacturing, from $3,612 million to $1,746 million. Although still below its early-2000 levels, inward paper manufacturing FDI has started to pick up pace again.

Chart 43: Foreign Direct Investment Position in the Forest Products Sector, 2000-2012



Note: Estimates refer to wood product and paper manufacturing. Data for forestry and logging were not available.
Source: Statistics Canada, Canada's International Investment Position, CANSIM table 376-0052.

i. Incidence of Innovation

Innovation at the firm and plant level is also an important indicator. Survey data allows for the characterization of how innovative firms are; how novel innovations are; and the market conditions that motivate innovation. Three occasional Statistics Canada surveys related to innovation provide a variety of insights into what constitutes innovation and how innovation is measured:

- The *Survey of Innovation*, last conducted in 2005, surveyed manufacturing and logging industries over the 2002-2004 period. Conceptually, this survey addresses the degree of innovation via the novelty of processes; the extent of collaboration between firms; and the use of government programs designed to foster innovation. As such, data from this survey is particularly useful for assessing the quality of linkages between innovation clusters and support infrastructure.

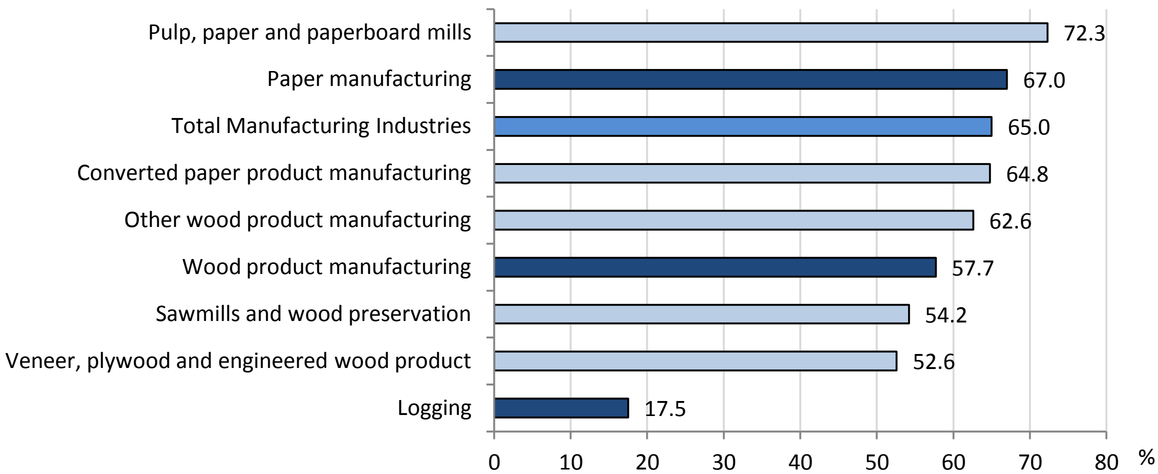
- The *Survey of Advanced Technologies*, conducted in 2007, goes a step further in developing a set of innovation indicators for Canada, inquiring about the acquisition and integration of advanced technologies.

- The *Survey of Innovation and Business Strategy (SIBS)*, a joint venture of Industry Canada, DFAIT and Statistics Canada, was conducted in 2010.[30] The SIBS was undertaken to provide useful statistical information on strategic decisions, innovation activities and operational tactics used by Canadian firms.

[30] SIBS surveyed 6,233 enterprises, randomly selected from a population of 37,216 in Statistics Canada's Business Register.

This section highlights the key results of these surveys related to the incidence of innovation. Chart 44, based on 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, the performance of the forest products sector was quite poor. Only 17.5 per cent of logging plants were considered innovative. Wood product manufacturing had a higher proportion of innovative plants (57.7 per cent), but still significantly below manufacturing as a whole. Paper manufacturing was the only forest products subsector that had a higher proportion of innovative plants than total manufacturing (67.0 per cent), due to the large proportion of innovative pulp, paper and paperboard mills (72.3 per cent). It is important to note, once again, that this survey used data from the 2002-2004 period, and the overall state of innovative plants in the forest products sector may have changed considerably since then.

Chart 44: Per Cent of Innovative Plants in the Forest Products Sector, 2002-2004



Source: Statistics Canada, Survey of Innovation.

SIBS data provide additional detail on the *type* of innovative activity conducted. Table 19 shows the percentage of firms in the forest products sector that introduced a product or process innovation between 2007 and 2009. 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. Data for the forest products subsector were not available.

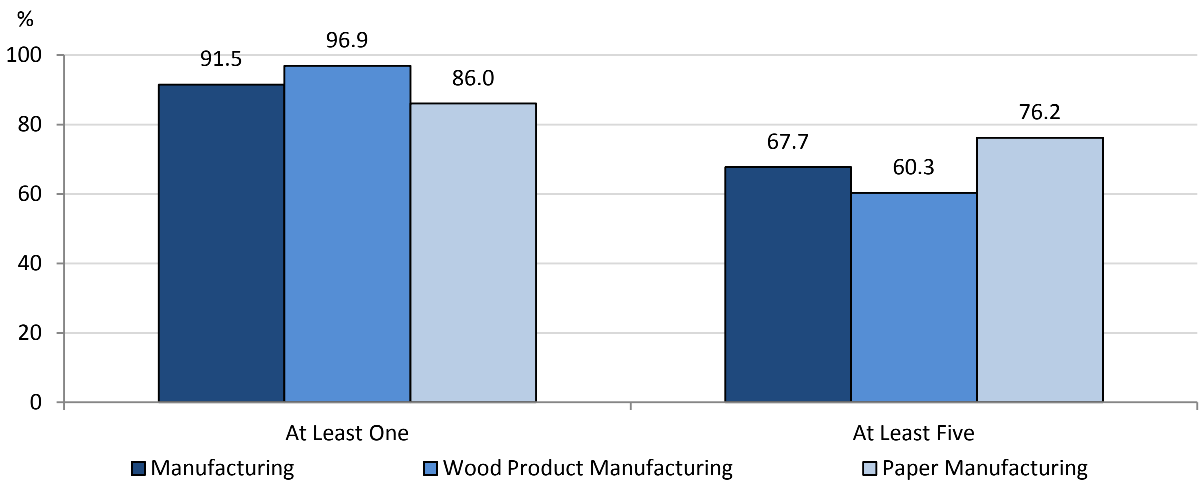
Table 19: Percentage of Enterprises Indicating they Introduced Product or Process Innovations, 2007-2009

	Product Innovation		Process Innovation		
	Goods	Services	Methods of Manufacturing or Producing	Logistics, Delivery or Distribution Methods	Supporting activities for processes
All Surveyed Industries	18.1	24.5	17.3	12.0	25.5
Manufacturing	42.6	21.7	49.7	15.7	31.4
Wood Product	34.3	21.7	51.6	13.8	27.0
Paper	33.8	17.8	50.7	15.4	32.9

Source: Statistics Canada, Survey of Innovation and Business Strategy.

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. Chart 45 shows that 96.9 per cent of wood product manufacturing plants were using at least 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 technology (76.2 per cent vs. 67.7 per cent for manufacturing as a whole and 60.3 per cent for wood product manufacturing)

Chart 45: Percentage of Manufacturing Plants Using Advanced Technologies, 2007



Source: Statistics Canada, Survey of Advanced Technology.

D. 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:

1) *Efficiency*: Production is assumed to be efficient. Thus, in order to produce one unit of output, profit-maximizing firms use the least amount of inputs possible. In this

sense, firms do not have excess labour or excess capital at their disposal; they have only as much labour or as much capital as they need;

2) *Constant returns to scale (CRS)*: Firms can double output produced simply by doubling inputs used;
3) *Perfect competition*: Firms do not have market power, i.e. they are *price takers*. Under perfect competition, the compensation of the factors of production (labour and capital) is equal to their marginal products.

Needless to say, these can be strong assumptions. In situations where they do not hold, MFP growth – and, as a consequence, labour productivity growth – will be affected. If, for instance, firms operate below capacity (i.e. they do not use all their capital in the production process), there will be a negative impact on productivity.

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. First, we analyze factors related to the business cycle, such as capacity utilization and labour hoarding; next, we look at returns to scale in the Canadian forest products sector; finally, we discuss other factors that can potentially influence MFP growth.

i. 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;

- *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.

Note that the two factors highlighted above are related to the efficiency of the production process. Statistics Canada collects data on the capacity utilization of industrial activities such as mining and oil and gas extraction; electric power generation, transmission and distribution; construction; and manufacturing. In particular, it has capacity utilization data for the three forest products subsectors. Labour hoarding, on the other hand, is harder to quantify, requiring an estimate of the "production function" used by the forest products sector.

Chart 46 shows how capacity utilization in the three forest products subsectors changed during the 2000-2012 period. A few points are worth highlighting:

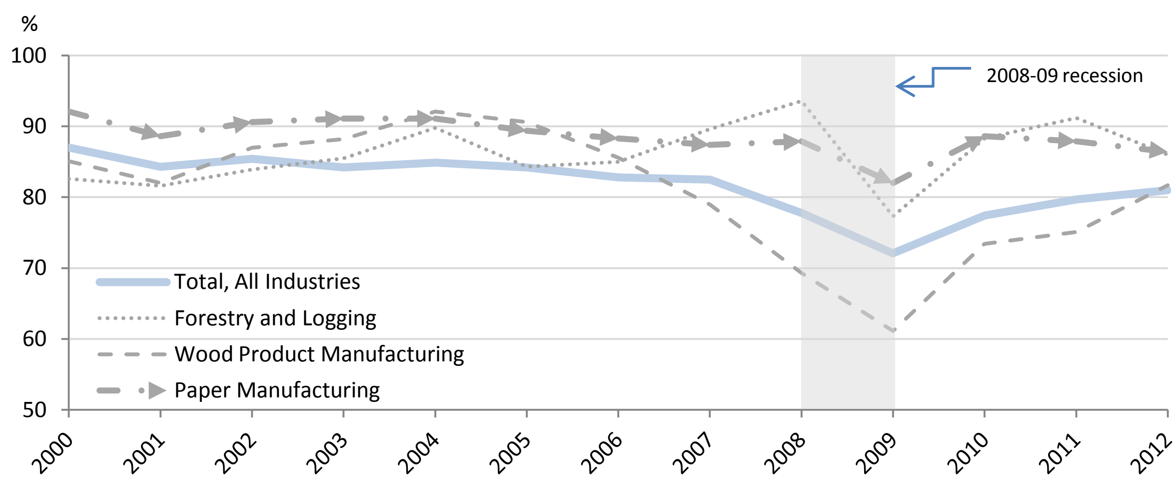
- In forestry and logging, capacity utilization remained relatively high in the 2000-2008 period, ranging from a low of 81.6 per cent in 2001 to a high of 93.6 per cent in 2008. With the recession, capacity utilization dropped 16.3 percentage points to 77.3 per cent, but quickly recovered;

- The story is very different in the case of wood product manufacturing, where capacity utilization was steadily falling even before the 2008-09 recession. After peaking at 92.1 per cent in 2004, it fell 21.3 percentage points to 69.3 per cent in 2008. With the recession, capacity utilization fell more 8.2 percentage points, to 61.1 per cent. Although capacity utilization in the subsector has increased substantially, now at 81.7 per cent, it is still well below its average in the early 2000s;

- Capacity utilization in paper manufacturing has been remarkably stable during the 2000-2008 period, ranging from a low of 87.4 per cent in 2007 to a high of 91.1 per cent in 2003 and 2004. It declined 5.9 percentage points during the recession, from 87.9 per cent to 82.0 per cent, but this was by far the smallest decline among the three forest products subsectors. Capacity utilization in the subsector also recovered quickly.

Chart 46: Capacity Utilization in Forest Products Subsectors, 2000-2012

(Actual output as % of potential output)

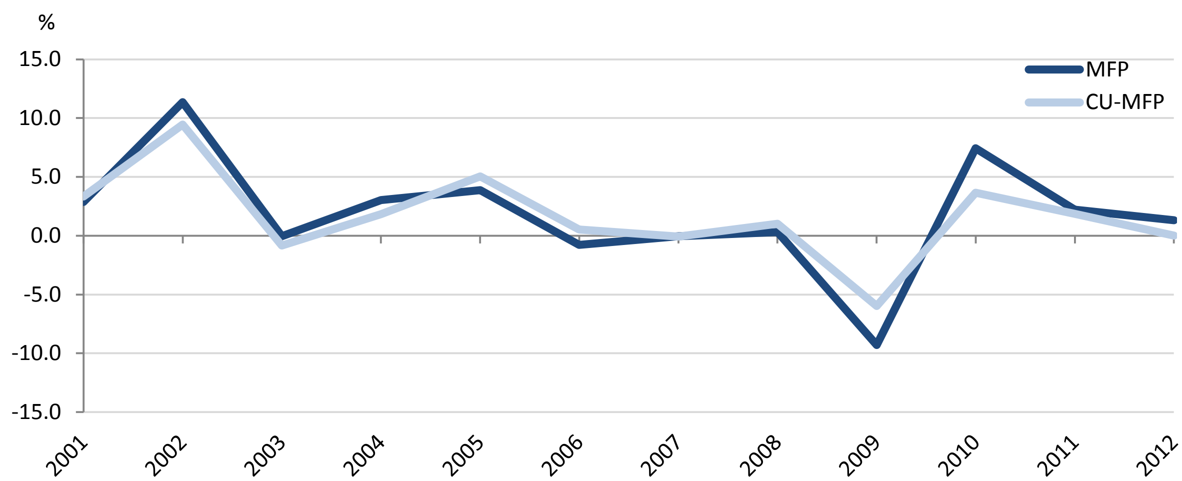


Source: Statistics Canada, Capacity Utilization Rates, CANSIM table 028-0002.

The sizeable fluctuations in the capacity utilization of the three subsectors – especially in wood product manufacturing – have an effect on measured MFP growth. Although this effect tends to be small in cyclically-neutral periods, it can be quite large in shorter time frames (see Tipper and Warmke, 2012). To better understand the impact of capacity utilization on MFP growth, the CSLS adjusted capital input growth in the three forest products subsectors by capacity utilization and recalculated MFP growth with this new measure of capital input.[31]

Chart 47 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. Not only that, it softened the productivity drop experienced in the 2009 recession. According to our baseline measure, MFP in the forest products sector fell 9.3 per cent in 2009; when capacity utilization is taken into account, there is only a 6.0 per cent fall.

Chart 47: MFP Growth in the Forest Products Sector Adjusted by Changes in Capacity Utilization, 2000-2012



Source: CSLS calculations based on Statistics Canada data.

Table 20 shows that, overall, the same holds true for all three forest products subsectors. Differences between the two measures are quite small for the 2000-2012 period, but significant during sub-periods, especially for forestry and logging and wood product manufacturing. In the case of forestry and logging, MFP growth was higher than CU-MFP growth in the 2000-2008 period (1.8 vs. 1.1 per cent per year), but lower than it in the 2008-2012 period (2.6 vs. 3.5 per cent per year). The opposite happened in wood product manufacturing, with MFP growth lower than CU-MFP growth in the 2000-2008 period (3.6 vs. 4.5 per cent per year), but higher than it in the 2008-2012 period (2.1 vs. 07 per cent per year). For all three subsectors, when capacity

[31] The adjusted capacity utilization-adjusted capital input measure is simply capital input multiplied by capacity utilization. There are more sophisticated ways of adjusting capital input by capacity utilization. See OECD (2001:73-75) for a brief discussion on the topic.

utilization was taken into consideration, the effect of the recession on productivity growth was dampened.

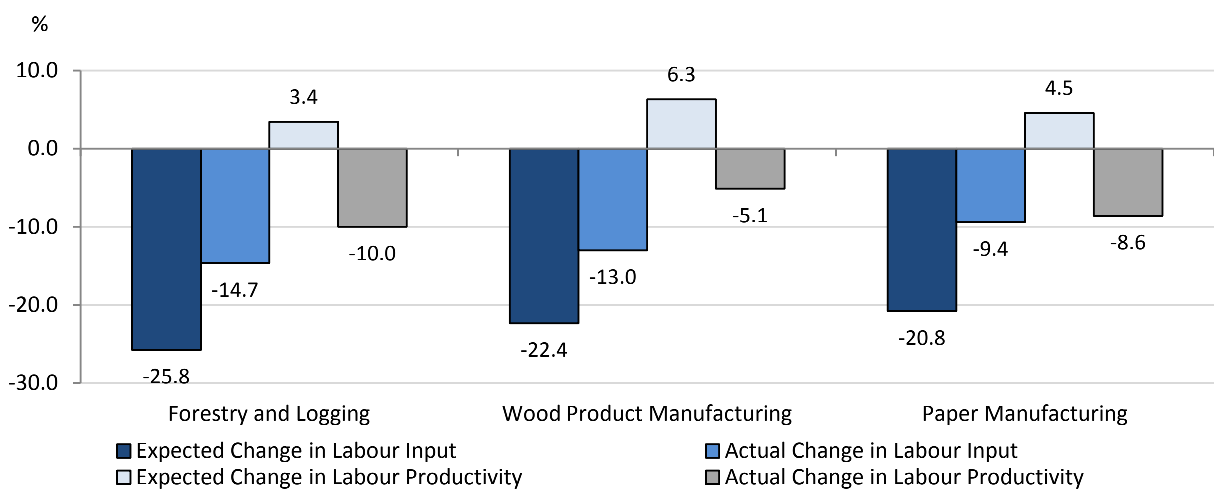
Table 20: MFP Growth in the Forest Products Sector Adjusted by Changes in Capacity Utilization, 2000-2012

	2000-2012		2000-2008		2008-2012		2009	
	MFP	CU-MFP	MFP	CU-MFP	MFP	CU-MFP	MFP	CU-MFP
	(CAGR, per cent)							
Forest Products Sector	1.7	1.6	2.5	2.5	0.2	-0.2	-9.3	-6.0
Forestry and Logging	2.0	1.9	1.8	1.1	2.6	3.5	-13.9	-6.9
Wood Product Manufacturing	3.1	3.2	3.6	4.5	2.1	0.7	-7.1	-3.1
Paper Manufacturing	-0.2	0.0	1.0	1.3	-2.6	-2.5	-9.8	-8.1

Source: CSLS calculations based on Statistics Canada data.

The effect of labour hoarding on productivity growth is harder to quantify. One way of measuring this effect is using a production function approach. Under the standard assumptions (highlighted in the beginning of this subsection), the elasticities of output with respect to labour and capital are equal to labour and capital compensation shares. Assuming, additionally, a given rate of MFP growth in each forest products subsector, we can estimate how much labour input should change for a given change in output and capital input if there was a perfect (and immediate) adjustment to changes in demand and supply conditions. Significant differences between the “expected” change and the actual change in labour input could provide a rough indication of whether labour hoarding played a role in driving down productivity in the forest products sector during the recent recession.

Chart 48: Labour Hoarding in the Forest Products Sector during the 2009 Recession



Source: CSLS calculations based on Statistics Canada data.

Chart 48 shows the actual and expected change in labour input and labour productivity for the three forest products subsectors under the assumption that CU-MFP growth for 2009 was equal to trend growth during the 2000-2008 period. In all three subsectors, the estimated fall in labour input using the production function approach was much larger than the actual fall, indicating labour hoarding. In the case of forestry and logging, for instance, the estimated production function tells us that, given the fall in output (of 23.2 per cent), labour input should have fallen 25.8 per cent instead of only 14.7 per cent. The same holds true for wood product manufacturing (22.4 vs. 13.0 per cent) and paper manufacturing (20.8 vs. 9.4 per cent). When labour hoarding and capacity utilization are taken into consideration, labour productivity growth for all three forest products subsectors becomes positive in 2009.

Despite the short-term impact of labour hoarding on productivity growth, it has very little lasting impact, since firms adjust their use of labour input more efficiently over the medium- and long-run.

ii. Returns to Scale and Firm Size

The standard theoretical framework used to compute MFP growth assumes constant returns to scale (CRS), that is, a doubling of inputs used 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.[32] When a firm with IRS doubles its use of labour and capital inputs, it *more than doubles* its output. 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 report, such estimates can be constructed using the methodology delineated 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.

Larger firms (or production plants) tend to benefit more from returns to scale, since they can readily increase their use of labour and capital inputs without being subject to short- or medium-term capacity constraints. Harrison and Sharpe (2009:61) summarize some of the key findings in the literature regarding the benefits enjoyed by larger firms in the forest products sector:

> According to the Forest Products Industry Competitiveness Task Force (2007), for instance, significant advantages enjoyed by large firms in the forest products sector include a lower cost of capital, greater scale economies in production and marketing, and more efficient risk management of innovation and major capital projects. Similarly, FPAC (2005:11) argues that consolidation in the sector could offer "critical competitive advantages" such as increased efficiency; asset, product, or geographic diversification; and lower capital costs. The report also notes that diversification is desirable as it reduces cash

[32] 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.

flow volatility and improves market access. Large firms are also able to attract more capital for innovative investments.

iii. Other Factors

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

a. Profits

Chart 49 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. In the case of wood product manufacturing, after peaking in 2004 at $4,968 million, the subsector experienced sizeable operating losses between 2007 and 2009. By 2011, the subsector had somewhat recovered, with operating profits of $344 million. Operating profits in the forestry and logging subsector were, in general, much more stable than in the other two subsectors, declining slightly from $476 million in 2000 to $394 million in 2011.

Chart 49: Operating Profits in the Forest Products Sector, 2000-2011

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

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 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.

b. 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*).[33]

Table 21: Contributions to Labour Productivity Growth in the Forest Products Sector, 2000-2012

	Total Contribution	Pure Productivity Effect	Reallocation Effect
		(percentage point contribution)	
Forest Products Sector	2.5	2.4	0.1
Forestry and Logging	0.6	0.6	0.0
Wood Product Manufacturing	1.8	1.8	0.0
Paper Manufacturing	0.1	0.0	0.1
		(per cent contribution)	
Forest Products Sector	100.0	95.4	4.6
Forestry and Logging	25.1	25.1	0.0
Wood Product Manufacturing	71.9	70.6	1.3
Paper Manufacturing	3.0	-0.3	3.3

Source: CSLS calculations based on Statistics Canada data.

As Table 21 shows, 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. Most of the productivity growth sector was due to productivity gains in wood product manufacturing, which explained 71.9 per cent of the overall productivity growth in the period, although productivity gains in forestry and logging were also important, accounting for 25.1 per cent of total labour productivity. Paper manufacturing productivity growth was responsible for only 3.0 per cent of productivity growth in the forest products sector.

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[33] For more on sectoral decompositions of labour productivity growth, see De Avillez (2012).

c. 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. As Harrison and Sharpe (2009:52) note:

> The reliance on less accessible timber stocks, for example, can raise the cost in terms of labour and capital of producing a given quantity of logs, decreasing productivity. This tendency toward depletion and diminishing returns can be, and often is, offset by technological advances (…) It is possible that Canada's relatively slow-growing forests, which result in long-distance hauling of logs being required, makes super mills less viable than in countries where wood fibre grows more quickly (Rheaume and Roberts, 2007:21). This situation could have a significant impact on productivity in the paper manufacturing subsector.

E. Key Findings

This section investigated the possible reasons behind the above-average labour productivity growth experienced by the Canadian forest products sector over the past 50 years, focusing on the more recent 2000-2008 period. A growth accounting exercise has shown that most of the labour productivity growth differential between the forest products sector and the Canadian business sector is explained by the fast MFP growth observed in forestry and logging and wood product manufacturing.

By definition, MFP growth is a residual, representing output growth that is not accounted for by measured input growth. It is often seen as a proxy for disembodied technological change, but the reality is that it encompasses a number of very different factors, such as improvements in technology and organization, capacity utilization, returns to scale, etc.

Overall, improvements in technology seem to have played a major role in driving MFP growth in the Canadian forest products sector. Canada conducts state-of-the-art research in several areas related to forest products. In forestry, for instance, "Canada's (…) 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). Furthermore, Canada had high R&D intensity in wood product and paper manufacturing, well above the international average and in line with the R&D intensity of countries such as Norway, Sweden and Finland, all of which have major forest products sectors.

It is important to keep in mind, however, that significant improvements can still be made. The falling levels of investment in physical capital, especially in paper manufacturing, 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.

In addition, despite noticeable gains in the education front over the past decades, workers in the forest products sector still have lower educational attainment levels than the average Canadian worker. In a sense, this is not surprising; the sector has very specific skill needs that, more often than not, require on-the-job training or a non-university post-secondary education (such as a trade certificate) instead of a university education. Nonetheless, the (still) high proportion of workers without a high-school diploma – especially in forestry and logging – raises legitimate concerns regarding basic literacy and numeracy skills, the lack of which can have a significant negative impact on worker productivity.

VI. The Role of Productivity in the Canadian Forest Products Sector

FPAC's *Vision 2020 Challenge* highlights three main goals for the Canadian forest products sector in the next seven years (FPAC, 2012):

- Reduce the sector's environmental footprint by 35 per cent;
- Generate an additional $20 billion in economic activity with new innovations and new markets;
- Renew the workforce, hiring 60,000 recruits, including women, Aboriginals, and immigrants.

Below, we highlight how productivity gains can help the Canadian forest products sector achieve these three objectives.

i. Energy Efficiency

Productivity growth can reduce the forest products sector's dependency on energy input, therefore reducing its environmental footprint. In fact, as we have seen in Section IV-C, this is already happening. Energy productivity, defined as the ratio between real gross output and an index of energy input use, has improved substantially in all three forest products subsectors over the last 50 years.

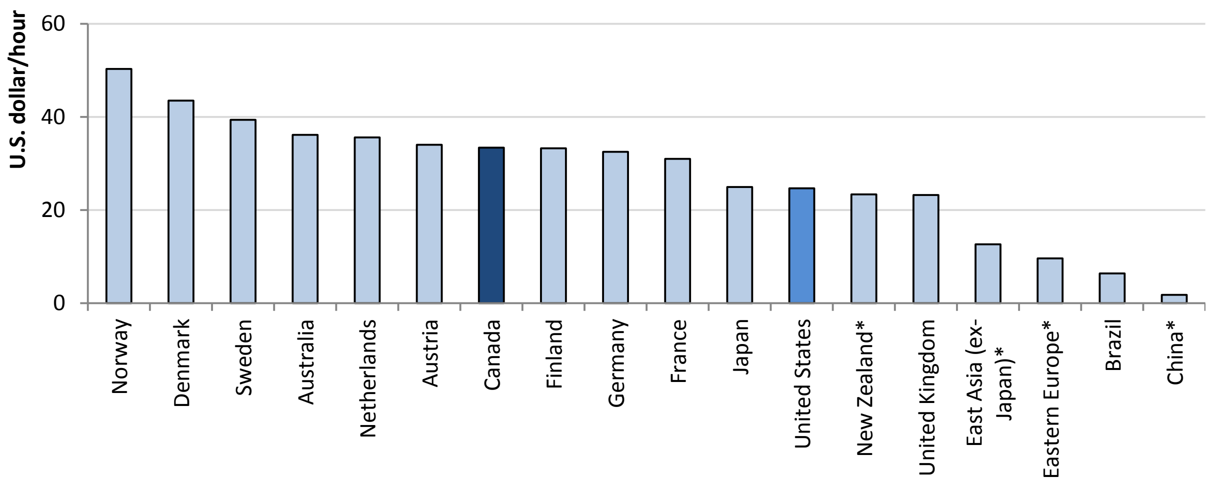
During the 1961-2000 period, energy productivity growth was particularly impressive in forestry and logging, where it averaged 2.9 per cent per year. In the other two forest products subsectors, energy productivity growth averaged 1.1 and 1.2 per cent per year, respectively, slightly less than the energy productivity gains observed for the manufacturing sector as a whole (1.6 per cent per year). More recently, wood product manufacturing saw marked improvements in its energy productivity, which grew at an average annual rate of 2.5 per cent per year between 2000 and 2008 (the last year for which data were available). In paper manufacturing, energy productivity growth was far less impressive (0.9 per cent per year), although still significantly above the energy productivity performance of the manufacturing sector as a whole (-0.1 per cent per year). In forestry and logging, energy productivity actually declined, falling 2.1 per cent per year.

ii. Output and Employment

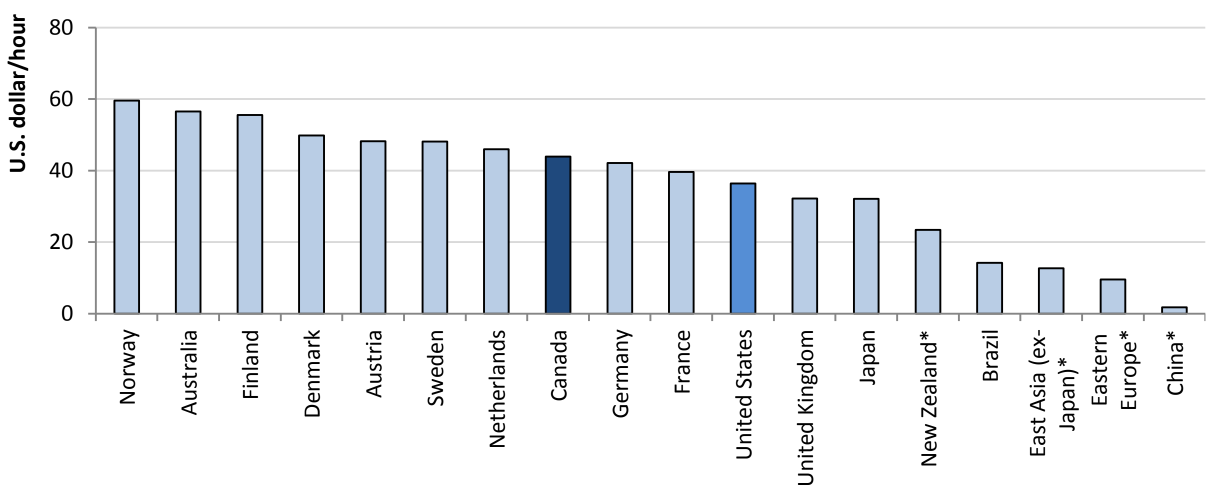
Productivity improvements allow firms to produce the same quantity of output by using fewer inputs, which reduces costs. However, the sector's competitiveness depends not only on productivity but also on other factors, such as exchange rates and input costs. Labour costs, in particular, represent a challenge to the Canadian forest products sector. High labour costs make it harder for the forest products sector in Canada 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 (Chart 50).

Chart 50: Hourly Compensation in the Forest Products Sector, International Comparison, 2011

A) Wood Product Manufacturing



B) Paper Manufacturing



* Hourly compensation estimates refer to the manufacturing sector as a whole
Note: For the Netherlands, estimates are for the year 2008; for China, East Asia (ex-Japan) and Eastern Europe, estimates are for the year 2009.
Source: U.S. Bureau of Labor Statistics, International Labor Comparisons.

According to data from the U.S. Bureau of Labor Statistics (BLS), hourly compensation in Canadian wood product manufacturing was US$33.40 in 2011, 136 per cent of U.S. hourly compensation (US$24.63). A similar situation can be seen in the case of paper manufacturing, where Canadian hourly compensation (US$43.96) was 121 per cent of U.S. compensation (US$36.39). The difference becomes even starker when looking at labour costs of developing countries. In Brazil, for example, hourly compensation of wood product and paper manufacturing was only US$6.34 and US$14.17 (respectively); hourly compensation in Chinese manufacturing, in turn, was even lower, US$1.80 in 2009.

Table 22 shows the main forest products exporters in the world, breaking them down by type of forest product and relative hourly compensation. Despite the recent troubles of Canada's forest products sector, this country is still a key international player in all main forest product markets, with the exception of recovered paper, where it was responsible for less than 5 per cent of total exports in 2011. Canada's role was particularly important in the sawn wood and pulp for paper markets, where the country was responsible, respectively, for 20 and 18 per cent of total world exports. Note, however, that hourly compensation in most of the other major international players in forest product markets are either significantly below Canada`s or in line with Canada`s. The only market where countries with hourly compensation levels above Canada`s had a large share of world exports was paper and paperboard, where Finland, Sweden, and Austria were responsible for 22 per cent of world exports.

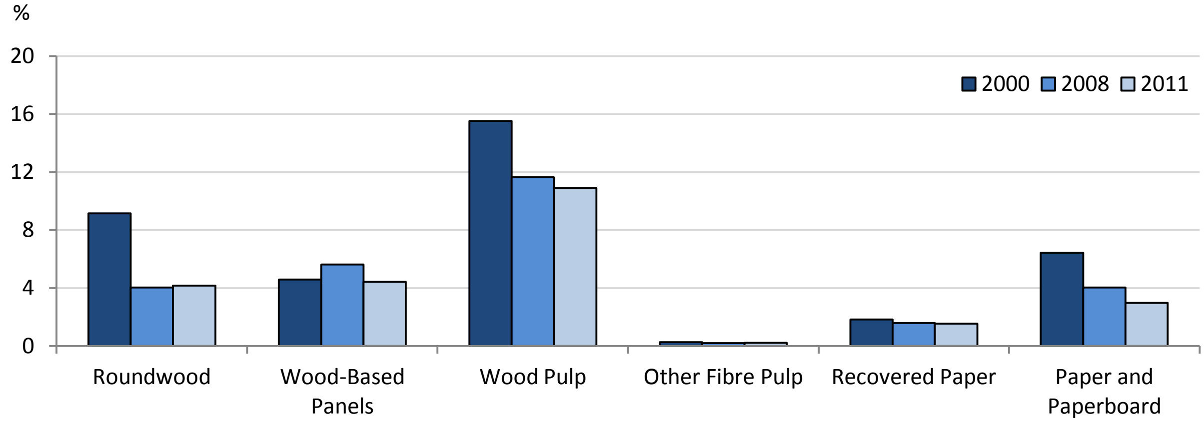
Table 22: Main Exporters of Forest Products and Labour Costs, 2011

		Canada's Percentage of Global Exports	Major Exporters with *Lower Hourly Compensation*	Major Exporters with *Similar Hourly Compensation*	Major Exporters with *Higher Hourly Compensation*
			(country name and percentage of global exports)		
Wood Product Manufacturing	**Industrial Roundwood**	5	Russia, 18 New Zealand, 11 USA, 10 Latvia, 4	France, 6	..
	Sawn Wood	20	Russia, 16	Germany, 6 Finland, 5 Austria, 5	Sweden, 10
	Wood-Based Panels	5	China, 18 Malaysia, 8 Thailand, 5 Indonesia, 4	Germany, 8 Austria, 4	..
Paper Manufacturing	**Pulp for Paper**	18	Brazil, 17 USA, 16 Chile, 8 Indonesia, 5 Russia, 4	Sweden, 6	Finland, 5
	Recovered Paper	< 5	USA, 35 United Kingdom, 8 France, 5	Netherlands, 6 Germany, 6	..
	Paper and Paperboard	8	USA, 12 China, 5	Germany, 12 France, 4	Finland,9 Sweden, 9 Austria, 4

Note: Countries were considered to have similar hourly compensation costs to Canada if compensation was less than $3/hour greater or lower than Canada's.

Sources: 1) U.S. Bureau of Labor Statistics, International Labor Comparisons; 2) Food and Agriculture Organization of the United Nations, FAOSTAT-Forestry.

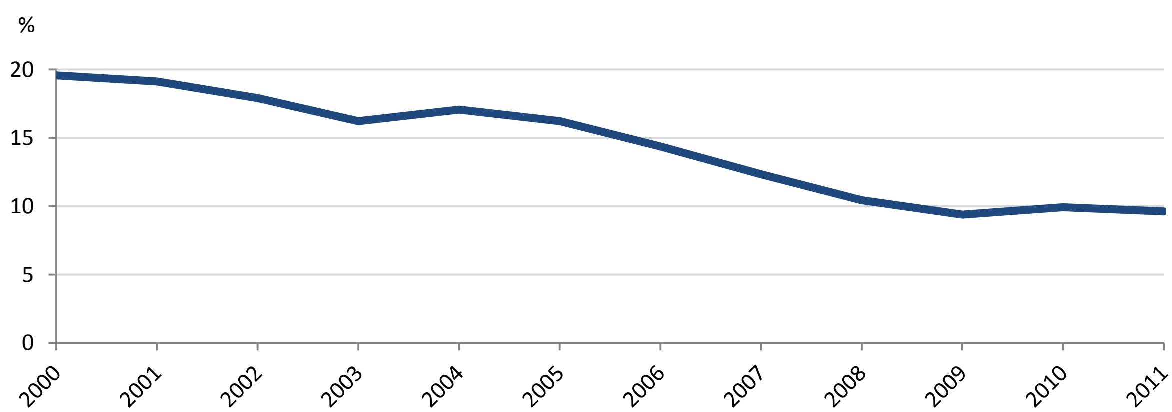
Table 23: Canada's Share in World Production of Major Forest Products, 2000-2011



Source: Food and Agriculture Organization of the United Nations, FAOSTAT-Forestry.

Despite falling demand for newsprint, global demand for forest products in general has steadily increased in the past decade, largely reflecting growth in emerging markets. Data from the U.N. Food and Agriculture Organization (FAO) show that global production of several forest products has increased, including production of roundwood, sawnwood, particleboards and fibreboards, recovered paper, and paperboard. The increased international competition has, however, taken its toll on the Canadian forest products sector, and demand for Canadian forest products has faltered. Between 2000 and 2011, production of all major forest products (with the exception of recovered paper) in Canada has fallen. Canada's production of sawnwood, for example, has declined by 23.0 per cent, from 50,465 thousand m^3 in 2000 to 38,858 thousand in 2011; paper and paperboard production saw an even steeper decline, 42.3 per cent, from 20,921 thousand tonnes in 2000 to 12,069 thousand tonnes in 2011. Overall, Canada's share in world production of all major forest products has fallen (Table 23). In addition, Canada's share in total world exports of forest products has halved in the past decade, declining from 18.8 per cent in 2000 to 9.1 per cent in 2011 (Chart 51).

Chart 51: Value of Canada's Forest Product Exports as a % of the World



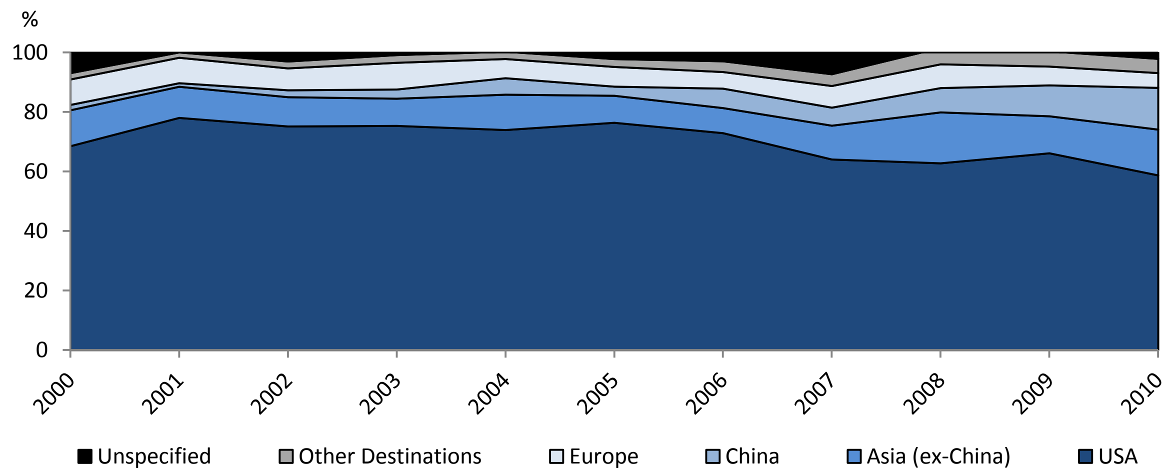
Source: CSLS calculations based on FAOSTAT-Forestry data.

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 production costs. This means, however, that employment in the sector might *fall* in the short-run. In the medium- and long-run, however, productivity gains in the sector can prove to be an important boon.

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. The increased demand for Canadian forest products may, in turn, lead to a rise in the sector's employment. Needless to say, new markets represent an important opportunity of expansion for the Canadian forest products sector, and should not be ignored. The strong demand for forest products in China, in particular, has taken front-stage in the past decade. In 2000 forest products exports to China accounted for only 2 per cent of total Canadian forest products exports; by 2010 they accounted for 14 per cent of Canadian forest product exports (Chart 52).

Chart 52: Canadian Forest Product Exports Broken Down by Destination, 2000-2010

(Per cent of total Canadian forest product exports)

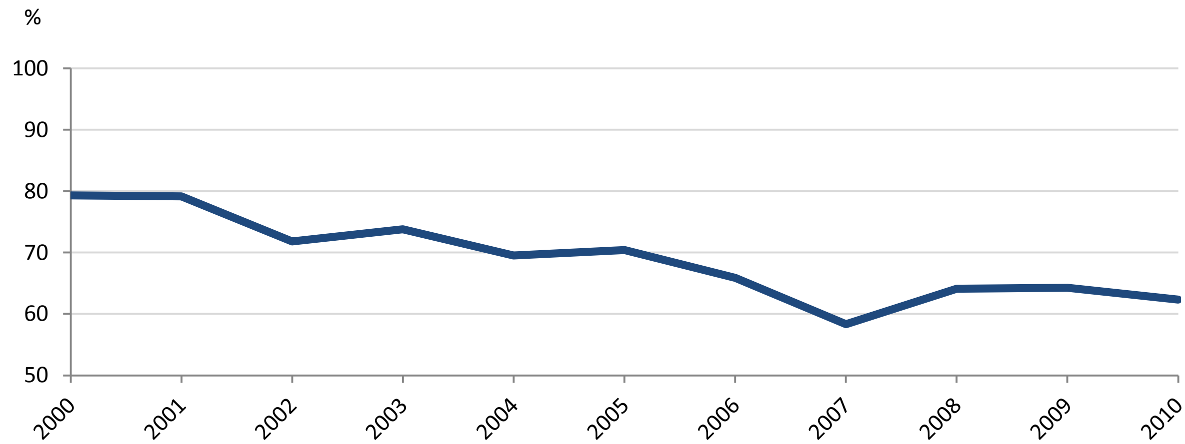


Source: CSLS calculations based on FAOSTAT-Forestry data.

Regaining market share in established markets should also be a key objective of the Canadian forest products sector. This applies in particular to the U.S. forest product market, where Canada has lost substantial ground. In 2000, Canadian imports represented 79 per cent of total U.S. forest products imports; by 2010, that figure had fallen to 62 per cent, a drop of 17 percentage points (Chart 53).

Chart 53: Canadian Forest Product Imports as a Share of Total U.S. Forest Product Imports, 2000-2010

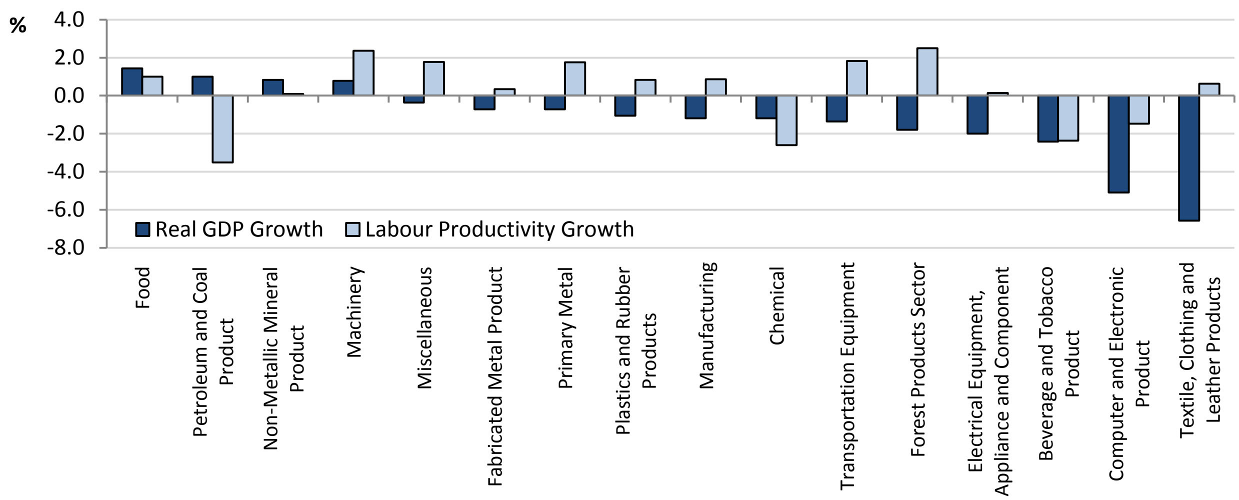
(Per cent of total U.S. forest products imports)



Source: CSLS calculations based on FAOSTAT-Forestry data.

Chart 54: Real GDP and Labour Productivity Growth in Canadian Manufacturing, 2000-2012

(Compound annual growth rates, per cent)



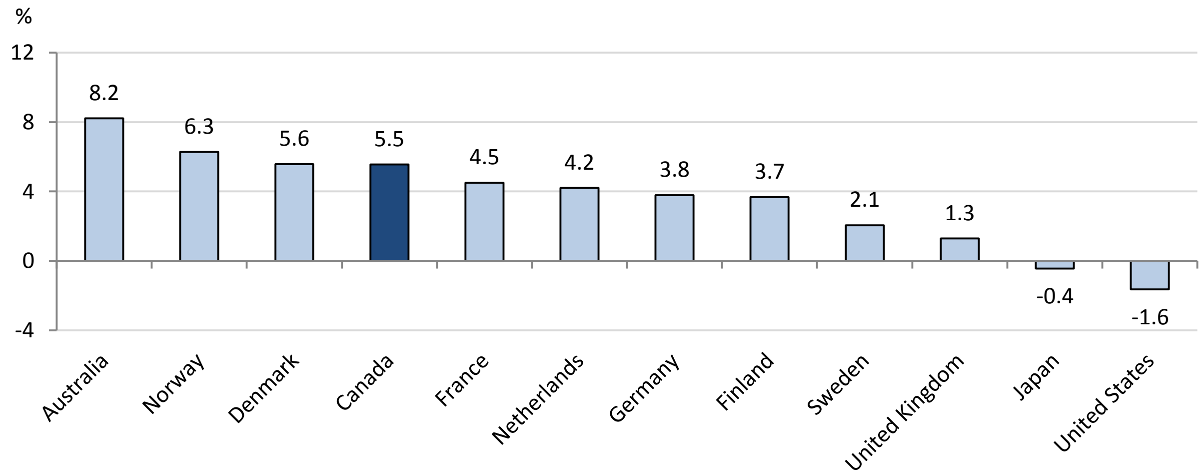
Source: CSLS calculations based on Statistics Canada data.

Finally, it is important to put the problems faced by the Canadian forest products sector into a broader perspective. High labour costs, a strong Canadian dollar, and increased international competition have affected not only the forest products sector, but the entire manufacturing sector in Canada. In fact, the past decade has not been kind to Canadian manufacturing. With few exceptions, manufacturing subsectors in Canada have seen real GDP decline during the 2000-2012 period (Chart 54). In addition to falling GDP, most manufacturing subsectors have experienced weak (or even negative) productivity growth in the period, further complicating their situation.

A useful indicator of a sector's competitiveness is unit labour costs, defined here as the ratio between real GDP and nominal labour compensation. As Chart 55 shows, while unit labour costs (in U.S. dollars) in Canada's manufacturing sector have increased at an average annual rate of 5.5 per cent between 2000 and 2011, unit labour costs in the U.S. manufacturing sector have actually *fallen* 1.6 per cent per year.

Chart 55: Unit Labour Costs (in U.S. dollars) in Manufacturing, International Comparison, 2000-2011

(Compound annual growth rates, per cent)



Source: U.S. Bureau of Labor Statistics, International Labor Comparisons.

The change in unit labour costs (in U.S. dollars) can be decomposed into three components: 1) the change in the exchange rates, where an appreciation of the Canadian dollar leads to an increase in labour costs; 2) the change in unit labour costs (in national currency); and 3) the change in labour productivity, where an increase in labour productivity leads to a fall in unit labour costs. Although hourly compensation in the Canadian manufacturing sector did not increase as much as in other developed countries (2.6 per cent per year), weak labour productivity gains (0.9 per cent per year) coupled with a strong Canadian dollar (3.8 per cent per year) meant rapidly rising unit labour costs and falling competitiveness. Much more effectively than other manufacturing subsectors, the Canadian forest products sector has managed to soften the blow of rapidly rising unit labour costs with major productivity gains.

VII. Policy

The previous section highlighted the importance of maintaining high rates of productivity growth in the Canadian forest products sector in order to keep unit labour costs down and regain competitiveness. 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.

This section provides an overview of public policies affecting the Canadian forest products sector, discussing whether the current policy environment is conducive to productivity growth, and making general suggestions regarding possible policy improvements. The section analyses human capital and innovation-related policies; how taxes influence investment in the forest products sector; and the role of government regulation in the sector.

A. Human Capital

Many recommendations have been made to address skill and labour shortages in the Canadian forest products sector. For example, the FPSC (2011) recommended that provincial governments develop detailed profiles of the occupations that are in demand in the forest products sector, highlighting skills and competencies need. These profiles could be used to "recruit and train workers, to assess knowledge transfer needs, to recognize workers' skills, and to support transitions between roles or occupations" (p.11). Detailed occupation profiles would also help new entrants to meet the demands of the labour market, facilitating recruitment and enhancing worker mobility.

Overall, there is a general need to assess and quantify the specific occupations where labour shortages occur. As mentioned in a report by the FPSC (2012:1) "the sector would benefit from sound, detailed and centralized information concerning apprenticeship and training participation rate and trends" that would help employers to take measures against current and future labour shortages and that would direct future workers to jobs where they are most needed.

At a more fundamental level, however, the sector needs to increase the participation in forest products-related apprenticeships. This can be done by better aligning training programs offered by training and education providers to the specific requirements of in-demand occupations. APEC (2008) identified the implementation of more standardized training programs and the strengthening of industry-education partnerships as a key step to address the skill gap in the forest product sector. In addition, incentives such as tax credits and subsidies could help overcome some of the barriers to training that we have highlighted in earlier sections of this report (fear of “poaching” by other industries, “hire and fire” mentality, lack of journeypersons, etc).

Additional efforts in training could have, however, sub-par outcomes if there is a lack of experienced journeypersons and mentors that can actually train new apprentices, which is a real concern given the sector’s aging workforce. In this sense, programs encouraging older workers to remain or get back on the labour market are also an important part of a long-term strategy to maintain a qualified workforce in the sector. APEC (2008:44) cites the Nova Scotia Christmas tree industry as an example of such a program. In Nova Scotia, “individuals [in this industry] can earn up to $4,000 without affecting benefits”, which creates an important incentive for workers to stay on the market.

The forest products sector also has to deal with its negative image problem. The industry downsizing has had a negative impact on how potential recruits perceive the sector, viewing “the lack of a stable employment outlook as a reason to avoid forest sector occupations” (FPSC, 2012:17). This problem is compounded by the closure of forest sector-specific training programs and by the inability of the sector itself to promote its many career opportunities. Among the solution proposed to this problem, there is a general call to “rebrand the forest industry as a knowledge industry, profiling firms that are innovation leaders within the region’s economy” (APEC, 2008:58). In line with this rebranding strategy, many studies have suggested that the industry must emphasize its sophistication in order to attract new workers.

It must be understood, however, that the sector’s image problem is intrinsically linked to other issues affecting its supply of both un-skilled and skilled labour. Halting the downward trend in the enrollment of forest products-related training; creating better incentives for employers to train new workers; putting an end to the “hire and fire” mentality wherever it exists, etc. all work to improve the perception that potential workers and the general public have of the forest products sector.

B. Innovation

The federal government has multiple programs that help promote innovation in the forest products sector, two of which stand out:

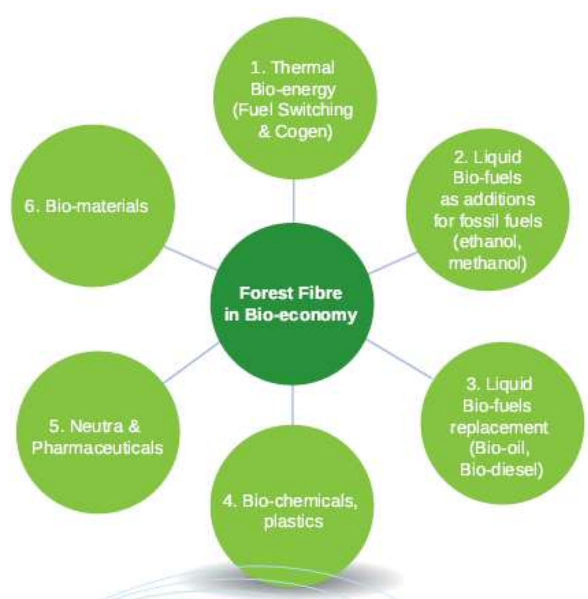
- The *Forest Innovation Program (FIP)*, the purpose of which is to “support research, development and technology transfer activities in Canada’s forest sector”. This program is expected to allocate $105 million to finance innovation in the sector over the next two years.

- The *Investments in Forest Industry Transformation (IFIT)* program, which was created with the Economic Action Plan of 2010 to support the implementation of innovative and promising technologies. Over the 2012-2016 period, $100 million will be allocated to this program for projects that implement new technologies leading to non-traditional high-value forest products and renewable energies.

Many of the recent efforts of the federal government, like IFIT program, were introduced in order to facilitate the changes currently taking place in the Canadian forest products sector. Before discussing policy suggestions, it is important to understand what exactly occurring in the sector.

In recent years, the discussion on innovation in the forest product sector in Canada has focused mostly around the development of new, high value-added products, called "forest bio-products". In its *Future Bio-pathways Project*, FPAC (2010) argued that the forest product sector is bound to change in the next years by enhancing its product mix and embracing new technologies and products. These new technologies include bio-fuels for energy production; bio-materials like nanocrystalline cellulose that can be "used in the aerospace industry to replace heavier more expensive non-renewable materials" (FPAC, 2010:2); green chemicals; as well as more uncommon products like forest product textiles and bio-drugs. The continuum of forest bio-products that can be created with those new innovations is illustrated in Exhibit 4.

Exhibit 4: The Forest Bio-Products Continuum



Source: FPAC (2010:4).

These new products and technologies have already started to transform the Canadian forest products sector. In 2010, for instance, "Domtar Inc. and FPInnovations announced a $32.4 million initiative to build the first commercial-scale pilot facility for the production of NCC. This facility will have a daily production capacity of one metric tonne and will be located at Domtar's plant in Quebec's Eastern Townships" (Standing Senate Committee on Agriculture and Forestry: 111). Other examples of the imminent transformation of the forest product sector include a demonstration plant at AbitiBowater's Thunder Bay pulp mill to produce lignin, and the imminent production of rayon, a component used in clothing, in Thurso, Quebec.

Of course, the risks involved in this transformation of the forest products sector are significant, and public policy can play an important role in minimizing them. The 2011 report by the Standing Senate Committee on Agriculture and Forestry has made a number of recommendations on how to support innovation in the forest product sector, which we will summarize below:

- *Guarantee access to long-term government funding to FPInnovations*. Most of the government funds allocated to forest products R&D are delivered by FPInnovations, a non-profit research centre created in 2007 by Natural Resources Canada as the merger of four institutions (Forintek, Feric, Paprican and the Canadian Wood Fibre Centre). FPInnovations is now the largest public–private forest products research institute in the world (Standing Senate Committee on Agriculture and Forestry, 2011) and a major player in the Canadian forest products sector. Natural Resources Canada (2010) concluded that "FPInnovations has generated short-term results in terms of productivity improvements and cost savings (…), as well as being an effective vehicle for bringing together research capacity (people, equipment and facilities) from the four divisions, as well as from external research organizations".

- *Increase access to venture capital and private equity*. Innovative forest product firms in Canada are frequently caught in what is called the "Valley of Death", i.e. the moment in the life cycle of a start-up company where "its technology is already too advanced for it to obtain funding for experimental research such as that offered by government agencies, yet not developed enough to attract private investors wanting to acquire shares in the firm" (Standing Senate Committee on Agriculture and Forestry, 2011:115). The Committee proposed the creation of an "Incubation Fund for Innovation in the Forest Sector" by Natural Resources Canada (in collaboration with the Business Development Bank of Canada) that could help businesses get through the valley of death, thus fostering innovation.

- *Improve the R&D tax credit regulation.* The regulation should be changed so that it focuses on technological content instead of business size.

Additionally, the government should also work to increase the stability of wood supply. The relatively insecure access to fibre supplies is identified by many (Globerman *et al.*, 1998; APEC, 2008; Woodbridge Associates, 2009) as one of the reasons why firms are reluctant to engage in R&D activities. Solutions to this problem would include designating certain areas as dedicated to timber production, with long-term and inalienable cutting rights granted to producers (Globerman *et al.*, 1998). Whether these areas should be managed by the private or the public sector, however, is open to debate. Woodbridge Associates (2008) argue, for instance, that empirical evidence shows that the private sector is usually more efficient managing commercial forest land than the public sector. APEC (2008:31), on the other hand, suggests that private ownership of forests in Nova Scotia, while increasing flexibility to market conditions, has also made it difficult to control the supply of timber, as many private owners may "be more resistant to investing in silviculture or incorporating advanced forest management practices".

C. Taxation

Taxation can influence productivity by affecting investment decisions. More investment means, *ceteris paribus*, higher capital intensity, which usually translates into higher productivity. In order to maximize profits, firms invest until the return from the last dollar invested equals the cost. Taxes on firms' profits reduce the return on investment, while tax allowances, like the allowance for capital consumption, reduce marginal cost. An example of this is the resource allowance royalty deductibility (which includes forestry) that allows firms to deduct the amount they pay in resource royalties to the government from their taxable income. Another example is the British Columbia Logging Tax Credit, which allows B.C. logging establishments to claim a credit of one third of their logging tax payable.

First, this section considers the effect of tax incentives on productivity and capital formation in Canada's sawmilling industry; next, marginal effective tax rates for the forest products sector are analyzed.

i. Effect of Tax Incentives on the Canadian Sawmilling Industry

Ghebremichael and Potter-Witter (2009) analyse the effect of tax incentives on the Canadian sawmilling industry during the 1961-2000 period. In order to study how tax changes affect capital formation and (multifactor) productivity in the sector, the authors investigated the effects of: 1) a doubling of the capital cost allowance rate for machinery and equipment assets; 2) a doubling the investment tax credit rate; 3) a 50 per cent reduction of the corporate income tax rate. Two key findings were made:

- Higher nominal GDP shares of capital costs were strongly correlated to tax incentives, indicating that the incentives enhanced the capital formation.

- Capital intensity under tax incentives showed stronger growth than without incentives. Over the whole 1961-2000 period, average annual intensities were $10,402 in real dollars per worker without tax incentives, and $15,263.70 in real dollars per worker with incentives.

By reducing its rental price, tax incentives can raise the demand for capital, leading to enhanced capital formation and faster MFP growth. This paper gives credence to the idea that in order for the forest products industry to remain competitive, government tax policy should reflect increased rates of capital cost allowance and investment tax credit as well as reduced rates of corporate income tax. That being said, with the 2012 corporate tax reductions from 16.5 per cent to 15.0 per cent, the effectiveness of further decreasing corporate tax rates would probably be very small (Chen and Mintz, 2012). While the paper focuses only on the sawmilling industry, the results can most likely be extended to the forest products sector as a whole.

ii. Marginal Effective Tax Rates

The marginal effective tax rate (METR) is the most common measure of the total impact that taxes and allowances have on the return to marginal investments. The theoretical METR on investment is the pre-tax return minus the post-tax return, divided by the pre-tax return and expressed as a percentage. All else being equal, a firm should invest in industries and assets with low METRs. Taxes on capital lower the return that investors receive from investment, which can reduce the overall level of investment and result in lower capital intensity and labour productivity. Chen and Mintz (2012) have constructed industry-level METR estimates for Canada and the provinces in 2012, as well as forecasts for 2014 based on planned tax policy changes. These estimates represent the total annualized value of corporate and capital taxes and the sales tax paid on capital purchases, expressed as a proportion of the gross rate of return on capital.

Table 24 presents the Chen and Mintz METR estimates for forestry, manufacturing, and the aggregate economy in Canada and key forest product provinces in 2012 and 2014 (expected).[34] Aggregate METR is expected to increase in Canada as a whole and all key forest product provinces, with British Columbia experiencing the largest increase of 10.3 percentage points, from 17.4 per cent in 2012 to 27.7 per cent in 2014, and Alberta experiencing the smallest increase of 1.4 percentage points, from 16.5 per cent in 2012 to 17.9 per cent in 2014. Despite facing an increase in METRs, forestry will still have a favourable tax environment in 2014, with below-average METRS in Canada and all key forest product provinces. Manufacturing METRs, although not as low as forestry METRs, are still significantly lower than aggregate METRs and are expected to continue this way.

[34] METR estimates for specific manufacturing subsectors – like wood product and paper manufacturing – were not available.

Table 24: Marginal Effective Tax Rates for Forestry, Manufacturing, and Aggregate Economy, 2012 and 2014

	Forestry			Manufacturing			Aggregate		
	2012	2014	Δ	2012	2014	Δ	2012	2014	Δ
					(per cent)				
Canada	-0.4	9.9	10.3	6.0	13.8	7.8	16.8	19.9	3.1
QC	-5.0	5.4	10.4	1.0	9.1	8.1	14.5	16.9	2.4
ON	8.3	16.2	7.9	10.3	17.6	7.3	17.6	19.8	2.2
AB	9.1	16.4	7.3	12.6	18.5	5.9	16.5	17.9	1.4
BC	9.1	20.0	10.9	11.2	22.0	10.8	17.4	27.7	10.3

Source: Chen and Mintz (2012).

D. Regulation

Government regulation can have both positive and negative effects on productivity growth in that it can either restrict or enable firms' decision making options.[35] For example, government regulations that restrict certain types of logging practices for safety or environmental reasons, or that require stringent controls on air and water emissions from paper plants, can increase operating and capital costs and thereby reduce productivity. Alternatively, government regulations can force firms to take actions they would not normally take. These actions may have unexpected positive consequences for productivity and competitiveness, particularly if other countries eventually adopt the same regulations, giving the early adopters an advantage. Government regulations can also enable firms to lower their costs, as is the case with stumpage fees being determined administratively in Canada rather than according to competitive auctions.[36] While the focus of this section is largely on the effects that government regulation can have on productivity growth, the evaluation of the effectiveness of government regulation must go beyond this and incorporate the societal benefits of non-economic factors such as reduced pollution and increased employment.

Regulation plays an important role in the Canadian forest products industry because around 93 per cent of forested land is publicly owned, mostly by provincial governments (FPAC, 2005:10). FPAC (2005) identifies three key areas of concern with respect to government regulation in the forest products sector: 1) the *Competition Act* fails to recognize the global nature of the sector and unnecessarily obstructs consolidation; 2) the overlapping jurisdictions of the federal and provincial governments create confusion and redundancy in the forest products sector; 3) specific policies tie access to resources to the maintenance of certain production facilities.

[35] This section draws heavily from and updates Harrison and Sharpe (2009).
[36] It has been argued that the Canadian stumpage system *de facto* subsidizes the price of Canadian stumpage. While there is provincial variation in how the stumpage is set in Canada, stumpage prices in Canada were well below the market stumpage prices experienced in the United States in 2006 (Sedjo, 2006:449).

First, the *Competition Act* may unnecessarily obstruct consolidation within the sector. Consolidation can provide the forest products sector with several competitive advantages, including increased efficiency and lower capital costs (FPAC, 2005).The main argument in favour of consolidation from a competition policy perspective is that forest products are integrated through free-trade, with prices that are set in global markets and with few barriers to entry in the sector. These characteristics make it unlikely that large Canadian forest product firms could adversely affect consumers through the anticompetitive exercise of market power. Excessively stringent competition policy could harm productivity growth in the sector if there are significant economies of scale to be exploited.

It is imperative that the *Competition Act* be applied to the forest products sector in a way in which the global nature of the market for Canadian forest products is further recognized and emphasized. Recent mergers within the sector have been met with restrictions and conditions imposed by the Competition Bureau which are not fully in line with the goals of the forest products sector to increase the amount of consolidation in the market. The previously mentioned conditions appear in two mergers in 2004, first between Canfor and Slocan and second between West Fraser and Weldwood. In the first merger, the Competition Bureau required Canfor to sell its mill located in Fort St. James and in the second merger West Fraser was required to sell its 90 per cent stake in Babine sawmills and related harvesting rights (Ministry of Forests of British Columbia, 2005).

Notwithstanding the limitations placed on certain mergers, there has been significant consolidation activity within the sector since the 1990s. For example, in Ontario, eight corporations maintained control of 90 per cent of all harvested timber in 2005, whereas in 1990, 24 corporations maintained control of the same proportion of timber (Ontario Ministry of Natural Resources, 2005). This trend of increasing consolidation, joint ventures, and strategic alliances has continued in more recent years. In 2012, 50 per cent of all CEOs in Canadian forestry, paper and packaging companies reported that they struck a new strategic alliance or joint venture, 32 per cent reported that they completed a closed domestic merger-and-acquisition (M&A) deal, and 34 per cent reported that they completed a cross-border M&A deal (PWC, 2013). All three of the previously mentioned rates were higher among forestry, paper and packaging companies than the economy-wide rates.[37]

The second key area of concern is the overlapping jurisdictions of the federal and provincial governments. Each province regulates harvesting levels and practices in forestry, such as through the Crown Forest Sustainability Act in Ontario, while the Federal government also regulates the forestry industry through the *Forestry Act.* There is also overlap in how mergers

[37] Specifically, 24 per cent of all economy-wide CEOs completed a domestic M&A deal, 19 per cent completed a cross-border M&A deal, and overall only 36 per cent of CEOs entered into a new strategic alliance or joint venture.

and acquisitions are reviewed. While the provinces regulate harvesting levels and practices, the federal government oversees the execution of the *Competition Act*. In 2004 three acquisitions (Canfor/Slocan, Tolko/Riverside/Lignum and West Fraser/Weldwood) in British Columbia were reviewed by both the British Columbia Ministry of Forests and the Competition Bureau (Ministry of Forests of British Columbia, 2005). The British Columbia government, who owned the resources and thus had an interest in maintaining a competitive and sustained marketplace, approved the mergers. The Competition Bureau subsequently undertook its own investigation of the mergers, seeking to also protect the competitiveness of the market, but to additionally protect Canadian consumers from adverse effects related to possible monopoly power. While these two governmental bodies have different mandates, the federal and provincial governments could better coordinate their regulatory actions in order to reduce redundant investigations and improve efficiency.

The final key area of concern is that governments' forest management policies often make resource access contingent upon the maintenance of specific production facilities. More specifically, the allocation of resources is determined by firms' willingness to continue to manage certain facilities that normally would not be likely operational. Presumably, the purpose of such policies is to prevent job losses among workers in the forest products sector. Such policies may encourage the maintenance of inefficient productive capacity.

VIII. 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, declining from 18.8 per cent in 2000 to only 9.1 per cent in 2011.

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. 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. During the 2000-2012 period, Canada's forest products sector has had an excellent labour 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.

The Canadian forest products sector is undergoing important transformations, moving from the production of traditional goods like newsprint to the development and commercialization of new technologies such as bio-energy and bio-chemicals. 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. For this to happen, two key issues must be addressed. 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, skill shortages are a key concern of forest product firms, and can significantly hinder productivity growth if not dealt with properly. In this sense, the report recommends renewed focus on both human and physical capital investment, as well as on R&D spending.

References

Arsenault, Jean-François and Andrew Sharpe (2008) "An analysis of the causes of weak labour productivity growth in Canada since 2000," *International Productivity Monitor*, No. 16, Spring, pp. 14-39

Atlantic Provinces Economic Council (APEC) (2008) "Building Competitiveness in Atlantic Canada's Forest Industries: A Strategy for Future Prosperity."

Baldwin, John R., Wulong Gu, and Beiling Yan (2007) "User guide for Statistics Canada's annual multifactor productivity program," *The Canadian Productivity Review*, Research Paper, Catalogue No. 15-206-XIE – No. 14 (Ottawa: Statistics Canada).

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).

Bogdanski, Bryan (2011) "Midterm outlook for the Canadian pulp and paper sector: 2011-2020," presentation given at the 2011 Western Forest Economists Meeting.

Natural Resources Canada (2011) "The state of Canada's forests," Annual Report, Canadian Forest Service

Canadian Institute of Forestry (CIF) (2006) "The crisis in post-secondary enrollments in forestry programs: a call to action for Canada's future forestry professional/technical workforce," white paper on post-secondary forestry recruitment.

Centre for Innovation Studies (2008) "The natural resource industries as engines of economic diversification," summary of the Second Annual Banff Innovation Summit 26-28 September.

Council of Canadian Academies (2006) "The state of science and technology in Canada, 2006."

Council of Canadian Academies (2012) "The state of science and technology in Canada, 2012."

De Avillez, Ricardo (2012) "Sectoral contributions to labour productivity growth in Canada: does the choice of decomposition formula matter?" CSLS Research Report 2012-09 (Ottawa: Centre for the Study of Living Standards).

Deloitte (2011) "Compass 2011 – Global forest, paper, and packaging sector outlook," Global Manufacturing Industry Group Report.

Deloitte (2012) "Compass 2012 – Global forest, paper, and packaging sector outlook," Global Manufacturing Industry Group Report.

Deloitte (2013) "2013 Global forest, paper, and packaging trend watch – A changing landscape: South America's influence on global markets," Global Manufacturing Industry Group Report.

Diewert, Erwin (2008) "The measurement of nonmarket sector outputs and inputs using cost weights," Discussion Paper 08-03, Department of Economics, University of British Columbia.

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. An earlier version of this paper can be found here.

Chen, Duanjie and Jack Mintz (2012) "2012 annual global tax competitiveness ranking – A Canadian good news story," University of Calgary, School of Public Policy Research Paper, Volume 5, Issue 28, September.

Forest Products Industry Competitiveness Task Force (2007) "Industry at a crossroads: choosing the path to renewal," Forest Products Association of Canada.

Forest Products Association of Canada (FPAC) (2005) "Competition and consolidation in Canada's forest products industry."

FPAC (2010) "Transforming Canada's forest product industry: summary of findings from the Future Bio-Pathways Project."

FPAC (2012) "Canada's Vision 2020 challenge," presentation to FPInnovations Board, September 26.

Forest Products Sector Council (FPSC) (2011) "Renewing Canada's greenest workforce: a labour market intelligence report."

FPSC (2012) "Linking innovation with skills: apprenticeships, regulated occupations and workforce development in Canada's forest products sector."

Ghebremichael, Asghedom and Karen Potter-Witter (2009) "Effects of tax incentives on long-run capital formation and total factor productivity growth in the Canadian sawmilling industry," *Forest Policy and Economics*, Vol. 11, No. 2, pp. 85-94.

Girard, Andrée, Jean-Pierre Maynard and Marc Tanguay (2006) "Producing hours worked for the SNA in order to measure productivity: the Canadian experience," *The Canadian Productivity Review*, Research Paper, Catalogue No. 15-206-XIE – No. 004 (Ottawa: Statistics Canada).

Globerman, Steven, Masao Nakamura, Karen Ruckman and Ilan Vertinsky (1998) "Innovation, strategy and Canada's forest products industry," Canadian Public Policy, Vol. 24, No. 2.

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

Maynard, Jean-Pierre (2005) "Annual measure of the volume of work consistent with the SNA: the Canadian experience," Economic Analysis Methodology Paper Series: National Accounts, Research Paper, Catalogue No. 11F0026MIE – No. 005 (Ottawa: Statistics Canada).

Ministry of Forests of British Columbia (2005) "Major primary timber processing facilities in British Columbia," Economics and Trade Branch.

Natural Resources Canada (2010) "Evaluation of Forest Innovation and Forest Research Institute Initiative Support to the Forest Research Institutes," Strategic Evaluation Division.

OECD (2001) *Measuring productivity – Measurement of aggregate and industry-level productivity growth* (Paris: OECD).

OECD/Eurostat (2005) *The measurement of scientific and technological activities: proposed guidelines for collecting and interpreting technological innovation data*, Oslo Manual, third edition.

Ontario Ministry of Natural Resources (2005) "Minister's council on forest sector competitiveness," Final Report, May.

PriceWaterhouseCoopers (PWC) (2013): "Global CEO survey."

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.

Sedjo, A. Roger (2005) "Comparative views of different stumpage pricing systems: Canada and the United States," *Forest Science*, Vol. 52, No. 4.

Sharpe, Andrew (2011) "Is ageing a drag on productivity growth? A review article on 'Ageing, health and productivity: the economics of increased life expectancy'," *International Productivity Monitor*, No. 21, Fall, pp. 82-94.

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).

Sharpe, Andrew and Ian Currie (2008) "Competitive intensity as a driver of innovation and productivity growth: a synthesis of the literature," CSLS Research Report 2008-03 (Ottawa: Centre for the Study of Living Standards).

Sharpe, Andrew and Ricardo de Avillez (2010) "Canada-U.S. ICT investment in 2009: the ICT investment per worker gap widens," CSLS Research Report 2010-08 (Ottawa: Centre for the Study of Living Standards).

Standing Senate Committee on Agriculture and Forestry (2011) "The Canadian forest sector: a future based on innovation."

Statistics Canada (2012) *North American Industry Classification System (NAICS) – Canada*, Cat. No. 12-501-X (Ottawa: Statistics Canada).

Statistics Canada (2013) *Industrial Research and Development: Intentions*, Cat. 88-202-X (Ottawa: Statistics Canada).

Statistics Canada (2008) "Guide to the Survey of Employment, Payrolls and Hours," in *Employment, earnings and hours, 2008,* Catalogue No. 72-002XIB (Ottawa: Statistics Canada).

Tang, Jianmin, Someshwar Rao, and Min Li (2010) "Sensitivity of capital stock and multifactor productivity estimates to depreciation assumptions: a Canada-U.S. comparison," International Productivity Monitor, No. 20, Fall, pp. 22-47.

Tang, Xiaoli (2008) "An economic analysis of North American pulp and paper markets, and a competitiveness study of the Canadian pulp and paper products," PhD Thesis, Faculty of Forestry, University of Toronto.

Tipper, Adam and Nicholas Warmke (2012) "Adjusting productivity statistics for variable capacity utilization – Working harder or hardly working?" Working Paper No. 12-02, Statistics New Zealand.

Trueblood, Michael and Vernon Ruttan (1992) "A comparison of multifactor productivity calculations of the U.S. agricultural sector," Staff Paper P92-29, Department of Agriculture and Applied Economics, University of Minnesota.

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

WMC (2012) "Research on worker retention."

Wernerheim C.M. and Blair Long (2011) "Commercial forestry at a cross-roads: emerging trends in the forest sector of Newfoundland and Labrador," Leslie Harris Centre of Regional Policy and Development Applied Research Fund Report.

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.

Yu, Kam. (2004) "Measurement of government output", forthcoming in *Essays on price and productivity measurement*, Vol. 3, W.E. Diewert, B. Balk, D. Fixler, K. Fox, and A.O. Nakamura (eds.) (Victoria: Trafford Publishing).

Appendix 1: Sources of Labour Productivity Growth

The standard neo-classical framework assumes a production function F(.) that combines inputs and transforms them into output (Y). In a value-added framework, inputs include labour (L) and capital (K), such that:

$$Y_t = A_t F(L_t, K_t) \tag{1}$$

where *A* represents multifactor productivity and *t* is a time subscript. In addition, labour input *L* can be decomposed into hours worked (*H*) and labour quality (*QL*):

$$L_t = H_t * QL_t; \tag{2}$$

and capital intensity (*KI*) can be defined as:

$$KI_t = \frac{K_t}{H_t} \tag{3}$$

A common functional form for F(.) used in growth accounting exercises is the Cobb-Douglas form, such that equation (1) becomes:

$$Y_t = A_t L_t^{\alpha} K_t^{\beta} \tag{4}$$

where the coefficients α and β indicate the output elasticity with respect to labour and capital, respectively.[38]

Since labour productivity is output per hour worked, we divide both sides of (4) by *H*:

$$\frac{Y_t}{H_t} = \frac{A_t L_t^{\alpha} K_t^{\beta} C_t^{\gamma}}{H_t} = \frac{A_t (H_t * QL_t)_t^{\alpha} K_t^{\beta}}{H_t} = A_t QL_t^{\alpha} * \left(\frac{K_t}{H_t}\right)^{\beta} = A_t QL_t^{\alpha} KI_t^{\beta} \tag{5}$$

Assuming constant returns to scale (such that $\alpha + \beta = 1$) and taking the natural logarithms of both sides of equation (5), we have that:

$$lp_t = (y_t - h_t) = a_t + \alpha\, ql_t + \beta(k_t - l_t) \tag{6}$$

where lower case letters denote the natural logarithm of the original variable (e.g. $y = lnY$) and lp_t denotes the natural logarithm of labour productivity.

[38] The output elasticity with respect to a certain input measures the per cent change in output given a one per cent change in that particular input. In other words: how much does output increase if we increase the use of a particular input by one per cent? Intuitively, the coefficients α and β reflect the importance of each input in the production process.

Thus, labour productivity growth from period *t-1* to period *t* can be approximated as:

$$\Delta lp = \Delta(y - l) = \Delta a + \alpha\, \Delta ql + \beta \Delta(k - l) \qquad (7)$$

where Δ indicates the change in the variables between periods *t* and *t-1*.

Equation (7) decomposes labour productivity growth into three components: 1) multifactor productivity growth; 2) labour composition growth (weighted by the coefficient α); and 3) capital input growth that exceeds hours worked growth (weighted by the coefficient β). It is clear, therefore, that what matters for productivity growth is not capital input growth *per se*, but capital input growth in excess of hours worked growth. In other words, what matters for productivity growth is *capital intensity* growth. Increased capital intensity indicates *capital deepening*, i.e. workers have more capital to work with.

If we assume, additionally, that factor and product markets are perfectly competitive, the coefficients α and β become equal to the (nominal) compensation shares of labour and capital (respectively) in output.

Appendix 2: A Detailed Breakdown of the Forest Products Sector

A detailed breakdown of the paper manufacturing subsector is shown below in Exhibit 1A.

Exhibit 1A: Detailed Breakdown of Paper Manufacturing

Paper Manufacturing (NAICS 322)	**Pulp, Paper and Paperboard Mills (NAICS 3221)**	Pulp Mills (NAICS 32211)
		Paper Mills (NAICS 32212)
		Paperboard Mills (NAICS 32213)
	Converted Paper Product Manufacturing (NAICS 3222)	Paperboard Container Manufacturing (NAICS 32221)
		Paper Bag and Coated and Treated Paper Manufacturing (NAICS 32222)
		Stationery Product Manufacturing (NAICS 32223)
		Other Converted Paper Manufacturing (NAICS 32229)

Source: Statistics Canada (2012).

While Statistics Canada produces data on nominal GDP and real GDP for the four-digit NAICS industry groups under paper manufacturing – namely: pulp, paper and paperboard mills (NAICS 3221) and converted paper product manufacturing (NAICS 3222) – they do not have data at the five-digit NAICS level. In other words, estimates for pulp mills (NAICS 32211) and paper mills (NAICS 32212) specifically **are not available**.

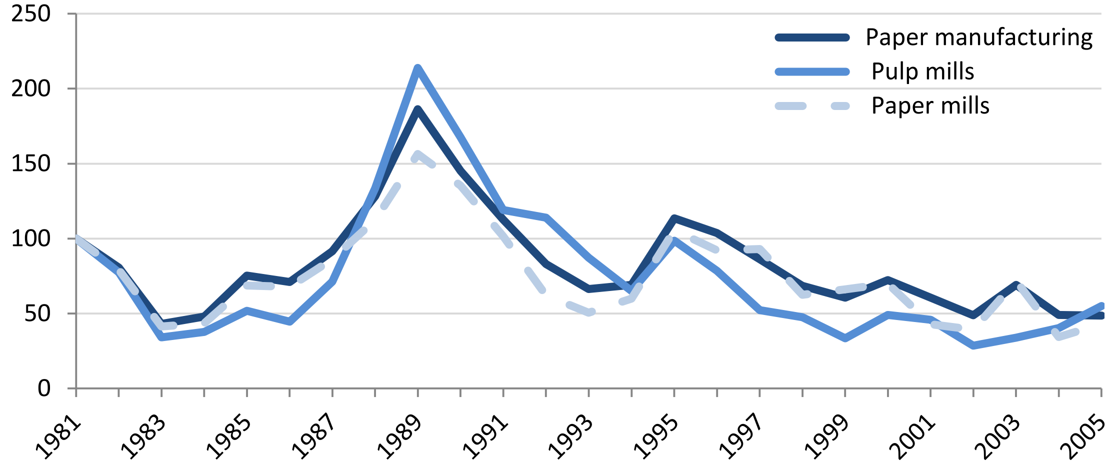
The CSLS contacted Statistics Canada and asked if such estimates could be obtained through a special order, but this was not possible. Prior to recent revisions to the System of National Accounts (SNA), this data might have been available through a special order. However, due to the falling total economy nominal GDP share of the Canadian manufacturing sector, Statistics Canada has reduced the level of detail of its GDP estimates for manufacturing industries, while at the same time increasing the level of detail provided for service industries.

Similarly, the two main surveys that offer employment (or hours worked) estimates broken down by NAICS code – namely, the Labour Force Survey (LFS) and the Survey of Employment, Payrolls and Hours (SEPH) – do not have data for the five-digit NAICS industries under paper manufacturing. The CSLS contacted Statistics Canada officials involved in both the LFS and the SEPH, and once again we were told that obtaining estimates at that level was not possible. Since neither real GDP nor employment estimates were available at the five-digit

NAICS level, labour productivity estimates for pulp mills and paper mills cannot be constructed using SNA, LFS or SEPH data. By extension, there are no separate estimates for output, employment or labour productivity for pulp and paper mills from the Canadian Productivity Accounts (CPA), which constructs its estimates using, among other sources, data from the SNA, the LFS, and the SEPH.

Investment and capital stock data for pulp and paper mills specifically used to be published by Statistics Canada's Fixed Capital Flows and Stocks (FCFS) program, but these series were terminated, with the last available data points referring to 2005. Estimates from the Capital and Repair Expenditure Survey, from which FCFS estimates are constructed, also refer only to the four-digit NAICS industry groups under paper manufacturing, not offering any additional level of detail.

Chart 1A: Real Investment in Pulp Mills and Paper Mills, 1981-2005
(index, 1981=100)



Source: Statistics Canada, FCFS, CANSIM Table 031-0002.

Below, we briefly discuss fixed, non-residential investment in pulp mills and paper mills in Canada during the 1981-2005 period. In 2005, real investment in pulp mills was $545 million (in chained 2007 dollars), down 45 per cent from $989 million in 1981. Experiencing an even larger drop, real investment in paper mills fell 57 per cent in the period, from $1,841 million (in chained 2007 dollars) to $792 million. Chart 1A shows the evolution of real investment in pulp and paper mills over the 1981-2005 period, with 1981 serving as a reference year. Table 1A provides additional details, highlighting variations in nominal investment shares and compound annual growth rates for real investment in pulp and paper mills.

It would have been interesting to decouple investment in pulp and paper mills for the 2010-2012 period to better understand the effects of the Pulp and Paper Green Transformation

Program (PPGTP). This decoupling is however, impossible, given that investment estimates for pulp and paper mills are not available post-2005.

Table 1A: Investment in Pulp Mills and Paper Manufacturing, 1981-2005

	Share of Nominal Paper Manufacturing Investment			Real Investment Growth		
	1981	2000	2005	1981-2005	1981-2000	2000-2005
	(per cent)			(CAGR, per cent)		
Paper Manufacturing	100.0	100.0	100.0	-3.0	-1.7	-7.6
Pulp Mills	32.3	20.4	32.4	-2.5	-3.7	2.4
Paper Mills	60.4	54.7	47.9	-3.5	-1.9	-9.2
Other Paper Manufacturing	7.3	24.9	19.7	..	..	..

Source: Statistics Canada, FCFS, CANSIM Table 031-0002.

Summarizing, the standard sources used to construct productivity estimates do not have data for pulp and paper mills separately. This does not mean, however, that data for these industries are not available from other sources. The Annual Survey of Manufacturers and Logging (ASML) has a wealth of data at the five-digit NAICS level (and even lower). The ASML has detailed estimates on the following variables for the 2004-2011 period:

- Revenue;
- Total expenses;
- Expenses with salaries and wages (broken down by category of worker: production workers vs. non-manufacturing employees);
- Cost of energy, water utility, and vehicle fuel;
- Cost of materials and supplies;
- Total number of employees (broken down once again by category of worker: production workers vs. non-manufacturing employees);
- Total opening inventories (broken down by category: goods or work in process vs. finished goods);
- Total closing inventories (broken down by category: goods or work in process vs. finished goods);
- Manufacturing value added;
- Number of establishments (up to 2010, after which the series was terminated).

With the exception of total number of employees and number of establishments, all of the variables above are expressed in current dollars. The above data can be used to construct *alternative* labour productivity estimates, with labour productivity defined here as **manufacturing value added** per employee. Manufacturing value added is defined as revenues (plus the net change in the value of inventories) minus the cost of intermediate inputs.

The manufacturing value added estimates from the ASML are systematically greater than the value added (GDP at basic prices) estimates produced by the Industry Accounts division at

Statistics Canada (which are used by the CPA). On the other hand, the employment estimates from the ASML are (at least for wood product and paper manufacturing) systematically lower than the estimates from the CPA. One reason for this is that the CPA uses number of jobs instead of number of persons employed, and some people are multiple job holders. Table 2A compares value added and employment level estimates in the ASML and the CPA, showing that there are notable differences in both value added and employment estimates in data sources.

Table 2A: Nominal Value Added and Employment Levels in Wood Product and Paper Manufacturing in 2010, ASML and CPA Comparison

	Value Added		Employment	
	ASML	CPA	ASML	CPA
	(current dollars, millions)		(number of persons)	
Wood product manufacturing	7,804	6,809	88,005	96,180
Sawmills and wood preservation	3,284	2,867	32,635	35,350
Veneer, plywood and engineered wood product manufacturing	1,632	1,464	17,354	19,060
Other wood product manufacturing	2,888	2,479	38,016	41,770
Paper manufacturing	9,442	8,519	56,343	67,460
Pulp, paper and paperboard mills	6,170	5,356	29,064	35,425
Converted paper product manufacturing	3,272	3,164	27,279	32,035

Source: Statistics Canada, ASML (CANSIM Table 301-0006), GDP by Industry (CANSIM Table 379-0030), and Labour Statistics by Business Sector Industry (CANSIM Table 383-0030).

Complementing Table 2A, Table 3A shows that there are also significant differences between the two programs in terms of value added *growth*. This is not surprising, given that the two programs use different value added concepts. It is interesting to note, however, that despite some significant differences regarding employment (level) estimates, employment *growth rates* are very similar in the ASML and the CPA. In wood product manufacturing, for instance, employment declined at an annual rate of 7.3 per cent according to the ASML, compared to a rate of 6.2 per cent in the CPA (Table 3). The only large difference is seen in veneer, plywood and engineered wood product manufacturing, which saw a decline in employment of 7.7 per cent per year according to the ASML, but only 1.1 per cent per year according to the CPA.

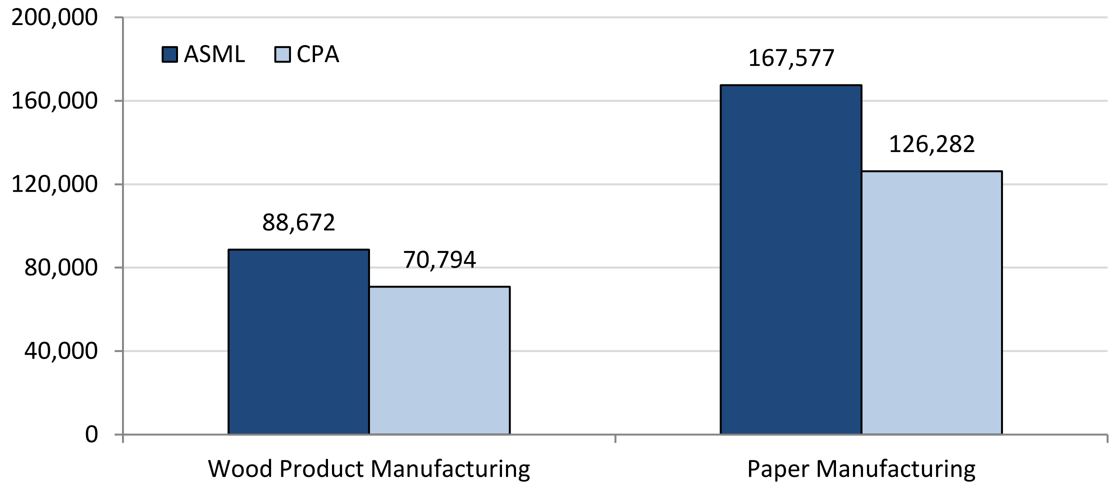
Table 3A: Nominal Value Added and Employment Growth in Wood Product and Paper Manufacturing in the 2007-2010 Period, ASML and CPA Comparison

	Value Added Growth		Employment Growth	
	ASML	CPA	ASML	CPA
	(CAGR, per cent)		(CAGR, per cent)	
Wood product manufacturing	-6.1	-10.9	-7.3	-6.2
Sawmills and wood preservation	-5.6	-11.4	-9.4	-9.2
Veneer, plywood and engineered wood product manufacturing	-6.1	-11.7	-7.7	-1.1
Other wood product manufacturing	-6.7	-9.9	-5.2	-5.5
Paper manufacturing	-5.0	-2.8	-6.9	-7.5
Pulp, paper and paperboard mills	-5.9	-2.7	-9.4	-10.8
Converted paper product manufacturing	-3.2	-2.9	-3.9	-3.3

Source: Statistics Canada, ASML (CANSIM Table 301-0006), GDP by Industry (CANSIM Table 379-0030), and Labour Statistics by Business Sector Industry (CANSIM Table 383-0030).

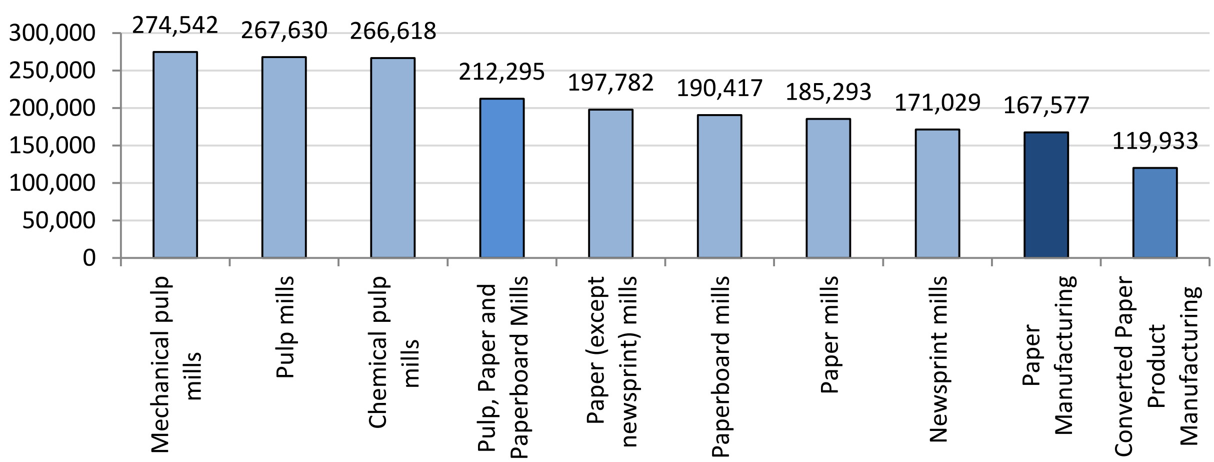
Chart 2A compares the (nominal) labour productivity levels for wood and paper manufacturing in 2010 using ASML and CPP data. Labour productivity levels are systematically higher using ASML data. In the case of wood product manufacturing, workers generated on average $88,672 in manufacturing value added vs. only $70,794 in value added according to CPA data. For paper manufacturing, the difference was even greater: $167,577 per worker according to ASML data and $126,282 per worker according to CPA data.

Chart 2A: Nominal Labour Productivity Levels for Wood Product and Paper Manufacturing in 2010, ASML and CPA Comparison
(nominal value added per worker)



Note: ASML labour productivity estimates are calculated using nominal manufacturing value added, while CPA estimates are calculated using nominal value added (i.e. GDP at basic prices).
Source: CSLS calculations using Statistics Canada data: 1) ASML (CANSIM Table 301-0006); 2) GDP by Industry (CANSIM Table 379-0030); 3) and Labour Statistics by Business Sector Industry (CANSIM Table 383-0030).

Chart 3A: Nominal Labour Productivity Levels for Paper Manufacturing Industries, 2010



Note: Five- and six-digit industries are represented in light blue; four-digit industry groups in solid blue; and three-digit subsectors in dark blue.
Source: CSLS calculations using Statistics Canada data, ASML, CANSIM Table 301-0006.

Chart 3A shows (nominal) labour productivity levels at the four-, five- and six-digit levels for paper manufacturing industries in 2010. At the four-digit NAICS level, the labour productivity level of pulp, paper and paperboard mills was significantly higher than that of converted paper product manufacturing ($212,295 per worker vs. 119,933 per worker, respectively). At the five- and six-digit levels, pulp mills had very high labour productivity levels, at $267,630 per worker, with mechanical pulp mills having a slightly higher labour productivity level than chemical pulp mills ($274,542 per worker vs. $266,618 per worker, respectively). Paper mills had a much lower labour productivity level, at $185,293 per worker, with newsprint mills having a labour productivity level of $171,029.

Finally, it should be noted that the manufacturing value added estimates provided by the ASML are all in current dollars. Thus, they reflect not only quantity changes, but also price changes. In order to obtain an estimate of actual labour productivity growth, we must remove the effect of price changes from manufacturing value added. This can be done by using an appropriate deflator. It is not clear at this point, however, what deflator we should use or even if such deflators can be obtained from Statistics Canada.

Appendix 3A: Other Wood Product Manufacturing

As Exhibit 2A shows, other wood product manufacturing can be broken down into three industries: millwork (NAICS code 32191); wood container and pallet manufacturing (NAICS code 32192); and all other wood product manufacturing (NAICS code 32199).

Exhibit 2A: Detailed Breakdown of Other Wood Product Manufacturing

Other Wood Product Manufacturing (NAICS 3219)	**Millwork (NAICS 32191)**	Wood Window and Door Manufacturing (NAICS 321911)
		Other Millwork (NAICS 321919)
	Wood Container and Pallet Manufacturing (NAICS 32192)	Wood Container and Pallet Manufacturing (NAICS 321920)
	All Other Wood Product Manufacturing (NAICS 32199)	Manufactured (Mobile) Home Manufacturing (NAICS 321991)
		Prefabricated Wood Building Manufacturing (NAICS 321992)
		All Other Miscellaneous Wood Product Manufacturing (NAICS 321999)

Source: Statistics Canada (2012).

Millwork, in turn, can be broken down into wood window and door manufacturing (NAICS code 321911), which is a fairly self-explanatory title, and other millwork (NAICS code 321919), which is a black box. Below, Exhibit 3A provides a more detailed description of what types of activities are included under other millwork.

Exhibit 3A: Other Millwork (NAICS code 321919)

Description: This Canadian industry comprises establishments, not classified to any other Canadian industry, primarily engaged in millwork. These establishments generally use woodworking machinery, such as jointers, planers, lathes and routers, to shape wood. Establishments primarily engaged in seasoning and planing purchased lumber are included. Wood millwork products may be covered with another material, such as plastic.
Illustrative Examples: Wood baseboards; wood and covered wood mouldings; hardwood (assembled) parquet flooring; softwood flooring; wood stairwork; interior and ornamental wood work.
Exclusions: Carpentry; manufacturing dressed lumber from logs; manufacturing wood kitchen cabinets and counters, and bathroom vanities; manufacturing wood signs and coffins.

Source: Statistics Canada (2012).

Wood container and pallet manufacturing seems to be a fairly self-explanatory title, so we will not discuss it here. Other wood product manufacturing can be broken down into three sub-industries: manufactured (mobile) home manufacturing (NAICS code 321991), which "comprises establishments primarily engaged in manufacturing mobile homes and non-residential mobile buildings"; prefabricated wood building manufacturing (NAICS code 321992), which "comprises establishments primarily engaged in manufacturing prefabricated or pre-cut wood buildings, sections and panels"; and all other miscellaneous wood product manufacturing (NAICS code 321999). Again, because this last sub-industry is a black box, we provide a more detailed description of it in Exhibit 4A.

Exhibit 4A: All Other Miscellaneous Wood Product Manufacturing (NAICS code 321999)

Description: This Canadian industry comprises establishments, not classified to any other Canadian industry, primarily engaged in manufacturing wood products.
Illustrative Examples: Wood bowls; burnt wood articles; wood clothes-drying frames; wood clothespins; cork products (except gaskets); prefabricated sections of wood fencing; wood handles; kiln drying of lumber; wood kitchenware; wood poles; wood toothpicks.
Exclusions: --

Source: Statistics Canada (2012).

Table 4A: Real GDP, Hours Worked and Labour Productivity in Wood Product Manufacturing Excluding NAICS code 3219, 2007, 2010 and 2012

	Year	Wood Product Manufacturing (NAICS 321)	Other Wood Product Manufacturing (NAICS 3219)	Wood Product Manufacturing (ex. NAICS 3219)
Real GDP			(millions, current dollars)	
	2007	9,628	3,384	6,244
	2010	7,571	2,455	5,116
	2012	8,203	2,807	5,396
Hours Worked			(millions)	
	2007	229	98	130
	2010	192	86	106
	2012	185	85	101
Labour Productivity			(real GDP per hour worked)	
	2007	42.11	34.45	47.88
	2010	39.40	28.56	48.16
	2012	44.29	33.16	53.66

Source: CSLS calculations using Statistics Canada data: 1) GDP by Industry (CANSIM Table 379-0031); 2) Labour Statistics by Business Sector Industry (CANSIM Table 383-0030).

Above, we provide real GDP, employment and labour productivity estimates for wood product manufacturing excluding NAICS code 3219 (other wood product manufacturing) for the 2007-2012 period (Tables 4A).[39] Note that, during the period, other wood product manufacturing accounted for approximately 45 per cent of total hours worked in wood product manufacturing.

[39] While real GDP estimates for four-digit wood product manufacturing industry groups are available from CANSIM Table 379-0031 for the entire 2000-2012 period, employment estimates from the CPA are only available for those industry groups for the 2007-2012 period. Consequently, labour productivity estimates for wood product manufacturing excluding NAICS code 3219 only span the 2007-2012 period.

Not only that, other wood product manufacturing also had fairly low labour productivity levels ($33.16 per hour worked vs. $44.29 per hour worked for wood product manufacturing as a whole in 2012), thus bringing down the overall labour productivity level of wood product manufacturing by more than $9.00 per hour worked.

Note, furthermore, that labour productivity *growth* in the wood product manufacturing subsector increases substantially once we exclude other wood product manufacturing, jumping from 1.0 per cent per year to 2.3 per cent per year during the 2007-2012 period (Table 5A).[40] This happens because labour productivity in other wood product manufacturing actually declined 0.8 per cent per year during the period, from $34.45 per hour worked in 2007 to $33.16 per hour worked in 2012.

Table 5A: Real GDP, Hours Worked and Labour Productivity in Wood Product Manufacturing Excluding NAICS code 3219, 2007, 2010 and 2012

	Wood Product Manufacturing (NAICS 321)	Other Wood Product Manufacturing (NAICS 3219)	Wood Product Manufacturing (ex. NAICS 3219)
		(CAGR, per cent)	
Real GDP	-3.2	-3.7	-2.9
Hours Worked	-4.1	-2.9	-5.1
Labour Productivity	1.0	-0.8	2.3

Source: CSLS calculations using Statistics Canada data: 1) GDP by Industry (CANSIM Table 379-0031); 2) Labour Statistics by Business Sector Industry (CANSIM Table 383-0030).

[40] It should be emphasized that the labour productivity growth rate of 1.0 per cent per year for wood product manufacturing during the 2007-2012 is actually slightly lower than the growth rate presented in the CSLS report (1.7 per cent per year). This difference is caused by two factors: 1) the growth rate presented in the CSLS report refers to the 2008-2012 period instead of the 2007-2012 period; 2) since the report was written, Statistics Canada real GDP estimates for wood product manufacturing have been revised downwards.

Appendix 4: A Note on R&D Personnel Estimates

It is important to note that the R&D personnel estimates referred to in Section V-C-e reflect **total R&D personnel**. In other words, the figures included not only researchers and scientists, but also technicians, technologists and other R&D support staff. According to the most recent RDCI estimates, there were 885 (full-time equivalent) R&D personnel in paper manufacturing in 2011, down 31 per cent from 1,279 in 2008. Of this total, 54 per cent were researchers and scientists, 39 per cent were technicians and technologists, and the remaining 7 per cent were support staff. Table 6A provides additional details on R&D personnel for paper manufacturing as well as for the other two forest products subsectors.

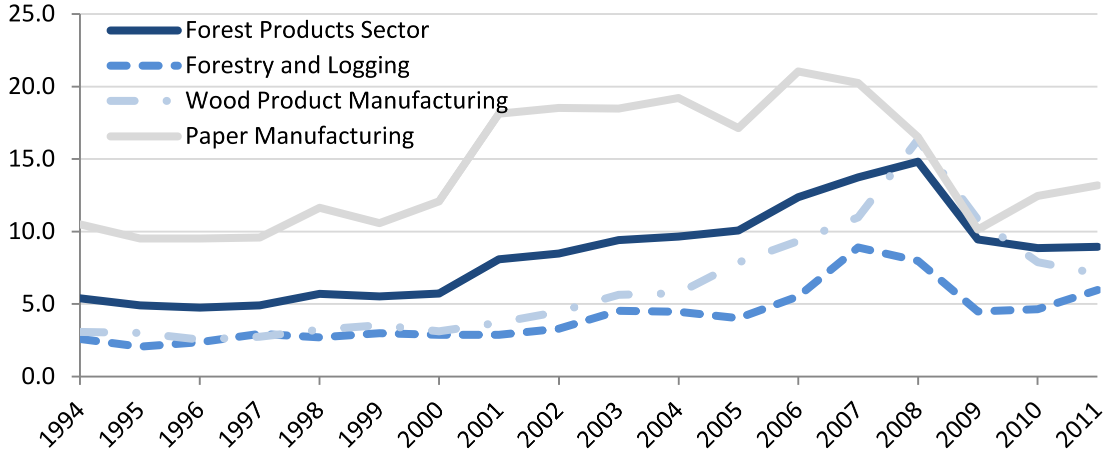
Table 6A: R&D Personnel in the Forest Products Sector

	2000	2008	2011	2000-2011
	(R&D Personnel, full-time equivalent)			(CAGR, per cent)
Forest Products Sector				
Total R&D Personnel	1,863	3,335	1,790	-0.4
R&D Professionals	842	1,334	931	0.9
Technicians and Technologists	632	1,400	704	1.0
Support Staff	389	601	155	-8.0
Forestry and Logging				
Total R&D Personnel	175	337	208	1.6
R&D Professionals	87	113	154	5.3
Technicians and Technologists	59	146	36	-4.4
Support Staff	29	78	18	-4.2
Wood Product Manufacturing				
Total R&D Personnel	529	1,719	697	2.5
R&D Professionals	236	662	300	2.2
Technicians and Technologists	189	782	320	4.9
Support Staff	104	275	77	-2.7
Paper Manufacturing				
Total R&D Personnel	1,159	1,279	885	-2.4
R&D Professionals	519	559	477	-0.8
Technicians and Technologists	384	472	348	-0.9
Support Staff	256	248	60	-12.4

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

Chart 4A shows R&D personnel intensity from 2000 to 2011 for the forest products sector as a whole and its subsectors. The estimates presented here differ from the OECD ones because they were calculated using CPA employment (whereas the OECD estimates probably used LFS estimates). After 2008, R&D personnel intensity in paper manufacturing suffered a significant fall, from 16.4 to 13.2 R&E personnel per 1,000 workers. R&D personnel intensity suffered an even greater fall in wood product manufacturing during the period, declining from 16.3 to 7.1. R&D personnel intensity also declined in the forestry and logging subsector, falling from 8.0 to 6.0 R&D personnel per 1,000 workers. Furthermore, it is important to keep in mind that, if we were only interested in knowing the number of researchers and scientists per 1,000 workers (excluding technicians and technologists and support staff), the R&D personnel intensity of the forest products sector would be only half of the R&D personnel intensity figures shown below.

Chart 4A: R&D Personnel Intensity in the Forest Products Sector, 2000-2011



Source: CSLS calculations based on Statistics Canada: 1) Research and Development in Canadian Industry (CANSIM Table 358-0024); and 2) Labour Statistics by Business Sector Industry (CANSIM Table 383-0030).