

The Impact of Oil Price Shocks on Canadian National and Provincial GDP

INTRODUCTION

Since 2000, Canada's economy has become increasingly dependent on the energy sector for growth.¹ While several studies have examined the relationship between Canadian GDP and oil prices,² few investigate the implications for provincial economies. Resource and energy endowments are unevenly distributed within the Canadian federation³ and recent declines in global commodity prices have diverse repercussions for provincial revenues, expenditures and households' well-being. This Policy Brief presents quantitative estimates of the effect of lower resource prices on provincial household incomes and the excess volatility generated by the resource sector. The results identify the important role of the energy and resource sectors within national and inter-provincial policy discussions, and aid provincial policy-makers and managers as they grapple with current and future changes in energy markets.

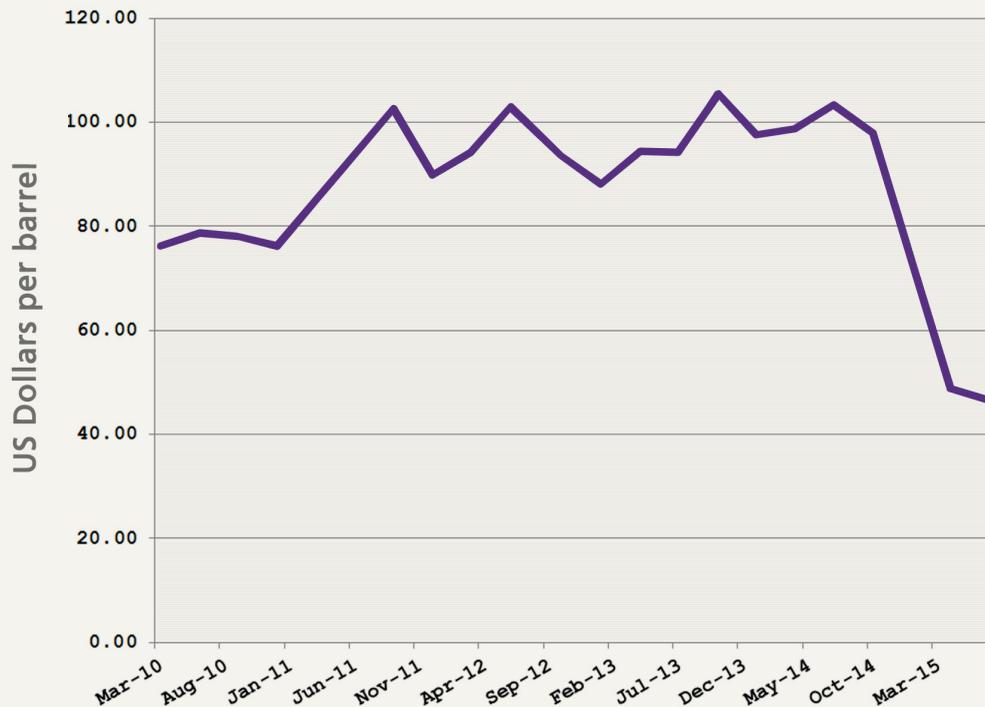
This Brief starts by outlining the recent declines in global oil prices and their implications for aggregate Canadian GDP. Next, for each province, the share of the energy and resource sectors as a fraction of GDP and the sectors' contribution to the variance in the province's output is evaluated. Finally, the implications of oil price changes for provincial household incomes are presented.

GLOBAL OIL PRICES AND THEIR EFFECT ON CANADIAN GDP

Global energy markets experienced dramatic shifts from 2014 to 2015. **Figure 1** plots the quarterly West Texas Intermediate (WTI) per barrel price of oil from 2010 through the third quarter of 2015.⁴ Driven by a combination of increasing supply, largely from OPEC and US producers, and decreasing demand in China, prices declined by more than 50% within a six month period.⁵ This drop follows a five year period of relative stability where the oil and gas sector occupied an increasing share of Canadian GDP.⁶ While lower international oil prices have a stimulative effect on the global economy, they are expected to "weigh significantly" on energy exporters such as Canada.⁷ Within this context, it is important to understand both the effect on Canada's GDP and the differential outcomes for households in various regions of the country.

A series of vector autoregression (VAR) models demonstrate the effect of an unexpected \$20.00 decline in the WTI price per barrel of oil (approximately half of the 2015 fall). **Figures 2a and 2b** trace the statistical predictions of the current and future path of real quarterly GDP in response to a one standard deviation decrease in the real price of oil (equivalent to approximately \$20/bbl).⁸ The solid line reflects the predicted effect, whereas the dashed lines illustrate the 95% statistical confidence bands. **Figure 2a** contains results derived from a longer time series, spanning from the first quarter of 1961 to the first quarter of 2015, while **Figure 2b** restricts the model to the post-2000 period.

Figure 1: Quarterly West Texas Intermediate per Barrel Price of Oil



Source: St. Louis Federal Reserve Database

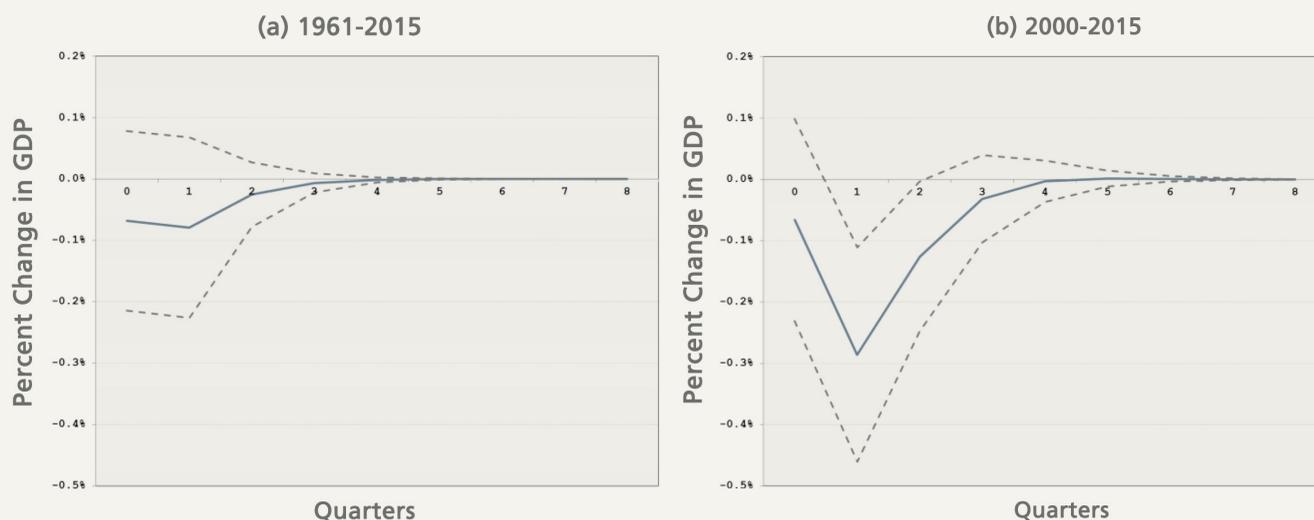
Over the extended period shown in [Figure 2a](#), oil price changes have historically had isolated and small implications for Canada’s aggregate economic performance. A shock to global energy prices causes Canadian GDP to decline slightly, but the estimated effects are not statistically different from zero. Placed within this long term perspective, the Canadian economy has been historically resilient to global oil markets. [Figure 2b](#) illustrates that this relationship has changed. The energy sector is now more integrated with the national economy, and oil price shocks have deeper, longer lasting implications for the Canadian economy. Since August 2014, oil prices have plunged by more than \$40/bbl. [Figure 2b](#) shows that a decrease of this magnitude translates into a 0.6% decrease in quarterly Canadian GDP in the period following the decline. The effect of this shock is statistically different from zero and takes a full year to dissipate.

Clearly, developments in energy markets matter to the Canadian economy, but concentrating on nationally aggregated statistics masks implications for specific regions. As a next step, the importance of these changes to provincial economies is evaluated.

THE ENERGY AND RESOURCE SECTORS’ CONTRIBUTION TO VOLATILITY OF PROVINCIAL GDP

Energy plays a large role in the economies of Newfoundland, Alberta and Saskatchewan, while occupying a smaller role in the other provinces. For each province, [Figure 3](#) plots the energy sector’s share as a percent of provincial GDP. Through out the Brief Statistics Canada’s definition of the energy sector (T016) is used which is

Figure 2: Effect of \$20/bbl. Reduction in Oil Prices on Canadian GDP



Source: Author calculations

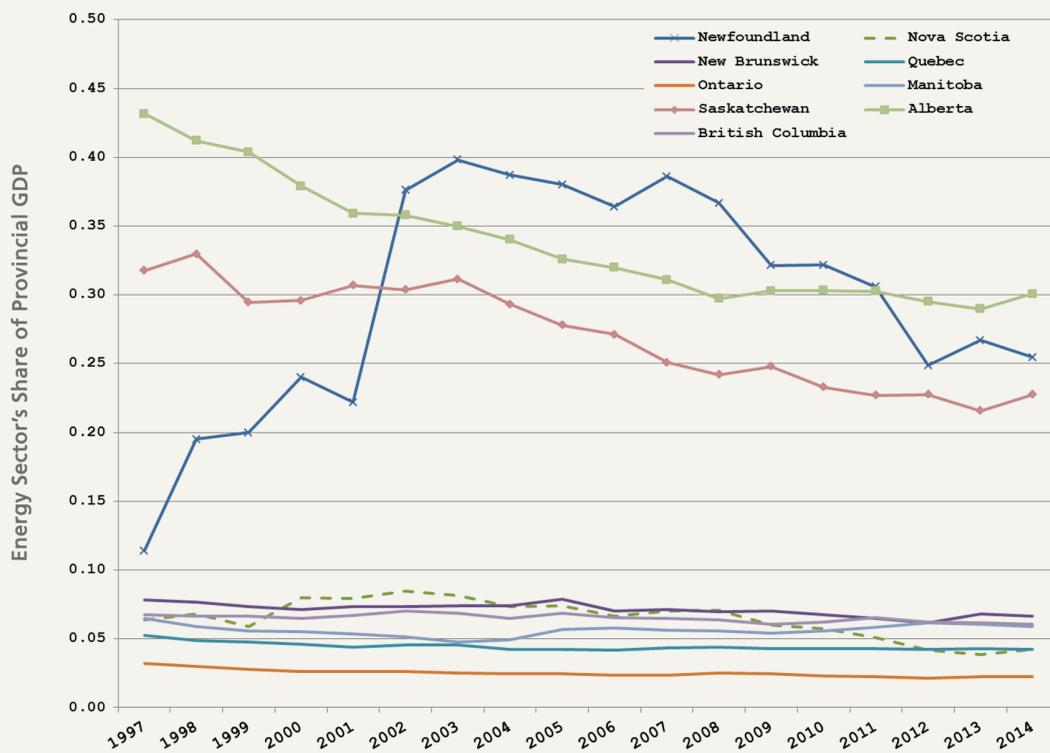
the combination of the following sub-sectors: oil and gas extraction (211), coal mining (2121), other metal ore mining (21229), support activities for mining, oil and gas extraction (21311A), electric power generation, transmission and distribution (2211), natural gas distribution (2212), petroleum refineries (32411), and pipeline transportation (486). Over the last twenty years, Newfoundland has seen the most dramatic change with the economic share of the energy sector increasing from 11% to over 30% of GDP. In 2011, resources in Alberta and Saskatchewan corresponded to 30% and 22.7% of GDP, respectively.⁹ Energy contributes less than 7% of total provincial output in all other provinces.

Yet, while the share of provincial output from energy is important for policy-makers, levels are only one part of a larger story. The energy and resource sectors' contribution to the volatility of provincial economies is a persistent concern that has occupied the attention of both researchers and decision-makers.¹⁰ To date however, few systematic methodologies measure this volatility. This section applies a variance decomposition to directly measure the energy and resource sectors' contribution to the variance of provincial GDP, ultimately yielding clear and robust estimates that can contribute

to provincial policy discussions.¹¹ The resource sector in the following analysis is defined as Statistics Canada's mining, quarrying, and oil and gas extraction sector (21).

For each province over 1997-2011, **Table 1** presents three statistics for each of the energy and resource sectors. The first value is the mean share of the sector as a percent of the provincial economy. For the energy sector this reflects an average of the data presented in **Figure 3**. The second statistic represents the sector's contribution to the volatility of each province's GDP. Specifically, the volatility of provincial GDP is separated or *decomposed* into the share coming from either the resource or energy sector and the share originating from all other sectors. Finally, the third statistic is called the coefficient of excess volatility which is the ratio of share of variance to share of GDP estimates. For a given level of importance of the sector in each province's economy, the coefficient of excess volatility states how much extra volatility in total GDP is attributable to the sector. A value of one indicates volatility proportional to the share of GDP whereas a value greater than one signifies a disproportionately large contribution to the variance of provincial GDP.

Figure 3: Provincial Resource Sector as a Share of Provincial GDP



Source: Author calculations

Table 1: Contribution of Energy and Resource Sectors to the Volatility of Provincial GDP, 1997-2014

	Resource Sector			Energy Sector		
	Share of GDP	Share of Variance	Excess Volatility Coefficient	Share of GDP	Share of Variance	Excess Volatility Coefficient
Newfoundland	0.234	0.762	3.3	0.297	0.888	3.0
PEI	0.001	0.007	7.0	-	-	-
Nova Scotia	0.028	0.177	6.3	0.065	0.291	4.5
New Brunswick	0.013	0.023	1.8	0.071	0.040	0.6
Quebec	0.005	0.005	1.0	0.044	0.038	0.9
Ontario	0.006	0.012	2.0	0.025	0.005	0.2
Manitoba	0.018	0.040	2.2	0.056	0.130	2.3
Saskatchewan	0.159	0.421	2.3	0.271	0.114	0.4
Alberta	0.221	0.508	2.3	0.338	0.274	0.8
British Columbia	0.031	0.023	0.7	0.065	0.094	1.4

Source: Author's calculations using Statistics Canada Table 379-0030

Table 1 shows several key facts about provincial economies. First, for energy dependent provinces such as Newfoundland, Alberta and Saskatchewan, fluctuations in the resource sector explain the majority of the variance in provincial output. In Newfoundland, fluctuations in the sector explain 76.2% of GDP volatility. Alberta and Saskatchewan have similar experiences with natural resources explaining 50.8% and 42.1% of GDP variance, respectively, during the 1997-2011 period. Second, the inclusion of stable industries such as electricity generation, pipelines, and energy-related manufacturing and the exclusion of mining and quarrying markedly reduces the volatility. This can be seen by comparing the excess volatilities of

the resource and energy series. The coefficient of excess volatility equals 3.0, 0.8, and 0.4 for Newfoundland, Alberta and Saskatchewan, respectively.

Overall, the coefficients of excess volatility demonstrate that the resource sector contributes a disproportionate share to output variance in every province except British Columbia and Quebec. The disproportionate contribution of the resource sector to the variance in provincial GDP suggests that global factors such as the recent decline in oil prices have larger implications for provincial energy policy today compared with previous decades.

OIL PRICES AND PROVINCIAL HOUSEHOLD INCOMES

Household spending comprises a large proportion of provincial GDP. The next set of figures show the response of annual household incomes in Alberta, Saskatchewan and Ontario to a shock to oil prices.¹² All figures represent orthogonalized impulse response functions from a series of vector autoregressions and should be interpreted as follows: a one standard deviation shock to the price of oil (equal to approximately \$20/bbl) generates the time path for future household income that is plotted in the figure.

ALBERTA

Figure 4 illustrates the implications for Alberta household income of a \$20/bbl reduction in the price of oil. The left panel uses data from 1950 through 2013. The right panel restricts analysis to the post-2000 period. Both cases show that falling oil prices generate statistically significant drops in income. Over the 1950-2013 period, a \$20 drop in the price of oil yields a 1% decrease in household income. The effect of this shock persists for two years before incomes revert to their steady state levels. Shocks in the post-2000 period have larger consequences with deeper income losses for Albertans. The model predicts that the recent fall in oil prices from approximately \$100/bbl in August 2014 to less than \$60/bbl should yield nearly a 5% decrease in Alberta household income, a decline that will not recover until 2017.

ONTARIO

Figure 5 illustrates the implications of a shock to oil prices for Ontario household incomes. Over the 1950-2013 period, there is virtually no effect of the recent decline in oil prices on Ontarian incomes. Limiting the analysis to the most recent 15 years demonstrates how Canada's energy sector is changing the fortunes across Canada – even in provinces with small resource sectors. While the results are not statistically significantly different from a no effect scenario, falling oil prices predict a 0.5% fall in household income for Ontarians. Even a province that historically has focused on manufacturing may now be adversely affected by lower oil prices.

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Figure 4: Effect of \$20/bbl. Oil Price Reduction on Alberta Household Income

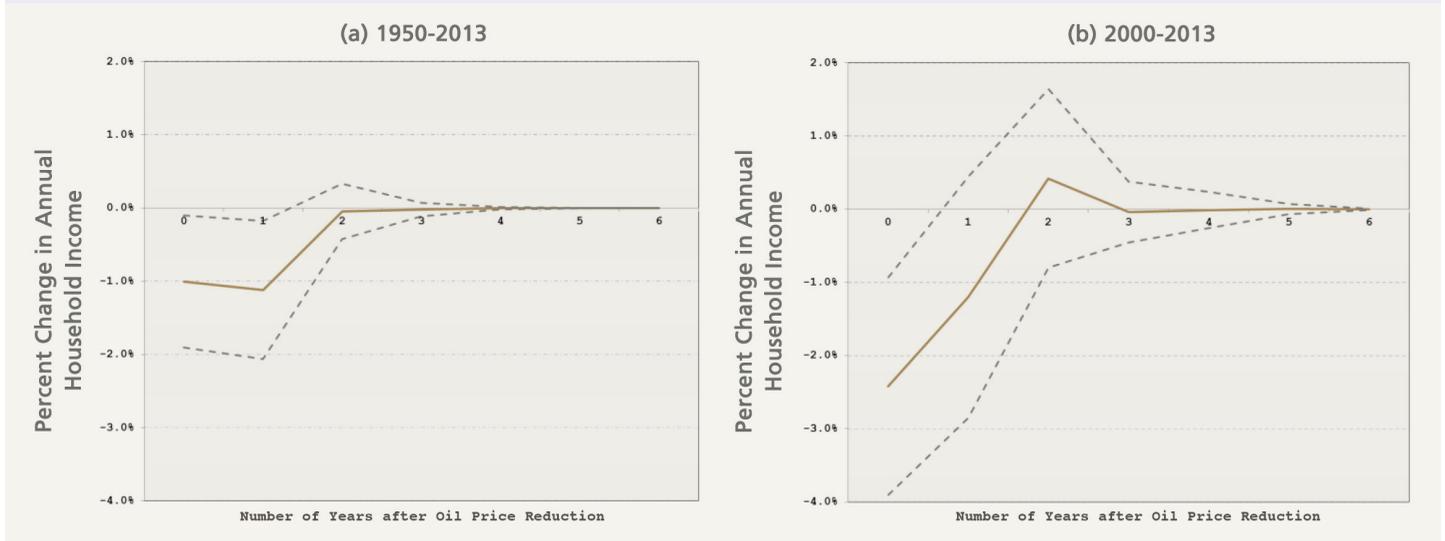
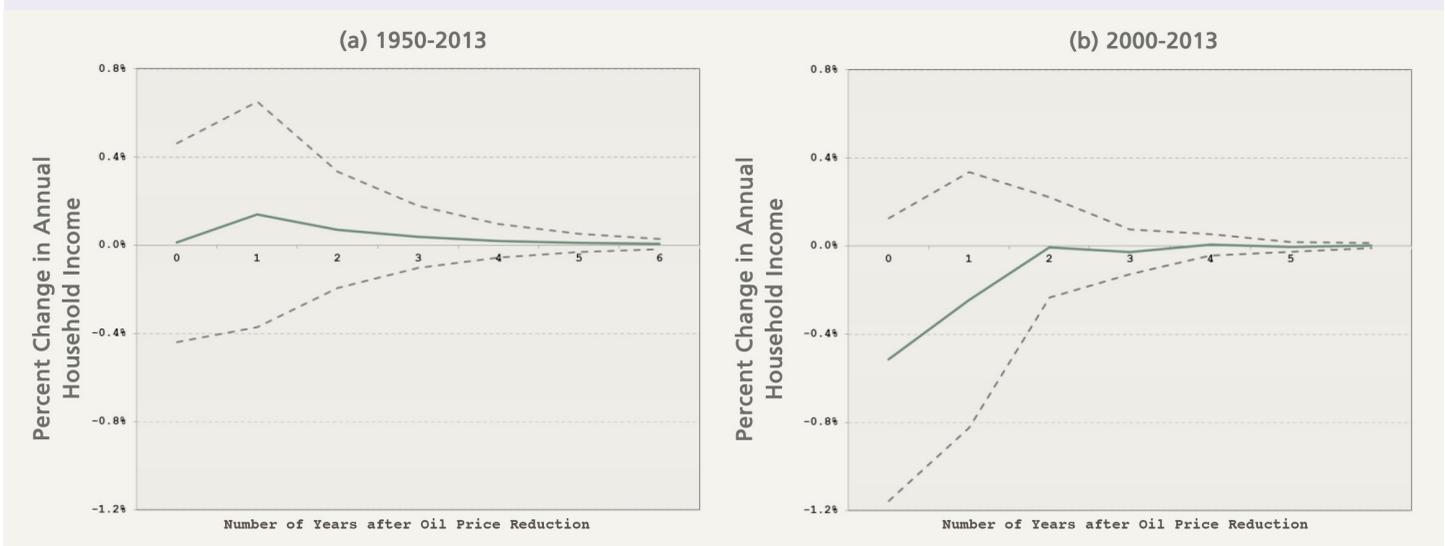


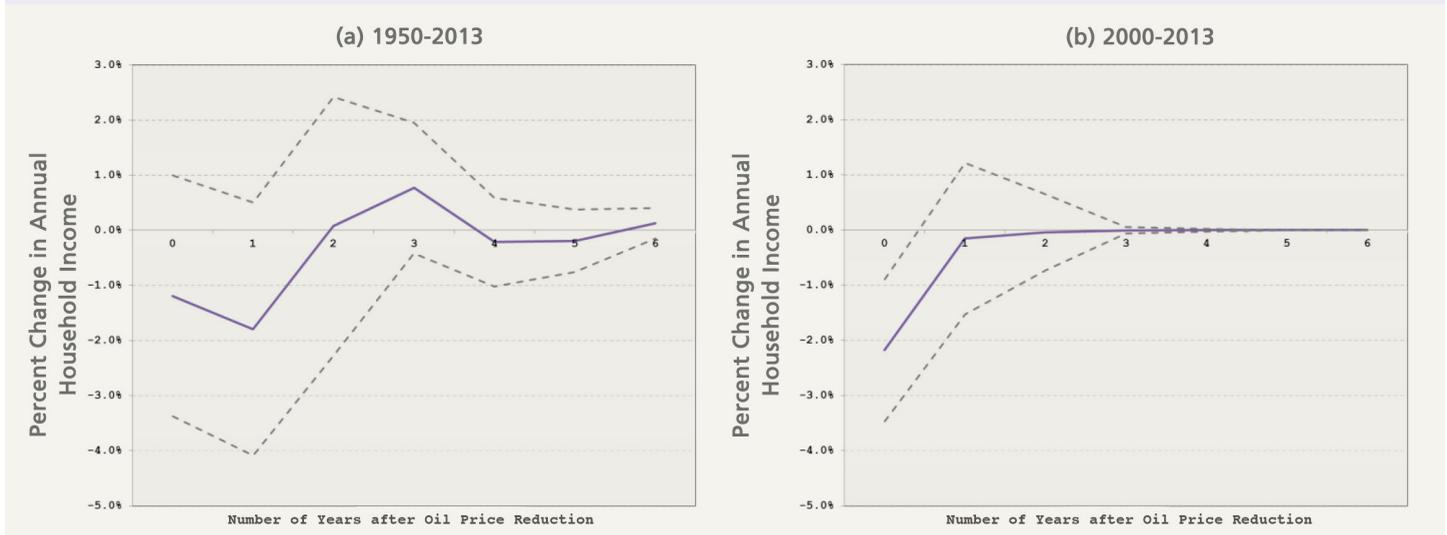
Figure 5: Effect of \$20/bbl. Oil Price Reduction on Ontarian Household Income



SASKATCHEWAN

Figure 6 shows how Saskatchewan's fortunes are increasingly tied to Canada's energy economy. Over the 1950-2013 period, price reductions initially yield a statistically insignificant 1% drop in income and, after a two year lag, incomes recover and experience positive effects. Historically, agriculture has comprised a large share of Saskatchewan's economy, and fuel is a key input into production. Lower fuel prices, therefore, may translate into higher incomes. Like the rest of Canada, however, Saskatchewan has become increasingly dependent on oil and gas production. In 2013 for instance, the energy sector comprised 22.6% of Saskatchewan's economy, while agriculture, even during a stretch of high agricultural commodity prices, contributed 11.0%. This dependence on the energy sector portends a greater effect of recent oil price declines. The right panel shows that a \$40 drop in the price of oil leads to more than a 4% decline in Saskatchewan household income in the post-2000 period.

Figure 6: Effect of \$20/bbl. Oil Price Reduction on Saskatchewan Household Income



CONCLUSION

The Policy Brief highlights several policy-relevant results. First, a series of statistical models demonstrates that an unexpected \$20.00 decline in the West Texas Intermediate price per barrel of oil—approximately half of the 2014–2015 fall—causes a 2.5% decrease in median household incomes in Alberta and Saskatchewan, an effect that lingers for over two years. Moreover, Canadian households are now demonstrably more sensitive to oil prices than in the past. This is especially true for the energy-dependent provinces, but it is also increasingly so for Ontario, a province whose economy is relatively dependent on manufacturing. In all provinces except British Columbia and Quebec, the resource sector contributes disproportionately to the volatility of provincial GDP. When energy dependent provinces are hit with a large shock to prices, they are forced to adapt and change policies. Ultimately, energy is more important to the provincial economies than ever before. These findings help both policy-makers and managers understand the preconditions and consequences of oil price shocks.

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NOTES

¹See Fremeth et al. (2014)

²See Bank of Canada (2015); Shenfeld, Buchanan and Lovely (2014)

³For example, Plourde et al. (2010)

⁴The data used in this analysis were retrieved from several sources. Time series on the West Texas Intermediate (WTI) per barrel price of oil are from the St Louis Federal Reserve's Database and the Wall Street Journal. Information on Canadian and provincial GDP, output from the resource sector and real provincial household incomes are from Statistics Canada. See McDonald, 2015.

⁵See Bank of Canada (2015)

⁶See Fremeth et al. (2014)

⁷See page 9 of Bank of Canada (2015)

⁸Descriptions of the empirical methodologies and data sources are contained in the Appendix.

⁹The visible jump in 1997 for Alberta and Saskatchewan is due to Statistics Canada redefining the variables used in this analysis.

¹⁰For example, Emery and Kneebone (2011); Landon and Smith (2010a,b); Plourde et al. (2010)

¹¹See Homann and Lemieux (2014)

¹²While not explicitly discussed, comparable figure for all other provinces are contained in the Appendix.

APPENDIX

A.1 Variance Decomposition and the Coefficient of Excess Volatility

Changes in provincial GDP over time can be written as the sum of the change in the contribution from the resource sector, R , and other sectors, O : $\Delta GDP = \Delta R + \Delta O$. The variance of the change in provincial output then is:

$$\begin{aligned} Var(\Delta GDP) &= Cov(\Delta GDP, \Delta R + \Delta O) \\ &= Cov(\Delta GDP, \Delta R) + Cov(\Delta GDP, \Delta O) \end{aligned}$$

Dividing both the right- and left-hand sides by $Var(\Delta GDP)$ gives:

$$1 = b_r + b_o$$

where b_r , which equals $\frac{Cov(\Delta GDP, \Delta R)}{Var(\Delta GDP)}$, is the share of variance in provincial GDP that is attributable to the variance in provincial resource sector. This value then is determined by regressing changes in the resource sector on changes in GDP:

$$\Delta R = \alpha + b_r \Delta GDP + \varepsilon. \tag{1}$$

I also consider the “excess volatility” of the resource sector. This value is found by taking the ratio of b_r from (1) to a scenario where the resource sector occupies a constant share of GDP, s_r , and hence does not contribute any excess volatility to provincial economies. If the resource sector is a constant fraction of GDP, then $R = s_r GDP$ and $Cov(R, GDP) = s_r Var(GDP)$, so

$b_r = \frac{Cov(R, GDP)}{Var(GDP)} = \frac{s_r Var(GDP)}{Var(GDP)} = s_r$. So, if $b_r > s_r$, then there is “excess variation” in overall GDP that can be attributed to the resource sector. Cyclically sensitive sectors have a larger b_r relative to s_r , so the ratio of excess volatility, $\frac{b_r}{s_r} > 1$.

A.2 Vector Autoregressions and Impulse Response Functions for Household Income

All impulse response functions are based on reduced-form vector autoregressions of the form:

$$\Delta \ln y_{it} = \alpha + \sum_{i=1}^p A_i \Delta \ln y_{t-i} + \varepsilon_{it}$$

where y_t reflects a vector of variables in natural logarithms, A_i is a matrix of coefficients and p is the lag length. Tests revealed unit roots for all series in levels; as a result, the models are estimated in first-differences, represented by the Δ operator.

Figures 2–13 display orthogonalized impulse response functions. These impulse response functions measure the effect of an unexpected change in one variable—oil prices—influences, say, GDP. That is, impulse response functions do not show relationship between oil prices and GDP, per se, rather they reflect only the unanticipated shock. The term orthogonalized therefore means that only shocks to oil prices are considered.

A.3 VAR Figures for Other Provinces

Figure 7: Response of Household Income to a Shock to Oil Prices—British Columbia

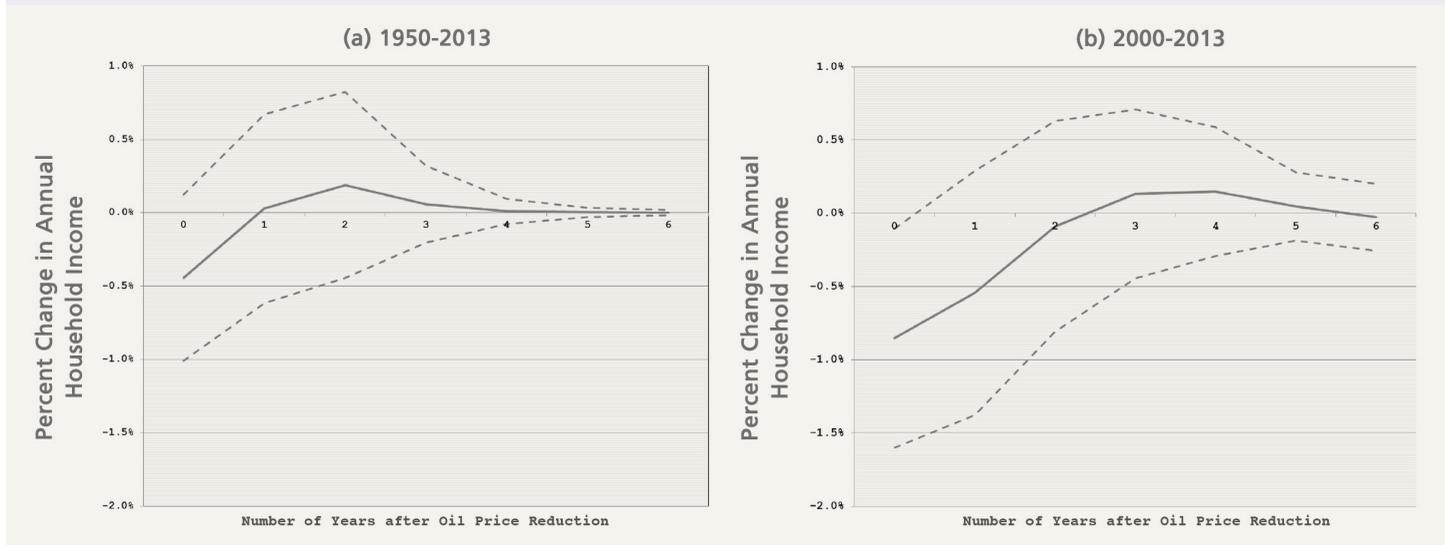


Figure 8: Response of Household Income to a Shock to Oil Prices—Manitoba

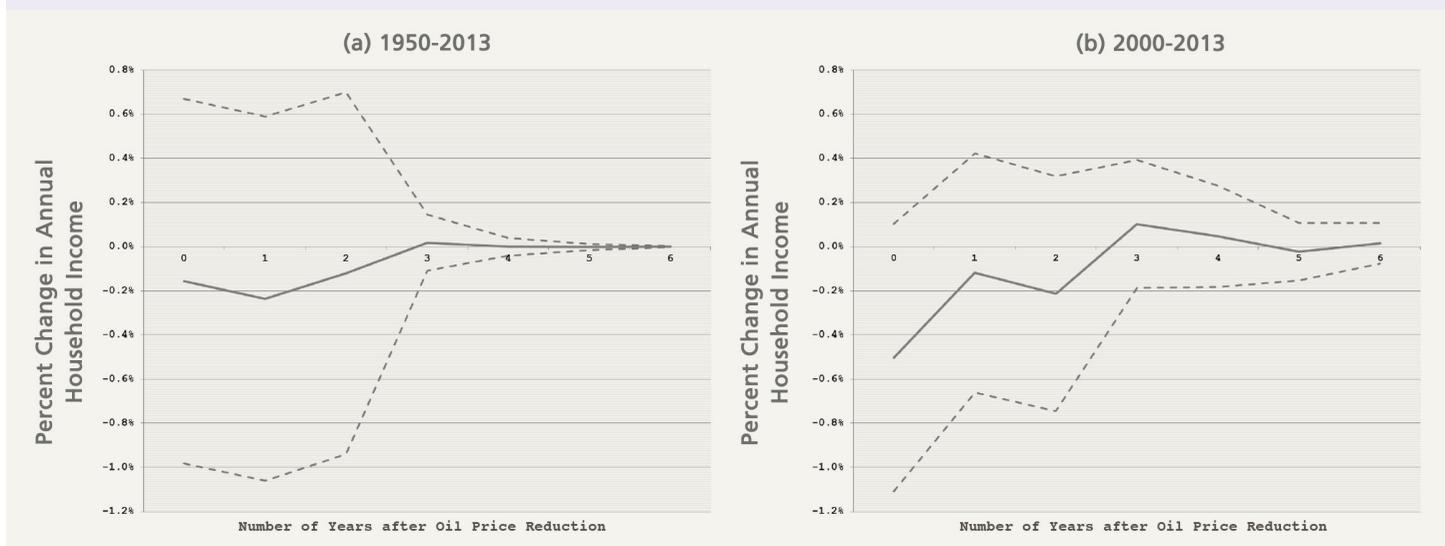


Figure 9: Response of Household Income to a Shock to Oil Prices—Quebec

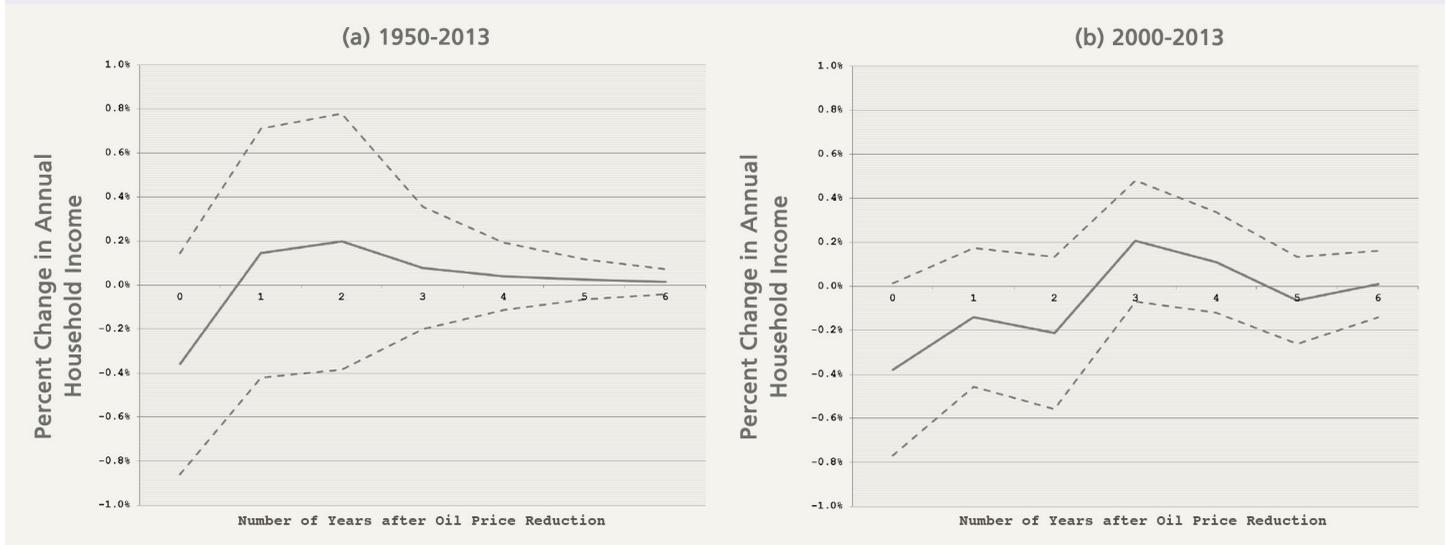


Figure 10: Response of Household Income to a Shock to Oil Prices—New Brunswick

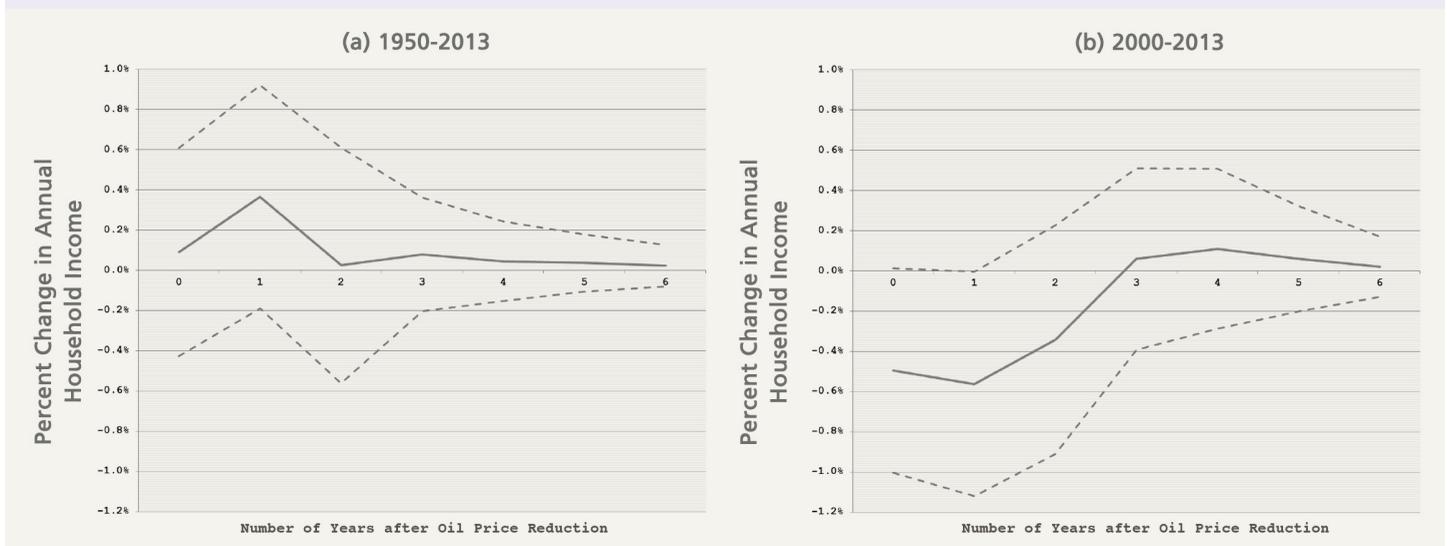


Figure 11: Response of Household Income to a Shock to Oil Prices—Nova Scotia

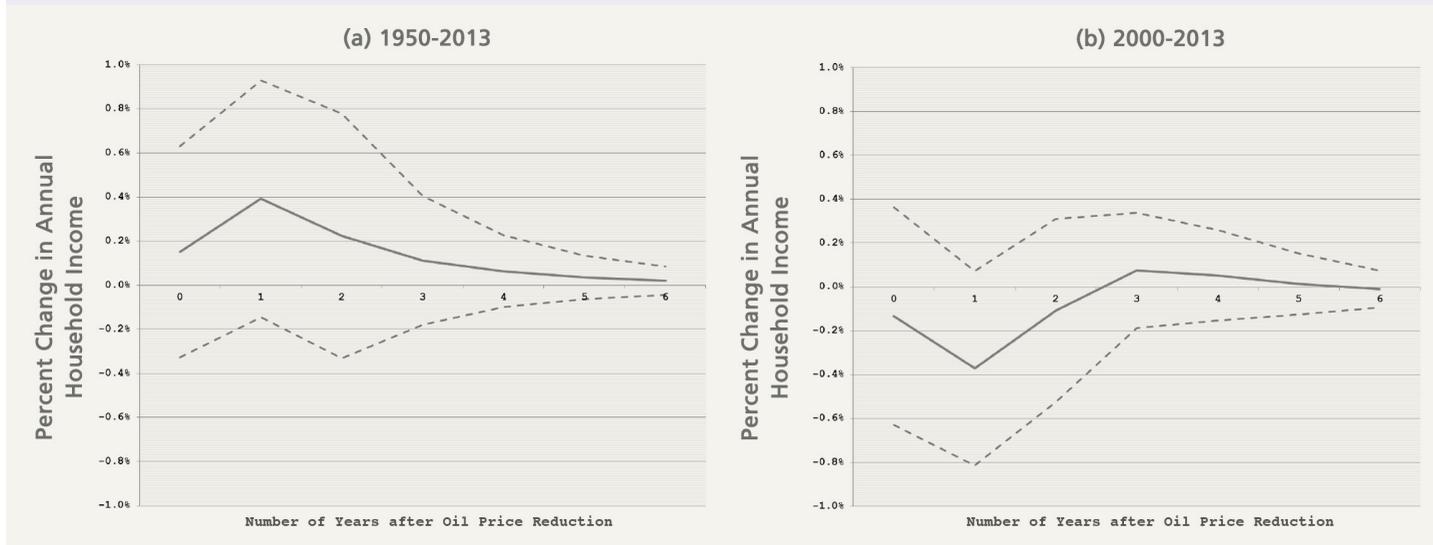


Figure 12: Response of Household Income to a Shock to Oil Prices—Prince Edward Island

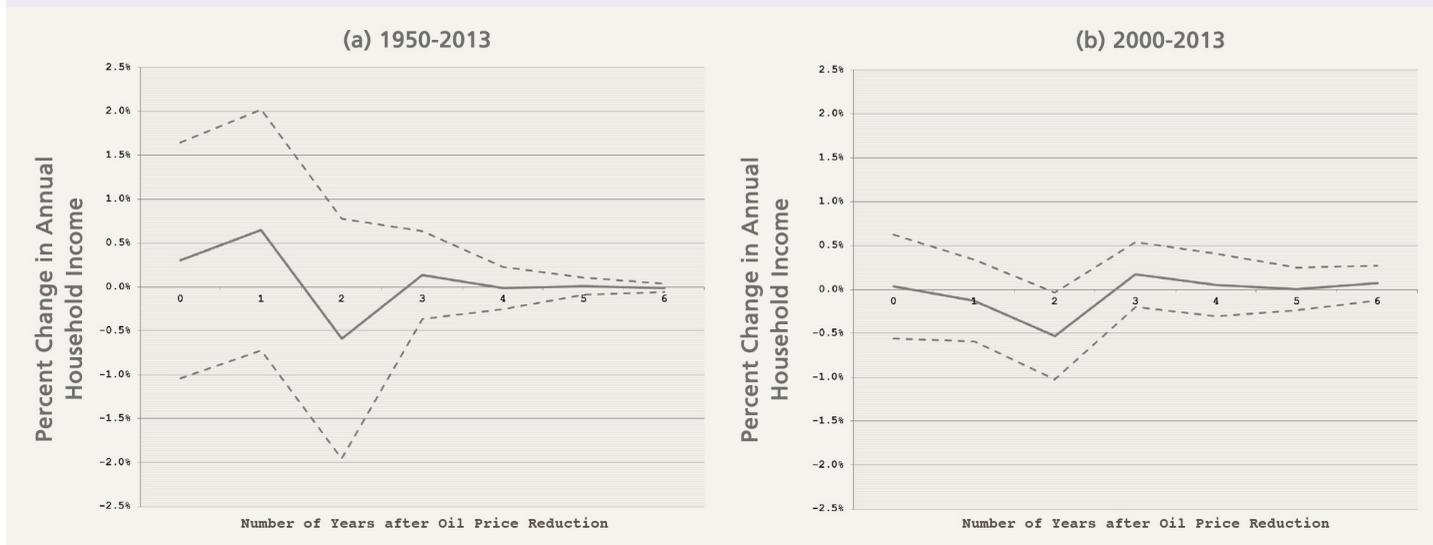
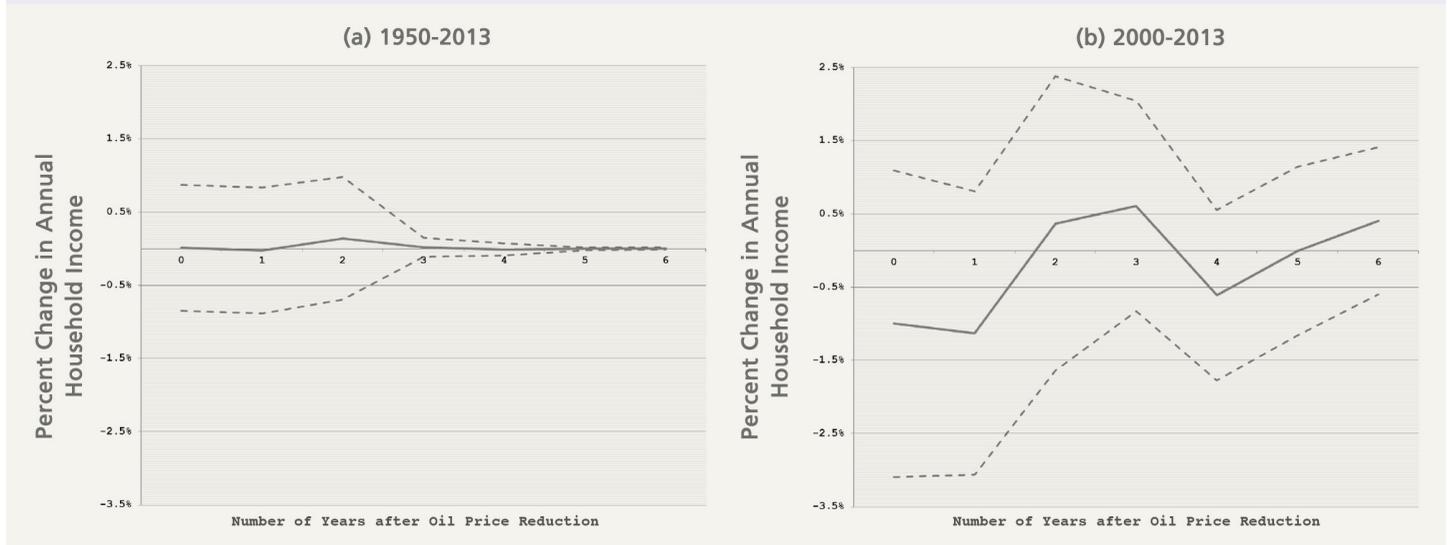


Figure 13: Response of Household Income to a Shock to Oil Prices—Newfoundland and Labrador



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