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LOW CRUDE OIL PRICES AND THEIR IMPACT ON THE CANADIAN ECONOMY

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Low Crude Oil Prices and Their Impact on the Canadian Economy

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Executive Summary

The decline in crude oil prices over the last year and a half is one of the most complex shocks for any economy and one that is important to measure and understand. This report attempts to measure potential impacts on the Canadian economy if low oil prices persist into the future. The modelling results indicate that the net effect of low crude oil prices on Canada is negative; as a rule of thumb, for every Canadian dollar gain in WTI price, Canadian GDP would gain almost $1.7 billion, on average.

At the global macro level, the positive effects of a decrease in crude oil price on energy-importing countries will likely more than offset the negative effects on exporting countries resulting in a net positive impact on global growth. For exporting countries, like Canada, however, the real complexity appears beneath the surface, where the drop in commodity prices mobilizes sectoral and regional forces that can take years to play out. These include higher consumer spending in response to lower energy costs, lower spending due to higher prices on imported goods and services (as a result of the falling Canadian dollar), falling investment and employment in the economy's resource sector, and rising investment and employment in the non-resource sectors.

The purpose of this report is to present economic impacts on the Canadian economy stemming from two short-term scenarios, spanning 7 years, starting in 2015: a Reference Case, where the oil prices are forecasted to grow from current levels to almost $73.00 per barrel (in 2014 dollars) and a Low Case, where oil prices reach only $51.00 per barrel by 2021. The modelling of these impacts is done using CERI's US-Canada Multi-Regional Input/Output Model (UCMRIO 3.0) to measure the impacts on major macroeconomic variables such as GDP, employment and tax revenues. The economic analysis involves establishing the economic impacts of low crude prices on the Canadian economy and comparing them with those stemming from a Reference Case.[1]

The basic assumptions are outlined in Table E.1.

Table E.1: Economic and Financial Assumptions

Parameter	Unit of Measurement	Reference Case	Low Case
Time Frame	Years	7	7
First Year of Forecast	Year	2015	2015
US/CDN exchange rate	US$/CDN$	0.85	0.75
WTI price	2014 $/bbl	$53.25(2015)-$72.88(2021)	$46.26(2015)-$51.52(2021)
Oil Sands Production	MMBPD	2.1(2015)-3.1(2021)	2.0(2015)-2.9(2021)
Capital Investment	CDN Mln $/year (avg)	19,575.64	13,702.95
Change in Non-Energy Exports	CDN Mln $(7-yr avg)	No Change	7,557.6

Source: CERI.

[1] The cases are described in Chapter 2.

The two cases present two alternative outlooks that could emerge into the near future depending on the level of crude oil prices, level of investment, production, exchange rate and exports, to name a few. In comparison, the Reference Case shows larger contributions to the Canadian economy than the Low Case, echoing the opinion of many analysts and central banks that, on a net basis, lower crude prices impact Canada's economy in a negative way.

Table E.2 shows the annual average impacts over the forecast period, Figures E.1-E.4 present year by year impacts.

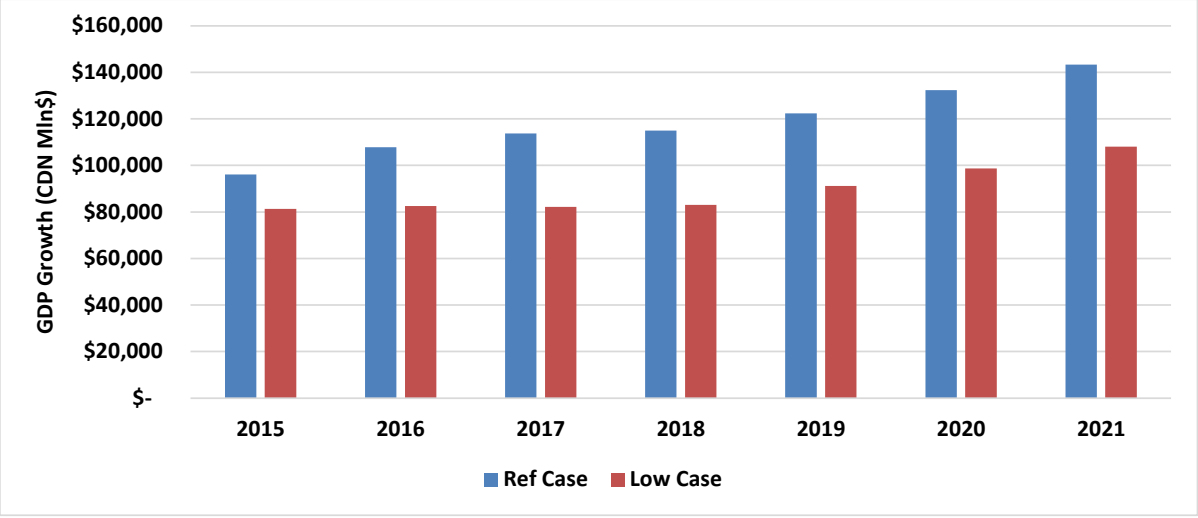
Table E.2: Comparison of Two Cases

2015-2021	Unit of Measure	Ref.Case	Low Case	Low vs. Ref. Case	% Change
GDP	Mlin CDN$	$ 118,619	$ 89,555	($29,064)	-24.5%
Compensation	Mlin CDN$	$ 54,940	$ 42,526	($12,414)	-22.6%
Employment	Jobs/year	587,006	471,118	(115,888)	-19.7%
Federal Taxes	Mlin CDN$	$ 13,580	$ 10,187	($3,394)	-25.0%
Provincial Taxes	Mlin CDN$	$ 8,363	$ 6,494	($1,870)	-22.4%

Source: CERI

Canada's GDP will be reduced by lower oil prices. This will cut into Canadian national incomes and spending power. On a cumulative basis, GDP growth will be 24.5 percent lower in the Low Case versus the Reference Case. Figure E.1 shows annual GDP impacts for both cases. The annual average GDP growth under the Reference Case is $118.6 billion in comparison to an annual average of $89.6 billion in the Low Case.

Figure E.1: GDP Impacts (2015-2021)



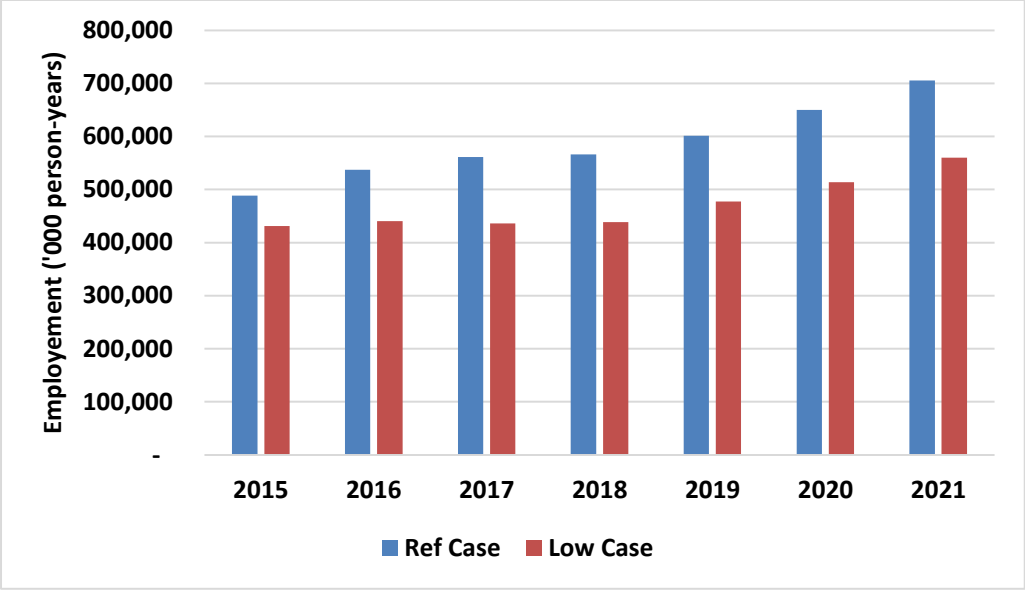
Source: CERI

The fall in oil prices will have a mixture of positive and negative effects on employment. Thousands of jobs have been lost already as a result of the recent price collapse, and more will be lost (if prices continue to fall) in the energy sector[2] – especially on new drilling and construction projects. Meanwhile, new jobs will be created in sectors which benefit from lower energy costs (such as transportation and some manufacturing), as well as for those sectors that would benefit from the low exchange rate.

There will be a net negative impact on overall employment levels as a result of low crude oil prices, however, it is the least impacted variable among other measured variables, such as GDP, compensation and tax revenues. Over the 7-year period, employment will be 19.7 percent lower in the Low Case than that under the Reference Case. The oil industry is very capital-intensive, but one of the least labour-intensive sectors in Canada's whole economy.

Other sectors such as manufacturing create more jobs per unit of investment than the energy sector. So while petroleum industry revenues and profits will fall sharply in coming years, the impact on overall employment will be less severe. It is important to note that while the job lay-offs are immediate in the energy sector, employment growth in non-energy related sectors might take a few years to materialize, but given the linear and static nature of the input-output modelling, it is impossible to incorporate the time lag feature. Figure E.2 illustrates annual changes in employment for both cases. Over the forecast period, it is estimated that, on average, there will be almost 116,000 fewer jobs (direct, indirect and induced) in Canada if crude oil prices remain low.

Figure E.2: Employment Impacts (2015-2021)

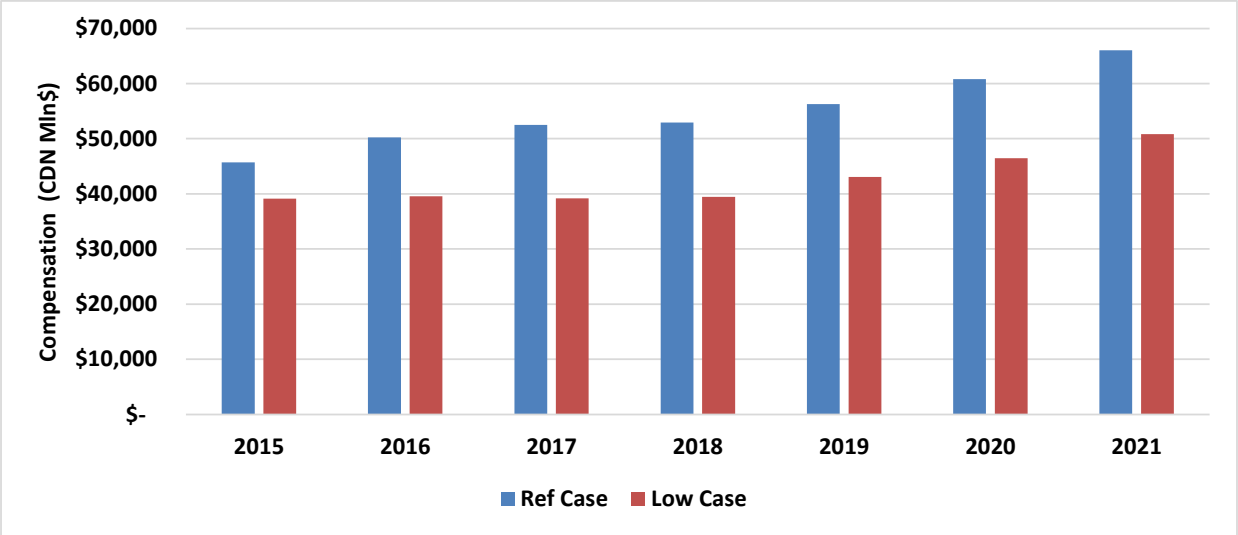


Source: CERI

[2] http://business.financialpost.com/news/energy/one-third-of-canadian-oil-and-gas-firms-expect-more-painful-job-losses-in-2016-survey

Even though the oil industry is less labour-intensive than other industries in Canada, it requires very skilled workers who are well compensated. The difference between the two cases in terms of compensation amounts to almost 23 percent, indicating that losing highly-skilled and higher paid jobs in the oil industry will have a larger impact than creating more less-skilled and lower paid jobs among other industries that are more labour-intensive.[3] Over the forecast period, the overall impact on compensation in the Canadian economy is estimated to be about $54.9 billion on an annual average basis in the Reference Case compared to $42.5 billion in the lower oil price scenario, for a decline of over $12 billion on an annual average basis (Figure E.3).

Figure E.3: Compensation Impacts (2015-2021)

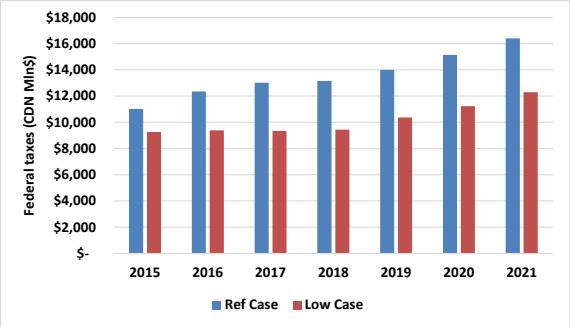


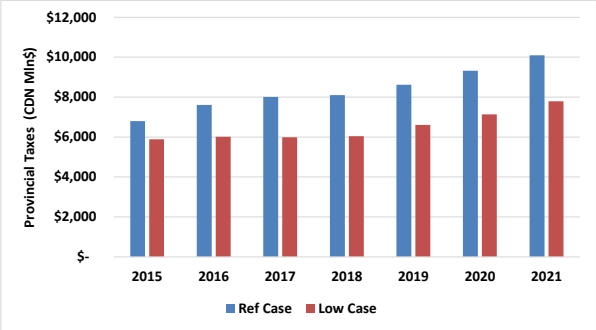
Source: CERI

With decreases in employment, employee compensation and profitability of the oil sector, government tax revenues will also be lower in the Low Case scenario. In fact, federally-collected tax revenues are the most impacted variable, with 25 percent difference between the Reference and Low cases. The federal government's tax revenues depend on corporate oil revenues as well as personal taxes paid by employees, hence with lower prices, production and labour, it is not surprising that federal tax revenues are highly impacted. On an annual average basis, the impact on federal tax revenues amounts to $13.6 billion in the Reference Case and $10.2 billion in the Low Case. As for provincial taxes, under the Low Case, the cumulative impact will be 22.4 percent lower than under the Reference Case. An annual average adds up to $8.4 billion under the Reference Case and $6.5 billion under the Low Case (Figure E.4).

[3] One model limitation is its static nature, hence, the model does not account for wage decreases associated with slower activity in the sector.

Figure E.4: Federal and Provincial Tax Revenues (2015-2021)





Source: CERI

In conclusion, Canadian economic growth could be on *average 23 percent* lower if low oil prices persist over the next seven years. The regional differences suggest that some provinces will hurt and some will benefit from lower crude prices, but on the national level, Canadian economic growth will suffer as a result of low crude prices.

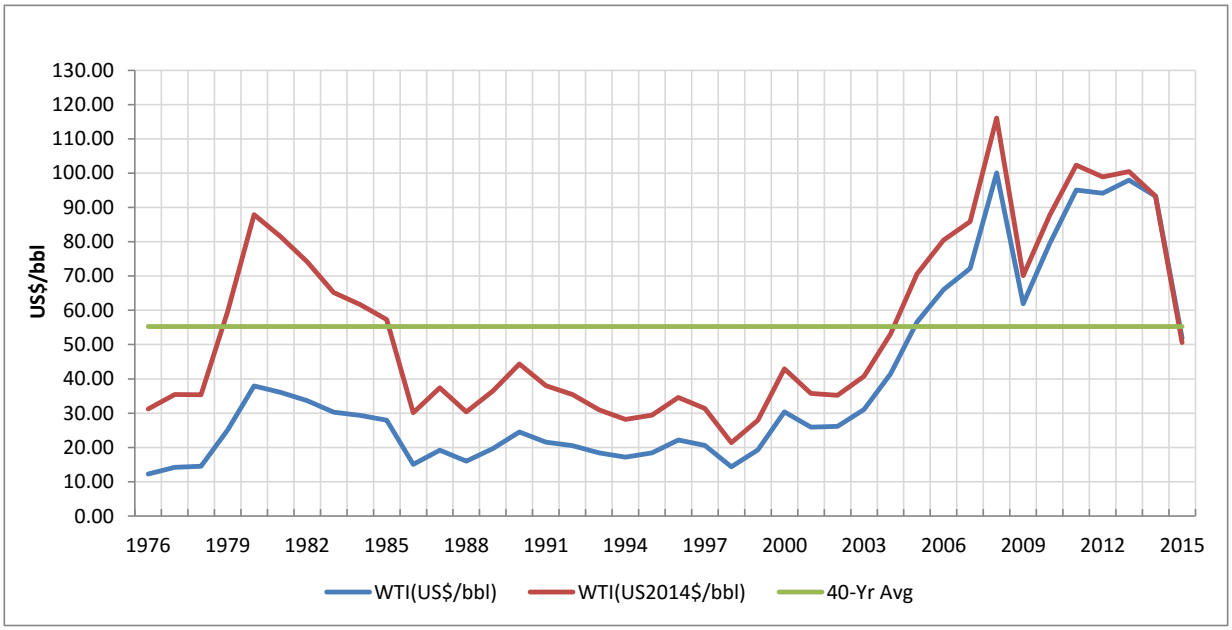
Despite some mitigating factors, lower oil prices are, on the whole, not favourable for Canada. For this report, there are two main takeaways from the drop in oil prices. First, the drop in price has an immediate and temporary negative effect on the oil industry and other service-oriented sectors that aid the upstream oil industry in Canada. Second, the broader impact of low oil prices on Canadian economic growth is on a net basis negative.

Chapter 1: Introduction

For the foreseeable future, crude oil is and will be a key element and input into many economic sectors in Canadian and global economies. The crude oil industry is central to Canada's energy industry and is a significant contributor to Canada's economy. The most recent drop in prices has directly impacted the energy sector and reverberated throughout the economy in other industries. The significant decline in crude oil prices over the past 18 months has affected the world economy. Canada was no exception. Oil prices plunged by more than 50 percent, from around US$100 per barrel in summer 2014, to around $50 today[1] (see Figure 1.1). Worse yet, Canada's oil output receives an even lower price: Western Canadian Select (WCS) – a Canadian benchmark for heavy crude exports – trades at a discount to West Texas Intermediate (WTI) because of its lower quality and regional supply glut.

Analysts, the central bank and governments are now studying how low crude oil prices will effect Canada's economy, and what policies would help to address the resulting consequences. Some of the effects are positive, some are negative. Whether low oil prices help or hurt depends on where you live, and what sector you work in.

Figure 1.1. Crude Oil Price (WTI in US$/bbl)



Source: BP Statistical Review 2014. 2015 figure is an average of monthly WTI prices from January to August 2015.

There are many factors pointing to the recent low price being the new 'norm', at least in the near-term, and the triple-digit oil price being a thing of the past, that is not to say that there is no possibility for large price upswings in the future. The recent decline in prices has caused a new

[1] At the time of writing, the prices were around US$50 per barrel.

rebalancing in the market, however the transition takes time. The International Energy Agency (IEA) in their most recent World Energy Outlook 2015 estimates that the global demand for crude oil will continue to grow, reaching 103.5 million barrels per day (MMBPD) by 2040 under the New Policies Scenario and an even higher level of 107 MMBPD in 2040 under the Low Oil Price Scenario. Lower prices are assumed to stimulate oil demand and diminish the case for efficiency investments (the New Policies Scenario assumes some $800 billion in energy efficiency investments) and switching to alternative fuels.

In the Low Oil Price Scenario, demand is nearly 4 MMBPD higher than in the New Policies Scenario with most of the incremental demand coming from the transportation sector. While oil consumers and importers benefit economically, the consequent rise in dependence on low-cost supply from the Middle East may raise concerns over oil security and could potentially lead to oil price shocks as seen in the past if investment in other regions dries up. Oil producers and exporters are worse off, as the volume gains from higher output are more than offset by the effect of lower prices. Furthermore, the IEA argues that the strains of a sustained low price would put pressure on the fiscal balances of key OPEC producers making the Low Oil Price Scenario increasingly unlikely the further it is extended into the future. The longer the oil price remains low, as demand continues to grow while supply (other than OPEC) is being cut off, the greater the risk of a market correction in the form of a price increase in the future.

To understand how prices could transform in the future, we must appreciate why prices fell in the first place. This Chapter discusses the uncertainties around fundamental economic forces and other factors affecting oil prices in relation to how lower oil prices impacted global, US and Canadian economies.

Fundamentals: Oil Supply and Demand

Since the year 2000, world oil prices, and commodity prices in general, experienced a continued upward movement, often referred to as the "super-cycle"[2] (Figure 1.1). One of the most important reasons for this long-term trend is the rising demand for crude products stemming from rapid economic growth in China and other emerging market economies.[3]

The emerging economies' appetite for energy had reflected itself in the changes on the world demand for energy and, consequently, oil. The economy of China alone doubled in size between 2007 and 2013, a tremendous growth built on the production of goods requiring energy to manufacture. With rising living standards, Chinese households have been able to afford cars and other products that consume energy. China's oil consumption followed suit, doubling over the

[2] Bloomberg View. "Maybe the Commodities Supercycle Is Actually Real". August 2015. http://www.bloombergview.com/articles/2015-08-07/maybe-the-commodities-supercycle-is-actually-real. Accessed on September 22, 2015.

[3] L.Kilian and T.K. Lee, "Quantifying the speculative component in the real price of oil: The role of global oil inventories", *Journal of International Money and Finance*, 42. April 2014. The authors estimated that demand shocks accounted for about 60 percent of the increase in oil prices during the increase from US$30/bbl to US$140/bbl.

past decade to about 10 MMBPD and making the country the world's second-largest consumer of crude oil.

The urbanization and industrialization of emerging economies and the growth of their middle classes is far from complete. China's urban population has grown by about 300 million people since 2000 but, even now, only 55 percent of its people live in urban areas, compared with more than 80 percent for North America and advanced Asian economies such as Japan and Korea.[4] Conservation efforts and efficiency gains might have helped to reduce consumption, nevertheless global oil demand is expected to increase in the long run.

Global economic growth has repeatedly fallen short of expectations in the aftermath of the financial crisis of 2007–08. First, the fallout turned out to be much more prolonged and severe than most economists expected.[5] Second, certain important structural factors suggest that, over the longer term, world economic growth will be slower than in the past. One important reason is demographics: the aging populations in advanced and some emerging economies. Another is the maturing growth of emerging economies such as China. It is improbable for China to sustain economic growth at the double digit rates of the 2000s, although its growth rate is still expected to stabilize at around 7 percent per annum for the foreseeable future.

Disappointing global growth and the resulting slower growth of energy demand are a significant part of the background to the recent movement in oil prices. But, increased supply most likely played a greater role.

High oil prices over the last decade have stimulated new sources of oil supply around the world. Over time, the industry responded by stepping up exploration, developing higher-cost sources, including US shale oil, Canadian bitumen, deep water offshore, and other high-cost sources while making some major technological breakthroughs. New supply has also come on stream from countries in the Middle East (including Iraq, Iran, and Libya).

North American production has grown the fastest, eventually contributing to the decrease in world prices. The so-called "shale revolution" that started 7 years ago has been nothing short of astounding. In 2008, the production of shale oil was almost non-existent. Today, the sector produces about 4 MMBPD and, before the recent drop in prices, was on track to increase its output to almost 4.8 MMBPD in 2020.[6]

[4] According to some estimates, another half-billion people in China and India alone will move to cities and likely join a growing middle class over the next two decades. As long as these trends continue, they will add to world demand for oil. Source: United Nations Database.

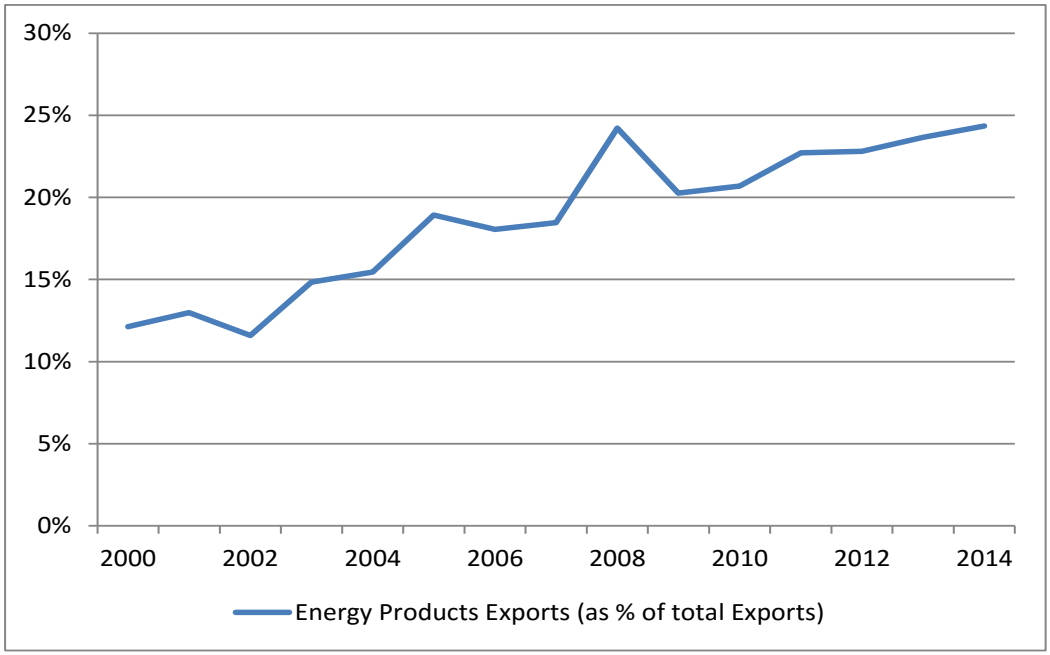
[5] Public and private indebtedness at a global level is at a historic high, and there is also the lingering uncertainty resulting from the experience of the past few years. The most recent Bank of Canada projections show a global growth rate of 3 percent this year and 3.5 percent for 2016 and 2017. The recovery is particularly robust in the United States, where the policy response to the financial crisis was more timely, aggressive and sustained than in other major advanced economies.

[6] US EIA. *Annual Energy Outlooks* 2013, 2014, 2015.

Canadian oil production also rose in response to increasing prices. Oil sands production grew fivefold between 1993 and 2014, to 2.3 MMBPD, and now accounts for more than 60 percent of Canada's crude production. Between 2006 and 2013, investment in the oil sands more than doubled to over $30 billion per year.[7]

In Canada, the energy sector accounts for about 10 percent of GDP[8] and an increasing share of total exports. The value of energy-related shares of exports has doubled from 12 percent in 2000 to 24 percent in 2014 (Figure 1.2).[9]

Figure 1.2. Value of Canadian Energy Exports (CDN$)

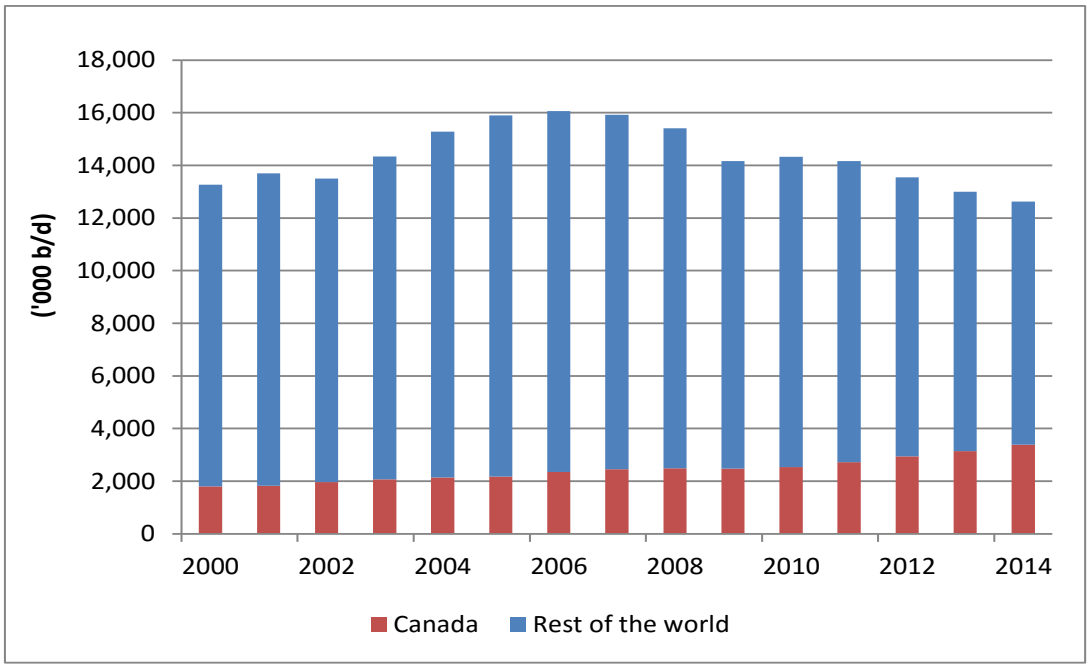


Source: Statistics Canada, Table 228-0059.

The US is still the world's largest consumer of oil and, with the emergence of shale oil production, has also become the biggest producer. Oil is also an important element of Canada-US economic relations. The US is the market for almost all of Canada's oil exports. Canadian oil exports to that country have been growing steadily over the last few years, even as the US has been reducing its overall reliance on imported oil due to increased domestic tight oil production. As a result, in 2014, Canadian oil was nearly 30 percent of US crude oil imports, and that share is expected to grow in the future (Figure 1.3).

[7] CERI Study 141, "Oil Sands Supply Costs and Development Projects (2014-2048)". July 2014.
[8] The figure is an annual average from 2010 to 2014. Statistics Canada, Table 379-0031 "Gross domestic product (GDP) at basic prices, by North American Industry Classification System (NAICS)".
[9] The figures are calculated as annual averages. Statistics Canada, Table 228-0059 "Merchandise imports and exports, customs and balance of payments basis for all countries, by seasonal adjustment and North American Product Classification System (NAPCS)".

Figure 1.3. Canadian Share of US Oil Imports



Source: US Energy Information Agency (EIA)

Geopolitics and Financial Markets

In the short run, there are a number of other important influences on the oil market that are more difficult to predict than fundamentals.

First, geopolitical developments often have a major impact on oil prices – since they can affect oil supply directly and abruptly and any threat of future supply disruptions can also build a so-called risk premium into oil prices. As a notable example, in the early part of 2014, conflicts in Libya and Iraq led to temporary outages in their oil production, keeping world prices high, even as supply elsewhere in the world continued to ramp up. Of course, such conflict situations and other geopolitical events can change very quickly in one direction or the other, and continue to pose an important source of risk.

Second, the Organization of the Petroleum Exporting Countries (OPEC) has had an important influence on the dynamics of world oil markets, and this influence may be changing. The drop in oil prices was accelerated in early December 2014 by OPEC's decision to leave its production target unchanged, even as prices were falling. In effect, OPEC members were allowing the price to fluctuate so that more supply adjustments would come from other producers, rather than acting as the "swing producers" as they had in some other times. In its *Oil Market Report*,[10] the IEA had measured the overall OPEC output at 31.2 MMBPD as of September 2015, up 1 MMBPD from a year ago and well in excess of the group's official 30 MMBPD production target. Supply looks set to hold above the 31 MMBPD mark for some time to come, with Saudi Arabia sticking

[10] IEA. *Oil Market Report*. September 2015.

to their policy of defending market share, not price, and Iraq striving to sustain its impressive growth. The group's 'effective' spare capacity stood at 2.3 MMBPD in August 2015, with Saudi Arabia accounting for 86 percent of the surplus.

Third, there was an increase in financial linkages to physical crude oil markets. Most buyers and sellers in the global oil market are neither oil producers nor oil consumers. Rather, they are financial investors, flowing investment into commodity-based mutual funds and exchange-traded funds; increased involvement by global investment banks in commodity-backed lending and physical commodity trading; and the prominent role of large commodity-trading houses. The Bank of Canada's research indicates that the role of investment flows in the commodities market shows that these flows may amplify or accelerate price movements, but do not create trends on their own.[11]

There is still a question of whether financial flows may have accelerated some of the price movements that were witnessed in 2014 and 2015. At this point, data on speculative positioning in oil markets do not suggest that such effects were driving recent market movements, but it cannot be ruled out completely that they may have been either a contributing or a mitigating factor. In other words, the possibility exists that financial linkages could transmit stress from oil markets to the financial system. Vice versa, the low price impact on the oil industry may be partially cushioned or absorbed through market instruments such as options futures and hedges, thus providing lead time for the oil industry to adjust to the lower price environment.

Global Economic Impact

What will the drop in oil prices mean for the world economy? The economics of supply and demand tell us that if a decline in oil prices is caused by new sources of supply, the price drop spreads the benefits of a favourable shock; if it is partly the result of slower demand growth, it mitigates the effects of an unfavourable shock.

Overall, lower oil prices benefit consumers and hurt producers. For the users of oil, a lower price is like a tax cut. The positive effect will work its way through the economy via two channels: first, it will give consumers more disposable income, which they can spend on goods and services; second, it will reduce input costs and encourage production in sectors other than oil, especially energy-intensive sectors.

The United States, as a net importer, will benefit from the drop in oil prices. Other economies that are large net importers of oil, such as China, Japan and Europe, will also get a boost to their economic growth. The decline in oil prices has clear adverse effects, however, on oil-exporting emerging economies. Some of these countries, which have relied on high oil prices to balance their budgets, could face financial, economic and political stresses.

[11] R. Alquist and O. Gervais, "The Role of Financial Speculation in Driving the Price of Crude Oil," Bank of Canada Discussion Paper No. 2011-6, 2011.

Canada has a complex, diverse economy, and the impacts of lower oil prices will also be complex and diverse. Canada, like other countries, has been trying to regain its economic position since the global financial crisis. Signs of a broadening recovery have been emerging during the past year. Stronger US growth and a weaker Canadian dollar have boosted non-energy exports.[12]

As a net oil exporter, Canada will face net negative impacts, although the impacts will be both positive and negative. The most immediate impact will be negative: impacts to Canada's terms of trade caused by the lower value of Canada's energy exports. This would be partially offset by a boost to consumers' disposable incomes and spending power through lower oil prices at the pump, although retail prices might take some time to adjust partly due to higher profit margins and refinery outages that have kept petroleum product prices high.

The positive effect of low crude prices on the world economy and the resulting stronger growth could also be positive for Canada. A recovered global economy could increase Canada's non-energy exports, boost confidence and lead to improved business investment.

However, these gains will be more than offset as lower revenues in the oil patch (resulting from low investment) and along the supply chain spill over to the rest of the economy. The lower prices, if they are expected to persist, will significantly discourage investment and exploration in the oil sector. Declines in upstream investment could cause Canada's crude production to fall, which in turn would translate to lower energy exports.

Lower oil prices are also typically accompanied by a weaker Canadian dollar, and this time is no exception. The dollar's depreciation against the US dollar will help to partially cushion the economy from the impact of lower oil prices. Lower oil prices will benefit many sectors, such as manufacturing, by reducing production costs, but consumers will face higher price tags on imported products.

Despite the mitigating factors, lower oil prices are likely, on the whole, to be a negative impact for Canada. Estimating the magnitude of that overall impact requires carefully analyzing the interplay between the various effects as they work through the economy. That is what this study analyzes. There are a few ways to estimate these impacts, usually this type of analysis is done using some form of a General Equilibrium model, which evaluates the impact of economic or policy shocks in the economy as a whole. The results of this study were computed using CERI's US-Canada Multi-Regional Input/Output Model (UCMRIO 3.0) model, a computable version of the Walras General Equilibrium model.

The purpose of this report is to present a potential scenario where crude prices remain low[13] using CERI's model to measure the impacts on major macroeconomic variables such as GDP, employment and tax revenues from such a scenario on Canadian provincial economies and

[12] A. Binette, D.l de Munnik, and É. Gouin-Bonenfant "Canadian Non-Energy Exports: Past Performance and Future Prospects". Bank of Canada Discussion Paper 2014-1. 2014.
[13] The oil price forecast is shown in Chapter 2.

sectors that are most-impacted. The economic analysis involves establishing the economic impacts of low crude prices on the Canadian economy and comparing them with those stemming from a Reference Case.[14]

This report is organized in the following manner. Chapter 2 presents the methodology and assumptions used in modelling; Chapter 3 presents the results in the form of economic impacts on Canadian and provincial economies; and Chapter 4 draws conclusions from the findings. Appendix A provides more detailed information on CERI's I/O model.

[14] The cases are described in the next Chapter.

Chapter 2: Methodology and Assumptions

This Chapter describes the modelling methodology, details about the assumptions used to build the scenarios, and a description of the variables used in the analysis.

Input-Output Methodology

There are several ways to estimate the impact of low crude oil prices on the Canadian economy, usually this type of analysis is done using some form of a General Equilibrium model, which evaluates the impact of economic or policy shocks in the economy as a whole.[1] The results of this study are computed using CERI's US-Canada Multi-Regional Input/Output Model (UCMRIO 3.0) model, a computable version of the Walras General Equilibrium model.[2] This section briefly discusses the modelling methodology, for more detail on the model description, see Appendix A. The I/O tables have been updated to the base year of 2009, the previous update was from 2006 data.

I/O analysis in general addresses the way economic circumstances in one part of an economy can ripple through the rest of it. In particular, it is concerned with inter-industry relationships, notably the use of output from industry as an input into another industry's production process. The model determines an approximate impact on various economic variables due to the introduction to the economy of a particular set of expenditures or 'shocks'. In the case of resource or infrastructure developments, the expenditures include those for the construction and operation phases of the project. An I/O model is one way to estimate the economic impact of a set of expenditures.

Any activity that leads to increased production capacity in an economy has two components: a) the construction or development of the capacity, and b) the operation of the capacity to generate outputs. The first component is referred to as *investment*, while the second is either *production or operation*. Both activities affect the economy through purchases of goods and services, as well as labour.

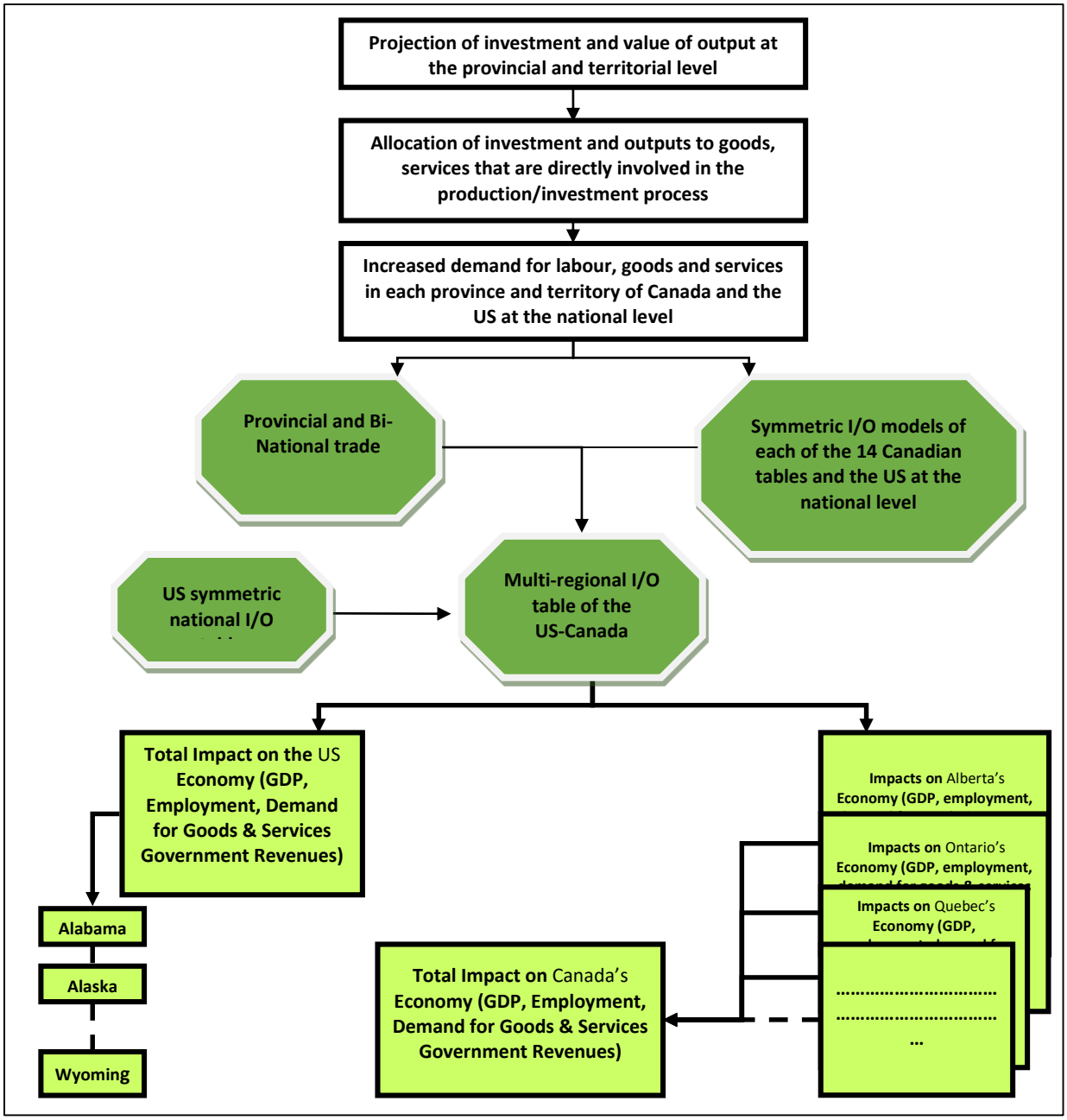
Figure 2.1 illustrates the overall approach CERI uses to assess economic impacts resulting from these activities. The first step is to estimate and forecast the value of investment (i.e., construction or development expenditures) and production (sales). Total investment or

[1] General equilibrium modelling reproduces the structure of the whole economy and therefore the nature of all existing economic transactions among diverse economic agents (productive sectors, households, and the government, among others). Moreover, CGE analysis, in comparison to other available techniques, captures a wider set of economic impacts derived from a shock or the implementation of a specific policy reform. In that sense, the CGE approach is especially useful when the expected effects of policy implementation are complex and materialize through different transmission channels.

[2] Modelling methodology and model limitations are described in detail in Appendix A.

development expenditures are then disaggregated into purchases of various goods and services directly involved in the production process (i.e., manufacturing, fuel, business services, etc.) as well as labour required, using the expenditure shares. Similarly, the value of total production (output or sales) from a production activity (i.e., conventional oil production, petroleum refinery, etc.) is allocated to the purchase of goods and services, payment of wages, payments to government (i.e., royalty and taxes), and other operating surplus (profits, depreciation, etc.).

Figure 2.1: Overall Bi-National Multi-Regional I/O Modelling Approach



Source: CERI

The forecasted values of investment and production are then used to estimate demand for the various goods and services and labour used in both development and production activities. These demands are met through two sources: a) domestic production, and b) imports. Domestic contents of the goods and services are calculated using Statistics Canada's (StatsCan) data.

The estimated bi-national trade flow tables, developed by CERI, are used to derive imports or exports of each type of good and service for provinces and territories in Canada (including Government Abroad) and the US at the national level. The value of goods and services used by a particular industry and produced in a different province or territory in Canada – or a state in the US – can then be calculated. This method captures the trade supply chains among all trading partners in Canada and the US, as well as their feedback effects. The latter are changes in production in one region that result from changes in intermediate and final demand in another region, which are in turn brought about by demand changes in the first region.

In this exercise, the investment and operation dollars are initially determined on a project basis. For example, in the case of the oil sands industry, the dollars are allocated to Mining and Extraction, In Situ, Integrated Mining and Upgrading, and the Stand-Alone Upgrading categories. Investment and operations spending stimulate Alberta's economy in various sectors simultaneously, including the Oil Sands, Construction, Refinery and Manufacturing sectors.

The relationship between the oil sands and the pipeline and refining industries is captured in the base economy, and thus inducement on the supply side results in impacts on these industries. Investment in Alberta also impacts other provincial economies; these impacts can be identified at the sector level. Thus, for example, infrastructure upgrades required in order to handle heavier oil sand crudes are not reflected by the model, but generic upgrades are implicitly accounted for in the indirect impact of investment in oil sands development upon activity in that sector. No direct shocks are made to the US sectors.

Assumptions and Limitations of Input-Output Modelling

No model is ideal, the input-output modelling does suffer from a few shortcomings. This section discusses various assumptions and limitations to the I/O analysis in general.

There are two main assumptions. The first assumption of any I/O analysis is that the economy is in equilibrium. Despite partial equilibrium analysis, it is assumed in the general equilibrium approach that the economy as a whole is in equilibrium. This means that supply of goods or services in any sector matches the demand. This is a realistic assumption in the long run, as it is difficult to imagine an economy remaining in disequilibrium for a long period of time.

A second important assumption in I/O analysis is the linear relationship between inputs and outputs in the economy. Each sector uses a variety of inputs in a linear fashion in order to produce various final products under the assumption of fixed proportions. Though the form of the "Leontief production function" is simple, it could be viewed as an approximation of the real

world's production function. Unlike other production functions, the Leontief production function contains no provision for substitution among inputs.

A very interesting aspect of this assumption is the constant return to scale (CRS) property of the Leontief production function, which turns out to be a proven property in the economy. Though the linearity of the production function gives a constant average and marginal products, these are justified if the analysis focuses on the medium term. Long run changes in the economy (beyond 20 years) may affect the fixed relationship between sectors.

Although the I/O approach has been widely used around the world for economic impact assessment, there are certain limitations that should be noted and are discussed below.

Static relationships. I/O coefficients are based on value relationships between one sector's outputs to other sectors. The relationship and, thus, the stability of coefficients, could change over time due to several factors including:

- Change in the relative prices of commodities;
- Technological change;
- Change in productivity; and
- Change in production scope and capacity utilization.

Since these attributes cannot be incorporated in a static I/O model, these models are primarily used over a short-run time horizon (5 to 10 years), where relative prices and productivity are expected to remain relatively constant. These models can be used for the comparison between two periods when the model incorporates new tables and coefficients. The model can then show the changes in productivity and energy efficiency.

Unlimited resources or supplies. The I/O approach simplistically assumes that there are no supply or resources constraints. In reality, increasing economic activities in a particular sector of the economy may put pressure on wages and energy prices in the short-run. However, in the long-run, the economy adjusts through the mobility of the factors of production (i.e., labour and capital).

Lack of capacity to capture price, investment, and production interactions. An I/O model is incapable of representing the feedback mechanism among price change, investment, and production. For example, an increase in oil price provides a signal to drivers to consume less gasoline or drive a more fuel efficient car. This response would in turn impact car manufacturing, the oil refining industry and tourism. However, this type of interaction cannot be modeled in a simple I/O model.

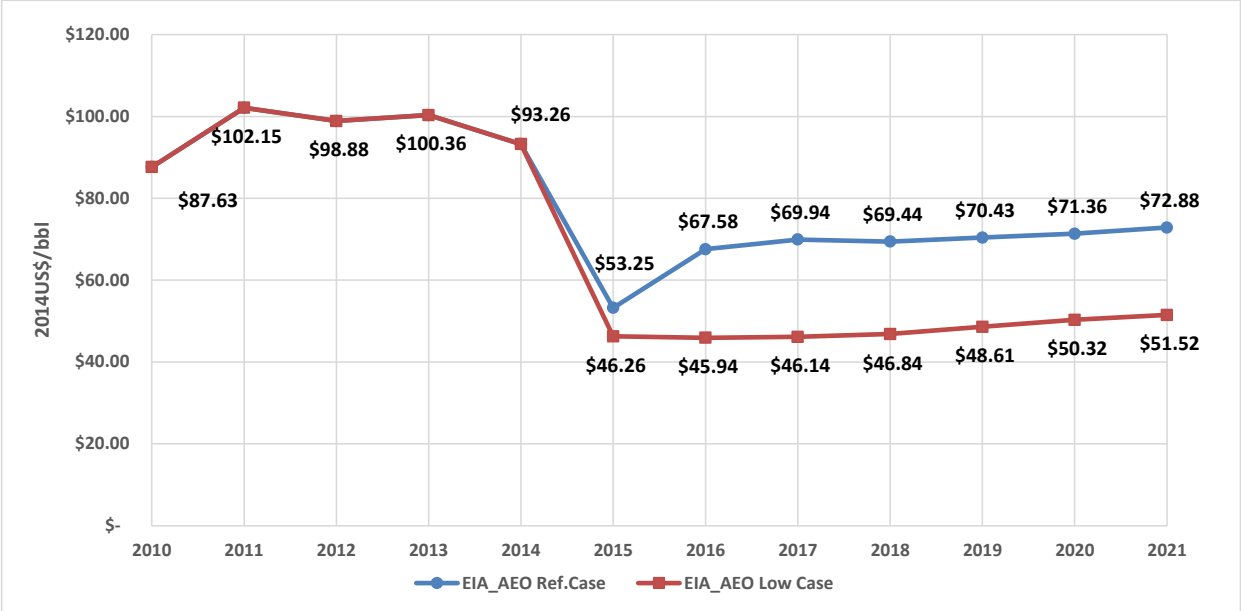
Lack of supporting data. There are segments of energy information that cannot be quantified due to a lack of or confidentiality of Statistics Canada data. These data are either estimated by using other sources or have been incorporated in aggregate levels without damaging the model's integrity or functionality.

Modelling Assumptions

Oil Prices

For the purposes of I/O modelling, more specifically to estimate oil revenues, a crude oil price forecast was required. The forecast of the WTI price was obtained from the US Energy Information Administration's (EIA's) Annual Energy Outlook (AEO), published in April 2015, for the 7-year period, stemming from 2015 to 2021 inclusive and for two cases – the Reference Case and Low Case price forecasts. Prices were then transformed to 2014 dollars as seen in Figure 2.2. The EIA-AEO's Reference Case price, where the WTI price grows to over US$70/bbl by 2019 was used in the I/O modelling of economic impacts of CERI's Reference Case Scenario; the AEO's Low Case price forecast was used as the new low price forecast, where WTI in real 2014 dollars grows only to just above $50/bbl in 2021 and was used to determine oil revenues in CERI's Low Price Scenario. To calculate the Canadian crude revenues, the WTI prices are adjusted for quality and transportation to domestic markets in Edmonton and Hardisty. For light crude volumes, the WTI differential and a toll, which includes gathering, tankage and transport, are CDN$1.00/bbl and CDN$4.00/bbl, respectively. For heavy barrel volumes, the differential is $8.00/bbl and a toll of CDN$6.00/bbl.

Figure 2.2: Oil Price Forecasts



Source: US EIA, Annual Energy Outlook 2015.

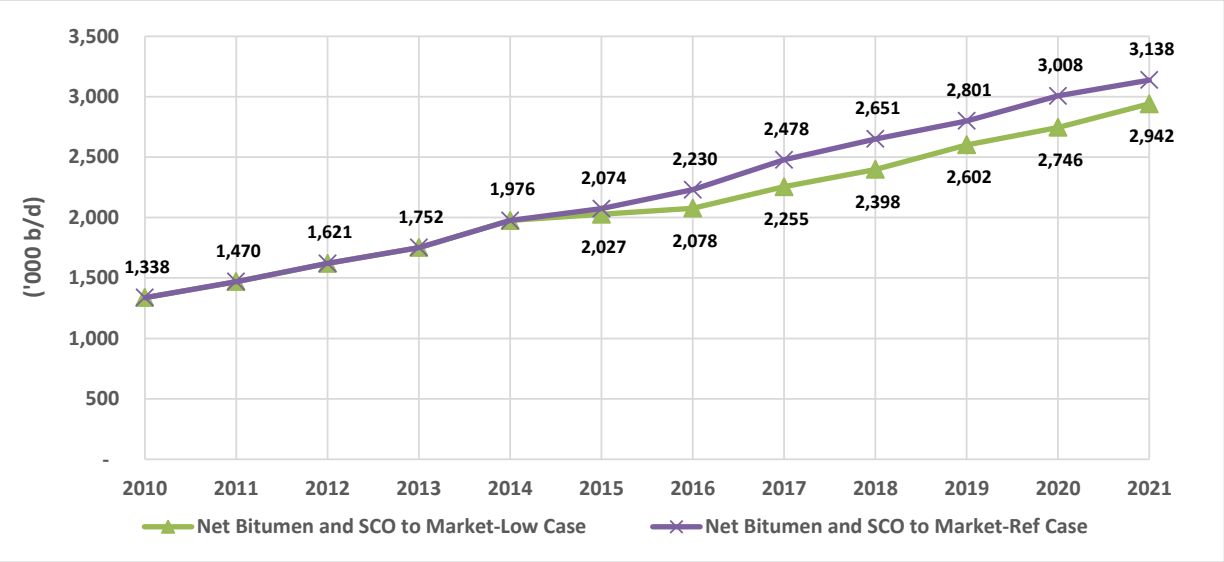
Oil Exports

Lower prices will have no major impact on existing oil sands production, unless the WTI price falls below $35/bbl for a sustained period.[3] Existing oil wells and bitumen facilities will keep pumping

[3] McDaniel & Associates Consultants Ltd. "Oil Sands Break Even Challenges and Opportunities", presented at CHOA Fall Conference.

crude, because their owners have already invested large sums of capital in those operations. Going forward, less capital is required to maintain the existing facilities than to begin constructing new projects. In fact, Canadian oil sands output will actually keep growing for several years due to partially completed new projects that are gradually coming online. As well, short-term marginal costs of keeping oil flowing from existing projects are still less than the current level of crude prices. Figure 2.3 presents CERI's Reference and Low Case forecasts for net bitumen and synthetic crude oil (SCO) available for export sourced from CERI's recent oil sands update (Study 152, published in August 2015). Under the Low Case, oil sands production grows, but not at the same rate as under the Reference Case – it continues to be flat over the next year and gradually starts to increase. The difference between the two cases in the 7-year period from 2015 to 2021 amounts to an average of 190,000 b/d per year.

Figure 2.3: Net Bitumen and SCO Available for Export



Source: CERI, CanOils

Oil sands production represents 60 percent of total Canadian crude oil production. The rest is made up of conventional light and heavy production, predominantly within the Western Canadian Sedimentary Basin (WSCB) and offshore production in Newfoundland and Labrador.

According to the latest National Energy Board (NEB) report,[4] in Alberta, Saskatchewan and British Columbia light oil production will decrease in the near term as a result of low oil prices and investment over the last year and a half.[5] As prices increase, the NEB forecasted that conventional production starts to grow early in the next decade, which is outside of the time horizon discussed in this report and hence any incremental investment and production growth

[4] NEB. "Canada's Energy Future: Energy Supply and Demand Projections to 2040", January 2016.

[5] As prices increase, conventional production starts to grow early in the next decade and then begins a long-term decline by 2030 as production rates from new wells start to decline with the maturing of oil reserves. The light oil production profiles reflect the focus on tight oil plays, using horizontal drilling and multi-stage hydraulic fracturing.

in those regions are not part of this I/O modelling. Furthermore, the report suggests that conventional heavy oil production in western provinces slowly declines through the projection period due to an inability of adopting the same hydraulic fracturing technology that is applied to tight oil reservoirs. Therefore, conventional heavy production is not considered either. In Manitoba, production declines over the projection period, reflecting the limited resource potential currently assigned to the tight oil plays in that province. Thus no assessment is made for incremental investment in the I/O modelling for the time horizon analyzed in this report. Newfoundland and Labrador produce most of the oil in eastern Canada, with Ontario and Nova Scotia contributing small amounts.

As the report indicates, in all of the NEB's price cases, medium-term production in Eastern Canada increases because of new fields coming online. This includes production from the Hibernia South and White Rose extensions, and the Hebron Field. The production volumes are projected to increase anywhere from 51,000 barrels per day (BPD) to 81,000 BPD from 2015 to 2021, depending on the price scenario. This incremental growth is not included as part of the oil revenues in the modelling due to lack of data on capital investment and operating costs. Other projections in offshore production include a discovery field that is assumed to start production as early as 2023 in the NEB's High Price Case, however this incremental growth is outside of the time horizon and hence not included in the I/O modelling.

New Petroleum Investment

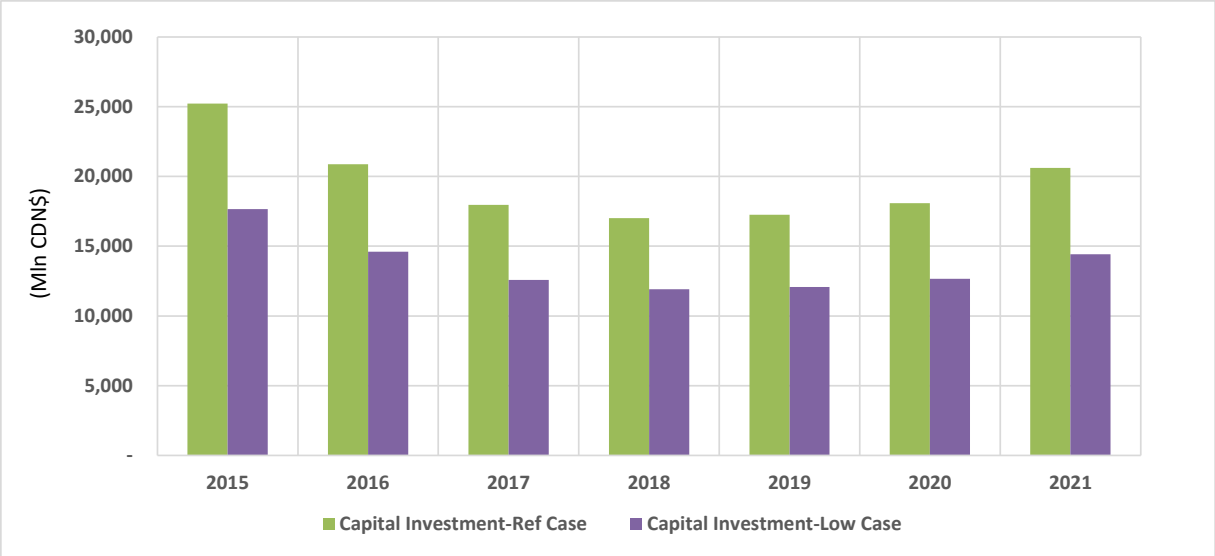
A bigger effect of lower oil prices on the oil industry is suspended spending on new exploration, drilling, and capital investment for new projects. Current production of oil sands will remain, but new capital spending has declined since prices started to fall – partly because companies are concerned they will not be profitable, and partly because companies have no free cash flow to pay for new projects. The situation is even worse for the conventional oil-directed drilling, which has already started to decline. It will take a few years before slower investment in the oil sands translates into reduced production. While this is true for oil sands production, conventional oil production is down year over year in 2015 compared to 2014 as is rig counts. Furthermore, there will be much less activity in the sectors that support the upstream industry, such as those servicing oil producers in the areas of engineering, drilling, construction, and other support services.

As conventional crude oil production is forecasted to decline, we assume that the new incremental capital will be invested within the oil sands projects only for the 7-year time horizon. Consequently, two forecasts of oil sands capital investment were estimated based on the incremental production capacity that would be added over the next 7 years and existing capacity that needs sustaining capital to maintain the production levels.[6] These forecasts are used as inputs in the I/O model.

[6] The capital investment forecast is based on incremental production capacity multiplied by an average capital intensity per barrel produced depending on the extraction method and technology.

Over the 7-year projection period from 2015 to 2021 inclusive, on average, the total initial and sustaining capital required is projected to be C$19.6 billion per year under the Reference Case and C$13.7 billion for the Low Case forecast, given the lower price forecast and production level. It could be argued that the capital investment forecast is too low in comparison to historic years, however the impact on capital investment could be greater due to constrained industry cash flow and inability to access capital markets for funding new projects in a low price environment.

Figure 2.4: Capital Investment



Source: CERI, CanOils

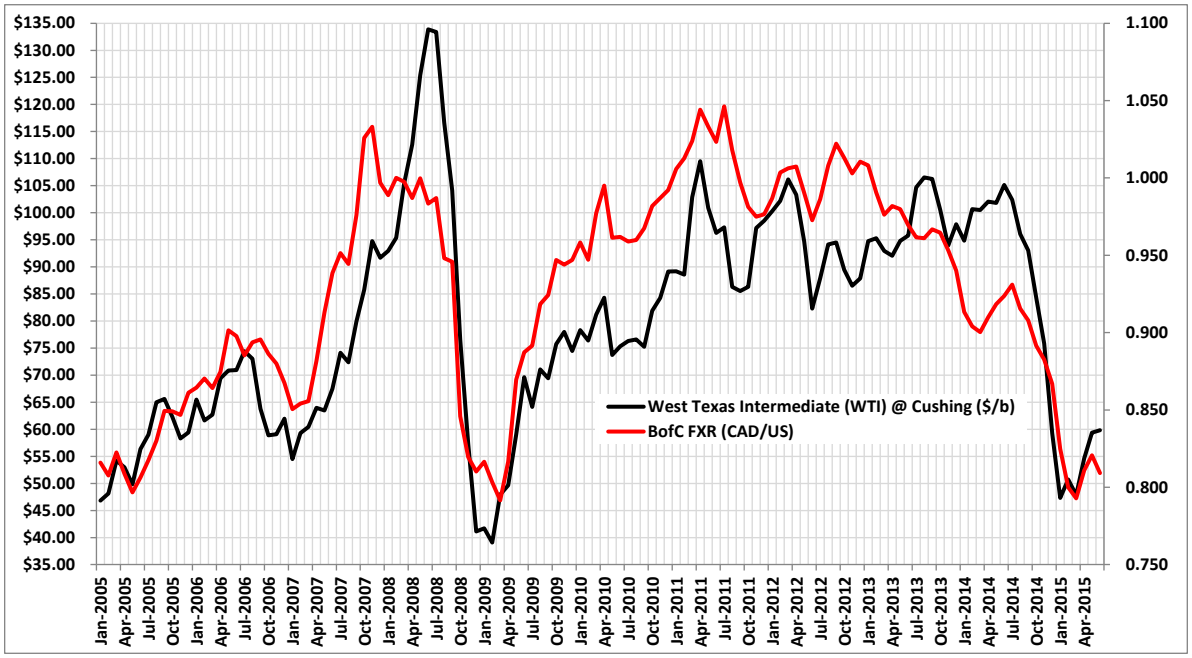
Canadian/US Exchange Rate

The biggest economic change to Canada as a result of lower oil prices has been the corresponding decline in the Canadian dollar. Since the summer of 2014, the price of oil has dropped to its lowest point in years – and so has the Canadian dollar, continuing an ongoing debate on how closely the two are related. Canada's dollar is often viewed as a petrocurrency because its movements often track oil prices (see Figure 2.5). In simple terms, a petrocurrency is a currency of an oil-producing country — such as Canada — whose oil exports as a share of total exports are sufficiently large enough that the currency's value rises and falls along with the price of oil. In other words, a petrocurrency appreciates when the oil price rises and depreciates when the oil price falls.

Since 2008, when the WTI price closed for the first time at over US$100/bbl and the Canadian dollar was trading at close to parity with the US dollar, prices and exchange rates have undergone change. The most recent 50 percent decline in oil prices in the summer 2014 coincides with the depreciation of the Canadian dollar. The US dollar's strength – driven by investors betting on the US Federal Reserve to raise interest rates – has also pressured the Canadian dollar, something analysts expect will be exacerbated if the US tightens their monetary policy, while the Bank of Canada remains accommodative with their rate strategy.

Given the two oil price forecasts and high correlation factor between the exchange rate and oil prices[7,8] a different exchange rate assumption was made for each Case. A US/CDN$0.85 will be assumed in the Reference Case, and for the Low Case we assume an exchange rate of US/CDN$0.75.

Figure 2.5: CDN/US Exchange Rate and WTI Price



Source: EIA, Bank of Canada

Other Economic Sectors

For the last decade the Canadian dollar has been gaining traction on international markets – mostly because financial speculators came to identify the currency with the global price of oil. That extrapolation made all other products (including manufactured goods, services, tourism, and more) in relation to the dollar seem more expensive to foreign buyers, and those sectors suffered a corresponding downturn. Now that the Canadian dollar has depreciated and is forecasted to remain low, there are positive signs for non-energy related businesses, especially if those businesses are involved in non-energy exports.

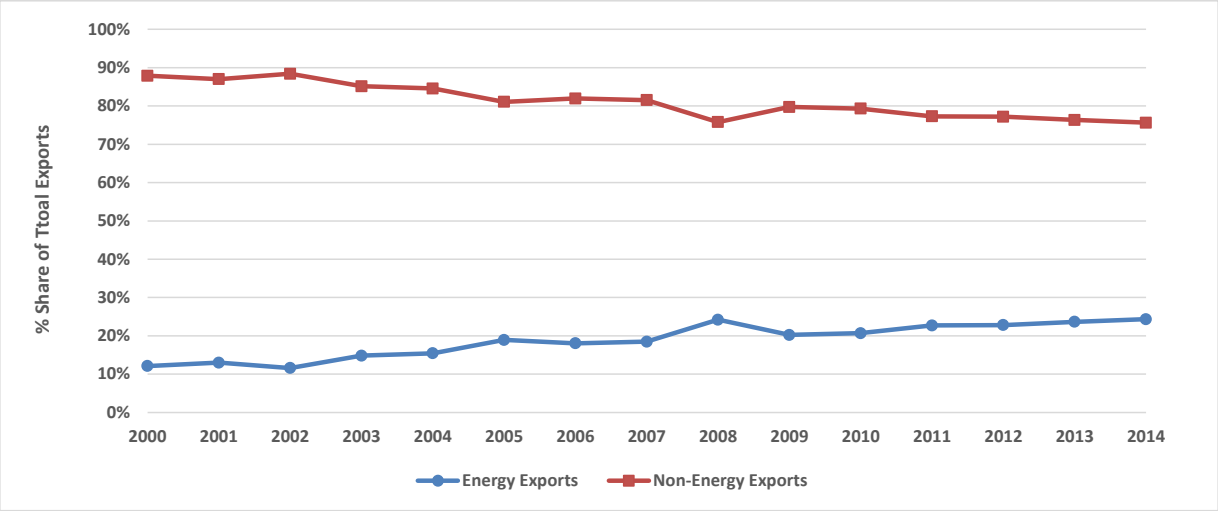
One negative side effect of the last oil boom was the damage it did to Canada's exports. Oil and other energy exports grew rapidly. But at the same time, all other exports (manufactured goods, services, and tourism) declined – partly because of the higher-valued currency. Canada's trade

[7] http://news.ubc.ca/2015/04/16/is-the-canadian-dollar-a-petrocurrency/

[8] http://www.bankofcanada.ca/wp-content/uploads/2012/02/workshop-exchange-rates-june2011-Ferraro-Rogoff-Rossi-presentation.pdf.

balance was pulled in two directions: a significant growth in energy exports, but a continued decline in other exported products and services (see Figure 2.6).

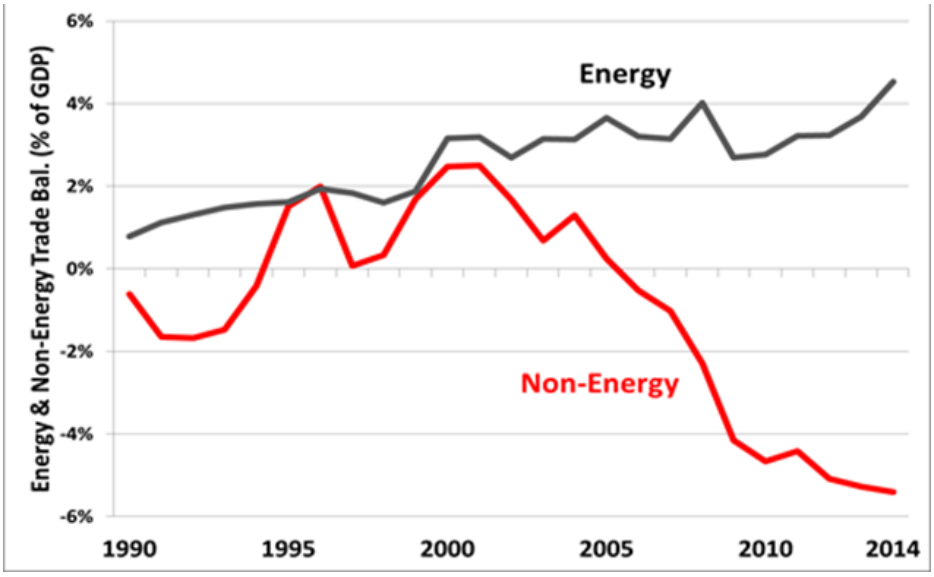
Figure 2.6: Energy and Non-Energy Exports



Source: Statistics Canada

This impacted Canada's trade balance, in essence, even when oil prices were high, energy revenues were not enough to pay off huge deficits in non-energy goods and services. As a result, Canada began to experience large deficits in international payments, beginning in 2008. Figure 2.7 shows a historical long-term view of Canadian energy and non-energy trade balances as a percentage of GDP since 1990.

Figure 2.7: Canadian Energy and Non-Energy Trade Balances



Source: Unifor Research, Statistics Canada.

Some parts of Canada's economy will benefit from lower energy prices, including airlines, other transportation providers, and some manufacturing. At the same time, some industries depend on the energy sector (such as factories which manufacture pipes and other oil equipment); they will feel the negative effects of the slowdown in oil investment. The sum total of positive and negative impacts that affect dozens of different industries are presented in the next chapter.

For the purposes of the I/O analysis under the Low Case, sectors that are impacted positively are assumed to be the ones that are export-oriented sectors of the economy, where devaluation of the Canadian dollar would contribute to higher levels of performance. Specifically, the five sectors that are evaluated are "Retail Trade", "Wholesale Trade", "Other Manufacturing", "Finance, Insurance, Real Estate and Rental and Leasing", and "Transportation and Warehousing".[9] The future outlook of those sectors in the I/O modelling was measured by the percentage difference of the forecasted value of non-energy exports in Canadian versus in US dollars.

It is important to note that while stronger growth in non-energy exports from a lower Canadian dollar is already occurring, the economic benefits from increased investment and jobs/salaries will take time and will lag behind the growth in exports.[10] However, the time element cannot be modelled in the I/O set-up since I/O coefficients are based on value relationships between one sector's outputs to other sectors based on a specific year. Even though the relationship and, thus, the stability of coefficients, could change over time due to several factors, it is not captured in the I/O model. Since these attributes cannot be incorporated in a static I/O model, the modelling is primarily used over a short-run time horizon, where relative prices and productivity are expected to remain relatively constant.

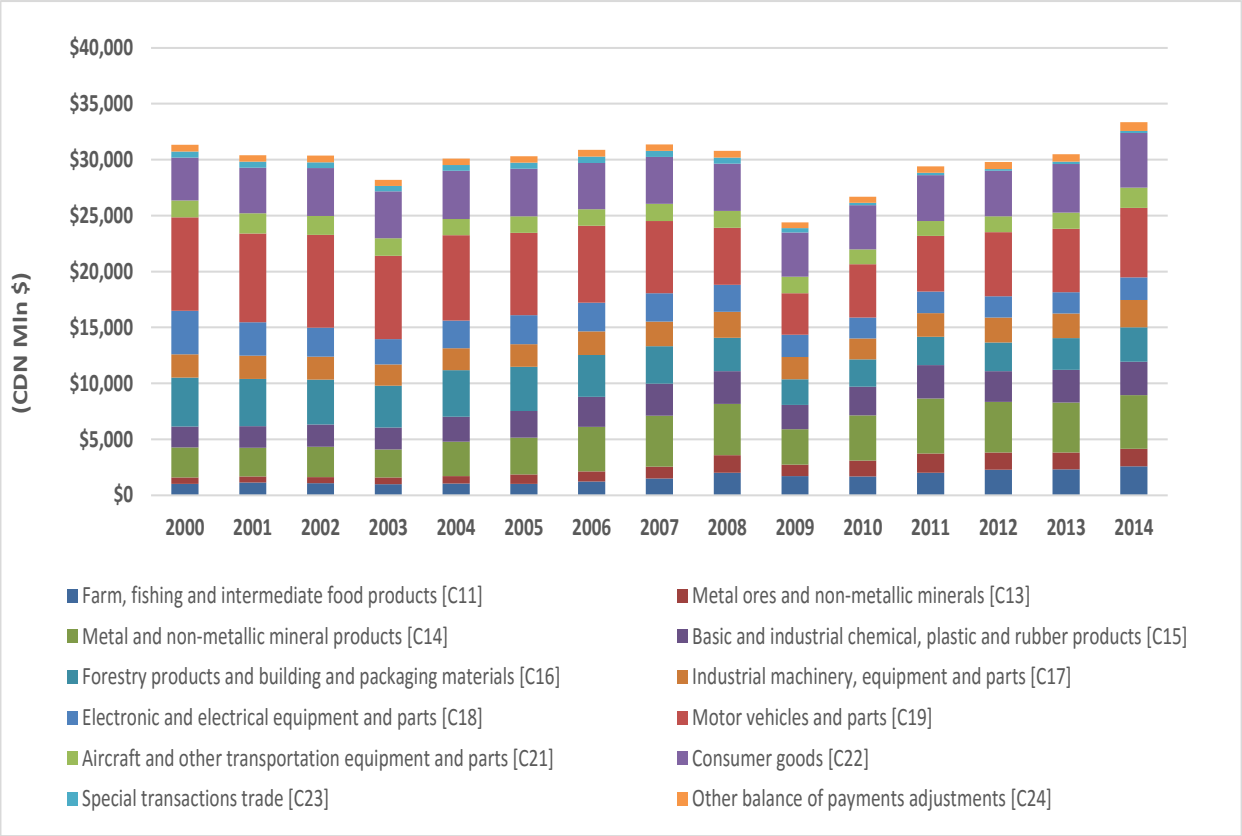
The increase in non-energy exports is considered as an incremental positive impact of the low exchange rate and inputted into the model under those five sectors in the provinces of British Columbia, Alberta (only for non-energy exports), Saskatchewan, Manitoba, Ontario, Quebec, and some in Atlantic Canada (again, only non-energy exports). These provinces were chosen based on historical data that suggests that their exports' share of total Canadian exports are the highest among all other provinces, together they account for 74 percent of all Canadian exports.

Hence, a forecast of Canadian non-energy exports was needed to capture the positive impact of low crude prices on the Canadian economy. First, historical exports were obtained from Statistics Canada and energy exports were taken out of the analysis. Figure 2.8 illustrates the total Canadian non-energy exports as classified by Statistics Canada. There are over 10 different categories which form 30 non-energy sub-sectors. Over the last ten years, the Canadian non-energy exports totalled just under C$30 billion per year on average.

[9] To see the full list of Canadian economic sectors that make up CERI's I/O model, refer to Appendix A.

[10] Bank of Canada. "Life after Liftoff: Divergence and U.S. Monetary Policy Normalization". Remarks by Stephen S. Poloz. January 2016.

Figure 2.8: Canadian Non-Energy Exports



Source: Statistics Canada, Table 228-0059

A forecast of non-energy exports was estimated by applying a calculated compound annual growth rate of 0.4 percent[11] to export categories that are found to be sensitive to movements in the CDN/US exchange rate. The sensitivity analysis of non-energy export categories was sourced from the Bank of Canada's discussion paper,[12] which finds that among the 31 evaluated sub-sectors, "around half of the [non-energy] sub-sectors appear to be quite sensitive to persistent movements in the exchange rate". Table 2.1 presents the non-energy categories that were assumed to be exchange rate sensitive and included in the analysis. Out of the 12 non-energy export categories, two were found to be non-sensitive and hence excluded from the modelling. They are C11 – Farm, fishing and intermediate food products and C16 – Forestry products and building and packaging materials.

[11] CAGR is calculated for the total Canadian non-energy exports using the historical data from 2000 to 2014.
[12] A. Binette, D. de Munnik, and E. Gouin-Bonenfant. "Canadian Non-Energy Exports: Past Performance and Future Prospects". Bank of Canada, Discussion Paper 2014-1. April 2014.

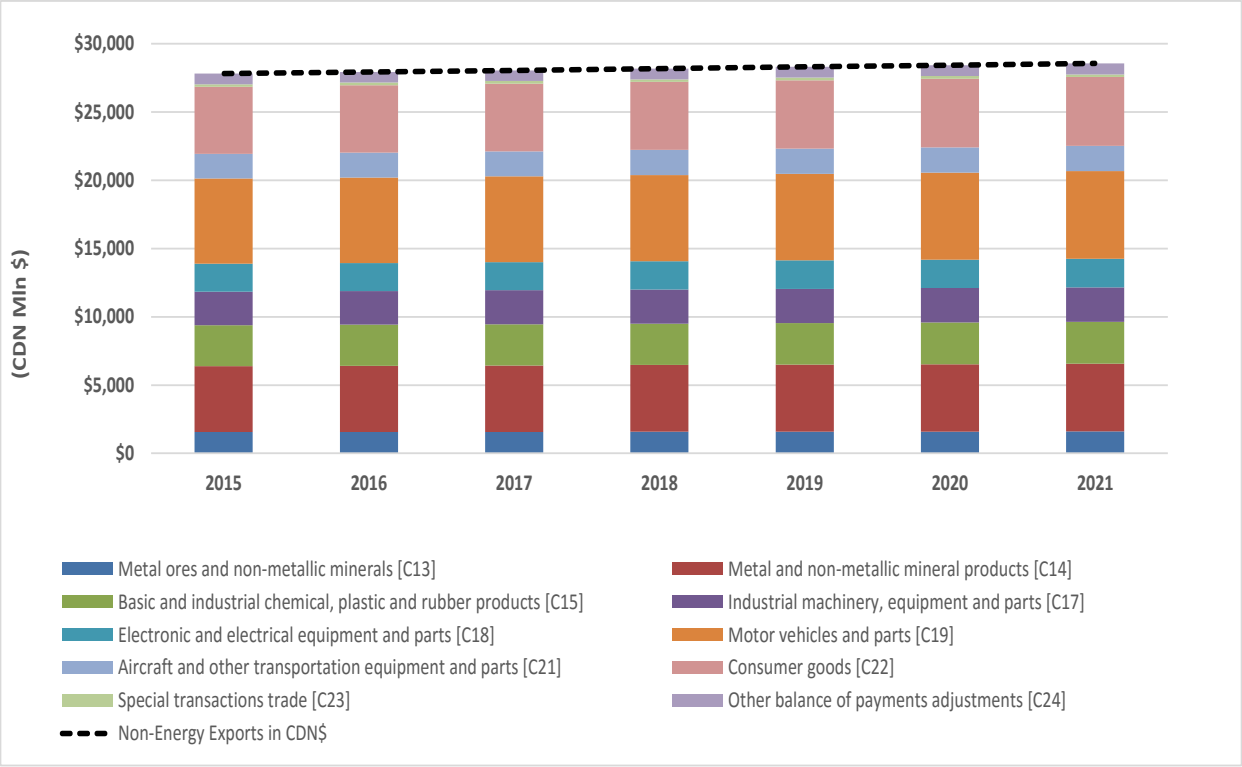
Table 2.1: Non-Energy Export Categories

Export Category	Ex.Rate Sensitive
Farm, fishing and intermediate food products [C11]	No
Energy products [C12]	Yes
Metal ores and non-metallic minerals [C13]	Yes
Metal and non-metallic mineral products [C14]	Yes
Basic and industrial chemical, plastic and rubber products [C15]	Yes
Forestry products and building and packaging materials [C16]	No
Industrial machinery, equipment and parts [C17]	Yes
Electronic and electrical equipment and parts [C18]	Yes
Motor vehicles and parts [C19]	Yes
Aircraft and other transportation equipment and parts [C21]	Yes
Consumer goods [C22]	Yes
Special transactions trade [C23]	Yes
Other balance of payments adjustments [C24]	Yes

Source: Statistics Canada, Bank of Canada

Figure 2.9 illustrates the forecast of non-energy exports that fall under the ten categories that are exchange rate sensitive. The non-energy exports are forecasted to grow at 0.4 percent per year, averaging a similar historical value of under CDN$30 billion per year (CDN$28,180 million) over the forecast period. By applying the assumed exchange rate (i.e., 0.75US$/CDN), the conversion of exports to the US dollar shows on average a 30 percent difference between the two currencies. This percentage difference translates to an annual average of CDN$7,557.6 million that, for the purposes of I/O modelling, is split among the five mentioned industry sectors ("Retail Trade", "Wholesale Trade", "Other Manufacturing", "Finance, Insurance, Real Estate and Rental and Leasing", and "Transportation and Warehousing") across the provinces. The split of this incremental growth among the sectors is as follows: "Retail Trade" and "Wholesale Trade" – make up 40 percent each of the total, while "Other Manufacturing", "Finance, Insurance, Real Estate and Rental and Leasing", and "Transportation and Warehousing" make up the rest and are split equally among the three sectors. These impacts are then weighted by each province's contribution to total non-energy exports.

Figure 2.9: Non-Energy Exports Forecast



Source: CERI, Statistics Canada

Table 2.2 summarizes the assumptions for the two different Cases.

Table 2.2: Summary of Assumptions

Parameter	Unit of Measurement	Reference Case	Low Case
Time Frame	Years	7	7
First Year of Forecast	Year	2015	2015
US/CDN exchange rate	US$/CDN$	0.85	0.75
WTI price	2014 $/bbl	$53.25(2015)-$72.88(2021)	$46.26(2015)-$51.52(2021)
Oil Sands Production	MMBPD	2.1(2015)-3.1(2021)	2.0(2015)-2.9(2021)
Capital Investment	CDN Mln $/year (avg)	19,575.64	13,702.95
Change in Non-Energy Exports	CDN Mln $(7-yr avg)	No Change	7,557.6

Source: CERI

As mentioned earlier, any activity that leads to increased production capacity in an economy has two components: a) the construction or development of the capacity, and b) the operation of the capacity to generate outputs. The first component is referred to as *investment*, while the second is either *production or operation*. Both activities affect the economy through purchases of goods and services, as well as labour. Table 2.3 shows how various inputs flow into the model under the two Cases.

Table 2.3: I/O Inputs

Reference Case

- Investment:
  - Reference Case Capital Investment in oil sands
- Operations:
  - Oil Sands Revenues (Reference Case price and production)

Low Case

- Investment:
  - Low Case Capital Investment in oil sands
- Operations:
  - Oil Sands Revenues (Low Case price and production)
  - Change in non-energy exports*

*We assume that the incremental change in non-energy exports as a result of a low exchange rate will only transpire on the operations side of the aforementioned economic sectors. In other words, no capital investment assumption is made to build production capacity in those five economic sectors in the 7-year time period.

Chapter 3: Impact Results

This Chapter presents the results of modelling the Reference and Low Cases utilizing CERI's I/O model. The results are presented for each Case and then compared side-by-side to illustrate the impact low crude oil prices could have on the Canadian economy. The results are shown on a cumulative (i.e., total for 2015-2021 time period) and annual basis.

National Impacts

The Reference Case results indicate that the total impacts associated with both construction and operation of projects in Alberta's oil sands industry and direct staging and assembling facilities in other communities in order to construct and operate these projects for the period 2015 to 2021 are forecasted to be significant. Table 3.1 presents these impacts.

Table 3.1: Economic Impacts – Reference Case

Investment and Operations	$CAD Million		Thousand Person Years
2015-2021	GDP	Compensation of Employees	Employment
Alberta	735,791	329,013	3,329
British Columbia	21,843	13,341	196
Manitoba	3,679	2,112	37
New Brunswick	1,090	608	11
Newfoundland/Labrador	513	232	4
Nova Scotia	872	541	9
Nunavut	75	53	1
Northwest Territories	172	107	2
Ontario	45,648	27,649	339
Prince Edward Island	75	44	1
Quebec	14,470	8,194	137
Saskatchewan	6,027	2,634	43
Yukon Territory	79	49	1
Governments Abroad	0	0	0
Total Canada	**830,336**	**384,578**	**4,109**

Source: CERI

The total cumulative Canadian GDP impact amounts to $830 billion (2014 Canadian dollars) and employment (direct, indirect, and induced) is projected to be just above 4 million person years, averaging 587,000 jobs per year (see Figure 3.2). Approximately 88 percent of the GDP impacts and 81 percent of the employment impacts occur in Alberta since oil sands projects are located in that province. Other provinces stand to gain, given that the service and manufacturing sectors located outside of Alberta are involved with these projects as well. Hence, Ontario and Quebec account for 7.2 percent of the GDP impacts and 11.6 percent of the employment impacts.

The other provincial impacts are also detailed in Table 3.1. Compensation impacts are almost $385 billion. Given that the other crude producing provinces such as Saskatchewan and Newfoundland are only shocked indirectly through the service sector and crude exports, the total economic impacts (including the potential impacts of upstream oil extraction outside of oil sands) might be underestimated.

The total corporate, indirect and personal taxes collected at the federal and provincial levels are presented in Table 3.2. Overall, the new investment and operation of existing projects will generate $95 billion in federal taxes and $58.5 billion in provincial taxes.

Table 3.2: Tax Revenues – Reference Case

Investment and Operations 2015-2021	Federal $CAD Million	Provincial $CAD Million
Alberta	85,294	50,123
British Columbia	2,275	1,585
Manitoba	337	342
New Brunswick	96	93
Newfoundland/Labrador	42	45
Nova Scotia	86	82
Nunavut	6	2
Northwest Territories	15	10
Ontario	4,914	4,035
Prince Edward Island	7	8
Quebec	1,467	1,734
Saskatchewan	518	480
Yukon Territory	6	3
Total Canada	95,063	58,543

Source: CERI

Under the Low Case, the measured economic impacts are less than under the Reference Case. Table 3.3 presents the summary of these findings.

In the 7-year period from 2015 to 2021, the GDP impact amounts to $627 billion, with 82 percent of the impact felt in Alberta and 13.5 percent in the provinces of Ontario and Quebec. The distribution of economic impacts had shifted slightly away from Alberta due to i) lower production and investment in the crude oil industry, and ii) an increase in the non-energy exports in central Canada. Employment grows by almost 3.3 million person years, averaging 471,000 jobs per year and compensation amounts to almost $298 billion.

Table 3.3: Economic Impacts – Low Case

Investment and Operations	$CAD Million		Thousand Person Years
2015-2021	GDP	Compensation of Employees	Employment
Alberta	510,916	228,789	2,315
British Columbia	19,772	12,183	179
Manitoba	3,886	2,200	38
New Brunswick	887	493	9
Newfoundland/Labrador	416	187	3
Nova Scotia	1,117	683	11
Nunavut	55	39	1
Northwest Territories	137	83	1
Ontario	61,797	37,747	486
Prince Edward Island	67	39	1
Quebec	21,658	12,413	211
Saskatchewan	6,119	2,786	44
Yukon Territory	60	37	1
Governments Abroad	0	0	0
Total Canada	**626,887**	**297,680**	**3,298**

Source: CERI

The tax revenues collected by the governments are presented in Table 3.4.

Table 3.4: Tax Revenues – Low Case

Investment and Operations	Federal	Provincial
2015-2021	$CAD Million	$CAD Million
Alberta	59,241	34,821
British Columbia	2,069	1,456
Manitoba	356	362
New Brunswick	78	76
Newfoundland/Labrador	34	37
Nova Scotia	111	109
Nunavut	4	2
Northwest Territories	12	8
Ontario	6,661	5,479
Prince Edward Island	6	7
Quebec	2,199	2,603
Saskatchewan	529	495
Yukon Territory	5	3
Total Canada	71,307	45,457

Source: CERI

The two cases present two, of many, alternative outlooks that could emerge into the near future depending on crude oil prices and level of investment. In comparison, the Reference Case shows larger contributions to the Canadian economy than the Low Case, which corresponds with the initial hypothesis that lower oil prices are likely, on the whole, to be net negative for Canada. Estimation of the magnitude of that impact is shown in Table 3.5, which compares the two cases side by side. The results are shown on the cumulative basis over the 7-year time period.

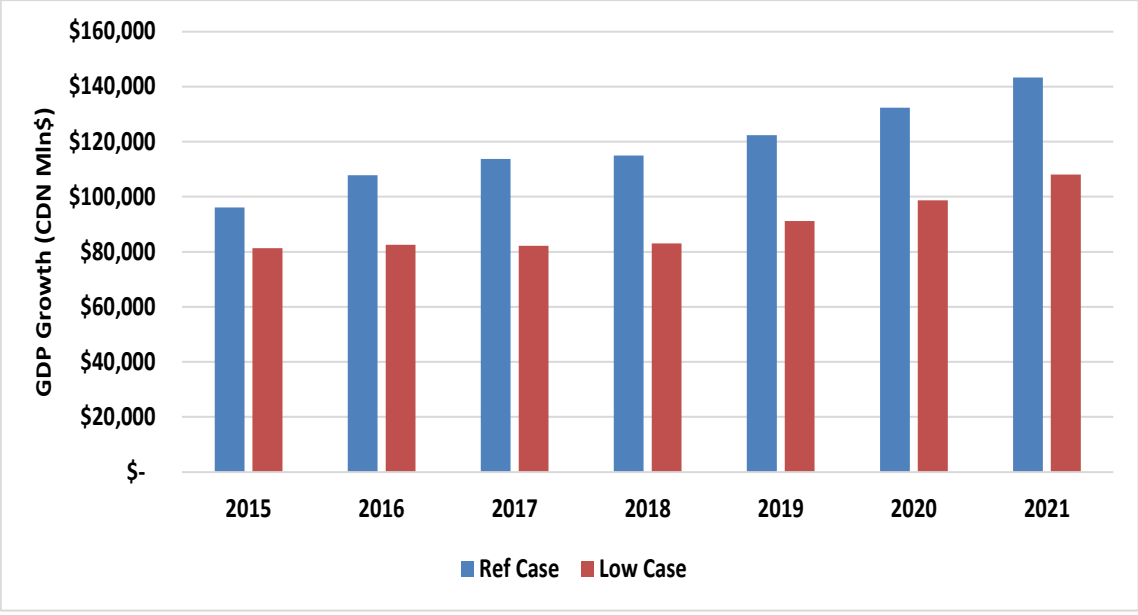
Table 3.5: Comparison of the Two Cases

2015-2021	Unit of Measure	Ref.Case	Low Case	Low vs. Ref. Case	% Change
GDP	Mlin CDN$	$ 830,336	$ 626,887	($203,449)	-24.5%
Compensation	Mlin CDN$	$ 384,578	$ 297,680	($86,898)	-22.6%
Employment	Thousand person-years	4,109	3,298	(811)	-19.7%
Federal Taxes	Mlin CDN$	$ 95,063	$ 71,307	($23,756)	-25.0%
Provincial Taxes	Mlin CDN$	$ 58,543	$ 45,457	($13,087)	-22.4%

Source: CERI

Canada's GDP will be reduced by lower oil prices and will cut into Canadian national incomes and spending power. GDP growth will be 24.5 percent lower in the Low Case versus in the Reference Case. Figure 3.1 shows annual GDP impacts for both cases. The annual average GDP impact under the Reference Case is $118.6 billion in comparison to an annual average of $89.5 billion in the Low Case.

Figure 3.1: GDP Impacts (2015-2021)

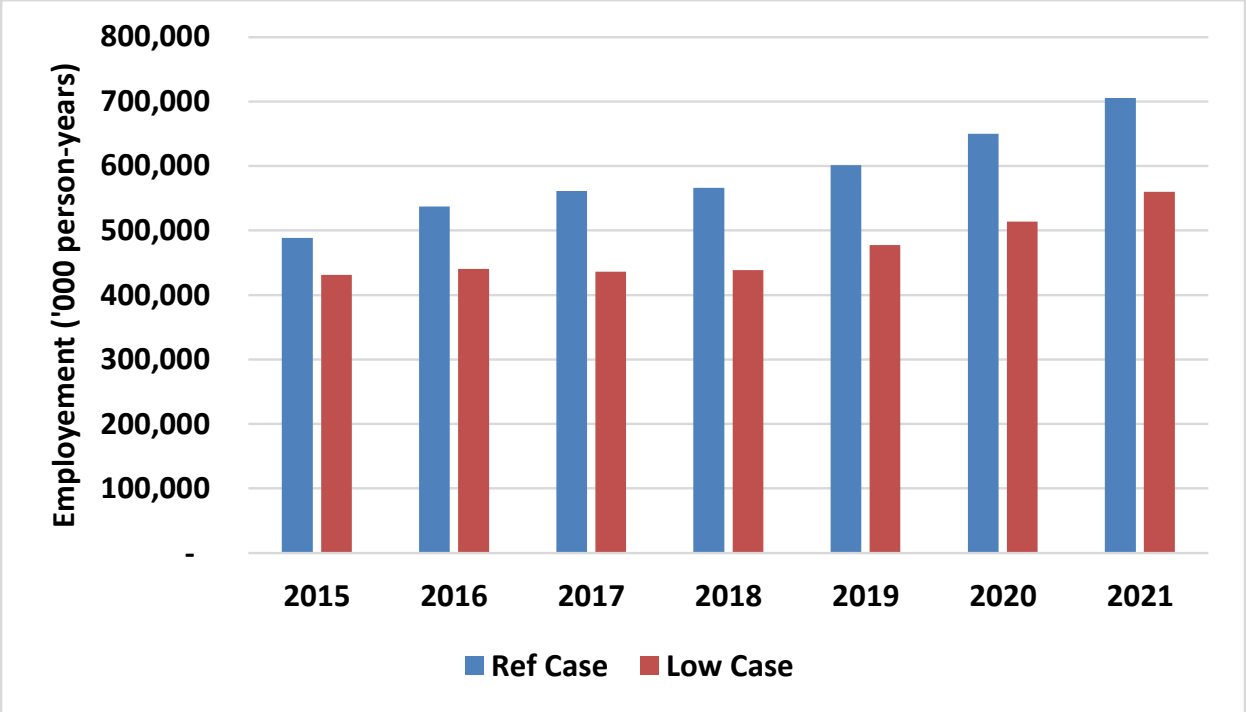


Source: CERI

The fall in oil prices will have a mixture of positive and negative effects on employment. Thousands of jobs have been lost already as a result of the recent price collapse, and more will be lost (if prices continue to fall) in the energy sector[1] – especially on new drilling and construction projects. Meanwhile, new jobs will be created in sectors which benefit from lower energy costs (like transportation and some manufacturing) even though that impact might take some time to be realized.

There will be net negative impacts on overall employment and compensation levels as a result of low crude oil prices. Overall, employment will be 19.7 percent lower in the Low Case than that under the Reference Case. The oil industry is very capital-intensive, but one of the least labour-intensive sectors in Canada's whole economy. Other sectors such as manufacturing create more jobs per unit of investment than the energy sector. So while petroleum industry revenues and profits will fall sharply in coming years, the impact on overall employment will be much less severe. Figure 3.2 illustrates annual changes in employment for both cases. Over the forecast period, it is estimated that, on average, there will be nearly 116,000 fewer jobs (direct, indirect and induced) in Canada if crude oil prices remain low.

Figure 3.2: Employment Impacts (2015-2021)

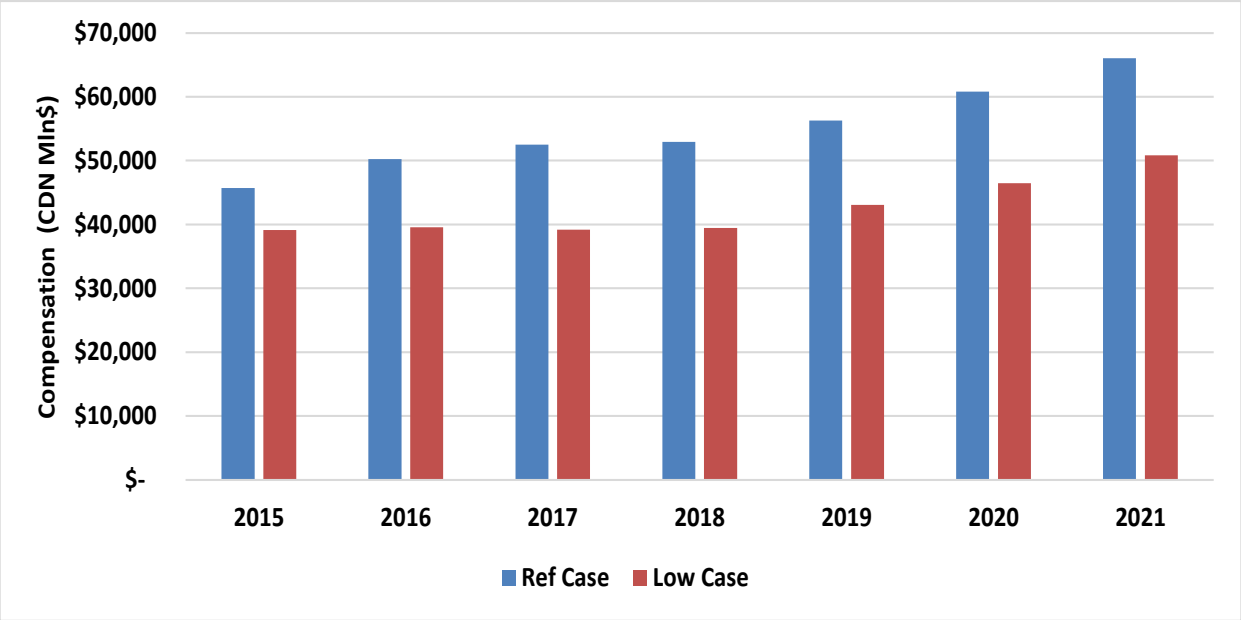


Source: CERI

[1] http://business.financialpost.com/news/energy/one-third-of-canadian-oil-and-gas-firms-expect-more-painful-job-losses-in-2016-survey

Even though the oil industry is less labour-intensive than other industries in Canada, it requires very skilled workers who are well compensated. The difference between the two cases in terms of compensation amounts to almost 23 percent, which indicates that losing highly skilled and higher paid jobs in the oil industry will have a larger impact than creating more less-skilled and lower paid jobs among other industries that are more labour-intensive. On an annual basis, an impact on compensation in the Reference Case adds up to $54.9 billion per year, which is over $12 billion more than in the Low Case, where the impacts measure at $42.5 billion per year (Figure 3.3).

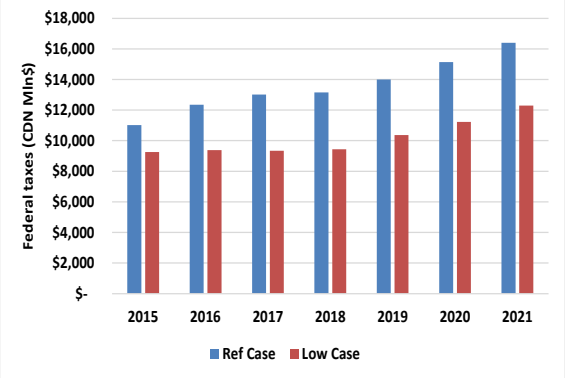
Figure 3.3: Compensation Impacts (2015-2021)

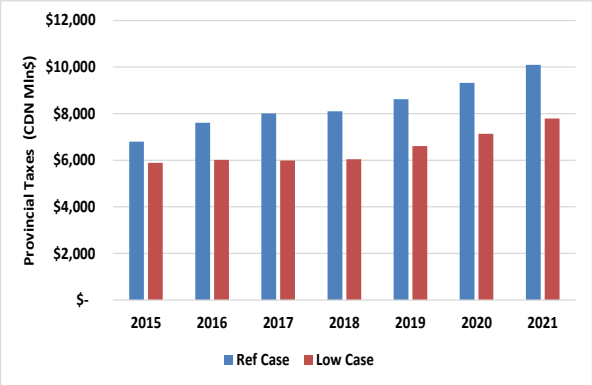


Source: CERI

With decreases in employment, employee compensation and profitability of the oil sector, government tax revenues will also be lower in the Low Case scenario. In fact, federally-collected tax revenues are the most impacted variable, with 25 percent difference between the Reference and Low Cases. The federal government's tax revenues depend on corporate oil revenues as well as personal taxes paid by employees, hence with lower prices, production and labour, it is not surprising that federal tax revenues are highly impacted. Annually, an impact on federal tax revenues amounts to $13.6 billion in the Reference Case and $10.2 billion in the Low Case. As for provincial taxes, under the Low Case, the cumulative impact will be 22.4 percent lower than under the Reference Case. An annual average adds up to $8.4 billion under the Reference Case and $6.5 billion under the Low Case (Figure 3.4).

Figure 3.4: Federal and Provincial Tax Revenues (2015-2021)





Source: CERI

Provincial Results

There isn't a province in the country that is not affected in some way by the drop in oil prices. Given that oil is Canada's leading export product, a drop-off in its value to the extent we are now witnessing cannot help but translate into slower economic growth in most regions of the country. It will also have a harmful effect on the federal government's revenues. When it comes to the West, the impact on the four provinces varies dramatically. Alberta's economy faces the largest negative impact. The lower economic performance is witnessed in Manitoba and Saskatchewan, while in British Columbia it is not nearly as acute. Ontario and Quebec, being the most populous and the least oil- and gas-oriented will in fact benefit from falling oil prices.

Given CERI's I/O model is based on StatsCan's provincial sectoral tables, we are able to see the impacts on a provincial basis, which is an important element, since the impact from low prices is not uniform across the provinces. The provincial impacts are presented below for some Canadian provinces. Some impacts are direct, like the oil sands sector, while others are impacted indirectly though the linkages in the I/O model.

Manitoba

While the oil and gas sector has been a solid contributor to economic growth in the province, it's not a major player. According to the provincial I/O results, the province's wholesale trades sector is expected to benefit the most from a lower Canadian dollar and rising US economy. The difference between the two cases in terms of Manitoba's GDP impact is 6 percent. In other words, under the Low Case, Manitoba will realize a higher GDP growth. The top five sectors, as determined by its contribution to provincial GDP, are presented in Table 3.6.

Table 3.6: Manitoba's Top Economic Sectors

Rank	Sector	Low Case		Ref Case	% Change
		%Share of Prov. GDP	(CDN$Mln)	(CDN$Mln)	%
1	Finance, Insurance, Real Estate and Rental and Leasing	18.99%	$ 738	$ 648	13.8%
2	Other Manufacturing	17.81%	$ 692	$ 755	-8.3%
3	Wholesale Trade	16.21%	$ 630	$ 390	61.7%
4	Household (Labour)	11.71%	$ 455	$ 429	5.9%
5	Transportation and Warehousing	8.19%	$ 318	$ 358	-11.0%

Source: CERI

Saskatchewan

While declining oil price impacts in the province are offset by the fall in the dollar (which helps other export sectors), it is still going to present challenges for the province's oil industry, which is one of the top-contributing industries in the province. Over the 7-year period, Saskatchewan's GDP impact is expected to be 2 percent more under the Low Case than under the Reference Case. Table 3.7 presents the top provincial sectors. While the oil sector is declining, other sectors will benefit from higher non-energy exports.

Table 3.7: Saskatchewan's Top Economic Sectors

Rank	Sector	Low Case		Ref Case	% Change
		%Share of Prov. GDP	(CDN$Mln)	Ref Case	
1	Other Manufacturing	13.79%	$ 844	$ 945	-10.7%
2	Wholesale Trade	12.77%	$ 781	$ 485	61.0%
3	Finance, Insurance, Real Estate and Rental and Leasing	12.06%	$ 738	$ 544	35.5%
4	Conventioanl Oil	9.83%	$ 601	$ 803	-25.1%
5	Transportation and Warehousing	8.91%	$ 545	$ 348	56.8%

Source: CERI

Alberta

It is not surprising that Alberta will be impacted the most from low crude oil prices. Since the oil price drop, investment in the oil industry has dropped sharply, corporate profits are declining, unemployment is rising and business activity is slumping. Economists in the country are talking about a fiscal shortfall in the province in the order of multiple billions of dollars. Overall, all top sectors will be in a bigger decline if the Low Case oil prices prevail over the next five years. The magnitude of GDP growth under the two cases is the largest among all other provinces and territories; GDP growth will be 31 percent lower under the Low Case. All the top economic sectors of the province will be in decline as shown in Table 3.8.

Table 3.8 Alberta's Top Economic Sectors

Rank	*Sector*	*Low Case*		*Ref Case*	*% Change*
		%Share of Prov. GDP	(CDN$Mln)	(CDN$Mln)	%
1	Oil Sands	39.72%	$ 227,898	$ 331,018	-31.2%
2	Household (Labour)	11.71%	$ 67,834	$ 97,582	-30.5%
3	Finance, Insurance, Real Estate and Rental and Leasing	7.89%	$ 46,115	$ 65,755	-29.9%
4	Conventioanl Oil	6.13%	$ 36,250	$ 51,080	-29.0%
5	Owner occupied dwellings	5.12%	$ 29,665	$ 42,675	-30.5%

Source: CERI

British Columbia

Obviously, British Columbia is not reliant on oil the way its neighbour is. In the meantime, a strong US housing market is helping the province's economy. A weak Canadian dollar is expected to aid the province's tourism sector. The effects of an economic slowdown in China, where BC has been shipping a greater percentage of its exports, will be partly offset by rising demand south of the border. Overall, British Columbia will experience an economic growth over the forecast time period, on average the impact is 9 percent lower in the Low Case versus the Reference Case (see Table 3.9). The sectors of this province that will see an increase in activity are the ones that are related to non-energy exports and trade.

Table 3.9: British Columbia's Top Economic Sectors

Rank	*Sector*	*Low Case*		*Ref Case*	*% Change*
		%Share of Prov. GDP	(CDN$Mln)	Ref Case	
1	Finance, Insurance, Real Estate and Rental and Leasing	16.05%	$ 3,173	$ 3,232	-1.8%
2	Household (Labour)	12.58%	$ 2,486	$ 2,727	-8.8%
3	Other Manufacturing	11.26%	$ 2,226	$ 2,460	-9.5%
4	Wholesale Trade	9.24%	$ 1,828	$ 1,370	33.4%
5	Transportation and Warehousing	8.59%	$ 1,699	$ 1,661	2.3%

Source: CERI

Ontario

If prices remain low, Ontario should see faster economic growth than provinces in the West. Again, the low Canadian dollar should boost the provincial trade and manufacturing sectors in the non-energy space. According to the Canadian Manufacturers & Exporters (CME), it will take some time for Ontario's manufacturing sector to be able to capitalize on lower production costs brought on by cheaper oil. That's because much of the excess capacity Ontario once had in its factories was closed during the financial crisis and subsequent recession and it will take time to

rebuild. Nonetheless, the increased demand for cheaper Canadian goods in the near term will at least increase the utilization of existing capacity.

Comparing the Reference and Low Case results suggests that the provincial economy of Ontario will grow more under the Low Case, an economic growth impact over the forecast time period, on average will be 35 percent higher in the Low versus the Reference Case. Table 3.10 illustrates the top-performing sectors of this province.

Table 3.10: Ontario's Top Economic Sectors

Rank	*Sector*	*Low Case*		*Ref Case*	*% Change*
		%Share of Prov. GDP	(CDN$Mln)	Ref Case	
1	Finance, Insurance, Real Estate and Rental and Leasing	23.22%	$ 16,083	$ 13,491	19.2%
2	Wholesale Trade	11.08%	$ 7,678	$ 3,310	132.0%
3	Household (Labour)	10.79%	$ 7,476	$ 5,407	38.3%
4	Other Manufacturing	10.16%	$ 7,037	$ 5,460	28.9%
5	Transportation and Warehousing	7.87%	$ 5,455	$ 2,893	88.6%

Source: CERI

Quebec

Quebec will experience a similar uptick in their economy as Ontario. Some of the drivers of growth are metal ore mining, manufacturing output such as aerospace products, food products, wood products and chemical products, services output like computer systems design services, financial investment services, legal services, transportation services and wholesale trade. The GDP impact difference between the two cases is the largest among all other provinces, averaging 50 percent. Table 3.11 presents the top economic sectors in Quebec.

Table 3.11: Quebec's Top Economic Sectors

Rank	*Sector*	*Low Case*		*Ref Case*	*% Change*
		%Share of Prov. GDP	(CDN$Mln)	Ref Case	
1	Finance, Insurance, Real Estate and Rental and Leasing	17.66%	$ 4,482	$ 3,262	37.4%
2	Household (Labour)	14.65%	$ 3,716	$ 2,424	53.3%
3	Other Manufacturing	13.48%	$ 3,421	$ 2,704	26.5%
4	Wholesale Trade	11.40%	$ 2,893	$ 997	190.1%
5	Transportation and Warehousing	7.66%	$ 1,943	$ 845	130.0%

Source: CERI

Atlantic Provinces

Provinces in Atlantic Canada will experience various impacts depending on whether crude oil and gas production is a dominant economic sector for that province or not. Newfoundland and Labrador, where offshore crude oil production contributes significantly to provincial economy, will experience a contraction in the economy under the Low Case. Similar to Alberta, economic growth will be 19 percent lower in the Low Case than in the Reference Case. However, the economy of Nova Scotia will expand under the Low Case scenario. Overall, between Newfoundland and Labrador, Nova Scotia, New Brunswick and Prince Edward Island, the difference in GDP growth between the two cases averages at 5 percent in favour of the Reference Case (see Table 3.12).

Table 3.12: Newfoundland and Labrador's Top Economic Sectors

Rank	*Sector*	*Low Case*		*Ref Case*	*% Change*
		%Share of Prov. GDP	(CDN$Mln)	Ref Case	
1	Conventioanl Oil	26.46%	$ 119	$ 155	-23.2%
2	Finance, Insurance, Real Estate and Rental and Leasing	8.30%	$ 37	$ 45	-18.0%
3	Transportation and Warehousing	7.60%	$ 34	$ 42	-17.9%
4	Household (Labour)	7.35%	$ 33	$ 41	-19.2%
5	Other Mining	7.16%	$ 32	$ 31	3.2%

Source: CERI

Northern Region

The economies of Northwest Territories, Yukon, and Nunavut will experience a contraction in their economies if the Low Case scenario prevails. On average, there will be a 24 percent difference between the Reference Case and the Low Case. The mining, quarrying, and oil and gas extraction sectors of the three regions will be on a decline, dragging down the overall economic growth.

Chapter 4: Conclusion

One of the biggest risks to Canada's economic outlook stems from the recent decline in the price of oil and other commodities. As a net oil exporter, Canada is and will be affected by the lower prices, operating through several channels as described in the report. These include changing consumer spending in response to lower energy prices and, consequently, the falling Canadian dollar, falling investment and employment in the economy's resource sector, and rising investment and employment in the non-resource sectors.

Signs of a broadening recovery have been emerging during the past year. Stronger US growth and a weaker Canadian dollar have boosted non-energy exports. Investment spending and job creation have also begun to pick up in non-energy sectors, although significant slack remains in the labour market. But overall, Canadian economic growth could be on average 23 percent lower if low oil prices persist over the next seven years. The regional differences suggest that some provinces will hurt and some will benefit from lower crude prices, but on the national level, Canadian economic growth will suffer as a result of low crude prices.

On a cumulative basis:

- GDP growth will be 24.5 percent lower in the Low Case versus the Reference Case. The annual average impact under the Reference Case is $118.6 billion in comparison to an annual average of $89.6 billion in the Low Case.
- Employment will be 19.7 percent lower in the Low Case than that under the Reference Case. Over the forecast period, it is estimated that, on average, there will be almost 116,000 fewer jobs (direct, indirect and induced) in Canada if crude oil prices remain low.
- Overall compensation in the Canadian economy is estimated to be about $54.9 billion on an annual average basis in the Reference Case compared to $42.5 billion in the lower oil price scenario, for a decline of over $12 billion on an annual average basis.
- Federal tax revenues amount to $13.6 billion in the Reference Case and $10.2 billion in the Low Case, a 25 percent decrease.
- Under the Low Case, provincial taxes have a cumulative impact of 22 percent lower than under the Reference Case. The annual average is $8.4 billion under the Reference Case and $6.5 billion under the Low Case.

It is not a surprise that Western Canadian provinces will be negatively impacted by low oil prices, the low exchange rate will not offset the decline of the energy sector. Provinces in eastern Canada will fare much better from the price decline and actually see higher economic growth.

Among various economic sectors, those that will be negatively impacted are the upstream energy sectors and those other service-oriented sectors that aid the upstream oil industry in Canada; other sectors that will be impacted are energy exports, refining, and other midstream and downstream sectors that rely on the upstream energy sector. The largest negative impacts are associated with the oil sands sector.

The sectors that will see economic growth are the ones that are non-energy related. Trade, tourism, some manufacturing, and finance are among the few that will see the positive impacts. The largest positive impacts are seen in the Finance, Insurance, Real Estate, Rental and Leasing sector.

In summary, for the duration of the forecasted time horizon (2015-2021), every dollar gain in the annualized price of WTI, as measured by the Canadian dollar per barrel, would increase national Canadian GDP by $1.7 billion on average.

Appendix A: Input-Output Model

CERI's US-Canada Multi-Regional I/O Model (UCMRIO 3.0)

Appendix A discusses CERI's US-Canada Multi-Regional Input/Output Model (UCMRIO 3.0) and the process to build it.

Development of the UCMRIO 3.0

The following illustrates how the bi-national UCMRIO 3.0 was developed, and how one can trace direct, indirect, and induced effects of the Canadian energy sector on the Canadian and US economies. The model provides insights at the provincial level for Canada and at the state level for the US. The base year for the I/O tables is 2009.

Compilation of the bi-national UCMRIO 3.0 includes the following:

1) Statistics Canada provides S level Symmetrical I/O tables (SIOTs) and Final Demand tables for 13 provinces and territories plus Government Abroad. Therefore, there are 14 regional tables for Canada plus one national table. Provincial data are only available at the S level due to confidentiality of more disaggregated data for some sectors in various provinces. The I/O tables used are at producer's prices (Basic Prices), meaning that CERI did not construct symmetrical tables from the Use and Make tables, as the compiled tables were available. As previously mentioned, the base year for the I/O tables is 2009.[1]
2) SIOTs are balanced. Hence, the use of inputs in the economy is equal to the production of outputs.
3) The US national Use and Make tables were sourced from the US Bureau of Economic Analysis (USBEA). These tables also use 2009 as the base year. These tables are at producer's prices (Basic Prices) and consist of 65 sectors and 13 final demand categories. CERI compiled the US SIOT table and carefully combined industry sectors in order to arrive at 24 industry sectors, consistent with Canadian S level aggregation.

   The intermediate and final demand part of the US SIOT table is constructed as follows:

$$B=V(\text{diag}(q-m))^{-1}U \quad \text{and} \quad F=V(\text{diag}(q-m))^{-1}Y \qquad \text{(Equation 1)}$$

   Where:
   B: Transformed intermediate part of use table to symmetric I/O table
   F: Transformed final demand part of use table for symmetric I/O table
   V: Transpose of make table excluding imports
   U: Intermediate demand part of use table
   Y: Final demand part of use table
   q: Vector of total supply of products

[1] Use tables show the inputs to industry production and commodity composition of final demand. Make tables show the commodities that are produced by each industry.

m: Vector of imports by products
diag(q-m): Matrix with q-m on the diagonal

By using these equations, the rectangular commodity by industry Use and Make tables are transformed to a symmetrical square I/O table and its corresponding final demand matrix.

4) In order to highlight the energy sectors in the Canadian provincial SIOTs, CERI disaggregated the "Mining and Oil and Gas Extraction'' industry into 5 sub-sectors: Conventional Oil, Oil Sands, Natural Gas and LNG, Coal, and Other Mining. In the same fashion, the manufacturing sector is divided into 3 sub-sectors: Refinery, Petrochemical, and Other Manufacturing.
5) It is important to note that the construction sector in this version is already split into the following 5 sub-sectors by Statistics Canada: Residential Construction, Non-residential Building Construction, Engineering Construction, Repair Construction and Other Activities of the Construction Industry.
6) Whereas the trade flow between Canadian provinces and territories is provided by Statistics Canada, the trade flow pattern between the individual provinces and the US is not available. The data is gathered from a variety of sources and compiled by CERI into a trade flow pattern between the two countries.
7) In the UCMRIO 3.0, an exchange rate is needed in order to link data from US and Canada to a common currency. CERI uses a parity exchange rate between the US and Canadian dollar for the base year 2009 to convert the trade flow matrix into Canadian dollars.
8) CERI combines 15 SIOTs (13 provincial tables, 1 for Government Abroad and 1 for the US at the national level) to compile one bi-national I/O matrix. The bi-national matrix is then merged with the trade flow matrix, and inverted to generate direct, indirect, and induced effect multipliers.

US-Canada Trade Table and Model Structure

An important component to the modelling process is the construction of the trade flow matrix. The trade flow matrix connects the US I/O table to the Canadian I/O tables, and depicts a trading pattern between each Canadian province or territory and the US national economy. The trade flow table for UCMRIO 3.0 depicts the export/import flows of each Canadian province with the US and with each other. In particular, the Alberta trade flow table shows the import (export) flows of Alberta from (to) other Canadian provinces and territories, as well as the US. It is important to mention that the industry specification of this table is the same as SIOTs, and thus covers the trade flows among all sectors of the economies.

The following is a brief discussion of the modelling.

Based on a standard I/O model notation, and considering total gross outputs vector (**X**) and final demand vector (**FD**), the following relationship in I/O context holds as:

$$AX+FD = X \rightarrow (I-A)X=FD \rightarrow X= (I-A)^{-1}FD \rightarrow X= L.FD \qquad \text{(Equation 2)}$$

Where:
A = the matrix of input coefficients (n×n),
I = identity matrix (n×n), and
L = the Leontief inverse matrix (n×n).

This is the core formula of the Leontief quantity model. This relationship estimates direct and indirect impacts for a single economy (i.e., no trade flow). CERI can expand this model to include induced effects by endogenizing the most important component of local final demand, namely private consumption. This captures the economic impact of increased consumption due to earned wages from new jobs.

After endogenizing the private consumption expenditure, CERI arrives at the following relationship:

$$\mathbf{X= (I-Aind)^{-1}FD^*} \qquad \textbf{(Equation 3)}$$

CERI endogenizes the household's private consumption expenditures and earnings by adding one column and one row to every province or to the US *intermediate matrix* which then creates a new matrix of input coefficients as labeled **Aind**. This relationship estimates direct and indirect impacts.

CERI can extend the model to involve other economies (regions) by incorporating the interregional trade flow matrix **C**(n×n). After several steps of calculation, we arrive at the final interregional formula:

$$\mathbf{X= (I-C.Aind)^{-1}C.FD^*} \qquad \textbf{(Equation 4)}$$

To have a finite solution, the above equation **(I-C.Aind**) must be a non-singular matrix.[2] As is the case for standard I/O models, the impact of an industry, such as the oil sands industry, is calculated by modelling the relationship between total gross outputs and final demand as follows:

$$\mathbf{\Delta X= (I-C.Aind)^{-1}C.\Delta FD^*} \qquad \textbf{(Equation 5)}$$

Where:

ΔX -- Changes (or increases) in total gross outputs of the US and all provinces and territories, at the sectoral level, due to construction and operation of projects (i.e., oil sands). Dimension is either n=485 or 500. As a result, this vector is a 485x1 or 500×1 vector.

I – is a 485x485 or 500×500 identity matrix, unity for diagonal elements and zero for off-diagonal elements.

A – is a 485×485 block diagonal matrix of technical coefficients at the sectoral level for the US and Canada. It is composed of 14 blocks of 33×33 matrix corresponding to each provinces

[2]For further information on Interregional I/O analysis please see Hertwich and Peters (2010), Miller and Blair (2009), CERI Study No. 120 (2009), Oosterhaven and Stelder (2008), and Sim, Secretario, and Suan (2007).

(or territory's) input technical coefficient matrix and one block of 23x23 matrix for the US.[3] An element of such a matrix is derived by dividing the value of a commodity used in a sector by the total output of that sector. The element represents requirements of a commodity in a sector in order to produce one unit of output from that sector.

Aind – is a 500×500 block diagonal matrix of technical coefficients at the sectoral level for the US and Canada. It is composed of 14 blocks of 34×34 matrix corresponding to each provinces (or territory's) input technical coefficient matrix and one block of 24x24 matrix for the US.[4] An element of such a matrix is derived by dividing the value of a commodity or household expenditure and earnings used in a sector by the total output of that sector or household expenditure. The element represents requirements of a commodity in a sector in order to produce one unit of output from that sector.

C – is a 485x485 or 500×500 transposed matrix of multi-regional trade coefficients. It includes import and export shares of a sector's total output in the US and province or territory. Each element on the row of this matrix measures the share of export to a particular sector in the US or a province from a given sector in another province or territory or the US.[5]

ΔFD* – is a 485x1 or 500×1 vector of changes (or increases) in the exogenous part of final demand at the sectoral level. Outputs from Canada and the US resulted from any change in the final demand components in the US or any province or territory, including commodities directly demanded (or purchased) for the construction and development of any sector.

The calculation of total impact is based on the multiplication of direct impact and the inverted matrix. Based on the direct impact on a sector, Equation 1 above is used to estimate all the direct, indirect, and induced effects on all sectors in all provinces, particularly in terms of changes in consumption, imports, exports, production, employment, and net taxes. The direct impact is referred to as **ΔFD*** in Equation 5. The change in final demand (**ΔFD***) consists of various types of investment expenditures, changes in inventories, and government expenditures. In the current model, the personal expenditures are not part of the final demand and have been endogenized to accommodate the induced impact.

Direct impacts are quantitative estimations of the main impact of the programs, in the form of an increase in final demand (increase in public spending, increase in consumption, increase in infrastructure investment, etc.). The assumption of increased demand includes a breakdown per sector, so that it can be translated into the following matrix notation:

[3]In other words, one can say all 14 Canadian tables (13 provinces and 1 Government abroad) and one US input technical coefficients matrices are stacked together in construction of a diagonal block matrix at the national level.
[4]ibid.
[5]In particular, this matrix is a bridge matrix which connects the US, or any province, to other provinces through import and export coefficients. See Miller and Blair (2009).

Direct, indirect, and induced impacts:

$$\Delta X = (I - C.Aind)^{-1} C.\Delta FD^* \qquad \text{(Equation 6)}$$

Direct and indirect impacts:

$$\Delta X = (I - C.A)^{-1} C.\Delta FD \qquad \text{(Equation 7)}$$

The difference between Equation 6 and 7 is referred to as the induced impact of any changes in final demand components.

Once the impact on output (change in total gross outputs) is calculated, the calculation of impacts on GDP, household income, employment, taxes, and so forth, are straightforward. In particular, as previously mentioned, the base year for the I/O tables used in this report is 2009. CERI utilizes the tax information derived from these tables and federal and provincial tax information from the Finances of the Nation, where these numbers reflect the tax structure of the Canadian economy in the year 2009.[6] CERI acknowledges that there have been changes, and there would be imminent changes to the corporate income tax structure and the goods and services sales tax (GST) since 2009. Any changes to the tax regime will result in changes in estimated tax figures as business responds to the new incentives. Therefore tax estimates should be interpreted on a 2009 basis.

These impacts are estimated at the industry level using the ratio of each (GDP, employment, etc.) to total gross outputs. Using the technical Multi-Regional I/O table, CERI is able to perform the usual I/O analysis at the provincial and national levels.

Industries in the UCMRIO 3.0

This section illustrates various industries in the UCMRIO 3.0. Table A.1 provides the details.

[6]Canadian Tax Foundation; Finances of the Nation; 2006, 2007 and 2008.

Table A.1: Sectors/Commodities in the CERI US-Canada Multi-Regional I/O Model

Serial No.	Sector or Commodity	Examples of activities under the sector or commodity
1	Crop and Animal Production	Farming of wheat, corn, rice, soybean, tobacco, cotton, hay, vegetables and fruits; greenhouse, nursery, and floriculture production; cattle ranching and farming; dairy, egg and meat production; animal aquaculture
2	Forestry and Logging	Timber tract operations; forestry products: logs, bolts, poles and other wood in the rough; pulpwood; custom forestry; forest nurseries and gathering of forest products; logging.
3	Fishing, Hunting and Trapping	Fish and seafood: fresh, chilled, or frozen; animal aquaculture products: fresh, chilled or frozen; hunting and trapping products
4	Support Activities for Agriculture and Forestry	Support activities for crop, animal and forestry productions; services incidental to agriculture and forestry including crop and animal production, e.g., veterinary fees, tree pruning, and surgery services, animal (pet) training, grooming, and boarding services
5	Conventional Oil	Conventional oil, all activities e.g., extraction and services incidental to conventional oil
6	Oil Sands	Oil sands, all activities e.g., extraction and services incidental to oil sands
7	Natural Gas and NGL	Natural gas, NGL, all activities e.g., extraction and services incidental to natural gas and NGL
8	Coal	Coal mining, activities and services incidental to coal mining
9	Other Mining	Mining and beneficiating of metal ores; iron, uranium, aluminum, gold and silver ores; copper, nickel, lead, and zinc ore. Mining; non-metallic mineral mining and quarrying; sand, gravel, clay, ceramic and refractory, limestone, granite mineral mining and quarrying; potash, soda, borate and phosphate mining; all related support activities
10	Refinery	Petroleum and coal products; motor gasoline and other fuel oils; tar and pitch, LPG, asphalt, petrochemical feed stocks, coke; petroleum refineries
11	Petrochemical	Chemicals and polymers: resin, rubber, plastics, fibres and filaments; pesticides and fertilizers; etc.
12	Other Manufacturing	Food, beverage and tobacco; textile and apparel; leather and footwear; wood products; furniture and fixtures; pulp and paper; printing; pharmaceuticals and medicine; non-metallic mineral, lime, glass, clay and cement; primary metal, iron, aluminum and other metals; fabricated metal, machinery and equipment, electrical, electronic and transportation equipment, etc.

Serial No.	Sector or Commodity	Examples of activities under the sector or commodity
13	Construction	Construction of residential, commercial and industrial buildings; highways, streets, and bridges; gas and oil engineering; water and sewer system; electric power and communication lines; repair construction
14	Transportation and Warehousing	Roads, railways; air, water & pipeline transportation services; postal service, couriers and messengers; warehousing and storage; information and communication; sightseeing & support activities
15	Transportation Margins	Transportation margins
16	Utilities	Electric power generation, transmission, and distribution; natural gas distribution; water & sewage
17	Wholesale Trade	Wholesaling services and margins
18	Retail Trade	Retailing services and margins
19	Information and Cultural Industries	Motion picture and sound recording; radio, TV broadcasting and telecommunications; publishing; information and data processing services
20	Finance, Insurance, Real Estate and Rental and Leasing	Insurance carriers; monetary authorities; banking and credit intermediaries; lessors of real estate; renting and leasing services
21	Professional, Scientific and Technical Services	Advertising and related services; legal, accounting and architectural; engineering and related services; computer system design
22	Administrative and Support, Waste Management and Remediation	Travel arrangements and reservation services; investigation and security services; services to buildings and dwellings; waste management services
23	Educational Services	Universities; elementary and secondary schools; community colleges and educational support services
24	Health Care and Social Assistance	Hospitals; offices of physicians and dentists; misc. ambulatory health care services; nursing and residential care facilities; medical laboratories; child and senior care services
25	Arts, Entertainment and Recreation	Performing arts; spectator sports and related industries; heritage institutions; gambling, amusement, and recreation industries
26	Accommodation and Food Services	Traveler accommodation, recreational vehicle (RV) parks and recreational camps; rooming and boarding houses; food services and drinking establishments
27	Other Services (Except Public Administration)	Repair and maintenance services; religious, grant-making, civic, and professional organizations; personal and laundry services; private households
28	Operating, Office, Cafeteria and Laboratory Supplies	Operating supplies; office supplies; cafeteria supplies; laboratory supplies
29	Travel, Entertainment, Advertising and Promotion	Travel and entertainment; advertising and promotion

Serial No.	Sector or Commodity	Examples of activities under the sector or commodity
30	Non-Profit Institutions Serving Households	Religious organizations; non-profit welfare organizations; non-profit sports and recreation clubs; non-profit education services and institutions
31	Government Sector	Hospitals and government nursing and residential care facilities; universities and government education services; other municipal government services; other provincial and territorial government services; other federal government services including defence

*Statistics Canada reports the oil, gas, coal, and other mining as one sector due to some confidentiality issues. CERI uses an in-house developed approach to disaggregate this sector into to five sectors: oil sands, conventional oil, natural gas + NGL, coal, and other mining.

Source: CERI