Taxes, Volatility and Resources in Canadian Provinces*

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Abstract

Tax policy often breeds controversy, especially when rate changes are motivated by volatile resource sectors. This paper examines how provincial tax policies respond to changes in resources revenues. Specifically, it (i) estimates the "tax-resource" elasticity for Canadian provinces and (ii) measures the resource sector's contribution to the volatility of provincial GDP. Empirical results suggest that a $1,000 decrease in per capita resource revenue leads to a 150bps increase in a province's marginal personal income tax rate and a 3% increase in excise taxes on gasoline. A variance decomposition demonstrates that resource-induced volatility accounts, respectively, for 76.2%, 50.8% and 42.1% of the variance of Newfoundland and Labrador, Alberta and Saskatchewan's GDPs.

Keywords: tax-resource elasticity; provincial income taxes; resource-induced volatility.

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1 Introduction

When Alberta released its 2014 budget the price of a barrel of oil equaled $101.82 USD and the government maintained its 10% flat rate on taxable income. Twenty months later, as the province's recently elected NDP government tabled its 2015 budget, the price had fallen by more than 50%. The province responded by increasing marginal tax rates on four newly created brackets.[1] Canada's other resource dependent provinces undertook similar actions: Newfoundland and Labrador increased personal tax rates by 50 basis points (bps) on their $125,000–175,000 bracket and by 100bps on income earned above $175,000 (Newfoundland and Labrador, 2015),[2] while Saskatchewan reduced a suite of tax incentives for middle-class families (Saskatchewan, 2015). These actions were derided by former Prime Minister Harper (among others) who claimed that they exacerbated Canada's economic downturn (Globe and Mail, 2015). It is unsurprising that tax policy is political fodder: taxes are subject to intense debate – especially when rate increases appear to be motivated by a volatile resource sector. Still, it is unclear to what extent the resource economy influences provincial tax policy.[3] This paper demonstrates that, given the negative shock to the resource sector, Alberta, Saskatchewan and Newfoundland and Labrador's personal income tax increases largely accord with Canada's historical personal income tax-resource elasticity. Of course, this does not mean that these decisions were optimal from a tax policy perspective. It merely implies that these choices align with previous behaviour.

Plummeting oil prices have dramatic consequences for government budgets. Figure 1 illustrates the implications for Alberta and Saskatchewan's personal income tax bases. Using data from 2000–2013 and a vector autoregression model, these graphs show the relationship between household incomes and oil prices.[4] Panel A presents the response of Albertan household income to a one

[1]The first bracket keeps the 10% rate on taxable income up to $125,000. The second bracket spans $125,000–150,000 and has a rate of 10.5%. The third and fourth brackets are for incomes of $150,000–200,000 and $200,000–300,000 with rates of 10.75% and 11.0%, respectively. Finally, a rate of 11.25% is applied to income earned over $300,000. In 2016, the rates on these five brackets increase to 10%, 11%, 12%, 13%, 14% and 15%.

[2]These two rates increase by an additional 50bps and 100bps in 2016.

[3]The definition of resource sector in this analysis starts with Statistics Canada's definition of the energy sector in Table 379-0030. It then removes the electricity and manufacturing components and adds mining and quarrying (i.e., industries in NAICS 212, not captured by the energy sector definition). Notably, the resource sector *excludes* agriculture, fishing and forestry.

[4]These are estimated from an orthogonalized impulse response function which uses reduced-form vector autoregression model 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 – real provincial

standard deviation negative shock to oil prices. This shock, approximately half of the recent decline, generates a 2.5% decrease in pre-tax household incomes. This result is duplicated in Saskatchewan where Panel B shows that a one standard deviation shock yields a 2.0% deterioration in income. The connection between energy prices and government budgets is straightforward: oil price shocks reduce the level of household taxable income and, as these tax bases shrink, budget deficits increase. Alberta, Saskatchewan and Newfoundland and Labrador, Canada's most resource-dependent provinces, projected budget deficits of \$6.1B, \$800M and \$1.1B in 2015. These shortfalls, in turn, motivate pro-cyclical increases to personal income tax rates (among other fiscal choices such as expenditure reductions and deficits).

This paper presents two sets of results that place the recent provincial policies in historical context. First, a reduced form "tax response" expression is specified that links per capita resource revenues to marginal personal income tax rates via two channels: a direct effect and a federal transfer effect. The reduced form elasticities from this model are estimated using data for all provinces over 25 years. The empirical results suggest that a \$1,000 decrease in per capita resource revenue leads to at least a 150bps increase of province's effective marginal income tax rates. For high income brackets, the estimate equals 120bps. Approximately 30% of these tax hikes are a result of the indirect, federal effect for the full sample of all Canadian provinces. The federal transfer channel is smaller for Canada's resource dependent provinces. More importantly, these elasticities imply that Alberta and Newfoundland and Labrador's 2015 tax increases accord with Canada's historical tax-resource relationship. Moving beyond personal income taxes, the effect on corporate income tax rates and excise taxes on gasoline are also examined. No relationship is found between corporate income tax rates and provincial resource revenues, but a \$1,000 decrease in per capita resource revenue yields a robust 3% increase in excise taxes on gasoline.

household income and oil prices – in natural logarithms, A_i is a matrix of coefficients and p is the lag length. Lag lengths are determined via inspection of Akaike and Schwartz Information Criteria. Augmented Dickey-Fuller and KPSS tests revealed unit roots for all series in levels; as a result, the models are estimated in first-differences, represented by the Δ operator. These impulse response functions measure the effect of an unexpected change in one variable – oil prices – on provincial household income. Orthogonalization uses the Cholesky decomposition which has a general form: $\Gamma_t = \Theta_i A_i \Lambda^{1/2}$ where A_i is the matrix of coefficients, Θ_i is a matrix which contains the one standard deviation shocks to the error terms and $\Lambda^{1/2}$ is lower Cholesky decomposition of the variance-covariance matrix for the error terms. Γ_t then shows the effect of a shock to the error terms to each y_t. The data used in this analysis were retrieved from two sources. Time series on the West Texas Intermediate per barrel price of oil are from the St Louis Federal Reserve's Database. Information on real provincial household incomes are from CANSIM (see, MacDonald, 2015).

Second, an attempt is made to gauge the challenge of fiscal management in resource dependent economies. Applying Hoffmann and Lemieux's (2014) decomposition, I measure the share of the variance of provincial output that is attributable to the variance in the resource sector. Energy and resources are traded on global markets. Rapid fluctuations in commodity prices such as those of 2014–15 may lead to sizable revisions in the economic performance of Canadian provinces. Instabilities in a single sector may dampen or amplify the variance of the entire economy. This accounting exercise demonstrates that the volatility in the resource sector accounts for 76.2% of the variance of Newfoundland and Labrador's provincial real GDP and corresponds to 50.8% and 42.1% of the variance in Alberta and Saskatchewan output. Interestingly, resource-driven volatility extends beyond Canada's resource dependent economies. The results indicate that, for a given contribution to a provincial economy, the resource sector contributes a disproportionate share of output variance for every province except British Columbia. Insofar as shocks to oil prices are exogenous to sub-national governments, volatile provincial resource revenues present difficulties for fiscal managers who attempt to match government revenues to expenditures.

The relationship between provincial budgets and their resource sectors has received renewed attention in Canadian policy discussions with much of the attention focusing on Alberta (see, for example, the papers in Ryan, 2013). Emery and Kneebone (2011), for instance, lament Alberta's "wild swings in economic activity" and claim that the province's resource revenues have led to unnaturally low taxes and excess spending. Landon and Smith (2010) document the volatility of Alberta's government revenues and review several potential mechanisms to smooth inflows and stabilize government budgets. Like Emery and Kneebone (2011), they advocate for additional savings via a "resource revenue stabilization fund". The complexity of managing government budgets given a large and volatile energy sector motivates this paper as well.[5] Yet, this study takes a slightly different perspective. Rather than lamenting options not pursued – whether optimal or not – I illustrate that the 2015 increases are proportional with the historical behaviour of previous provincial governments. These results provide needed context when evaluating the 2015–2016 budgets and complement the recommendations of Emery and Kneebone (2011), Landon and Smith

[5] Another stream of literature examines Canada energy shocks vis-à-vis the prospect of so-called "Dutch Disease", the irreversible hollowing out of Canadian manufacturing that results from a booming resources sector (e.g., Beine, Bos and Coulombe, 2012; Carbone and McKenzie, 2015). This paper is concerned with provincial fiscal responses to the resource sector not the dynamics of cross-province reallocations of labour and capital.

(2010) and the contributions in Ryan (2013).

There are three additonal sections to this paper. Section two reviews the the relationship between taxes and resources, presenting the primary econometric specification and estimates of the tax-resource elasticity. Section three introduces the variance decomposition. The final section concludes.

2 Historical Tax-Resource Relationship

2.1 Econometric Specification

An econometric specification the in spirit of James (2015) and Milligan and Smart (2014*a*,*b*) is estimated to obtain the provincial tax-resource elasticity. Specifically, I estimate a two equation reduce-form model:

$$\begin{aligned} \tau_{it} &= \beta_1 \hat{T}_{it} + \beta_2 \hat{r}_{it} + \theta_t + \psi_i + \alpha_1 \log \sigma_{it} + \varepsilon_{it} \\ \hat{T}_{it} &= \beta_3 \hat{r}_{it} + \theta_t + \psi_i + \alpha_2 \log \sigma_{it} + u_{it} \end{aligned} \tag{1}$$

where τ_{it} is the effective marginal personal income tax rate in province i and year t. Two rates are used in the empirical analysis: (i) a rate for a middle income household which is comprised of two adults and two children and (ii) a high income rate, reflecting the maximum marginal tax rate for the same family of four. $\hat{T}_{it}$ and $\hat{r}_{it}$ are the variables of interest. $\hat{T}_{it}$ is the per capita net federal transfer to province i in year t, while $\hat{r}_{it}$ is the realized per capita resource revenues generated in the prior calendar year (i.e., it is the latest known resource revenues at the point of the budget's release).[6] Two channels are of interest: β_2 captures the direct effect of province-specific resource revenues on personal income tax rates, while $\beta_1\beta_3$ captures the indirect, federal transfer effect. The total effect then is given by $\beta_1\beta_3 + \beta_2$. (1) includes time and province fixed effects, θ_t and ψ_i. The year fixed effects capture factors that are common to all provinces within a given year such as federal tax and trade policy. The province-specific coefficients remove all time invariant factors such as geography that are specific to a particular province. Coefficients are therefore

[6] Often governments do develop forecasts for future revenues that are more sophisticated than this naive prediction. This means that this variable may be measured with error and the estimate is attenuated.

identified via province-year variation. $\log \sigma_{it}$ is the logarithm of the share of the resource sector as a percent of total provincial GDP. It is included to control for other time varying economic factors which may influence tax rates. Finally, ε_{it} and u_{it} are error terms and the model is estimated equation-by-equation via least squares.

The objective of this study is to examine the recent tax policy changes in Canada's three resource dependent provinces. Therefore, I am interested in the partial correlation between tax rates and a province's resource sector, not a causal effect *per se*. Still, a series of uncontrolled province-by-year confounders may bias estimates. As an example, resource revenues contribute to other tax bases. Results for corporate income and excise taxes on gasoline are examined in section 2.3.2, yet a wide-variety of connected corporate and personal financial decisions could lead to tax interaction effects that may potentially lead to an over- or under-estimate of the true effect of the resource sector on personal income tax rates (Goulder and Williams III, 2003). Likewise, implications for the sales tax base and cross-provincial leakage may arise from shocks to oil markets, especially via the labour market. To mitigate these (and other) concerns, two key robustness checks are completed. First, models are estimated using a sample of all Canadian provinces and a subset limited to Alberta, Saskatchewan and Newfoundland and Labrador, the resource dependent group. As the term "resource dependent" suggests, Canada has substantial cross-sectional variation is energy and resource endowments and the relationship between taxes, transfers and resources may not be linear across such large spreads. Second, as in James (2015), oil reserves are used to instrument for per capita resource revenues. Two additional tables of instrumental variable results are available upon request. The pattern of the results from these instrumental variable models is consistent with the least squares estimates but the magnitudes are roughly 100bps greater. These tables use time-varying, province-specific reserves of light sweet crude to instrument for resource revenues. The level of reserves predicts the level of resource revenues for two reasons. First, revenues are usually greater where energy endowments are greater. Further, as reserves are a long-run geological endowment, it may be reasonable to exclude this variable from province's year-to-year personal income tax rate decisions – i.e., the extraction of energy reserves requires multi-year investments and planning, so that short-run provincial responses to resource shocks should not be influenced by a stock *in situ*, only by extracted flow from this stock whose rate is determined by global commodity markets.

Second, larger reserves may also have lower variable extraction costs on a per barrel basis if the resource is readily accessible. Taken together, these checks hint that the primary empirical results are fairly robust and, if anything, attenuated towards zero.

In addition to personal income tax, I also investigate the effect of resource sector revenues on corporate income tax rates and excise taxes on gasoline. Rather than a two equation specification, I estimate:

$$t_{it} = \delta_1 \hat{r}_{it} + \theta_t + \psi_i + \alpha_1 \log \sigma_{it} + \epsilon_{it} \tag{2}$$

where t_{it} represents either the corporation tax income tax rate or the logarithm of the excise tax per litre of gasoline in province i during year t. θ_t, ψ_i and $\log \sigma_{it}$ – the fixed effects and log share of resource revenues – are identical to (1). The coefficient of interest in (2) is δ_1. δ_1 captures the reduced form effect of resource revenues on taxes – the tax-resource elasticity. In (2), δ_1 combines the direct and indirect effects from (1). Finally, ϵ_{it} is the conventional additive error term.

2.2 Data

The analysis of personal and corporate income taxation covers the 1984-2011 period using data from several sources.[7] The sample for gasoline excise taxes is for 1990-2011. Effective province-specific marginal tax rates are obtained for two household income levels. The first is a single-earning family of four with a real income income of $70,000 in 1984 dollars. The second is identical except their real 1984 income equals $300,000. Neither of these series take advantage of any boutique tax credits that were offered or repealed as a consequence of fluctuating resource revenues. Saskatchewan, for example, reduced the availability and refundability of their "active families benefit" and in-province tuition credits (Saskatchewan, 2015). By omitting this class of credit, the coefficients in (1) will likely under-estimate the true response of negative shocks. Information on the effective marginal tax rates is from Milligan's (2012) Canadian Tax and Credit Simulator, a model that has been applied extensively (e.g., Finkelstein, 2002; Jones, Milligan and Stabile, 2015; Milligan and Smart, 2014*b*; Smart and Stabile, 2005). Information on provincial corporation income tax rates is from

[7] All code and data are available from the author and will be posted on my website.

Cahill et al. (2007) and the Canada Revenue Agency (CRA, 2016). Excise taxes on gasoline are collected by Kent Marketing Services for Natural Resources Canada (NRCan, 2016). Data on real provincial resource revenues, population, the resource share of provincial GDP and net federal transfers to provinces are from CANSIM. Finally, the supplementary instrumental variables tables instrument per capita resource revenues with proven light oil reserves within provinces. These data were retrieved from the Canadian Association of Petroleum Producers (CAPP, 2016).

Table 1 presents key summary statistics. The mean combined federal-provincial marginal tax rate on middle incomes equals 47.1% and ranges from 36.0% to 58.8%. For high income households, the rate increases to 49.4% with a minimum of 39.0% and a maximum of 63.1%. Provincial corporate income taxes range from 5% to 17% with a mean of 13.1%, while the mean excise tax on gasoline is 13.5 cents per litre. The spread of per capita resource revenue and federal transfers in Canada is large with means of $1,913 and $1,790, respectively. The minimum per capita province-year level of resource revenues equals $2 while the maximum is $12,123. For per capita federal transfers, these values equal $441 and $7,854.

2.3 Results

2.3.1 Personal Income Taxes

Figure 2 previews the main results. A scatterplot and a locally weighted (LOWESS) regression demonstrates a downward sloping relationship between personal income taxes and the resource sector. For both middle income and upper marginal tax rates, the tax-resource relationship is negative. This non-parametric curve strongly suggests that the recent decisions of Canada's resource dependent provinces to increase personal income taxes in response to a downturn in oil prices (and hence resource revenues) match prior tax choices. Moreover, the linearity of the curve supports the specification assumptions used in (1). Of course, unlike in (1), this regression does not control for province-specific or common time-specific effects.

The econometric results for personal income tax rates are presented in two tables. Table 2 uses data on middle income households and Table 3 looks at top marginal brackets. Both have four columns of results. The first two columns include data for all provinces while the last two columns restrict the sample to Alberta, Saskatchewan and Newfoundland and Labrador.

Table 2 shows that historically Canadian provinces have behaved in accordance with their recent decisions. The first two columns of results in Table 2 show that a $1,000 reduction in resource revenues leads to a 1.46 percentage point (pp) increase in personal income tax rates. This increase can be decomposed into a 1.1pp direct effect and a 0.4pp (0.203*0.018) increase through federal transfers. This latter, indirect effect comprises 27% of the total change. The results are similar when the sample is restricted to Canada's resource dependent provinces. The rightmost two columns illustrate that a $1,000 decrease in per capita resource revenues leads to an increase in personal income tax rates of 1.53pp. The key difference is that the direct effect dominates in this scenario explaining 98% of the increase. This result is expected as the provinces of Alberta, Saskatchewan and, recently, Newfoundland and Labrador fund a larger share of publicly-provided goods from own-sources of revenue.[8] Also, while the direct effect is statistically significant within the restricted sample, the standard errors on the indirect effect show that it is not possible to reject the null hypothesis of no effect at conventional significance levels.

Table 3 replicates Table 2 but concentrates on the top marginal tax bracket. It too predicts the recent provincial tax policy choices with coefficients that are slightly smaller in magnitude than those for middle incomes. When all provinces are included, a $1,000 fall in per capita resource revenues leads to a 117bps increase in top provincial marginal tax brackets. The direct effect comprises 68% of the change and both the direct and federal effects are statistically significant at a 5% level. Examining the results for Alberta, Saskatchewan and Newfoundland and Labrador shows few differences from Table 2. The total effect of a $1,000 decrease in per capita resource revenues generates a 1.47pp increase in top marginal tax rates. Again this is dominated by the direct effect which accounts for 95% of this change. In contrast with the full, all provinces sample however, it is not possible to claim that the estimate on net federal transfers is statistically distinguishable from zero.

[8] While equalization is an important component of the data, the federal transfer effect includes more than just equalization.

It is useful to place these estimates within the context of recent economic developments. Data on the reduction in resource revenues attributable the 2014-2015 oil price shock are not yet available. Under the conservative assumptions based on the results in Figure 1, a reasonable guess of the per capita resource-induced income decline in Alberta and Saskatchewan is $750 and $650 for Newfoundland and Labrador.[9] Estimates from Table 2 then predict that Alberta should increase personal tax rates by 115bps (0.75*153bps), a value that is larger than their 2015 increase but less than their 2016 rates. Newfoundland and Labrador increased rates on their top two brackets by 50 and 100bps, respectively. The estimates from Tables 2 and 3 predict increases of 99 and 96 bps, implying that Newfoundland and Labrador's 2015 policy decisions align with the prevailing Canadian tax-resource elasticity. Overall, these results illustrate that the recent tax policy decisions by Alberta, Saskatchewan and Newfoundland and Labrador are consistent with the historical precedent. This is the paper's first main result: recent tax increases match prior policy choices. This does not mean that these decision are optimal, merely that they resemble the standard pattern.[10] Finally, Canada's tax-resource elasticity is markedly smaller than those estimated in James (2015) for the US. He finds that a $1,000 positive shock to resource revenues in US states leads to a 588bps and 181bps reduction in top and bottom marginal tax rates, respectively.

Increasing income taxes may accord with prior Canadian experience, but higher taxes do distort economic decision-making. Using a conservative back-of-the-envelope approach, it is possible to approximate incremental deadweight of these personal income tax increases using Harberger's familiar excess burden calculation. Incremental excess burden, the difference between the welfare loss and tax collected on the tax increase (Dahlby, 2008), is calculated via:

$$EB \approx \frac{1}{2}\frac{(2\tau_1\tau_2 + \tau_2^2)\varepsilon_{Lw}(wL)}{1-\tau_1}$$

where τ_1 and τ_2 are the initial and new tax rates, ε_{wL} is the "tax-price" elasticity or elasticity of

[9] It is extremely likely these are underestimates as the procedure to obtain them is *very ad hoc*. I combined estimates from Figure 1 and data from Statistics Canada. For example, in 2013, Alberta's per capita GDP equaled $84,390 and over the past 15 years, resources comprised an average of 22.1% of its economy (see Table 6). Assume that the oil price shock proportionally reduced the province's personal income tax base by 4% (it was probably greater than this). Then $84,390*0.04*0.221=$746.

[10] The instrumental variable estimates (which are available from the author) suggest a notably larger (approximately 100bps) response by provincial governments. Using these results, the $750 and $650 drops in per capita resource revenues suggest at least a 183bps increase for Alberta and 155bps increase for Newfoundland and Labrador, estimates nearer to the 2016 rates.

taxable income and wL is the tax base (labour income). Table 4 presents results on the incremental deadweight losses for each Alberta, Saskatchewan and Newfoundland and Labrador under the following assumptions: (i) $\tau_2 = 1.025\tau_1$, where τ_1 is the province's 2011 marginal tax rate; and, (ii) the tax increase applies to the entire labour income tax base in 2013[11] (this implies that the deadweight loss numbers will over-estimate the true values). Three elasticities of taxable income are presented: 0.3 which is approximately equal to the value estimated by Sillamaa and Veall (2001) and Saez, Slemrod and Giertz (2012); 0.7, a value loosely taken from Milligan and Smart's (2014*a*) recent estimate for high income earners;[12] and, an elasticity of 1.1, which captures longer run responses to tax increases (Dahlby and Ferede, 2011).

Table 4 shows that Alberta's excess burden from a 2.5% tax increase on its entire tax base would equal \$21M or less than 1bps of total provincial GDP with the lowest elasticity of taxable income. This increases to \$48M and \$77M, respectively, when the elasticity increases to 0.7 and 1.1. The values for Saskatchewan and Newfoundland and Labrador are \$6M and \$3M when ε_{Lw} equals 0.3 and comprise an equally tiny share of provincial output. The estimates are four times larger with the larger 1.1 values, equalling \$23M and \$11M.

Granted these deadweight losses are rough, ballpark estimates, their paucity does have several policy implications. First, lost economic welfare due to the tax increases is small and swamped by the losses resulting from lower overall incomes. Second, initiatives such as Canada's Ecofiscal Commission have little scope to reduce labour market distortions via shifting from income to environmental taxes. Instead, their recommendations may be best served by focusing on areas where the prospective environmental benefit is greatest. Third, Table 4 adds merit to calls for additional savings of resource revenues (either to reduce revenue volatility or to smooth expenditures over time) (e.g., Emery and Kneebone, 2011; Landon and Smith, 2010, and many others). These results suggest that there is few incremental gains from the so-called "Alberta Advantage" of low personal and corporate income tax rates funded through resource revenues. Obviously however, a more complete analysis on the intertemporal merits of dedicated sovereign funds vis-à-vis private

[11] These data are from CANSIM (table 111-0024).

[12] Milligan and Smart (2014*a*,*b*) demonstrate that the tax avoidance elasticity for high income earners equals 0.664, indicating that the taxable income of high earning households is sensitive to the prevailing tax rate. Still, recent evidence seems to indicate the labour supply elasticities have decreased over time (see Dostie and Kromann, 2012, for recent Canadian evidence).

savings is required before drawing definitive conclusions. The next section measures the response of corporate income tax rates and excise taxes on gasoline to give a more complete picture of the portfolio of tax changes enacted by governments in response to changes in a volatile resource sector.

2.3.2 Effect of Resource Revenues on Corporate Income and Excise Taxes

Figure 3 duplicates Figure 2 but looks at two different tax bases: corporation income taxes and excise taxes on gasoline. Unlike the personal income tax rates scenario, the results are mixed. Panel A, the left-hand graph, shows an ambiguous relationship between per capita resource sector GDP and corporate tax rates. While the figure does not control for province- or time-specific factors, it is challenging to visually distinguish any meaningful pattern in the plot. Panel B, the right-hand figure displaying excise taxes, does have an perceptible trend. Similar to personal income taxes, there is a visually detectable negative relationship between excise taxes on gasoline and per capita resource revenues – at least for provinces with larger resource economies. Still the distribution of observations above $5,000 in per capita resource sector GDP is sparse and this figure may simply be capturing province-specific preferences. The econometric analysis allows me to control for time-invariant province-specific factors and common time trends across all jurisdictions.

Table 5 displays the results from estimating (2) (the model that combines the direct and indirect channels). The econometric results largely corroborate the trends presented in Figure 3. The top panel shows the corporate income tax-resource elasticity for all provinces and the resource dependent provinces, respectively. Per capita resource revenues have virtually no effect on corporate tax rates with coefficients equalling 0.003pp for all provinces and 0.007pp when the sample is limited to Alberta , Saskatchewan and Newfoundland and Labrador. Further, neither of these estimates is statistically distinguishable from zero.

Panel B in Table 5 shows the effect of the resource sector on (logged) excise taxes on gasoline. These specifications do find economically and statistically meaningful results. Increasing revenues in the resource sector by $1,000, in the column that has results for all provinces, reduces the excise tax on gasoline by 2.1%. This translates into lower taxes of approximately 0.28 cents per litre.

When the sample is limited to resource dependent provinces, this estimate is larger at 3.3% or 0.45 cents per litre. Both coefficients are precisely estimated and statistically different from zero at conventional levels.

3 The Resource Sector's Contribution to the Variance of Provincial GDP

Provincial governments respond to resource sector shocks by changing tax rates; yet, the forgoing analysis underplays the sensitivity of provincial economies to the energy and resource sectors. For each province, Figure 4 plots the sector's share of provincial GDP. The outsized role of energy and resources in the economies of Newfoundland and Labrador, Alberta and Saskatchewan is apparent as is the smaller role in the other provinces. Over the last twenty years, Newfoundland and Labrador experienced a dramatic change with the economic share of the resource sector increasing from 5% to over 30% of GDP. In 2011, resources in Alberta and Saskatchewan correspond to 19.2% and 13.4% shares.[13] Resources contribute less than 5% of total provincial output in all other provinces.

Volatility of resource revenues within the larger economy presents a challenge for both fiscal managers and the private sector. Resource volatility makes smoothing provincial expenditures more difficult as unpredictability influences the investment decisions of households and firms. To measure the extent to which resource sector volatility influences provincial economies, the approach of Hoffmann and Lemieux (2014) is applied, whereby the variance of provincial GDP is decomposed into two components: a part attributable to the variance of the resource sector and a component that arises from all other sectors. Start by writing first-differenced provincial GDP (i.e., the change in GDP) 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 equals:

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

[13] The jump in 1997 for Alberta and Saskatchewan is due to Statistics Canada revising their data collection methodology. This figure stitches together two separate series, one for 1984–1996 and another for 1997–2011. Table 6, which contains the results on the variance decomposition, presents independent analysis for the full span and the later 1997-2011 period.

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

$$1 = b_r + b_o \tag{3}$$

where the variance of provincial GDP is the sum of two shares, one reflecting resources, b_r, and the other capturing the variance from all other sectors, b_o. b_r, the share of variance in provincial output derived from the variance in provincial resource sector, is the statistic of interest. Inherently, this metric is useful for understanding the resource sector's influence on aggregate output, yet it is also useful for calculating the *excess volatility* of the resource sector (Hoffmann and Lemieux, 2014). Excess volatility is a statistic that is analogous to a coefficient of variation but one that is more informative about the role of resource sector volatility as one component of a larger, diverse economy. Landon and Smith (2010), for instance, consider the coefficient of variation of own-source provincial government revenues, finding that "Alberta's own-source revenues were more than twice as variable as those of [British Columbia, Saskatchewan and Ontario]" (pg. 3). Yet, coefficients of variation ignore how fluctuations in different sectors interact in the economy to mitigate or intensify the variance of aggregate output. The coefficient of excess volatility is in a similar category as Dahlby, Macaspac and McMillan's (2013) portfolio variance approach. Based on data from 1984–2003, they find that Alberta's economy has stabilized over the previous 20 years, but that there is a negative covariance between the oil and gas sector and output in most other sectors. The procedure used here supplements these studies but has the added advantage of yielding a single summary index of within economy variance. The coefficient of excess volatility normalizes a sector's contribution to GDP variance by its relative importance to the economy. It is calculated as the ratio of b_r to a scenario where the resource sector occupies a proportionally constant share of GDP volatility, s_r.[14] Cyclically sensitive sectors have $\frac{b_r}{s_r} > 1$ as b_r is larger than s_r. The coefficient of excess volatility measures the extent to which the volatility of the resource sector *relative to its size* contributes to the variance of the economy as a whole.

Obtaining an estimate for b_r is straightforward. As $b_r = \frac{Cov(\Delta GDP, \Delta R)}{Var(\Delta GDP)}$, a simple regression of

[14] 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.

changes in the resource sector on changes in GDP yields the relevant value:

$$\Delta R = \alpha + b_r \Delta GDP + \varepsilon. \tag{4}$$

These estimates are presented in Table 6. For each province, there are seven columns. Columns two through four presents three statistics for 1984-2011, while columns five to seven repeat the preceding three columns but restrict the time period to 1997-2011 to account for the change in Statistics Canada methodology. The first value is the mean share of the resource sector as a percent of the provincial economy. This reflects an average of the data presented in Figure 4. The second statistic represents the resource sector's contribution to the volatility of each province's GDP, b_r. Specifically, the volatility of provincial GDP is separated or *decomposed* into the share coming from the resource sector and the share originating from all other sectors. Finally, the third statistic is the coefficient of excess volatility, the ratio of the second to first statistics. Relative to the resource sector's importance to a provincial economy, this estimates how much extra volatility in output is attributable to the sector. A value of one indicates proportional volatility whereas a value greater than one signifies a disproportionate contribution to the variance of provincial GDP.

Table 6 illustrates several key trends in provincial economies. First, for energy dependent provinces such as Newfoundland and Labrador, Alberta and Saskatchewan, fluctuations in the resource sector explain the majority of the variance in provincial output. In Newfoundland and Labrador for example, the fluctuations in the sector explains 69.4% of GDP volatility over the full 1984-2011 period, a value which increases to 76.2% for the shorter, 1997-2011, sample. Alberta and Saskatchewan have similar experiences with resources explaining 50.8% and 42.1% of output variance in this latter period. Second, it is possible to compare the 1984-2011 and 1997-2011 samples. Across eight out of ten provinces, the energy and resource sector has maintained or increased its share of provincial output, but the sector has contributed even more to the variance of provincial GDP over the more recent time period. By inspecting the coefficients of excess volatility, the resource sector contributes a disproportionate and increasing share of output variance in every province except British Columbia. (For Quebec, the influences of resources is proportional to their economic contribution, while the variance declined for PEI, a province with a virtually non-existent resource sector.) In the resource intensive provinces of Newfoundland and Labrador, Alberta and

Saskatchewan, over the 1997-2011 period, the coefficient of excess volatility equals 3.3, 2.3 and 2.3, respectively. For Alberta, as an example, this means that the resource and energy sectors comprise 22.1% of output but contribute 50.8% to the variance of provincial GDP. Further, the disproportional contribution of the resource sector to the variance in provincial GDP has increased slightly over time. This hints that the influence of global factors such as the recent decline in oil prices may have a larger effect today than in previous decades.[15] Ultimately, resource volatility, as measured by a share of provincial GDP variance, does present a challenged of fiscal managers.

4 Conclusion

Two years ago, the price of oil plunged. As a consequence, Alberta, Saskatchewan and Newfoundland and Labrador, Canada's resource dependent provinces, experienced meaningful shocks to their economies and government budgets. The resulting deficits motivated wide-ranging changes tax and spending policies. Several of these decisions attracted controversy, yet managing provincial budget processes against the backdrop of volatile global commodity markets is tricky. This study examined Alberta, Saskatchewan and Newfoundland and Labrador's recent tax policies within Canada's prevailing tax-resource relationship. This note concentrates on personal income taxes as these are the dominant source of revenues for Canadian provinces, but it also estimates the corporate and excise tax-resource relationships. The results suggest that Canada's resource dependent provinces adopted a historically consistent fiscal response to these negative oil price shocks. While the optimality of these decisions is unclear, the policies that were enacted are consistent with Canada's prevailing tax-resource elasticity. Generally in Canada, a $1,000 reduction in per capita resource revenues yields a 150bps increase in personal income tax rates and a 3% increase in excise taxes on gasoline, results that closely match recent policies. In contrast to these recent announcements however, Canadian provinces have not historically revised corporate taxes rates in response to declining resource revenues. Supplementing the analysis on the tax-resource elasticity, an accounting exercise demonstrates that the resource sector contributes a disproportionate share to the economic volatil-

[15] Of course, this conclusion requires an important caveat: the analysis for the 1984–2011 period combines two data series. As such, different results from the two time periods may merely reflect revisions in Statistics Canada methodologies.

ity of the majority of Canadian provinces. Specifically, resources respectively contributed 76%, 42% and 51% to the variance of GDP in Newfoundland and Labrador, Saskatchewan and Alberta over the 1997-2011 period. These results underline a small sample of the challenges that fiscal managers face when designing tax and expenditure policies conditional on the whims of unpredictable commodity markets.

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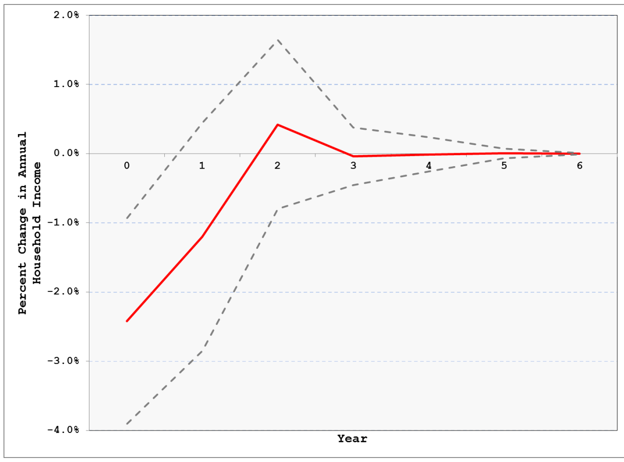
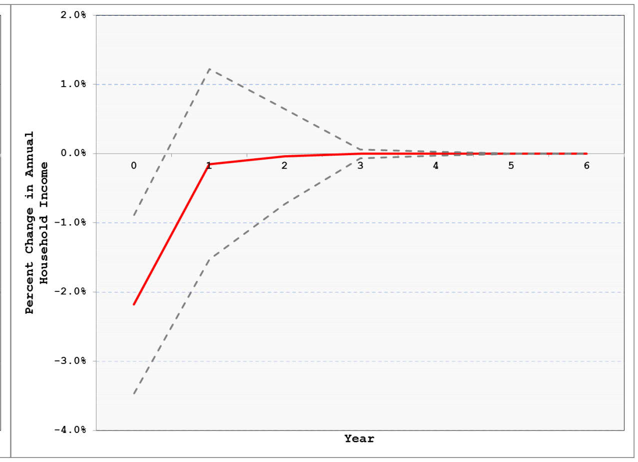


(a) Alberta



(b) Saskatchewan

Figure 1: Response of Household Income to a Shock to Oil Prices

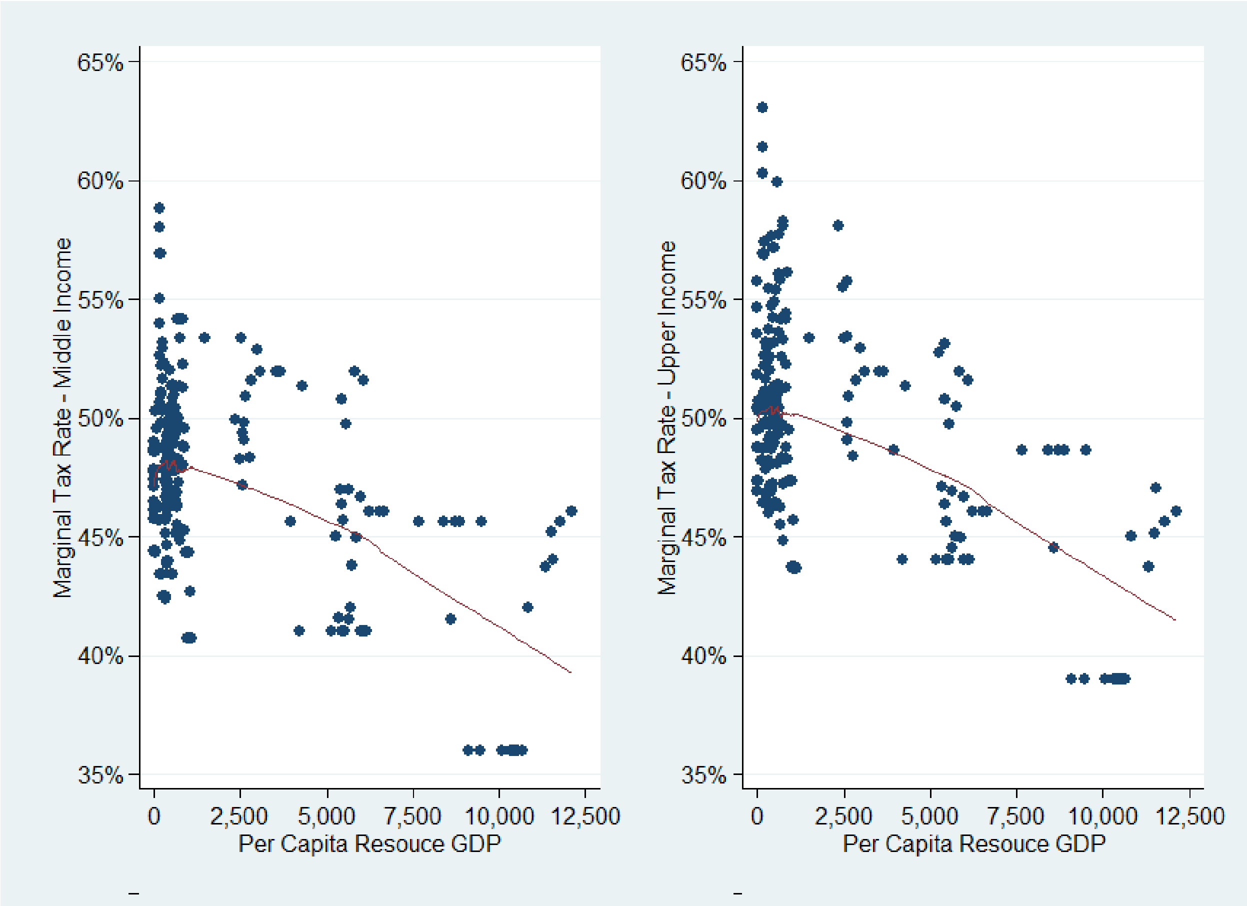


Figure 2: Scatterplot of Provincial Middle (Left) and Upper (Right) Income Marginal Tax Rates and Per Capita Resource Revenues and LOWESS Curve

This figure plots the provincial marginal income tax rates for middle (left) and high (right) income households against the province's per capita resource revenues. Overlaid on both plots is a non-parametric, locally weighted (LOWESS) regression curve.

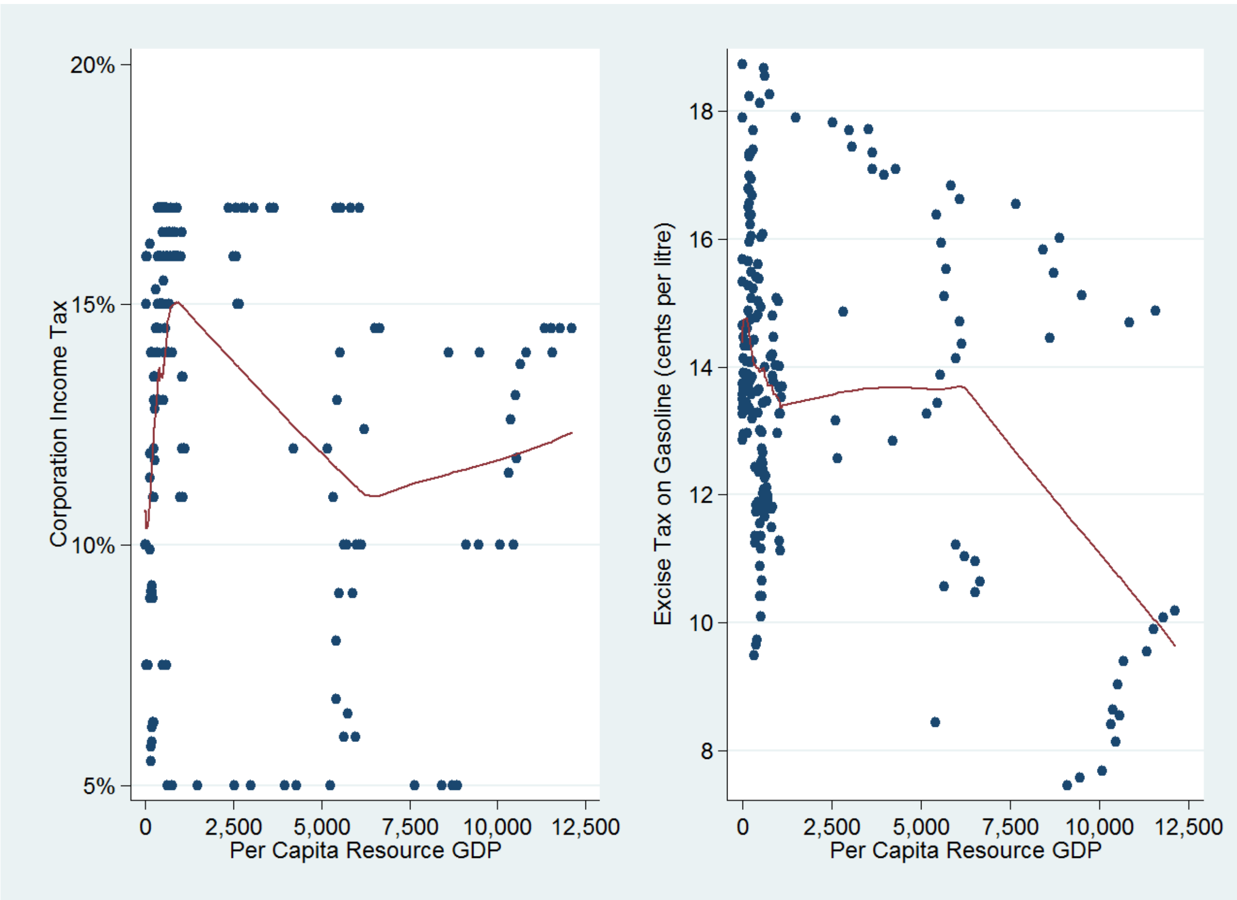


Figure 3: Scatterplot of Provincial Corporation Income Tax (Left) and Excise Taxes on Gasoline (Right) and Per Capita Resource Revenues and LOWESS Curve

This figure plots the provincial corporation income tax rates (left) and per litre excise taxes on gasoline (right) against the province's per capita resource revenues. Overlaid on both plots is a LOWESS regression curve.

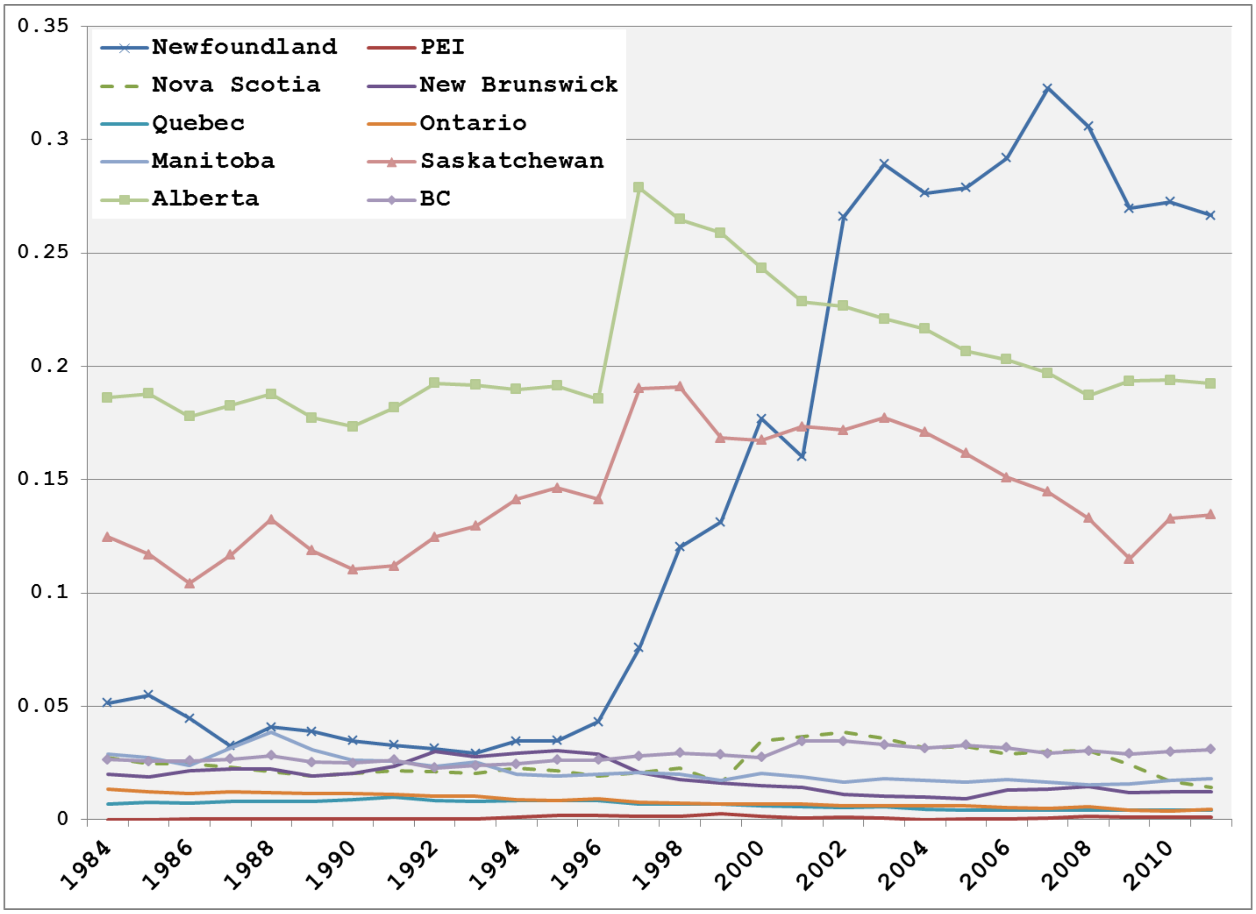


Figure 4: Provincial Resource Sector as a Share of Provincial Output

This figure illustrates the trend of the resource sector as a share of provincial GDP over 1984–2011. Two series are stitched together with the "jump" in 1997 attributable to a change in Statistics Canada methodology.

Table 1: Summary Statistics for Marginal Tax Rates and Per Capita Federal Transfers and Resource Revenues

	Mean	Standard Deviation	Minimum	Maximum
Marginal Tax Rate - Middle Class (%)	47.1	4.3	36.0	58.8
Marginal Tax Rate - High Income (%)	49.4	4.2	39.0	63.1
Corporation Income Tax Rate (%)	13.1	3.6	5.0	17.0
Excise Tax on Gasoline (cents)	13.5	2.5	7.2	18.7
Resource Revenue per Capita ($)	1,913	2,981	2	12,123
Net Federal Transfers per Capita ($)	1,790	1,124	441	7,854

Table 2: Response of Middle Income Marginal Tax Rates to a Change in Resource Revenues

	All Provinces		*Resource Dependent Provinces*	
	Effective Marginal Tax Rate	Net Federal Transfer[a]	Effective Marginal Tax Rate	Net Federal Transfer[a]
Resource Revenues ($1,000)	-0.011	0.203	-0.015	0.132
	(0.002)	(0.091)	(0.003)	(0.122)
Net Federal Transfer ($1,000)	-0.018		-0.002	
	(0.008)		(0.010)	
Observations	250	250	75	75
Effect of $1,000 increase in per capita resource revenues on marginal tax rates				
Change in tax rate (bps)	-146		-153	

a – per $1,000 of net federal transfer.

Clustered standard errors are in parentheses with clustering on provinces. All specifications include provincial fixed effects, year fixed effects and the log share of the resource sector.

Table 3: Response of Top Bracket Marginal Tax Rates to a Change in Resource Revenues

	All Provinces		*Resource Dependent Provinces*	
	Effective Marginal Tax Rate	Net Federal Transfer[a]	Effective Marginal Tax Rate	Net Federal Transfer[a]
Resource Revenues ($1,000)	-0.008	0.203	-0.014	0.131
	(0.003)	(0.091)	(0.003)	(0.122)
Net Federal Transfer ($1,000)	-0.018		-0.005	
	(0.007)		(0.008)	
Observations	250	250	75	75
Effect of $1,000 increase in per capita resource revenues on marginal tax rates				
Change in tax rate (bps)	-117		-147	

a – per $1,000 of net federal transfer.
Clustered standard errors are in parentheses with clustering on provinces. All specifications include provincial fixed effects, year fixed effects and the log share of the resource sector.

Table 4: Approximate Deadweight Loss from a 2.5% Tax Increase

	Deadweight Loss ($millions)		
Elasticity of Taxable Income	0.3	0.7	1.1
Alberta	20.9	47.7	76.6
Saskatchewan	6.3	14.7	23.1
Newfoundland	3.1	7.1	11.2

Table 5: Response of Other Taxes to Changes in Resource Revenues

Panel A: Corporation Income Tax Rates		
	All Provinces	*Resource Dependent Provinces*
Resource Revenues ($1,000)	0.003	0.007
	(0.003)	(0.005)
Observations	250	75

Panel B: (Log) Gasoline Excise Taxes		
	All Provinces	*Resource Dependent Provinces*
Resource Revenues ($1,000)	-0.021	-0.033
	(0.008)	(0.006)
Observations	196	60

Clustered standard errors are in parentheses with clustering on provinces. All specifications include provincial fixed effects, year fixed effects and the log share of the resource sector.

Table 6: Results from Variance Decomposition, Resource Sector Shares and Coefficient of Excess Volatility

	1984-2011			*1997-2011*		
	Regression Coefficient	Share	Excess Volatility Coefficient	Regression Coefficient	Share	Excess Volatility Coefficient
Newfoundland	0.694	0.143	4.9	0.762	0.234	3.3
	(0.062)			(0.075)		
PEI	0.008	0.001	8.0	0.007	0.001	7.0
	(0.004)			(0.009)		
Nova Scotia	0.104	0.025	4.2	0.177	0.028	6.3
	(0.065)			(0.113)		
New Brunswick	-0.003	0.018	0.2	0.023	0.013	1.8
	(0.032)			(0.113)		
Quebec	-0.005	0.007	0.7	-0.005	0.005	1.0
	(0.005)			(0.006)		
Ontario	0.009	0.008	1.1	0.012	0.006	2.0
	(0.005)			(0.006)		
Manitoba	0.024	0.022	1.1	0.040	0.018	2.2
	(0.025)			(0.024)		
Saskatchewan	0.296	0.143	2.1	0.421	0.159	2.3
	(0.062)			(0.069)		
Alberta	0.454	0.204	2.2	0.508	0.221	2.3
	(0.067)			(0.094)		
British Columbia	0.027	0.028	1.0	0.023	0.031	0.7
	(0.021)			(0.030)		

Two distinct series are used in this table. The first covers 1984–1996. The second is from 1997–2001. Columns two through 4 combine these two series, while the rightmost three columns exclusively use the second dataset. The coefficient of excess volatility is the ratio of the regression coefficient to the share of the resource sector in provincial GDP. A value of one indicates that the volatility of the resource sector is proportional to the volatility of provicial GDP. A value greater than one indicates that the resource sector contributes a greater than proportional share (i.e., an excess amount) of volatility to the variance of provincial GDP.