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CENTRE FOR THE STUDY OF LIVING STANDARDS

THE IMPACT OF THE OIL BOOM ON CANADA'S LABOUR PRODUCTIVITY PERFORMANCE, 2000-2012

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Abstract

The objective of this report is to evaluate the impact of the oil and gas industry on labour productivity growth in Canada since 2000 through an exploration of the various channels, both direct and indirect, by which the oil and gas sector affects aggregate productivity. The report sheds light on the paradoxical lack of a direct negative contribution of the oil and gas sector to aggregate labour productivity growth despite the very large fall in productivity experienced by the sector. It highlights the divergent productivity growth paths for the oil and gas sectors in Alberta and Newfoundland and Labrador, which drove the aggregate productivity performance of these two provinces. The report also discusses how developments in the oil and gas industry, notably the increase in the price and production of petroleum, have affected productivity growth in other parts of the economy. It finds that the oil boom has had a substantial negative effect on the cost competitiveness of manufacturing by putting upward pressure on the value of the Canadian dollar – the so-called Dutch Disease. Counteracting this are positive effects associated with demand and incomes generated by the oil boom, as well as increases in spending on R&D and education by the major oil-producing provinces.

The Impact of the Oil Boom on Canada's Labour Productivity Performance, 2000-2012

Executive Summary

Since the beginning of the millennium Canada became a major exporter of oil as the world price of oil reached new heights. At the same time, the manufacturing sector declined, and aggregate productivity growth slowed relative to previous periods and the United States. There has been an intense debate about whether these two developments are connected, as the external value of the Canadian dollar increased and made Canada's manufacturing sector less competitive internationally. How strong has this impact been? What other effects has the oil boom had?

This report addresses these questions through an exploration of the various channels, both direct and indirect, through which the oil boom may affect aggregate productivity growth. It begins by describing the oil boom and developments in the oil and gas sector over the 2000-2012 period. The focus is then put on real output and labour productivity in the oil and gas extraction sector in Canada and the two major oil-producing provinces, Alberta and Newfoundland and Labrador. The performance of the business sector as a whole is also reviewed.

A framework is then presented that identifies specific impacts that oil and gas extraction has on aggregate productivity in the form of direct contributions and indirect effects. The former include *within-industry effects*, such as the diminishing yield of natural resources (the "Alberta story"), and *reallocation effects*, reflecting the high labour productivity levels of oil and gas extraction activities (the "Newfoundland and Labrador story"). The effects are calculated precisely and compared with another approach found in the literature.

The indirect effects are the myriad impacts of the oil boom on productivity in other sectors and on other economic variables that affect productivity. The study examines the following mechanisms in some depth: the effect on the exchange rate and, through it, on cost competitiveness of the traded-goods sector; the effect on the labour market and wages; the effect on behaviour regarding education; the effect on innovation efforts by businesses; the effect on government revenues and government expenditures on education and research and development; and the effect on aggregate demand.

Although the negative labour productivity growth in the sector may lead one to assume that oil and gas extraction has reduced Canada's aggregate productivity growth, the report finds that this has not been the case. In fact, the reallocation of workers from low-productivity sectors into this high-productivity sector boosted aggregate labour productivity growth to such an extent

that it almost completely offset the effect of the sector's negative productivity growth rate on aggregate labour productivity growth.

A clearly negative effect is the loss of cost competitiveness of manufacturing through the appreciation of the Canadian dollar, the so-called Dutch Disease. The report evidences the existence of symptoms of Dutch Disease in Canada.

The report also finds a number of positive indirect effects on the nation's productivity: higher wages throughout the economy that foster capital deepening; a boost to enrolment in post-secondary education; greater business R&D that was financed by oil and gas profits; additional government revenues that have been invested in R&D and education; and increased demand for the goods and services produced in other sectors, both from the oil and gas extraction industry and from the additional income generated by the oil boom.

Whereas the direct contribution of the oil and gas sector to overall productivity growth lends itself to analysis with an exact formula, the indirect impacts are varied and wide-ranging and cannot be captured with that kind of precision. Nonetheless, the report attempts to determine the direction and size of the various indirect impacts of the oil boom on overall productivity growth in order to arrive at an overall picture of the effect of the oil boom on productivity.

The Impact of the Oil Boom on Canada's Labour Productivity Performance, 2000-2012

I. Introduction[1]

Oil and gas extraction is one of Canada's most important, and controversial, industries. In 2010, it represented 4.8 per cent of nominal GDP, up from 3.0 per cent in 2000, and it accounted for 20 per cent of nominal GDP growth between those two years. As Canada enjoyed a large and increasing trade surplus in hydrocarbons, the rising price of petroleum contributed to improved terms of trade, and during 2000-2012 real gross domestic income (GDI) grew 0.4 percentage points per year faster than real GDP (2.3 per cent versus 1.9 per cent).

But labour productivity growth in the oil and gas sector has been dismal since 2000, as real output – measured by the value added of the industry – has remained weak while employment has surged. Real labour productivity in oil and gas extraction fell 6.4 per cent per year between 2000 and 2012. Yet, paradoxically, despite this performance, the sector did not make a negative contribution to aggregate labour productivity growth.

The oil and gas sector is particularly important for two provinces – Alberta and Newfoundland and Labrador – yet the overall productivity performance of these provinces has been drastically different. Over the 2000-2012 period, Newfoundland and Labrador enjoyed the most rapid productivity growth in Canada (Grand'Maison and Sharpe, 2013), while Alberta experienced the worst. Oil and gas extraction played a key role in the productivity performance of both provinces – positive in the case of Newfoundland and Labrador, and negative in the case of Alberta.

The objective of this study is to increase our understanding of the impact of developments in the oil and gas sector on labour productivity growth in Canada since 2000. The report will shed light on both the paradoxical lack of a negative contribution of the oil and gas sector to aggregate labour productivity growth and the divergent productivity growth paths in Alberta and Newfoundland and Labrador. It will also explore a variety of channels through which the oil boom affected productivity.

To accomplish this, the report describes the oil boom and the evolution of output, employment and productivity in oil and gas extraction in Canada and the two major oil-

[1] Andrew Sharpe is Executive Director of the Centre for the Study of Living Standards (CSLS). Bert Waslander is a Senior Research Associate at the CSLS. The authors would like to thank Ricardo de Avillez, Etienne Grand'Maison, Pierre St-Amant, Rick Harris, Roland Tusz and Kevin Fung for their contributions to the paper. The CSLS would like to thank Industry Canada for financial support for this research.

producing provinces. It then develops a framework for identifying specific impacts of the oil and gas sector on aggregate productivity, including both direct contributions and indirect effects.

The direct contributions comprise *within-industry effects* – due, for example, to diminishing returns on the extensive margin (the "Alberta story") – and *reallocation effects* – reflecting the high labour productivity levels of oil and gas extraction activities (the "Newfoundland and Labrador story"). The direct contributions of productivity growth in an industry to overall productivity growth are analyzed with exact formulas, in particular one developed by CSLS.

The latter effects, which can be considered knock-on effects, include the myriad impacts of developments in oil and gas extraction on productivity in other sectors, and on other economic variables that affect productivity, such as the exchange rate and wages. Such spillover impacts include: the effect of the oil boom on the dynamism of the economy, especially the manufacturing sector; the effect of the oil boom on the labour market, through scarcity of workers and higher wages; and the effect of the oil boom on incentives for young people to invest in higher education. Business R&D can be affected, within and outside the oil and gas sector, and rising government revenues can be spent on productivity-enhancing programs such as higher education and R&D. The oil boom also has generated demand throughout the Canadian economy, with effects on productivity.

Clearly, the indirect effects are wide-ranging. The sources of productivity growth and the channels by which resource exploitation and pricing can influence it are many. Some of these, especially the so-called Dutch Disease, have been explored in numerous studies, internationally and in Canada, and our discussion draws on this body of work. For some transmission channels such as the labour market, a scan of some key data gives a strong indication of an effect. The aim of the discussion is to demonstrate that an effect has occurred, and to indicate its direction and order of magnitude.

The report consists of seven sections. The current section introduces the report. The second section provides a review of productivity definitions, concepts and data sources used in the report. The third section sketches developments in the oil and gas sector, presents data on output, labour input and labour productivity in oil and gas extraction in Canada, Alberta, and Newfoundland and Labrador, places the industry in the context of the business sector of these jurisdictions and reports on growth accounting analysis of productivity change. The fourth section develops a framework for assessing both the direct and indirect impacts of oil and gas extraction on productivity. The fifth and sixth sections analyze, respectively, the direct and indirect effects of oil and gas extraction on business sector labour productivity growth in Canada, Alberta and Newfoundland and Labrador. A seventh section concludes.

II. Definitions, Concepts and Data Sources

This section discusses the main definitions, concepts and data sources used in this report. First, we discuss the concept of productivity and why it is of interest. Next, we describe our main data sources.

A. Productivity Primer

Productivity can be broadly defined as a measure of how much output is produced per unit of input used. 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: gross output or value-added; and 2) different measures of inputs.

i. Gross Output Productivity vs. Value Added Productivity

Gross output consists of all goods and services produced by an economy, 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 aggregate output. In practice, the value-added approach is also the standard choice in most sectoral productivity analyses. 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 use of both primary and intermediate inputs. 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.) currently play a much more prominent role than they did in the past. It also applies to the mining sector, including oil and gas extraction, where the yield of various deposits can vary greatly over time.

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 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). For example, value-added labour productivity growth represents the increase of real GDP per hour worked over time, and 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/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/reference year. 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

The main productivity measured used in this report is v*alue-added labour productivity*, defined 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; and 2) shifts from full-time to part-time employment.

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, including economies of scale, capacity utilization, and measurement error, not only technical change – thus, it is a mistake to attribute the entirety of MFP growth to technical change.

- **Measuring efficiency improvements.** From an engineer's 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; and 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).

This report is chiefly motivated by the fourth of these reasons, an interest in productivity as a major determinant of living standards. It is concerned with contributions of one industry – an industry that experienced dramatic changes in product prices and output – to the productivity of the business sector as a whole and of other industries (i.e., with transmission of productivity growth within the economy). It is meant to enhance understanding of how the economy works.

B. Data Sources

The analysis in this report draws on a variety of data sources about the oil and gas sector and its impacts. As regards the core productivity data, it uses the 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 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 data on labour and capital inputs are available in CANSIM tables 383-0024 and 383-0025, respectively.

The analyses contained in this report focus on the 2000-2012 period, so as to provide an up-to-date view of the contribution of oil and gas extraction to aggregate labour productivity growth. The year 2000 was chosen as a start date because it represents a business cycle peak. The reader should bear in mind that, in some cases, data are not available for the entire 2000-2012 period – industry-level nominal GDP estimates, for instance, are only available up to 2010. When this occurs, a shorter time period is discussed.

III. The Oil Boom and Productivity in Oil and Gas Extraction in Canada, Alberta, and Newfoundland and Labrador

This section of the report describes developments in the oil and gas extraction sector during 2000-2012 in Canada and in two key oil-producing provinces: Alberta and Newfoundland and Labrador. The story of these 13 years is rather eventful, as it includes a huge increase in the real world price of oil, increasing depletion of conventional oil wells in the West, and an unprecedented expansion of non-conventional and offshore production followed by a sharp decline of the latter. The price of natural gas also increased while output changed little, but the market then experienced a glut and prices fell very sharply in the latter part of the period. This section sketches these developments briefly, and describes the output, employment and productivity data for the industry that they gave rise to. It then goes on to report on productivity growth in the business sector as a whole. The section concludes with a brief analysis of productivity growth through a standard growth accounting framework.

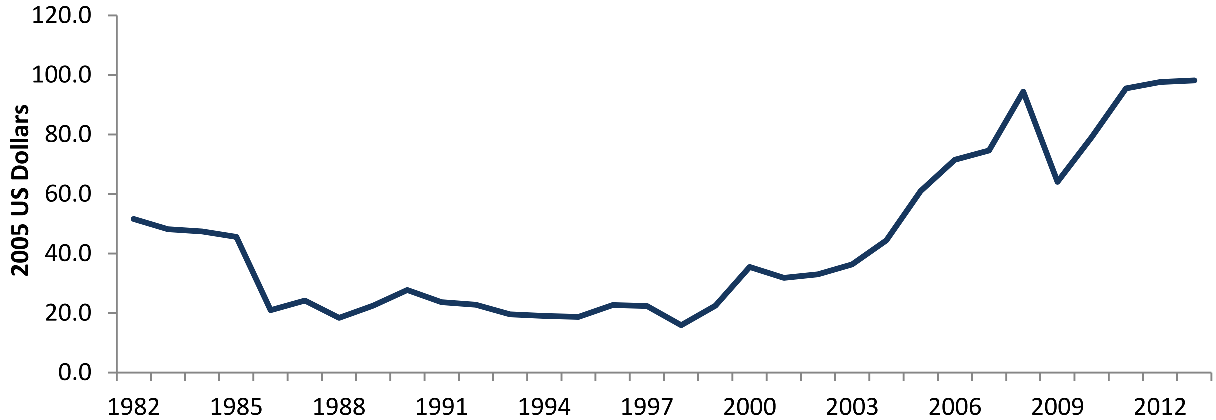
A. The Oil Boom: Production and Prices of Petroleum and Natural Gas

The first decade of the millennium saw a large and sustained increase in the world price of crude oil (Chart 1). From a low of around $20 per barrel from the mid-1980s to the end of the 1990s, the real world price increased to $35 in the year 2000, rose steadily to over $90 in 2008 and climbed to the $100 range more recently.

Canada was poised to take advantage of the opportunity this presented through exploitation of the Alberta oil sands and the offshore reserves of Newfoundland and Labrador. Production of oil expanded from 343 thousand cubic meters per day in 2000 to 516 thousand cubic meters per day by 2012 (Chart 2).[2] While output of conventional light crude oil remained steady nationally, production declined in Alberta, where producing wells reached exhaustion, and increased in Newfoundland and Labrador, where several new offshore platforms began production. Production of both synthetic light crude and heavy crude expanded rapidly. The increase came entirely from the oil sands.

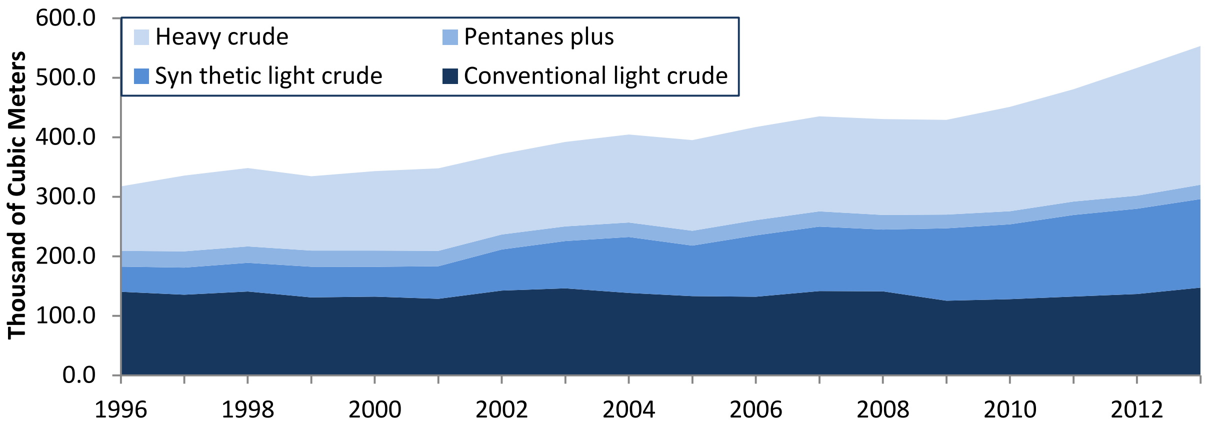
[2] Cubic meters per day is a commonly used volume measure for oil. A cubic meter is equal to 6.292 barrels.

Chart 1: Real Oil Prices, 2005 U.S. Dollars per Barrel, 1982-2013



Note: "Real oil prices" are the average spot prices (2010$/bbl) for crude oil based on WTI, Dubai, and Brent.
Source: World Bank, DataBank, Global Economic Monitor (GEM) Commodities.

Chart 2: Production of Oil by Type, Thousands of Cubic Meters per Day, Canada, 1996-2013

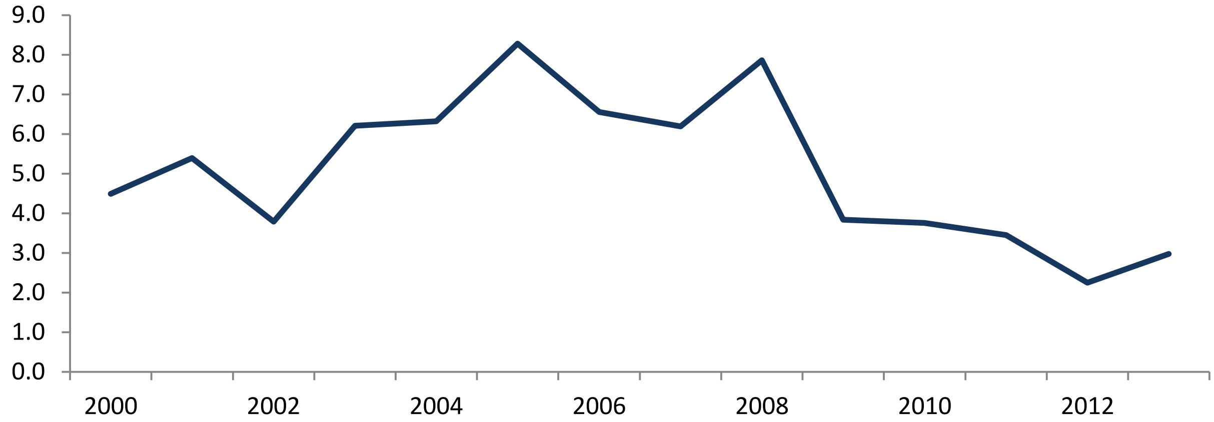


Source: National Energy Board, Statistics, Crude Oil and Petroleum Products Statistics, Disposition of Domestic Crude Oil and Imports – Annual. A cubic meter of oil equals 6.292 barrels.

Natural gas prices also increased in a major way during the first decade of the millennium, but fell back below mid-decade levels by 2010 (Chart 3). This overall pattern was attended by several spikes due to weather and other disruptions. The first of these was the energy crisis in California in 2000, with a shortage of electricity and gas pipelines shutdowns. A spike in late 2004 was due to cold weather. In 2005, hurricanes Katrina and Rita damaged natural gas rigs in the Gulf of Mexico. High oil prices caused a further price spike in 2008, and after that prices declined because of increased production of shale gas in the U.S. and the global recession. Production in Alberta declined sharply after 2007 (Chart 4).[3]

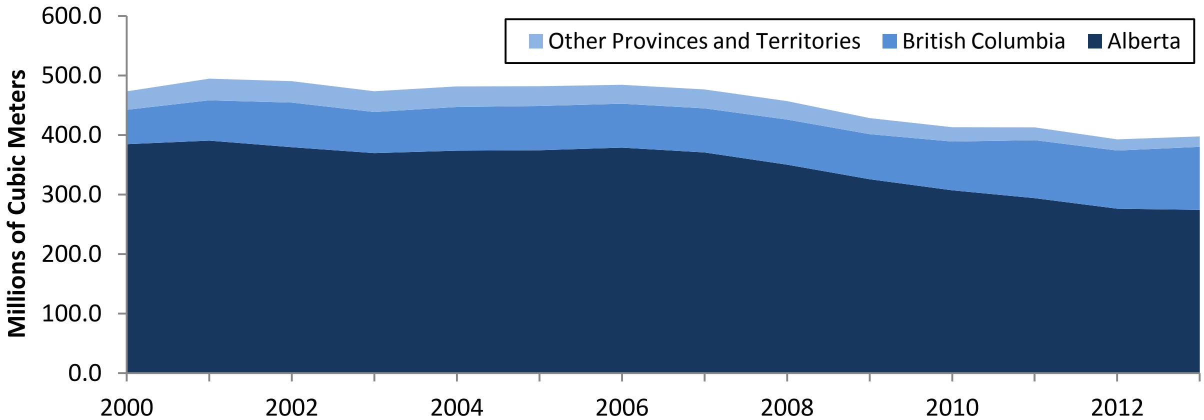
[3] This description is based on "Canadian Energy Price Trends 2000-2010", Energy Facts, the National Energy Board.

Chart 3: Alberta Reference Price of Natural Gas, Average of Monthly Prices, 2000-2013



Source: Alberta Energy

Chart 4: Average Daily Production of Natural Gas, Millions of Cubic Meters per Day, Canada and Provinces, 2000-2013



Source: National Energy Board, Statistics, Marketable Natural Gas Production in Canada. A cubic meter of natural gas equals 35.3 square feet, at 14,73 psia and 60 degrees F.

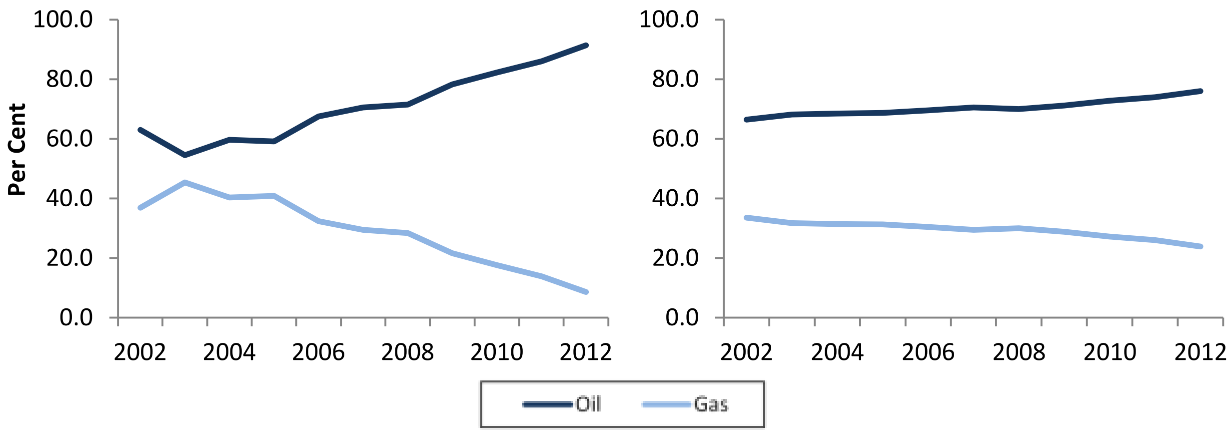
In short, while there was a large hike in the price of petroleum coupled with a steady increase in output, the price of natural gas dropped sharply following higher prices in the mid-2000s and output of gas declined steadily after 2007. This pattern gave rise to an increasing share of oil in the gross output of the oil and gas extraction sector, both in nominal and real terms. By 2012, petroleum accounted for 90 per cent of the oil and gas sector's nominal output, up from about 60 per cent in 2002 (Chart 5).[4] Similarly, petroleum's share of the oil and gas sector's real

[4] To calculate the shares, the annual average West Texas Intermediate (WTI) price of petroleum (source : CANSIM), expressed in Canadian dollars, and the simple average of the monthly Alberta Reference Price of natural gas (source : Alberta Energy) were applied to the volume of production of petroleum and natural gas measured in petajoules, as reported by the National Energy Board. The Alberta Reference Price is the price calculated by the province for the purpose of determining royalties on natural gas; it is a producer price. The WTI price is a commonly used benchmark for oil prices and is relevant to Alberta, Canada`s major producer of oil. Proceeds to the Canadian industry from the sale of petroleum are lower because bitumen and petroleum of lesser quality gather a lower price, and prices in markets in Canada and the U.S. may differ from the benchmark. The share of oil in industry revenue and real gross output is probably overstated to a modest extent in this calculation.

output rose from two-thirds to more than three-quarters. The oil and gas extraction industry is treated as a single industry by Statistics Canada, and hence in the analysis of output and productivity in this report. Our calculation, though approximate, gives a good indication of how the relative importance of the two types of products within the industry changed over time.

Chart 5: Estimated Shares of Gross Output of the Oil and Gas Extraction Sector, 2002-2012

(A) Current Dollars *(B) Constant 2007 Dollars*



Source: Calculations by CSLS based on data from the National Energy Board, Alberta Energy and Statistics Canada.

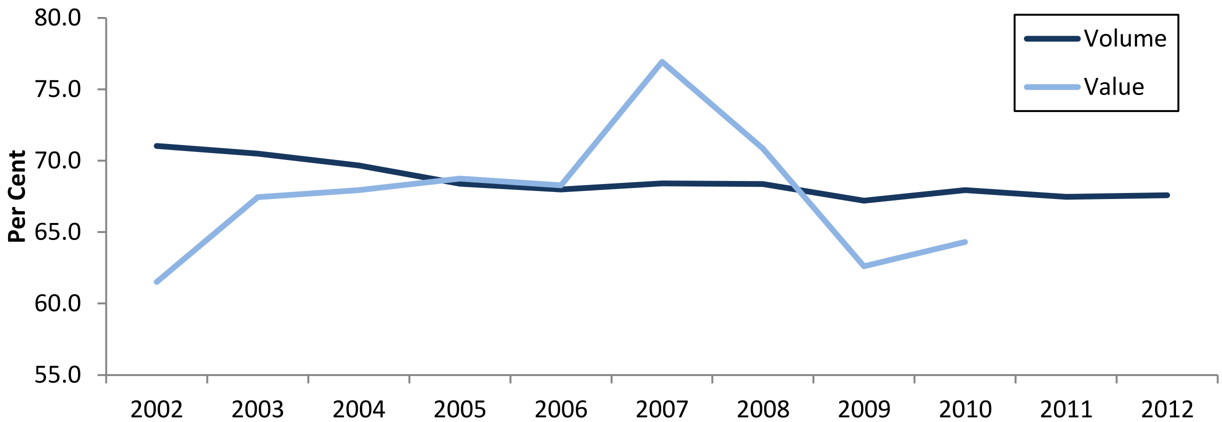
Chart 6 shows GDP of the oil and gas extraction industry in current and constant dollars, as published by Statistics Canada, as a percentage of current and constant dollar gross output of the industry, calculated as described in the text and footnote above. Real GDP measured in constant dollars gradually declines from 71.0 per cent of gross output in 2002 to 67.6 per cent in 2012, whereas nominal GDP varies from 61.5 per cent to 76.9 per cent of gross output. The variation in the latter ratio reflects the prices of oil and gas. As has been shown, the prices of oil and gas were quite high in 2007, and as prices of intermediate inputs would not have shown such a marked spike, net revenues were a high share of gross revenues in that year. The gradual decline in the ratio of net to gross output volume may be related to the changing shares of oil and gas in output and to changes in the sources of oil (conventional land-based and off-shore and non-conventional) as discussed in the next section of this report.

In terms of real output and productivity of the oil and gas sector, the role of natural gas is too substantial to be ignored. When output is evaluated at 2007 prices, the share of natural gas varies from one-third at the beginning of the period to one-quarter at the end. Although it is impossible to know, it seems reasonable to assume that the decline in production of natural gas contributed to the decline in labour productivity of the oil and gas extraction sector that is examined in this report.[5]

[5] If natural gas is mostly produced from existing wells by applying fixed amounts of physical capital and labour, then a decline in production would imply a decline in labour productivity. This is a simplification, but perhaps not an oversimplification.

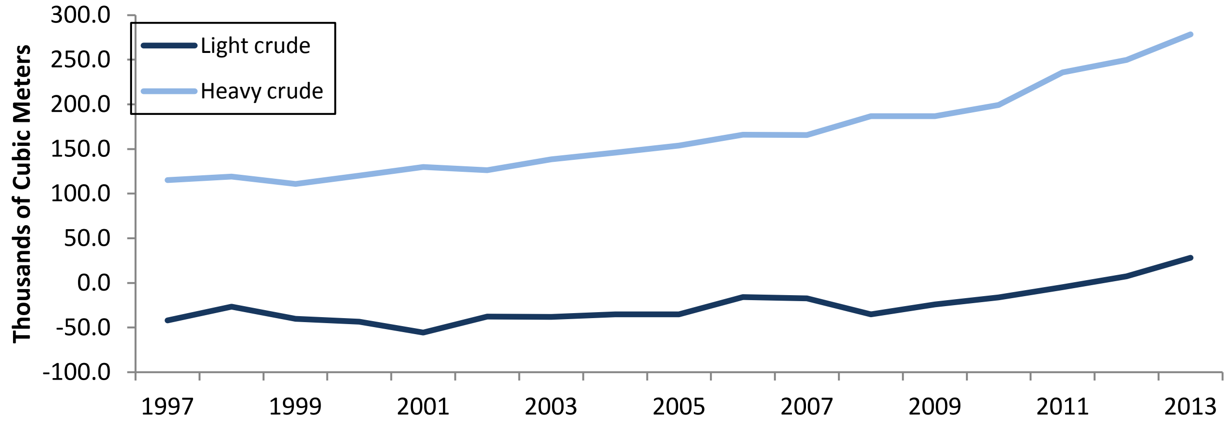
However, in terms of revenues it is appropriate to characterize the first thirteen years of the millennium as an oil boom. Natural gas revenues peaked in 2005 and declined sharply after that, while petroleum revenues kept on rising to 2008, fell rapidly in 2009 and then recovered to an even higher level by 2012. The dramatic rise in revenues was also the result of a steady expansion of production of oil. These revenues are a main driver of some of the impacts of oil and gas on productivity in the economies of Canada and the oil- and gas-producing provinces.

Chart 6: Ratio of GDP to Gross Output in Current and Constant Dollars, Oil and Gas Extraction Sector, Per Cent, 2002-2012



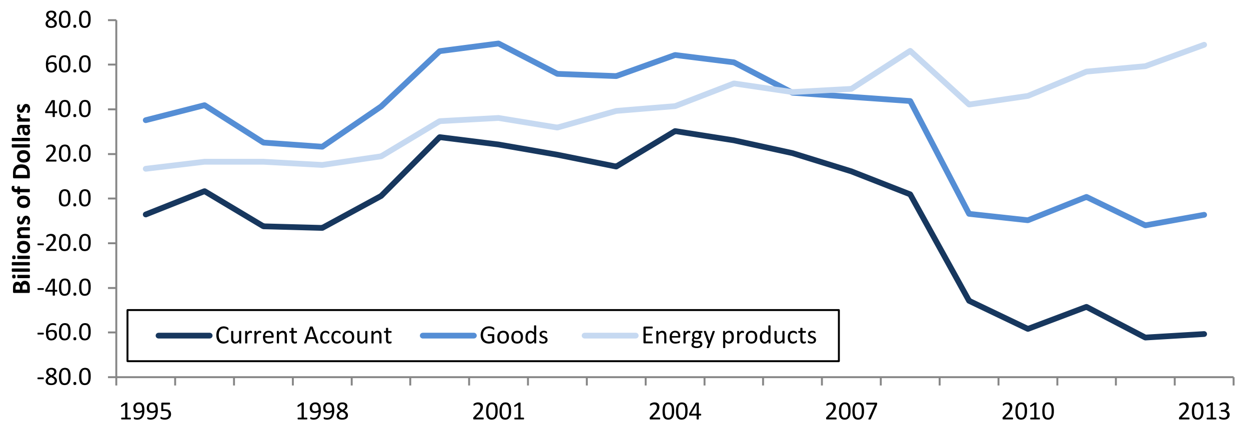
The bonanza brought about by the high price of oil, of course, mainly took the form of sales outside Canada. The volume of net exports of heavy crude doubled between 1997 and 2012, and that of light crude became positive by the end of the period (Chart 7). This along with the price hike made the trade balance in energy products increase from less than $20 billion before the year 2000 to more than $60 billion by 2008, giving a tremendous boost to the current account balance (Chart 8). Although after the financial crisis of 2008 the current account balance turned sharply negative, net revenues from energy products remained strongly positive through 2013.

Chart 7: Net Exports of Oil, Thousands of Cubic Meters per Day, 1997-2013



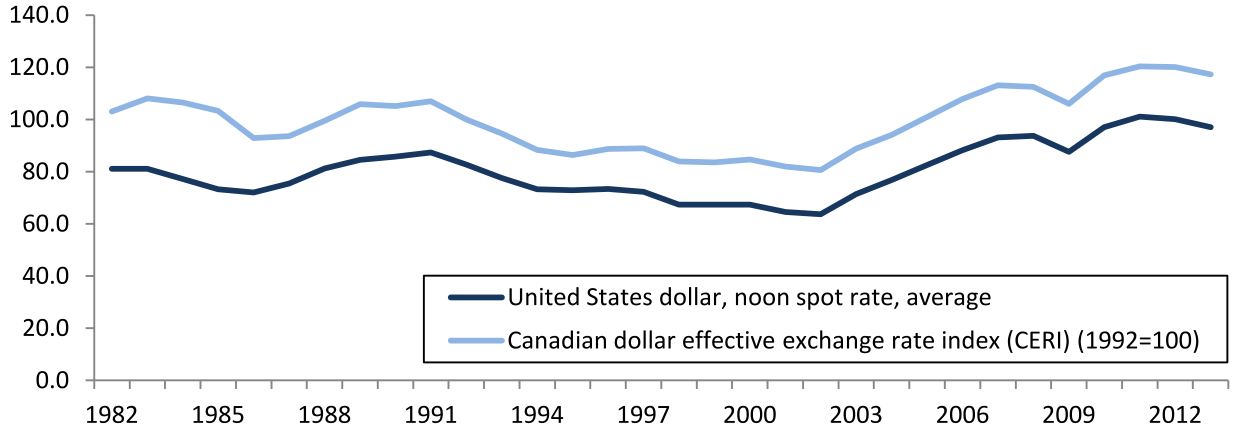
Source: National Energy Board, Statistics, Crude Oil and Petroleum Products, Disposition of Domestic Crude Oil and Imports.

Chart 8: Balance of Payments, Canada, Billions of Dollars, 1995-2013



The oil bonanza also boosted the value of the Canadian dollar. After staying close to 80 U.S. cents during the 1980s, and dropping steadily during the 1990s to less than 65 U.S. cents by 2002, the dollar rose strongly to reach par with the U.S. dollar in 2011 (Chart 9). Using quarterly data for 1994-2013, Courchene (2014) found a positive correlation of 0.94 between the price of crude oil and the Canada-U.S. exchange rate. There can be no doubt that the enormous increase in the price of oil and Canada's ability to expand production are a factor behind the rise of the Canadian dollar. Accordingly, in this report the increase in the external value of the Canadian dollar is treated as one of the developments that resulted at least in part from oil and gas extraction, and its effects on productivity growth through the economy will be considered.

Chart 9: External Value of the Canadian Dollar, 1982-2013



Source: Statistics Canada, CANSIM Table 176-0064

B. A Portrait of the Oil and Gas Extraction Subsector

We now turn to real GDP, employment and labour productivity in oil and gas extraction. First we discuss data availability. Second, we sketch a brief portrait of the sector.

i. The Data

Using the North-American Industry Classification System (NAICS), Statistics Canada categorizes establishments based on the similarity of their production processes. 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.

Oil and gas extraction (NAICS code 211) is a subsector within the mining, quarrying and oil and gas extraction (NAICS code 21) sector, which is comprised of two additional subsectors: mining and quarrying (except oil and gas) (NAICS code 212) and support activities for mining and oil and gas extraction (NAICS code 213). A more detailed breakdown of all the activities included in mining, quarrying and oil and gas extraction can be seen in Exhibit 1 (for conciseness purposes, the rest of this report refers to this sector only as mining and oil and gas extraction).

Exhibit 1: A Breakdown of Mining, Quarrying and Oil and Gas Extraction (NAICS Code 21) by NAICS Code

21	**Mining, Quarrying and Oil and Gas Extraction**	
	(Breakdown by NAICS Codes)	
211	**Oil and Gas Extraction**	
	211113	Conventional Oil and Gas Extraction
	211114	Non-conventional Oil and Gas extraction
212	**Mining and Quarrying (except Oil and Gas)**	
	2121	Coal Mining
	2122	Metal Ore Mining
	2123	Non-metallic Mineral Mining and Quarrying
213	**Support Activities for Mining and Oil and Gas Extraction**	
	Support Activities for Oil and Gas Extraction, combining	
	213111	Oil and Gas Contract Drilling
	213118	Services to Oil and Gas Extraction
	Support Activities for Mining, combining	
	213117	Contract Drilling (except Oil and Gas)
	213119	Other Support Activities for Mining

Source: Statistics Canada 2012

At the time of the analysis, data availability for GDP, real output and employment was as follows:

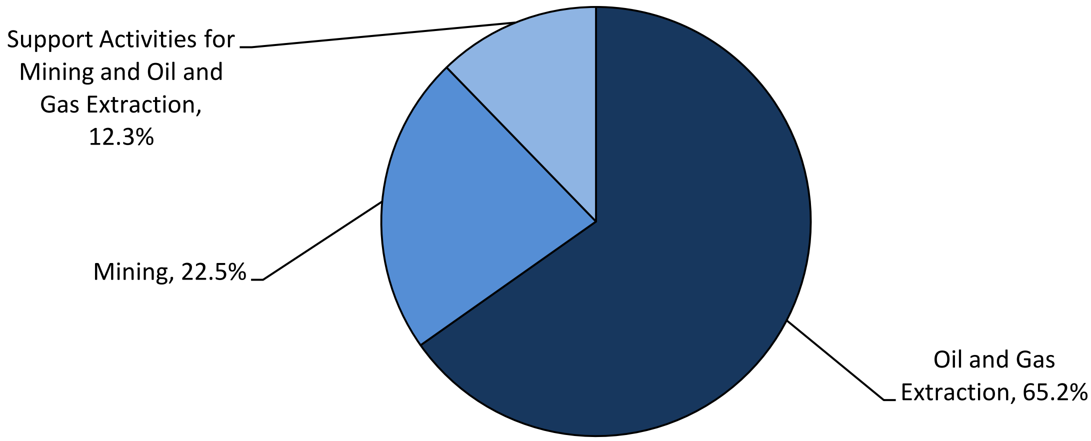
- The period of analysis is 2000-2012. Real output and employment, when available, are available for the entire period. Nominal output is available only to 2010.
- For the oil and gas extraction sector (NAICS code 211), the three series are available for Canada and Alberta.
- For Newfoundland and Labrador there are no data for oil and gas extraction. However, there are data for mining, quarrying and oil and gas extraction (NAICS code 21), and for mining and quarrying except oil and gas (NAICS code 212). It is therefore possible to derive residually data series for oil and gas extraction plus support services to the mining, quarrying and oil and gas extraction sector (NAICS code 211 + NAICS code 213). This industry will be referred to as oil and gas extraction^{+}.

The importance of the data limitations regarding Newfoundland and Labrador will be examined in the next section, among other things.

ii. A Brief Portrait

Currently, oil and gas extraction makes up the lion's share of all mineral extraction activities in Canada. The mining and oil and gas extraction sector generated $114,686 million in nominal value added in 2010, accounting for 7.3 per cent of Canada's nominal GDP. Of its three subsectors, oil and gas extraction was the largest, responsible for $74,804 million or close to two-thirds (65.2 per cent, Chart 10).

Chart 10: Breakdown of Nominal GDP in Mining and Oil and Gas Extraction, 2010



Source: Statistics Canada.

Over the past decade, nominal GDP in oil and gas extraction as a share of Canada's total economy GDP has fluctuated between 3.7 per cent in 2002 and 7.8 per cent in 2008 (Chart 11). In 2010, nominal GDP of oil and gas extraction represented 4.8 per cent of Canada's economy, almost back to its level of 4.7 per cent in 2000. Support activities for oil and gas extraction accounted for 0.7 per cent of Canada's total economy GDP in 2010, up from 0.6 per cent in 2007[6].

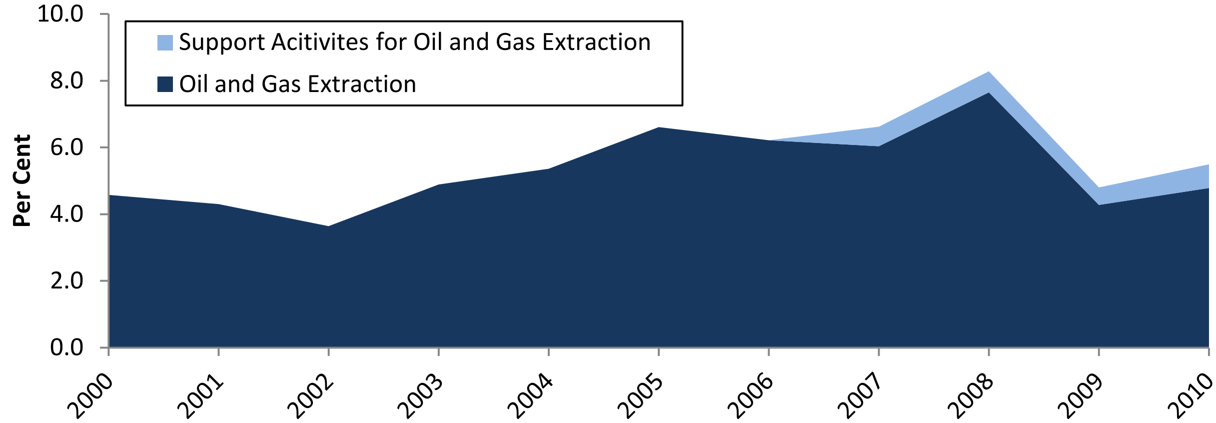
Three provinces accounted for over 90 per cent of the nominal value added in the oil and gas extraction subsector in 2010: Alberta (70.4 per cent), Saskatchewan (12.4 per cent), and Newfoundland and Labrador (10.3 per cent) (Table 1). Other provinces had only a marginal role in oil and gas extraction activities.

Oil and gas extraction activities were responsible for a significant share of nominal GDP in the three oil-producing provinces. The subsector accounted for 28.5 per cent of the Newfoundland and Labrador economy in 2010; 20.1 per cent of Alberta's economy; and 15.3 per

[6] Data for support activities for oil and gas extraction are not available before 2007. Before that year, the subsector is included in support activities for mining, quarrying and oil and gas extraction (NAICS code 213). GDP of the latter subsector increased from 0.5 percent of total GDP in 2000 to 0.7 per cent in 2007.

cent of Saskatchewan's economy (Chart 12). For all other provinces, the subsector's contribution was very small.

Chart 11: Nominal GDP in Oil and Gas Extraction as a Share of Total Economy GDP, Canada, 2000-2010



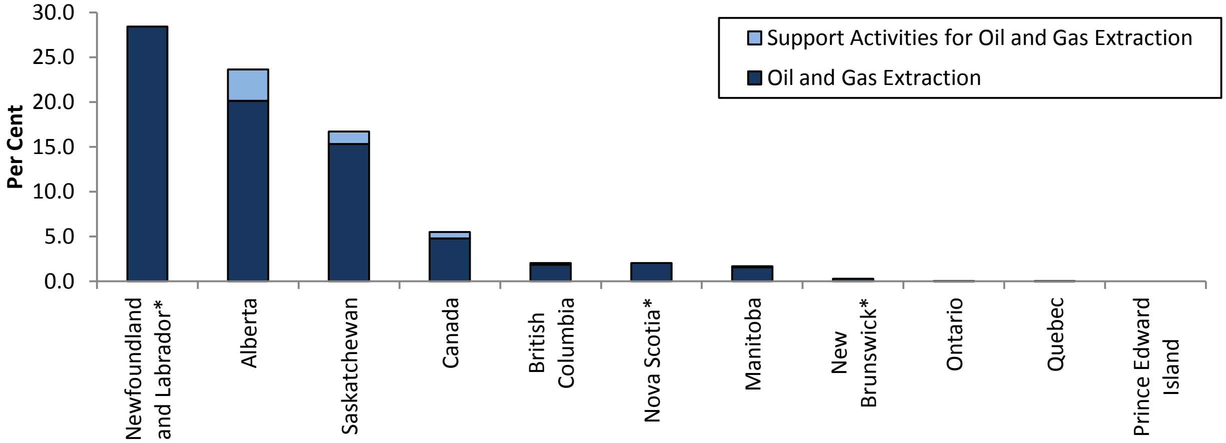
Note: The time series for support activities for oil and gas extraction starts in 2007.
Source: Statistics Canada.

Table 1: Nominal GDP in Mining, Oil and Gas Extraction, Canada and the Provinces, 2010

	Mining and Oil and Gas Extraction	Oil and Gas Extraction	Mining	Support Activities for Mining and Oil and Gas Extraction	Support Activities for Oil and Gas Extraction
			(millions, current dollars)		
Canada	114,686	74,804	25,829	14,053	11,107
British Columbia	9,047	3,570	4,328	1,150	343
Alberta	63,461	52,691	1,153	9,617	9,192
Saskatchewan	15,296	9,278	5,052	966	843
Manitoba	1,975	775	1,065	134	51
Ontario	6,213	48	4,888	1,277	197
Quebec	4,555	2	4,292	261	20
Maritimes	1,525	814*	711	..	..
Newfoundland and Labrador	10,203	7737*	2466	..	..
Territories	2,413	394	..	..	..
			(as a share of Canada, per cent)		
Canada	100.0	100.0	100.0	100.0	100.0
British Columbia	7.9	4.8	16.8	8.2	3.1
Alberta	55.3	70.4	4.5	68.4	82.8
Saskatchewan	13.3	12.4	19.6	6.9	7.6
Manitoba	1.7	1.0	4.1	1.0	0.5
Ontario	5.4	0.1	18.9	9.1	1.8
Quebec	4.0	0.0	16.6	1.9	0.2
Maritimes	1.3	1.0*	2.9**	..	..
Newfoundland and Labrador	8.9	10.3*	9.6**	..	..
Territories	2.1	0.5	..	..	..

* Estimates refer to oil and gas + support activities for mining and oil and gas extraction. Source: Statistics Canada.

Chart 12: Nominal GDP in Oil and Gas Extraction as a Share of Total Economy GDP, Canada and the Provinces, 2010



* Estimates refer to oil and gas + support activities for mining and oil and gas.

Due to confidentiality issues, Statistics Canada does not produce real GDP estimates for oil and gas extraction in Newfoundland and Labrador. However, estimates for oil and gas extraction plus support activities for mining and oil and gas extraction – which we will refer to as oil and gas extraction$^+$ from now on – can be derived residually by subtracting the subsector mining from mining and oil and gas extraction. These calculations show that oil and gas extraction$^+$ accounted for between 75 and 83 per cent of nominal GDP in mining, quarrying and oil and gas extraction in the province during 2007-2010, and for between 75 and 90 per cent of real output of the industry during 2000-2009, falling to 64 per cent in 2012. Further, in 2010, nominal GDP in support activities is at most 7 per cent of the GDP of oil and gas extraction$^+$ in Newfoundland and Labrador.[7] In light of this it is reasonable to assume that the productivity of the mining, quarrying and oil and gas industry of the province, and even more so that in oil and gas extraction$^+$, reflects mainly developments in the oil and gas extraction sector.

iii. Real GDP

In 2012, real GDP or value added in the oil and gas extraction subsector was $91.3 billion (chained 2007 dollars) in Canada, up from $78.5 billion in 2000, which represents an average annual growth of 1.3 per cent (Table 2, Panel A). Measured by energy content, production of oil increased at an average annual rate of 2.9 per cent over 2002-2012, while natural gas production declined at a rate of 1.9 per cent in that time frame. Weighted together using 2007 prices, physical output of oil and gas increased at an annual rate of 1.5 per cent.

[7] The 7.0 per cent estimate is based on the data in Table 1. GDP for support activities for mining and oil and gas extraction in the three regions for which they are not given add to $648 million. If all these activities were located in Newfoundland and Labrador, they would amount to 7.0 per cent of GDP of $9,088 million in oil and gas extraction plus support activities for mining and oil and gas extraction.

Since 2007, Statistics Canada has broken the output of the oil and gas extraction sector into conventional and non-conventional oil extraction (primarily the oil sands in Northern Alberta). Conventional oil and gas extraction output was $58.9 billion 2007 dollars, about two-thirds of total oil and gas production, and down 14.5 per cent from $68.9 billion in 2007 when it represented nearly four-fifths. Non-conventional oil extraction has risen 53 per cent from $19.6 billion 2007 dollars in 2007 to $30.0 billion in 2012 and now accounts for just over one-third of real value added in the oil and gas sector.

Table 2: GDP in Oil and Gas Extraction, Canada, Alberta, and Newfoundland and Labrador, 2000-2012

A) Real GDP

	Canada			NFLD	Alberta
	Total	Conventional	Non-conventional		
	(millions, chained 2007 dollars)				
2000	78,504	..	..	3,733	62,253
2001	77,150	..	..	3,542	58,151
2002	82,855	..	..	7,694	59,538
2003	84,251	..	..	8,767	59,581
2004	84,870	..	..	8,490	60,964
2005	84,294	..	..	8,370	59,982
2006	86,498	..	..	8,180	62,101
2007	88,513	68,933	19,580	9,630	62,840
2008	85,554	65,265	20,228	9,051	60,215
2009	82,053	57,987	23,278	6,988	59,821
2010	84,751	57,770	25,655	7,066	61,472
2011	87,893	58,363	27,747	6,917	63,563
2012	91,285	58,946	30,048	5,015	67,712
	Compound Annual Growth Rates, per cent				
2000-2012	1.3	..	..	2.5	0.7
2000-2007	1.7	..	..	14.5	0.1
2007-2012	0.6	-3.1	8.9	-12.2	1.5

B) Nominal GDP

	Canada			NFLD	Alberta
	Total	Conventional	Non-conventional		
	(millions, current dollars)				
2000	46,910	..	..	2,029	35,873
2001	45,503	..	..	1,829	34,697
2002	39,870	..	..	3,673	28,448
2003	56,561	..	..	4,546	40,859
2004	65,999	..	..	5,334	48,375
2005	86,749	..	..	n.a.	63,441
2006	86,281	..	..	n.a.	62,675
2007	88,513	68,933	19,580	9,630	62,840
2008	118,706	88,635	30,071	12,184	82,679
2009	62,985	41,609	21,375	5,9868	44,431
2010	74,804	46,671	28,133	7,737	52,691
2011	..	..	..	..	..
2012	..	..	..	..	..
	Compound Annual Growth Rates, per cent				
2000-2010	4.8	..	..	14.3	3.9
2000-2007	9.5	..	..	24.9	8.3
2007-2010	-5.5	-12.2	12.8	-7.0	-5.7

Note: Estimates for Newfoundland and Labrador refer to oil and gas extraction plus support activities for mining and oil and gas extraction.

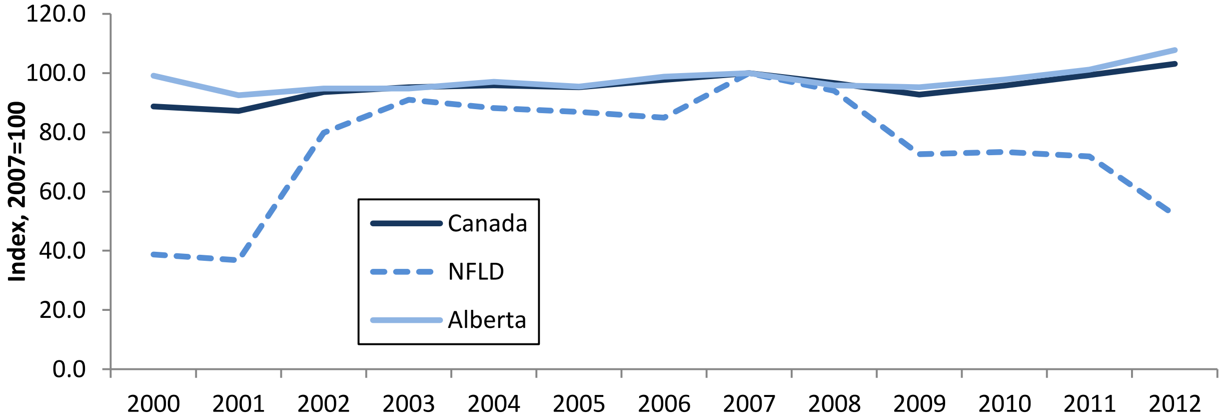
Source: CSLS calculations based on Statistics Canada data, CANSIM Tables 379-0025/27/30/31.

In 2012, oil and gas extraction+ in Newfoundland and Labrador generated $5.0 billion 2007 dollars, up from $3.7 billion in 2000, after peaking at $9.6 billion in 2007.

In 2012, real GDP in oil and gas extraction in Alberta was $67.7 billion chained 2007 dollars, up 8.8 per cent from $62.2 billion in 2000. This growth rate of 0.7 per cent per year was well below the province's business sector growth rate of 2.9 per cent for the 2000-2012 period. Under the assumption that all or virtually all non-conventional oil and gas production in Canada ($30.0 billion chained 2007 dollars) takes place in Alberta, conventional oil and gas output in Alberta can be estimated at $37.7 billion chained 2007 dollars, making Alberta responsible for 64.0 per cent of conventional oil and gas production, compared to 73.6 per cent of total oil and gas production.

Chart 13 shows the evolution of real GDP in the oil and gas subsector for Canada, Alberta, and Newfoundland and Labrador, and Chart 14 gives the composition of oil output in the Alberta over time, another illustration of the shift in the product mix in that province.

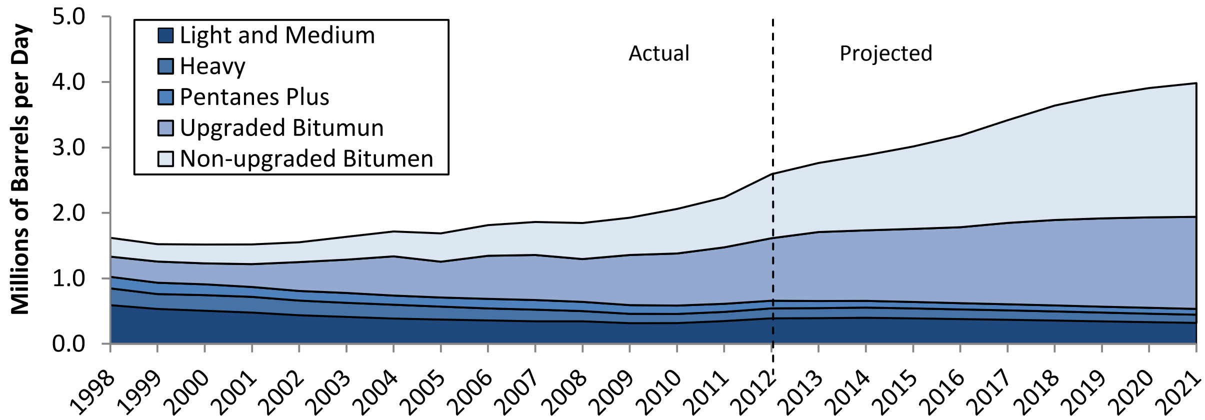
Chart 13: Real GDP in Oil and Gas Extraction, Canada, Alberta, and Newfoundland and Labrador, 2000-2012



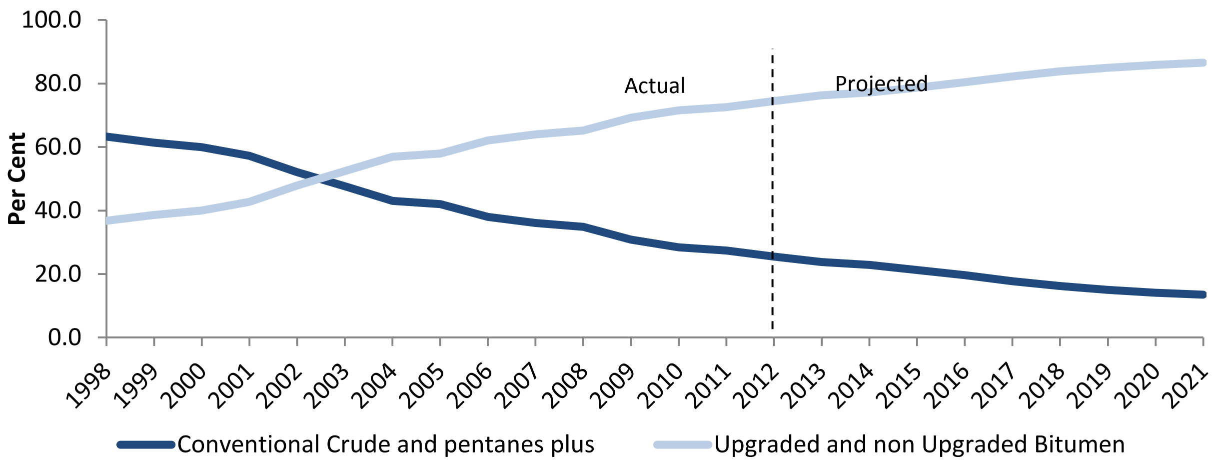
Note: Estimates for Newfoundland and Labrador refer to oil and gas extraction plus support activities for mining and oil and gas extraction.
Source: CSLS calculations based on Statistics Canada data, CANSIM Tables 379-0025/27/30/31.

Chart 14: Actual and Projected Oil Production in Alberta, 1998-2021

A) Absolute



B) Relative



Note: Pentanes Plus means a mixture mainly of pentanes and heavier hydrocarbons that ordinarily may contain some butanes and which is obtained from processing of raw gas, condensate or crude oil.
Source: Energy Resource Conservation Board, *Alberta's Energy Reserves & Supply/Demand Outlook*.

iv. Labour Input

Labour input can be measured either by total hours worked or by the number of employees. Hours is the more appropriate measure from a productivity perspective, as it captures changes in the average work week. However, in recent years there has been little change in the average length of the work week in oil and gas extraction so the rate of growth in total hours worked has closely tracked that of employment (8.2 vs. 7.8 per cent per year in the business sector from 2000 to 2012). As employment is easier to relate to – at least in absolute terms – the discussion in the section will focus on employment.

Employment in the oil and gas extraction subsector in Canada was 65.4 thousand in 2012, up from 26.5 thousand in 2000, an average annual rate of increase of 7.8 per cent (Table 3).

Employment growth in the subsector was nearly six times faster than the growth experienced by the overall business sector (1.3 per cent per year), and resulted in the oil and gas extraction subsector more than doubling its share of total business sector employment to 0.47 per cent in 2012 from 0.22 per cent in 2000.

Conventional oil and gas extraction employed 49.2 thousand in 2012, accounting for 75 per cent of total oil and gas extraction employment, up from 34.6 thousand in 2007, when it represented 65.0 per cent of total oil and gas employment. Perhaps surprisingly, given the growing importance of oil sands output, employment in non-conventional oil extraction has fallen, from 18.2 thousand in 2007 to 16.3 thousand in 2012, with its employment share down from 35 per cent to 25 per cent. This development may reflect the growing importance of the less labour-intensive steam-assisted gravity drainage (SAGD) technology for the extraction of bitumen from the oil sands.

Table 3: Employment in Oil and Gas Extraction, Canada, Alberta, and Newfoundland and Labrador, 2000-2012

	Canada			NFLD	Alberta
	Total	**Conventional**	**Non-conventional**		
	(thousands of jobs)				
2000	26.5			1.3	22.5
2001	29.7			0.9	25.2
2002	30.0			1.1	25.4
2003	30.9			1.2	26.4
2004	35.2			1.4	30.4
2005	42.7			1.5	36.6
2006	45.9			2.0	39.3
2007	52.8	34.6	18.2	2.0	44.4
2008	64.6	46.4	18.2	2.1	54.8
2009	61.7	42.3	19.3	1.4	54.3
2010	55.3	41.4	13.9	2.1	49.5
2011	62.8	47.1	15.7	2.8	55.7
2012	65.4	49.1	16.3	3.1	57.3
	Compound Annual Growth Rates, per cent				
2000-2012	7.8	..	..	6.4	8.1
2000-2007	10.3	..	..	9.1	10.2
2007-2012	4.4	7.3	-2.2	7.5	5.2

Note: Estimates for Newfoundland and Labrador refer to oil and gas extraction + support activities for mining and oil and gas extraction.

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

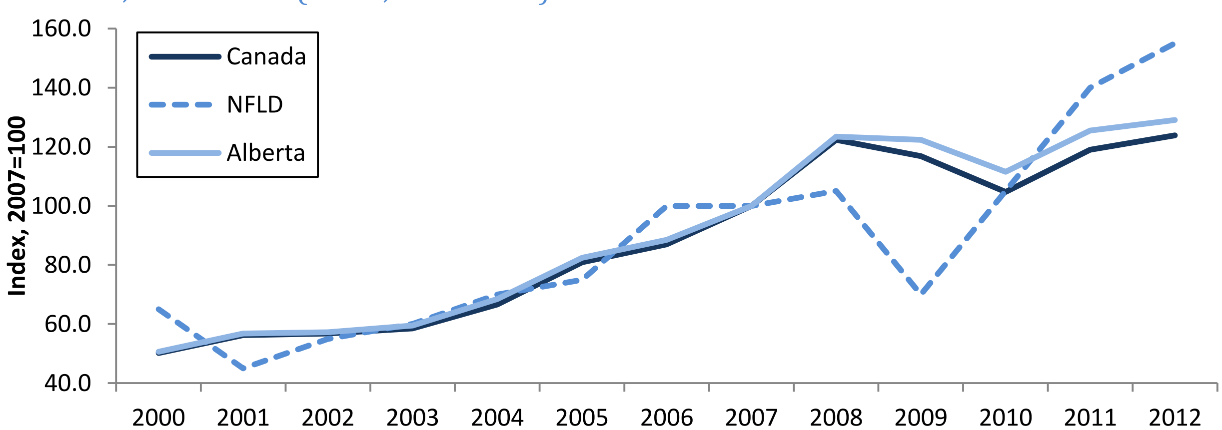
It is interesting to note that employment in support activities for oil and gas extraction in Canada in 2012 exceeded that of oil and gas extraction: 83.0 versus 65.4 thousand, respectively. The focus of this report, however, is the oil and gas extraction subsector, where labour productivity levels are much higher than in support activities for oil and gas extraction.

In 2012, Newfoundland and Labrador's oil and gas extraction+ subsector employed 3.1 thousand people, more than twice the level of 1.3 thousand in 2000. Employment in the subsector accounted for only 1.3 per cent of Newfoundland and Labrador's business sector employment in 2012. The province accounted for 4.1 per cent of total employment in Canada's oil and gas extraction subsector in 2012.

Employment in the oil and gas extraction sector in Alberta was 57.3 thousand in 2012, up from 22.5 thousand in 2000, representing an average annual rate of increase of 8.1 per cent. Employment growth in the subsector was over three times faster than the growth experienced by the overall business sector (2.5 per cent), and resulted in the oil and gas extraction sector almost doubling its share of total business sector employment, from 1.7 per cent in 2000 to 3.7 per cent in 2012.

Unfortunately, Statistics Canada does not provide a breakdown of employment in Alberta's oil and gas extraction sector into conventional oil and gas extraction and non-conventional oil extraction. However, the national figures are likely relevant as Alberta has almost all of Canada's non-conventional oil production. This would imply that employment in conventional oil and gas extraction in Alberta increased from 26 thousand to 41 thousand between 2007 and 2012, compared to the drop in non-conventional oil and gas extraction from 18 thousand to 16 thousand. Chart 15 shows the evolution of employment in the oil and gas subsector for Canada, Alberta, and Newfoundland and Labrador.

Chart 15: Employment in Oil and Gas Extraction, Canada, Alberta, and Newfoundland and Labrador, 2000-2012 (index, 2007=100)



Note: Estimates for Newfoundland and Labrador refer to oil and gas extraction + support activities for mining and oil and gas extraction.
Source: CSLS calculations based on Statistics Canada data, CANSIM Tables 383-0010/30.

v. Labour Productivity

While the most appropriate expression of productivity *levels* refers to *nominal* GDP per hour worked, the analysis of industry contributions to aggregate labour productivity *growth* is best done using *real* GDP (in chained 2007 dollars) per hour worked. Consequently, both definitions of productivity will be presented.

The labour productivity performance of the oil and gas extraction subsector has been dismal. (Chart 16, Panel A). At the national level, the subsector saw labour productivity decline at a rate of 6.4 per cent per year. The decline was particularly sharp in Alberta (-7.1 per cent per year). Productivity in Saskatchewan's oil and gas extraction subsector fell 3.9 per cent per year, while the Manitoba subsector actually saw its productivity increase (6.4 per cent per year). Data for the oil and gas extraction subsector in the Atlantic Provinces are not available for the 2000-2012 period, but for Newfoundland and Labrador we find that the oil and gas extraction^{+} sector saw its productivity decline at a rate of -4.8 per cent per year.

This abysmal productivity performance follows from the evolution of real output and labour input growth presented earlier. With a massive increase in labour input between 2000 and 2012 (total hours worked increased by 8.2 per cent per year), and weak output gains (1.3 per cent per year), labour productivity plummeted sharply.

Manitoba had by far the highest (nominal) labour productivity level in oil and gas extraction in 2010 (last year for which industry-level nominal GDP data were available), $2,322 per hour worked, well above the national average of $630 per hour (Chart 16, Panel B).[8] Saskatchewan and British Columbia also had above-average labour productivity levels in oil and gas extraction ($1,675 and $859 per hour worked, respectively), while Alberta had a below-average level ($500 per hour worked). Despite the subsector's negative labour productivity growth, the absolute level of labour productivity in oil and gas extraction remained very high, almost thirteen times the business sector average in 2010. The oil and gas extraction^{+} sector in Newfoundland and Labrador had a relatively high level of productivity, $1,508 per hour worked.

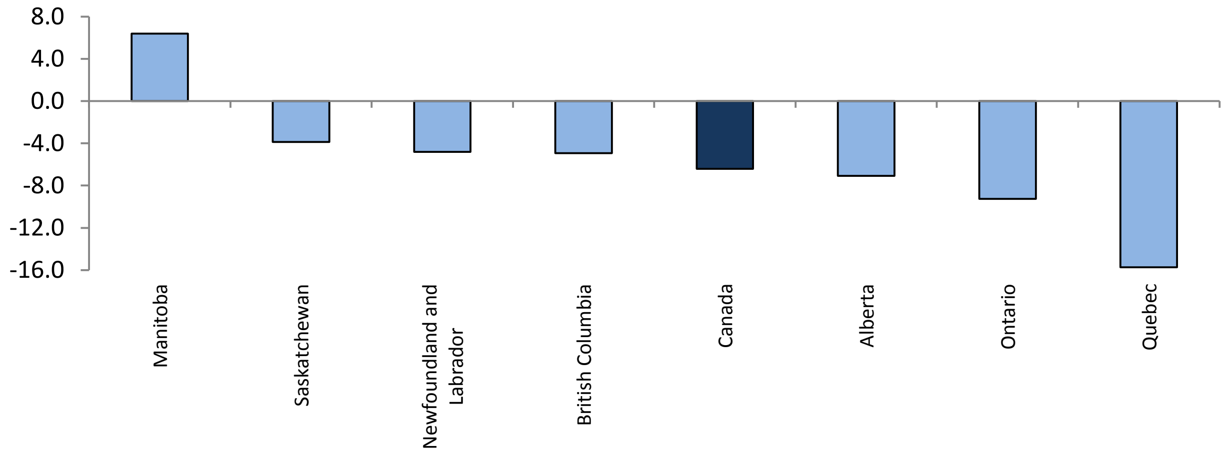
With the exception of Newfoundland and Labrador, the ranking of the provinces is identical in terms of real labour productivity levels in 2012, two years later. Manitoba had the highest (real) labour productivity level in oil and gas extraction, $2,575 per hour, well above the national average of $629 per hour (Chart 16, Panel C). Saskatchewan and British Columbia ranked second and third, respectively, with above-average labour productivity levels ($1,109 and $925 per hour), while Alberta had a below-average level ($545 per hour). Newfoundland and Labrador's oil and gas extraction^{+} industry produced $654 worth of real labour productivity in the year 2012. This is less than half of current dollar GDP of the sector in 2010, two years earlier, mainly as a result of a sharp fall in output caused by temporary shutdowns of offshore oil production platforms and the depletion of these reserves.

[8] It is interesting to note that the (nominal) labour productivity level of oil and gas extraction ($630.16 per hour in 2010 at the national level) is 10 times greater than that of support activities for oil and gas extraction ($62.63 per hour). This difference is largely explained by the large economic rents in oil and gas extraction, which are not present in support activities.

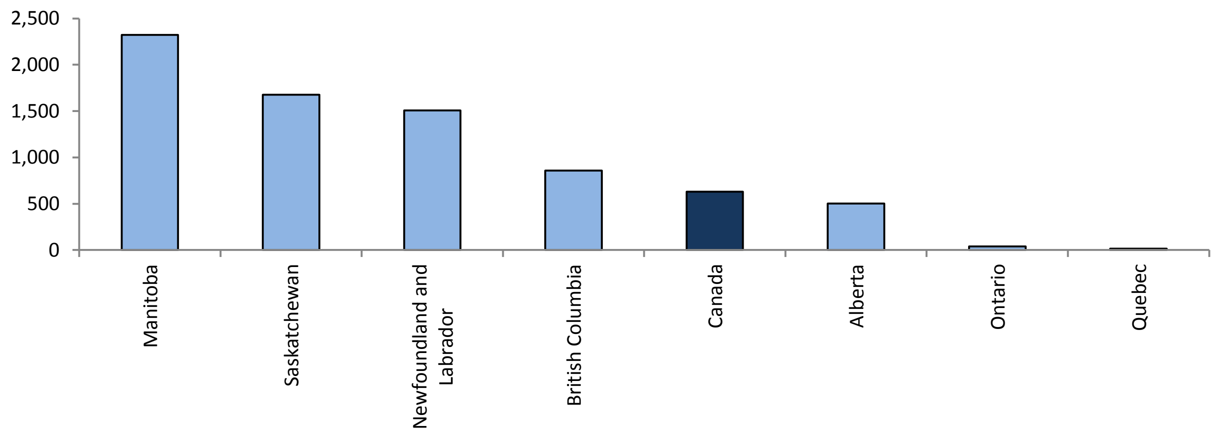
Table 4 summarizes labour productivity growth trends in the oil and gas extraction sector for Canada, Alberta, and Newfoundland and Labrador during the 2000-2012 period, while Chart 17 plots these trends.

Chart 16: Labour Productivity in Oil and Gas Extraction, Canada and the Provinces

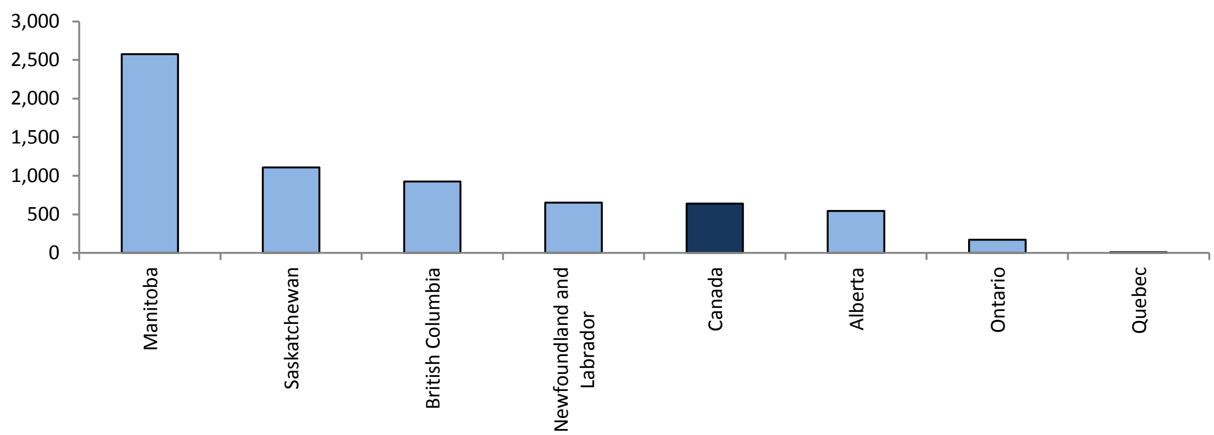
A) Real GDP per Hour Worked, CAGR, Per Cent, 2000-2012



B) Nominal GDP per Hour Worked, Levels, 2010

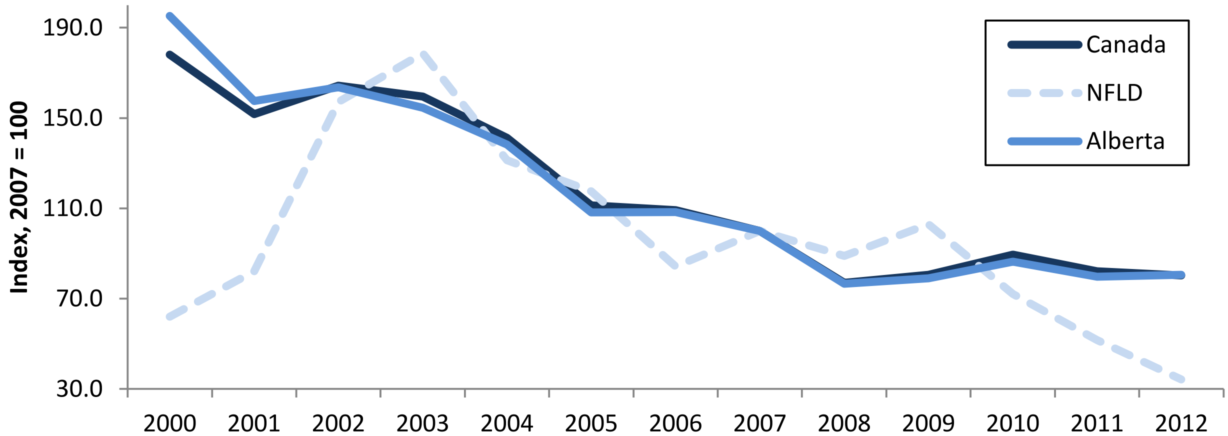


C) Chained 2007 Dollars per Hour Worked, Levels, 2012



Source: CSLS calculations based on Statistics Canada data. Data for Newfoundland are for oil and gas extraction+.

Chart 17: Labour Productivity in Oil and Gas Extraction, Canada, Alberta, and Newfoundland and Labrador, 2000-2012



Note: Estimates for Newfoundland and Labrador refer to oil and gas extraction + support activities for oil and gas.
Source: CSLS calculations based on Statistics Canada data.

Table 4: Labour Productivity in Oil and Gas Extraction, Canada, Alberta, and Newfoundland and Labrador, 2000-2012

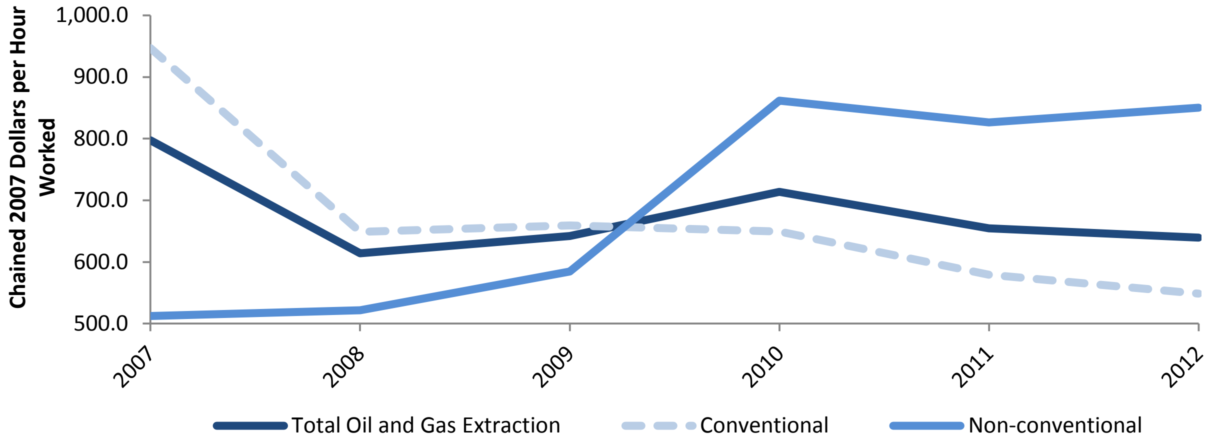
	Canada			NFLD	Alberta
	Total	Conventional	Non-conventional		
	(chained 2007 dollars per hour worked)				
2000	1,419.14	..	..	1,185.29	1,320.39
2001	1,209.10	..	..	1,570.23	1,065.56
2002	1,309.83	..	..	3,002.05	1,107.13
2003	1,271.71	..	..	3,413.18	1,045.65
2004	1,125.37	..	..	2,507.79	934.88
2005	887.85	..	..	2,244.96	731.54
2006	870.84	..	..	1,608.71	733.01
2007	797.16	946.54	512.43	1,910.69	676.39
2008	613.89	648.74	521.88	1,700.43	517.60
2009	642.24	659.46	584.45	1,967.78	534.47
2010	713.95	649.66	861.43	1,377.66	583.85
2011	654.51	579.53	826.27	985.78	538.86
2012	639.48	548.80	850.21	654.04	545.29
	Compound Annual Growth Rates, per cent				
2000-2012	-6.4	..	..	-4.8	-7.1
2000-2007	-7.9	..	..	7.1	-9.1
2007-2012	-4.3	-10.3	10.7	-19.3	-4.2

Note: Estimates for Newfoundland and Labrador refer to oil and gas extraction + support activities for oil and gas.
Source: CSLS calculations based on Statistics Canada data.

Alberta was already an important oil producer in 2000, with oil and gas extraction accounting for 25 per cent of the province's total economy nominal GDP. Since 2000, oil and gas production has increased in Alberta. The real output of oil and gas extraction, as measured by GDP in chained 2007 dollars, grew 0.7 per cent per year between 2000 and 2012, and oil production, as measured in barrels of oil, increased at a faster rate. But, as noted earlier, the oil and gas extraction industry in Alberta comprises two very different sectors, conventional oil and gas and the oil sands, each with very different productivity performance.

Labour productivity in conventional oil and gas extraction fell 10.3 per cent per year during the 2007-2012 period, while in non-conventional oil and gas extraction it increased by 10.7 per cent per year (Table 4). Thus the fall in labour productivity in oil and gas extraction, at least during the 2007-2012 period, was entirely driven by conventional oil and gas extraction, as employment surged 42 per cent and real output fell l5 per cent. By 2012, labour productivity in non-conventional oil was significantly higher than in the conventional oil and gas sector ($850 versus $549 chained 2007 dollars per hour), the opposite of the situation prevailing in 2007 ($512 versus $947). This is illustrated in Chart 18.

Chart 18: Labour Productivity in Conventional and Non-Conventional Oil and Gas Extraction, Canada, 2007-2012



Source: CSLS calculations based on Statistics Canada data.

Two factors are at play in the collapse of labour productivity in conventional oil and gas since 2007. First, yields are decreasing in the exploitation of conventional oil and gas deposits in Western Canada as the easily accessed reserves and basins have been increasingly exploited. Second, high oil prices have made it profitable to exploit lower quality, and hence higher cost, oil and gas deposits. Profits trump productivity in any decision to use resources to produce oil and gas. As long as production is profitable, it will be carried out, whatever the implications for labour productivity. Perhaps, as well, the ample revenues during this period made the industry less vigilant in controlling labour cost.

The robust labour productivity growth in non-conventional oil production, a very promising and little known development, likely reflects two factors. First, the increasing importance of stream-assisted gravity drainage (SAGD) technology for extraction of bitumen, which is less labour intensive than mining of the oil sands, has likely reduced labour requirements per unit of output. Second, given that the oil sands have now been in production for a number of decades, the industry is benefiting from process improvements through learning-by-doing.

C. Business Sector Productivity

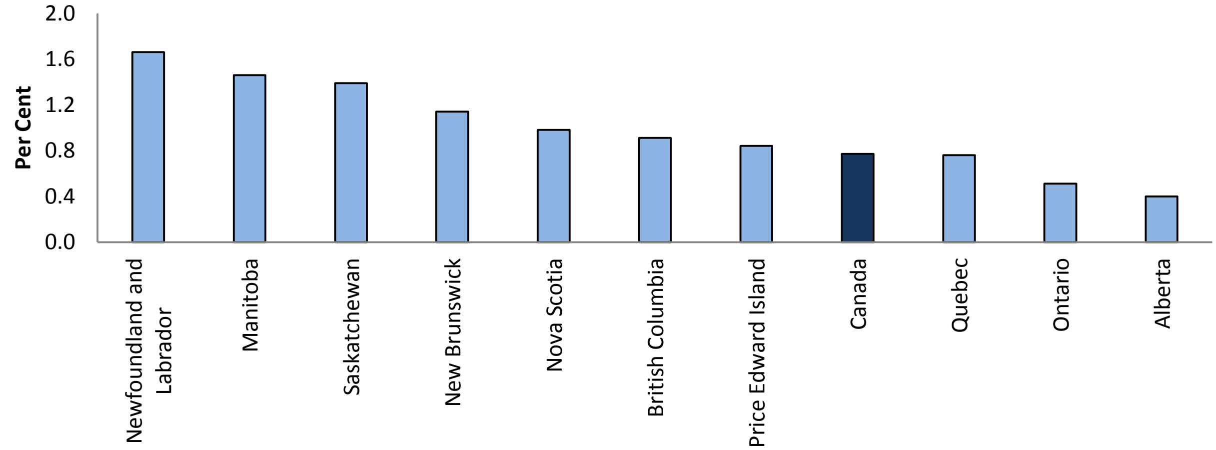
As illustrated in Chart 19 (Panel A), during the 2000-2012 period Alberta had the slowest business sector labour productivity growth of all provinces (0.45 per cent per year), while Newfoundland and Labrador had the fastest (1.66 per cent). Saskatchewan – also an oil-producing province – saw above-average labour productivity growth in the period (1.39 per cent per year).

Newfoundland and Labrador had the highest (nominal) labour productivity level in the country in 2010 (the last year for which industry-level nominal GDP data are available), $79 per hour worked, well above the national average of $49 per hour (Chart 19, Panel B). Alberta came second, with a labour productivity level of $69 per hour, and Saskatchewan came third ($64 per hour).

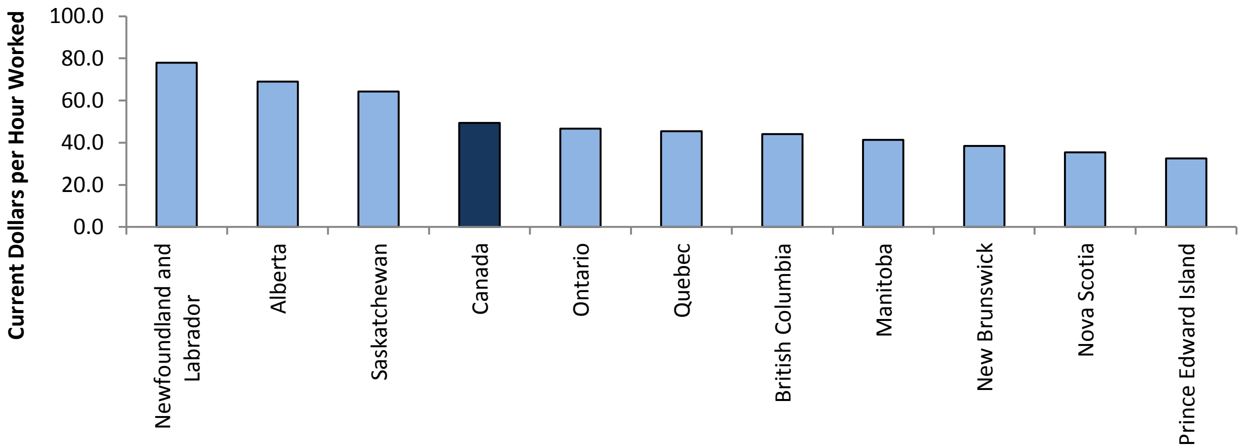
Alberta had the highest (real) labour productivity level in the country in 2012, $69 per hour worked, well above the national average of $48 per hour (Chart 19, Panel C). Newfoundland and Labrador came second, with a labour productivity level of $68 per hour, and Saskatchewan came third ($57 per hour).

Chart 19: Business Sector Labour Productivity, Canada and the Provinces

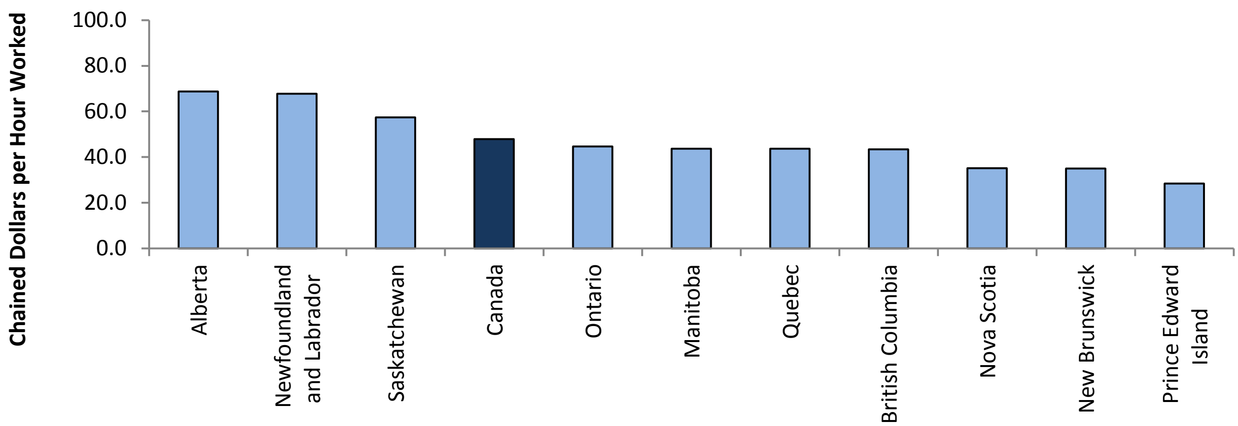
A) Growth in Real GDP per Hour Worked, CAGR, Per Cent, 2000-2012



B) Nominal GDP per Hour Worked, Levels, 2010



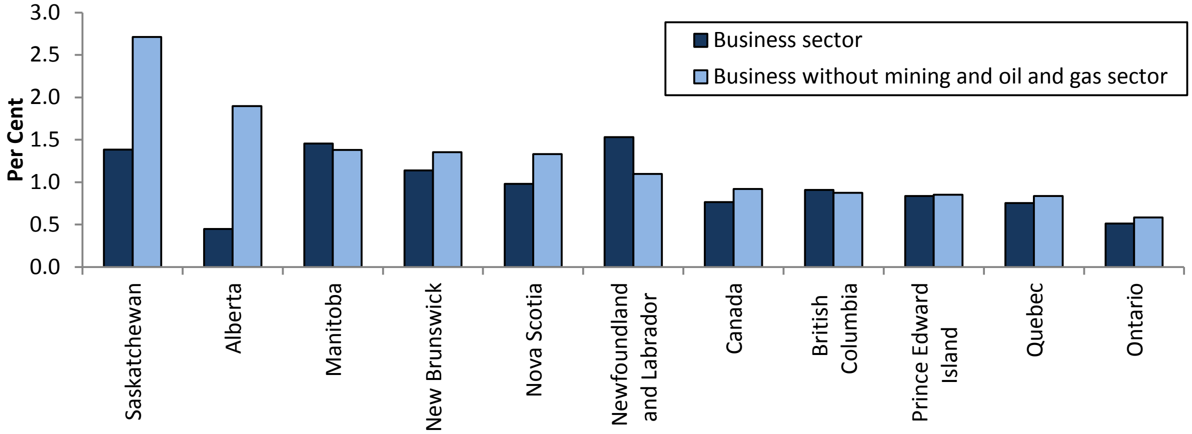
C) Chained 2007 Dollars per Hour Worked, Levels, 2012



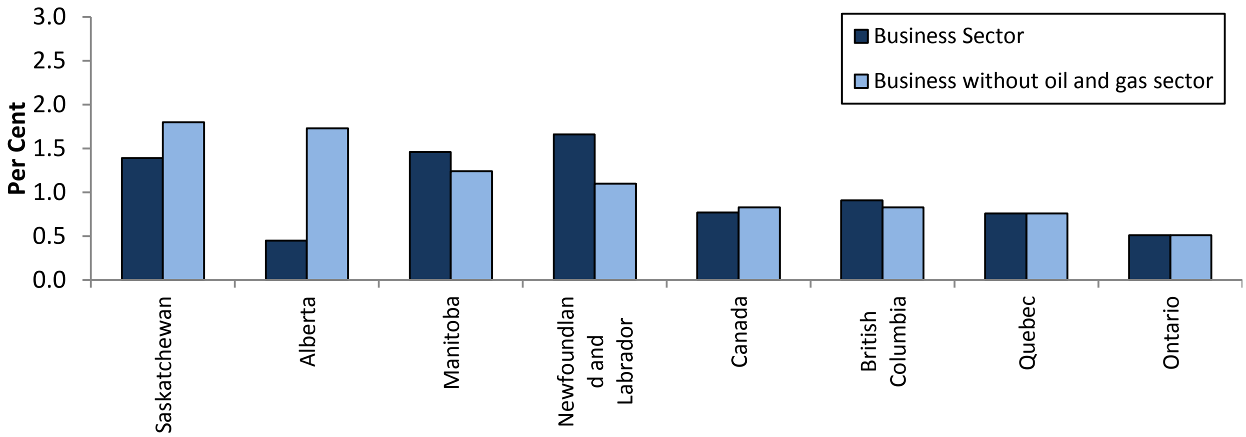
Source: CSLS calculations based on Statistics Canada data.

Chart 20: Labour Productivity Growth in Canada and the Provinces, Business Sector and Business Sector excluding Oil and Gas Extraction Activities, 2000-2012

A) Business Sector Excluding Mining and Oil and Gas Extraction



B) Business Sector Excluding Oil and Gas Extraction



Source: CSLS calculations based on Statistics Canada data.

How do we explain the very different productivity growth performance of the two major oil-producing provinces? Oil and gas extraction, which plays a major role in both economies, experienced a drastic decline in labour productivity in both economies. Nonetheless, business sector labour productivity growth was weak in Alberta and quite strong in Newfoundland and Labrador; this disparity is related to differences in the contribution of oil and gas extraction to aggregate labour productivity growth between the two provinces (Chart 20). The contribution of the oil and gas extraction subsector to business sector labour productivity growth was *positive* in Newfoundland and Labrador while it was *negative* in Alberta. The level of labour productivity and the relative size of the oil and gas extraction sector may explain this difference.

The increase in Newfoundland and Labrador's labour productivity was caused in large part by the increasing share of value added generated by the high-productivity oil and gas extraction sector. In fact, the province's labour productivity boom can be clearly traced back to the beginning of operations in the Terra Nova oil field in 1997. During the 1997-2000 period, business sector labour productivity in the province increased 5.6 per cent per year, with mining and oil and gas extraction labour productivity growing at an astounding pace of 32 per cent per year. After 2000, a shift of employment into the high-productivity oil and gas sector boosted productivity in the business sector as a whole. In Alberta, the large size of the oil and gas extraction industry makes the decline in the labour productivity of that sector a more important factor in the productivity performance of the business sector. In either province the significant presence of the oil and gas industry may have affected overall productivity in many, more indirect, ways as well. These matters are explored in Sections V and VI of this report, following the presentation of the analytical framework applied in those sections.

To conclude this subsection we present a brief review of productivity in the mining, quarrying and oil and gas extraction industry. The reason for this is that some of the data and analysis that follows pertains to this industry and not to the subsector, oil and gas extraction that is the focus of this study. Of course, the oil and gas sector accounts for a very large share of the mining, quarrying and oil and gas extraction industry.

Labour productivity in mining and oil and gas extraction declined at an annual rate of 3.5 per cent from 2000 to 2012 (Chart 21, Panel A).[9] This reflects the sector's poor labour productivity performance across nearly all provinces, including Saskatchewan (-4.9 per cent per year), Alberta (-4.0 per cent), and Newfoundland and Labrador (-3.4 per cent). The only province that saw positive labour productivity growth in mining and oil and gas extraction in this period was Manitoba (0.5 per cent per year).

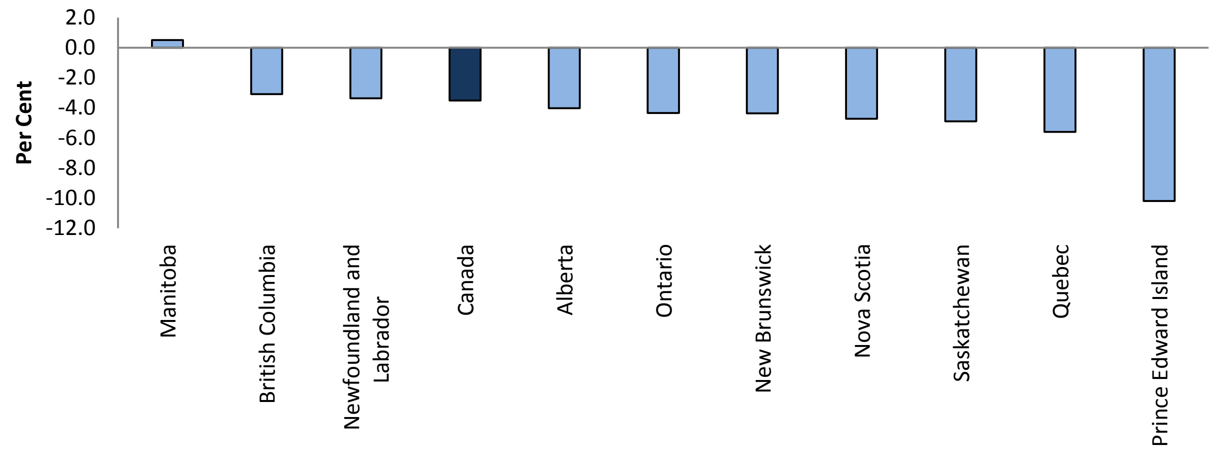
Newfoundland and Labrador had by far the highest (nominal) labour productivity level in mining and oil and gas extraction in 2010 (last year for which industry-level nominal GDP data were available), $899 per hour worked, well above the national average of $251 per hour (Chart 21, Panel B). Saskatchewan came second, with a labour productivity level of $383 per hour, well above Alberta's level ($240 per hour).

Newfoundland and Labrador also had the highest (nominal) labour productivity level in mining and oil and gas extraction in 2012, $429 per hour worked, well above the national average of $233 per hour (Chart 21, Panel C). Manitoba and Saskatchewan came second and third, respectively, with labour productivity levels of $381 per hour and $286 per hour, well above Alberta's level ($246 per hour).

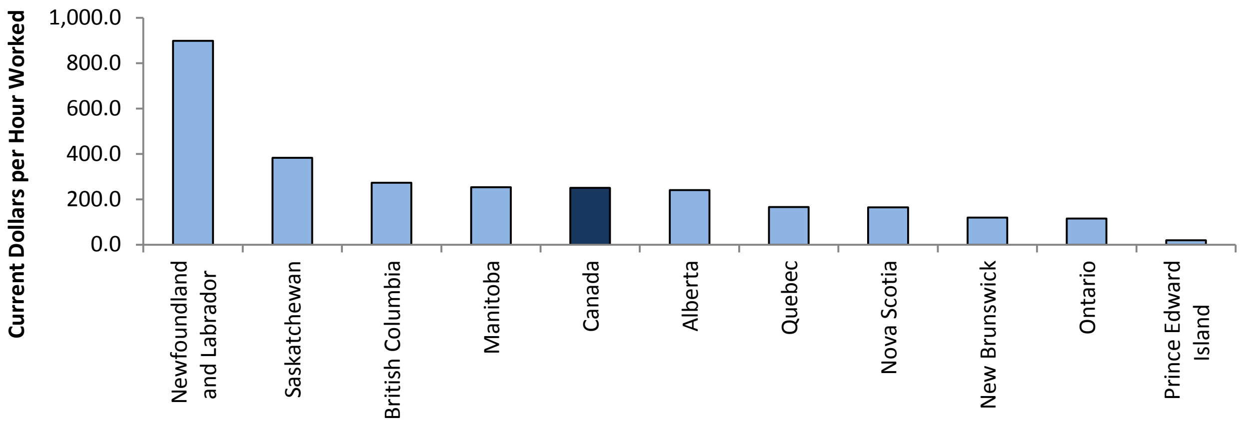
[9] For the 1997-2000 period, labour productivity in Canada's mining and oil and gas sector increased by 3.1 per cent per year. During this period, labour productivity in Newfoundland and Labrador's mining and oil and gas sector experienced extraordinary growth (31.9 per cent per year), due to the start of operations of the Terra Nova oil field. In Alberta, productivity in the sector was practically stagnant, growing at 0.2 per cent per year.

Chart 21: Labour Productivity in Mining and Oil and Gas Extraction, Canada and the Provinces

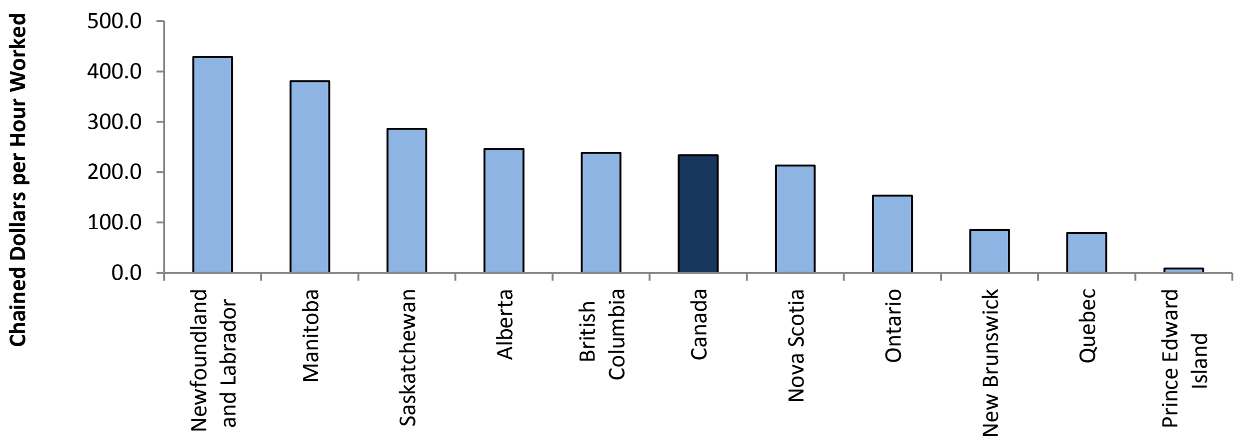
A) Real GDP per Hour Worked, CAGR, Per Cent, 2000-2012



B) Nominal GDP per Hour Worked, Levels, 2010



C) Chained 2007 Dollars per Hour Worked, Levels, 2012



D. Sources of Labour Productivity Growth: Growth Accounting

A widely used method for analyzing productivity growth is the growth accounting framework. The method involves decomposing labour productivity growth into three broad factors: improvements in the quality of labour, capital deepening (increases in the amount of capital per labour input, or more precisely, per hour worked) and multifactor productivity growth (MFP). MFP growth reflects output growth that is not accounted for by combined input growth. It can be explained by a number of very different factors, such as improvements in technology and organization, capacity utilization, increasing returns to scale, etc. It also embeds errors due to the mismeasurement of inputs. In a value added context, MFP growth is calculated as the ratio between real GDP growth and an index of combined labour and capital input growth.

At the national level, the Canadian Productivity Accounts (CPA) made public by Statistics Canada provide sources of growth estimates for the business sector and two-digit NAICS sectors for up to 2011 and for three-digit NAICS subsectors up until 2008. Provincial estimates for sources of growth are available only for business sector and two-digit sectors up until 2010. For consistency, this subsection focuses on the 2000-2010 period for the business sector and two-digit sectors at both the national and provincial levels. The reader should also keep in mind that the labour productivity growth rate estimates discussed in this section differ slightly from those discussed in previous sections since they come from different CPA tables.

For the oil and gas extraction subsector, data are available only at the national level, and only to 2008. The subsector suffered a massive decline in labour productivity in the period (Table 5). This decline of 7.32 per cent per year was almost entirely caused by the sharp fall in the subsector's MFP growth, which contributed -6.98 percentage points to labour productivity growth, although negative developments in capital intensity growth also played a minor role in the subsector's poor labour productivity performance.

Table 5: Sources of Labour Productivity Growth in the Oil and Gas Extraction Subsector, Canada, 2000-2008

	Canada
	(percentage point contributions)
Labour Productivity	*-7.32*
Contribution of Capital Intensity	-0.37
Contribution of Labour Composition	0.00
Contribution of MFP	-6.98
	(per cent)
Labour Productivity	*100.0*
Contribution of Capital Intensity	5.0
Contribution of Labour Composition	-0.1
Contribution of MFP	95.3

Source: Statistics Canada, CPA, CANSIM Table 383-0022.

It is useful to know that there was no capital deepening in oil and gas extraction. One might have guessed otherwise, given the large investments in tar sands facilities and the enormous platforms that were floated out into the Atlantic. Ascribing the sharp productivity decline to MFP does not provide any useful insight into developments in oil and gas production. Clearly the sharp MFP decline relates to the factors considered earlier: conventional oil and gas wells becoming less productive, and requiring more intensive processes to continue producing; the growing importance of oil sands production; a decline in off-shore production; and a fall in the output of natural gas.

The decline in labour productivity in oil and gas extraction caused labour productivity in the mining and oil and gas extraction sector to plummet. It fell at a rate of 2.85 per cent per year during the 2000-2010 period (Table 6). The decline was entirely due to MFP, which contributed -4.84 percentage points per year to labour productivity growth and more than offset the positive contribution from capital intensity (2.03 percentage points). This is not surprising as oil and gas extraction is such a large part of the sector.

Table 6 shows that the national story is largely a reflection of labour productivity developments in Alberta's mining and oil and gas extraction sector, given that the province accounts for 55 per cent of the value added generated by the sector. Alberta's industry is, of course, dominated by oil and gas extraction.

In Newfoundland and Labrador, on the other hand, the mining and oil and gas extraction sector experienced very strong labour productivity growth (5.86 per cent per year) due to robust MFP growth, which contributed 7.53 percentage points per year to labour productivity growth. Here too the sector is dominated by oil and gas extraction, but it is small compared to the industry in Alberta and thus makes a smaller contribution to national MFP performance. Both at the national and provincial levels, changes in labour composition explained only a very small part of total labour productivity growth in the period.

Table 6: Sources of Labour Productivity Growth in the Mining and Oil and Gas Sector, Canada and Oil-producing Provinces, 2000-2010

	Canada	Newfoundland and Labrador	Alberta
		(percentage point contributions)	
Labour Productivity	*-2.85*	*5.86*	*-3.92*
Contribution of Capital Intensity	2.03	-1.48	2.83
Contribution of Labour Composition	0.07	-0.08	0.10
Contribution of MFP	-4.84	7.53	-6.67
		(per cent)	
Labour Productivity	*100.0*	*100.0*	*100.0*
Contribution of Capital Intensity	-71.3	-25.3	-72.2
Contribution of Labour Composition	-2.5	-1.4	-2.6
Contribution of MFP	170.1	128.6	170.2

Source: Statistics Canada, CPA, CANSIM Table 383-0021/26.

From 2000 to 2010, labour productivity in the Canadian business sector increased 0.85 per cent per year. During this period, MFP growth was negative (contributing -0.50 percentage points per year), counteracting the positive effect of rising capital intensity, which contributed 1.06 percentage points to total growth (Table 7).

In the case of Alberta, the contribution of strong capital intensity growth (2.65 percentage points per year) was almost entirely offset by the negative MFP growth (-2.62 percentage points), for weak overall labour productivity growth (0.19 per cent per year). It would appear that outside the oil and gas extraction sector labour productivity was boosted by capital deepening, while negative MFP growth reflects what happened in oil and gas extraction.

The strong labour productivity growth experienced by Newfoundland and Labrador during the period (3.31 per cent per year), on the other hand, was a result of rapid MFP growth (2.23 percentage points per year), with capital intensity growth also playing an important role (0.89 percentage points). For Canada and the two oil-producing provinces, the contribution of labour composition growth was relatively small (between 0.18 and 0.29 percentage points).

Table 7: Sources of Business Sector Labour Productivity Growth, Canada and Oil-producing Provinces, 2000-2010

	Canada	**Newfoundland and Labrador**	**Alberta**
		(percentage point contributions)	
Labour Productivity	*0.85*	*3.31*	*0.19*
Contribution of Capital Intensity	1.06	0.89	2.65
Contribution of Labour Composition	0.29	0.18	0.22
Contribution of MFP	-0.50	2.23	-2.62
		(per cent)	
Labour Productivity	*100.0*	*100.0*	*100.0*
Contribution of Capital Intensity	124.0	26.8	1,432.6
Contribution of Labour Composition	33.9	5.5	118.4
Contribution of MFP	-59.2	67.3	-1,411.6

Source: Statistics Canada, CPA, CANSIM Tables 383-0021/26.

IV. A Framework for Analyzing the Impact of Oil and Gas Extraction on Canadian Productivity Growth

One explanation for the poor productivity performance of the Canadian economy since 2000, it has been suggested, is the sharp decline of labour productivity, at a rate of 6.4 per cent per year, in the oil and gas extraction industry. However, as the industry's share of hours worked in the business sector is only 0.61 per cent in 2012, up from 0.25 per cent in 2000, the industry has made only a very small negative contribution of 0.61 x 6.4 = 0.04 percentage points per year to labour productivity growth of the business sector.

However, the effects of the oil and gas industry on aggregate productivity growth are much more complex than suggested by this simple calculation. First, any attempt to calculate the direct contribution of oil and gas extraction to aggregate productivity growth must include the composition effect of a greater share of hours worked in a high-productivity sector. Second, the indirect effects of oil and gas extraction on productivity, both positive and negative, cannot be ignored.

This section of the report presents a framework to identify the direct contribution and the indirect effects of the oil and gas sector on productivity growth.[10] The next section provides empirical estimates of the direct contribution, and the section following discusses and presents evidence regarding the indirect effects, both for Canada as a whole and for Alberta and Newfoundland and Labrador, the two provinces where the oil and gas sector is most important.

Exhibit 2 provides a schema for identifying and quantifying the different ways in which developments in and arising from the oil and gas industry impact, both directly and indirectly, aggregate productivity growth, whether at the national or provincial levels.[11] To keep the discussion manageable, labour productivity, specifically, real GDP per hour worked, will be the focus of the report.

The framework has two parts:

- The **direct contribution** of productivity and productivity growth in the industry to aggregate productivity growth.

- The **indirect effects** of developments in the oil and gas sector on the productivity of other sectors and implications for aggregate productivity growth.

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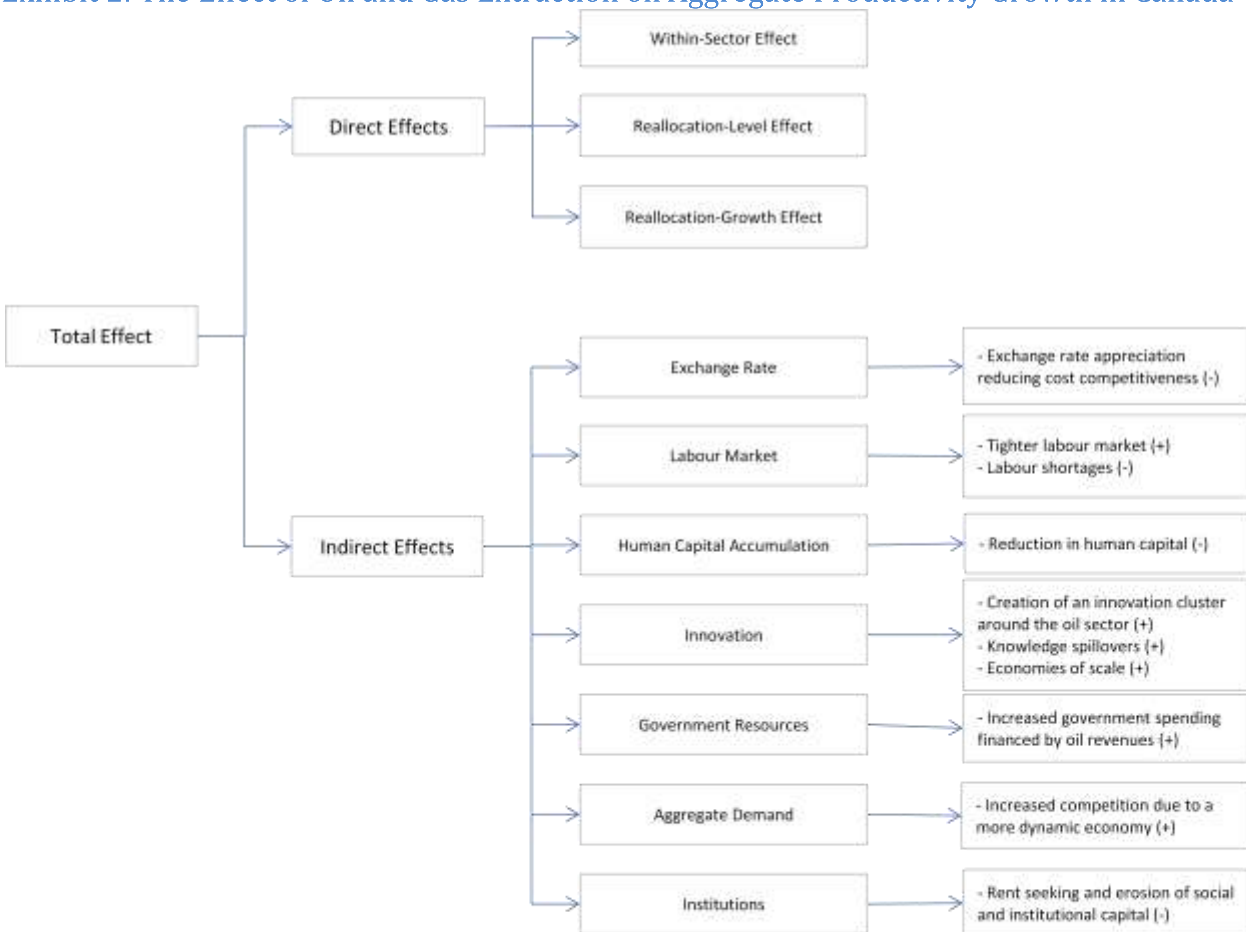
[10] The usefulness of this framework as a tool for assessing the effect of a sector on aggregate productivity is not limited to the oil and gas sector and can be applied to other industries, especially other natural resource industries such as mining.

[11] The aggregate can refer to either the total economy or the business sector. In this report the latter definition is used. Aggregate productivity measures include both labour productivity and multifactor productivity.

Exhibit 2: The Effect of Oil and Gas Extraction on Aggregate Productivity Growth in Canada



The three components of the direct contribution of a sector to productivity growth are as follows:

- The **within-sector effect (WSE)** is the labour productivity growth rate of the sector, scaled to reflect the share of the sector in the aggregate. As noted in the opening paragraph of this section, this contribution of the oil and gas sector is negative but rather small in Canada over the 2000-2012 period.

- The **reallocation-level effect (RLE)** measures the effect of a shift of resources in or out of a sector whose productivity level differs from the average. The productivity level of a sector may be very different from the average of all sectors, and this is especially the case with the oil and gas sector whose output per worker in 2012, measured in current dollars, was thirteen times the business sector average. Clearly, shifting resources into a sector with such a high level of productivity will be reflected in productivity growth while the shift takes place.

- The **reallocation-growth effect (RGE)** measures the effect of a shift of resources into a sector that has a rate of productivity growth that differs from the aggregate rate of productivity growth. The oil and gas sector has had a high level of labour productivity but a negative growth. Shifting labour into the sector, while immediately boosting overall productivity, will create a drag on productivity growth as productivity in the sector declines. As this effect reflects differences growth rates rather than in output per hour worked, it tends to be smaller than the reallocation-level effect.

This breakdown of the contribution of an industry to productivity growth is a numerical exercise that does not include any behavioural reactions. Behavioural effects are addressed under the rubric of indirect effects.

Accounting frameworks for calculating the three components have been developed by the CSLS (Sharpe and Thomson, 2010) and Tang and Wang (2004). Both these frameworks will be used in this report to calculate the direct contribution. The data about productivity and productivity growth in the oil and gas sector that are the input to this analysis have been described in Section III above.

The indirect or spillover effects of developments in the oil and gas sector on productivity trends in other sectors and hence on aggregate productivity growth are relatively easy to identify, but much harder to quantify. The oil and gas sector can have productivity-related effects in at least seven areas: the exchange rate, the labour market, human capital accumulation, innovation, government resources, aggregate demand, and institutions (Exhibit 2). These effects may be positive or negative, and it is difficult to know a priori whether the combined effects in some areas or overall are positive or negative.

Positive effects of developments in the oil and gas sector on productivity in other sectors and on aggregate productivity include the following:

- A tighter labour market caused by increased oil and gas activity raises labour costs, leading to increased substitution of capital for labour and rising labour productivity, or to the demise of low productivity level activities such as fast food outlets (e.g., Tim Horton stores in Fort McMurray) that cannot afford to pay higher wages and a boost to aggregate productivity through a re-allocation level effect;

- Knowledge spillovers from the oil and gas sector to other sectors through demonstration effects whereby non-oil and -gas firms adopt the technological and organizational best practices of the leading oil and gas sector, through the movement of skilled workers from the oil and gas sector to other sectors;

- Increased human capital investment due to the higher returns in skilled occupations in the oil and gas sector and in other sectors benefiting from increased economic activity of the oil and gas sector;

- Creation of an innovation cluster around the oil and gas sector, leading to productivity advances in ancillary industries servicing the sector;

- Productivity-enhancing effects of any increased government spending (e.g., post-secondary education and R&D) financed by greater revenues from the oil and gas sector;

- Increased competition through a growing and more dynamic economy fuelled by the oil and gas sector, which may induce firms to improve productivity; and

- Increased capacity utilization in non-oil and gas industries arising from a greater level of economic activity related to purchases of capital and intermediate inputs by the oil and gas sector as well as the purchase of final goods and services from the incomes generated in the oil and gas sector. This increased demand and output leads to higher productivity growth through the spreading of overhead costs, less labour hoarding, and more economies of scale and scope.

Negative effects of developments in the oil and gas sector on productivity in other sectors and on aggregate productivity include the following:

- An exchange rate appreciation driven by increased value of exports of the oil and gas sector, reducing the cost competitiveness of other export sectors, leading to lower output and capacity utilization and hence productivity in these sectors. This is sometimes referred to as the Dutch Disease;

- The emergence of labour shortages in certain occupations outside the oil and gas sector due to the high labour demand in the oil and gas sector, resulting in production bottlenecks and falls in output and productivity;

- Reduction in human capital investment (lower high school completion rate, lower post-secondary participation) because of the availability of high paying employment opportunities in low-skill positions in the oil and gas sector; and

- Increased rent-seeking and erosion of social and institutional capital because of the large profits generated by the oil and gas sector, resulting in less willingness to embrace change, with negative implications for productivity advance.

The following two sections of this report discuss, and where possible provide empirical estimates for, both the direct contribution and the indirect effects of the oil and gas sector on Canada's productivity performance, with particular attention to the two provinces where the oil and gas sector is most important, namely Alberta and Newfoundland and Labrador.

V. Assessing the Direct Contribution of Oil and Gas Extraction to Business Sector Labour Productivity Growth

This section examines the direct contribution of the oil and gas extraction subsector – or, when data are not available for this subsector, the mining and oil and gas extraction sector – to aggregate productivity growth in Canada, Alberta and Newfoundland and Labrador for the 2000-2012 period. The subsector's (or sector's) contribution to business sector labour productivity growth is broken down into three components using labour productivity growth decomposition formulas. Two formulas are used: one developed by CSLS, and the Generalized Exactly Additive Decomposition (GEAD) formula.[12]

The section is divided as follows: first, we describe the CSLS decomposition formula, comparing it to the GEAD formula. Next, the results of the CSLS decomposition for Canada, Alberta, and Newfoundland and Labrador are analyzed. The CSLS results are then compared to the GEAD results, and key findings are summarized.

A. The CSLS and GEAD Decomposition methods

The CSLS formula calculates the three components as indicated in Table 8. The formulas in the top row of the table describe the decomposition of productivity growth in the business sector as a whole which results from summing each component over all industries. This total is then expressed as a growth rate by dividing by real GDP per hour worked at the beginning of the period.

The numerators of the three components are calculated for each industry as follows:

- For the *within-sector effect* (WSE), the absolute change in real GDP per hour worked in the sector times the sector's share of hours worked;

- For the *reallocation level effect* (RLE), the difference in real GDP per hour worked between the sector and the aggregate at the beginning of the period times the change in the sector's share of hours worked; and

- For the *reallocation growth effect* (RGE), the difference in the absolute change in real GDP per hour worked between the sector and the aggregate times the change in the sector's share of hours worked.

[12] For more on labour productivity decompositions, see Tang and Wang (2004), Diewert (2008), Sharpe and Thomson (2010), Almon and Tang (2011), de Avillez (2012), and Reinsdorf (2014).

It can be easily shown that when summed over all industries, the three components sum to the absolute change in aggregate real GDP per hour. By dividing by real GDP per hour worked, as per the formulas in Table 8, the three components are expressed in terms of the rate of growth of aggregate real GDP per hour. This is the procedure for decomposition of the growth of labour productivity over the period as a whole.

We have followed a slightly different procedure, so as to express the three components for each industry in terms of the average annual growth of real GDP per hour in the aggregate. The numerators for each industry are calculated using the formulas in Table 8. Each value is then divided by the absolute change of aggregate real GDP per hour worked. The resulting ratios are then applied to the average annual growth rate of labour productivity.

Much like the CSLS formula, the GEAD formula also breaks down sectoral contributions to aggregate labour productivity growth into the three effects defined. In the GEAD formula, however, the three effects are specified in a different way – more specifically, all three effects incorporate changes in *relative prices*, which does not happen in the CSLS formula earlier (Table 8, second row). To understand how these formulas were derived, see De Avillez (2012)

Table 8: Two formulas for decomposing productivity growth

	Within-Sector Effect	Reallocation Level Effect	Reallocation Growth Effect
CSLS	$\sum_i \frac{\Delta Z_t^i l_{t-1}^i}{Z_{t-1}}$	$\sum_i \frac{(Z_{t-1}^i - Z_{t-1})\Delta l_t^i}{Z_{t-1}}$	$\sum_i \frac{(\Delta Z_t^i - \Delta Z_t)\Delta l_t^i}{Z_{t-1}}$
GEAD	$\sum_i \frac{Y_{t-1}^i}{Y_{t-1}} G_t^i$	$\sum_i \frac{Z_{t-1}^i}{Z_{t-1}}(p_t^i l_t^i - p_{t-1}^i l_{t-1}^i)$	$\sum_i \frac{Z_{t-1}^i}{Z_{t-1}}(p_t^i l_t^i - p_{t-1}^i l_{t-1}^i) G_t^i$

Notation:

Z	Real GDP per hour worked for the business sector
Z^i	Real GDP per hour worked for sector i
l^i	Hours share for sector i
Y	Aggregate nominal GDP
Y^i	Nominal GDP for sector i
p^i	Relative prices for sector i
G^i	Labour productivity growth for sector i
t, t-1	Periods t and t-1, respectively

Real GDP can be calculated using fixed-base or chained indexes. In the former, price weights are fixed at a given base period, while in the latter they are updated every period. Real GDP in constant dollars is calculated using fixed indexes, while real GDP in chained dollars is calculated using chained indexes. The three components in the CSLS decomposition formula for aggregate productivity growth are perfectly additive only when labour productivity estimates are constructed using constant dollars real GDP, but not when real GDP is measured in chained dollars. Contributions from the GEAD formula are perfectly additive regardless of whether constant or chained dollars are used to calculate labour productivity.

B. Direct Contribution of the Oil and Gas Subsector Using the CSLS Formula

This section examines the direct contributions of the mining and oil and gas sector and the oil and gas extraction subsectors according to two labour productivity growth decomposition formulas (CSLS and GEAD). Contributions were calculated using only the first and last years of the period in question, which means that within-sector and reallocation effects within the period were not captured. In addition, as explained above, contributions were calculated in terms of the absolute change in overall business sector labour productivity over the period as a whole and then rescaled to match the period's compound annual growth rate.

i. Canada

Business sector output per hour in Canada grew at a 0.77 per cent average annual rate from 2000 to 2012 (Table 9, Panel A). In contrast, labour productivity in the mining and oil and gas extraction industry fell at a 3.51 per cent average annual rate.[13] The level of real GDP per hour worked in mining and oil and gas in 2012 was $233 (chained 2007 dollars), 4.9 times the business sector average. Between 2000 and 2012, the share of hours worked of the mining and oil and gas sector rose 0.8 percentage points from 1.4 per cent to 2.2 per cent of total business sector hours worked, which represents a 55 per cent rise in the share. The combination of the high labour productivity level and significant change in the hours share means that the mining and oil and gas sector had important effects on aggregate productivity growth.

The decomposition formula reveals that despite the strong negative within-sector contribution from mining and oil and gas extraction (-0.32 percentage points), the sector only made a relatively small negative contribution to overall business sector labour productivity growth (-0.06 percentage points). This result was due to the very large positive reallocation level effect (0.45 percentage points), reflecting the large influx of workers into this very high productivity sector. This very important positive reallocation effect of the oil and gas sector on productivity is seldom recognized, as the focus of discussion is generally on within-sector performance.

Because of the negative productivity growth within the mining and oil and gas sector, there was a negative reallocation growth effect (-0.18 percentage points). Consequently, the net reallocation effect of 0.27 percentage points (0.45 - 0.18) was less than the reallocation level effect, but still large enough to offset most of the negative contribution of within-sector productivity growth (-0.32 percentage points).

In passing we note that whereas the contribution of the mining and oil and gas extraction industry to productivity growth was smaller than that of several other industries (especially

[13] The basic data used to construct the estimates presented in Table 9, Table 11, and Table 12 can be found in the Appendix.

manufacturing, wholesale trade and retail trade), no other industry comes close to the mining and oil and gas extraction industry with regard to each of the three components of the contribution. This shows how extreme the level and negative growth rate of productivity in the subsector have been.

Table 9: CSLS Labour Productivity Growth Decomposition for Canada, 2000-2012

A) Two-digit NAICS Decomposition

	WSE	RLE	RGE	Total
	(percentage point contribution to aggregate labour productivity growth)			
Business sector industries	**0.61**	**0.49**	**-0.29**	**0.77**
Mining and oil and gas extraction	-0.32	0.45	-0.18	-0.06
All other industries combined	**0.94**	**0.04**	**-0.10**	**0.88**
Agriculture, forestry, fishing and hunting	0.09	0.06	-0.02	0.13
Utilities	0.01	0.00	0.00	0.01
Construction	0.00	-0.04	-0.03	-0.06
Manufacturing	0.23	-0.03	-0.03	0.18
Wholesale trade	0.20	0.01	-0.01	0.19
Retail trade	0.16	0.01	0.00	0.17
Transportation and warehousing	0.03	0.00	0.00	0.03
Information and cultural industries	0.08	0.00	0.00	0.08
FIRE	0.03	0.10	-0.01	0.12
Professional, scientific and technical services	0.06	-0.01	0.00	0.05
ASWMRS	0.00	-0.04	-0.01	-0.06
Arts, entertainment and recreation	0.00	0.00	0.00	-0.01
Accommodation and food services	0.01	0.01	0.00	0.02
Other private services	0.03	-0.01	0.00	0.02
	(per cent contribution to aggregate labour productivity growth)			
Business sector industries	**79.8**	**63.7**	**-37.4**	**100.0**
Mining and oil and gas extraction	-42.0	58.5	-24.0	-7.5
All other industries combined	**121.9**	**5.2**	**-13.4**	**113.7**
Agriculture, forestry, fishing and hunting	11.1	7.4	-2.1	16.4
Utilities	1.7	-0.3	0.0	1.5
Construction	0.4	-5.1	-3.7	-8.3
Manufacturing	30.4	-3.4	-3.4	23.6
Wholesale trade	26.2	0.7	-1.6	25.3
Retail trade	21.0	0.9	-0.1	21.8
Transportation and warehousing	4.3	0.0	0.0	4.3
Information and cultural industries	10.5	-0.1	0.0	10.4
FIRE	4.0	12.6	-0.7	15.8
Professional, scientific and technical services	7.7	-0.9	0.0	6.8
ASWMRS	-0.4	-5.6	-1.5	-7.4
Arts, entertainment and recreation	-0.3	-0.3	-0.1	-0.7
Accommodation and food services	1.3	0.8	0.1	2.2
Other private services	3.9	-1.5	-0.2	2.2

B) Three-digit Breakdown of Mining and Oil and Gas Extraction

	WSE	RLE	RGE	Total
	(percentage point contribution to aggregate labour productivity growth)			
Mining and Oil and Gas Extraction	-0.44	0.88	-0.50	-0.05
Oil and Gas Extraction	-0.37	0.85	-0.48	0.00
Mining and Quarrying (except oil and gas)	-0.07	0.04	-0.02	-0.05
Support Activities for Mining and Oil and Gas Extraction	0.00	0.00	0.00	0.00
Business sector industries	**0.50**	**0.92**	**-0.60**	**0.77**
	(per cent contribution to aggregate labour productivity growth)			
Mining and Oil and Gas Extraction	-56.6	114.7	-65.1	-7.0
Oil and Gas Extraction	-47.4	109.8	-62.6	-0.2
Mining and Quarrying (except oil and gas)	-8.9	4.8	-2.1	-6.2
Support Activities for Mining and Oil and Gas Extraction	-0.3	0.2	-0.5	-0.6
Business sector industries	**65.2**	**119.9**	**-78.5**	**100.0**

Note: Contributions do not add up exactly to business sector labour productivity due to the use of chained dollar estimates instead of constant dollar estimates. Source: CSLS calculations based on Statistics Canada data.

Breaking down mining and oil and gas extraction into its three subsectors (Table 9, Panel B), it is interesting to note that although the overall contribution of the sector remains the same (-0.05 percentage points), the greater level of disaggregation captures within-sector and reallocation effects that were not captured at the two-digit level. These are reflected in a different values for the three components for the business sector aggregate (compare the values in panels A and B). In particular, oil and gas extraction experienced a massive reallocation level effect (0.88 percentage points). This effect was completely offset by the negative within-sector and reallocation growth effects (-0.37 and -0.48 percentage points, respectively), resulting in an overall contribution of zero to business sector labour productivity growth. In other words, oil and gas extraction – despite experiencing negative productivity growth during the period – did not make a negative contribution to aggregate labour productivity growth. The slightly negative contribution of the mining and oil and gas extraction sector to aggregate productivity growth was due entirely to mining.

A breakdown of labour productivity growth of the oil and gas extraction into conventional and non-conventional oil and gas extraction is only available for the 2007-2012 period (Table 10). But a decomposition of oil and gas extraction productivity for this period provides fascinating insights into recent developments in the sector. It shows that conventional oil and gas extraction has made a significant negative contribution to business sector labour productivity growth (-0.22 percentage points), while the oil sands have made a positive contribution (0.18 percentage points). This result derives from the very large negative contribution of the within-sector effect in conventional oil and gas extraction (-0.52 percentage points), following from the sector's very large fall in labour productivity. In contrast, the oil sands made a large positive within-sector contribution to business sector labour productivity growth (0.23 percentage points) because of the sector's robust labour productivity growth.

Table 10: CSLS Contributions from Conventional and Non-conventional Oil and Gas Extraction to Labour Productivity Growth in Canada, 2007-2012

	WSE	RLE	RGE	Total
	(percentage point contribution to aggregate labour productivity growth)			
Business sector	0.05	0.78	-0.38	0.49
Oil and gas extraction	-0.29	0.50	-0.26	-0.04
Conventional oil and gas extraction	-0.52	0.53	-0.24	-0.22
Non-conventional oil and gas extraction	0.23	-0.03	-0.02	0.18
	(per cent contribution to aggregate labour productivity growth)			
Business sector	10.6	158.0	-77.4	100.0
Oil and gas extraction	-58.1	102.3	-51.9	-7.7
Conventional oil and gas extraction	-104.9	108.0	-47.9	-44.7
Non-conventional oil and gas extraction	46.7	-5.6	-4.1	37.0

ii. Alberta

Business sector output per hour in Alberta grew at a 0.45 per cent average annual rate from 2000 to 2012 (Table 11). In contrast, labour productivity in the mining and oil and gas extraction sector fell at a 4.02 per cent average annual rate. Alberta's level of real GDP per hour worked in mining and oil and gas extraction in 2012 was $246 (chained 2007 dollars), 3.6 times the business sector average. Between 2000 and 2012, the share of hours worked of the mining and oil and gas sector rose 2.3 percentage points from 6.8 per cent to 9.1 per cent of total business sector hours worked, which represents a 35 per cent rise in the share. Again, the combination of the high labour productivity level and significant change in the hours share means that the mining and oil and gas sector had important effects for the industry sources of aggregate productivity growth.

The decomposition formula reveals that the strong reallocation level effect (with a contribution of 1.00 percentage points) was not enough to offset the negative within-sector effect (-1.32 percentage points) and the negative reallocation growth effect (-0.48 percentage points). This resulted in a strongly negative contribution of mining and oil and gas extraction to Alberta's business sector (-0.79 percentage points or -176.1 per cent of business sector labour productivity growth). The sector's overall reallocation effect was positive (1.00 - 0.48 = 0.52), reflecting once again the large influx of workers into this high-productivity sector.

Table 11: CSLS Labour Productivity Growth Decomposition for Alberta, 2000-2012

A) Two-digit NAICS Decomposition

	WSE	RLE	RGE	Total
	(percentage point contribution to aggregate labour productivity growth)			
Business sector industries	**-0.25**	**1.21**	**-0.61**	**0.45**
Agriculture, forestry, fishing and hunting	0.17	0.19	-0.07	0.28
Mining and oil and gas extraction	**-1.32**	**1.00**	**-0.48**	**-0.79**
Utilities	-0.03	0.01	0.00	-0.03
Construction	0.01	-0.11	-0.02	-0.12
Manufacturing	0.12	0.04	-0.02	0.14
Wholesale trade	0.11	0.01	0.00	0.11
Retail trade	0.15	0.02	0.00	0.17
Transportation and warehousing	0.05	0.00	0.00	0.05
Information and cultural industries	0.13	-0.01	-0.03	0.09
FIRE	0.12	0.01	0.01	0.14
Professional, scientific and technical services	0.10	-0.02	0.01	0.09
ASWMRS	0.03	-0.02	0.00	0.00
Arts, entertainment and recreation	0.00	0.01	0.00	0.01
Accommodation and food services	0.04	0.07	0.00	0.11
Other private services	0.07	0.01	0.00	0.08
	(per cent contribution to aggregate labour productivity growth)			
Business sector industries	**-55.6**	**268.1**	**-135.6**	**100.0**
Agriculture, forestry, fishing and hunting	37.2	42.6	-16.5	63.3
Mining and oil and gas extraction	**-293.4**	**223.3**	**-105.9**	**-176.1**
Utilities	-6.7	1.4	-0.4	-5.6
Construction	2.2	-25.5	-4.2	-27.4
Manufacturing	25.7	9.8	-3.5	32.1
Wholesale trade	23.7	1.3	-0.7	24.3
Retail trade	34.3	4.0	-0.6	37.7
Transportation and warehousing	11.4	0.4	-0.1	11.7
Information and cultural industries	28.8	-2.1	-6.5	20.2
FIRE	27.3	3.1	1.5	32.0
Professional, scientific and technical services	22.8	-4.2	1.3	19.9
ASWMRS	5.7	-5.1	0.1	0.7
Arts, entertainment and recreation	0.5	1.6	0.1	2.2
Accommodation and food services	9.3	15.1	-0.1	24.3
Other private services	15.7	2.2	-0.2	17.7

B) Three-digit Breakdown of Mining and Oil and Gas Extraction

	WSE	RLE	RGE	Total
	(percentage point contribution to aggregate labour productivity growth)			
Mining and oil and gas extraction	-1.83	2.84	-1.77	-0.75
Oil and gas extraction	**-1.81**	**2.86**	**-1.77**	**-0.72**
Mining and quarrying (except oil and gas)	-0.02	-0.01	0.01	-0.02
Support activities for mining and oil and gas extraction	0.01	-0.01	0.00	-0.01
	(per cent contribution to aggregate labour productivity growth)			
Mining and oil and gas extraction	-405.9	631.6	-392.8	-167.1
Oil and gas extraction	-402.8	635.8	-393.8	-160.8
Mining and quarrying (except oil and gas)	-4.9	-1.3	1.3	-4.8
Support activities for mining and oil and gas extraction	1.7	-3.0	-0.3	-1.5

Source: CSLS calculations based on Statistics Canada data, CANSIM Tables 383-0011/29.

Breaking down mining and oil and gas extraction into its three subsectors (Table 11, Panel B), it is interesting to note (once again) that the overall contribution of the sector remains (roughly) the same, but the greater level of disaggregation captures within-sector and reallocation effects that were not captured at the two-digit level. In particular, oil and gas extraction experienced a massive reallocation level effect (2.86 percentage points). This effect was completely offset by the negative within-sector and reallocation growth effects (-1.81 and -1.77 percentage points, respectively), resulting in an overall contribution of -0.72 percentage points to business sector labour productivity growth. Other mining and support activities contributed very little to aggregate productivity growth.

iii. Newfoundland and Labrador

Business sector output per hour in Newfoundland and Labrador grew at a 1.66 per cent average annual rate from 2000 to 2012 (Table 12). In contrast, labour productivity in mining and oil and gas extraction fell at a 3.36 per cent average annual rate. The level of real GDP per hour worked in mining and oil and gas extraction in the province in 2012 was $429 (chained 2007 dollars), 6.3 times the business sector average. Between 2000 and 2012, the share of hours worked of the mining and oil and gas sector rose 3.3 percentage points from 3.0 per cent to 6.3 per cent of total business sector hours worked, which represents a 112 per cent rise in the share.

The decomposition formula reveals that despite the strong negative within-sector labour productivity growth in mining and oil and gas (-0.89 percentage points or -53.5 per cent of business sector labour productivity growth), the sector actually made a significant positive contribution (0.77 percentage points or 46.1 per cent). This result was due to the extremely large positive reallocation level effect (2.70 percentage points or 162.8 per cent of business sector labour productivity growth), which was more than enough to offset both the negative within-sector effect and the negative reallocation growth effect (-1.05 percentage points or 63.2 per cent). The positive combined reallocation effect (2.70 - 1.05 = 1.65) reflected the large influx of workers into this very high productivity sector.

Table 12 also highlights one of the limitations of the CSLS decomposition formula: when labour productivity is calculated in chained dollars (instead of constant dollars), the sum of the contributions does not equal aggregate business sector labour productivity growth. At the national level, the difference is relatively small; for Newfoundland and Labrador, however, the difference is quite significant: sectoral contributions summed up to 2.25 percentage points while business sector labour productivity growth was only 1.66 per cent. The main reason for this difference is the changes in the relative price of oil in the period, given the importance of the oil and gas extraction subsector for Newfoundland and Labrador's economy.

Table 12: CSLS Labour Productivity Growth Decomposition for Newfoundland and Labrador, 2000-2012

A) Two-digit NAICS Decomposition

	WSE	RLE	RGE	Total
	(percentage point contribution to aggregate labour productivity growth)			
Business sector industries	**0.63**	**2.79**	**-1.17**	**1.66**
Agriculture, forestry, fishing and hunting	0.23	0.24	-0.05	0.41
Mining and oil and gas extraction	**-0.89**	**2.70**	**-1.05**	**0.77**
Utilities	0.08	-0.03	-0.01	0.04
Construction	0.19	-0.27	0.01	-0.08
Manufacturing	0.16	0.07	0.00	0.23
Wholesale trade	0.10	0.00	0.00	0.11
Retail trade	0.22	0.08	0.01	0.31
Transportation and warehousing	0.08	0.04	0.01	0.12
Information and cultural industries	0.21	-0.01	-0.07	0.14
FIRE	0.12	0.00	0.00	0.12
Professional, scientific and technical services	0.05	-0.01	0.00	0.05
ASWMRS	0.04	0.00	0.00	0.03
Arts, entertainment and recreation	0.01	0.02	0.00	0.03
Accommodation and food services	0.04	0.04	0.01	0.08
Other private services	0.00	-0.07	-0.03	-0.10
	(per cent contribution to aggregate labour productivity growth)			
Business sector industries	**37.8**	**168.1**	**-70.5**	**100.0**
Agriculture, forestry, fishing and hunting	13.6	14.5	-3.2	24.9
Mining and oil and gas extraction	**-53.5**	**162.8**	**-63.2**	**46.1**
Utilities	5.1	-1.9	-0.7	2.5
Construction	11.2	-16.4	0.7	-4.6
Manufacturing	9.4	4.0	0.3	13.7
Wholesale trade	6.3	0.3	-0.1	6.5
Retail trade	13.0	4.9	0.5	18.4
Transportation and warehousing	4.6	2.3	0.4	7.3
Information and cultural industries	12.9	-0.8	-3.9	8.2
FIRE	7.4	0.0	0.0	7.4
Professional, scientific and technical services	3.2	-0.4	-0.1	2.7
ASWMRS	2.2	-0.3	0.0	1.8
Arts, entertainment and recreation	0.4	1.0	0.2	1.5
Accommodation and food services	2.4	2.2	0.4	5.0
Other private services	-0.3	-4.2	-1.7	-6.1

B) Three-digit Breakdown of Mining and Oil and Gas Extraction

	WSE	RLE	RGE	Total
	(percentage point contribution to aggregate labour productivity growth)			
Mining and oil and gas extraction	-0.89	2.70	-1.05	0.77
Oil and gas extraction	**-0.89**	**2.24**	**-1.08**	**0.27**
Mining and quarrying (except oil and gas)	0.02	0.50	-0.01	0.50
	(per cent contribution to aggregate labour productivity growth)			
Mining and oil and gas extraction	-53.5	162.9	-63.3	46.1
Oil and gas extraction	**-53.7**	**134.8**	**-64.8**	**16.3**
Mining and quarrying (except oil and gas)	1.1	30.0	-0.7	30.4

Note: Contributions do not add up exactly to business sector labour productivity due to the use of chained dollar estimates instead of constant dollar estimates.

Source: CSLS calculations based on Statistics Canada data.

Contribution estimates for Newfoundland and Labrador's oil and gas extraction subsector could not be calculated due to data confidentiality issues. The CSLS, however, was able to compute contribution estimates for oil and gas extraction plus support activities for mining and quarrying and oil and gas extraction (Table 12 Panel B). These show that the very strong reallocation level effect of the mining and oil and gas sector is largely due to the oil and gas extraction+ subsector. However, the mining subsector also makes a contribution (0.50), as it has a higher than average productivity level and increased its share of hours worked.

C. Comparing the CSLS and GEAD Analyses

This subsection discusses the differences between the sectoral contributions to aggregate labour productivity growth obtained using the CSLS formula and those obtained using the GEAD formula. GEAD estimates were calculated for Canada, Newfoundland and Labrador and Alberta for the 2000-2010 period. A longer time period could not be used because the GEAD formula relies on industry-level nominal GDP and price deflator estimates, and those currently go up only to 2010. For consistency purposes, the CSLS estimates were recalculated for the 2000-2010 period, and thus differ (usually only slightly) from the estimates analyzed in the previous section.

Using the GEAD formula to break down Canada's business sector labour productivity growth, we obtain markedly different results from what we had seen using the CSLS formula (Table 13, Panel A). Using the CSLS formula, mining and oil and gas extraction had a slightly *negative* contribution to labour productivity growth in Canada during the 2000-2010 period (-0.07 percentage points, or -8.1 per cent of business sector labour productivity growth). According to the GEAD formula, however, the sector had a *positive* contribution to growth (0.28 percentage points or 35.4 per cent of business sector labour productivity growth).

This difference results largely from differences in how the two formulas define the reallocation level and the reallocation growth effects. In the CSLS formula, reallocation effects are a function only of the change in the share of hours worked of a specific sector; in the GEAD formula, however, reallocation effects are also a function of relative price changes.

Breaking down mining and oil and gas extraction into its three subsectors (Table 13, Panel B), it is interesting to note (once again) that the overall contribution of the sector remains the same, but (once again) the greater level of disaggregation captures within-sector and reallocation effects that were not captured at the two-digit level. In particular, oil and gas extraction experienced a strong reallocation level effect (0.77 percentage points). This effect was largely offset by the negative within-sector and reallocation growth effects (-0.29 and -0.38 percentage points, respectively), resulting in an overall contribution of 0.10 percentage points (or 12.1 per cent of aggregate labour productivity growth).

Table 13: Business Sector Labour Productivity Growth Decomposition Using the GEAD Formula, Canada, 2000-2010

A) Two-digit NAICS Decomposition

	WSE	RLE	RGE	Total
	(percentage point contribution to aggregate labour productivity growth)			
Business sector industries	**0.82**	**0.33**	**-0.36**	**0.80**
Agriculture, forestry, fishing and hunting	0.11	-0.12	-0.05	-0.06
Mining and oil and gas extraction	**-0.21**	**0.69**	**-0.20**	**0.28**
Utilities	0.00	-0.01	0.00	-0.01
Construction	0.01	0.43	0.00	0.44
Manufacturing	0.23	-0.97	-0.10	-0.83
Wholesale trade	0.23	-0.09	-0.03	0.10
Retail trade	0.17	-0.02	-0.01	0.14
Transportation and warehousing	0.03	0.00	0.00	0.03
Information and cultural industries	0.10	-0.04	-0.01	0.06
FIRE	0.04	0.16	0.00	0.20
Professional, scientific and technical services	0.06	0.11	0.01	0.18
ASWMRS	0.01	0.10	0.00	0.11
Arts, entertainment and recreation	0.00	0.01	0.00	0.01
Accommodation and food services	0.02	0.00	0.00	0.02
Other private services	0.04	0.08	0.01	0.12
	(per cent contribution to aggregate labour productivity growth)			
Business sector industries	**103.4**	**42.0**	**-45.4**	**100.0**
Agriculture, forestry, fishing and hunting	13.6	-14.5	-6.0	-6.9
Mining and oil and gas extraction	**-26.9**	**86.9**	**-24.6**	**35.4**
Utilities	0.2	-0.9	0.0	-0.7
Construction	0.6	53.6	0.5	54.7
Manufacturing	29.3	-121.2	-12.1	-104.0
Wholesale trade	28.7	-11.8	-4.2	12.7
Retail trade	21.2	-3.0	-0.8	17.4
Transportation and warehousing	3.5	0.4	0.0	3.9
Information and cultural industries	13.0	-4.4	-1.2	7.4
FIRE	5.6	19.4	0.6	25.7
Professional, scientific and technical services	7.6	13.3	1.3	22.3
ASWMRS	0.7	12.9	0.3	13.9
Arts, entertainment and recreation	-0.1	1.5	0.0	1.5
Accommodation and food services	1.9	0.1	0.0	2.0
Other private services	4.4	9.6	0.7	14.7

B) Three-digit Breakdown of Mining and Oil and Gas Extraction

	WSE	RLE	RGE	Total
	(percentage point contribution to aggregate labour productivity growth)			
Mining and oil and gas extraction	-0.31	1.01	-0.41	0.28
Oil and gas extraction	**-0.29**	**0.77**	**-0.38**	**0.10**
Mining and quarrying (except oil and gas)	-0.02	0.17	-0.03	0.12
Support activities for mining and oil and gas extraction	0.00	0.07	0.00	0.07
	(per cent contribution to aggregate labour productivity growth)			
Mining and oil and gas extraction	-38.9	126.1	-51.9	35.3
Oil and gas extraction	-36.2	96.0	-47.7	12.1
Mining and quarrying (except oil and gas)	-2.9	21.8	-4.3	14.7
Support activities for mining and oil and gas extraction	0.1	8.3	0.1	8.5

Source: CSLS calculations based on Statistics Canada data.

Table 14 compares the estimated contributions for the mining and oil and gas sector according to the CSLS and the GEAD formula for Canada, Alberta, and Newfoundland and Labrador for the 2000-2010 period. For Newfoundland and Labrador, note that the total contribution according to the CSLS formula is quite significant (2.68 percentage points), but the GEAD contribution is actually larger (3.19 percentage points), due to the much stronger reallocation level effect. In the case of Alberta, both formulas show a negative contribution for the mining and oil and gas extraction sector, but the GEAD contribution is only -0.23 percentage points, while the CSLS contribution is -0.82 percentage points. This difference is due in large part to the within-sector effect (-1.30 vs. -0.93 percentage points in GEAD and CSLS formulas, respectively).

Table 14: Contribution of the Mining and Oil and Gas Extraction Sector according to the CSLS and the GEAD formulas, Canada, Alberta, and Newfoundland and Labrador, 2000-2010

	Canada		Alberta		Newfoundland and Labrador	
Aggregate LP Growth	0.80		0.40		2.72	
	(percentage point contribution to aggregate LP growth)					
	CSLS	**GEAD**	**CSLS**	**GEAD**	**CSLS**	**GEAD**
TC	-0.07	0.28	-0.82	-0.23	2.68	3.19
WSE	-0.32	-0.21	-1.30	-0.93	1.00	0.77
RLE	0.38	0.69	0.79	1.01	1.26	1.83
RGE	-0.13	-0.20	-0.31	-0.32	0.42	0.60
	(per cent contribution to aggregate LP growth)					
Aggregate LP Growth	100.0		100.0		100.0	
TC	-8.8	35.0	-206.0	-58.5	98.6	117.4
WSE	-40.0	-26.3	-326.1	-231.5	36.8	28.2
RLE	47.5	86.3	197.1	253.5	46.5	67.2
RGE	-16.3	-25.0	-77.0	-80.5	15.3	22.1

Source: CSLS calculations based on Statistics Canada data.

Looking specifically at the oil and gas extraction subsector, we can see that, at the national level, the estimated contribution using the CSLS formula is slightly negative (-0.03 percentage points), while using the GEAD formula it is positive (0.10 percentage points) (Table 15). In the case of Alberta, the difference between the two estimates is much wider (-0.43 vs. -0.88 percentage points according to the GEAD and the CSLS formulas, respectively). In both formulas the negative WSE and RGE were more than enough to offset the strong RLE. For Newfoundland and Labrador, estimates specifically for oil and gas extraction for the 2000-2010 period were unavailable (estimates for the 2007-2010 period for oil and gas extraction plus support activities for oil and gas extraction can be found in the Appendix).

Table 15: Contribution of the Oil and Gas Extraction Sector According to the CSLS and the GEAD formulas, Canada and Alberta, 2000-2010

	Canada		Alberta	
Aggregate LP Growth	0.80		0.40	
	(percentage point contribution to aggregate LP growth)			
	CSLS	**GEAD**	**CSLS**	**GEAD**
TC	-0.03	0.10	-0.88	-0.43
WSE	-0.40	-0.29	-2.09	-1.48
RLE	0.77	0.77	2.93	2.37
RGE	-0.40	-0.38	-1.72	-1.32
	(per cent contribution to aggregate LP growth)			
Aggregate LP Growth	100.0		100.0	
TC	-3.5	12.5	-220.0	-106.8
WSE	-50.0	-36.3	-521.6	-369.3
RLE	96.3	96.3	732.0	592.2
RGE	-49.8	-47.5	-430.4	-329.7

Source: CSLS calculations based on Statistics Canada data.

D. Summary of Findings

A few key points are worth highlighting from the above analysis:

- The overall effect of oil and gas extraction on aggregate labour productivity growth in Canada during the 2000-2012 period was near zero (according to the CSLS formula) – or slightly positive (according to the GEAD formula), despite the large decline in the subsector's labour productivity;

- The large influx of workers into the oil and gas extraction subsector coupled with its high labour productivity level led to strong reallocation level effects at both the national and provincial levels during the 2000-2010/12 period, regardless of which decomposition formula is used;

- Both the GEAD and CSLS formulas point to a negative contribution from the within-sector effect of oil and gas extraction for Canada and both oil-producing provinces during the 2000-2012 period (although Newfoundland and Labrador did experience a positive within-sector effect during the shorter 2000-2010 period);

- The negative labour productivity growth experienced by the oil and gas extraction subsector for Canada as a whole and for Alberta caused a strong, negative reallocation growth effect during the 2000-2010/12 period (estimates for Newfoundland and Labrador were not available for this period);

- Differences in the overall contribution of the oil and gas extraction subsector as calculated by the CSLS and GEAD formulas were, in general, a matter of differences in the magnitudes of the WSE, RLE and RGE, not differences in the sign of each effect; and

- Both the CSLS and GEAD approaches provide insights into the contributions of the oil and gas extraction subsector – or the mining and oil and gas extraction sector – into business sector labour productivity growth. The differences between estimates produced by these two formulas reflect the fact that the GEAD decompositions include the contribution of a substantial increase in the relative price of the mining and oil and gas extraction sector, and a more modest price increase for the oil and gas extraction sector, to the two reallocation effects.

VI. Assessing the Indirect Effects of Oil and Gas Extraction on Business Sector Labour Productivity Growth

This section investigates the indirect effects of oil and gas extraction on the aggregate productivity performance of Canada, Alberta, and Newfoundland and Labrador during the 2000-2012 period. The section first provides a rationale for investigating the indirect effects of oil and gas extraction on aggregate productivity by looking specifically at the experience of Newfoundland and Labrador, where the productivity performance outside the mining and oil and gas sector has improved markedly since the offshore oil production started in 1997. The section then discusses the potential effects of oil and gas extraction on productivity. These effects are: 1) the exchange rate effect; 2) the effect on the labour market; 3) the impact on human capital accumulation; 4) the effect on innovation; 5) the effect on government resources, which interacts with the other effects; and 6) the effect on aggregate demand.

A. The Case of Newfoundland and Labrador

One of the most intriguing questions about the nature of aggregate labour productivity in Newfoundland and Labrador relates to the existence of productivity spillovers from oil and gas extraction activities to the rest of the economy. Has the productivity performance of the non-oil producing industries in Newfoundland and Labrador picked up since 1997, particularly relative to the national performance, and can such a development be linked to oil and gas extraction? In order to answer such a question, we need to examine a longer period.

It appears that labour productivity growth did accelerate in the economy outside the oil and gas extraction industry (Table 16). During 1987-1997, there was virtually no difference in annual labour productivity growth between the total economy and the total economy without the mining and oil and gas extraction sector (0.98 per cent and 0.96 per cent). Oil and gas accounted for only a small fraction of the province's output during this period and so had little effect on the aggregate.

This situation changed dramatically in the 1997-2010 period. Total economy labour productivity grew at an annual compound rate of 3.01 per cent.[14] Outside the mining and oil and gas sector – which enjoyed an extremely robust labour productivity growth rate of 11.37 per cent per year – labour productivity growth grew by 1.61 per cent per year, an increase of 0.65 percentage points over the 1987-1997 rate. In Canada, the pick-up was only 0.36 percentage points (1.02 per cent to 1.38 per cent). A greater acceleration in Newfoundland and Labrador than in Canada is *prima facie* evidence of productivity spillover effects from developments in oil and gas extraction in Newfoundland and Labrador. It suggests that the rise of the oil and gas

[14] It is important to note that this productivity growth rate differs from the one given in the previous section since it refers to the total economy whereas the previous section refers to the business sector. Unfortunately, due to a lack of availability of data, we were unable to calculate business sector labour productivity growth before 1997.

sector in Newfoundland and Labrador has been advantageous to the non-oil sectors of the economy in terms of labour productivity.

Table 16: Labour Productivity Growth in Newfoundland and Labrador and Canada, Special Aggregation, 1987-2010

(Compound annual growth rates, per cent)

		Newfoundland and Labrador			Canada		
		Total economy	Mining and oil and gas extraction	Total economy, excluding mining and oil and gas extraction	Total economy	Mining and oil and gas extraction	Total economy, excluding mining and oil and gas extraction
(1)	1987-1997	0.98	-1.41	0.96	1.04	1.80	1.02
(2)	1997-2010	3.01	11.37	1.61	1.25	-1.32	1.38
(3)	1997-2007	4.20	16.25	1.00	1.47	-1.70	1.58
(4)	2007-2010	-0.86	-3.47	3.66	0.52	-0.07	0.71
(5)	(2)-(1)	2.03	12.78	0.65	0.20	-3.12	0.36
(6)	(3)-(1)	3.22	17.66	0.04	0.42	-3.49	0.56
(7)	(4)-(1)	-1.84	-2.06	2.70	-0.52	-1.87	-0.31

Sources:
1. For real GDP CANSIM Table 379-0025 in which chained 2002 Fisher dollar series are available 1997-2010. These series were extended back (starting in 1996) using the growth rates of the corresponding constant-dollar series from the same CANSIM table.
2. For hours worked CANSIM Table 383-0011 for 1997-2010. Series were extended back using the growth rate of the corresponding series from the Labour Force Survey.
3. Real GDP without mining and oil and gas was calculated using a Törnqvist index. Nominal shares for 1984-2008 are from CANSIM Table 379-0025 for Newfoundland and Labrador and CANSIM Table 379-0022 for Canada. Series were extended to 2009 and 2010 using CANSIM Table 379-0028.

Table 17 also shows that productivity spillover effects have started only in recent years. Between 1997 and 2007, labour productivity growth in the total economy excluding mining and oil and gas in Newfoundland and Labrador was only 1.00 per cent per year, not much faster than the 0.96 percent during 1987-1997. But between 2007 and 2010, labour productivity grew 3.66 per cent per year, an impressive rate in comparison to that experienced at the national level (0.71 per cent per year). Between the 1987-1997 and 2007-2010 periods, labour productivity growth in Newfoundland and Labrador accelerated 2.70 percentage points in the total economy excluding the mining and oil and gas sector, compared to a deceleration of 0.31 percentage points in Canada. Thus, the productivity spillover that may have occurred has taken place only recently, with a considerable time lag.

It is useful to identify which industries have experienced the largest acceleration of labour productivity growth in Newfoundland and Labrador since 1997 (Table 17). Of the fourteen major industries, eight experienced acceleration in labour productivity growth between the 1987-1997 and 1997-2010 periods in Newfoundland and Labrador. The very rapid growth of output from off-shore oil platforms meant that mining and oil and gas had by far the greatest labour productivity growth pick-up (12.78 percentage points). This was followed by retail trade (4.47 points), agriculture, forestry, fishing and hunting (3.66 points), construction (3.60 points), finance, insurance and real estate (2.48 points), manufacturing (1.52 points), professional, scientific and technical services (0.95 points), and transportation and warehousing (0.85 points). The other six industries experienced slower labour productivity growth after 1997.

The acceleration in productivity growth in Newfoundland may just be part of a national phenomenon. However, the eight industries in Newfoundland and Labrador where productivity growth accelerated each experienced a greater acceleration than their counterparts in Canada as a whole (Table 17, last column). This suggests that it is province-specific factors that account for the labour productivity accelerations in these sectors.

We now turn to a discussion of various channels by which the oil and gas sector may have affected productivity growth in the economy. The first of these concerns the exchange rate of the Canadian dollar.

Table 17: Labour Productivity Newfoundland and Labrador and Canada, Business Sector Industries, 1987-2010

(Compound annual growth rates, per cent)

	Newfoundland and Labrador			Canada			
	1987-1997	1997-2010	Difference	1987-1997	1997-2010	Difference	Comparison
	(1)	(2)	(3)= (2)-(1)	(4)	(5)	(6)=(5)-(4)	(7)= (6)-(3)
Agriculture, forestry, fishing and hunting	2.36	6.02	3.66	1.51	4.94	3.43	0.23
Mining and oil and gas extraction	-1.41	11.37	12.78	1.80	-1.32	-3.12	15.90
Utilities	1.98	0.43	-1.55	1.05	-0.41	-1.45	-0.09
Construction	-0.94	2.66	3.60	-0.32	0.82	1.14	2.46
Manufacturing	-0.11	1.41	1.52	2.13	1.79	-0.33	1.85
Wholesale trade	5.17	4.73	-0.44	3.4	3.29	-0.11	-0.33
Retail trade	-0.93	3.54	4.47	-0.29	2.75	3.03	1.44
Transportation and warehousing	-0.37	0.48	0.85	1.50	1.17	-0.33	1.18
Information and cultural industries	7.57	3.72	-3.85	3.19	1.49	-1.71	-2.14
FIRE	0.25	2.73	2.48	2.09	1.38	-0.71	3.19
Professional, scientific and technical services	-0.93	0.03	0.95	0.49	1.11	0.62	0.33
ASWMRS	4.21	0.4	-3.82	-3.02	-0.02	3.00	-6.82
Arts, entertainment and recreation	2.34	-2.48	-4.81	-1.13	-0.78	0.35	-5.16
Accommodation and food services	2.05	1.9	-0.15	-0.57	0.62	1.19	-1.34
Other Private Services	x	x	x	X	x	x	x

Sources:
1. For real GDP CANSIM Table 379-0025 in which chained 2002 Fisher dollar series are available 1997-2010. These series were extended back (starting in 1996) using the growth rates of the corresponding constant-dollar series from the same CANSIM table.
2. For hours worked CANSIM Table 383-0011 for 1997-2010. Series were extended back using the growth rate of the corresponding series from the Labour Force Survey.
3. Real GDP without mining and oil and gas was calculated using a Törnqvist index. Nominal shares for 1984-2008 are from CANSIM Table 379-0025 for Newfoundland and Labrador and CANSIM Table 379-0022 for Canada. Series were extended to 2009 and 2010 using CANSIM Table 379-0028.

B. Exchange Rate Effects: the Dutch Disease

Canada exported $73 billion nominal dollars worth of crude oil and crude bitumen in 2012, up from $19 billion in 2000. The massive increase in both the volume and the price of oil exported put upward pressure on the exchange rate, which rose from $0.73 U.S. in 2000 to $1.04 U.S. in 2012. This appreciation has had important implications for the productivity performance of the non-oil and gas sector, as discussed in this section.

i. The International Literature

There is an extensive literature on the effects of resource sectors on national and regional economies. The term "Dutch Disease", named after the experience of the Netherlands following discovery of an enormous natural gas field in 1961, is commonly used to describe this effect. The Dutch Disease focuses on the effect a resource price boom or exploitation of rich deposits may have, primarily through the exchange rate, on the manufacturing sector, which many regard as vital for economic development. In other words, newfound resource riches may damage the engine of long-term growth of the economy. This literature often includes analysis of the effects of the resource sector on productivity growth.

A much cited article by Van Wijnbergen (1984) about the Dutch Disease postulates an economy with traded and non-traded goods. An influx of income from the export of resources boosts demand for non-traded goods, and this will increase the relative price of such goods and draw resources away from the traded-goods sector. This is considered the main economic effect, and it may have a negative effect on economic growth if the traded goods sector – manufacturing – is the engine of growth.

Sachs and Warner (1995) observed that countries with high exports of natural resources in the early 1970s experienced slow GDP growth in the 1970s and 1980s. Regression analysis on data for many countries showed this connection to be quite robust. The effect of the ratio of resource exports to GDP on the growth of GDP remained significant in the presence of controls for a number of factors that are thought to affect the rate of economic growth, including: initial GDP, trade policy, terms of trade volatility, inequality, and the effectiveness of the bureaucracy. Sachs and Warner suggested that these findings lend support to endogenous growth theories that regard manufacturing as more conducive to growth, as well as a dynamic version of Dutch Disease.

Krugman (1987) explored the effect of a resource boom using a model of industry-wide productivity gains through learning-by-doing (LBD). He assumed that the greater the size of the manufacturing sector, the greater the gains from learning-by-doing. Anything that reduces the scale of the manufacturing sector in a country, such as a resource boom that raises the exchange rate, then directly reduces the rate of productivity growth in manufacturing. Thus, if a country experiences a long period of extensive resource exploitation which displaces manufacturing, productivity in manufacturing will not grow as fast.

Torvik (2001) took issue with the analyses of Krugman and others that stress the negative effects of the resource sector on growth. He proposed a model with positive productivity growth in the non-traded as well as the traded sector, and with learning spillover effects from either sector to the other. If, as in the Van Wijnbergen approach, an increase in output of natural resources leads to a larger share of the workforce being employed in the non-traded goods sector, the rate of productivity growth through LBD should increase in that sector, which will counteract the decline in productivity growth in the traded goods sector. These direct effects may be mitigated but not eliminated by learning spillover effects. Depending on the rates of productivity growth in the two sectors, the size of the shift in employment between the sectors, and the size of the spillover effects, a resource boom may have various effects on overall productivity growth. Thus, Torvik provided a theoretical basis for the different experiences countries have had with expansion of their resource sector.

Haouas and Soto (2012) pointed out that the heavy reliance on oil exports by the United Arab Emirates (UAE) seemed to be an example of the Dutch Disease since the UAE has experienced low productivity growth, major economic fluctuations due to oil price volatility, and massive over-employment and declining productivity in the public sector. The authors first examine whether oil has crowded out physical, human and institutional capital. Secondly, in a country with weak institutions, resource riches may lead to rent-seeking behaviour and reduce social capital. Thirdly, high wages and non-wage income brought about by oil riches may reduce the incentive to accumulate human capital. The authors find that social and institutional capital did not decline in the UAE. Rather they attribute the low productivity growth to the migration policy, which allows for massive immigration of low-skilled workers who are restricted to working for the employer they were sponsored by. The ready, ample availability of low-cost labour removes incentives to increase efficiency and invest in human and physical capital, and rather encourages use of labour-intensive production methods.

Larsen (2007) argues that Norway escaped the resource curse because the oil sector took over the role of manufacturing in generating productivity gains itself and spillover effects on productivity in other sectors. Norway's oil is found offshore in the North Sea, and extraction requires more capital than land-based operations, and advanced technologies. Norway realized the potential of the oil sector as a driving force for productivity gains by investing heavily in education of the workforce for the sector and in research on the technology of off-shore oil extraction. This effort was complemented by policies to avoid overheating of the economy, increase the labour force as a share of the population, and wage and income policies that established a form of social contract (an understanding about spreading of the resource revenues).

Wright and Czelusta (2007) have generalized the example of Norway. They see oil production as a knowledge industry. The long American domination of world oil production in the 20th century was seen not due to the country's resource endowment but to the geological knowledge that it developed and nurtured. It is this kind of learning that leads to productivity gains, they argue. As well, the oil sector can lead to growth of output and productivity in other sectors, as illustrated by the development of the high-productivity petrochemical industry in the United States as a spin-off from the oil industry. More generally, the history of the U.S. economy from the mid-19th to the mid-20th century illustrates how a major resource producer can also have a thriving manufacturing industry.

This brief review shows that the international literature about the effects of resource bonanzas is rich in the variety of both analytical models and experience of countries. Resource riches can be disastrous (the "resource curse") but also quite beneficial. Much depends on the general setting, institutions and policies. The literature suggests caution in attributing developments in the economy at large to a resource boom. It shows, for instance, that adverse developments outside the oil and gas sector may be due to factors unrelated to natural resources, and that resource development may lead to positive spin-offs in manufacturing instead of displacing the industry. Let us turn to the Canadian story.

ii. The Canadian Experience

Labour productivity in manufacturing advanced at only 0.7 per cent per year on average between 2000 and 2012 in Canada, down from 2.9 per cent per year between 1981 and 2000. This development reflected a decline in real output in manufacturing at a rate of 1.2 per cent per year in 2000-2012, down from growth of 3.3 per cent per year in 1981-2000. In 2000-2012, employment in manufacturing fell by 1.9 per cent per year.[15] A fall in demand and hence output, either in the growth rate or in absolute terms, has negative short- and long-term implications for productivity growth. Short-term effects include less spreading of overhead costs, greater labour hoarding, less learning by doing and fewer economies of scale. Long-term effects include less investment in human capital, R&D, and physical capital (Spiro, 2013 and Lin and Rao, 2013).

The cause of the lack of output growth is to be sought at least in part in the appreciation of the exchange rate, and this in turn is associated with oil and gas. There are three links in the nexus between oil and gas and manufacturing that need to be investigated:

- The degree to which the appreciation of the exchange rate is due to the price of and external trade in oil;

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[15] Of the 328.3 thousand manufacturing jobs that disappeared between 2002 and 2008 in Canada, 60.7 per cent were lost in Ontario and 32.4 per cent were lost in Quebec. Manufacturing employment fell in these provinces by 18.2 per cent and 16.4 per cent, respectively.

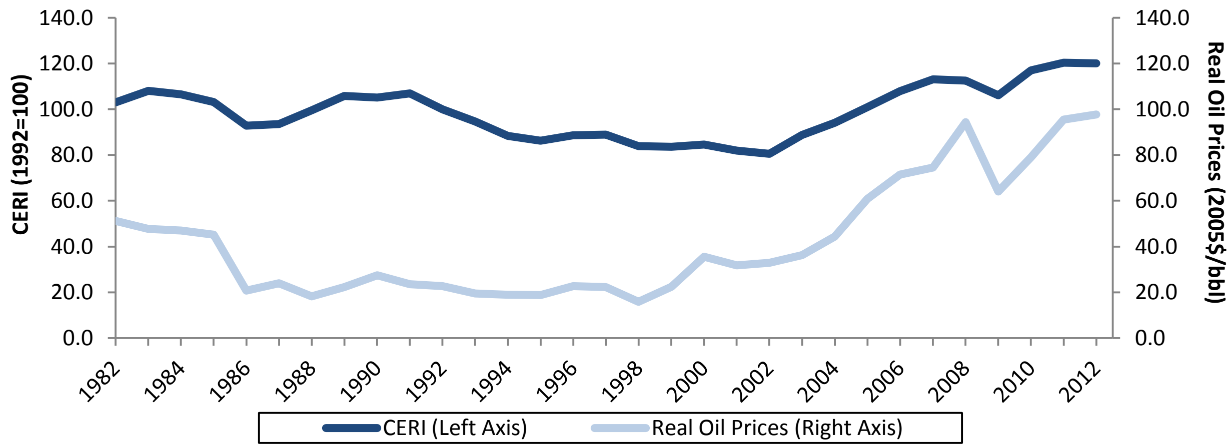
- The degree to which the deterioration of the cost competitiveness of the manufacturing sector is driven by the exchange rate; and

- The degree to which the loss of cost competitiveness in manufacturing affects output and productivity.

As regards the first linkage, the appreciation of the Canadian dollar effective exchange rate (CERI) after 2002 coincided with and follows the same pattern as the rise in real oil prices (Chart 22). The effective exchange rate appreciated 39.7 per cent between 2002 and 2008, driven by a 186.4 per cent increase in real oil prices. Both indicators declined in 2008-2009 as the great world recession set in, but recovered fully in the next two years.

Net exports of oil increased enormously during the period, as shown earlier (Chart 7) and kept on increasing through 2012. The current account balance deteriorated by $60 billion in 2008-2009 and stayed in negative territory (Chart 8), yet the exchange rate recovered and reached new heights in 2011 and 2012. This suggests that similarity between the price of oil and the exchange rate is not a coincidence, but that the Canadian dollar has increasingly become a petro currency.

Chart 22: Canadian Dollar Effective Exchange Rate Index (CERI) (1992=100) and Real Oil Prices (2005 U.S. Dollars per Barrel), 1982-2012



Note: "Real oil prices" are the average spot prices (2005$/bbl) for crude oil based on WTI, Dubai, and Brent.
Source: (i) World Bank, DataBank, Global Economic Monitor (GEM) Commodities; and (ii) Bank of Canada. CANSIM Table 176-0064.

While this evidence is suggestive, it is not definitive, and it does not show what part of the appreciation is due to oil. An interesting attempt to do so has been made recently by Michel Beine, Charles Bos and Serge Coulombe (Beine et al., 2012). Beine et al. (2012) argues that much of the appreciation in the Canadian dollar between 2002 and 2008 was due the weakness in the U.S. dollar that was unrelated to changes in energy and commodity prices. They estimate that

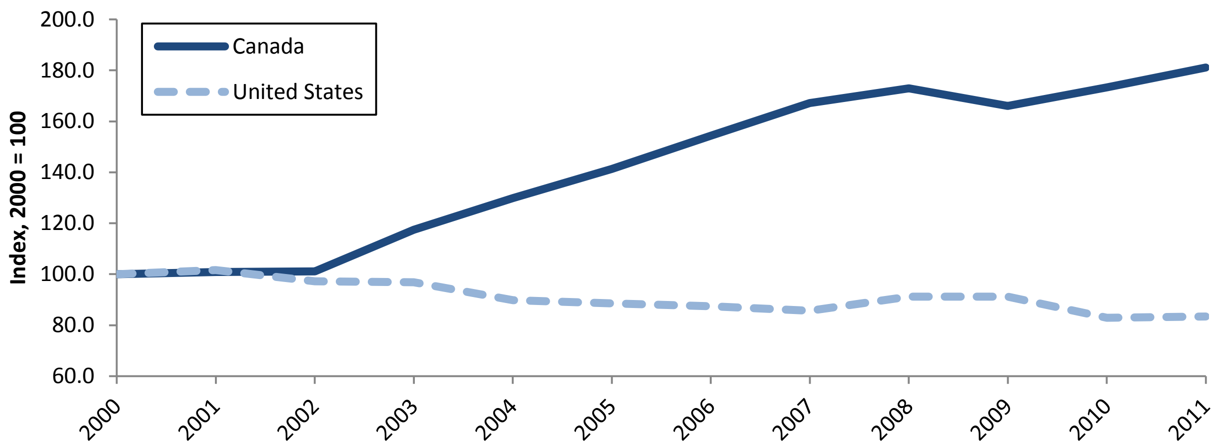
58 per cent of the appreciation of the Canada-U.S. bilateral exchange rate between 2002 and 2008 was due to the weakness of the U.S. component, while only 42 per cent was due to the strength of the Canadian component, which they regard as being related to energy price movements. Similarly, in 2012, Mark Carney (2012), who was Governor of the Bank of Canada at that time, estimated that half of the appreciation of the Canada-U.S. exchange rate was due to the rise of global commodity prices, and about 40 per cent was due to the depreciation of the U.S. dollar against other major currencies.

Beine et al. (2012) covers the period through 2007 and does not take account of the most recent five years in which, we have suggested, the price and exports of oil had a major effect on the currency. During this period the American dollar regained strength as the U.S. was seen as a secure financial haven. We are inclined to regard the estimate from the study as a minimum measure of the influence of oil on the exchange rate.

Beine et al. (2012) estimate that 33-39 per cent of the manufacturing employment loss was attributable to the appreciation of the Canadian component of the Canada-U.S. exchange rate and therefore the Dutch Disease.

Chart 23: Unit Labour Cost in the Manufacturing Sector (US$), Canada-U.S. Comparison, 2000-2011

(Index, 2000=100)



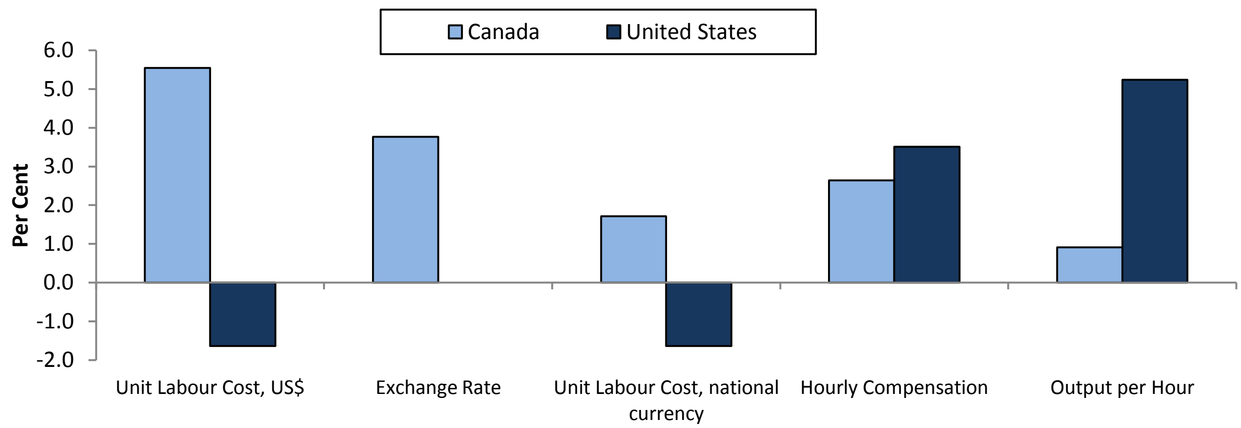
Source: U.S. Bureau of Labor Statistics, International Labor Comparisons.

As regards the second linkage in the chain of causation from oil and gas to productivity in manufacturing, unit labour cost in manufacturing expressed in U.S. dollars is a key metric of the cost competitiveness of the Canadian economy. Chart 23 shows that unit labour costs in U.S. dollars in Canada rose 80 per cent between 2000 and 2012 in Canada but declined by 20 per cent in the United States. This represented a massive deterioration in Canada's cost competitiveness.

Changes in unit labour costs in US dollars reflect changes in the three factors: nominal labour costs, labour productivity and the exchange rate. Chart 24 shows developments in these variables for Canada and the United States for the 2000-2012 period. Unit labour cost grew 5.5 per cent per year over the period in Canada, compared to a decline of 1.6 per cent in the United States, for a difference of 7.1 per cent per year. Just over one half of this decline is due to the 3.8 per cent average annual appreciation of the Canadian dollar. The difference in labour productivity growth (0.9 per cent vs. 5.2 per cent) contributed even more to the loss in Canada's cost competitiveness. The slower rate of hourly compensation increases in Canada (2.6 per cent vs. 3.5 per cent) offset the two negative developments only in small part.

Chart 24: Unit Labour Cost in the Manufacturing Sector (US$), Canada-U.S. Comparison, 2000-2011

(compound annual growth rates, per cent)



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

It should be noted that the contribution of productivity performance to the fall in cost competitiveness is likely overestimated, as productivity growth is endogenous to demand conditions. To the degree that productivity growth is a function of output growth, the weak productivity growth reflects the fall in output growth, which was in part caused by the appreciation of the Canadian dollar. As discussed more fully in the recent report on Ontario`s productivity performance (CSLS 2012), it is well-known that changes in output are reflected in productivity performance. This is known as the Verdoorn Law. If output growth had not been so low, output per hour would have increase more and unit labour cost less. The appreciation of the exchange rate would then have accounted for a larger share of the decline in cost competitiveness.

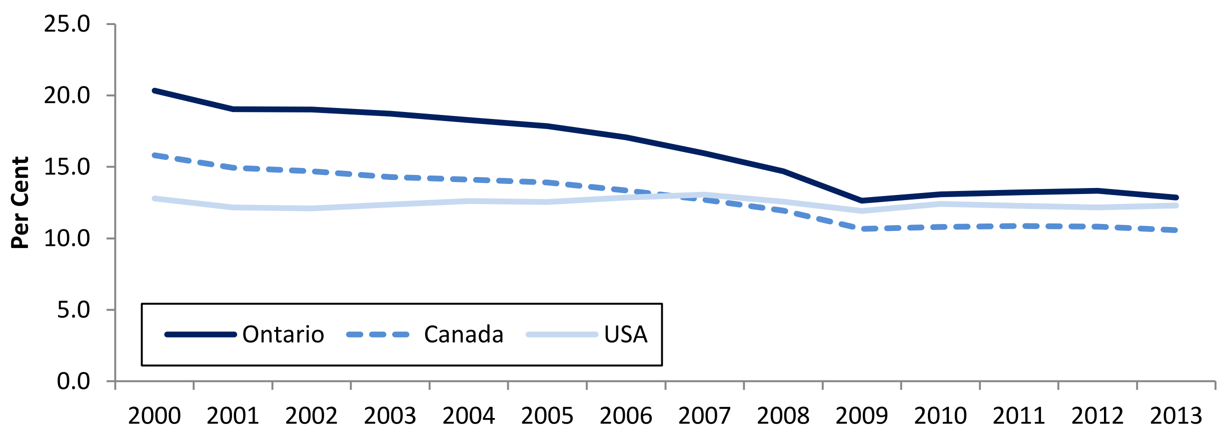
As regards the third issue, the appreciation of the Canadian dollar and loss of cost competitiveness was, of course, not the only factor leading to a fall in foreign demand for Canadian manufactured products. Weak economic growth in the United States, our major market, as well as the emergence of low-cost producers of manufactured goods, especially

China, also played a role. These developments have been highlighted by Shakeri, Gray and Leonard (2012) and Cross (2013).

The real output of the Canadian manufacturing industry was 14 per cent lower in 2012 than in 2000, and the industry performed much more poorly than its U.S. counterpart. Chart 25 and Chart 26 provide further evidence for the existence of Dutch Disease in Canada. One would expect that the U.S. and Canadian manufacturing sectors experienced the same structural phenomena in recent years. In principle, these structural phenomena – most importantly, the shift of low-skill manufacturing activities to emerging markets – should have affected the U.S. and Canadian manufacturing sectors roughly equally, *ceteris paribus*. However, manufacturing's share of total economy real GDP declined much more dramatically in Canada than in the United States from 2000 to 2009 (Chart 25). Admittedly, the U.S. manufacturing sector experienced a significant decline its share of total economy real GDP earlier than Canada, as Canada's manufacturing sector was supported by a low dollar in the 1990s and early 2000s.

In Canada, manufacturing's share of total economy real GDP fell from 15.8 per cent in 2000 to 10.7 per cent in 2009, while the manufacturing sector's share of total economy real GDP was quite stable in the United States. It is important to note that declines in the Canadian average were largely driven by declines in Ontario, which accounts for the lion's share of Canada's manufacturing sector. In Ontario, manufacturing's share of total economy real GDP fell from 20.3 per cent in 2000 to 12.6 per cent in 2009, a decline of 7.7 percentage points (vs. a decline of 5.1 percentage points for Canada as a whole).[16]

Chart 25: Manufacturing as a Share of All Industries, Real GDP, Canada, Ontario and the United States 2000-2013

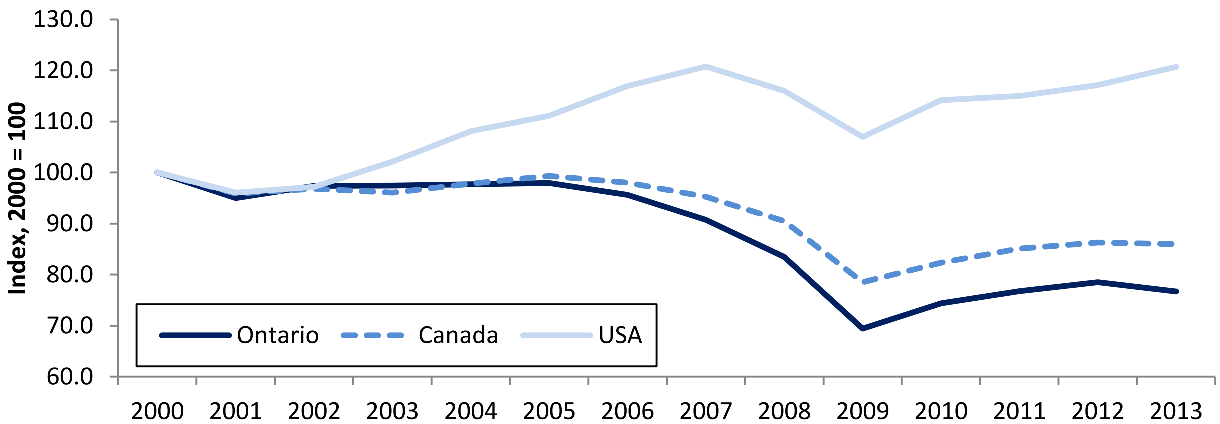


Source: Statistics Canada, CANSIM Tables 379-0030 and 379-0031. BEA, GDP by Industry.
Note: Real GDP for the US are in 2009 Chained Dollars. Real GDP for Canada and Ontario are in 2007 Chained Dollars.

[16] The story is the same in terms of nominal GDP. While the U.S. manufacturing sector's share of total economy nominal GDP fell 2.9 percentage points from 15.1 per cent in 2000 to 12.2 per cent in 2010, the Canadian manufacturing sector's share of total economy nominal GDP fell 10.5 percentage points from 23.3 per cent in 2000 to 12.8 per cent in 2010.

Chart 26 also evidences the divergence between the United States and Ontario in terms of value added in the manufacturing sector. In particular, real GDP in the U.S. manufacturing sector was 20.7 per cent above its 2000 level in 2013, while real GDP in Ontario's manufacturing sector was 23.3 per cent below its 2000 level in 2013. Coinciding with Canada's oil boom, much of the divergence between Ontario and the United States occurred in 2002-2007, with real GDP in U.S. manufacturing rising dramatically and falling in Ontario. In 2008-2009, real GDP in manufacturing fell dramatically in both the United States and Canada due to the Great Recession. However, manufacturing experienced a more rapid recovery in the United States, with real GDP rising 12.9 per cent from 2009 to 2013. While real GDP in Ontario's manufacturing sector rose 13.1 per cent from 2009 to 2012, it declined again in 2013.

Chart 26: Index of Real GDP in Manufacturing, Canada, Ontario and the United States, 2000-2013



Source: Statistics Canada, CANSIM Tables 379-0030 and 379-0031. BEA, GDP by Industry.

Note: Real GDP for the US is in 2009 Chained Dollars. Real GDP for Canada and Ontario is in 2007 Chained Dollars.

To sum up, there exists a causal link between the price and export of oil to output in manufacturing, but this explains only a part of what happened to the latter industry. The appreciation of the Canadian dollar was quite large but also reflects a weakening of the U.S. dollar that was unrelated to oil. Both factors have been more or less equally responsible for the appreciation. The appreciation in turn accounts for a substantial part, but not the entire dramatic increase in relative unit labour cost in manufacturing. Some part of the increase in Canada's relative unit labour cost is due to the Canadian industry's failure to keep up with the rapid rate of increase in labour productivity in the United States. Taken together, these two observations mean that a significant part, but less than one-half, of the decline of manufacturing output relative to that in the U.S. should be attributed to the effect of the oil boom on the Canadian exchange rate. It is important to note that the negative effect of the Dutch Disease phenomenon on output may have been greater than that on productivity, as the industry made efforts to remain competitive in the face of adverse relative cost changes.

The story is not over yet. At the time of writing, the price of oil is still near recent peaks, and export volume remains strong. In addition, the dollar has been kept high by investment inflows. The dollar has recently declined but, at more than 90 U.S cents, continues to be above its purchasing power equivalent value, which was U.S. $0.81 as of 2011.[17] Relative unit labour cost in manufacturing continues to be very much above its value at the beginning of the century. New car plants are going to the U.S rather than Canada, according to recent reports. The Dutch Disease is not the only affliction suffered by Canadian manufacturing, but it looks to be a chronic one.

C. Labour Market Effects

Developments in the oil and gas sector can have spillover effects on the labour market and, through these, influence labour productivity in other sectors both positively and negatively.

Demand for labour by the oil and gas sector may lead to an increase in wages for other sectors. This increase in labour cost may cause a substitution away from labour to capital and thus increase labour productivity. It may further cause the destruction of low productivity activities which are not viable with higher wages, and this too increases labour productivity as workers shift from low-productivity activities to high-productivity activities. On the other hand, if the labour market becomes overly tight, labour shortages may emerge in non-oil and gas sectors, and these can potentially result in bottlenecks in production, restricting output and productivity.

In this section, we review vacancy and unemployment rates and then wages and wage growth to find out if the oil and gas sector in Alberta is creating a tight labour market and affecting wages in the province.

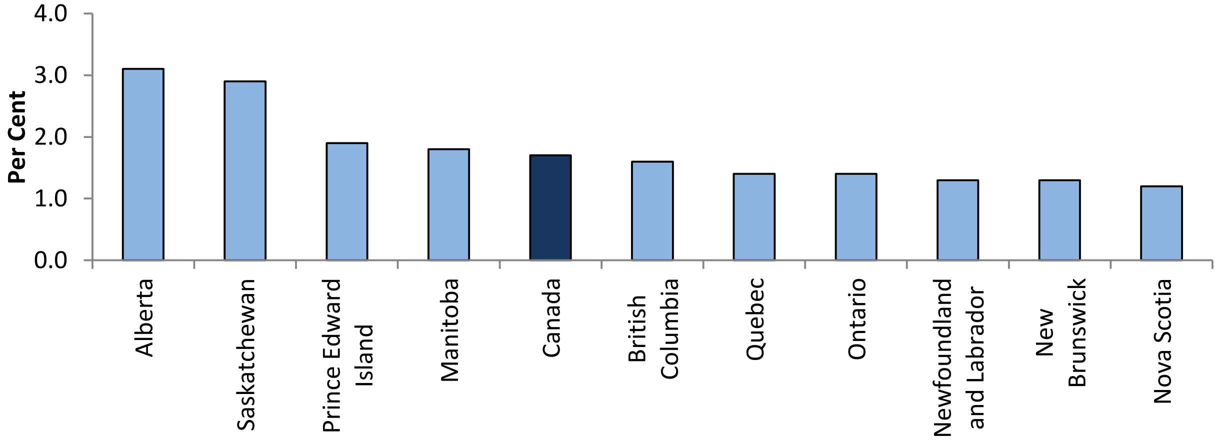
i. The Job Vacancy Rate

Chart 27 shows the job vacancy rate, the unemployment rate, and their ratio for Canada and the provinces in 2012. According to Statistics Canada, Alberta had a job vacancy rate of 3.1 per cent in 2012, the highest in Canada and well above the national average of 1.7 per cent. The unemployment rate in Alberta was 4.6 per cent, the lowest in Canada and well below the national average of 7.3 per cent. The ratio of the unemployment rate to the job vacancy rate in Alberta was 1.48, also the lowest in Canada. These three measures of labour market conditions indicate that in 2012 Alberta had the tightest labour market of all provinces.

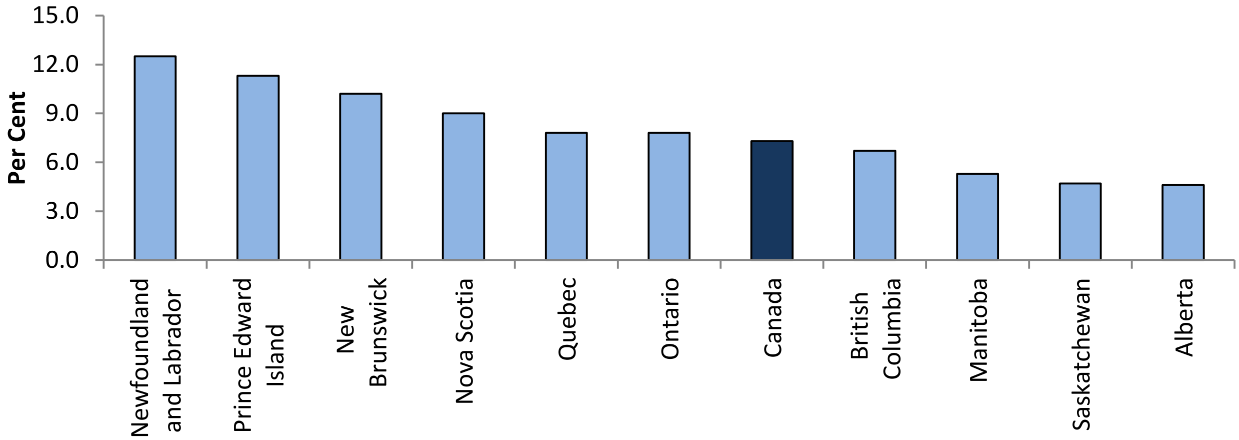
[17] From 2000 through 2011, the purchasing power parity for Canada's GDP varied between 81 and 84 cents U.S., according to the OECD. Source: CANSIM Table 380-0037.

Chart 27: Job Vacancy Rate and Unemployment Rate in Canada and the Provinces, 2012

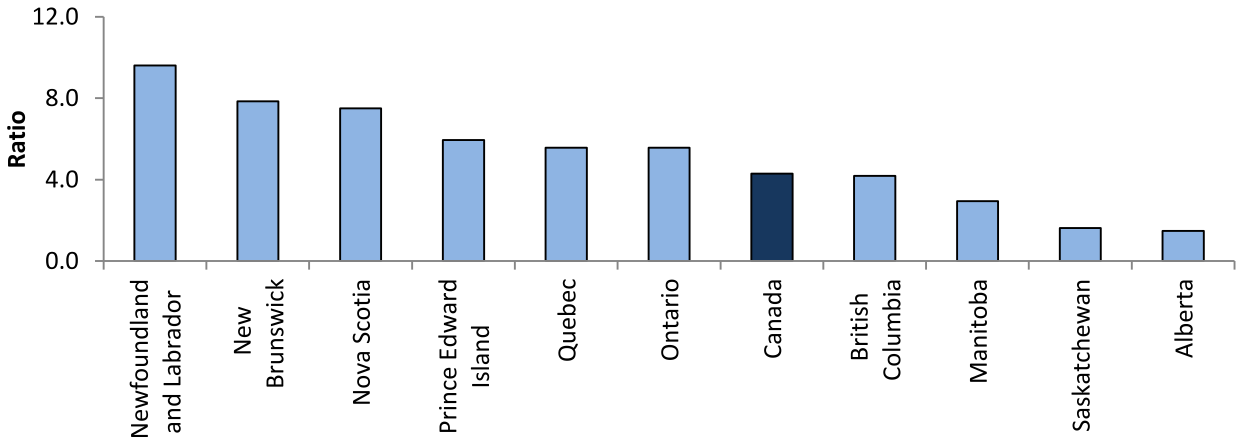
A) Industrial Aggregate Job Vacancy Rate



B) Unemployment Rate



C) Ratio of Unemployment Rate to Job Vacancy Rate

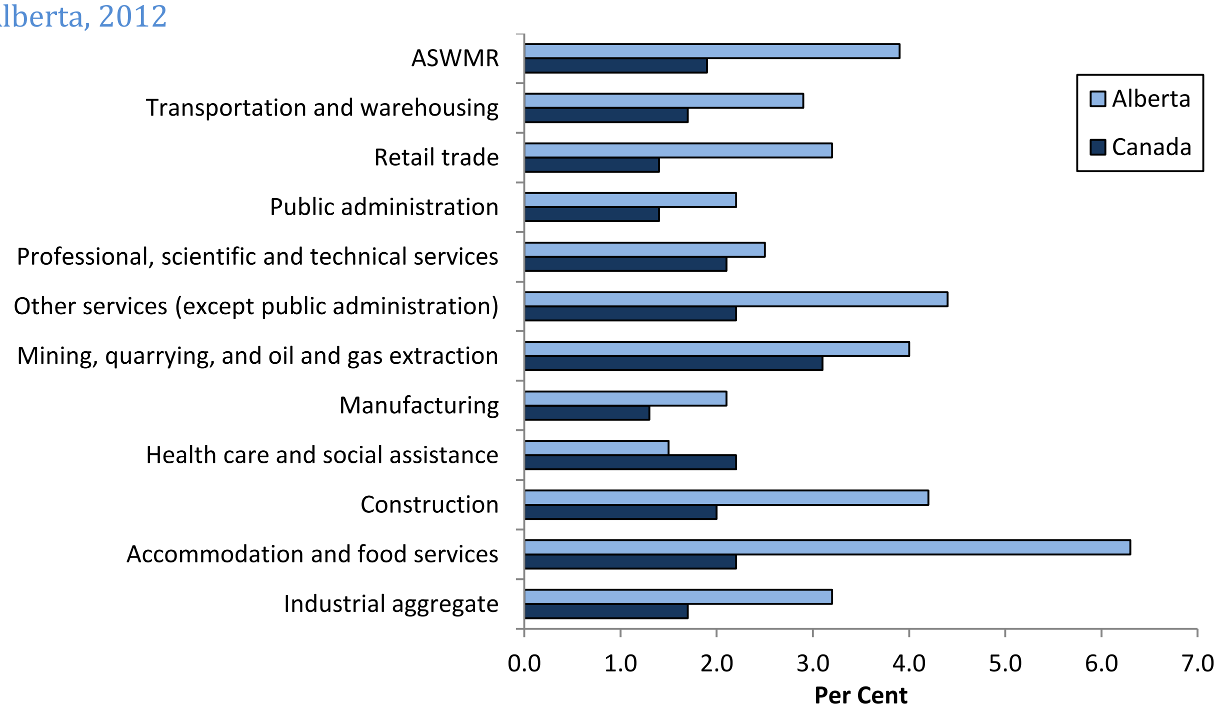


Source: Statistics Canada, JVS, CANSIM Table 284-0002

In Chart 28, the 2012 job vacancy rate for Alberta and Canada is broken down by industry. In Canada, mining, quarrying and oil and gas extraction had the highest job vacancy rate (3.1 per cent). In Alberta, this industry took fourth place with a rate of 4.0 per cent, behind accommodation and food services (6.3 per cent), other services (4.4 per cent) and construction (4.2 per cent).

It is interesting that Alberta's job vacancy rate in the accommodation and food service sector is almost three times the national average; the construction sector's job vacancy rate is about twice the national average; the retail trade sector's job vacancy rate is over two times the national average. These high job vacancy rates may be attributed to the oil and gas sector, where the wages are much higher than in construction, retail trade, and accommodation and food services, making it hard for employers in these sectors to attract workers. Sectors with high vacancy rate must increase their wages to keep up with the oil and gas sector to attract workers. If wages grow beyond the ability of the sector to pay, then there would be an exodus of firms from the sector.

Chart 28: Job Vacancy Rate in Canada and Alberta by Two-digit NAICS Sector, Canada and Alberta, 2012



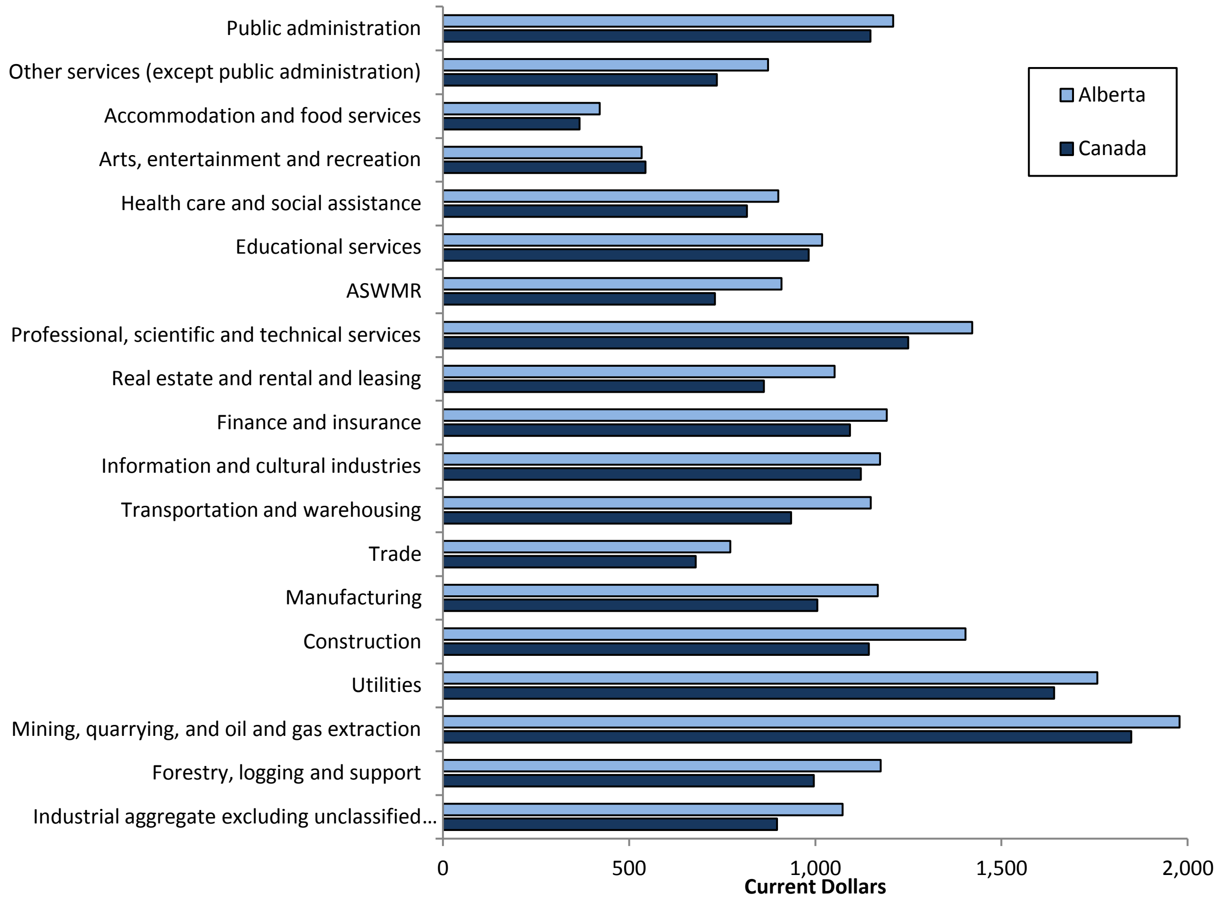
Source: Statistics Canada, JVS, CANSIM Table 284-0002

*Data from certain sectors were unavailable or unreliable to use

ii. Wage Levels and Growth

Chart 29 shows the average weekly earnings in 2012 by industry in Canada and Alberta. It is interesting to note that the weekly earnings of all of Alberta's industries are higher than the national average with the exception of arts, entertainment, and recreation sector. At the aggregate level, Alberta's average weekly earnings are approximately 20 per cent higher than Canada's.

Chart 29: Average Weekly Earnings in Canada and Alberta by Two-digit NAICS Sector, 2012



Source: Statistics Canada, SEPH, CANSIM Table 281-0027

Between 2001 and 2012, average weekly earnings for the industrial aggregate grew at a 4.3 per cent average annual rate in Alberta, compared to 2.9 per cent in Canada (Chart 31). This trend resulted in a growing gap in wages between Alberta and Canada, with wages in Alberta rising from 102.8 per cent of the national average in 2001 to 119.6 per cent in 2012.

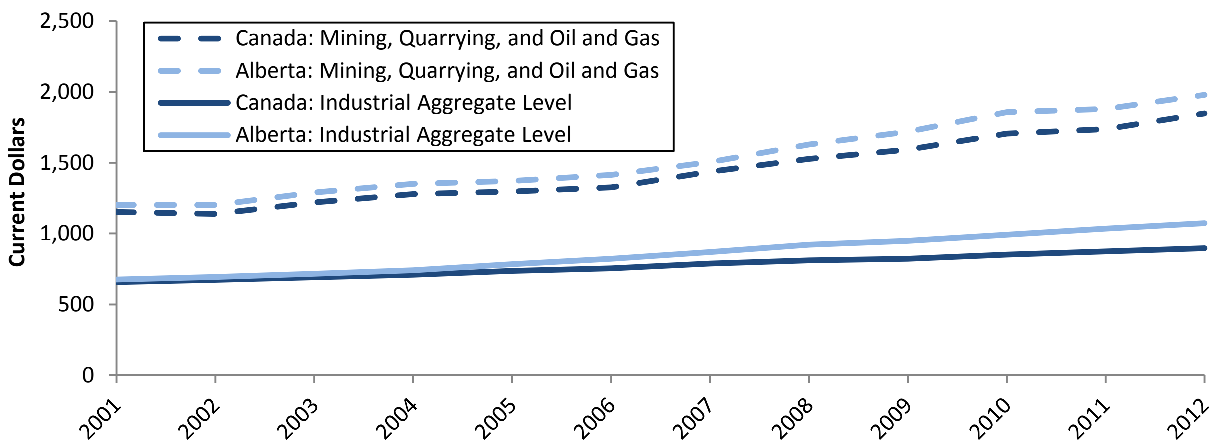
All of Alberta's sectors have shown wage growth in excess of the national average (Chart 31). However, in certain sectors the difference has been small. For example, average weekly earnings in the Alberta mining, quarrying and oil and gas sector increased only 0.2 percentage points faster than the national average (4.6 per cent versus 4.4 per cent) with the relative rising from 104.4 per cent of the national average in 2001 to 107.0 per cent in 2012. Wages were already the highest among all industries, both in Alberta and in Canada, and it appears that the industry was able to attract the additional workers it needed without having to raise wages more rapidly than other sectors. The same applies to the sector in other parts of the country.

The oil and gas boom in Newfoundland and Labrador also has greatly tightened labour market conditions in the province, with potential effects on productivity. The unemployment rate plummeted from 18.1 per cent in 1997 to 12.5 per cent in 2012, while in St. John's it fell from 13.5 per cent in 1997 to 7.7 per cent in 2010. The tighter labour market in both provinces would have lead to higher wages and skill shortages, giving producers a greater incentive to substitute capital for labour, boosting labour productivity.

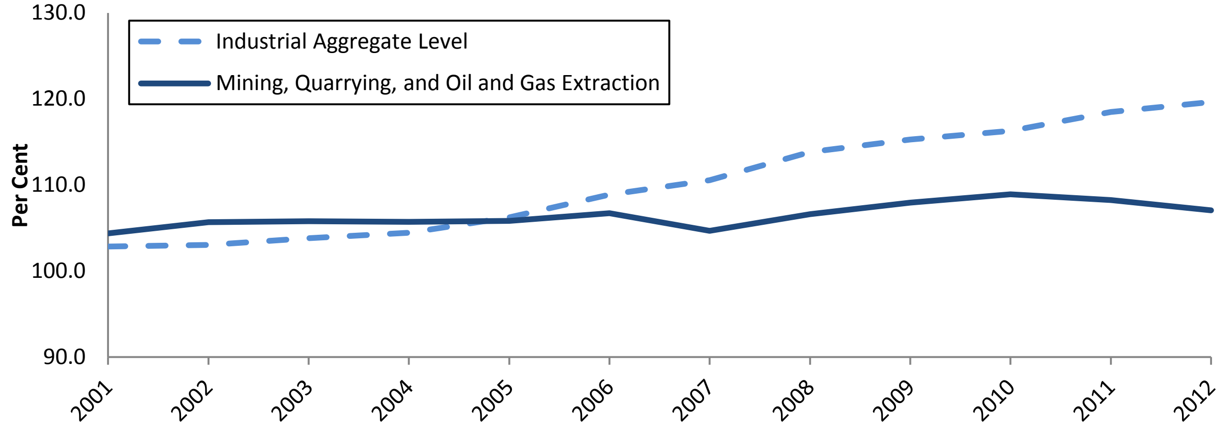
In all, this evidence indicates a possible positive effect. One caveat needs consideration: If the labour market becomes too tight, skills shortages and production bottlenecks could appear, and these can be detrimental to productivity. However, there appears to be ample supply of labour available to Alberta's employers through interprovincial migration and immigration, while outmigration did continue in Newfoundland and Labrador. There have been no indications of a general labour shortage or widespread skill shortages in either province. Accordingly, we conclude as follows: Labour market tightening in Alberta and (to a lesser extent) Newfoundland and Labrador is likely to have had a positive effect on labour productivity in various sectors in these provinces through the greater incentives to substitute capital for labour.

Chart 30: Average Weekly Earnings in Canada and Alberta, 2001-2012

A) Levels (Current Dollars)



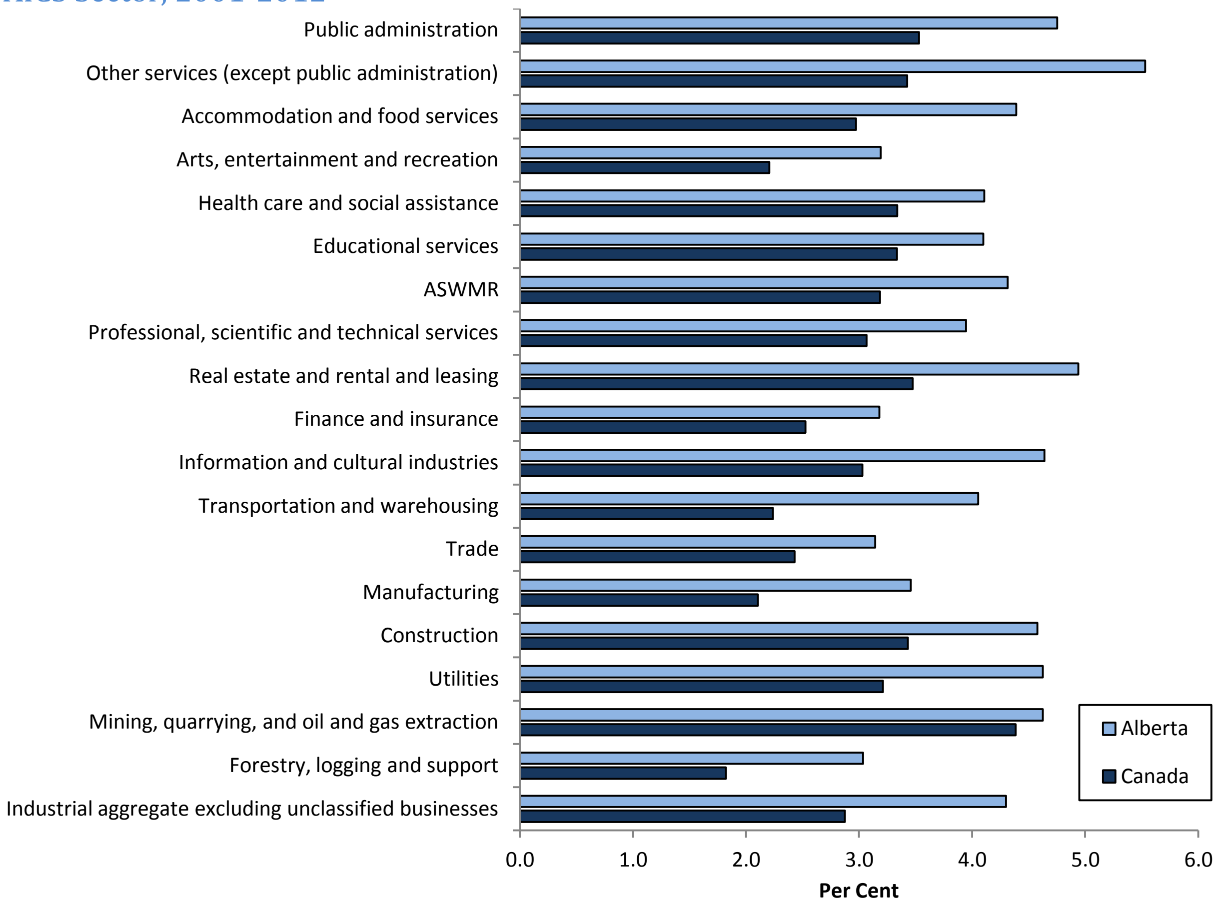
B) Relative to Canada



Source: Statistics Canada, SEPH, CANSIM Table 281-0027

Source: CSLS Calculations based on Statistics Canada, SEPH, CANSIM Table 281-0027

Chart 31: Average Weekly Earnings Growth Rates in Canada and Alberta by Two-digit NAICS Sector, 2001-2012



Source: CSLS Calculations based on Statistics Canada, SEPH, CANSIM Table 281-0027

Notes: 1) 2001 data for real estate and rental and leasing sector, and finance and insurance sector were unavailable; hence the growth rate calculations start from 2002; 2) 2009, 2010 and 2011 data for forestry, logging and support sector were unavailable. Data were linearly interpolated to allow for growth rate calculations.

D. Human Capital Accumulation Effects

Accumulation of human capital is vital for the productivity growth of a nation over the longer haul. The oil and gas sector may influence productivity growth if it impacts on educational attainment, positively or negatively. A negative effect is suggested by the work of Gylfason (2001). He found a negative correlation between natural resource abundance and public education expenditure, expected years of schooling for females, and secondary school enrolment across countries.

The oil and gas sector and its support activities create low skill jobs with high wages which can attract youth away from schooling. This increases the opportunity cost of post-secondary education. There are two possible scenarios for the long term effects. In the first scenario, the high wages are permanently attracting youths away from pursuing higher education. In the second scenario, the high wages are temporarily attracting youths from pursuing higher education. This temporary attraction allows youths to accumulate savings to fund their higher education. Hence, it is only affecting the timing of education attainment and not the long term education attainment levels. There may also be a positive effect, if the emergence of a thriving oil and gas sector creates employment opportunities that require a high level of education where such jobs used to be scarce.

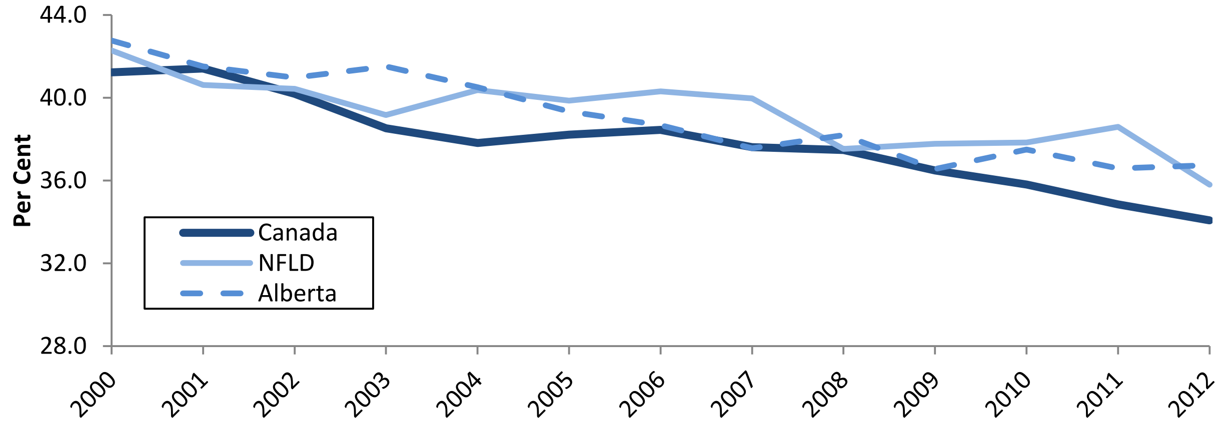
This section presents evidence regarding trends in educational attainment in Alberta and Newfoundland and Labrador between 2000 and 2012 and contrasts this with the experience in Canada generally. Three indicators are reviewed: the high school non-completion rate, the post-secondary enrolment rate, and average years of schooling.

Chart 32 shows the proportion of the population aged 15 to 24 years that had not completed high school in Canada, Alberta, and Newfoundland and Labrador.[18] Since 2000, there has been a significant fall in non-completion in all three jurisdictions, a positive factor for the overall quality of the labour force. In Canada, the high school non-completion rate fell from 41.2 per cent in 2000 to 34.1 per cent in 2012. In Newfoundland and Labrador, it fell from 42.3 per cent to 35.8 per cent and in Alberta from 42.8 per cent to 36.7 per cent.

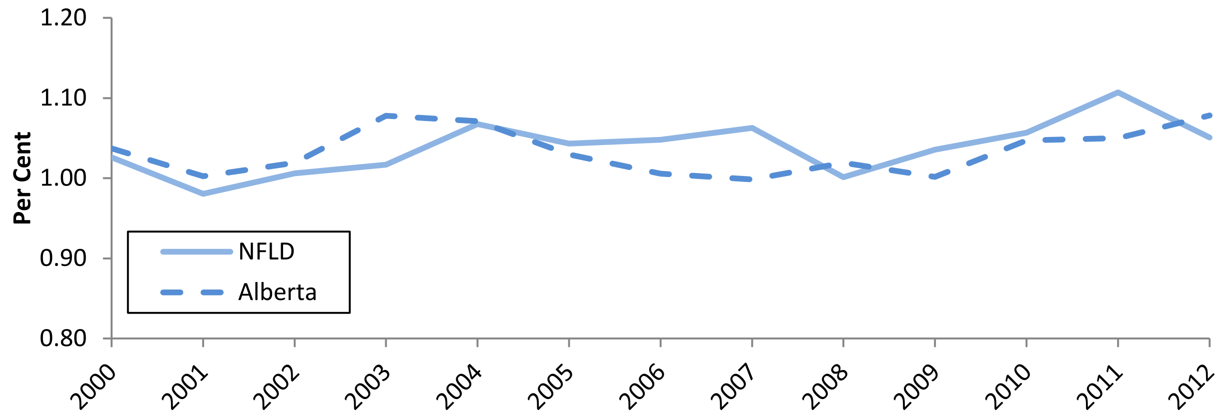
[18] Unfortunately, data were not available at the provincial level for the more relevant 20-24 age group. Many of the 15-19 age group are still in high school and are included with those who have not completed high school.

Chart 32: High School Non-Completion Rate of Population Age 15-24

A) Absolute



B) Relative to Canada



Source: CSLS Calculations based on Statistics Canada, LFS, CANSIM Table 282-0004

*The LFS did not provide a breakdown of age group 20 – 24; hence, age group 15- 24 was used

It appears that the rate of decline in high school non-completion was somewhat slower in the two oil producing provinces than at the national level. The relative high school non-completion rates in these provinces have risen slightly, from 102.6 per cent of the national level for Newfoundland and Labrador in 2000 to 105.0 per cent in 2012 and from 103.7 per cent of the national level in Alberta in 2000 to 107.8 per cent in 2012. This suggests that the relatively tight labour market in Alberta and the greatly improved labour market in Newfoundland and Labrador may have enticed some young persons to take jobs rather than complete high school.

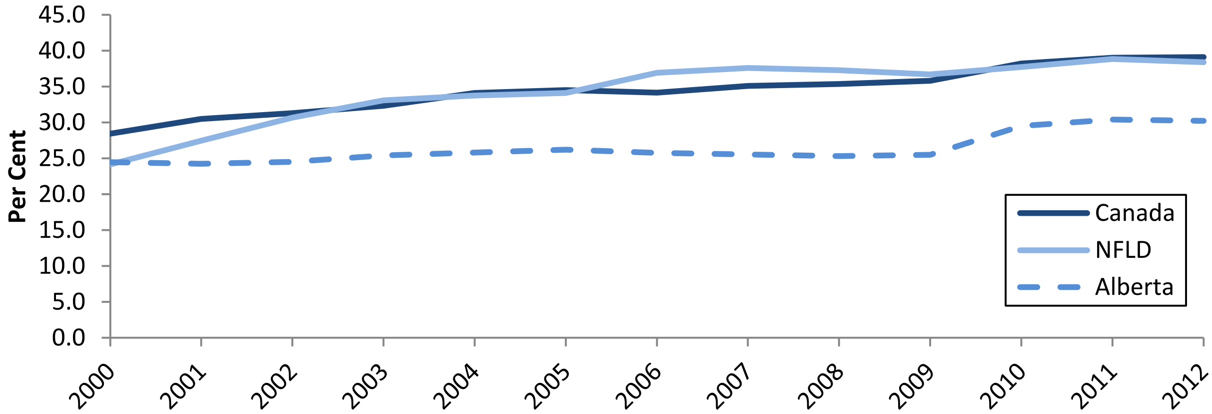
Chart 33 shows the proportion of the population of 15 to 24 years of age who are enrolled in post-secondary education in Canada, Alberta, and Newfoundland and Labrador.[19] Since 2000 there has been a significant upward trend in all three jurisdictions, again a positive factor for the overall quality of the labour force. In Canada, the post-secondary enrolment rate increased from

[19] Unfortunately, data were not available at the provincial level for the more relevant 20-24 age group. Many of the 15-19 age group are still in high school and are included with those who have not completed high school.

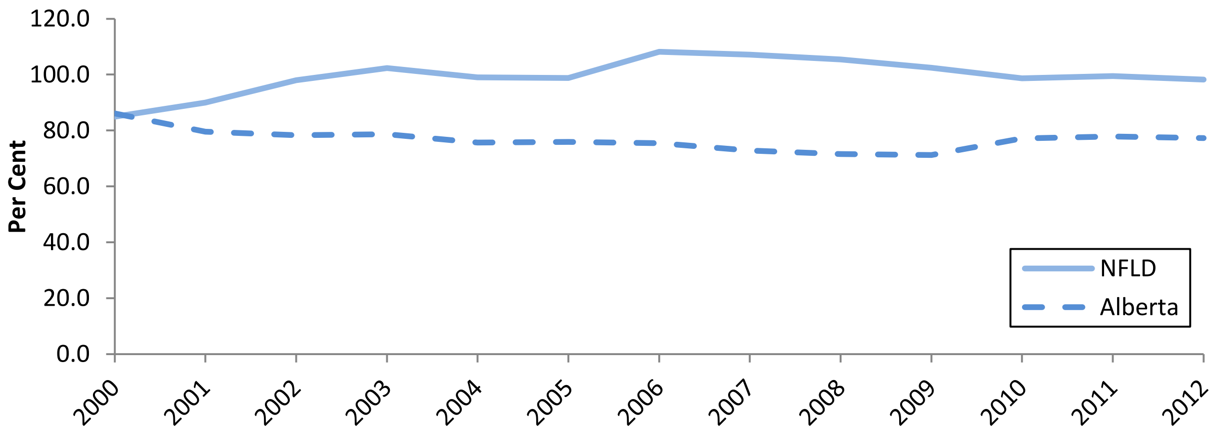
28.4 per cent in 2000 to 39.1 per cent in 2012, in Newfoundland and Labrador, it rose from 24.2 per cent to 38.4 per cent and in Alberta from 24.5 per cent to 30.2 per cent.

Chart 33: Post-Secondary Enrolment Rate for Age 15-24

A) Absolute



B) Relative to Canada



Source: CSLS Calculations based on Statistics Canada, Post-secondary enrolments, CANSIM Table 477-0033 - and Estimates of Population, CANSIM Table 051-0001

*The enrolment numbers are individuals that are younger than 24 year olds. The assumption in the calculation is individuals of 16 or 17 years of age are an insignificant proportion of the post-secondary population.

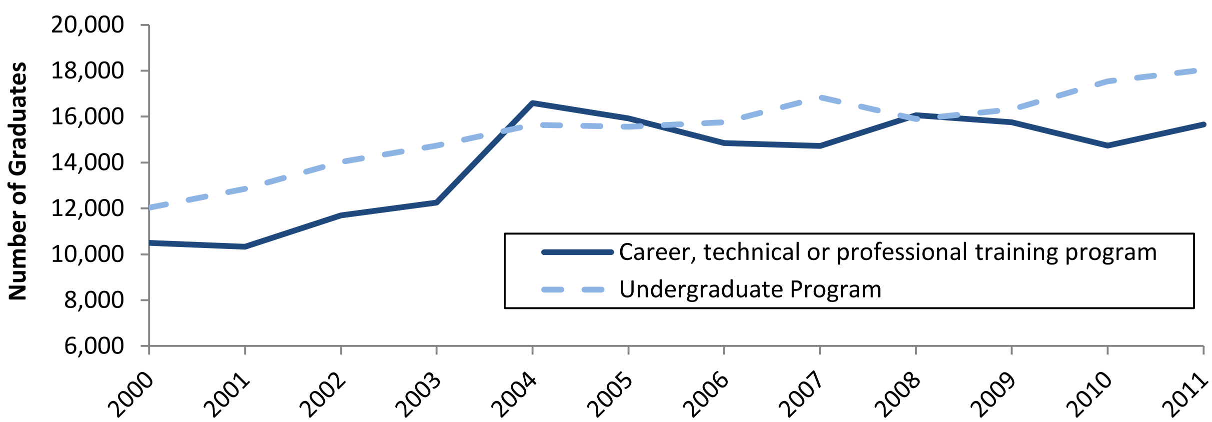
The rate of increase in the post-secondary enrolment rate was well above the national average in Newfoundland and Labrador, and well below in Alberta. Consequently, the relative enrolment rate in Newfoundland and Labrador rose significantly from 84.9 per cent of the national level in 2000 to 98.2 per cent in 2012. In contrast, the relative enrolment rate fell in Alberta from 86.0 per cent of the national average in 2000 to 77.3 per cent in 2012. It is quite surprising that Alberta has only around three students enrolled in post-secondary education for every four students enrolled at the national level. The ample and well-paying employment opportunities in Alberta appear to lead to the postponement or the abandonment of post-secondary studies for many young people in the province.

It is interesting to note that there was a spike in the post-secondary enrolment rate between 2009 and 2010 in Canada and Alberta. The 2008 recession made it more difficult for youths to gain employment. Hence, many returned to school to better their employment prospects. The spike was especially pronounced in Alberta, where enrolment of 15 to 24 year olds jumped from 25.5 per cent to 29.5 per cent. The decline in oil prices in 2009 made non-conventional oil extraction less profitable, causing the oil and gas sector and related industries to shed jobs.

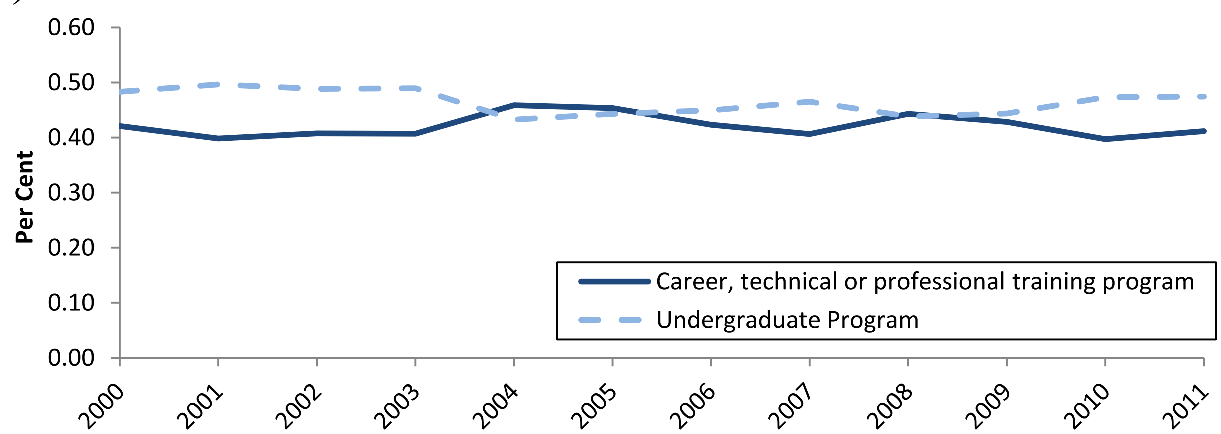
One can also ask whether the strong demand for workers in oil and gas related occupations in Alberta is changing the composition of the output of the education system. The oil and gas sector may require college training, as opposed to university education. But Chart 34 shows that there has been no change between 2000 and 2011 in the relative importance of the two types of post-secondary graduates.

Chart 34: Graduates by Program in Alberta

A) Absolute



B) Relative to Canada

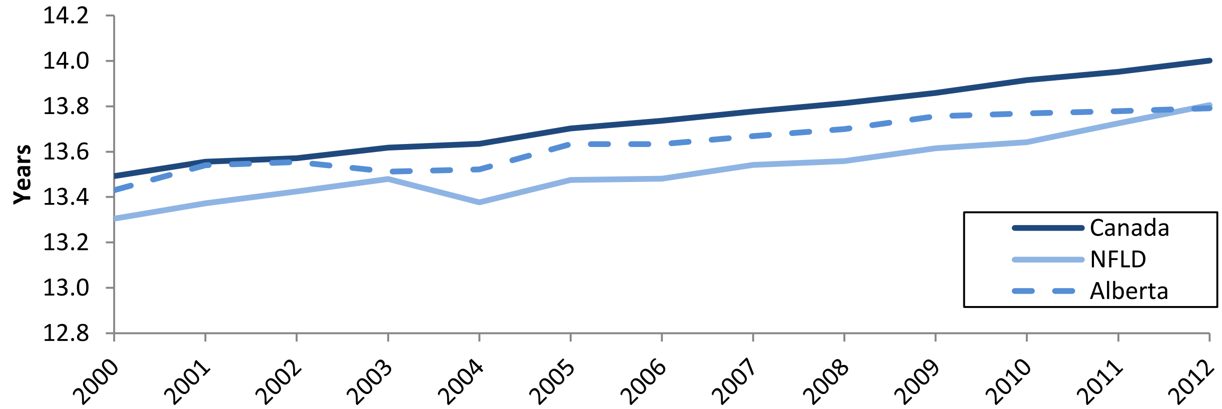


Source: CSLS Calculations based on Statistics Canada, Post-Secondary Graduates, CANSIM Table 477-0030

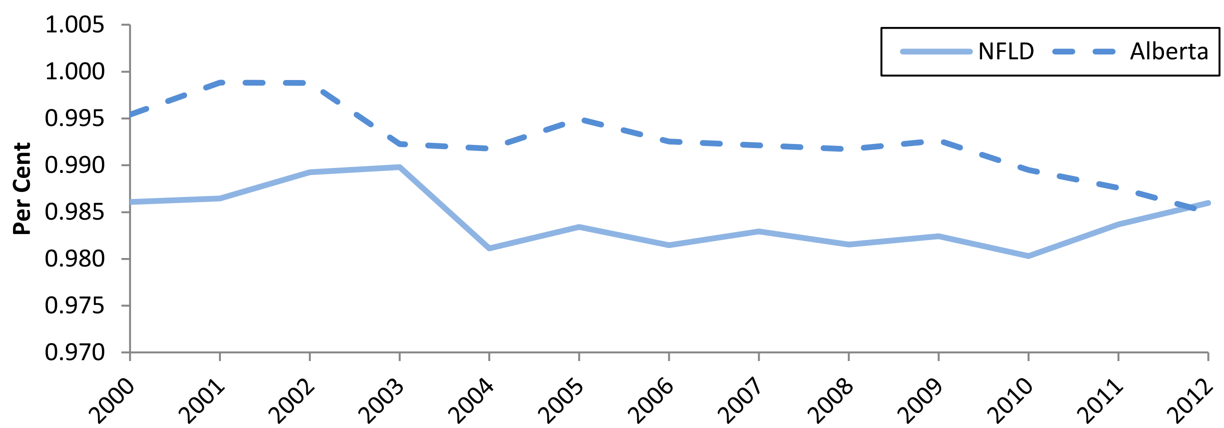
Chart 35 shows the average years of educational attainment of the population of 15 years of age and over in Canada, Alberta, and Newfoundland and Labrador. Consistent with the other two education metrics discussed above, since 2000 there has been an upward trend in educational attainment in all three jurisdictions, again a positive factor for the overall quality of the labour force. In Canada, the average number of years of schooling has risen from 13.5 years in 2000 to 14.0 years in 2012. Alberta also saw a similar increase (from 13.4 years to 13.8 years), as did Newfoundland and Labrador (from 13.3 years to 13.8 years). The average number of years of schooling for both oil producing provinces remained below but close to that of Canada. Educational attainment is a measure of the stock rather than the flow of education. It cannot change very rapidly, and is affected by interprovincial migration as well as school completion in a province. It is therefore not a very sensitive measure for the question at issue in this section.

Chart 35: Average Years of Schooling for Population Age 15 and Over

A) Absolute



B) Relative to Canada



Source: CSLS Calculations based on Statistics Canada, LFS, CANSIM Table 282-0004

The strongest evidence of an effect of oil and gas on human capital accumulation is the increase in post-secondary enrolment in Newfoundland and Labrador, where the rate came very close to the national rate from a much lower level in the year 2000. It seems likely that the oil and gas sector is at the root of this development, not just for the employment opportunities it created and was expected to create, but also through its effect on the economy of the province and on government revenues. As a have-not province became an affluent province because of oil, the young population responded by preparing itself for good jobs.

Table 18: Summary of Absolute and Relative Rates of Educational Attainment

	Canada			Newfoundland and Labrador			Alberta		
	2000	2012	Change 00-12	2000	2012	Change 00-12	2000	2012	Change 00-12
High School Non-Completion Rate Ages 15-24									
Absolute	41.2	34.1	-7.1	42.3	35.8	-6.5	42.8	36.7	-6.1
Relative to Canada (%)	..	..	..	102.7	105.0	2.3	103.9	107.6	3.7
Post-Secondary Enrolment Rate for Under 25 Year Olds									
Absolute	28.5	39.1	10.7	24.2	38.4	14.2	24.5	30.3	5.8
Relative to Canada (%)	..	..	..	84.9	98.2	13.3	86.0	77.5	-8.5
Average Years of Schooling for Age 15 and Over									
Absolute	13.5	14.0	0.5	13.3	13.8	0.5	13.4	13.8	0.4
Relative to Canada (%)	..	..	..	98.5	98.6	0.1	99.3	98.6	-0.7

For Alberta, the evidence suggests a negative effect on human capital accumulation of young people. While there has been continued progress in reducing the high school non-completion rate and in increasing post-secondary enrolment rates, the gains in human capital have been smaller than at the national level. This development was also found by Morissette et al. (2013), where they examined the effects of increases in world oil prices on full-time university enrolment rates in Alberta, Saskatchewan and Newfoundland and Labrador. Morissette et al. (2013) found that wage growth induced by increases in world oil prices reduced full-time university enrolment among young men in oil-producing provinces.

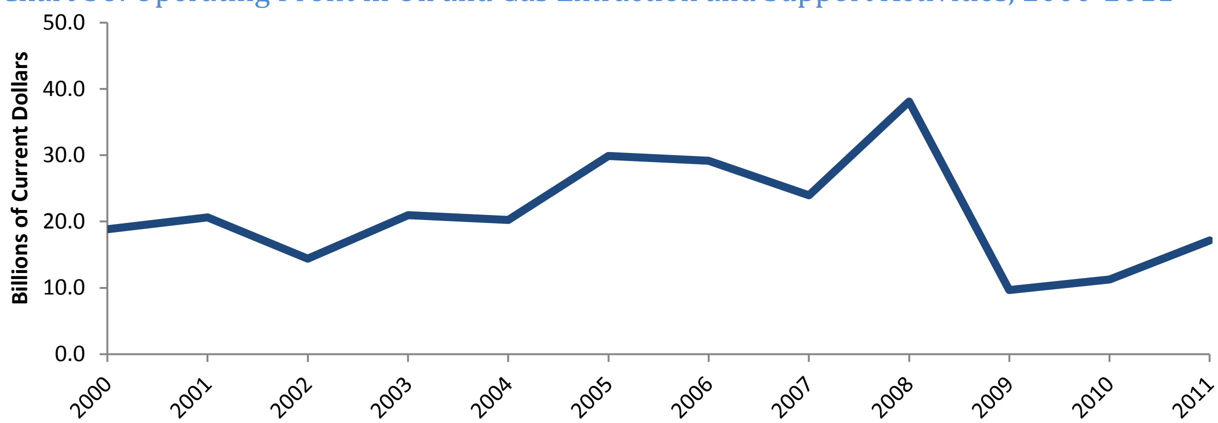
However, there is more to this story. Using data from the Census and the 2003 International Adult Literacy Survey (IALS), Emery, Ferrer and Green (2011) found that the resource boom changed the timing of schooling, but did not reduce the total accumulation of human capital. On the contrary, they show that males of school age during the OPEC oil boom achieved higher education levels over the long run than they would have in the absence of the boom. They speculate that money saved out of high earnings during the boom was used to fund later studies. The effect was on college, non-university education rather than university education, and it did not persist beyond the oil boom.

Thus we find that, although there was some relative deterioration in high school completion in the two major oil-producing provinces, enrolment at the secondary level increased in a major way in Newfoundland and Labrador, while in Alberta a decline in the 15-24 age (shown above) may have been more than offset by increases of older age groups. Overall, the effect of the oil boom on human capital formation appears to have been positive.

E. Innovation Effects: Business Expenditures on Research and Development

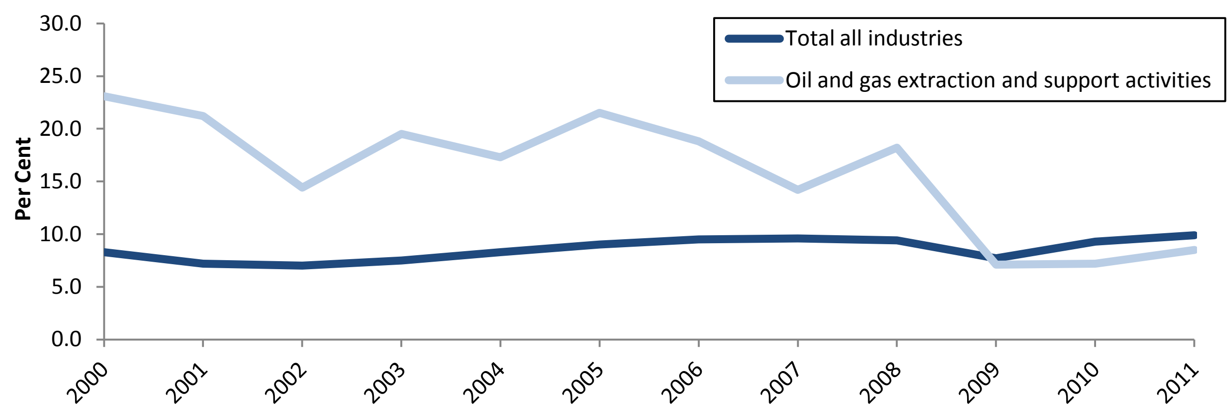
Productivity growth is driven by innovation, and innovation in turn is spurred by competition. There are several channels by which the rapid development of the oil and gas sector can foster innovation in the sector itself and in other sectors. First, the high profits arising from economic rents in the oil and gas sector give firms the resources to undertake R&D. Second, technologies developed in the oil and gas sector can have spillover effects on other sectors. Third, a robust oil and gas sector can create greater opportunities throughout the economy, leading to more firms entering the market and fostering competition, spurring the adoption of best practices because of the increased competitive intensity. This section examines the first of these effects, using information about business enterprise research and development (BERD) expenditures.

Chart 36: Operating Profit in Oil and Gas Extraction and Support Activities, 2000-2011



Source: CANSIM Table180-0003.

Chart 37: Profit Margins in Oil and Gas Extraction and Total Industries, 2000-2011



Source: CANSIM Table 180-0003.

Profits in oil and gas extraction and support activities in Canada were strong in the 2000s, rising from around $20 billion in 2000 to a peak of $37 billion in 2008 before plummeting with the financial crisis and fall in oil prices (Chart 36). Although oil prices have rebounded significantly since 2009, the weakness of natural gas prices has meant that total profits in the oil and gas sector had not regained their 2000 level by 2011. For much of the 2000s, the profit margin of the oil and gas sector was double that of the industrial aggregate (Chart 37). The steadily improving profit picture of the oil and gas sector between 2000 and 2008 meant that resources were available to expand R&D.

Indeed, increasing profits in the oil and gas sector led to a marked increase in its business enterprise research and development (BERD) expenditures for both Canada and Alberta after 2000 (Table 19). Though faltering slightly since 2007, total R&D, R&D intensity, and the oil and gas sector's share of total industry BERD expenditures have all increased significantly since 2000, both in Canada and in Alberta.[20]

Table 19: BERD Intramural Expenditures, Growth, and Intensity: Canada, Alberta and Newfoundland and Labrador, 2000-2011

	Expenditures				**Annual Growth Rates**			**BERD Intensity**		
	2000	2007	2010	2011	2000-2011	2000-2007	2007-2011	2000	2007	2010
Canada	(millions, current dollars)				(per cent)			(per cent)		
Total all industries	12,395	16,756	15,467	15,960	2.1	4.4	-1.0	1.45	1.38	1.22
Mining and oil and gas extraction	182	781	959	966	14.9	23.1	4.3	0.30	0.64	0.84
Oil and gas extraction, contract drilling and related services	129	714	862	839	16.9	27.7	3.3	0.27	0.81	1.15
Mining and related support activities	53	67	..	126	7.5	3.4	13.5	1.10	0.63	..
Alberta	(millions, current dollars)				(per cent)			(per cent)		
Total all industries	583	1,449	1,474	1,340	7.2	13.9	-1.6	0.47	0.65	0.65
Mining and oil and gas extraction	129	578	469	571	13.2	23.9	-0.2	0.33	0.82	0.74
Oil and gas extraction, contract drilling and related services	127	577*	..	..	..	24.1	..	0.35	0.92	..
Mining and related support activities	1	..	..	..	..	..	..	0.03	..	..
Newfoundland and Labrador	(millions, current dollars)				(per cent)			(per cent)		
Total all industries	20	89	72	66	13.2	23.8	-5.8	0.21	0.39	0.33
Mining and oil and gas extraction	..	..	..	..	..	..	..	..	..	..
Oil and gas extraction, contract drilling and related services	..	..	..	..	..	..	..	..	..	..
Mining and related support activities	..	..	..	..	..	..	..	..	..	..

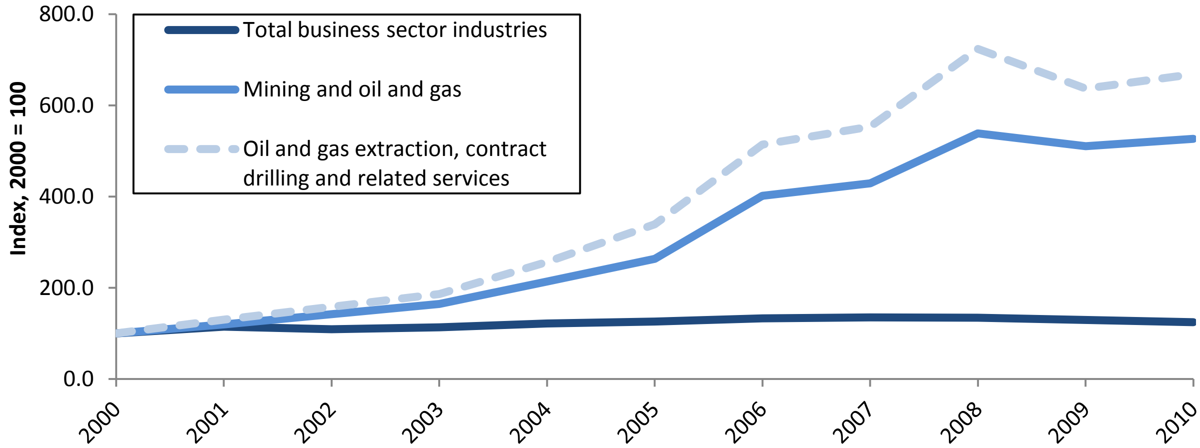
Sources: Statistics Canada, CANSIM Tables 358-0161 and 358-0024.
*Value estimated in accordance with 2006-2008 expenditure trends.

[20] In this section, figures for total industries refer to the business sector in order to maintain comparability with business sector research and development spending.

Between 2000 and 2007, BERD expenditures grew in all industries, at 4.4 per cent annually for Canada. The oil and gas extraction, contract drilling and related services sub-sector enjoyed impressive annual growth in R&D, at 27.7 per cent nation-wide. Since 2007, however, BERD spending overall gradually declined. Canadian total industry spending fell 1.0 per cent per year, and in Newfoundland and Labrador it fell by 5.8 per cent per year.

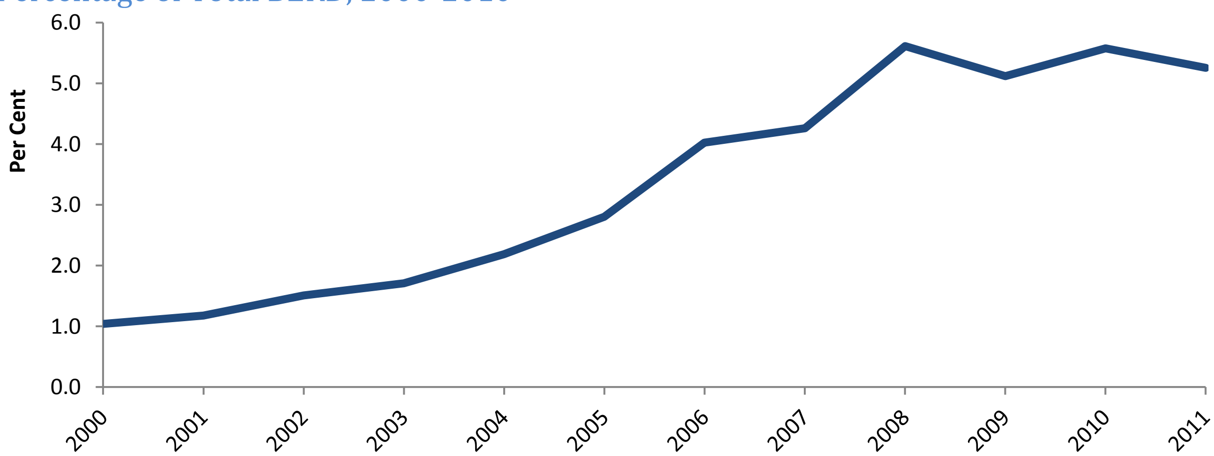
Chart 38 shows BERD expenditure for the mining and oil and gas sectors as well as for the total economy. While total industry BERD expenditures have increased moderately since 2000, total expenditure within oil and gas extraction soared from $129 million in 2000 to $839 million in 2010.

Chart 38: Nominal BERD Expenditures for Total Economy, Mining and Oil and Gas, and Oil and Gas Extraction, 2000-2010



Sources: Statistics Canada, CANSIM Tables 358-0161 and 358-0024.

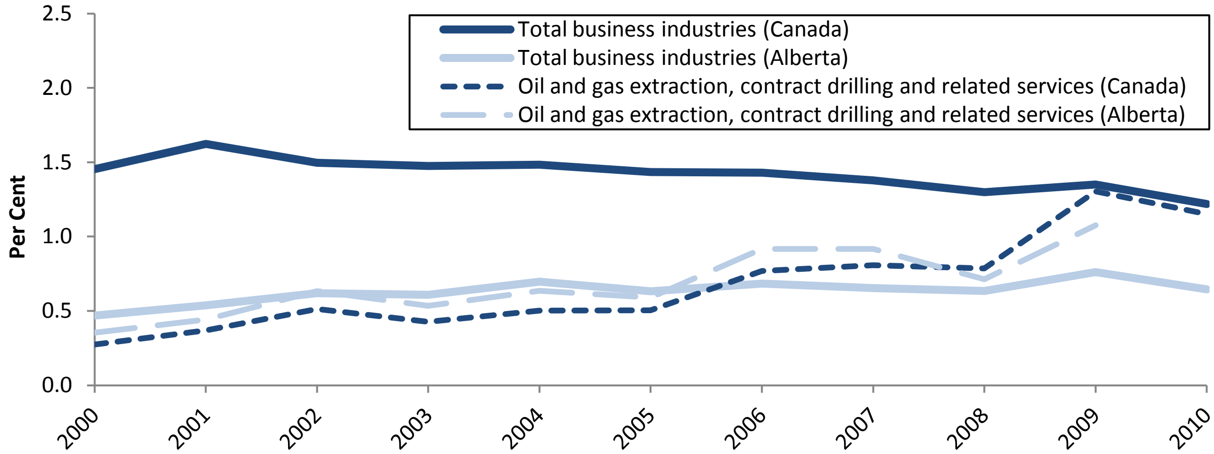
Chart 39: Nominal BERD Expenditures in Canada's Oil and Gas Extraction Sector as a Percentage of Total BERD, 2000-2010



Sources: Statistics Canada, CANSIM Tables 358-0161 and 358-0024.

BERD expenditure of Canada's oil and gas extraction sector increased as a proportion of total BERD spending for all industries, from 1 per cent to over 5 per cent (Chart 39). R&D intensity in oil and gas extraction and contract drilling and related services has continued to climb as well (Chart 40), even as total industry BERD intensity has declined in Canada. It came very close to the total business sector average in 2009 and 2010.

Chart 40: BERD Intramural Expenditure Intensity in Oil and Gas Extraction for Alberta and Canada, Per Cent of Nominal GDP, 2000-2010



Source: CSLS calculations based on Statistics Canada data.

In Alberta, virtually all mining and oil and gas business sector R&D spending falls within the oil and gas extraction, contract drilling and related services sector. Alberta itself accounts for most national BERD spending within the oil and gas extraction sector, at $478 million out of $821 million dollars in 2011 (58 per cent).

Between 2000 and 2007, BERD expenditures grew sharply in all Albertan industries, at 13.9 per cent per year, and a large part of this growth was contributed by the oil and gas contract extraction, contract drilling and related services subsector, where spending grew at an annual rate of 24.1 per cent. Since 2007, however, BERD spending has gradually declined, at an average annual rate of 1.6 per cent for Alberta, though only at 0.2 per cent for the mining and oil and gas extraction sector.

R&D intensity for all industries in Alberta has been consistently lower than the national average while avoiding the long-term downward trend for total industry BERD intensity that has occurred nation-wide since 2001. However, BERD expenditure in Alberta outside the mining and oil and gas extraction sectors increased at a higher rate than in Canada as a whole, which suggest some positive effect.

As for Newfoundland and Labrador, business sector R&D expenditures grew by 13.4 per cent per year, $20 million in 2000 to $72 million in 2010. This was a faster rate than in Canada and than what the province experienced during the 1987-1997 period, when it grew 7.12 per cent per year. Lack of detail makes it impossible to determine if this increase came from the oil and gas sector or from other parts of the business sector.

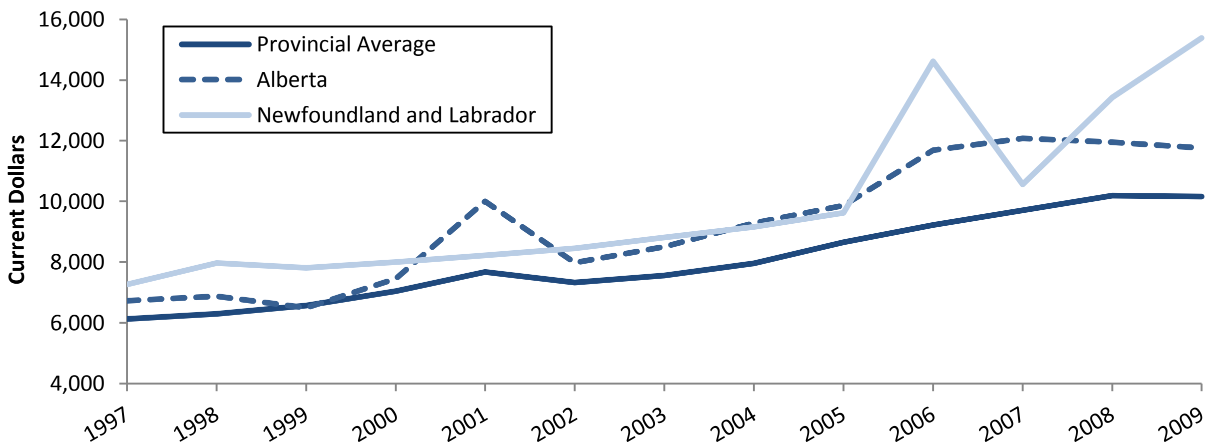
F. Effect on Government Spending

A key characteristic of the oil and gas sector is that when prices are high, substantial rents are accrued to governments, who benefit from corporate and income taxes, as well as taxes and royalties from the resources themselves.[21] High government revenues permit increased expenditures, which can be allocated to productivity-enhancing investments such as postsecondary education or R&D. In this way, the oil and gas boom may indirectly improve productivity within the Canadian economy through increased government spending.

i. Total Revenues and Spending per Capita

In the period of high oil prices during the 2000s and the rapid growth of the oil and gas extraction industry, the provincial governments of Alberta and Newfoundland and Labrador have enjoyed fast-growing revenues. Since 1997, per capita government revenues have increased annually for these two provinces at 6.5 per cent and 4.8 per cent respectively, compared to 4.3 per cent for the provincial average (Chart 41).[22] In 2009, per capita government revenues in Newfoundland and Labrador were 48 per cent greater than the average of the 10 provinces.

Chart 41: Total Government Revenue per Capita, Alberta and Newfoundland and Labrador, 1997-2009

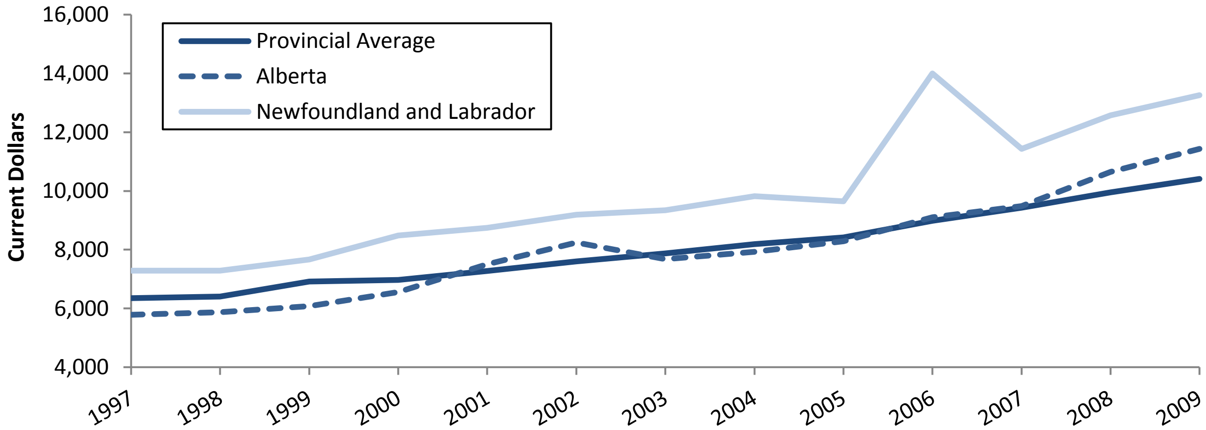


Source: CANSIM Table 385-0001.

[21] A Conference Board of Canada (2012) study estimates that oil sand investment will generate $45.3 billion in federal revenues and $34.1 billion in provincial revenues between 2012 and 2035 on an inflation-adjusted basis.
[22] In terms of total revenue (not per capita), Alberta's revenues actually grew faster, at 7.1 per cent versus 5.9 per cent, owing to Newfoundland and Labrador's declining population and Alberta's growing one.

Increased revenues permit increased expenditures, including investments in productivity-enhancing activities. In the past 25 years, Alberta and Newfoundland and Labrador have both, on average, spent more per capita than the other provinces, and this remains true as of 2009 (Chart 42). While average expenditure per capita within the provinces grew annually at 4.2 per cent between 1997 and 2009; the growth rate for Alberta was 5.8 per cent per year, and 5.1 in Newfoundland and Labrador. As of 2009, provincial government spending in these provinces was 10 per cent and 27 per cent greater than the provincial average, respectively.

Chart 42: Government Expenditure per Capita in Alberta and Newfoundland and Labrador, 1997-2009



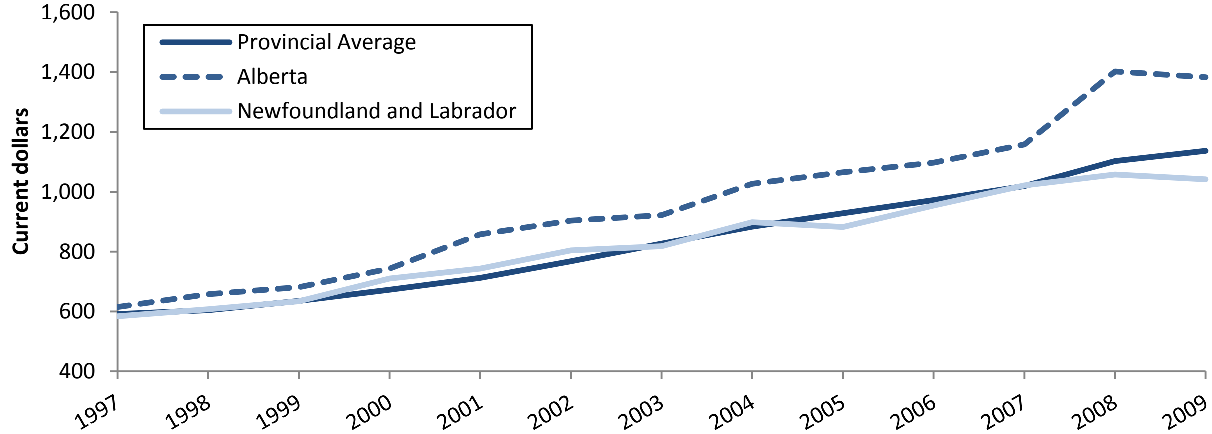
Source: CANSIM Table 385-0001.

ii. Expenditures on Post-secondary Education

Spending on postsecondary education is one of the principal ways in which governments may attempt to boost productivity in the long run. Provincial responses in terms of this type of expenditure vary according to province. Postsecondary education spending per capita in Newfoundland and Labrador has consistently hovered around the provincial average since 1997, and as of 2009 had even fallen slightly (Chart 43), with postsecondary expenditure growing at just 4.9 per cent per year, compared to 5.6 per cent for all provinces.[23] Alberta, on the other hand, has invested more aggressively in postsecondary education, with per capita expenditures growing at 7.0 per cent annually since 1997, and by 2009 was spending 22 per cent more than the provincial average (approximately $1,380 per person versus $1,130).

[23] Provincial averages for this section have been weighted according to population, and include the Territories.

Chart 43: Per Capita Expenditure for Postsecondary Education in Alberta and Newfoundland and Labrador, 1997-2009

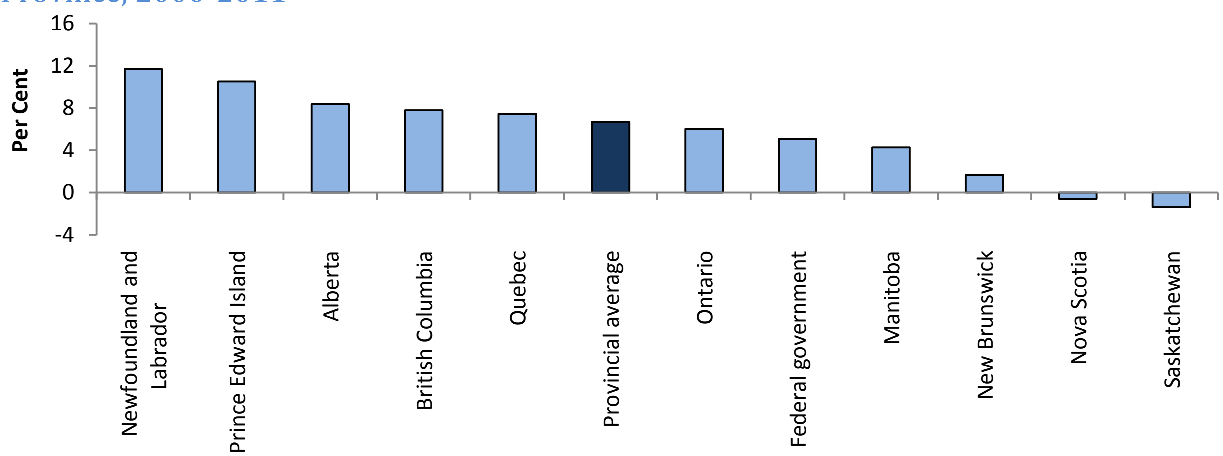


Source: CANSIM Table 385-0001.

iii. Support for R&D

Funding research and development is another channel by which governments may improve long-term productivity. This funding may be for government R&D, support for higher education or for business R&D. Chart 44 reveals that Newfoundland and Labrador and Alberta are among the top three provinces where government funding for R&D has grown the fastest, at 11.7 and 8.4 per cent annually, compared with a (weighted) provincial average of 6.7 per cent per year. This indicates that these two provinces are using the additional government revenues arising from oil and gas exploitation for productivity enhancement.

Chart 44: Growth in Provincial Government Funding for Research and Development by Province, 2000-2011



Source: CANSIM Table 358-0001.

G. Demand Effects

The development of the oil and gas sector has important effects on others sectors of the economy, both in the province of production and in other provinces. The oil and gas sector purchases intermediate inputs and capital equipment from other sectors and the incomes generated in the oil and gas sectors are in turn spent on goods and services. Such effects boost demand for goods and services, which affects capacity utilization, a key determinant of productivity growth. Unfortunately, estimates of capacity utilization rates are not available by province, so the impact of the oil and gas sector on capacity utilization in Alberta and Newfoundland and Labrador cannot be assessed.

Investment in the oil and gas sector increased from $21 billion in 2000 to $41 billion by 2005 and $59 billion in 2012. The Conference Board of Canada (2012), in a study of the economic benefits of oil sands investment for Canada's regions, estimated the supply chain effects of the oil sands. The study found that between 2012 and 2035 the expected investment of $364 billion on oil sand development is expected to generate 1.45 million person years of employment through supply chain effects that will be felt across a wide range of industries, including manufacturing, transport, financial services and wholesale and retail trade. While around two-thirds of the benefits will accrue to Alberta, Ontario will receive 14.8 per cent, British Columbia 6.7 per cent and Quebec 3.9 per cent. This increased demand will have positive implication for productivity growth through increased rates of capacity utilization and economies of scale and scope.

The oil boom generated large amounts of income. Governments claimed a large share of the natural resource rents, and spent some of this on R&D and education, as discussed earlier. A good part of the natural resource rents, however, is collected by the industry as profits and remuneration of employees. These incomes are in turn spent on goods and services. The effect of this is perhaps most palpable in St. John`s, where oil revenues are a relatively new and very large source of income.

H. Summary of Findings

Developments in the oil and gas sector have impacted on productivity growth in Canada during the period 2000-2012. This review indicates the following effects:

- In Newfoundland and Labrador, productivity growth of the business sector has accelerated after the oil and gas sector gained a large share of activity.

- High resource prices and exports have reduced the cost competitiveness of the Canadian manufacturing sector. This "Dutch Disease" is a real phenomenon in Canada, but it accounts for less than one-half of the poor output and productivity performance of the industry. This finding is based on analysis of three links in the causal chain from oil and gas to manufacturing, and is informed by several recent Canadian studies.

- Several indicators show that both Alberta and Newfoundland and Labrador have experienced relatively tight labour market conditions. These may have lead to productivity gains in other sectors in the two provinces.

- Postsecondary enrolment in the 15-24 age group has increased substantially in Newfoundland and Labrador and approached the national average. This suggests a positive effect of the oil boom. Enrolment of the same age group in Alberta did not keep pace with that in the rest of the country, perhaps because of the attraction of low-skilled jobs in the oil and gas industry. A study found that people defer studies. Overall, then, there has been a positive effect on education in both provinces.

- Business expenditures on research and development have increased dramatically in the oil and gas industry in Alberta, and increased in other sectors in that province more rapidly than elsewhere, suggesting a positive indirect effect from oil and gas.

- The two provincial governments gained substantial revenues from oil and gas and invested some of these in R&D. Alberta spends high amounts on education.

- The oil and gas sector spends large amounts on investment and intermediate inputs and generates a large amount of personal income. All this may enhance productivity growth by boosting capacity utilization and economies of scope and scale in the oil-producing provinces and elsewhere.

VII. Conclusion

Two major developments characterized the Canadian economy of the 2000s, the oil and gas boom and a fall-off in productivity growth. Increased oil prices led to a major expansion of the oil and gas sector, peaking at 8 per cent of nominal GDP in 2008. After advancing at a 1.5 per cent average annual rate in the 1981-2000 period, the growth rate of output per hour in the business sector fell in half to 0.8 per cent in the 2000-2012 period. A number of observers have linked these developments, with causation running from the oil boom to lower productivity growth. The motivation for this report was to explore the ways in which the oil and gas sector can affect, both directly and indirectly, total economy productivity growth, and shed light on the contribution of the sector to Canada's post-2000 productivity growth slowdown.

The report has six main conclusions. First, the oil and gas sector did indeed experience a major fall in labour productivity growth since 2000, 6.4 per cent per year between 2000 and 2012. This development is largely explained by high oil prices which made it profitable to develop reserves where more labour was needed to extract a barrel of oil, including both conventional deposits and the oil sands. Profits trump productivity in the decision-making of oil and gas companies. While production and the price of natural gas were lower in 2012 than in 2000, this sector may also have experienced declining yield of resource deposits.

Second, despite the negative within-sector labour productivity growth in the oil and gas sector, the overall contribution of the sector to business sector labour productivity was small. This was because of a large positive reallocation effect. In 2010, the average labour productivity in the sector was 10 times the all-industry average. This meant that the rise in the share of total business sector hours worked in the oil and gas sector from 0.4 per cent in 2000 to 0.8 per cent in 2010 offset the negative within-sector productivity effect.

Third, the oil and gas sector did have a negative effect on manufacturing productivity and hence on business sector labour productivity growth through its effect on the value of the Canadian dollar, a phenomenon known as Dutch Disease. It is estimated that around one half of the appreciation of the exchange rate was due to domestic factors, especially commodity price increases, mostly oil and gas prices. This development in turn led to a major decline in Canada's international cost competitiveness, resulting in a fall in exports of manufactured products.

Falls in output growth in manufacturing are closely associated with falls in productivity. Manufacturing output growth in Canada fell from 3.3 per cent per year in the 1981-2000 period to -1.2 per cent in the 2000-2012 period while output per hour growth in the sector fell from 2.9 to 0.7 per cent per year. With only 15 per cent of total hours worked in 2012, manufacturing accounted for 40 per cent of the post-2000 fall-off in business sector labour productivity growth.

Fourth, the oil and gas sector was found to have positive productivity impacts though various mechanisms. The increased economic activity related to the oil and gas sector boosted wages, which would lead to greater substitution of capital for labour, increasing labour productivity. The increased profits of oil firms boosted R&D spending. Higher government revenues from the oil and gas sector lead to greater spending on education and R&D. However, because the oil and gas sector is concentrated in Alberta and Newfoundland and Labrador, these effects were largely regional in nature and had limited effects at the national level. Demand from the industry for inputs and investment goods, and from the personal income of the workforce of the industry has boosted activity throughout the economy and particularly in the major oil-producing provinces, with positive effects on productivity.

Fifth, enrolment in post-secondary education of young people did not keep up with national trends in Alberta because of well-paying employment opportunities for youth. In Newfoundland and Labrador post-secondary enrolment increased to close to the national level.

Sixth, while labour productivity growth in the oil and gas sector was strongly negative over the 2000s, it fell more rapidly in the first half of the decade. Since 2007, the productivity level in the non-conventional sub-sector has increased at a high rate. This bodes well for the future contribution of the sector to aggregate productivity growth as the importance of the oil sands in the overall sector is expected to rise.

To conclude, the oil and gas boom has not been the main cause of the slowdown in labour productivity growth in Canada since 2000. However, it has contributed to this development both directly though the large fall in labour productivity in the sector (although offset by positive reallocation effects), and more importantly, through its effects on the exchange rate and the competiveness of the Canadian manufacturing sector.

Of course, as stressed at the beginning of this report, increases in living standards do not only come from productivity growth, but also from improved terms of trade. The dampening of living standards growth though slower productivity growth arising from the oil boom has been largely offset by this development. Real GDI, which incorporates terms of trade effects, grew 0.4 percentage points faster than real GDP (2.3 per cent versus 1.9 per cent per year) in Canada from 2000 to 2012. In 2012, gross domestic income was 4.7% higher than it would have been without improvement of the terms of trade. From this perspective, the oil boom has contributed significantly to Canadian prosperity.

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Appendix: Decomposing Labour Productivity Growth by Sector[24]

To begin we note that at any given point in time

$$P \equiv \frac{Q}{H} = \frac{\sum Q_i}{H} = \frac{\sum H_i P_i}{H} = \sum P_i\, h_i \qquad (1)$$

where

$P = Aggregate\ labour\ productivity\ level$
$P_i = Labour\ productivity\ level\ in\ sector\ i$
$H = Aggregate\ hours\ worked$
$H_i = Hours\ worked\ in\ sector\ i$
$h_i = Share\ of\ hours\ worked\ in\ sector\ i$
$Q = Aggregate\ real\ output$
$Q_i = Real\ output\ of\ sector\ i$

Equation (1) says that aggregate labour productivity P is equal to the weighted average of labour productivity in each of the sectors that make up the economy. The weight for each sector is its share of the total number of hours worked in the economy.

Because we are interested in how shifts in hours worked across sectors affect aggregate labour productivity growth, we must move beyond a single point in time. Equation (2) expresses the absolute change in aggregate labour productivity from period 0 to period 1, $\Delta P = P^1 - P^0$ where superscripts denote the period.

$$\Delta P = \sum h_i^0 \Delta P_i + \sum P_i^0 \Delta h_i + \sum \Delta h_i \Delta P_i \qquad (2)$$

In equation (2) h_i^0 and P_i^0 are respectively the share of total hours worked in sector *i* and the level of labour productivity in sector *i* in period 0, expressed in dollars.

In order to obtain economically meaningful sectoral contributions to aggregate productivity growth, we adjust the second term of equation (2) by subtracting the average level of labour productivity $\bar{P}^0$ from the level of labour productivity in each sector in period 0, P_i^0. In the third term, we subtract the average change in labour productivity $\Delta\bar{P}$ from the change in labour productivity in each sector, ΔP_i. The first adjustment ensures that an increase in the hours share in a sector with a below-average labour productivity level makes a negative contribution to aggregate labour productivity growth. The second adjustment also ensures that an increase in the hours share in a sector with below-average absolute growth in labour productivity makes a

[24] This appendix is an extract from Sharpe and Thomson (2010).

negative contribution to aggregate labour productivity growth. The result of these adjustments is equation (3):

$$\Delta P = \sum h_i^0 \Delta P_i + \sum (P_i^0 - \bar{P}^0)\Delta h_i + \sum \Delta h_i (\Delta P_i - \Delta \bar{P}) \qquad (3)$$

We are able to subtract $\bar{P}^0$ from equation (2) because the terms $\Delta\bar{P}\Delta h_i$ and $\bar{P}^0\Delta h_i$ each sum to zero across all sectors, since $\bar{P}^0$ and $\Delta\bar{P}$ are constant and all changes in hours share Δh_i sum to zero across sectors.

The three terms in equation (3) represent respectively the within-sector, reallocation level and reallocation growth effects. The within-sector effect captures the change in labour productivity within a sector. The reallocation level effect indicates whether changes in hours share have favoured sectors with above- or below-average labour productivity levels. The reallocation growth effect is the sum of the product of the absolute change in the share of hours worked and the absolute change in the labour productivity level for each of the *i* sectors. It measures whether an economy is subject to a phenomenon akin to Baumol's cost disease, *i.e.* the tendency of labour to move towards sectors with relatively small absolute increases in labour productivity. A negative reallocation growth effect at the aggregate level means that labour is moving to sectors with relatively smaller absolute labour productivity increases.

There are some limitations to this analysis. First, the analysis assumes that differences in technological, institutional and market structures across sectors lead to differences in average levels of labour productivity, even if marginal products are the same. It also assumes that when a sector loses or gains labour, the changes in output per hour are equal to the sector's average labour productivity. Second, these results are sensitive to the level of disaggregation. For instance, we use 12 sectors at the two-digit level. If within a sector, resources shift from one subsector to another, and these subsectors have different levels of labour productivity, then the measured impact of the reallocation effect on aggregate labour productivity growth would be different.