DÉPARTEMENT DE SCIENCE ÉCONOMIQUE
DEPARTMENT OF ECONOMICS

CAHIERS DE RECHERCHE / WORKING PAPERS

0807E

Resource Revenues and Fiscal Sustainability in Alberta

by Leslie Shiell and Colin Busby

March 2008

ISSN: 0225-3860

CP 450 SUCC. A
OTTAWA (ONTARIO)
CANADA K1N 6N5

P.O. BOX 450 STN. A
OTTAWA, ONTARIO
CANADA K1N 6N5

uOttawa

Faculté des sciences sociales
Faculty of Social Sciences

Abstract

Alberta's public finances depend upon volatile revenues from an exhaustible resource base. The question arises of what proportion of current resource revenues the government should spend on current priorities and what proportion it should save for future generations. The paper uses the Permanent Resource Income Model to answer the following four questions:

- *Has Alberta saved enough of its resource revenues to date?*
- *What level of spending out of resource wealth is sustainable moving forward?*
- *What are the implications of a sustainable policy for the province's current budget planning?*
- *Should Alberta follow Norway's example of saving all of its resource revenues in a fund and spending only the resulting investment income?*

Keywords: Natural resource revenues; Fiscal sustainability
JEL: H6, Q32, Q33

Résumé

Les finances publiques de l'Alberta dépendent de la volatilité des revenus en provenance de ressources épuisables. La question se pose de savoir quelle proportion des revenus tirés des ressources naturelles le gouvernement devrait dépenser sur les priorités actuelles et quelle proportion devrait être placée pour les générations futures. Cette recherche utilise le Modèle de Revenu Permanent des Ressources afin de répondre aux quatre questions suivantes :

- *Est-ce que l'Alberta a épargné assez de ses revenus en provenance des ressources?*
- *Quel est le niveau de dépenses soutenable à partir de la richesse des ressources pour aller de l'avant?*
- *Quelles sont les implications d'une politique soutenable pour la planification du budget actuel de la province?*
- *Est-ce que l'Alberta devrait suivre l'exemple de la Norvège de sauver l'ensemble de ses revenues des ressources dans un fonds et de dépenser que les revenus des investissements?*

Mots clé: Revenus de ressources épuisables; soutenabilité fiscale
JEL H6, Q32, Q33

Introduction

Alberta has enjoyed unprecedented prosperity thanks to the recent run-up in oil and natural gas prices. This development has had a major impact on the government's finances. Between 1999 and 2006, direct resource revenues accruing to the government increased 152 percent, program expenditures increased 80 percent, and the government paid off all outstanding debt.[1]

Nonetheless, it is well known that this state of affairs rests on a precarious foundation of volatile revenues from an exhaustible resource base. For this reason, many Albertans are asking whether the province has saved enough for the future. This question has taken on particular importance in light of recent media reports on Norway, an oil-rich country which places more emphasis on saving its resource revenues than Alberta.[2] In order to address these concerns, we will focus on the following four questions:

- Has Alberta saved enough to date?
- What level of spending out of resource wealth is sustainable moving forward?
- What are the implications of the sustainable policy for the province's current budget planning?
- Should Alberta follow Norway's example?

To begin to answer these questions, policy makers must identify the principles that should guide fiscal policy over the long run. In recent years, the concept of sustainability has emerged as a prominent candidate for this role.

Economists define fiscal sustainability in terms of the Permanent Income Model, first proposed by Milton Friedman in the 1950's. In recent years, researchers working at the International Monetary Fund have adapted this model to the case of resource-rich jurisdictions, in a version we call the Permanent Resource Income Model (PRIM). In simple terms, the model identifies the highest level of annual government spending which can be continued indefinitely, given what is known and expected about the resource endowment. We argue that this level should be calculated in per capita terms – i.e. government spending per resident of the province – in order to balance competing objectives of inter-generational equity, economic efficiency, and

[1] Figures based on data from Alberta (2007).
[2] See for example Saunders (2008) and Scoffield (2006).

fiscal prudence. The model deals with the eventual exhaustion of the resource base by building up sufficient financial wealth to provide an alternative stream of income in the future.

Applying the model to Alberta yields the following answers to our four questions:

- Alberta has in fact saved more than enough to date, in relation to a hypothetical sustainable policy implemented at the beginning of oil and gas exploitation in 1948.
- Notwithstanding the positive result above, the province must now begin an aggressive savings policy if it wishes to sustain a constant level of per capita expenditure moving forward. In particular, given our reference forecast of future revenues, the government must aim to save an amount equal to 139 percent of direct resource revenues over the next five years. Failure to meet this target will lead to a permanent decline in spending capacity this century, as the resource base and thus revenues diminish.[3]
- The current Fiscal Responsibility Act provides for less than half the savings called for by the benchmark policy during the next five years, and its relative performance will deteriorate beyond that point. While further increases in resource royalties may help, our analysis suggests that the government will also have to undertake a combination of spending cuts and increases in non-resource tax levels.[4]
- The Permanent Resource Income Model is conceptually different from the approach followed by Norway. In particular, while PRIM seeks to equalize per capita spending over time, the Norwegian approach provides an explicit bias in spending in favour of future generations. Nonetheless, under present circumstances, PRIM actually calls for Alberta to save more than the Norwegian approach, not less.

Beyond specific targets and values, the Permanent Resource Income Model provides the ground rules for a process of sustainable fiscal planning which any jurisdiction can follow. At its centre is the idea that government expenditure out of resource wealth should be smoothed over time so that all citizens share equally in the resource bounty.

In contrast, present debates usually revolve around the government's short-term record. In this vein, the government of Alberta has resorted in recent years to legislated fiscal rules to

[3] Our forecasts shows the resource base being depleted in 2095.
[4] Our estimation of the sustainable benchmark already takes into account the increases in royalty rates announced following the Alberta Royalty Review Panel.

eliminate deficits and constrain the budgeting process.[5] While these rules have proven useful as statements of the government's budgeting priorities, they are in general too ad hoc to provide long lasting guidance on fiscal policy. Indeed, their history is one of constant revision as new developments render yesterday's rules obsolete. Unfortunately, repeated revisions have led to increased complexity, including a proliferation of savings funds. This complexity has reduced the transparency of the budgeting process and does not serve Albertans well.

In contrast, the Permanent Resource Income Model provides a permanent, comprehensive and clear framework for guiding fiscal policy in the long-term. The model supersedes all other fiscal rules. It also calls for the consolidation of the province's various savings funds, thus increasing the transparency of the budgeting process and the public accounts.

Fiscal Sustainability

Debates about the management of resource revenues revolve around how much should be saved in a year and how much should be spent for the immediate benefit of citizens (i.e. program spending). By saving we mean payment of interest or principal, if the government is a net debtor, or accumulation of financial assets, if it is a net creditor.[6]

We interpret sustainability to mean that a given policy can be continued at the current level indefinitely. It follows that sustainability requires a shift of focus from the short-term to the long-term. Short-term thinking about fiscal policy revolves around the current budget balance. In contrast, long-term thinking focuses upon the government's total wealth – in particular whether the government's wealth is adequate to support a long-term fiscal plan, of which the current budget balance is only one element. For this purpose, the government's total wealth consists of two components: its financial position (the different between assets and liabilities) and the present value of the stream of future revenues.

Economists interpret fiscal sustainability in terms of the Permanent Income Model of budget planning, originally due to Friedman (1957). Permanent income is defined as the annuity value of total wealth. In effect, it is as if the government could invest its total wealth in the bond

[5] See Kneebone (2006) for a history of such rules in Alberta.

[6] We include debt interest payments in the saving envelope, although it is conventional to account for them as current expenditure. Interest payments represent a transfer from taxpayers to bond holders, and thus do not provide a net benefit for society in the period in which they are made.

market (including the rights to future streams of revenue) and receive an annual return on the investment. Permanent income indicates the amount that can be spent in a year consistent with maintaining total wealth constant.[7] Spend more than this amount and wealth will fall; spend less and wealth will grow. Thus permanent income corresponds with the maximum annual spending level that can be maintained indefinitely (assuming nothing changes).

When assessing fiscal sustainability for resource based economies, economists typically narrow the focus of the model to resource-based wealth only, i.e. financial assets plus the present value of future resource revenues.[8] For this purpose, we denote spending out of resource wealth[9] as G^R. We take the view that all Albertans, including those alive and those yet to be born, are entitled to an equal share of spending out of resource wealth. Therefore we define fiscal sustainability in terms of the maximum constant value of G^R per capita. By definition, this value is equivalent to permanent resource income per capita, which is the annual return on per capita resource wealth.

In a given year, resource revenue may be less than or greater than G^R. If less, then the difference is covered by either investment income or borrowing. If greater, the surplus is savings. The role of borrowing springs from the fact that resource revenues do not in general flow at a constant rate. In particular, if revenues start out low at the beginning of extraction and increase over time, the Permanent Income Model entails borrowing against future revenues at the outset, then paying off the debt and building positive wealth later, when revenues are greater. This way, all generations can enjoy the same level of spending per capita from the resource base, despite variations in the flow of revenues. In the long-run, it is important to build significant financial wealth to provide a base for continued spending once the resource base is exhausted. Thus, over time, the flow of resource revenue is replaced by a flow of investment income, as in-ground wealth is converted into financial wealth.

This blending of borrowing and saving is analogous to household financial planning. When income is temporarily low, the household may borrow against future earnings; when income is unexpectedly high, the household may save the surplus. And ultimately the household will probably wish to accumulate adequate financial wealth to provide for spending during

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[7] In fact, following Engel and Valdes (2000), what we have here is a special case of the Permanent Income Model in which the agent's subjective discount rate is equal to the (exogenous) real interest rate.
[8] See for example Tersman (1991), Liuksila et al. (1994), Davoodi (2002), and Barnett and Ossowski (2002).

retirement. In this context, debt is not a bad thing, because it is manageable within a long-term plan.

Other perspectives on fiscal sustainability have been presented in the economics literature. For example, Tersman (1991) defines sustainability in terms of a constant ratio of G^R to non-resource GDP. Assuming non-resource GDP grows over time, this rule entails that G^R must grow at the same rate. Further, if non-resource GDP grows faster than population – necessary for per capita growth – it follows that G^R per capita must also grow faster than population. While such growth may sound attractive on the surface, it comes with a price. In particular, compared with the constant path we propose, G^R per capita in this case must start out lower, with more of the resource revenue saved in every period. Thus, the growth in G^R per capita in this approach benefits future generations at the expense of early generations. In light of the fact that future generations will likely benefit from higher non-resource GDP per capita (due to technical change for example), we see no ethical basis for skewing resource-based spending in their favour as well.

Engel and Valdes (2000) point out that even constant G^R per capita may be too generous to future generations, since, as mentioned, they will likely benefit from higher non-resource GDP per capita. With this in mind, they propose that resource wealth be used to compensate early generations for lower non-resource incomes. This approach entails a declining path of G^R per capita.[10]

Fiscal policy must also take into account the impacts of taxation and uncertainty. A constant or declining path of G^R per capita will likely lead to an increasing path of non-resource tax rates. In this scenario, increasing GDP per capita leads to increasing demand for public goods per capita (as well as private goods). With G^R per capita constant or declining, the government will have to increase non-resource tax rates in order to finance the growth in public goods. These increases have an efficiency cost in terms of greater economic distortion. Economists argue that the distortionary cost of taxation can be minimized by stabilizing tax rates over time – a

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[9] We use "spending out of resource wealth", "resource-based spending", "resource spending", and "resource expenditure" synonymously.

[10] Engel and Valdes present two models of this type. The first is a full application of the permanent income approach, in which the government uses taxes and transfers to achieve a constant level of total spending (private plus public) per capita over time. In the second, which they call the "conditionally normative model", the government does not touch the inter-generational distribution of private spending (consumption in their vocabulary) but rather uses resource revenues to top up the spending of early generations, because they are poorer in terms of private spending.

condition known as "tax smoothing".[11] But stabilizing tax rates while increasing the provision of public goods would require a constant G^R/GDP ratio, which is not consistent with constant G^R per capita.

Uncertainty complicates fiscal planning further. The Permanent Income Model generates a prescription for a constant level of resource expenditure, provided nothing changes. However, in reality most of the relevant factors, including resource prices, extraction rates, costs, and reserve size, have proven to be quite volatile over time. Applied analysis takes a "certainty equivalent" approach, in which expected values of variables take the place of certain values, with no other adjustments.[12] This approach is followed here as well. However, risk-averse agents respond to uncertainty by undertaking more saving – and therefore less expenditure – than the certainty equivalent level, a phenomenon referred to as "precautionary saving".

To summarize, we have identified three arguments for deviating from our rule of constant G^R per capita. First, the equity argument: since early generations will likely be poorer, we should skew G^R in their favour. Second, following the theory of tax smoothing, we should maintain a constant G^R/GDP ratio to keep tax rates constant and minimize related distortions. This approach entails skewing G^R in favour of future generations. Third, precautionary savings requires more saving and less spending than certainty equivalence, thus skewing G^R in favour of future generations compared with our rule.

Accounting formally for these effects is beyond the scope of the paper. However, we note that our bias on the first item is opposite to our biases on the second and third items. Thus we have reason to believe that the effects may be at least partially offsetting. Further, we note that Alberta's present tax system is among the least distorted in Canada, with flat tax rates of 10 percent on both personal and corporate income and no provincial consumption tax.[13] Thus, the argument for tax smoothing may be weaker in this case. Since equity and efficiency are pulling policy in opposite directions here, a rigorous approach would require finding an optimal balance, which of course would lie somewhere in the middle. We conjecture that our constant G^R per capita rule may not be far off.

Finally, we note that, as a practical matter, uncertainty of future variables means that regular revisions of the fiscal plan will be necessary as new information becomes available. At a

[11] Blanchard and Fischer (1989, 583-589) provide a discussion of the related literature.
[12] See Tersman (1991), Liuksila et al. (1994), and Davoodi (2002) for examples of this approach.

given planning date, the permanent income approach yields a prescription for a constant level of resource-based spending, based on expected values of variables and assuming nothing changes. But of course conditions change. Thus, in the next planning period (e.g. next fiscal year) the exercise would need to be repeated, using realized values for the elapsed period and updated forecasts of future variables. In light of these changes, the prescribed level of resource spending would change as well. Thus, viewed in retrospect, the path of per capita resource spending would be variable, while in any given year the plan would call for a constant value moving forward.

Historical Perspective: Has Alberta Saved Enough?

Part of the debate over resource management in Alberta concerns whether successive governments have saved enough to provide for future generations once the resource stock runs out. This question reflects a widely held belief, or at least a suspicion, that too much of the finite resource wealth has been spent to date and not enough saved.[14] This concern has been fuelled by numerous stories in the press (e.g. Scoffield 2006, Saunders 2008) comparing Alberta's approach with that of Norway, which places a greater emphasis on saving.[15]

On the surface, this question appears to be backward looking, as it concerns whether governments have made appropriate decisions in the past. However, upon examination, it is apparent that one cannot answer this question without also taking into account probable conditions in the future. One needs a roadmap of where Albertans want to go – or more precisely a statement of what future citizens have a right to expect – in order to assess whether adequate provisions have been made in the past. Such a roadmap is provided by the Permanent Resource Income Model.

For this purpose, we suggest a "perfect foresight" approach, in which past values are taken as given and forecast values are assumed to be certain as well. This approach amounts to a thought experiment, in which spending and saving decisions are arranged starting in 1948 through to the end of extraction, according to the model, assuming our forecast values are in fact the true values.[16] Of course, the government of Alberta was not in this position in 1948, since it most certainly could not foresee the paths of prices, reserves, extraction and other variables.

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[13] See Chen, Mintz and Tarasov (2007).

[14] For many expressions of this point of view, see the submissions to the Alberta Royalty Review Panel, available on-line at <http://www.albertaroyaltyreview.ca>.

[15] We provide a detailed analysis of Norway's approach later in the paper.

Nonetheless, one can ask whether by accident the government managed to save as much as this hypothetical scenario.

As described previously, the task is to calculate the annuity value from the government's total wealth, which consists of current financial assets plus the present value of future resource revenues. Estimating future resource revenues requires forecasts of key variables, including resource prices, reserves, extraction rates, royalties, interest rates, inflation and population. We have based our forecasts on the leading authorities in the field, including the International Energy Agency, the Energy Information Administration of the US Department of Energy, the Canadian Association of Petroleum Producers and others. We consider high, medium and low forecasts associated with these variables. The medium case is the most likely, and we refer to it henceforth as the reference forecast. Appendices A and B describe the data we use and the mechanics of the model.

Based on the model, we estimate that, under the reference forecast, a perfectly foresighted planner would have fixed G^R at a constant value of $3576 per capita, starting in 1948, and would have carried a net debt of approximately $74 billion at the beginning of the 2007-08 fiscal year.[17] In contrast, the province actually managed to accumulate positive net financial holdings of $35.7 billion by the beginning of fiscal 2007-08. Thus, we conclude that Alberta has in fact saved more than enough of its resource wealth to date, compared with our benchmark.

The high level of debt prescribed under "perfect foresight" for 2007 results from the unequal flow of resource revenues over time. Figure 1 presents the paths of total resource revenues, budget balance under perfect foresight (PRIM), and actual budget balance, for the planning horizon 1948-2095.[18] As shown, most of Alberta's resource revenues are expected to be realized after 2005.[19] Thus our hypothetical planner, standing in 1948, fully informed of what is to come, and facing no credit limit, borrows against future earnings until 1999 (with minor

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[16] See Tersman (1991), Liuksila et al. (1994), and Davoodi (2002) for examples of this approach.

[17] Except where noted, all monetary values are in 2007 dollars.

[18] We are referring here to the consolidated budget of the province, including all saving funds. This version differs from the common notion of the government's budget, which corresponds with the General Revenue Fund. Note our numbers for the actual budget balance (as opposed to PRIM) only cover the sub-period 1981-2007.

[19] As the figure presents nominal values, inflation accounts for some of this skew in the flow of revenues. Of course, inflation works to the advantage of debtors, as it erodes the value of debt principal. The brief decline and recovery of revenues during 2026-2031 reflects the forecast exhaustion of conventional oil and natural gas in 2026, followed by the forecast peak in revenues from the oil sands in 2031.

exceptions) in order to finance spending in early periods. Then, from 2000 to 2013, the planner pays off debt. Finally, the planner begins to accumulate net wealth in 2014.[20] In contrast, the actual experience of the province to date has involved more frequent surpluses, as evidenced by the positive value of net wealth in 2007 ($35.7 billion) and by the actual budget balance series shown in the figure for the sub-interval (1981-2007).

Looking Forward: a Sustainable Policy for Resource Revenues

The fact that Alberta has accumulated more wealth to date than the "perfect foresight" scenario allows the province to sustain a more generous level of G^R per capita moving forward. Starting in 2007-08, based on net financial wealth of $35.7 billion, the model returns a G^R value of $4501 per capita in the reference case (roughly $900 more per capita than under "perfect foresight").

This plan requires an aggressive program of saving starting immediately. To illustrate, Figure 2 compares resource revenues during the five years 2007 -2011 under the reference forecast with the required budget surpluses under the model, and with the forecast budget surpluses under current fiscal rules.

The figure presents both total and direct resource revenues. As explained in Appendix A, we classify resource revenues as direct, indirect or diversified. Direct revenue is equivalent to the line item labelled "resource revenues" in the public accounts, which includes royalty taxes, Crown land leases, rentals and fees. Indirect revenue corresponds with all other tax revenues generated by oil, gas and related sectors in the province – for example, corporate and personal income taxes from these sectors. Diversified revenue corresponds with taxes paid by upstream and downstream firms which have diversified away from reliance on the domestic oil and gas sector. For example, firms which started by servicing the oil and gas sector may eventually find clients outside the province or in unrelated domestic sectors. Although no longer generated by domestic oil and gas activity, these revenues are still classified as resource revenues since they would not have come about without the impetus provided by the resource sector.

As shown in Figure 2, the required savings under PRIM (total budget balance) exceeds direct resource revenues by a significant margin. In particular, for the first five years of the plan, the cumulative surplus under PRIM amounts to 53 % of total resource revenues and 139 % of

[20] The series on net wealth is not shown in the figure.

direct revenues – i.e. more than one third greater than the cumulative value of resource royalties, land leases, rentals and fees. Furthermore, these proportions are set to increase progressively beyond the dates shown in the figure.

In contrast, the current rule, established by the Fiscal Responsibility Act of 2007 (FRA), results in a much lower level of savings. Under this rule, the first $5.3 billion of direct resource revenues are to be allocated to current spending, with the remainder saved. The figure shows the estimated size of the remainder, based on our reference forecast of resource revenues.[21] For the five years shown, cumulative savings under FRA amount to only 36 % of the level prescribed by PRIM (alternatively 48 % of direct resource revenues). We conclude therefore that the current savings commitment is insufficient to maintain a constant level of C^R per capita in the future, under the reference forecast. This conclusion is supported as well under high and low forecasts of the variables, as shown in Appendix C.

We can also forecast the effect of the Fiscal Responsibility Act over the long-term (Figure 3, reference forecast). Initially, the lower savings rate under the FRA results in higher G^R per capita than the PRIM benchmark, but the spending level declines steadily. By 2034, resource spending under the FRA falls permanently below the benchmark. By 2095, when the resource base is exhausted, the spending level under the FRA is only 25 % of the benchmark. This level is sustained thereafter by interest on accumulated savings and by the flow of diversified revenues (assumed constant after exhaustion).[22] By 2068, direct resource revenues (not shown) fall permanently below the $5.3 billion threshold, and no further saving of resource revenues is undertaken under the FRA. At this point, we assume the government adopts a minimalist wealth preservation strategy, by saving enough out of investment income every year to inflation-proof the accumulated fund. The remainder of investment income under this strategy is spent.

Figure 3 highlights the choice Albertans must make between a sustainable policy of resource-based spending and the current policy which favours present over future generations. We summarized earlier the debate among economists over skewing resource expenditure in one direction or another (the equity argument versus tax smoothing and precautionary savings). Following Engel and Valdes (2000), one could justify the FRA policy provided non-resource

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[21] As well, extra savings could come from unbudgeted surpluses. Thus, the values presented in Figure 2 represent a minimum expected level of savings under the FRA. However, we note that the In-Year Surplus Allocation Policy requires two thirds of unbudgeted surpluses to be allocated to the Capital Account – in other words spending rather than saving.

GDP per capita were to grow in an offsetting fashion. However, as discussed, tax smoothing and precautionary savings pull policy in the opposite direction.

Moreover, while non-resource GDP may indeed grow, it is doubtful that it will grow quickly enough to fully compensate for the decline in G^R under the FRA, which we forecast at an average annual decline rate of 1.88 % (real) in the reference case. Given the difference in size of the sectors, it is likely that non-resource GDP would have to grow faster than this to fully offset the lost resource revenues. For example, for the 25-year period 1981-2006, we estimate Alberta's resource-based GDP was on average 35 percent larger than its non-resource GDP.[23] It follows that the annual growth rate of non-resource GDP per capita would have to be 35 percent larger than this decline rate – i.e. 2.54 percent. In contrast, the average actual real growth rate of non-resource GDP during this period was only 1.2 percent per annum. In neighbouring British Columbia, the annual real growth rate for total GDP per capita during this period was only 0.9 percent.[24] Moreover, these rates are set to erode with the aging of the population, as the labour force participation rate drops. Thus, there is ample reason to doubt that non-resource growth could fully compensate for the decline in G^R entailed by the FRA.

Over the three years 2007-2009, we forecast the shortfall of planned savings under the Fiscal Responsibility Act compared with the benchmark will average \$8.8 billion per year (\$2007) – equivalent to 26 percent of total expenditures planned for this period in Budget 2007. Part of this gap could be covered by unbudgeted surpluses, but part would undoubtedly have to be made up by either reductions in current expenditure, increases in resource tax rates, or increases in non-resource tax levels.[25]

Resource tax rates include royalty rates (direct resource revenues) as well as personal and corporate taxes on income earned in the sector (indirect resource revenues). While increasing these rates would generate increased government revenue if nothing else changed, in reality it would also generate a number of offsetting effects. First, increasing resource taxes would lead to an increase in the government's wealth, through the present value of future resource revenues,

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[22] In the absence of diversification, the long-run expenditure level would be lower under both PRIM and the FRA.
[23] We focus on private GDP. i.e. net of government expenditure. Mansell and Shlenker (2006) estimate resource activity accounts for approximately 50 percent of Alberta GDP. Therefore, multiplying GDP values (Statistics Canada, CANSIM V3839827) by 0.5 and subtracting total government expenditure (Alberta budget documents) yields private non-resource GDP.
[24] Statistics Canada, CANSIM V3839831.
[25] Our reference forecast already makes provision for the announced increases in resource royalties in response to the Alberta Royalty Review Panel.

and therefore it would lead to an increase in the prescribed level of G^R per capita. Depending what stage the government was at in the borrowing / saving cycle of the model, this change would lead to either an increased or decreased demand for saving (less saving early on, more saving later). Second, increasing resource taxes would have a dampening effect on activity in the sector, an effect which was much discussed in the context of the recent royalty review in the province.

While accounting for these effects explicitly is beyond the scope of the paper, we have conducted sensitivity analysis on the effect of increasing royalty rates holding everything else constant.[26] Our results indicate that, while increasing royalty rates (increasing prices) does reduce the savings gap (111 percent of direct revenues vs. 139 percent), it does not come close to eliminating it. Therefore, we expect that the government would also have to pursue reductions in expenditure and increases in non-resource tax rates to close the savings gap.

The prescribed policy provides a level of per capita expenditure based on resource wealth that could be sustained indefinitely if the forecast proved to be true. The key to sustainability is the gradual replacement of resource revenues with income from accumulated savings. Figure 4 illustrates this process of replacement, for the reference forecast. Initially, investment income amounts to only a few hundred dollars per capita, while resource revenue amounts to more than $7,000. By 2048, the two series are equal. By the end of our horizon, investment income accounts for approximately 86 % of the total value of G^R per capita ($4501). The remaining 14 % ($633) is made up by diversified resource income, which we assume continues at a constant level after the exhaustion of the resource base.[27]

The Bird-in-the-Hand Approach: Should Alberta Follow Norway's Example?

Much discussion in recent years has focused on whether Alberta should follow Norway's example in saving more of its resource wealth.[28] Bjerkholt and Niculescu (2004) refer to this as the Bird-in-the-Hand approach (BIH), because it does not treat resource revenue as part of the government's wealth until the resource is extracted and the revenue is actually realized. In this

[26] The results of the sensitivity analysis are presented in Table C1, Appendix C. We model an increase in resource royalty rates as equivalent to an increase in resources prices holding royalty rates constant.
[27] Prior to exhaustion in 2095, the sum of resource revenues and investment income exceeds the value of G^R per capita by the amount of savings (total budget surplus). In our low variant of the forecast, diversified revenues are zero and investment income equals 100 % of G^R after exhaustion. See Appendix C for the presentation of the various forecast scenarios.

view, the government's wealth consists solely of current financial assets. Resource revenues are to be saved in a fund, and only the income on the fund is made available to the government for spending in the annual budget.

Norway began managing its oil revenues in this fashion in 1991. Since then it has accumulated \$368.2 billion in its saving fund, equivalent to approximately \$78,000 for every Norwegian (Saunders 2008). Legislation permits an annual transfer of 4 per cent of the equity for spending in the government's budget, equal to the average expected rate of return of the fund (Bjerkholt and Niculescu 2004). At present, approximately 10 percent of the government's budget comes from this source (Saunders 2008).

Alberta also has a vehicle for saving resource wealth, namely the Alberta Heritage Savings Trust Fund – commonly referred to as The Heritage Fund. Established in 1976, it grew to \$12.7 billion by 1987, but no further deposits were made until 2005. It now stands at \$16.6 billion, or approximately \$4,900 per Albertan (AHST 2007, 2008 and Statistics Canada). In contrast, since 1976, the province has received a total of \$148.1 billion in direct oil and gas revenues and an estimated \$330.7 billion in total revenues (direct + indirect + diversified). During the same period (1976-2007), direct revenues (net of deposits into the Heritage Fund) accounted for 29% of current government spending, while total revenues (net of deposits into the Heritage Fund) accounted for an estimated 69% of current spending. Finally, investment income received from the Heritage Fund accounted for an additional 6% of spending (Boothe 1995, Alberta budget documents, and authors' estimation).

Arguments that have been put forward in support of the Bird-in-the-Hand approach include inter-generational equity, precautionary savings, and maintaining competitiveness in manufacturing and other non-resource sectors (avoidance of the so-called "Dutch disease").[29] The equity argument here differs from the one discussed earlier (i.e. skewing G^R in favour of present generations to compensate for lower non-resource GDP). Here equity reflects the perception that current spending of resource revenue is wasteful essentially by definition while saving is far-sighted and disciplined. Precautionary saving, as above, responds to the possibility of negative shocks, such as a sudden downturn in resource prices or an adverse shock to the non-

[28] See for example Saunders (2008), Scoffield (2006) and ARRP (2007).
[29] Saunders (2008), Scoffield (2006), Bjerkholt and Niculescu (2004).

oil economy. Similarly, the prospect of increasing government obligations for health care spending in an aging society would seem to recommend saving more for the future.

The Dutch disease phenomenon consists of two effects, one operating through the currency and one through aggregate demand. The first effect involves the appreciation of the local currency, as export revenues are brought home. The higher exchange rate makes domestically manufactured goods more expensive in comparison with foreign goods, thus undermining the competitiveness of the domestic manufacturing sector. The second effect involves the potentially inflationary impact of high government spending when it is financed by resource revenues rather than taxation. If inflation feeds through to wage levels, competitiveness is again undermined. The BIH or savings-fund approach limits these effects provided the equity of the fund is held in foreign assets. This practice limits the pressure on the domestic currency by limiting the annual inflow of revenue. In the same way, the inflationary impact of government spending is restrained.

We believe that most of these arguments either go too far in favouring future generations or do not apply fully to Alberta. Barnett and Ossowski (2002) describe the Bird-in-the-Hand approach as "an extreme form of precautionary savings, in that it is tantamount to assuming that there would be no future oil revenues" (p.9). Such an outcome would occur, for example, if there were a sudden, permanent collapse in the price of oil. But since the likelihood of such an outcome is extremely small, the BIH approach is excessively cautious. Further, as we will show below, the BIH approach in its pure form entails an extreme bias in the allocation of resource benefits in favour of future generations.[30]

In terms of Dutch disease, we note that, as one province in a large federation, Alberta's influence on the Canadian dollar is more limited than it would be if, as Norway, it were a national economy with its own currency. Further, labour mobility within the federation helps moderate wage pressures, compared with what they would be otherwise. Historically, there has been scant evidence of adverse impact on non-resource sectors in Alberta. Indeed, one could argue that a diversified economy did not exist in Alberta prior to the discovery of oil and gas, and it is the exploitation of these resources which has stimulated the development of manufacturing in upstream and downstream industries. More recently, manpower shortages and

[30] York (2008) provides a telling illustration of the future bias of BIH in the context of East Timor.

wage pressures have started to resemble the symptoms of Dutch disease. Yet these results are clearly due to the investment boom in the oil sands rather than the government's fiscal policy.

Thus, we conclude that the Bird-in-the-Hand approach does not provide a compelling framework for guiding fiscal policy. Nonetheless, some of the arguments above have validity in terms of savings funds in general. To the extent that the recent surge in the Canadian dollar may be partially due to increased exports of oil and natural gas, holding the equity of the fund "offshore" – i.e. in foreign assets – could provide some benefit by reducing upward pressure on the dollar.[31] Similarly, any savings plan would by definition restrain government spending, thereby moderating potential inflationary pressures.

In any case, starting from 2007, the Permanent Resource Income Model actually calls for more saving than BIH in all but the most optimistic forecast scenario, if one follows the Norwegian approach of saving only direct resource revenues.[32] Thus we arrive at the somewhat unexpected conclusion that Alberta should not follow Norway's example but in fact it should save more, given realistic assumptions about the forecast.

To illustrate, we consider both pure and practical applications of Bird-in-the-Hand under the reference forecast (Figure 5). The pure application would save both direct and indirect resource revenues[33] while the practical (Norwegian style) application focuses only on direct revenues. We apply a transfer rate of 3.5 % to the fund equity; this amount of investment income is transferred each year to the government's budget for spending. This rate is equal to our reference forecast for the real return on investment.

The extreme future bias of the pure BIH approach is evident. As argued above, we do not find such a bias to be ethically compelling. Moreover, the savings commitment for this version of BIH is extreme. As shown in Figure 2, the sum of direct and estimated indirect revenues is only slightly less than total resource revenue initially. During the three years 2007-09, this sum amounts to approximately 77 percent of the forecast for total government spending provided in Budget 2007 and two and half times the value of direct resource revenues. In political terms, this savings plan would probably be impossible, even if it were desirable.

[31] See Laidler (2008) for a discussion of the link between the Canadian dollar and resource prices. According to AHST (2008), just over 30 percent of the equity of the Heritage Fund was held in foreign denominated investments, as of December 31, 2007.
[32] See Appendix C for the sensitivity analysis.

In contrast, the practical version of BIH (saving only direct revenues) entails a gradual downward trend in G^R per capita. While this trend is not so pronounced as under the Fiscal Responsibility Act and therefore perhaps more acceptable (compare Figure 3), we note a tendency for fluctuations in the first twenty-five years of the plan which cannot be justified in terms of any meaningful economic or social objectives. This outcome results from the arbitrary decision to limit savings to a particular category of revenue rather than focusing on a compelling long-term goal, such as sustaining G^R per capita. Thus, as argued above, we favour the constant spending policy (PRIM). As already discussed, this policy requires savings in excess of direct resource revenues – 39 % more during the five years 2007-11, under the reference forecast. In return, it results in a long-run value of G^R per capita that is approximately 29 % higher than the practical (Norwegian) version of BIH ($4,501 versus $3,502 after 2095).

Reforming the Budgeting Process

Budget planning

Our discussion leads to the following recommendations for changes to the way Alberta conducts the budgeting process.

- Target a constant per-capita level of spending out of resource wealth.[34]

Our estimate of G^R per capita in the reference case is $4501. The sensitivity analysis (Appendix C) shows how this value varies with assumptions about the forecast.

- Pursue an aggressive program of savings, based on the estimates of the model.

In our reference case, required saving in the near-term (2007-11) is equal to 139 percent of direct resource revenues. The sensitivity analysis (Appendix C) shows how this requirement varies with assumptions about the forecast. In the most plausible scenarios, the savings requirement is uniformly greater than direct revenues.

In comparison, the current rule under the Fiscal Responsibility Act translates into a savings rate (near-term) of less than 50 percent of direct resource revenues in the reference case. Thus the government has significant work to do in closing the gap between our recommended

[33] It would not save diversified revenues, since these revenues are sustained after exhaustion of the resource. Unlike PRIM, which focuses on smoothing the benefits from all sources, BIH only saves revenues from exhaustible sources.

[34] In technical terms, this is known as the Non-resource Primary Deficit. See Appendix B for a discussion.

target and the existing policy. Achieving the target will require a combination of reductions in annual spending and increases in non-resource tax levels.

- Revise the plan regularly.

As discussed, the estimate of a constant value of G^R per capita depends upon forecast values of future variables. As information changes, the forecast changes, and therefore the estimated value of G^R must change as well. It follows that the goal of a constant value of G^R will only be realized in the hypothetical sense, within the context of a given year's plan. In reality, the attained value of G^R will vary from year to year as information – and thus the plan – changes as well.

Reporting and data

Implementing this approach to budget planning also calls for changes in the way the government reports its results and in the data available to budget planners and the general public.

- Consolidate the government's savings funds.

A coherent approach to long-term fiscal planning requires a comprehensive view of the government's budget. The current practice of presenting "the budget" in terms of a single account (the General Revenue Fund), distinct from various other funds and accounts (e.g. the Heritage Fund, the Sustainability Fund, the Capital Account, the Alberta Heritage Medical Research and Endowment Fund) diverts attention from the big picture and makes a long-term focus difficult. The Permanent Resource Income Model assumes one comprehensive savings fund for financial assets and one current budget account.

- Publish estimates of indirect resource revenues in addition to direct revenues in the public accounts and budget documents.

Currently the government's financial reporting distinguishes only direct resource revenues from other forms of taxation. This presentation significantly underestimates the true level of revenues from natural resources and thus distorts the public's perception of the sources of government wealth. An informed public debate about the allocation of resource wealth over time requires full information about the amounts involved.

- Improve estimation techniques for indirect and diversified resource revenues.

Unlike direct revenues, which can be easily identified through the accounting trail, estimating indirect revenues requires an economic modeling exercise in order to isolate the components of corporate and personal income taxes (and other taxes) which come from resource-based activities. Further research effort is needed to improve the available modeling capacity. This requirement is even more acute in relation to diversified revenues. Our current ability to estimate this category amounts to little more than educated guessing, and yet as demonstrated these revenues play a key role in planning a coherent fiscal policy.

- Display long-term consequences.

Budget debates typically focus on next year's total balance – i.e. whether the budget is forecast to be in surplus or deficit. In addition, the government also produces a three-year plan with the budget. Yet, because non-renewable natural resources will run out, the consequences of spending resource revenues are permanent. Therefore, budget planners should present the expected consequences of current spending decisions in the short, medium and long-term. For example, our analysis of the Fiscal Responsibility Act above (Figure 3) shows in a simple and clear way that the consequence of high spending today will be permanently lower spending in the future, under the assumptions of the forecast. This type of information is essential for an informed public debate.

Conclusion

In this paper, we have sought to answer (i) whether the government of Alberta has saved enough of its resource wealth to date, (ii) what policy is sustainable moving forward, (iii) what are the implications of this policy for current budget planning, and (iii) whether the province should follow Norway's example of saving all of its direct resource revenues. We concluded that, although the government has saved more then enough to date, it now needs to embark on an aggressive savings program (139% of direct resource revenues during the five years 2007-11, under the reference forecast) in order to sustain a constant level of per capita spending out of resource wealth. Indeed, in most scenarios, it must save more than the Norwegian standard, not less.

This result may seem somewhat paradoxical. On the one hand, the savings rate has been more than sufficient to date. On the other hand, the current rule under the Fiscal Responsibility Act – which on its own will take resource savings to new highs – nonetheless falls seriously short of what is required to meet the sustainability benchmark in the future.

The explanation for this apparent contradiction lies in the very large scale of borrowing and saving entailed in the Permanent Resource Income Model. Unlike the Norwegian approach, the PRIM manages all three categories of resource revenues over time – direct, indirect and diversified. Given the large sums involved, the model generates very large targets, both for borrowing, when appropriate, and for saving. Our analysis of the historical question (starting in 1948) shows that Alberta has only recently passed the prescribed transition date from borrowing to saving (1999). Thus the sudden swing from more than enough saving to grossly inadequate saving is consistent with the model.

We have followed a rather conventional, optimistic view of prospects for the oil and gas sector – one that foresees only moderate downside risks in terms of prices and revenues. In contrast, the possibility exists for major negative shocks. For example, the development of alternative technologies or stringent environmental standards could render the resource obsolete even before exhaustion. Alternatively, environmental degradation or resource scarcity may make future generations worse off than present. All these possibilities point to a heightened precautionary motive for savings.[35] Thus an argument can be made that our savings target – as aggressive as it is – perhaps should be viewed as a minimum threshold for current policy.

Planning for a sustainable fiscal policy is complicated by large uncertainties and approximation errors related to future oil and gas prices, recoverable reserves, indirect revenues, and diversification, among other things. Combined with the more garden variety fluctuations in the economic environment, these factors entail that the estimate of permanent income which underlies the model will constantly change. While this volatility is less than ideal, it is certainly not unusual in public affairs. For example, Canadians are accustomed to variability in the conduct of monetary policy, and we have developed significant institutional capacity and mechanisms to manage uncertainties in this context. Therefore, there is every reason to believe that stakeholders would be able to adapt to variability in the conduct of a sustainable fiscal policy. Provided the government updates its estimate of permanent income in a timely and transparent manner, the adoption of this approach should bring greater coherence and discipline to the formulation of fiscal policy than has been experienced to date.

[35] On the other hand, we note that the most efficient approach to environmental and scarcity problems is to control them at the outset, rather than letting them get out of hand and then seeking to compensate victims after the fact.

Appendix A
Data

A1. Historical data

Horizon

Our historical period begins in 1948, which marked the beginning of major oil exploitation in Alberta, and continues until fiscal 2006/07 inclusive.[36]

Direct resource revenues

We define direct revenues as those which are levied on the resource rather than the company. This category includes royalty taxes and Crown land leases, and for practical purposes we take it as equivalent to the line item labelled "resource revenues" in the public accounts.[37] We have assembled this data from Boothe (1995), for the period 1948 to 80, and from Alberta budget documents, for 1981 to 2007. Due to the quasi-consolidation techniques applied by Boothe (1991, 1995), the values from 1976 to 1980 had to be increased to account for transfers to the Heritage Fund.

Indirect resource revenues

We define indirect resource revenues as all other tax revenues generated by the oil and gas sector in the province. This category includes: corporate income taxes paid by oil and gas firms as well as upstream and downstream firms – i.e. firms that either service the sector or process its outputs; personal income taxes paid by employees of such firms; and other taxes and fees paid by households that derive their income from such firms. Indirect resource revenues are not distinguished by particular line items in the public accounts, and therefore it is necessary to employ some method for estimating them from available data. Thus the challenge is to extract the portion of revenues in these line items (e.g. corporate income tax, personal income tax) that can be attributed to oil and gas activities in the province.

An ideal approach would involve using a dynamic simulation model of the Alberta economy to counterfactually identify indirect resource revenues. Unfortunately, to the best of our knowledge such a model does not exist. Mansell and Shlenker (2006) employ Statistics Canada's

[36] The government's fiscal year runs April 1 – March 31, whereas our analysis employs calendar years. For simplicity, we attribute data to the first year of the split fiscal year, e.g. 2006 in the case of fiscal 2006-07.
[37] One could quibble whether royalty taxes are levied on the resource or the company, since royalty formulas typically take into account much firm-related detail, including revenues and costs. However, in theory the royalty represents a payment to the owner for the sale of the resource. Therefore, we classify it as a direct charge on the resource.

Interprovincial Input-Output Model to estimate the total impact of oil and gas extraction on Alberta's economy during the period 1971 to 2004, and we use their results as the basis for a simple multiplier showing the relationship between indirect resource revenues and activity in the oil and gas sector. The Interprovincial Input-Output Model is static in nature, which means that it is calibrated for a particular year – 2001 in the version used by Mansell and Shlenker.[38] Given the length of our time frame – 149 years from 1948 to 2095 – we opted against using the model directly.

We define the indirect revenue multiplier (IRM) as the ratio of the total value of indirect resource revenues in an average year to the total value of production of oil and gas (sales revenue) in the year. The value of production seems a plausible base for the multiplier, since both current activity levels and resource-related investment are positively correlated with it over the medium to long-term. Furthermore, by relating our multiplier to the value of production, which we must forecast anyway, we avoid the further difficulty of forecasting GDP or other macroeconomic variables.

Mansell and Shlenker's simulation indicates that a cumulative value of approximately $277 billion in government revenues was generated by the oil and gas sector, broadly defined, during the period 1971-2004. During the same period, the cumulative value of direct resource revenue was approximately $126 billion. The difference of $151 billion gives the cumulative value of indirect resource revenues during this period. CAPP (2007a) provides data on aggregate sales revenue per year for oil and gas in Alberta. The cumulative value of sales revenue for 1971-2004 was $710 billion. Thus, the baseline estimate of our multiplier is 0.213 (equal to $151/710$). We then apply this multiplier to the sales revenue in every year to obtain an expected value of indirect resource revenue in the year.

We are aware that this calculation may be subject to distortion, arising from (i) changes in the tax code over time, and (ii) changes in the relative importance of conventional oil, natural gas and oil sands in the product mix. For this and other reasons, we conduct sensitivity analysis in Appendix D to investigate the effects of changes in the value of the multiplier. In addition to the baseline estimate of IRM of 0.213, which we label medium, we also test high and low values of 0.25 and 0.15 respectively. These values are summarized in Table 2. Alberta Finance (2007) claims that the use of the input-output model overestimates the relative size of the oil and gas

[38] Statistics Canada has versions of the model available for the years 2000-2003.

sector in provincial GDP. We conclude therefore that the weight of uncertainty on the IRM is likely on the low side.

Non-resource primary deficit

This measure is defined as the difference between non-resource primary revenues (i.e. non resource total revenues minus investment income) and current program expenditures. The necessary data on revenue and expenditure are obtained from the same sources as direct resource revenues.

Net financial wealth

This measure is defined as the difference between all of the government's financial assets, including the equity in savings funds, and its financial liabilities. At present our series is only partial: we have an initial data point for 1948, obtained from the Public Accounts (Alberta 1948), and a subsequent series 1981 to 2007, obtained from Alberta budget documents.

Rate of return

We have calculated annual rates of return for the Heritage Fund using data on income and equity obtained from AHSTF (2007) and AHSTF (2008). We consider these rates indicative of the opportunities available to Alberta government planners during the period of operation of the fund (1977 to 2007), and in particular we use these rates as the basis for calculating present values during this period.

For the earlier period (1948 to1976), we consider returns on a hypothetical portfolio consisting of a mix of bonds and equities. For 1948 to 56, we assume an equal mix of government and industrial bonds. For 1957 to 76, we assume one third government bonds, one third industrial bonds and one third equities. For government bonds, we use average yields on ten year maturities. For industrial bonds, we use annual average yields reported by McLeod, Young and Weir. For equities, we use the benchmark index of the Toronto Stock Exchange. The data are obtained from Statistics Canada, *Historical Statistics of Canada,* Cat. No.11-516-XIE, sections J471-480 (bond yields) and J481-494 (TSE index).

Table 1 summarizes the rate of return data. A maximum nominal value of 15.7 percent is obtained in 1980, with a minimum value of -8.4 percent in 1948. The decadal averages are indicated as well.

Inflation

Our measure of the inflation rate for 1948 to 1978 is the national consumer "all-items" price index, obtained from Statistics Canada, CANSIM series v41693271. For 1979 to 2007, we use the provincial consumer "all-items" price index, CANSIM series v41694625. While the implicit GDP price deflator would seem to be a more comprehensive measure of inflation, we could not find consistent data on this statistic prior to 1961.

Population

We have obtained annual population data from Statistics Canada, CANSIM series V15.

A.2. Forecast data

Horizon

Our forecast period begins in 2007 and terminates with the anticipated exhaustion of the resource stock in 2095 (see below for details).

Resource prices

EIA (2008) and IEA (2007) long term price forecasts of oil are averaged into one price path for our reference case. The EIA forecasts of oil prices are based on a weighted average price of imported low-sulphur oil delivered to U.S. refiners, whereas the IEA forecasts are based on the price of crude oil imports. Natural gas prices are taken from EIA (2008) and are based on average wellhead prices for the US (lower 48 states). Prices are converted into $C at a fixed rate of 0.90 US/C. According to this forecast, the price of conventional oil falls from $91.65 per barrel in 2008 to $65.35 in 2016, and then rises gradually to $75.55 in 2030, where it remains subsequently (all figures $C 2007).

For oil sands, most of Alberta's royalty taxes after 2007 will be based on the price of bitumen, a lower grade commodity than the benchmark light, sweet grades. For the years 2006-10, Alberta (2007) uses an average price conversion factor between bitumen and the light, sweet benchmark (WTI) of approximately 0.45. Applying this factor to the price for conventional oil yields our forecast of the price of bitumen. The trend of the bitumen price follows that of conventional oil, adjusted by the conversion factor.

The forecast of the natural gas price falls from a value of $7.02 per thousand cubic feet in 2008 to $5.91 in 2016 and then rises gradually to $7.37 in 2030 ($C 2007). The EIA attributes the softening in price during the first decade to increased supply of liquefied natural gas and demand destruction due to the relatively high near term prices.

Sensitivity analysis on resource prices is based on the deviation between the reference and low price forecasts from EIA (2007). The gradual separation of the forecasts, starting from a common value in 2007, results in a 40 percent deviation between the two in 2030. We apply the same deviation pattern to our reference price data (discussed above) to obtain both our low and high (inverse deviation pattern) price forecasts.

Reserves

Our forecast assumes recoverable reserves in the oil sands of 78 billion barrels as of 2007, which is an average of the values reported in BP (2007) and *World Oil Journal* (2006). Based on data from CAPP (2007a), we estimate remaining reserves of conventional oil and natural gas of 1.623 billion barrels and 40,300 billion cubic feet respectively. Due to uncertainty, estimates of reserves from coal bed methane have not been included in our forecast.

Recent experience indicates an average replacement rate of reserves of conventional oil and natural gas, due to new drilling, equal to 60 percent of annual production.[39] Moreover, Scott (2007) argues this rate will diminish. To approximate these trends, our forecast begins with a 60 percent replacement rate in 2007 for both conventional oil and natural gas, with conventional oil falling to zero in 2013, and with natural gas falling to 30 percent in 2018 and zero thereafter.

Production

For the oil sands, the forecast follows CAPP (2007b) initially, rising to 1387 million barrels per year (3.8 million per day) in 2020. We conjecture that the trend continues rising subsequently, reaching 1643 million barrels per year (4.5 million per day) in 2027, where it remains until starting to fall in 2032. We assume a decline rate of 3 percent per annum for the remainder of the period, which is similar to assumptions made in Segura (2006) and Davoodi (2002) regarding conventional oil. This production profile leads to exhaustion of reserves in 2095.

For conventional oil, we assume a constant rate of decline of production of 9 percent per year, based on data from Alberta (2007) and CAPP (2007a). This value is slightly higher than the actual decline rate over the last 10 years in CAPP (2007a), signifying an ongoing decrease in production as reserves dwindle. The forecast starts at 183 million barrels per year in 2007 and falls thereafter, taking into account the decline rate and the partial replacement of reserves discussed above. Production falls to zero with the exhaustion of reserves in 2026. The same

[39] Authors' calculation for the period 2000-2006, based on data from CAPP (2007a).

decline rate is used for natural gas. Thus, following a similar approach, we forecast gas production falling from 5.2 trillion cubic feet in 2007 to exhaustion in 2026.

Sector revenues

The preceding forecasts of prices and production allow us to calculate forecasts of the total sales value of oil and gas production in Alberta during the next century, which we then use as the basis for our forecast of direct and indirect resource revenues for the government.

Direct resource revenues

We base our forecast of direct resource revenues (royalties, leases, rentals and fees) on the sector revenues using historical absorption rates. In reality, there is an endogenous relationship between royalty rates and sector revenues, as firms' production decisions depend in part on royalty rates. However, a rigorous modeling of these feedbacks is beyond the scope of the paper. Instead we employ sensitivity analysis in Appendix C to test different scenarios.

Royalty rates are set at historical levels for the first two years of our forecast period and then shift upwards in 2009 with the implementation of the new royalty regime, announced following the report of the Alberta Royalty Review Panel. These shifts were stress tested against the forecasts outlined on p.17 in ARRP (2007). For natural gas, we assume royalty taxes initially accrue at a rate of 14 percent of production value, shift to 16 percent in 2009, fall to 15 percent in 2012, and finally 14 percent in 2016, remaining at this level until exhaustion. For conventional oil, we assume royalty taxes initially accrue at 6 percent of production value, shift to 10 percent in 2009, fall to 9 percent in 2016, then remain at this level thereafter. For oil sands, we assume royalty taxes initially accrue at a rate of 6 percent of production value, shift to 8 percent in 2009, rise to 9 percent in 2026, then 8 percent in 2042, 7 percent in 2055, and 6 percent in 2069 where it remains for the last years before exhaustion in 2095. Reductions in absorption rates over time are due to "low productivity offsets" as the quality of remaining reserves declines.

Based on Alberta budget documents, we note that lease sales amounted on average to 15 percent of royalty taxes from oil and gas during the period 2004-2007. We assume this rate to continue in our forecast. Finally, rentals and fees yielded the government $150 million annually during the period 2000-2006, which we assume to continue in our forecast.

Indirect resource revenues

We estimate indirect resource revenues by the application of two multipliers to the forecast sales values. The first is the indirect revenue multiplier (IRM) defined in the historical data. The second, which we call the diversification rate (DR), is intended to capture the rate of transfer of economic activity in upstream and downstream sectors from servicing and processing domestic oil and gas to exporting goods and services out-of-province or servicing other unrelated domestic sectors. If these upstream and downstream firms do not achieve any diversification – i.e. if they remain completely dependent on the domestic oil and gas industry – then they will dwindle and die as the resource base diminishes and is exhausted. In this case, the government's indirect resource revenues will also diminish to zero with the resource base. In contrast, if upstream and downstream firms succeed at diversifying away from domestic oil and gas, then the government's revenues from these industries will be sustained.

Our view of economic development is that the pressure for diversification becomes particularly acute when the original base for upstream and downstream firms starts to diminish. In this vein, we note that the maximum value of indirect revenues in our reference forecast – and thus the maximum value oil and gas production – occurs in 2005. We use this year and the corresponding value of indirect revenues as the benchmark for defining values of the diversification rate in subsequent years. For example, if indirect resource revenues in 2010 are $5 billion lower than in 2005 and DR = 0.15, then 15 percent of this loss – i.e. $750 million – will be recouped by diversification away from domestic oil and gas. In this case, the net loss to the government's coffers will only be $4.25 billion.[40] By assumption, the value of DR prior to 2005 is always zero. Thus the diversification rate directly addresses the question of how much of indirect revenues can be maintained as oil and gas resources diminish.

Unfortunately, we are not aware of any empirical research which can be used to ground our value of DR. Therefore we must resort to plausible conjectures. We believe it is prudent to err on the low side with this value. First of all, diversification can only occur in upstream or downstream industries, not the primary oil and gas sector itself. While we do not know the relative contributions of the sectors to indirect revenues, we suggest that 50 percent is a reasonable hypothesis on the upper bound of the contribution of the upstream and downstream sectors, leaving the remaining 50% for the oil and gas industry itself. Thus complete diversification would be represented by a value of DR = 0.5.

[40] We apply DR to differences in the real value of indirect revenues from the 2005 benchmark, rather than nominal differences.

Second, we believe that complete diversification is unlikely to occur as domestic oil and gas production diminishes. Complete diversification would entail immediate replacement of lost business with either export sales or new domestic customers. In contrast, anecdotal evidence suggests that diversification is a much slower process, usually following upon a period of crisis and contraction. Furthermore, some upstream and downstream industries simply may not be diversifiable. In this vein, ARRP (2007, 33) observes that the petrochemical industry "once had access to inexpensive natural gas as feedstock, but as pipeline capacity expanded, the gas was available for export and its price became set by market forces. Low natural gas prices had been this industry's main advantage, but that advantage has disappeared in recent years as North American natural gas prices have strengthened." Mansell and Shlenker (2006, 22) note that the petrochemical industry accounted for "over 20 percent of manufacturing value added in Alberta" in 2003, and further that "it would be hard to argue that the petrochemical industry would exist in Alberta in the absence of the oil and gas industry."

Finally, companies that are diversifying away from the Alberta market are also liable to relocate some portion of activity to their new markets, with the result that some portion of tax revenues would be lost to other jurisdictions. For example, head office jobs may remain in Alberta while field activities, manufacturing or processing may relocate.

Ultimately, it seems implausible that an economy would experience the decline of a major extractive industry without experiencing some degree of contraction. Therefore, we suggest 0.25 as a maximum plausible value for DR, and we test lower values of 0.15 and 0 as well, the latter representing the extreme (and also implausible) case of no diversification at all. In the text, we refer to these values as high, medium and low respectively. These values are summarized in Table 2.

Inflation

The inflation rate is forecast constant at 2.0 percent, which is the central value of the Bank of Canada's present target range.

Rate of return

The real return on investment is forecast to be constant at a rate of 3.5 percent per annum, compared with an average actual rate of 3.4 percent over the period 1948-2007and 4.8 percent over the more recent period 1990-2007. This real rate is equivalent to a nominal value of 5.57

per cent per annum, given the expected inflation rate. Sensitivity analysis is performed in Appendix C at low and high rates of 3.0 and 4.0 percent respectively.

Population projections

Following C.D. Howe Institute population projections, the population is forecast to grow at a rate of 1.77 percent in 2008, compared with an average actual growth rate of 1.93 percent during the period 2000-2007 The growth rate is forecast to fall gradually in subsequent periods, reaching zero in 2058, yielding a steady state population of 4.54 million. For sensitivity analysis in Appendix C, a high population scenario forecasts population growth to continue until 2069, yielding a steady state value of 4.66 million, and a low population scenario forecasts growth continuing until 2038, for a steady state value of 3.91 million.

Appendix B
Mechanics of the Permanent Resource Income Model

Most theoretical treatments of the permanent income model deal with constant rates of interest, inflation and population growth. In contrast, given the large historical component of our data set, we have variable rates over approximately 40 percent of the planning horizon. A particular challenge concerns how to handle negative real interest rates, which occurred 13 times in our 59-year historical sample (1948-2006). Negative real interest rates have the effect of inflating present values, and they raise important conceptual issues regarding our assumption of complete knowledge or foresight. In particular, is it reasonable to assume that a planner with complete knowledge would hold financial assets during a period of negative real interest rates? Upon reflection, it seems clear that such a planner would switch into commodities during such periods – for example oil – since their values would be growing faster than financial assets. Therefore, we set the planner's discount rate during the historical period as the maximum of the real interest rate and 0 (equivalently the maximum of the nominal interest rate and the inflation rate).

Further, we note that the duality between constant expenditure and constant wealth is broken when rates of return vary over a subset of the planning period. This result is proven formally in Appendix D. Therefore, with variable returns, the modeller must choose between holding expenditure constant and wealth constant. We choose the former, since we view wealth as the means to an end – expenditure – and not an end in itself. In this approach, fluctuations in wealth can act as a shock absorber to help smooth expenditure during periods of volatility in returns. When we move into our forecast period (2007-2095), rates of return are assumed constant (expected value) and the link between constant expenditure and constant wealth is restored. Thus in the long-run the interpretation of permanent income as the return on total wealth is valid.

Davoodi (2002) provides a useful presentation of the model with variable rates; however, his formulae are based on smoothing wealth rather than expenditure. In contrast, we present a version of the model for smoothing expenditure. Let i_t, r_t, π_t, and n_t represent the nominal interest rate, real interest rate, inflation rate and population growth rate respectively, in period t. Let T denote the last period of extraction (2095 in our forecast); i.e. the resource is exhausted in all periods $t > T$. During the historical period (1948-2006), i_t, r_t, π_t, and n_t are variable, while during the forecast period ($t \geq 2007$) they are constant and satisfy the relationship

$$(1+i) > (1+n)(1+\pi) \tag{B1}$$

or equivalently $r > n$.[41] Assumption (B1) requires that the nominal rate of return is large enough to cover more than the increase in population and the price level – a necessary condition for maintaining a constant real per capita level of expenditure out of savings in steady state (i.e. after T).

Let R_t denote the government's resource revenues at t, G_t^R its expenditure out of resource wealth, and A_t its stock of financial assets. It is important to note that G_t^R is not the only source of spending, as the government also has non-resource tax revenues, which we denote NR_t. However, if our concepts are to be meaningful, then the government can only have one source of borrowing – borrowing to finance G_t^R when it exceeds R_t – and one source of saving – the surplus of R_t when it exceeds G_t^R. These values would not equal net borrowing or net saving if the government offset them in some other account – for example if the government ran a surplus in a resource account while running a deficit in a general budget account. For this reason, the budgeting process must take a unified view of all government accounts and funds. It follows that, since all saving is resource saving, all financial assets or debts are resource-based as well.

Due to the integration of accounts, the sustainability rule imposes discipline on all components of the budget. In particular, discipline takes the form of a requirement that total government expenditure is covered by the sum of G_t^R and NR_t; there is no other source of borrowing or revenue on a separate account. Denoting total government expenditure G_t, we have

$$G_t = G_t^R + NR_t.$$

Rearranging yields

$$G_t - NR_t = G_t^R, \tag{B2}$$

where the left side is referred to as the non-resource primary deficit (NRPD). This measures the amount by which non-resource tax revenues fall short of covering total government expenditure, and the shortfall is made up by G_t^R.

[41] The absence of a time subscript indicates a constant value.

The literature on fiscal sustainability identifies the NRPD as the target of policy. Permanent income determines G_t^R, which in turn is equal to the allowable annual NRPD. Since G_t^R is constant (in per capita terms in our version), NRPD must also be constant (in per capita terms). The government can meet this target by adjusting total expenditure or non-resource taxation levels. Thus, the setting of G_t, NR_t, and G_t^R are integrated in the budgeting process, consistent with a sustainability rule based on equal sharing of resource wealth.

The government's budget constraint is

$$A_{t+1} = (A_t + R_t + NR_t - G_t)(1 + i_{t+1}),$$

which upon substituting from (B2) becomes

$$A_{t+1} = (A_t + R_t - G_t^R)(1 + i_{t+1}). \tag{B3}$$

This equation can be rewritten to show the contribution of the budget's primary and total balances. In particular,

$$A_{t+1} - A_t = (R_t - G_t^R) + i_{t+1}(A_t + R_t - G_t^R) \;. \tag{B3′}$$

The first term on the right of $(B3')$ is the primary balance, the second term is net investment income, and the sum is the total balance. The primary balance provides a measure of saving out of resource revenues, while the total balance provides a measure of net saving taking account of net investment income (income on financial assets less interest payments on debt). It is the latter measure, total balance, which gives the change in the government's financial position for the year and which provides the most common measure of the government's surplus or deficit.

To demonstrate our solution of the model, it will be useful to consider (B3) in real, per capita terms. For this purpose, let N_t and P_t denote population and price level at t, respectively. By definition $N_{t+1} = N_t(1 + n_{t+1})$ and $P_{t+1} = P_t(1 + \pi_{t+1})$. Further the Fisher identity defines the relationship between real and nominal interest rates, i.e. $1 + r_t = \frac{1 + i_t}{1 + \pi_t}$. Then dividing through both sides of (B3) by N_{t+1} and P_{t+1} yields

$$a_{t+1} = (a_t + \rho_t - g_t^R)\left(\frac{1 + r_{t+1}}{1 + n_{t+1}}\right), \tag{B4}$$

where lower case letters denote real, per capita values (ρ denotes real resource revenues per capita, to avoid confusion with the real interest rate, r). Note that $\left(\frac{1+r_{t+1}}{1+n_{t+1}}\right)$ reflects the real rate of interest net of adjustment for population growth.

Equation (B4) defines a first-order difference equation which can be solved iteratively to obtain the government's present value budget constraint (in real, per capita terms), i.e.

$$g_0^R + \sum_{k=1}^{T} \frac{g_k^R}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)} + \frac{a_{T+1}}{\prod_{j=1}^{T+1}\left(\frac{1+r_j}{1+n_j}\right)} = a_0 + \rho_0 + \sum_{k=1}^{T} \frac{\rho_k}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)}. \tag{B5}$$

The left-hand side is equal to the present value of resource-based expenditure plus the present value of financial wealth at T+1 (the period after exhaustion of the resource base). The right-hand side is equal to the government's total wealth at time 0, i.e. initial financial assets a_0 plus the present value of the stream of resource revenues.

Let g^* represent the maximum level of real, per capita expenditure out of resource wealth which can be sustained indefinitely. By assumption $r_t = r$ and $n_t = n$ for $t \geq T$. Thus, from (B4) we have

$$a_{T+2} = \left(a_{T+1} - g^*\right)\left(\frac{1+r}{1+n}\right). \tag{B6}$$

Furthermore, sustainability requires after exhaustion that $a_{T+2} = a_{T+1}$. Substituting into the expression above yields

$$a_{T+1} = \left(a_{T+1} - g^*\right)\left(\frac{1+r}{1+n}\right), \tag{B6′}$$

which upon solving yields

$$a_{T+1} = g^*\left(\frac{1+r}{r-n}\right). \tag{B6″}$$

Note that this expression reflects the standard annuity formula, adjusted for per capita terms. Now substituting for g_k^R and a_{T+1} in (B5), we obtain our solution for g^*:

$$g^* = \frac{a_0 + \rho_0 + \sum_{k=1}^{T} \frac{\rho_k}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)}}{1 + \sum_{k=1}^{T} \frac{1}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)} + \frac{(1+r)/(r-n)}{\prod_{j=1}^{T+1}\left(\frac{1+r_j}{1+n_j}\right)}}$$

Interpretation of this expression is easier in the special case when $r_t = r$ and $n_t = n$ in all periods. In that case,

$$g^* = \left(\frac{r-n}{1+r}\right)\left[a_0 + \sum_{k=0}^{T} \rho_k \left(\tfrac{1+n}{1+r}\right)^k\right]. \qquad \text{(B7)}$$

The expression in square brackets is the government's total wealth at time 0, while the preceding expression in parentheses is the standard annuity formula (adjusted for population growth). Thus we have g^* equal to permanent income.

In fact, our calculation of g^* is altered by the continued flow of diversified revenues after the exhaustion date. As explained in Appendix A, these are revenues of upstream and downstream industries which have managed to diversify away from dependence on the domestic oil and gas sector. Until T, we include these revenues in the measure of total resource revenues, ρ_t. However, after T, we must account for them separately. We denote these post-exhaustion revenues as *v*, and we conjecture the level to be constant in per capita terms. (Our forecast of population growth is zero after 2058 anyway.) In practice, the adjustment is easily made. We replace g^* in equations (B6), $(B6')$ and $(B6'')$ with $(g^* - v)$ and then proceed as above. The solution for g^* is now

$$g^* = \frac{a_0 + \rho_0 + \sum_{k=1}^{T} \frac{\rho_k}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)} + v\frac{(1+r)/(r-n)}{\prod_{j=1}^{T+1}\left(\frac{1+r_j}{1+n_j}\right)}}{1 + \sum_{k=1}^{T} \frac{1}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)} + \frac{(1+r)/(r-n)}{\prod_{j=1}^{T+1}\left(\frac{1+r_j}{1+n_j}\right)}},$$

the only difference being the addition of the term $v\frac{(1+r)/(r-n)}{\prod_{j=1}^{T+1}\left(\frac{1+r_j}{1+n_j}\right)}$ to the numerator. This term is simply the present value of the indefinite stream of *v*, starting at T and discounted back to 0. Thus the government's total resource wealth (the numerator) is increased by this amount.

The exercises we perform are purely partial in nature, in that they do not take into account the feedback that alternative savings policies would have on the economy. It is not clear to us that this represents a major omission. The main effect of alternative policies would be to impose greater restraint on government spending in some periods and less restraint in others. Since the Alberta economy is largely export driven, it is not clear that the real growth rate would be much affected by these changes.

Appendix C
Sensitivity Analysis

Our estimate of the fiscal plan under the Permanent Resource Income Model (PRIM) depends upon the forecasted values of uncertain variables, including resource prices, reserve size, annual production rates, royalty rates, the indirect revenue multiplier (IRM), the diversification rate (DR), the real interest rate, and annual population growth. Appendix A presents reference forecasts for these variables, as well as high and low forecasts for selected variables to be subjected to sensitivity analysis. We have presented the results based upon the reference forecast in the main body of the text. Here we consider the impacts of adopting the higher or lower forecasts.

Certain regularities emerge. For example, resource prices, reserve size, production rates and royalty rates affect the fiscal plan symmetrically, through their role in determining the government's resource revenues. Therefore, it is not necessary to subject them to sensitivity analysis separately. For our purposes, we focus on resource prices among this group. In addition, we test the impact of IRM, DR, the real interest rate, and population growth.

Table C1 shows the impacts of high and low forecasts of the variables individually (partial sensitivity analysis) as well as two combined scenarios. The impacts are summarized in terms of the constant value of G^R per capita which the model generates and in terms of the near-term savings required. Savings are expressed as a percent of direct resource revenues during the five-year period 2007-11. The "highest G^R case" corresponds with high resource prices, high IRM, high DR, high rate of return, and low population growth. The "lowest G^R case" is defined symmetrically.

High prices, high IRM and high DR all contribute to high wealth, through the present value of resource revenues. The rate of return has two opposite influences. First, a higher rate of return translates into lower present values ceteris paribus and thus lower wealth at any given time. Second, a higher rate of return increases the expenditure possibilities from any given level of wealth. From our experiments, we see that the second effect dominates, as a higher rate of return generates a higher value of G^R per capita in the model. Finally, population growth affects G^R per capita in an inverse fashion, as expected.

Table C1 indicates that, while numerical values vary, the qualitative features of our results are quite robust. In particular, the required near-term savings under PRIM (2007-11) exceeds direct resource revenues in all cases except the highest G^R case. This exception is not surprising, since it corresponds with a case in which government wealth is extremely high and much of it accrues in the future. It follows that some of the burden of saving is shifted forward in this case. Yet even this scenario implies an aggressive near-term savings program by historical standards (87% of direct resource revenues). In contrast, we noted earlier that in the reference case the Fiscal Responsibility Act only entails a near-term savings rate of 47% of direct revenues. Thus, we conclude that the requirement of an aggressive savings program under PRIM is robust to changes in the underlying variables.

Appendix D
Constant Expenditure and Constant Wealth in the Permanent Resource Income Model

Most theoretical treatments of the permanent income model assume constant rates of interest and population growth. Under these conditions, consuming the annuity value of total wealth leaves wealth unchanged over time, and thus constant expenditure and constant wealth are linked in the model. However, as mentioned in Appendix A, we have variable rates of interest and population over a significant subset of our planning horizon, and therefore the question arises whether the duality between constant expenditure and constant wealth holds during this subset.

To answer this question, consider an arbitrary period $0 < \tau < T$, and define W_τ as the government's total wealth at τ. To calculate W_τ, we modify the government's budget constraint (equation B5) as follows:

$$\sum_{k=\tau}^{T} \frac{g_k^R}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)} + \frac{a_{T+1}}{\prod_{j=1}^{T+1}\left(\frac{1+r_j}{1+n_j}\right)} = a_0 + \rho_0 + \sum_{k=1}^{T} \frac{\rho_k}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)} - g_0^R - \sum_{k=1}^{\tau-1} \frac{g_k^R}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)}$$

Next we multiply both sides of the equation by the growth factor $\prod_{j=1}^{\tau}\left(\frac{1+r_j}{1+n_j}\right)$, which changes the base period to τ.

$$\prod_{j=1}^{\tau}\left(\frac{1+r_j}{1+n_j}\right)\left[\sum_{k=\tau}^{T} \frac{g_k^R}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)} + \frac{a_{T+1}}{\prod_{j=1}^{T+1}\left(\frac{1+r_j}{1+n_j}\right)}\right] = \prod_{j=1}^{\tau}\left(\frac{1+r_j}{1+n_j}\right)\left[a_0 + \rho_0 + \sum_{k=1}^{T} \frac{\rho_k}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)} - g_0^R - \sum_{k=1}^{\tau-1} \frac{g_k^R}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)}\right]$$

The right-hand side is total wealth at τ. Substituting g^* for g_k^R, we have

$$W_\tau = \prod_{j=1}^{\tau}\left(\frac{1+r_j}{1+n_j}\right)\left[a_0 + \rho_0 + \sum_{k=1}^{T} \frac{\rho_k}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)} - g^* - \sum_{k=1}^{\tau-1} \frac{g^*}{\prod_{j=1}^{k}\left(\frac{1+r_j}{1+n_j}\right)}\right]. \tag{D1}$$

We now state our result.

Proposition: Attainment of the maximum sustainable expenditure level g^* in every period corresponds with a constant value of total wealth in all periods if and only if the interest rate net of population growth – i.e. $\frac{1+r_j}{1+n_j}$ – is constant.

Proof: To prove sufficiency, re-write (D1) with constant r and n:

$$W_\tau = \left(\tfrac{1+r}{1+n}\right)^\tau \left[a_0 + \sum_{k=0}^{T} \rho_k \left(\tfrac{1+n}{1+r}\right)^k - g^* \sum_{k=0}^{\tau-1} \left(\tfrac{1+n}{1+r}\right)^k \right].$$

The geometric series in the last term in square brackets reduces to $\tfrac{1+r}{r-n}\left[1-\left(\tfrac{1+n}{1+r}\right)^\tau\right]$. Substituting this in, as well as substituting for g^* from equation (B7), yields initial wealth; i.e.

$$W_\tau = a_0 + \sum_{k=0}^{T} \rho_k \left(\tfrac{1+n}{1+r}\right)^k = W_0 .$$

To prove necessity, consider the first difference

$$W_{\tau+1} - W_\tau = \prod_{j=1}^{\tau+1}\left(\tfrac{1+r_j}{1+n_j}\right)\left[a_0 + \rho_0 + \sum_{k=1}^{T} \frac{\rho_k}{\prod_{j=1}^{k}\left(\tfrac{1+r_j}{1+n_j}\right)} - g^* - \sum_{k=1}^{\tau} \frac{g^*}{\prod_{j=1}^{k}\left(\tfrac{1+r_j}{1+n_j}\right)} \right]$$
$$- \prod_{j=1}^{\tau}\left(\tfrac{1+r_j}{1+n_j}\right)\left[a_0 + \rho_0 + \sum_{k=1}^{T} \frac{\rho_k}{\prod_{j=1}^{k}\left(\tfrac{1+r_j}{1+n_j}\right)} - g^* - \sum_{k=1}^{\tau-1} \frac{g^*}{\prod_{j=1}^{k}\left(\tfrac{1+r_j}{1+n_j}\right)} \right]$$

which reduces to

$$W_{\tau+1} - W_\tau = \left(\frac{r_{\tau+1} - n_{\tau+1}}{1+n_{\tau+1}}\right) W_\tau - g^* \left(\frac{1+r_{\tau+1}}{1+n_{\tau+1}}\right). \tag{C2}$$

Denote constant wealth as W; i.e. $W_\tau = W$ and $W_{\tau+1} - W_\tau = 0$ for all τ. From (D2), we have

$$\frac{r_{\tau+1} - n_{\tau+1}}{1+r_{\tau+1}} = \frac{g^*}{W}.$$

This is just the standard annuity formula, adjusted for population growth. Since the right-hand side of the expression is constant, the left-hand side must be too; i.e. $r_{\tau+1} = r$ and $n_{\tau+1} = n$ for all τ. ■

References

Alberta. 2007. *Alberta Budget 2007*. Ministry of Finance, April.

Alberta. 1948. *Public Accounts 1947-1948*. Treasury Department.

Alberta Finance. 2007. *Economic Spotlight,* September. *"Energy and the Alberta Economy."* <http://www.finance.alberta.ca/aboutalberta/spotlights/2007_0918_energy_ and_ab_economy.pdf> (Date of access: March 24, 2008)

AHSTF. 2007. Alberta Heritage Savings Trust Fund, Annual Report 2006-2007. <www.finance.gov.ab.ca> (Date of access: September 7, 2007).

AHSTF. 2008. Alberta Heritage Savings Trust Fund, Third Quarter Update 2007-2008. <www.finance.gov.ab.ca> (Date of access: September 7, 2007).

ARRP. 2007. *Our Fair Share*. Report of the Alberta Royalty Review Panel, September 18, 2007. <www.albertaroyaltyreview.ca> (Date of access: February 8, 2008).

Barnett, Steven, and Rolando Ossowski. 2002. "Operational Aspects of Fiscal Policy in Oil-Producing Countries." IMF Working Paper 00/118 (Washington: International Monetary Fund). <www.imf.org> (Date of access: July 7, 2007).

Bjerkholt, Olav, and Irene Niculescu. 2004. "Fiscal Rules for Economies with Nonrenewable Resources: Norway and Venezuela." in George Kopits, ed., *Rules-Based Fiscal Policy in Emerging Markets* (International Monetary Fund), pp. 164-179

Blanchard, Olivier Jean, and Stanley Fischer. 1989. *Lectures on Macroeconomics* (MIT Press).

Boothe, Paul. 1995. *The Growth of Government Spending in Alberta,* Canadian Tax Foundation.

Boothe, Paul. 1991. "Time Consistent Data for Alberta's Public Finances, 1968 to 1989." *Canadian Tax Journal* 39(3), pp. 567-89.

BP. 2007, *Statistical Review of World Energy 2007,* June. <www.bp.com> (Date of access: August 30th, 2007)

CAPP. 2007a. *Statistical Handbook*, Canadian Association of Petroleum Producers. <www.capp.ca> (Date of access: July 1, 2007)

CAPP. 2007b. *Canadian Oil and Gas Industry Outlook 2007*. Canadian Association of Petroleum Producers. <www.capp.ca> (Date of access: August 3, 2007)

Chen, Duanjie, Jack Mintz, and Andrey Tarasov. 2007. "Federal and Provincial Tax Reforms: Let's Get Back on Track." C.D. Howe Institute. Backgrounder No. 102, July <www.cdhowe.org>. (Date of access: March 26, 2008)

Davoodi, Hamid R. 2002. “Assessing Fiscal Vulnerability, Fiscal Sustainability, and Fiscal Stance in a Natural Resource Rich Country.” chapter 2 in International Monetary Fund, *Republic of Kazakhstan: Selected Issues and Statistical Appendix*. IMF Country Report No. 02/64, March. <www.imf.org> (Date of access: July 23, 2007)

EIA. 2007. “Annual Energy Outlook 2007 with Projections to 2030.” Energy Information Administration, U.S. Dept. of Energy. February. <http://www.eia.doe.gov> (Date of access: August 1st, 2007).

EIA. 2008. “Annual Energy Outlook 2008: Revised Early Release.” Energy Information Administration, U.S. Dept. of Energy. <http://www.eia.doe.gov/oiaf/aeo/index.html> (Date of Access: March 16th, 2008).

Engel, Eduardo and Rodrigo Valdes. 2000. “Optimal Fiscal Strategy for Oil Exporting Countries.” IMF Working Paper 00/118 (Washington: International Monetary Fund). <www.imf.org> (Date of access: August 15, 2007)

Fiscal Responsibility Act. 2007. Queens Printer, Alberta Government. < http://www.qp.gov.ab.ca/Documents/acts/F15.CFM > (Date of access: March 17, 2008).

Friedman, Milton. 1957. *A Theory of the Consumption Function* (Princeton University Press).

IEA. 2007. “World Energy Outlook 2007: China and India Insights.” International Energy Agency.

Kneebone, Ronald. 2006. “From Famine to Feast: The Evolution of Budgeting Rules in Alberta,” *Canadian Tax Journal* 54(3), pp.657-73.

Laidler, David. 2008. “Fixing the Exchange Rate: Still a Bad Idea.” C.D. Howe Institute e-brief <www.cdhowe.org>. (Date of access: March 24, 2008).

Liuksila, Claire, Alejandro Garcia, and Sheila Bassett. 1994. “Fiscal Policy in Oil-Producing Countries.” IMF Working Paper 94/137. International Monetary Fund: Washington.

Mansell, Robert., and Ron Shlenker. 2006. “Energy and the Alberta Economy: Past and Future Impacts and Implications.” Working Paper No. 1. Alberta Energy Futures Project: University of Calgary. Institute for Sustainable Energy, Environment, and Economy. <www.iseee.ca> (Date of access: August 17, 2007).

Popp, David. 2004. “ENTICE: Endogenous Technological Change in the DICE Model of Global Warming.” *Journal of Environmental Economics and Management* 48, pp.742-768.

Saunders, Doug. 2008. “Frugal Norway Saves for Life After the Boom.” *Globe and Mail*. January 31st.

Scott, Norval. 2007. “Oil Firms Find Reserves Elusive.” *Globe and Mail*. July 25th.

Scoffield, Heather. 2006. “Too Much, Too Fast: Can Alberta Learn from Norway?” *Globe and Mail.* October 21st.

Segura, Alonso. 2006. “Management of Oil Wealth Under the Permanent Income Hypothesis: The Case of Sao Tome and Principe.” IMF Working Paper 06/183. International Monetary Fund Washington.

Tersman, Gunnar. 1991. “Oil, National Wealth, and Current and Future Consumption Possibilities.” IMF Working Paper 91/60. International Monetary Fund Washington.

World Oil Journal. 2006. Gulf Publishing Co. September.

York, Geoffrey. 2008. “Oil Riches Amid the Squalor,” *Globe and Mail*. February 17th.

Table 1
Rates of Return (nominal %)

max value:	1980	15.7
min value:	1948	-8.4
averages:	1948-07	7.6
	1948-59	2.5
	1960-69	7.4
	1970-79	9.0
	1980-89	12.1
	1990-99	8.7
	2000-07	6.5
	2008+	5.6

Table 2
Multipliers

	IRM	DR
high	0.250	0.250
medium	0.213	0.150
low	0.150	0.000

IRM: indirect revenue multiplier
DR: diversification rate

Table C1
Permanent Resource Income Model

	G^R per capita ($C 2007)	Required savings 2007-11 (% of direct resource revenue)
reference case	4,501	139%
partial sensitivity analysis		
resource prices - high	5,439	111%
resource prices - low	3,564	171%
IRM - high	4,872	150%
IRM - low	3,870	119%
DR - high	4,713	134%
DR - low	4,185	145%
real interest rate - high	5,015	124%
real interest rate - low	3,832	158%
pop - high	4,449	141%
pop - low	4,933	123%
highest G^R case	6,884	87%
lowest G^R case	2,339	158%

Figure 1
Revenue and Savings
(reference forecast)

Figure 2
Revenue and Savings
(reference forecast)

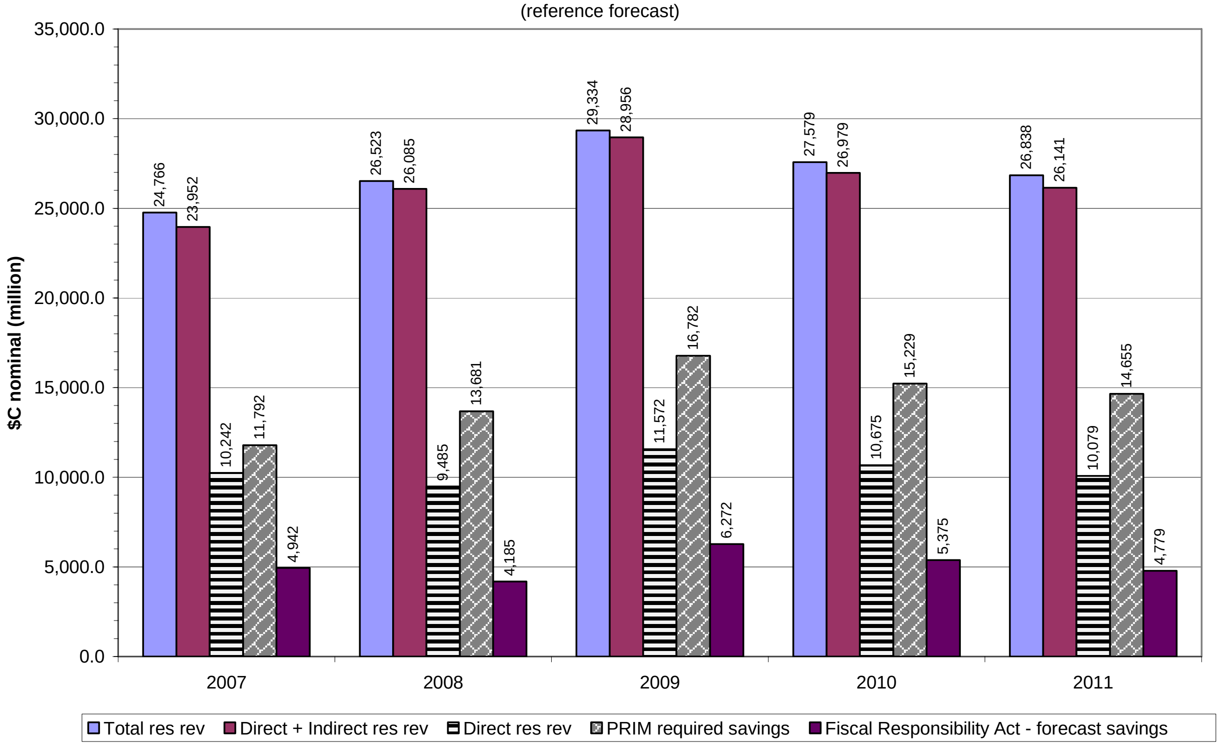

Figure 3
Resource-based Spending under
PRIM and the Fiscal Responsiblity Act
(reference forecast)

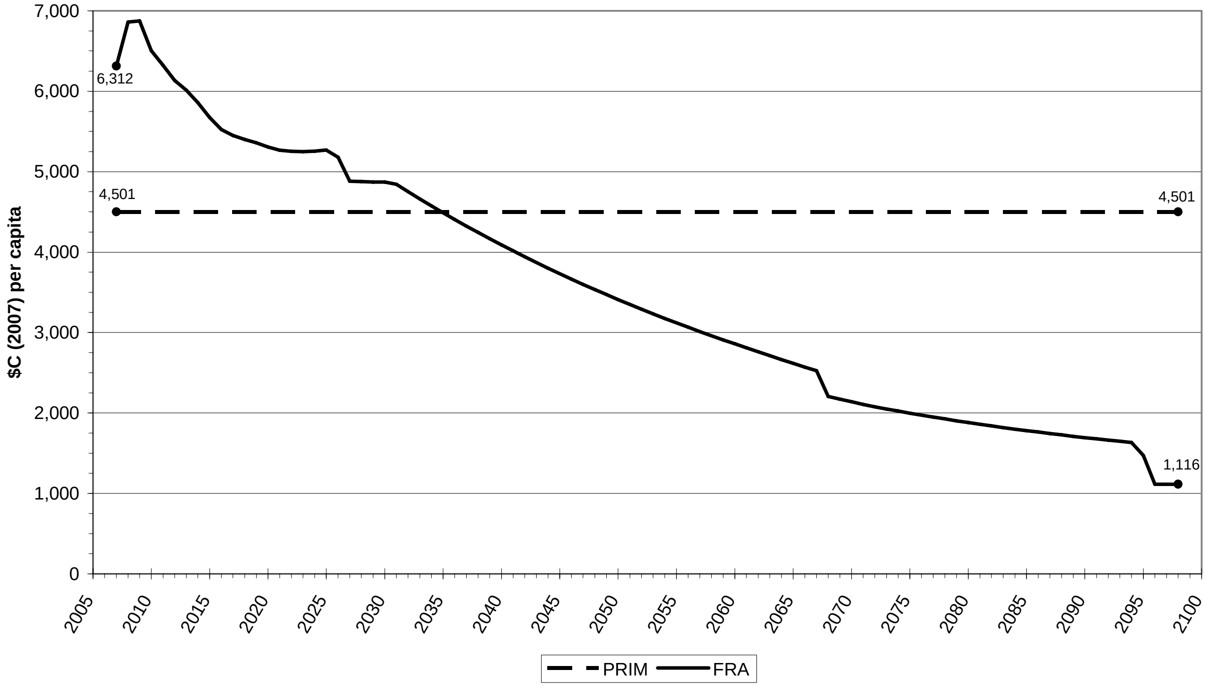

Figure 4
Sources of Resource-based Income
(reference forecast)

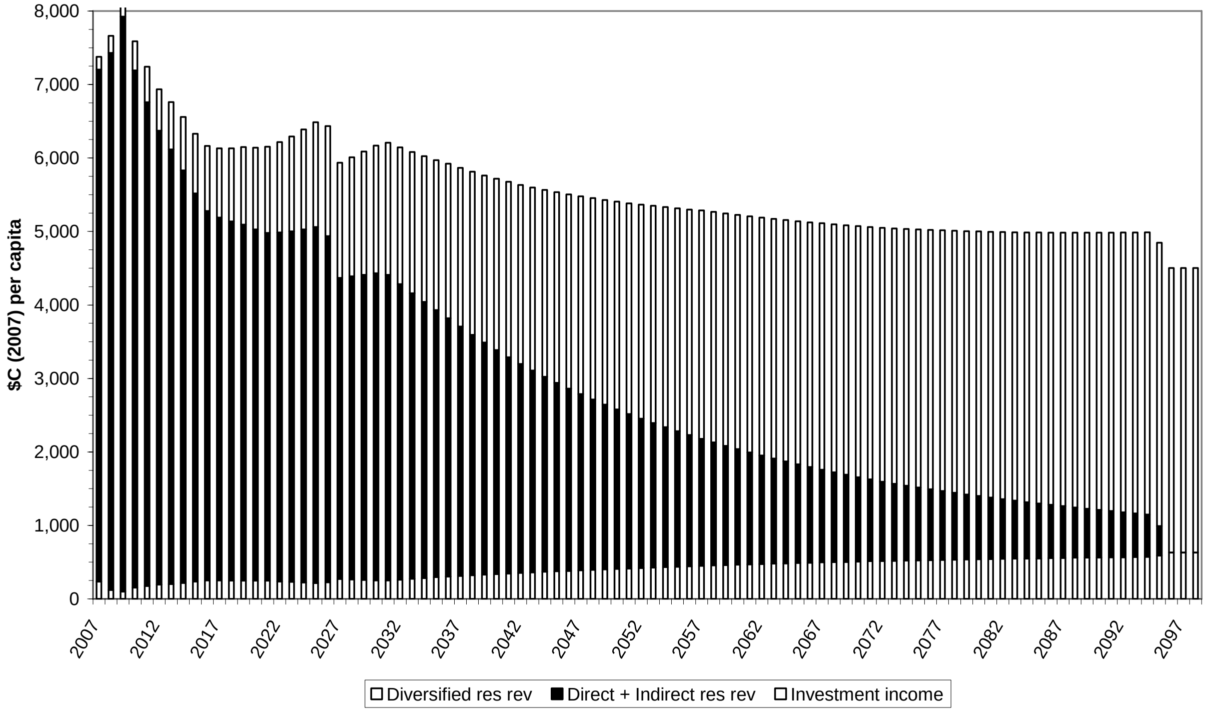

Figure 5
Resource-based Spending under PRIM and BIH
(reference forecast)