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ALBERTA'S FISCAL RESPONSES TO FLUCTUATIONS IN NON-RENEWABLE-RESOURCE REVENUE

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1. INTRODUCTION

Alberta's provincial government has been heavily reliant on non-renewable-resource revenues coming from the energy sector. Over the past half-century, non-renewable-resource revenue has accounted for about 30 per cent of the provincial government's total revenue. This poses a fiscal challenge as resource revenue is volatile and uncertain. Consequently, the provincial budget is very exposed to the vagaries of global energy price shocks, pipeline disruptions and other events, such as the federal government's previous National Energy Program. Often, the downside to excessive dependence on volatile resource revenue comes to the forefront of public policy discussions when global commodity prices related to the resource sector plummet and budget deficits ensue. Not surprisingly, the recent dramatic decline in resource revenue and the associated budget deficit have been a focus of hot debates in the province's political and academic circles. When a government faces growing budget deficits, sooner or later it may be forced to raise taxes, reduce spending or both to achieve fiscal sustainability.[2] However, the way the provincial government responds, and the timing of its responses, can have significant impacts on society. Thus, examining the dynamics of Alberta's fiscal responses to changes in non-renewable-resource revenue is crucial to enhancing informed public discussions and policy-making in the province.

How do non-renewable-resource revenue shocks affect Alberta's provincial government budget balance? How do the various components of Alberta's budget respond to changes in resource revenue? Are there asymmetries in the budgetary responses to shocks in non-

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1 I would like to thank Bev Dahlby and two anonymous referees for their comments and suggestions. All remaining errors are my own.

2 For instance, a recent analysis from the Parliamentary Budget Officer (PBO) (2017) casts doubt on the long-term sustainability of Alberta's fiscal policy. The study suggests that the provincial government requires an increase in the provincial revenue or a reduction in spending equivalent to about 4.6 per cent of gross domestic product (GDP) to attain long-term fiscal sustainability.

renewable-resource revenue? The main objective of this paper is to analyze these and other related important public policy issues using time series data for Alberta spanning about half a century.

There is generally a paucity of empirical studies that examine the fiscal adjustment of Alberta. Landon and Smith (2010) investigate the volatility of Alberta's government revenue and ways of minimizing this volatility. They argue that an important way to overcome this revenue volatility caused by fluctuations in non-renewable-resource revenue is to create a stabilization fund for non-renewable-resource revenue. Their analysis was largely conducted through the comparison of the volatility of the various revenue sources using statistical measures of volatility. In a somewhat related study, Ferede (2013) also examines how Alberta's tax bases respond to the business cycle by focusing on the volatility of the economy and the tax bases. However, these two studies do not provide an empirical investigation of how the various budget components respond to fluctuations in non-renewable-resource revenue.

To the best of our knowledge, Kneebone and McKenzie (1997) and Kneebone (2015) are the only two studies that deal with similar provincial fiscal issues. Using an empirical strategy proposed by Poterba (1994), Kneebone and McKenzie (1997) investigate Alberta's budgetary responses to fiscal shocks over the fiscal period 1970–71 to 1993–94. They find that current provincial expenditure does not respond to past unanticipated revenue and spending shocks. On the other hand, they find that past revenue increases are associated with a reduction in the current revenue of the government. In their analysis, they employ seemingly unrelated regression methods and investigate only total revenue and total spending without looking into the various components.

Kneebone (2015) examines how resource-rich Canadian provinces — Alberta, Saskatchewan and Newfoundland and Labrador — deal with global commodity price shocks. Although his analysis was largely descriptive, he also provides a simple regression of non- resource-revenue budget gaps (i.e., the budget balance that excludes resource revenues) on lagged resource revenues for the three provinces. His analysis indicates that the budgetary gap — defined as the difference between total government expenditure and total non-resource revenue — is positively associated to resource revenues, suggesting that positive resource-revenue shocks encourage these provinces to spend more, raise less revenue from other sources or both. However, Kneebone (2015) does not investigate how the various budget components respond to resource-revenue changes. The analysis was also quite limited in its use of the appropriate empirical methodology, mainly because the focus of the paper was to provide a descriptive analysis of the issue.

In this paper we analyze the budgetary responses to fluctuations in resource revenue using annual time series data for Alberta over the fiscal period 1970–71 to 2016–17. Following the empirical methodology employed in Bohn (1991) and Buettner and Wildasin (2006), we employ a vector autoregression (VAR) model and consider the main components of the budget constraint of the provincial government. This approach helps us explore the provincial government's responses to various spending and revenue shocks. More importantly, such an approach enables us to investigate the budgetary responses of the provincial government to resource-revenue shocks.

The empirical results of this paper show that a one-dollar increase in real per capita non-renewable-resource revenue is associated with a 56-cent increase in program spending in the following fiscal year. We also find evidence of asymmetric responses of program spending and corporate income tax (CIT) revenue to non-renewable-resource revenue. Program spending and CIT revenue rise with resource-revenue increases but they do not decline with a reduction in resource revenue. Other sources of provincial government revenue seem to be unresponsive to changes in resource revenue. This may be surprising since one would expect tax bases and the associated tax revenues to follow the boom-bust cycle of oil prices. This could also imply that tax rates do not change in response to fluctuations in resource revenue.

The asymmetric budgetary responses to resource-revenue shocks have implications for the long-run sustainability of the provincial government's fiscal policy. The results indicate that the various budget components seem unresponsive to a fall in resource revenue. Only program spending and CIT revenue rise when resource revenue increases, but the magnitude of the response of the former is larger. Thus, the budget deficit increases (or the budget surplus declines) when resource revenue declines, but the budget balance improves by less than the increase in resource revenue during resource boom times. The long-run implication of this is that the public debt ratchets up over time as downturns in resource revenue are not offset by saving resource-revenue increases. In fact, our analysis indicates that asymmetric fiscal responses would result in a decline in the province's net financial asset position. Based on our simulation, the cumulative effects of the asymmetric fiscal response on the province's net debt would be roughly $30.4 billion in 2017 dollars. The policy implication of our results is that the provincial government should put unanticipated increases in resource revenue in a fiscal stabilization fund, or the Alberta Heritage Savings Trust Fund, rather than increase spending in the short term.

The remaining part of the paper is organized as follows. The model specification and discussion of the data are presented in Section 2. Section 3 presents and discusses the empirical results. Section 4 concludes.

2. SPECIFICATION AND DATA

2.1. Specification

The empirical specification of this paper is based on a model of fiscal adjustment that was originally outlined in Bohn (1991) to investigate the budget-balance adjustment of the U.S. federal government. This method was also later adopted in other studies such as Buettner and Wildasin (2006), Buettner (2009), and Solé-Ollé and Sorribas-Navarro (2012) to investigate the dynamic fiscal adjustment of a panel of U.S, German, and Spanish municipalities, respectively. The method essentially uses the intertemporal budget constraint of the government and considers all the various components of the government's budget. Consequently, it provides a suitable framework to assess Alberta's fiscal responses to non-renewable-resource revenue shocks.

Consider Alberta's provincial government budget. The provincial government has various revenue sources and spends on many expenditure categories. For the sake of analytical simplicity, we group the various revenue sources into four categories: non-renewable-resource revenue (NRR_t), corporate income tax revenue (CIT_t), personal income tax revenue (PIT_t), and all other revenue sources including federal transfers (OR_t). Similarly, we group the provincial government's expenditure into: program spending (PS_t) and debt-service payments (DS_t). We denote the fiscal year with the time subscript *t*. The government uses the total revenue to finance program expenditure and debt-service charges. Consequently, in any given fiscal year, the current budget deficit of the provincial government (D_t) can be given by the budget equation as:

$$D_t = PS_t + DS_t - NRR_t - CIT_t - PIT_t - OR_t. \qquad (1)$$

Bohn (1991) shows that the intertemporal budget constraint of Eq. (1) has a vector error correction representation of the following form:

$$\Delta Z_t = B_0 D_{t-1} + B_1 \Delta Z_{t-1} + B_2 \Delta Z_{t-2} + \cdots + B_p \Delta Z_{t-p} + u_t\,, \qquad (2)$$

where the vector Z_t includes PS_t, DS_t, NRR_t, CIT_t, PIT_t and OR_t. Δ denotes first-difference, *p* is the lag-length order, and u_t is the error term. B_0 is a vector of the coefficients of the lagged budget deficit and B_p is a matrix of the coefficient estimates of the variables for lag length *p*. Note that the specification in Eq. (2) assumes that the budget deficit is stationary.[1] However, this must be empirically confirmed with appropriate unit-root tests before one uses Eq. (2) in empirical analyses. While previously mentioned studies found that the budget deficit is indeed stationary for the U.S. federal government and U.S., German, and Spanish municipal governments, this may not be necessarily true for some other economies with persistent budget deficits or budget surpluses. If the budget deficit happens to be non-stationary, then a VAR on the first-differences of the budget components, excluding the lagged budget deficit, is the appropriate empirical methodology.

The use of first-differenced variables (i.e., change in the fiscal variables) in Eq. (2), as outlined in previous studies, also has an important advantage to investigate the presence of possible asymmetric responses of the various budget components. In our case, we can separate the change in the NRR into increases and decreases to assess if there are asymmetric fiscal responses to increases and decreases in NRR. That is, the first-differenced resource-revenue variable (ΔNRR_t) is decomposed into: $NRRI_t = Max\,\{0, \Delta NRR_t\}$ and $NRRD_t = Min\,\{0, \Delta NRR_t\}$, where Δ denotes first-difference, $NRRI_t$ is the non-renewable-resource revenue increase, and $NRRD_t$ is non-renewable-resource revenue decrease. Such an approach is commonly employed in the energy literature. See, for instance, Mork (1989), Gamkhar and Oates (1996), and Arezki and Ismail (2013). Thus, Eq. (2) can be estimated by replacing the change in the non-renewable-resource revenue variable (ΔNRR_t) with $NRRI_t$ and $NRRD_t$. This helps us examine if Alberta's budget responds differently to increases and decreases in resource revenue. During the period under consideration, resource-revenue changes were positive about 59 per cent of the time and negative about 41 per cent of the time.

An important feature of the VAR estimation strategy outlined above is that, in addition to considering all the important budget components, the model effectively deals with the potential problem of endogeneity and the associated bias in estimates. Note also that this strategy allows current NRR shocks (fiscal shocks) to influence future budget components but not contemporaneously. This is important because, generally, once the budget is announced, revenue shocks will have effects on future budget components.

The Alberta provincial government established the Alberta Heritage Savings Trust Fund (AHSTF) in 1976 to save some of the government's non-renewable-resource revenue for future generations. Accordingly, the provincial government was transferring a portion of its non-renewable-resource revenue to the AHSTF over the fiscal period 1976–77 to 1986–87.[2] The part of resource revenue that is saved in the AHSTF is not expected to influence the provincial government's spending and revenue-raising choices. For this reason, in our analysis, we exclude the part of the resource revenue that is saved in the AHSTF from the non-renewable-resource revenue data. Of course, on the government's part, this decision to save part of the non-renewable-resource revenue is an important fiscal policy decision. We control for this fiscal policy event by including a dummy variable that is equal to one in the fiscal years in which the government was saving in the AHSTF.

We also include other exogenous variables that are likely to affect the province's budget. It is known that the various components of the provincial budget can be influenced by the business cycle. Thus, following Buettner and Wildsain (2006), we account for the potential effects of the business cycle by including one-period lagged changes in the provincial employment and unemployment rates. Another important exogenous factor that is often cited in provincial budget documents as being important in influencing the provincial government's oil royalty revenue is the

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1 Roughly speaking, an economic variable is considered as "stationary", if its mean and variance are constant over time.

2 See Alberta Treasury Board and Finance, "Alberta Heritage Savings Trust Fund 2016–17 Annual Report," available at: https://open.alberta.ca/publications/0702-9721. The government also deposited some of the non-renewable-resource revenue to the AHSTF in 2005–06 to 2007–08.

Canadian-U.S. dollar exchange rate. For this reason, we control for this factor by including one-period lagged changes in the Canadian-U.S. dollar exchange rate.

2.2 Data

We use annual time series data for Alberta for the fiscal year 1970–71 to 2016–17. The data for the fiscal variables were obtained from Kneebone and Wilkins (2018).[3] All the fiscal variables are in per capita 2017 dollars and measured in fiscal-year terms. We use the province's consumer price index (CPI) to deflate nominal variables. The data on exchange rates, unemployment rates and employment rates come from Statistics Canada's CANSIM data source. The basic summary statistics of the main variables of interest are shown in Table 1 below. All variables are in per capita 2017 Canadian dollars.

TABLE 1 SUMMARY STATISTICS FOR THE KEY VARIABLES, 1970–71-2016–17

Variables	Symbols	Mean	Std. Dev.	Minimum	Maximum
	Variables in levels, 1970-71 to 2016-17				
Non-renewable-resource revenue	NRR_t	2,843.2	1,326.6	687.0	5,186.4
Corporate income tax revenue	CIT_t	791.6	349.1	243.5	1,561.0
Personal income tax revenue	PIT_t	1,860.6	606.0	763.1	2,819.6
Other revenue	OR_t	4,392.9	1,085.5	2,372.7	5,816.0
Debt-service payments	DS_t	321.0	336.4	30.9	1,076.5
Program spending	PS_t	9,395.0	2,160.0	4,708.9	12,872.1
Budget deficit	BD_t	-172.3	1,585.7	-3,186.6	3,776.2
	Variables in first-differences, 1971-72 to 2016-17				
Non-renewable-resource revenue	ΔNRR_t	-4.9	990.8	-2,452.6	2,762.3
Corporate income tax revenue	ΔCIT_t	14.4	203.3	-463.0	450.7
Personal income tax revenue	ΔPIT_t	39.6	228.9	-688.6	937.5
Other revenue	ΔOR_t	36.7	582.2	-1,267.7	2,420.6
Debt-service payments	ΔDS_t	4.2	86.2	-247.5	222.1
Program spending	ΔPS_t	141.8	743.9	-1,265.2	2,518.5
Non-renewable resource revenue increase	$NRRI_t$	358.0	586.5	0.0	2,762.3
Non-renewable resource revenue decrease	$NRRD_t$	-362.9	610.0	-2,452.6	0.0

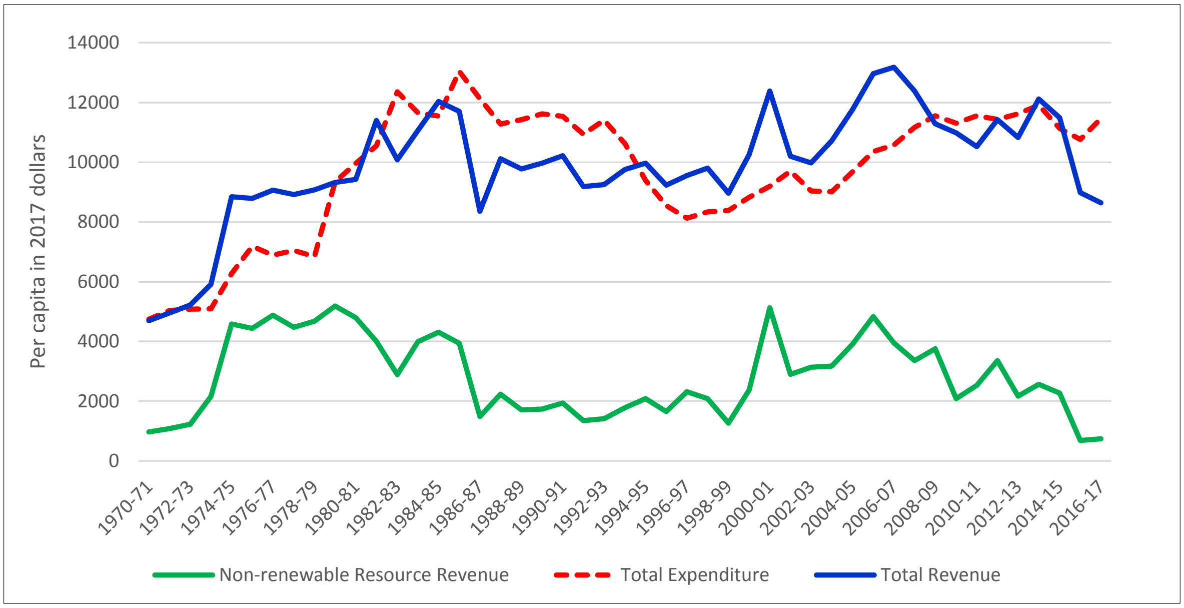
Note: All fiscal variables are per capita in 2017 Canadian dollars. Total number of observations is 47 for variables in levels.

The provincial budget components show significant variations over the sample period. Program spending shows an upward trend during most of the sample period and it ranged from $4,709 in 1970–71 to $12,872 in 1985–86 in real per capita terms. In the last fiscal year of our sample period, real per capita program spending was about $11,233. During the period under consideration, the average real per capita budget surplus was about $172. But this masks the significant variation that occurred during the period. In fact, the budget balance ranged from a deficit of $3,776 in 1986–87 to a surplus of $3,187 in 1978–79, all in per capita 2017 dollars. Most recently, the real per capita budget balance that was a surplus of $1,218 in just 2007–08 turned to a budget deficit of $2,823 in 2016–17. Over the same period, the share of non-renewable-resource revenue in the provincial government's total revenue fell from about 27 per cent in 2007–08 to just nine per cent in 2016–17. This suggests the presence of a strong relationship between the province's budget balance and non-renewable-resource revenue.

[3] The dataset is available online at: https://www.policyschool.ca/publication-category/research-data/

What does the evolution of Alberta's budget components look like over the period under consideration? In Figure 1 we plot the provincial government's non-renewable-resource revenue (green line), total expenditure (red broken line), and total revenue (blue line). The gap between total spending and total revenue shows the province's budget balance. The pattern of the province's total revenue very much follows the pattern of non-renewable-resource revenue while the budget balance also mirrors the fluctuations in non-renewable-resource revenue. Alberta's budget balance improves as non-renewable-resource revenue increases but deteriorates as global oil prices plummet and the non-renewable-resource revenue falls. In the 1970s, when non-renewable-resource revenue was increasing, the province was running a budget surplus. However, this changed in the 1980s, as oil prices plummeted and non-renewable-resource revenue fell. The figure also shows the most recent dramatic increase in the budget deficit following the huge fall in the province's non-renewable-resource revenue. The sharp fall in the province's total spending around 1993 is due to the policies of the Ralph Klein government during his first term as premier.

FIGURE 1 THE EVOLUTION OF ALBERTA'S REVENUE AND EXPENDITURE, 1970–71 TO 2016–17



While one may infer a positive relationship between non-renewable-resource revenue and Alberta's overall budget balance from Figure 1, a better insight can be obtained if we just plot the budget balance and non-renewable-resource revenue together.

FIGURE 2 ALBERTA'S OVERALL BUDGET BALANCE AND RESOURCE REVENUE PER CAPITA IN 2016/17 DOLLARS, 1970-71 TO 2016-17

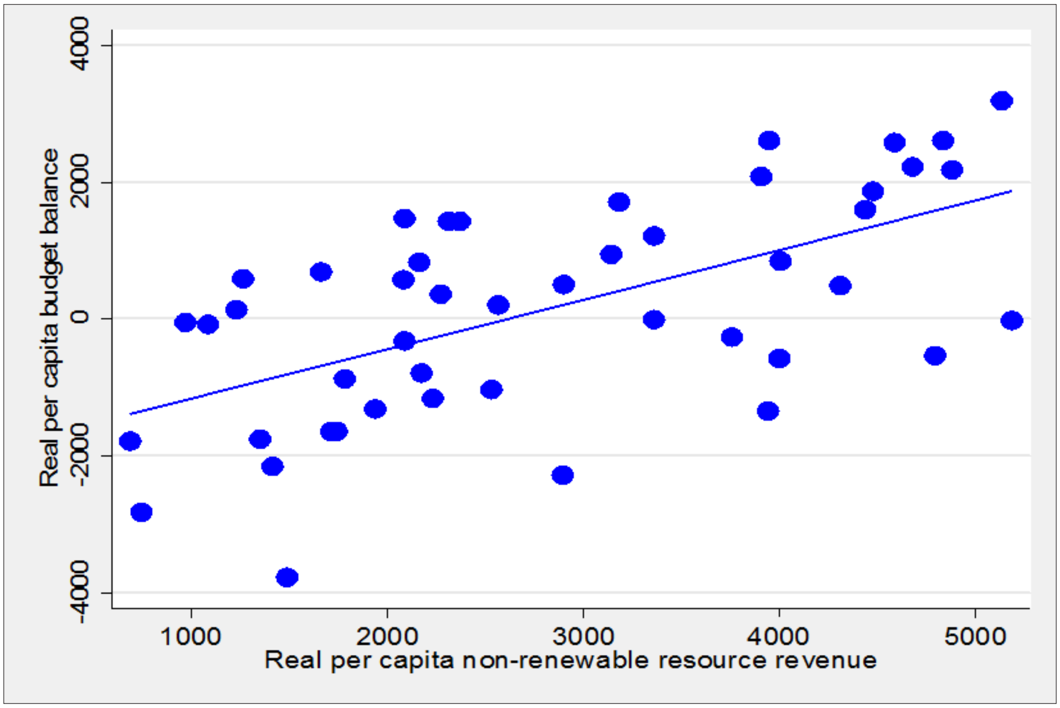


Figure 2 shows the relationship between Alberta's real per capita overall budget balance and non-renewable-resource revenue over the sample period. Note that negative values of the budget balance show a budget deficit. The straight line shows a fitted trend line. The figure shows that the evolution of Alberta's budget balance is positively related to its non-renewable-resource revenue. The slope of the trend line is 0.78, suggesting that a one-dollar increase in non-renewable-resource revenue is associated with a 78-cent improvement in the overall budget balance. In the next section, we empirically investigate how the various budget components respond to changes in non-renewable-resource revenue.

3. EMPIRICAL RESULTS

3.1. Unit-Root Tests

In time-series-based empirical analysis such as ours, one needs to first determine the time series properties of the key variables of interest using appropriate unit-root tests. There are various alternative unit-root tests that are widely used in the literature. In this paper, we use the most commonly used Augmented Dickey-Fuller (ADF) and Phillips-Perron unit-root tests. We also employ the relatively recent and more efficient unit-root test proposed by Elliott et al. (1996). This test modifies the familiar Dickey-Fuller test and is commonly referred to as DF-GLS, as it uses the generalized least squares (GLS) method. We report the unit-root-test results in Table A1 in the appendix. The results indicate that all the fiscal variables of interest are non-stationary in levels. However, they are all stationary in first-differences. Note that the budget deficit is found to be non-stationary in levels. This has an important implication for our empirical methodology. As discussed previously, while the vector error correction model is appropriate when the budget deficit is stationary, in our case this approach is not feasible as the budget deficit is non-stationary. Thus, as is common in the literature, we use the VAR method on the first-differences of the key fiscal variables to avoid the potential problem of spurious regression results.

3.2. Asymmetric Fiscal Responses

A boom in global oil prices results in an increase in the province's non-renewable-resource revenue. The bonanza in the provincial coffers may encourage pressure on the provincial government to increase wages and salaries for public servants and raise its expenditure on various public services. On the other hand, when oil prices collapse and non-renewable-resource revenue falls, austerity measures by the government may be politically challenging as various groups may resist cuts in public services. Attempts to raise revenue from other areas, such as through tax increases, may also be politically infeasible in the face of a decrease in oil prices and overall economic downturn. Thus, one may expect asymmetric fiscal responses to resource-revenue shocks. This section provides an empirical examination of the issue using VAR methodology as outlined previously.

The dynamic coefficient estimates for the VAR are shown in Table A2 in the appendix. The results suggest that a significant part of fluctuations in Alberta's program spending is explained by resource-revenue increases rather than decreases. That is, Alberta's program spending rises when resource revenue increases, but it does not significantly adjust downwards in response to an unexpected fall in resource revenue. The coefficient estimates suggest that a one-dollar increase in real per capita resource revenue is associated with a $0.56 increase in program spending one year after the shock. The coefficients of NRRD (non-renewable-resource revenue decrease) on the other hand, are statistically insignificant showing that program spending does not adjust downwards following resource-revenue decreases. This suggests that there is an asymmetric response in Alberta's program spending to resource-revenue innovations. In fact, we conduct a formal statistical test for the possible presence of asymmetric responses to resource-revenue innovations and confirm that there is indeed an asymmetric response of Alberta's program spending to resource-revenue shocks.[4]

The empirical results also show that an increase in non-renewable-resource revenue increases the provincial government's CIT revenue. According to the coefficient estimate, a one-dollar increase in the non-renewable-resource revenue is associated with an increase of CIT revenue by about $0.14. The reason for this is that an increase in non-renewable-resource revenue that is caused by increases in global commodity prices raises economic activity in the energy sector. This in turn boosts the corporate income tax base and CIT revenue. Regarding the other budget components, the results show that resource-revenue increases have, as expected, negative effects on debt-service payments, but these effects are statistically insignificant. We also do not find statistically significant responses of the other budget components to changes in non-renewable-resource revenue.

It is important to note that resource-revenue decreases seem to have no statistically significant effects on the other budgetary components as well. This implies that resource-revenue decreases will be simply reflected as increases on the overall budget deficit or decreases in the budget surplus, as the case may be. The implication of this is that the decline in Alberta's budget-balance position during resource-revenue decreases is larger than corresponding improvements in the budget following resource-revenue increases. As we discuss below, the long-run implication of this is that the public debt ratchets up every time resource revenue falls, as the other budgetary components are unresponsive to this adverse shock.

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[4] We formally check for the presence of asymmetry by statistically testing if the coefficients of NRRI and NRRD are pairwise equal. We reject the null hypothesis that the coefficients are equal (symmetry) at the five-per-cent significance level. This provides empirical evidence of the presence of asymmetric responses.

Since it is difficult to precisely interpret the many coefficient estimates of the above VAR model, as is common in the literature, we use the estimated model to construct impulse response functions (IRFs). Impulse response functions show how the budget adjustment occurs in response to any unexpected changes in one of the budget components. Our empirical approach can shed light on the responses of any budget component to innovations in any other budget component. However, we focus our investigation on the responses of future budget components to current innovations in resource revenue. Previous studies such as Bohn (1991), Buettner and Wildsain (2006), Romer and Romer (2010), and others also use impulse response functions to investigate the effects of unexpected changes in government budget components. Note that the IRF of the VAR shows the effect of a one-time, one-dollar increase in the real per capita non-renewable-resource revenue on the levels of the various budget components after a certain year. This is important to understanding the time path of the provincial fiscal responses to changes in resource revenue.

Thus, we assess the fiscal responses to resource-revenue changes by looking at the simple IRFs associated with resource-revenue increases and decreases separately for the various budget components of interest in Table 3 below.

TABLE 3 IMPACTS ON ALBERTA'S BUDGET OF A ONE-DOLLAR INNOVATION IN NON-RENEWABLE-RESOURCE REVENUE (ASYMMETRIC CASE), 1970/71–2016/17

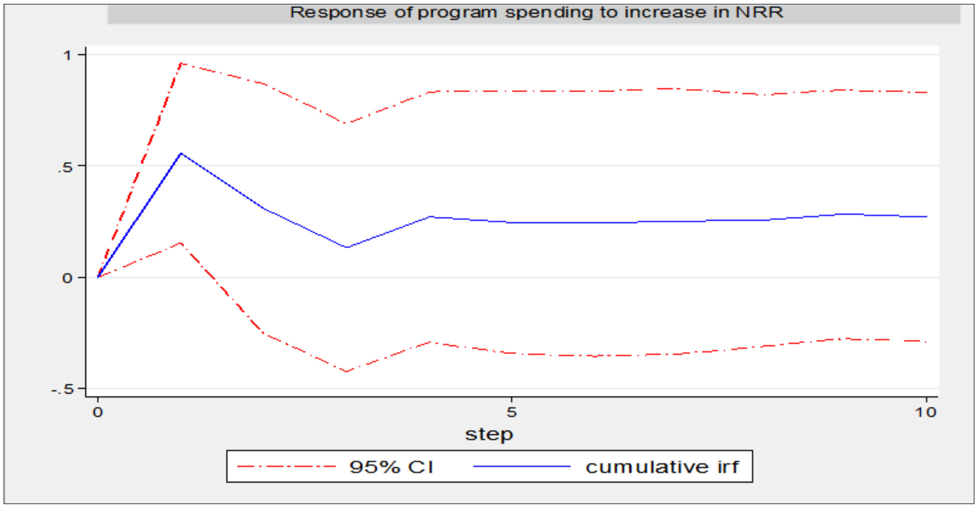
Response of	*Years after resource revenues **increase***			*Years after resource revenues **decrease***		
	1	2	3	1	2	3
Program spending	0.557**	-0.247	-0.176	-0.131	0.246	0.231
	(0.206)	(0.212)	(0.299)	(0.200)	(0.197)	(0.193)
Debt service	-0.005	-0.015	-0.020	-0.026	-0.027	-0.028
	(0.022)	(0.024)	(0.022)	(0.022)	(0.024)	(0.021)
CIT revenue	0.135**	-0.092	-0.059	0.052	0.051	0.067
	(0.057)	(0.064)	(0.055)	(0.056)	(0.059)	(0.051)
PIT revenue	-0.081	-0.049	0.087	-0.061	0.120**	0.000
	(0.059)	(0.064)	(0.061)	(0.058)	(0.060)	(0.057)
Other revenue	- 0.081	-0.061	0.227	0.148	-0.232	-0.033
	(0.166)	(0.166)	(0.149)	(0.162)	(0.146)	(0.147)

Note: The figures are IRFs in dollars. Standard errors are shown in parentheses. Significance levels are indicated by *** for one per cent, ** for five per cent, and * for 10 per cent.

The above results show the impact of a one-dollar increase or decrease in non-renewable-resource revenue on the levels of the various components of Alberta's budget over a certain period after the shock occurs. Since the IRFs show that the effects of resource-revenue innovations on Alberta's budget become statistically significant only in the first three years, we limit our discussions to the first three years. The results show that a one-dollar increase in real per capita resource revenue results in an increase in Alberta's real per capita program spending by $0.56 one year after the resource-revenue shock. In the second and third years, the effect becomes negative and statistically insignificant. On the other hand, a one-dollar decrease in real per capita resource revenue seems to have no statistically significant effect on program spending in all the years after the shock. This is consistent with the asymmetric responses of program spending that we discussed before. Regarding CIT revenue, the results show that, as expected, the provincial CIT revenue rises after non-renewable-resource revenue increases and it also falls as non-renewable-resource revenue decreases. However, the latter effect is not statistically significant. The results also suggest that PIT revenue falls in the second year after non-renewable-resource revenue decreases. However, as discussed before, all the other budget components seem to be largely unresponsive to shocks in non-renewable-resource revenue.

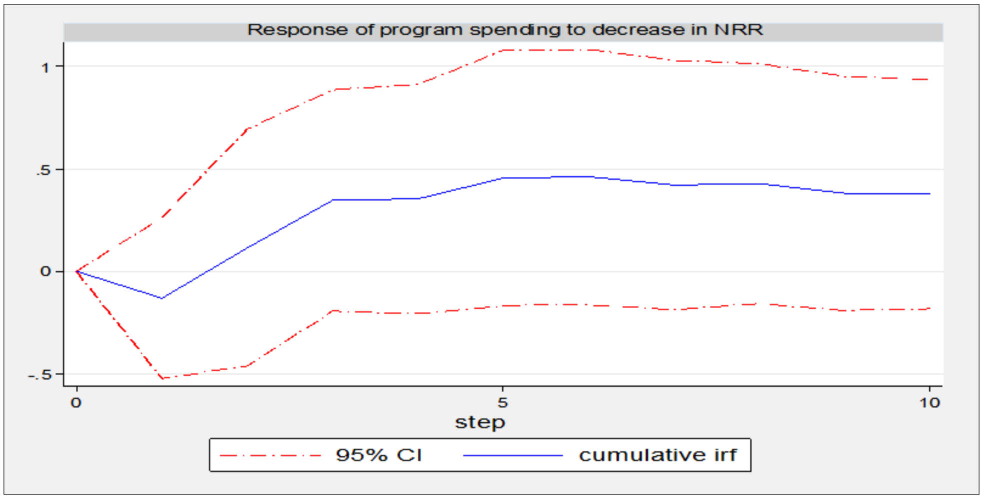
Perhaps one can obtain better information about the fiscal responses to non-renewable-resource revenue changes by looking at the total or cumulated responses over the different time periods. The cumulated impulse response functions (CIRFs) provide us with this important information. We focus our discussion on program spending and CIT revenue and the implications for the budget balance as these two budget components are responsive to non-renewable-resource revenue. The CIRFs in Figures 3a and 3b below show the total effects of the non-renewable-resource revenue shocks on Alberta's program spending after a given number of years. Note that when the zero line is between the 95-per-cent confidence interval bands, it indicates that the IRFs are statistically insignificant. As discussed above, the impulse response graphs show that program spending rises during the first year after the increase in resource revenue, but it becomes statistically insignificant afterwards. When resource revenue falls, on the other hand, there is no downward adjustment in program spending. The IRF is statistically insignificant throughout in the case of a resource-revenue decrease.

FIGURE 3A THE TOTAL RESPONSE OF PROGRAM SPENDING TO A ONE-DOLLAR INCREASE IN NRR (SOLID LINE).



Note: The vertical axis shows changes in program spending in dollars and the years ahead are shown in the horizontal axis. The dotted line represents the 95-per-cent confidence interval and the solid line is the response of program spending (or CIRF).

FIGURE 3B THE TOTAL RESPONSE OF PROGRAM SPENDING TO A ONE-DOLLAR DECREASE IN NRR (SOLID LINE)



Note: The vertical axis shows changes in program spending in dollars and the years ahead are shown in the horizontal axis. The dotted line represents the 95-per-cent confidence interval and the solid line is the response of program spending (or CIRF).

Further, to visualize the total effects of resource-revenue increases and decreases on Alberta's budget, we show the responses of program spending, CIT revenue and the overall budget deficit in figures 4a and 4b below. Again, these are CIRFs and show the total responses of the budget components. Note that the total response of the overall budget deficit is obtained by considering the responses of all the budget components. However, we ignore the other budget components as their responses are statistically insignificant.

FIGURE 4A THE EFFECTS OF A ONE-DOLLAR INCREASE IN NON-RENEWABLE-RESOURCE REVENUES ON ALBERTA'S BUDGET

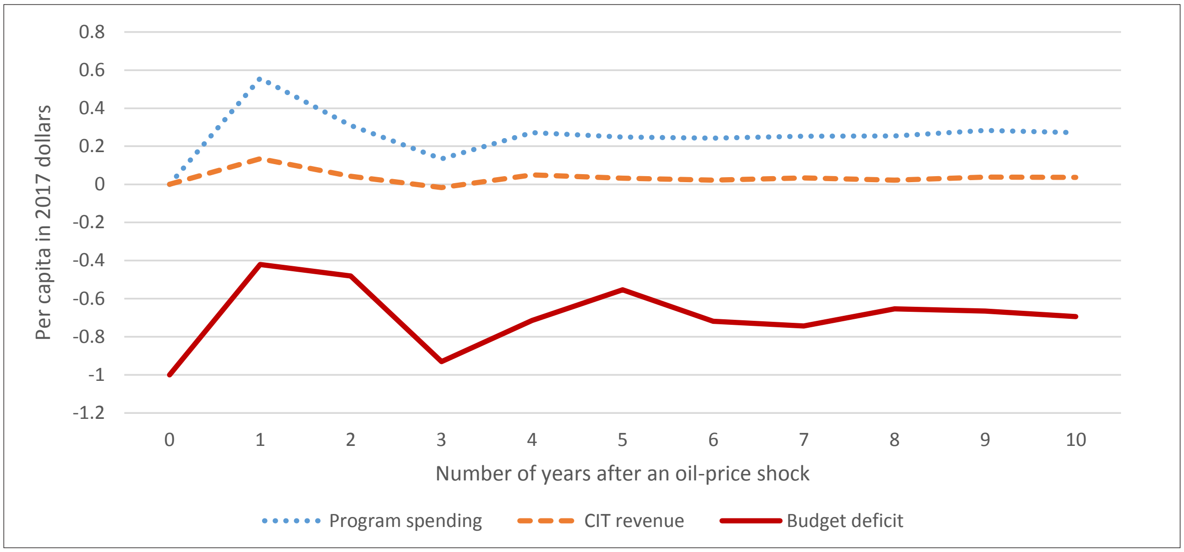
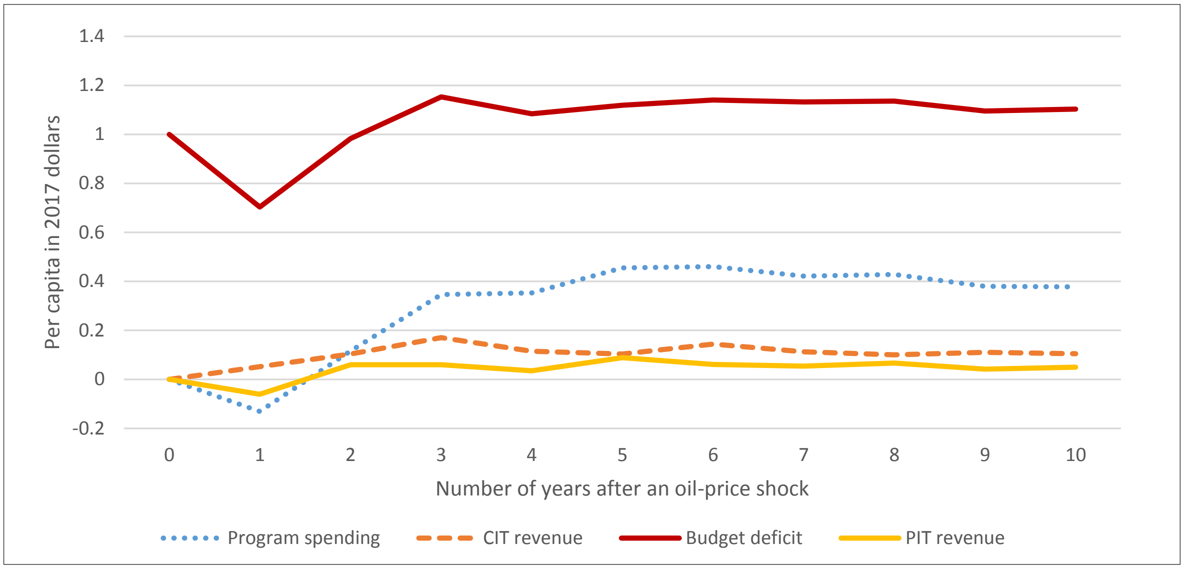


Figure 4a shows that when there occurs a one-dollar positive shock to resource revenue, the first immediate effect is to reduce the budget deficit (or increase the budget surplus) by one dollar. One year after the shock, program spending rises by about \$0.56 and CIT revenue increases by \$0.14. Because of this, without much change in other budget components, the reduction in the budget deficit (or improvements in the budget balance) falls just to \$0.42 in the second year after the shock. However, after the second year of the shock, the responses of the fiscal variables will be statistically insignificant. Thus, increases in the non-renewable-resource revenue are associated with much lower improvements in the overall budget balance of the province.

How does the overall budget deficit respond to adverse shocks in non-renewable-resource revenue? Figure 4b shows the total responses of program spending, CIT revenue, and the budget deficit to negative resource-revenue shocks.

FIGURE 4B THE EFFECTS OF A ONE-DOLLAR DECREASE IN NON-RENEWABLE-RESOURCE REVENUES ON ALBERTA'S BUDGET



The immediate effect of a one-dollar adverse shock in non-renewable-resource revenue on the overall budget deficit is to increase the budget deficit (or reduce the budget surplus) by one dollar. In the year following the adverse shock, the other budget components remain largely unresponsive. Only PIT revenue shows a statistically significant response to resource-revenue changes in the second year. That is, PIT revenue decreases as resource revenue falls. Thus, taking all responses into account, the effect of the adverse shocks in non-renewable-resource revenue will fall mainly on the budget balance. The long-run implication of this is that the public debt ratchets up every time there is a fall in the provincial government's resource revenue, as the budgetary components are mostly unresponsive to this adverse shock. In sum, the IRFs support the result that there is an asymmetric response in Alberta's program spending and overall budget balance to changes in non-renewable-resource revenue. This of course will have important implications for the long-term fiscal position of the province, as discussed below.

3.3. Long-Term Fiscal Implications

What are the implications of the empirical results for Alberta's long-term financial position? We explore this issue by looking at the effects of the asymmetric fiscal responses to resource-revenue changes on Alberta's net financial assets. The net financial assets refer to the difference between the province's total financial assets and total liabilities. While a position of positive net financial assets indicates that the province has more financial assets than liabilities, negative values indicate net public debt. Like many aspects of Alberta's budget, the net financial position of the province is significantly intertwined with the fluctuations in the province's resource revenue. The province's net financial asset position has shown a remarkable decline over the past decade. As recently as 2008–09, the net financial assets of the province were about $31.7 billion. However, due to successive budget deficits, mainly driven by the decrease in resource revenue, the fiscal position of the province has declined to a net financial debt of $8.9 billion in 2016–17.[5] In fact, the provincial

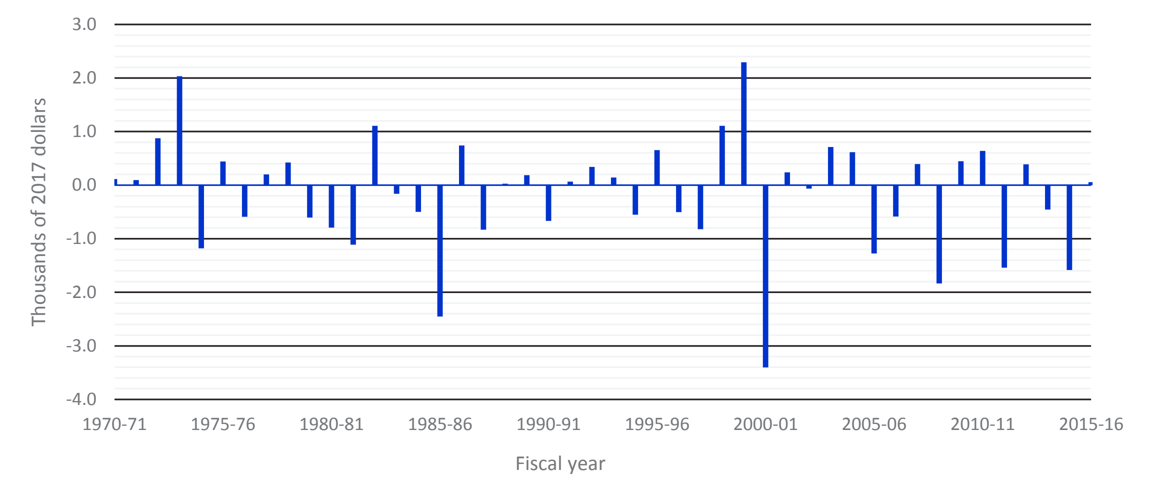
[5] Government of Alberta, 2016–17 Annual Report (available at: https://www.alberta.ca/government-and-ministry-annual-reports.aspx).

government's budget forecast for 2017–18 indicates that the net financial debt would grow to $20.3 billion for the fiscal year.[6]

If the province runs budget deficits and public debt rises, this will reduce net assets or increase the net debt of the province. Any adverse effect of the asymmetric responses on the province's net financial position will impact the long-term sustainability of the public debt. Obviously an increase in the public debt (or a deterioration in the province's net financial position) is a significant fiscal challenge as it would require a future increase in taxes or a cut in public spending or both. Alberta's net financial position also has implications on the credit rating of the province, which in turn impacts current and future costs of borrowing for the provincial government.

As discussed before, our empirical results suggest that program spending responds asymmetrically to changes in resource revenue. In the long run, this causes the ratcheting up of the public debt every time resource revenue declines, as other budgetary components are largely unresponsive to the adverse shock. We simulate the effects of resource-revenue fluctuations on the province's net financial asset position using our estimates shown in Table 3. When resource revenue increases, the budget balance of the province increases, and this will have a positive effect on the net asset position of the province. This is the immediate *direct effect* of the resource-revenue change. However, our results indicate that the increase in resource revenue is followed by a large increase in program spending and a small rise in CIT revenue, with little effect on the other components of the budget. This response reduces the budget balance and the net financial assets of the province and this is the *indirect effect*. Thus, the simulated effect of resource-revenue changes on net financial assets is the sum of these direct and indirect effects.[7] We plot the effects on net financial assets in Figure 5 below.

FIGURE 5 IMPACT OF RESOURCE-REVENUE FLUCTUATIONS ON PER CAPITA NET FINANCIAL ASSETS (000S OF 2017 DOLLARS)



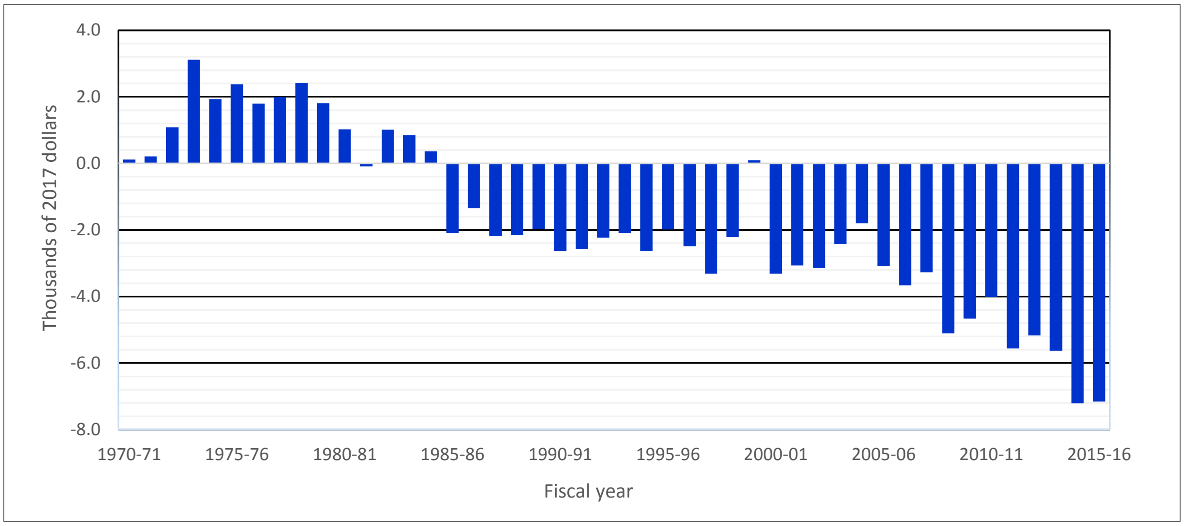
6 Government of Alberta, 2017–18 Third Quarter Fiscal Update and Economic Statement (available at: http://www.finance.alberta.ca).

7 The results are obtained using the statistically significant coefficient estimates (or simple IRFs) of program spending and CIT revenue. That is, the direct and immediate effect of the non-renewable-resource-revenue increase on the budget balance is simply ΔNRR_t. In the year following the NRR increase, program spending rises by 0.557* ΔNRR_{t-1} and CIT revenue rises by 0.135*ΔNRR_{t-1} . This is the *indirect effect*. The indirect effect causes the budget deficit to increase by 0.422* ΔNRR_{t-1} when resource-revenue increases. Thus, the computation is done for all years this way and the results are shown in Figure 5. The summing of all these effects over the different fiscal years provides the cumulative changes in net financial assets shown in Figure 6.

The above figure shows the fluctuations in the province's net financial assets caused by changes in the resource revenue and the asymmetric budgetary responses. While positive values show increases in net financial assets, negative values show a decline in net financial assets, or a rise in net financial debt.

Perhaps one can obtain a better picture of the effects of asymmetric fiscal responses on the province's net financial assets (and hence the province's long-term fiscal position) by looking at the cumulative effects of these asymmetric responses. Figure 6 below shows the cumulative effects of resource-revenue fluctuations and the associated asymmetric fiscal responses on net financial assets.

FIGURE 6 CUMULATIVE CHANGE IN NET FINANCIAL ASSETS PER CAPITA (000S OF 2017 DOLLARS)



The above figure highlights the impacts of asymmetric fiscal responses on the net financial assets of the province. As before, negative values indicate net financial debt. Figure 6 shows that when successive Alberta governments respond by raising program spending during resource-revenue booms, with little or no downward adjustment during resource-revenue busts, the net financial assets of the province decline. The cumulative impact of this asymmetric response on the province's net financial debt for 2017 is about $7,153 per capita. This corresponds to roughly a net debt of $30.4 billion in 2017 dollars.

In sum, the foregoing analysis shows that Alberta's fiscal responses to fluctuations in non-renewable-resource revenue are asymmetric. The provincial government's program spending tends to go up during resource-revenue increases, but it is sticky downwards when global commodity prices plummet and the province's non-renewable-resource revenue falls. Due to the crucial role the energy sector plays in the economy, CIT revenue also increases when resource revenue rises. The other budget components do not show statistically significant responses to changes in resource revenue. The net result of all of this is that the improvement in the provincial budget balance during resource booms is less than the associated decline in the budget balance caused by resource-revenue falls. This has an important, adverse impact on the long-term fiscal position of the province.

4. CONCLUSIONS

Resource-based economies such as Alberta's are often exposed to the vagaries of global commodity-price fluctuations. Alberta's provincial government has been heavily dependent on non-renewable-resource revenue from its energy sector. Over the past half-century, non-renewable-resource revenue on average accounted for about one-third of the provincial government's total revenue. However, that revenue has been volatile during the sample period, and such a volatile revenue source poses a challenge in maintaining stable and predictable budgeting. Thus, understanding how the various budget components respond to fluctuations in non-renewable-resource revenue, which is largely driven by global commodity prices, is crucial to foster informed public discussion and policy-making.

This paper employs vector autoregression empirical methodology and uses annual data over the fiscal period 1970–71 to 2016–17 to examine how the various components of the provincial budget respond to changes in non-renewable-resource revenue. The empirical results show evidence of asymmetric responses of program spending and CIT revenue to resource-revenue changes. The provincial government's program spending tends to go up by about $0.56 in response to a one-dollar increase in resource revenue, but it is sticky downwards when global commodity prices plummet and the province's non-renewable-resource revenue falls. Due to the crucial role the energy sector plays in the economy, CIT revenue also increases by about $0.14 when resource revenue rises by one dollar. The other budget components do not show statistically significant responses to changes in resource revenue. The results confirm that fluctuations in Alberta's provincial budget balance are strongly associated with the boom-bust cycle in resource revenues. Further, the results suggest that decline in the provincial budget balance caused by resource-revenue falls is higher than the improvement in the budget balance during resource booms ultimately impacting the long-term fiscal position of the province. In fact, the impact of these asymmetric fiscal responses on the province's net financial debt for 2016–17 is about $7,153 per capita, which is roughly equivalent to a net debt of $30.4 billion in 2017 dollars. The policy implication of the results is that provincial governments should put increases in non-renewable-resource revenue in a fiscal stabilization fund or in the Alberta Heritage Savings Trust Fund, rather than opting, as it historically has, to spend more than half of any short-term increase in non-renewable-resource revenue. This would result in a less volatile spending pattern and a sustainable fiscal policy with better services and lower tax rates.

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APPENDIX

TABLE A1 UNIT-ROOT TESTS, 1970–71 TO 2016–17

Variables	Symbols	ADF	Phillips-Perron	DF-GLS
	Variables in levels, 1970-71 to 2016-17			
Non-renewable-resource revenue	NRR_t	-2.659	-2.626	-1.847
Corporate income tax revenue	CIT_t	-2.349	-2.225	-1.550
Personal income tax revenue	PIT_t	-1.680	-1.552	-0.714
Other revenue	OR_t	-2.203	-2.076	-1.319
Debt-service payments	DS_t	-1.039	-1.417	-1.450
Program spending	PS_t	-2.106	-2.135	-1.343
Budget deficit	BD_t	-2.579	-2.516	-2.139
	Variables in first-differences, 1970-71 to 2016-17			
Non-renewable-resource revenue	ΔNRR_t	-7.747***	-7.982**	-5.885***
Corporate income tax revenue	ΔCIT_t	-7.121***	-7.38***	-6.297***
Personal income tax revenue	ΔPIT_t	-6.739***	-6.942***	-5.566***
Other revenue	ΔOR_t	-7.837***	-8.020***	-5.967***
Debt-service payments	ΔDS_t	-3.625***	-3.591**	-2.824***
Program spending	ΔPS_t	-5.780***	-5.817***	-2.526**
Budget deficit	ΔBD_t	-8.093***	-8.384***	-6.621***
Non-renewable-resource revenue increase	$NRRI_t$	-6.117***	-6.085***	-4.715***
Non-renewable-resource revenue decrease	$NRRD_t$	-7.850***	-7.967***	-5.058***

Notes: The unit-root tests include intercepts. Significance levels are denoted by *** for one per cent and ** for five per cent. For DF-GLS, the optimal lag is chosen according to the Schwarz Information Criterion (SIC).

TABLE A2 VAR ESTIMATES, 1970–71 TO 2016–17

	(1) ΔPS_t	(2) ΔDS_t	(3) ΔCIT_t	(4) ΔPIT_t	(5) ΔOR_t	(6) $NRRI_t$	(7) $NRRD_t$
$NRRI_{t-1}$	0.557***	-0.005	0.135**	-0.081	-0.081	0.277	-0.083
	(0.206)	(0.022)	(0.057)	(0.059)	(0.166)	(0.185)	(0.182)
$NRRI_{t-2}$	-0.332	-0.007	-0.069	-0.043	-0.085	-0.026	0.033
	(0.219)	(0.024)	(0.061)	(0.063)	(0.176)	(0.197)	(0.193)
$NRRD_{t-1}$	-0.131	-0.026	0.052	-0.061	0.148	0.005	-0.031
	(0.201)	(0.022)	(0.056)	(0.058)	(0.162)	(0.181)	(0.177)
$NRRD_{t-2}$	0.214	-0.006	0.097*	0.125**	-0.147	0.171	-0.100
	(0.187)	(0.020)	(0.052)	(0.054)	(0.151)	(0.169)	(0.166)
ΔPS_{t-1}	-0.085	0.023	0.005	-0.026	0.078	-0.039	-0.075
	(0.152)	(0.016)	(0.042)	(0.044)	(0.123)	(0.137)	(0.135)
ΔPS_{t-2}	-0.300**	0.007	-0.020	0.066	0.352***	0.052	-0.282**
	(0.147)	(0.016)	(0.041)	(0.042)	(0.118)	(0.132)	(0.130)
ΔDS_{t-1}	0.002	0.487***	0.018	0.763*	0.843	-2.053*	0.408
	(1.366)	(0.148)	(0.378)	(0.395)	(1.101)	(1.229)	(1.208)
ΔDS_{t-2}	-2.203	0.136	-0.141	-0.633	-0.602	0.553	0.002
	(1.402)	(0.152)	(0.388)	(0.406)	(1.131)	(1.262)	(1.241)
ΔCIT_{t-1}	0.194	-0.128*	-0.238	0.119	-0.037	-1.105**	0.162
	(0.622)	(0.067)	(0.172)	(0.180)	(0.501)	(0.560)	(0.550)
ΔCIT_{t-2}	1.379**	-0.112*	-0.131	0.353**	-0.287	-0.201	0.486
	(0.559)	(0.060)	(0.155)	(0.162)	(0.450)	(0.503)	(0.494)
ΔPIT_{t-1}	0.501	0.015	0.386***	-0.145	0.009	0.516	0.306
	(0.534)	(0.058)	(0.148)	(0.154)	(0.430)	(0.480)	(0.472)
ΔPIT_{t-2}	-0.081	0.080	-0.164	-0.190	-0.552	0.615	-0.365
	(0.483)	(0.052)	(0.134)	(0.140)	(0.390)	(0.435)	(0.428)
ΔOR_{t-1}	0.231	0.009	-0.053	-0.031	-0.309**	0.143	-0.143
	(0.178)	(0.019)	(0.049)	(0.052)	(0.144)	(0.160)	(0.157)
ΔOR_{t-2}	-0.258	-0.006	-0.010	0.017	-0.404***	0.198	-0.165
	(0.188)	(0.020)	(0.052)	(0.055)	(0.152)	(0.169)	(0.167)

Note: See Table 1 for definitions of the variables. Standard errors in parentheses. Significance levels are indicated by * for 10 per cent, ** for five per cent, and *** for one per cent. The exogenous variables and the constant term are estimated but not reported for the sake of brevity. Total number of observations is 44.

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Ergete Ferede is currently an associate professor of Economics at MacEwan University and a Research Fellow at The School of Public Policy. His BA and MSc are from Addis Ababa University in Ethiopia and his PhD is from the University of Alberta in 2005. His main research areas are public finance and economic growth. His research has been published in the *National Tax Journal*, *International Tax and Public Finance*, *Small Business Economics*, etc. He previously taught a wide range of courses at Addis Ababa University, the University of Alberta and the University of Windsor. He was a winner of the University of Windsor Teaching Score Award for the academic year 2005/6.

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