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Hedging Alberta Government's Oil and Gas Revenue:
Is Acting Like a Farmer a Viable Strategy?

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Abstract

The provincial government of Alberta in Canada experiences significant annual revenue variability arising from changes in crude oil and natural gas prices. This research evaluated whether Alberta's non-renewable revenue risk could be managed using a derivatives hedging program. Results from a historical hedging simulation approach suggested that such a program would not have been the most effective method of managing revenue risk over the period of 1995-96 to 2003-04. Total impacts of hedging would have varied from Can-$8 Billion to Can $6 Billion over this time period. These results suggest the Alberta government explore alternative methods to manage non-renewable resource revenue risk.

JEL Classification: Q480, G11

Key Words: Government Hedging, Risk Hedging

Introduction

Canadian provincial government revenue and expenditure are subject to changing economic conditions creating uncertainty around provincial budget forecasts. A substantial source of revenue variability for many Canadian provincial governments may be derived from the equalization payment portion of federal government transfers made to provinces (Snoddon 2004, Boadway and Hayashi 2004, Smart 2004, Boothe 2002). However, unlike the majority of provincial governments, Alberta does not receive equalization payments and instead relies heavily on revenues derived from non-renewable natural resources (NNR). Alberta' NNR revenue variability and associated budgetary risks are primarily due to the variability of oil and natural gas prices. Alberta, (Alberta Government 2005) when compared to other countries in 2004, was the second largest exporter of natural gas in the world and had crude oil exports comparable to OPEC nations such as Libya or Iraq.

Alberta's revenue dropped substantially partway through the fiscal year 2001-2002 when crude oil and natural gas prices were much lower than budget forecasts. The Alberta government cut 1.3 billion (Canadian dollars) from the budget in October 2001 in response to this shortfall (Thomson 2002). Taxpayers, municipal governments and other organizations expressed strong concerns to the provincial government over this unexpected cut in expenditures. In response to these concerns, the provincial government formed the Alberta Financial Management Commission (AFMC) to investigate provincial revenue variability. The commission was given many tasks, but the Alberta finance minister publicly asked this commission to "investigate whether hedging [in regards to energy prices] could work for the government as well as it does for farmers" (Thomson 2002, p. A.6). The final report from AFMC (2002) included twenty-five recommendations. Recommendation seventeen suggested Alberta research "…alternative ways of managing the risks of weather-related costs and energy prices, and the use of forward pricing options such as hedging, collars, derivatives and swaps[1]" (p.66) in an overall risk management framework.

The purpose of this study was to evaluate the feasibility of the Alberta government to use derivative based hedging strategies[2] to manage budgetary risks stemming from the variability of non-renewable resource revenue. A historical simulation model was developed to measure the potential impact of hedging on reducing deviations between actual revenue and budget projections. Specifically, futures derivatives strategies were evaluated to provide insights into more sophisticated derivative based risk management programs. The analysis provided insights into whether the Alberta government should consider hedging NRR or under what conditions such a program may be feasible.

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[1] Derivatives are contracts on some underlying asset such as crude oil. The value of the derivative is "derived" from the underlying value of the asset. Futures contracts can be opened at zero cost (ignoring transaction costs) and fix the price of the underlying asset in the future for a specified location, with the owner of the futures contract responsible for any daily losses or gains in the value of the contract (i.e. margin). Options give the owner the right but not the obligation to buy or sell the underlying asset. To gain ownership of the option the owner must pay an option premium. Forward contracts are similar to futures contracts but the owner is not responsible for any gains or losses in the contract value until the date of contract expiry. Swaps are a portfolio of forward contracts with different dates of maturity and with one fixed price. Collars are a portfolio of positions in options that allow prices to vary within a range but fix a lower and upper bound on the price variation.

[2] Derivative based hedging is the use of derivative contracts such as futures contracts, forward contracts, option contracts or swap contracts to reduce risk.

Non-Renewable Resource Revenue and Derivatives Usage to Manage NNR

Kneebone (2002) reported that Alberta government dependence on NNR revenue began in 1931. NNR has contributed to 41% of Alberta's total revenue within the last few years, and as high as 79% during the 1979-80 fiscal year (Figure 1). When revenue falls short of budget expectations, governments may reduce the revenue shortfall through methods such as increasing taxes, running deficits (a consistent practice of Alberta from 1985-94) or stop and go expenditures where planned expenditures are put on hold until revenues increase. Due to the provincial Fiscal Responsibility Act, the Alberta government was not allowed to run budget deficits in 2001-02. This meant that Alberta's ability to offset revenue shortfalls was limited to increasing taxes or decreasing planned expenditures. Tax increases and expenditure cuts are not viewed positively by the voting public and may have political costs (Swidler et al. 1999).

The problem of unstable NNR revenue is not unique to Alberta. State governments in the United States such as Alaska and Texas, and national governments such as Mexico have relied on NNR revenue. Alaska's, Texas' and Mexico's NNR revenue has comprised as much as 75% (Lindahl 1996), 10% (Overdahl 1987), and 31% (Daniel 2001) respectively of total government revenue.

Alaska has not participated in derivative based hedging and has instead used a stabilization fund to help manage NNR revenue risk. Both Mexico and Texas have used hedging programs to help manage their NNR risks. Although the specific hedging program details of Mexico are not known, Mexico was reported to have successfully used derivative markets to stabilize revenue in the early 1990's (Daniel 2001).

Swidler et al. (1999) and Lindahl (1996) both evaluated the hypothetical use of various derivative based hedging strategies for Texas. Swidler et al. (1999) found that derivatives could reduce the chance of severe budget deficits. Lindahl (1996) found that the use of swaps during the 1991 period could have locked in prices of oil U.S. $0.85/barrel above the average and that straddled costless collars generated extra revenue and protected against further losses during market downturns. Thus, from these studies it can be hypothesized that derivatives may provide potential benefits for Alberta.

Derivative based hedging strategies may have financial and political costs. The Alaska Department of Revenue (2002) estimated that the transactions costs of using futures contracts could be U.S. $18-20 million with potential margin calls reaching U.S. $950 million, and the premium costs of options reaching U.S. $300 million. Margin calls are payments made by the owner of the futures contract to the futures exchange market on derivatives positions that are losing money. Swidler et al. (1999) found that although hedging could reduce extreme budget deficits for Texas, hedging increased the chance of a deficit occurring. There is also the financial cost of missing out on higher revenues as strategies such as swaps and futures may remove the possibility of realizing higher revenue during market upturns. Politically, the loss of potential revenues may not be viewed favorably by the public, and politicians may not be rewarded when hedging programs are successful (Alaska Department of Revenue 2002).

Hedging Description

Prior to outlining the methodology employed, a description of derivative based hedging is provided. An example of a derivative is a futures contract, which is traded on a variety of exchanges such as the New York Mercantile Exchange (NYMEX) and the Chicago Mercantile Exchange (CME). Futures contracts include specifications on price, type of product, quantity and delivery location, and the specific time in the future when the product must be delivered. The specified delivery month (e.g. June 2004 delivery for crude oil) differentiates one futures contract from another futures contract on the same product (e.g. August 2004 delivery for crude oil). An individual or business may buy or sell these contracts by putting up a small fraction of the contracts nominal dollar value (i.e. margin). Thus, these contracts are highly levered financial instruments. The futures contract may be cancelled by entering into the opposite contract position (e.g. buy or sell) prior to the contract expiry date. Delivery of the underlying product specified in the contract does not actually have to be completed if the initial futures position is offset prior to the delivery date. Users often pay a transaction fee to enter into derivatives contracts.

Typically, derivative based hedging refers to establishing a position (i.e. buying or selling contracts) in a derivative that is opposite to the position or intended position in the cash market. Essentially, hedging transfers the price risk to another party. Under ideal circumstances, the position in the derivatives contract cushions changes in the cash market. For example, for an oil producer or a farmer selling commodities, the hedge position would be set up such that the hedge is making enough money to offset losses in commodity sales when prices are dropping. This has a flip side. If commodity prices are rising for the oil producer or farmer, then the hedge position will be losing money and offset gains on commodity sales. Hedging attempts to lock in a fixed price or price range using derivative contracts such as futures and reduce the variability in revenue or cost forecasts.

Positions are generally taken in futures contract months, matching the time of sale or purchase of the underlying assets. However, the number of future positions needed over the year to hedge revenues as large as Alberta's may comprise the majority of open positions in that specific derivative market. This may create liquidity problems, as liquidity in the market often declines quickly for derivative contracts that mature at later expiry dates. Thus, it may not be feasible for Alberta to enter into a large number of futures positions in distant contract months.

A rolling hedge strategy was employed in the simulation to overcome liquidity problems in distant contract months for crude oil, natural gas, and currency risk facing the Alberta government. This strategy consisted of entering into the total number of futures positions needed for the year in the nearest (nearby) contract month. A portion of the futures positions held in the nearby contract were then offset/closed systematically, reflecting the actual market transactions of the underlying asset. Any futures positions that were not offset by the current nearby contract's expiration date were offset just prior to the expiration of the contract and immediately re-entered again in the next nearby contract month. This process of transferring open positions from one nearby contract to the next was a rolling hedge strategy. Although the rolling hedge strategy helps to overcome liquidity issues it can introduce other financial risks, such as unexpected changes in price differences between nearby futures and later contract months (Edwards 1995).

Alberta could enter into a derivatives program to manage NNR revenue using public risk markets such as the NYMEX (e.g. crude oil contract and natural gas contracts) or private markets such as the over-the-counter markets (OTC). The startup costs may differ depending upon the derivative instrument used however the model results would be representative of the long run direct or indirect costs that would have to be absorbed by the government of Alberta.

Methodology

The ability of the Alberta government to use derivative based hedging to offset their revenue forecast risks stemming from changing crude oil prices (NYMEX) and natural gas prices (NYMEX) was evaluated using a historical simulation. Alberta has reported budget sensitivity values since the 1995-96 budget estimating how associated revenues will change with changes in average annual crude oil price, gas price, and the U.S.$/CAN$ exchange rate. These sensitivity values are directly comparable to delta hedge estimates. Delta is defined in the hedging literature as an estimate which relates the change in portfolio value to the change in price of the underlying asset or derivative. Mathematical descriptions of delta can be found in Hull (2002). Delta is used to estimate the number of underlying derivatives positions that should be held to offset changes in the portfolio value. Delta estimates become less accurate and effective when large changes in the portfolio's underlying asset price occur and a new delta should be estimated when prices change significantly.

Alberta's sensitivity values are reported once per budget period and are estimated under the assumption of annual price changes. The sensitivities can be used to estimate hedge positions to offset NNR risk where the same delta is used through out the year. The effectiveness of the delta hedge may become less useful overtime as energy prices change.

Using the sensitivity values reported in the budget periods of 1995-96 to 2003-04, 100% delta hedges were estimated and used to determine the number of futures contract positions needed to offset Alberta's revenue risks stemming from crude oil, natural gas, and the $U.S./$CAN exchange rate[3]. The annual budget period started in April and ended in March of the following year. A rolling hedge strategy was used, where the entire upcoming budget year's worth of estimated futures hedge positions were entered into on the last Friday of March using the nearby futures contract month. The weekly portion of the total futures hedge (1/52) matching the expected NNR revenue for the week was then offset on the Friday or last open trading day of each week. On the last Friday prior to the contract closing date, the futures positions still open in the market were rolled over to the next nearest futures contract.

Cash received or paid out from hedge position gains/loses were estimated from the simulation. The difference between the budget forecasts and the actual revenue inflow were calculated from Alberta budgets and annual financial reports. The transaction costs of entering and exiting the hedge positions were calculated using the number of futures transactions that occurred during the simulation and using a transaction cost typically charged by brokerage firms for a low risk high volume client. The cost or revenue on borrowing or investing for the hedge program was calculated using the 3-month spot U.S. Treasury Bill rate.

The hedge results were compared to the NNR budget forecast errors (i.e. Actual NNR Revenue - Budget NNR Revenue forecasts) using Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) measures. However governments may use price forecasts that differ significantly from market based price forecasts. Overly conservative or optimistic price forecasts would bias the NNR revenue forecast error up or down. Comparing the simulated hedge results to the budget forecast NNR revenue error may

[3] Delta hedges were adjusted to match the currency and measurement units used in each

provide misleading conclusions on the benefits of the hedging program. A swap price methodology was employed with budget delta sensitivity estimates to provide an alternative market based price estimate and adjust budget NNR revenue forecasts.

Swap prices were calculated for oil and gas following the commodity valuation formulae in Das (1994). Essentially, a single swap price for oil or gas for each budget year was calculated using prices from the futures contract term structure (i.e. the prices of contracts for different contract maturity months) from the NYMEX and an estimate of the quantity of crude oil and natural gas production affecting the budget each week. LIBOR interest rates were used in the swap price formula.

Data

Alberta's revenue projections were obtained from annual budgets for the years of 1978-79 to 2003-04 (Government of Alberta). The annual budget documents also provided the sensitivity estimates (i.e. delta) for crude oil, natural gas and $U.S. currency for 1995-96 to 2003-04. These are reported in Table 1. For example, a U.S. $1.00/barrel (bbl) decrease in the annual price of crude oil was estimated to decrease NNR revenue from crude oil by Can $195 Million (M) in 1995-96. Similar budget sensitivities are reported for natural gas and U.S.-Can currency (Table 1). The historic pricing data to July 2004 for crude oil and natural gas futures and spot prices, $U.S./$CAN exchange rates, U.S. T-Bill rate, and LIBOR were from BRIDGE CRB.

Results

Alberta's total revenue is plotted using the three general revenue categories of income tax, NNR, and other revenue sources for the years of 1978-79 to 2003-04 in Figure 2. Overall, Alberta's total revenue steadily increased over the periods of 1978-79

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futures market.

to 2003-04, however, there have been several sharp increases (e.g. 2000-01) and decreases (e.g. 1986-87). Comparing the three revenue categories, revenue variability was primarily due to variability in NNR revenue over the study period.

The values reported in the column next to the oil sensitivities (Table 1) are the number of short (i.e. sell) crude oil futures contract positions required on the NYMEX to hedge 100% of Alberta's estimated oil revenue sensitivity. This would be the initial number of contracts required by Alberta on April 1, the beginning of the fiscal year. The number of crude oil contracts opened[4] at the beginning of the 1996-97 budget year would be 146,345. The number of futures contract positions for that fiscal year would decline until reaching zero in the last week of March. A NYMEX crude oil contract is on 1000 barrels (bbls) of crude oil.

Alberta's revenue sensitivity to natural gas peaked at Can $209 M for a Can $0.10/Mcf[5] change in the fiscal year average price of natural gas in 1998-99 (Table 1). The values reported in the next column are the estimated number of short contracts in NYMEX natural gas (Henry Hub) futures contracts to provide a 100% hedge.

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[4] The number of crude oil futures contracts is calculated as follows.

$$NumberofContracts = \frac{Can\$\,\text{Sensitivity}}{\left(\$\text{US}/\text{barrel}\right)} \frac{\$US}{\$Can} \frac{1}{\left(1000\,barrels/contract\right)}$$

. From Table 1 for 1996-97 the initial hedge position is calculated as -199,000,000 $Can *0.7354 $U.S./$Can * contract/1000 bbls = 146,345 contracts.

[5] MCF (thousand cubic feet) reported in budget have been adjusted as appropriate for the NYMEX natural gas unit of measure used which is 10,000 million British thermal units (MMBTU) per futures contract. The conversion used was 1 MMBTU=1.036 MCF. There are a number of slightly different conversions reported. The number of hedge futures contracts was calculated similar to the crude oil calculation. The Alberta Government sensitivities are based on changes in the Alberta Reference price of gas, which is essentially a weighted average of the price paid by Alberta consumers' and an ex-border price, reduced by allowances for transporting and marking the gas.

The final sensitivity values used were revenue changes with a U.S.$0.01/Can$ change in the fiscal year average currency rate (Table 1). Commodity prices in Alberta are sensitive to international prices and changes in the value of the U.S. currency will change commodity prices in Alberta. Alberta budgets reports this sensitivity as the price of Canadian dollars in U.S. currency. The numbers of Canadian dollar futures contracts required for a 100% hedge are reported in the final column of Table 1. It would not be feasible to trade this many contracts (e.g. 84,925 contracts in 2003-04) on the CME due to liquidity constraints. However, the hedge results and transactions costs from the CME would be highly representative of the costs of using the more liquid OTC currency markets.

Historical Hedging Simulation

The hedge positions from Table 1 and historical weekly futures price data from March 1995 to March 2004 were used to simulate a hedging program in crude oil, natural gas and $U.S.-$Can currency. Hedge results such as transactions costs and cost of using a rollover strategy were generated by the historical simulation. For example the transactions costs, cost of buying and selling contracts and the cost of borrowing to maintain the contracts, ranged from 0.16% (Can-$25M) to slightly over 1% (Can-$213M) of annual provincial expenses[6]. However, the focus of the discussion below is on the overall hedge results and whether hedging reduced budget revenue forecast risk.

The mean benefit of crude oil hedging was Can $367 M from 1995-96 to 2003-04 and crude oil hedge net profits, including transactions costs, varied from Can $1,005 M to -$1,488 M (Table 2). Natural gas hedges had a much wider range of results with the impact on revenue ranging from Can $5,736 M to -$6,407 M. The objective of hedging for Alberta would be to reduce errors in budget forecasts. Table 2 shows the actual budget forecast error and the forecast error when the net crude oil, natural gas and currency hedge results are included. For example, hedging crude oil, natural gas and currency would have provided a positive revenue boost in the 2001-02 fiscal year and changed the forecast error from -$747 M to $5,360 M.

A hedging program in fiscal years other than 2001-02 may have had significant negative revenue impacts. A hedging program in 2000-01 would have changed a positive budget forecast error of Can $6.5 Billion (B) to a negative budget forecast error of -$1.6 B. The forecast error was lower with hedging but the hedge program by itself would have reduced provincial revenues by over Can 8 B. Politically, it might be difficult to justify to the public a risk program that had missed out on revenues worth approximately 30% of projected provincial expenses.

The main purpose of implementing the hedges as a risk management strategy is to reduce the variability of the Alberta government's revenue. In the hedging literature, a successful farm revenue hedging program should reduce the forecast error between projected revenue and actual revenue. The difference between the actual revenue and the budget forecasts provides a measure of errors. Two measures of forecast error, Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) are presented in Table 3. Formulae for RMSE and MAE are commonly found in the literature and versions of the

[6] The transaction costs in 2001-02 would have added net $Can 42 M due to interest on the cash inflow from the hedges during the fiscal year. This value excludes the profits or losses from the ownership of the futures contracts.

formulae are defined in Table 3. These risk measures need to be interpreted with caution due to the low number of error estimates available.

The first four rows in Table 3 provide a comparison between the error measures without hedging and the errors with hedging based upon the actual budget forecasts and the hedge results. Hedging reduced the RMSE in all cases for the NNR revenue error for crude oil, natural gas and for the entire budget. Since there was no separate revenue category reported for currency, it was not feasible to estimate a RMSE for the currency hedge. The results for the MAE were similar for the total budget error however natural gas hedging increased the MAE slightly. In aggregate these results suggest that a full hedge program would lead to a slight reduction in budget revenue forecast errors. Hedging would have reduced the budget revenue risk.

Governments may expressly or inadvertently bias revenue projections up or down by using overly conservative or optimistic NNR price forecasts. The mean budget forecast error without hedging in Table 2 was $2.3 B and the annual errors showed that actual revenues exceeded forecast revenues in eight years out of nine. Alberta may have been overly conservative in their NNR price forecasts during the period of this hedging study. Analyzing a hedge program with a biased revenue forecast may lead to incorrect conclusions about the benefits of the program.

An alternative budget revenue forecast at the beginning of the budget year was developed using the futures prices from the NYMEX for crude oil and natural gas to estimate a swap price for each commodity. This swap price represented an alternative market based average price forecast for the budget year (Figure 3). Comparisons of the estimated swap prices to the budget prices (Figure 3) are suggestive of conservative budget price forecasts over the latter part of the simulation period. The difference between the market based swap price and the price forecast reported in Alberta's budget were combined with the budget sensitivities in Table 1 to adjust the budget NNR revenue up or down.

The RMSE and the MAE were calculated using the swap revised budget forecasts and are reported in the last four rows in Table 3. Forecast error was lower for both RMSE and MAE measures of swap revised budget forecast errors versus the errors using Alberta's budget forecasts. This suggests the swap prices provided a better forecast of crude oil and natural gas prices than the estimates used in the budgets. Hedging combined with swap price adjusted budget forecasts generally resulted in higher RMSE and MAE than if no hedging had been implemented. The only exception to this increase in risk was the MAE on natural gas. Generally hedging would not reduce provincial revenue risk if improved market based price forecasts were used in the budget.

Implications and Conclusions

Historically, the Alberta government has experienced both positive and negative revenue shocks, primarily due to variability in non-renewable resource revenues. These revenue shocks have at times contributed to budget deficits, forced planned expenditures to be postponed, and have also generated large surpluses. With a large portion of the province's revenues attributable to non-renewable resource revenues (Figure 1), the provincially legislated inability to run deficits (Fiscal Responsibility Act) and potential political costs of cutting planned expenditures, there are incentives for Alberta to manage the variability of NNR revenues. The feasibility of a derivatives hedging program for NNR revenue, a recommendation from the 2002 Alberta Financial Management Commission, was evaluated.

Over the study period of 1995-96 to 2003-04, a derivative based risk strategy appeared unfavorable. Actual budget revenue forecast errors may have been reduced but when the budget NNR forecasts were adjusted using readily available market information, hedging using futures contracts may have increased revenue risk. These results may be due in part to the specific time period of the analysis, as oil and gas prices followed an upward trend, generating positive revenue shocks and numerous realized surpluses. This result could also be partially due to the inability of the hedge model to re-estimate budget sensitivities (i.e. hedge deltas) during the fiscal year. Considering the above factors, as well as the transactions costs of the strategies (e.g. occasionally exceeding 1% of provincial expenditures), a derivative based hedging strategies may have generated political criticism if implemented.

However, considering the performance of the strategies strictly from a risk management perspective, the strategies did perform well in one aspect. The strategies would have prevented the negative shock that was incurred by the province in 2001-02. Rolling hedge strategies would have generated up to Can $ 6 B in additional revenues in 2001-02 when the government was forced to cut Can $1.3 B from spending. However if the risk management program had been started the previous year of 2000-01, the hedge strategy program would have reduced provincial revenues by over Can $8 B leading to a net budget forecast error of Can-$1.6 B. It is unlikely that a risk management program that had a Can -$8 B impact in 2000-01, equal to about 30% of provincial expenditures, would have survived to be implemented in 2001-02.

Limitations of this research include the fact that it was accomplished under a set of assumptions, such as assuming adequate liquidity in the futures markets. Also, this research used published Alberta government sensitivities, which were annual numbers. Further research could study if adequate liquidity exists in derivatives markets and whether improved sensitivity estimates would change the overall conclusions. Alternative derivative instruments such as options could be evaluated however since these instruments would also be based on the same NNR revenue sources, the results are suggestive of the costs Alberta directly or indirectly would have to pay to use alternative derivatives.

The recommendation from the AFMC was to explore comprehensive risk management programs employing a variety of risk tools and adjusting the risk program for interactions between different risks. This type of program is currently beyond the ability of the Alberta budget model to manage. Budget price sensitivities are updated infrequently if at all during the budget year. Budget NNR price forecasts may be consistently biased as suggested by the decrease in NNR revenue forecast error when market estimated swap prices were used to adjust budget revenue forecasts. Comprehensive risk management would require more sophisticated models of revenue and expenditure sensitivities. Such a model might assist in guiding a risk management program using public risk markets and OTC markets. However this model would require significant testing and the usefulness of such a model would be limited if biased forecasts were continually used for major sources of revenue or expenditure risk. The results from this study suggest that alternative ways to manage NNR revenue risk in Alberta be explored and that a derivatives based risk program may not reduce revenue risk. Alberta may not be able to hedge NNR revenue in the same way as farmers hedge their commodity risk.

References

Alberta Government 2005 (September). Alberta in the World. International and Intergovernmental Relations.

Alberta Financial Management Commission (AFMC). 2002 (July). Moving From Good to Great – Enhancing Alberta's Fiscal Framework. Government of Alberta .http://www.albertafmc.com/2002_0708_fmc_final_report.pdf

Alaska Department of Revenue 2002. Hedging Oil Summary – October 21. http://www.revenue.state.ak.us/treasury/publications/Hedging%20Summary.pdf

Boadway, R. and M. Hayashi. 2004. An Evaluation of the Stabilization Properties of Equalization in Canada. *Canadian Public Policy*. 30(1): 91-109.

Boothe, P. 2002. The Stabilization properties of equalization: Evidence from Saskatchewan. Working Paper Kingston: Institute for Intergovernmental Relations, Queen's University

Daniel J. A. 2001. Hedging Government Oil Price Risk. *IMF Working Paper*. Nov. WP/01/185.

Das S. 1994. Swap and Derivative Financing. Revised Edition, Irwin Professional Publishing, Burr Ridge Illinois.

Edwards F.R. 1995. Derivatives Can Be Hazardous to Your Health: The Case of Metallgesellschaft. *Derivatives Quarterly*, Spring: 8-17.

Government of Alberta (1978-2004), Budgets for the periods of 1978-2004.

Hull J.C. 2002.*Fundamentals of Futures and Options Markets*, Fourth Edition, Prentice Hall, upper Saddle River, New Jersey.

Kneebone, R. 2002. Recent and Not so Recent Trends in Provincial Government Spending in Alberta. University of Calgary, Department of Economics, Discussion Paper 2002-04 http://econ.ucalgary.ca/fac-files/rdk/GovtSpendABPaper.PDF.

Lindahl, M. 1996. A Hedging Strategy for Alaska: Learning from the Texas Experience. *The Journal of Energy Finance and Development*. 1(1):.9-20.

Overdahl, J. A. 1987. The Use of Crude oil Futures by the Governments of Oil-producing States. *The Journal of Futures Markets*. 7(6): 603-17.

Smart, M. 2004. Equalization and Stabilization. *Canadian Public Policy*. 30(2): 195-208.

Swidler, S., R.J. Buttimer Jr., and R. Shaw. 1999. Government Hedging: Motivation, Implementation, and Evaluation. *Public Budgeting & Finance*. 19(4): 75-90.

Snoddon, T. 2004. Budgetary shocks and revenue adjustment: How governments respond to unexpected fiscal shocks. *Economics of Governance*. 5: 149-166.

Thomson, G. 2002, Alaska Reviewed, But Rejected Hedging Plan as Risky. The Edmonton Journal. April 13 p. A.6.

Table 1: Alberta Budget Sensitivities (Deltas) to Price Changes in Crude Oil, Natural Gas and U.S.-Canada Currency and Associated Number of Futures Contract Positions to be 100% Hedged at the Beginning of the Fiscal Year.

Budget Year	Crude Oil Delta: Change of -$1US/bbl[1] ($ Can)	Hedge Position in Crude Oil: Number of Futures Contracts[2]	Natural Gas Delta: Change of -$Can 0.10/MCF. ($ Can)	Hedge Position in Natural Gas: Number of Futures Contracts	$U.S./$Can Currency Delta: Change of $U.S. 0.01/$Can ($ Can)	Hedge Position in Can. Dollar Contract: Number of Futures Contracts
1995-96	-195,000,000	139,308	-130,000,000	134,729	-60,000,000	42,864
1996-97	-199,000,000	146,345	-134,000,000	138,874	-61,000,000	44,859
1997-98	-190,000,000	137,712	-134,000,000	138,874	-45,000,000	32,616
1998-99	-152,000,000	107,236	-209,000,000	216,603	-37,000,000	26,104
1999-00	-135,000,000	90,113	-167,000,000	173,075	-63,000,000	42,053
2000-01	-150,000,000	103,440	-154,000,000	159,602	-82,000,000	56,547
2001-02	-153,000,000	97,079	-142,000,000	147,166	-120,000,000	76,140
2002-03	-108,000,000	67,716	-163,000,000	168,929	-132,000,000	82,764
2003-04	-76,000,000	51,634	-106,000,000	109,856	-125,000,000	84,925

1. These are Alberta sensitivities as reported in annual budgets. For example a $U.S. 1.00/bbl drop in average crude oil price during the budget year 1995-96 is estimated to decrease Alberta NNR revenue by Can-$195 Million.
2. The NYMEX crude oil futures is 1000 bbls/contract. The NYMEX natural gas futures is 1 MMBTU/contract which is approximately 1000 MCF (MCF=1000 cubic feet). The CME Canadian dollar futures is $100,000 Can./contract.

Table 2: Net Hedge Results and Overall Impact on Alberta Budget Forecast Error

Budget Year	Crude Oil Hedge Profit or Loss ($ 1000 Can)	Natural Gas Hedge Profit or Loss ($ 1000 Can)	Currency Hedge Profit or Loss ($ 1000 Can)	Error: Total Actual Revenue-Budget Forecast[1] ($ 1000 Can)	Error: All Hedge Results + Total Actual Revenue-Budget Forecast[2] ($ 1000 Can)
1995-96	-248,775	-242,483	124,866	998,000	631,608
1996-97	-1,471,739	-332,157	-20,678	3,062,000	1,237,426
1997-98	449,034	-950,932	-75,981	765,000	187,121
1998-99	1,005,140	2,226,802	-161,340	256,000	3,326,601
1999-00	-989,995	-356,314	71,460	3,335,000	2,060,152
2000-01	-1,488,370	-6,406,986	-237,290	6,522,000	-1,610,646
2001-02	303,358	5,735,597	67,986	-747,000	5,359,941
2002-03	-488,840	-1,462,945	255,746	2,813,000	1,116,960
2003-04	-374,660	367,117	725,195	3,959,000	4,676,653
mean	-367,205	-158,033	83,329	2,329,222	1,887,313

1. This is the Total Revenue - Budget forecast of Total Revenue.
2. The profits from hedging crude oil, natural gas and currency are added to the Error column to evaluate improvements in actual revenue versus budget projections.

Table 3: Alberta RSME[1] and MAE Measures of Budget Forecast Errors for Crude Oil, Natural Gas Using AB Budget and Budget Adjusted with Swap Price Forecast

Category	Crude Oil Revenue and Budget Forecasts[2] ($ 1000 Can)	Natural Gas Revenue and Budget Forecasts Error ($ 1000)	Total Budget Forecast Error ($ 1000 Can)
RMSE from Actual - Budget	703,574	2,153,657	3,332,154
RMSE from Hedging + Actual - Budget	495,480	2,029,550	2,994,109
MAE from Actual - Budget	518,444	1,375,000	2,495,222
MAE from Hedging + Actual – Budget[3]	382,991	1,432,424	2,245,234
RMSE from Actual – Swap Price Adjusted Budget	417,636	1,739,978	2,384,961
RMSE from Hedging +Actual – Swap Price Adjusted Budget	629,538	1,596,806	2,463,281
MAE from Actual – Swap Price Adjusted Budget	337,549	1,088,122	1,754,849
MAE from Hedging +Actual – Swap Price Adjusted Budget	420,219	1,160,216	1,971,463

1. RMSE (Root Mean Square Error) is defined as the square root of summed and squared forecast errors. $RMSE = \left[\sum_{year=95-96}^{03-04} (Budget\ Error)^2_{year} \Big/ (9-1) \right]^{0.5}$.

2. The crude oil column includes only the revenue and budget forecasts from crude oil. Hedging is from the crude oil hedges only. The natural gas column includes only natural gas related calculations. Total budget column includes all revenue and all hedging (i.e. crude oil, natural gas and currency) as calculated from the last two columns in Table 2.

3. Mean Absolute Error $MAE = \sum_{year=95-96}^{03-04} |\,Budget\ Error\,|_{year} \Big/ 9$

Figure 1 Percent of Alberta's Total Revenue Derived from Non-renewable Resource Revenue, Income Tax Revenue (Personal and Corporate) and Other from 1978-79 to 2003-04

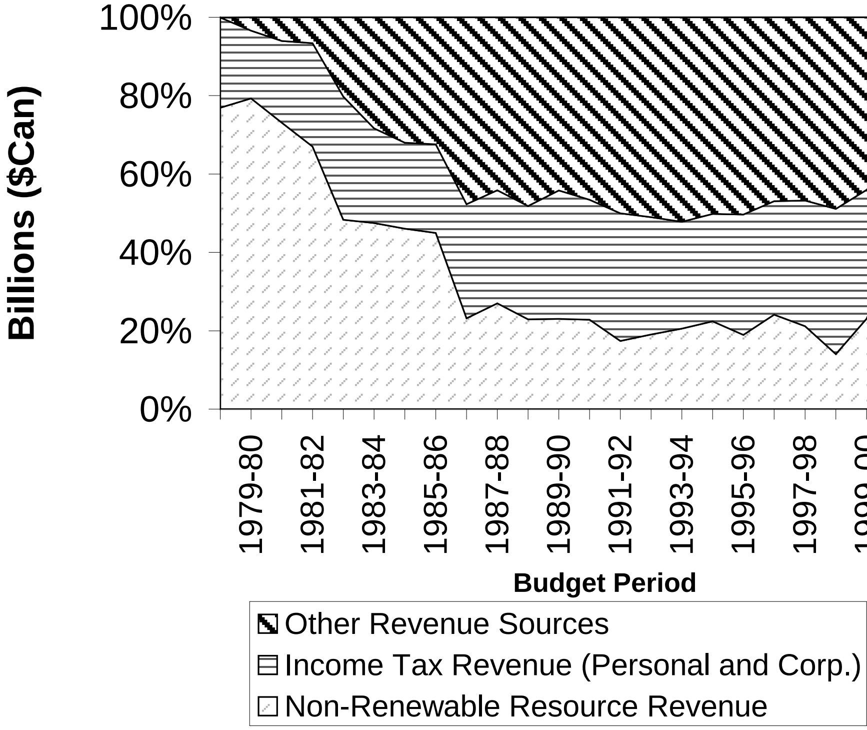

Figure 2 - Alberta Income Tax, Non-Renewable Resource, and Other Sources of Revenue from 1978-79 to 2003-04

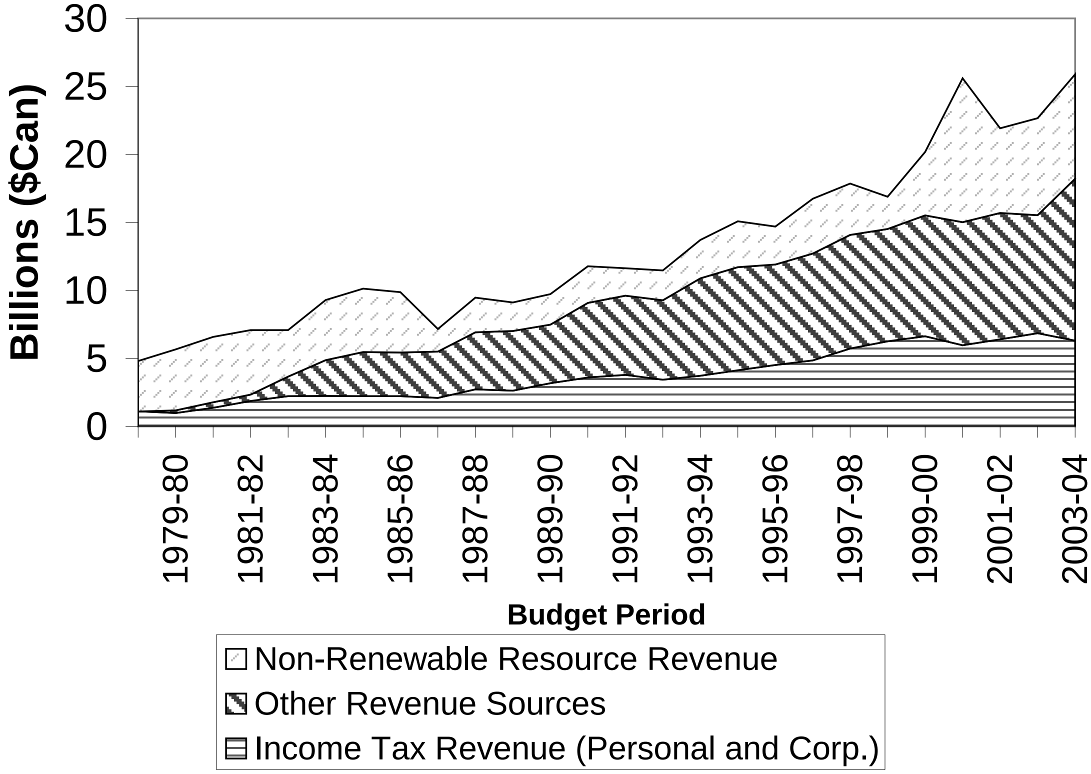

Figure 3 – Comparison of Estimated Swap Price to Alberta Budget Price Forecasts for Crude Oil and Natural Gas