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Official Forecasts and Management of Oil Windfalls

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OFFICIAL FORECASTS AND MANAGEMENT OF OIL WINDFALLS

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Abstract

Official forecasts for oil revenues and the burden of pensioners are used to estimate *forward-looking* fiscal policy rules for Norway and compared with permanent-income and bird-in-hand rules. The results suggest that fiscal reactions have been partial forward-looking with respect to the rising pension bill, but backward-looking with respect to oil and gas revenues. Our measure of permanent oil income derived from official forecasts performs better than the one derived from a time-series model of oil income. Solvency of the government finances might be an issue with the fiscal rules estimated from historical data. Simulation suggests that declining oil and gas revenue and the costs of a rapidly graying population will substantially deteriorate the net government asset position by 2060 unless fiscal policy becomes more prudent or current pension and fiscal reforms are successful.

Keywords: oil windfalls, official forecasts, forward-looking fiscal policy rules, permanent income hypothesis, graying population, debt sustainability, Norway

JEL code: H20, H63, Q33

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1. Introduction

Oil windfalls and the anticipation of such windfalls can have a large impact on the public finances of a country. The often recommended permanent-income prescription states that oil-rich countries borrow in advance of an anticipated windfall, pay back and save during a windfall, and live of the interest on the accumulated assets after the windfall. If the windfall is unanticipated, they should only borrow once they get new information that net oil wealth has increased. Related is the celebrated Hartwick rule which is the point of departure for many policy makers in oil-rich states. It states that all oil revenue must be invested to transform the oil wealth in the crust of the earth into financial or other assets above the ground (Hartwick, 1977). The more conservative bird-in-hand rule says that the windfall can only be used once the oil revenue has come in.

The main contribution of this paper is to use official forecasts of future oil revenue, meticulously derived from a range of official documents, to estimate *forward-looking* fiscal rules for an oil-rich country and assess their sustainability. To the best of our knowledge, we believe this is the first time this has been done. Forecasts are more relevant for this purpose than estimating a data generating process for oil revenue from a small set of historical data, which would effectively lead to *backward-looking* fiscal rules. The great advantage of using official forecasts over some estimated data generating process is that much more detailed information on future oil and gas revenue (new fields, future, announced changes in the tax and royalty system) and on the rising costs of a graying population are incorporated. Furthermore, official forecasts which are often of a technical nature are the ones that impinge on practical policy making, not forecasts from some data generation process. The continual revisions in forecasts also offer much needed variability to estimate fiscal rules. We test statistically whether our measure of permanent oil income derived from official forecasts indeed performs better than the measure derived from a time-series model of oil income.

Although various studies offer *cross-country* estimates of fiscal rules and discuss the sustainability of fiscal stances for oil-rich countries (e.g., Ossowski et al., 2008; Bornhorst et al., 2009), for emerging and industrial economies (e.g., Mendoza and Ostry, 2008) and for advanced economies (e.g., Ghosh et al., 2011), none of them have used official forecasts. Furthermore, the estimates are confounded by differences in institutional quality, rule of law, corruption, etc. across countries, suffer from omitted variable bias as anticipated windfalls and the rising pension burden are not included, and fail to take account of the endogeneity of resource windfalls. Being inherently cross-sectional in nature, they do not offer a convincing treatment of intertemporal issues of managing oil windfalls.

We therefore offer *time-series* estimates of forward-looking fiscal rules for a particular oil-rich country, Norway. We empirically test the permanent income hypothesis (PIH) and the associated principles of tax and consumption smoothing (e.g., Barro, 1979; Deaton, 1992)[2]. We also allow for asset targets, habit persistence (Leigh and Olters, 2006; Olters, 2007) and relate our optimal rules to the pragmatic bird in hand (BIH) rule for the management of oil windfalls (e.g., Davis et al., 2002; Barnett and Ossowski, 2003; Medas and Zakharova, 2009). We also use official demographic forecasts to allow a graying population and rising pension burden.

Thanks to long-term budgeting in Norway since the 1950s, we can construct a time series of official forecasts of oil revenue and the pension burden. Our time-series estimates of fiscal rules and analysis of sustainability build on earlier work (e.g., Barro, 1979; Bohn, 2007). We allow for anticipation effects of fiscal policy, but abstract from the role of anticipation effects on the real impacts of fiscal policy rules stressed in the recent literature (e.g., Mertens and Ravn, 2010; Romer and Romer, 2010).

We focus on Norway, which puts its oil and gas revenue in a Savings Fund and draws roughly 4 percent per annum from it to finance public spending or tax cuts.[3] This 4-percent rule was implemented in 2001 and allows Norway to spread oil and gas revenues to future generations. The Savings Fund also allows Norway to stabilize the economy across the business cycle, since the 4% is meant to be an average over the business cycle. Also, as the value of the Fund varies with world asset markets, the government has the discretion to deviate from the 4% rule when it deems this necessary. Since Norway's budgetary policies take account of declining oil revenue and possibly also of rising pension costs[4], it has elements of the PIH rule. Some have argued (e.g, Barnett and Ossowski, 2003) that Norway's budgetary policies also have elements of the so-called bird-in-hand (BIH) rule, which has two features: (i) all oil and gas revenue is put in a Fund; (ii) each year a percentage of the Fund is withdrawn for financing the budget deficit; and (iii) no borrowing takes place with future oil and gas revenue as collateral. We will estimate Norway's fiscal reaction functions from historical data and see to what extent they have elements of the PIH and the BIH rules and examine whether Norway's estimated fiscal stance is sustainable given declining oil and gas revenue and the rapidly rising pension burden.[5] Our estimates suggest that Norway's fiscal stance can be characterized as a blend of BIH and PIH and that Norway's future pension costs will lead to evaporation of accumulated assets

[2] We allow for unemployment and business cycle variations, but abstract from behavioral relationships and general equilibrium effects. We take prices as given and focus on social welfare and intertemporal government budget constraints. An alternative is to evaluate fiscal policy rules in a DSGE framework (Pieschacon, 2008). We do not consider the resource curse, i.e., the negative effect of natural resource exports on the rate of economic growth found in cross-section studies emanating from Sachs and Warner (1997).

[3] From now on we refer to 'oil' or 'hydrocarbons' when we mean 'oil and gas'.

[4] Earlier studies also pay attention to old-age demographics and the pension bill (Jafarov and Leigh, 2007).

[5] General equilibrium studies suggested that the aging of Norway's population setting in after 2020 would require either an increase in taxes or a reform of the pension system (Heide, et al., 2006; Holmøy and Stensnes, 2008). Galaasen(2009) finds that continuation of the current fiscal rule is consistent with a reduction of the tax rate in the short run and an increase of the tax rate towards 60 percent in the long run. These technical calibration exercises suggest that further policy reforms are needed, which indeed have been started. We estimate reaction functions describing actual government behavior over the past fifty years and use these to simulate what would have happened in the absence of recent reforms.

by 2060 unless the fiscal stance is tightened or the pension system is reformed.[6] In fact, recently further policy reforms have been undertaken so that the outlook for the net government asset position may not be so bleak.

Section 2 discusses optimal management of a windfall in face of a graying population and offers some testable propositions on fiscal policy rules. Section 3 calculates permanent values of oil and gas revenues and spending needs from official forecasts of the Norwegian government. Section 4 tests the theory by estimating the cointegrating relationship and the resulting fiscal policy rules. Section 5 estimates the short-run dynamics and presents impulse responses of fiscal policy and offers a test that rejects a traditional measure of permanent oil income derived from a time-series model of oil income in favor of our measure of permanent oil income derived from official forecasts. Section 6 offers some weak governments solvency tests and then simulates our estimated fiscal rules and compares them to PIH and BIH rules. Section 7 concludes.

2. Managing windfall revenue: permanent income or bird in hand?

Let d_t denote net government debt (liabilities minus assets) at the end of period t, g_t government spending (excluding net interest payments), τ_t the non-oil tax rate, y_t the output gap (logarithmic deviation of output from its long-run trend value), and n_t oil revenue accruing to the government in period t. We then have the government *flow* budget constraint:

(1) $$d_t = (1+r)d_{t-1} + g_t - \tau_t - \phi y_t - n_t,\ \phi > 0,$$

where the parameter ϕ allows for automatic stabilizers. Variables are expressed as fractions of national income, so r is the growth-corrected real rate of interest. The government has access to international capital markets but the private sector is credit constrained.[7] Given the no-Ponzi condition ($\lim_{s\to\infty}(1+r)^{-s}d_{t+s} = 0$), the present value of future oil revenues must cover government commitments (outstanding net government debt plus present value of future non-oil primary deficits, $b_t \equiv g_t - \tau_t - \phi y_t$). Hence, we have the government *present-value* budget constraint:

(2) $$\sum_{s=0}^{\infty}(1+r)^{-s}n_{t+s} \geq (1+r)d_{t-1} + \sum_{s=0}^{\infty}(1+r)^{-s}b_{t+s}.$$

[6] The recent 2009 White Paper on Long-Term Perspectives uses generational accounting to make projections of oil revenue and demographic trends to 2060 and also concludes that fiscal policy has to become more prudent; taxes have to be increased by 1 percent of GDP in 2060. These calculations are, of course, very sensitive to projections of the price of petroleum. In addition, the historical real return on the fund has been just below 3%. All this prompts the new director of Statistics Norway to argue for a 3% rather than a 4% rule, thereby providing the financial leeway for a less steeply rising non-oil deficit.

[7] Of course, many Norwegians do have access to good capital markets. Still, even in developed economies there are many hand-to-mouth consumers who cannot borrow. Their existence is crucial in understanding the time series behaviour of aggregate consumption (e.g., Campbell and Mankiw, 1989).

Private consumption is given by output minus taxes and minus the quadratic costs of tax collection:

(3) $c_t = 1+\phi y_t - \tau_t - \frac{1}{2}\theta\,\tau_t^2,\ \theta > 0.$

The government maximizes the following intertemporal welfare function,

(4) $$\sum_{s=0}^{\infty}\beta^s\left[c_{t+s}-\frac{1}{2}\psi\left(g_{t+s}^{*}-g_{t+s}\right)^2\right],\quad 0<\beta<1,$$

which is (using (3)) equivalent to minimizing the intertemporal welfare loss function,

(4′) $$\sum_{s=0}^{\infty}\beta^s\left[\tau_{t+s}+\frac{1}{2}\theta\tau_{t+s}{}^2+\frac{1}{2}\psi\left(g_{t+s}^{*}-g_{t+s}\right)^2\right],\quad 0<\beta<1,$$

subject to the present-value budget constraint (2), where we assume $\beta(1+r) = 1$ and $\psi > 0$ is the priority given to the spending target g_t*. The problem of choosing the controls $\{g_{t+s},\tau_{t+s},d_{t+s},s\geq 0\}$ to minimize the welfare loss (4′) subject to the budget constraints (1) follows from the Lagrangian:

(5) $$L\equiv\sum_{s=0}^{\infty}\beta^s\left[\tau_{t+s}+\frac{1}{2}\theta\tau_{t+s}{}^2+\frac{1}{2}\psi\left(g_{t+s}^{*}-g_{t+s}\right)^2+\eta_{t+s}\left((1+r)d_{t+s-1}+g_{t+s}-\tau_{t+s}-\phi y_{t+s}-n_{t+s}-d_{t+s}\right)\right],$$

where the present-value Lagrangian multipliers η_t corresponds to the marginal cost of funds at time *t*. Hence, the intra-temporal first-order conditions for g_{t+s} and τ_{t+s} imply the following conditions:

(6a) $$\psi\left(g_{t+s}^{*}-g_{t+s}\right)=1+\theta\tau_{t+s}=\eta_t>1,\quad \forall s\geq 0,$$

Hence, (6a) implies that the marginal utility of spending on public goods must equal the marginal cost of funds. Furthermore, (6a) implies that a higher tax rate pushes up the cost of funds and thus lowers demand for public goods. The inter-temporal first-order condition for d_{t+s} requires that the marginal cost of fund is the same for all future time periods:

(6b) $$(1+r)\beta\eta_{t+s+1}=\eta_{t+s}\ \text{ or }\ \eta_{t+s}=\eta_t,\quad \forall s\geq 0 \text{ if } (1+r)\beta=1.$$

Hence, all expected future tax rates equal the current tax rate and similarly for all expected future shortfalls of public spending from target. Upon substitution of efficiency conditions (6a) and (6b) into the present-value budget constraint (2), we get the optimal responses implied by the PIH:

(7a) $$\tau_t=\frac{rd_{t-1}-\psi^{-1}+g_t^{*P}-n_t^P}{\theta\left(\phi^{-1}+\psi^{-1}\right)},$$

(7b) $$b_t\equiv g_t-\tau_t=g_t^{*}-g_t^{*P}-\phi y_t-rd_{t-1}+n_t^P,$$

(7c) $$g_t = g_t^* - g_t^{*P} - \phi y_t - rd_{t-1} + n_t^P + \frac{rd_{t-1} - \psi^{-1} + g_t^{*P} - n_t^P}{\theta\left(\phi^{-1} + \psi^{-1}\right)},$$

(7d) $$d_t - d_{t-1} = g_t^* - g_t^{*P} - \phi y_t + n_t^P - n_t,$$

where permanent oil revenue (the annuity value of current and future oil revenue or the return on oil wealth in the ground) and the permanent target spending share are given by:

(7e) $$n_t^P \equiv \frac{r}{1+r}\left[n_t + \sum_{s=1}^{\infty}\left(\frac{1}{1+r}\right)^s E[n_{t+s} / I_t)\right] \text{ and } g_t^{*P} \equiv \frac{r}{1+r}\left[g_t^* + \sum_{s=1}^{\infty}\left(\frac{1}{1+r}\right)^s E[g_{t+s}^* / I_t)\right].$$

The optimal responses (7) can be interpreted as policy rules which map the policy instruments (taxes, non-oil primary deficit, public spending, and the mutation in net government debt, all as fractions of GDP) to the state variable (last year's ratio of net government debt to GDP) and exogenous variables (i.e., current and permanent values of oil revenue and desired public spending and the output gap). If meeting spending targets is of overriding importance ($\psi \to \infty$), $g_t = g_t^*$ and solvency must be attained by variations in taxes rather than spending. The permanent value of the output gap is set to zero.

In general, the optimal policy responses given in (7) imply the following PIH rules. First, (7a) and (7c) indicate that neither the cost of funds nor the tax rate nor spending should react to *current* oil revenues or spending needs. Second, (7b) indicates that in recessions (booms) the non-oil deficit must be loosened (tightened). Third, (7b) also indicates that with current spending targets below future expected spending targets (e.g., due to graying of the population), there should be a non-oil surplus in excess of permanent oil rents to provide for future spending needs (i.e., $b_t > n_t^P$). Third, the cost of funds rises if future spending needs increase or the return on oil wealth falls. Fourth, (7d) implies that a high net debt in itself does not warrant debt reduction as the required temporary tax hikes and spending cuts violate tax and consumption smoothing. Finally, (7b) and (7d) state that the non-oil deficit should react one-for-one with permanent oil revenues. Borrowing is called for ahead of a windfall, but during a windfall paying off debt followed by saving is warranted. The saving can be accumulated in a sovereign wealth fund during the oil boom, so that the increase in public and private consumption is sustained after the windfall has ceased. Falling oil wealth is thus gradually replaced by fund assets (cf. Hartwick, 1977). Finally, the size of the fund at the end of the windfall should exactly equal the permanent value of the stream of oil revenue evaluated at time zero when the news of the future windfall becomes known. The interest on the steady-size of the fund is just sufficient to finance the higher non-oil primary deficit.

The PIH with habit persistence implies that society gets hooked on high consumption during a windfall, but finds it tough to cut consumption afterwards (Leigh and Olters, 2006; Olters, 2007). This leads to an extra term $\xi(b_{t-1} - g_{t-1} - rd_{t-1})$ in the expression for the optimal non-oil primary deficit (7b), where $0 < \xi < 1$ is the degree of habit persistence. With ever-lasting habits ($\xi = 1$), the non-oil primary deficit follows a random walk if public spending does not change, so that (7b) becomes $b_t = g_t - g_{t-1} + b_{t-1} + \varepsilon_t$, where ε_t is the normally distributed stochastic error term.

If the government does not borrow against future windfalls or respond to future needs such as a rising pension bill, we get the BIH rule which states that the government should put all oil revenue in a Sovereign Wealth Fund and draw 4 percent per year from the Fund for general budget purposes, i.e., to finance an increment in the non-oil primary deficit, Δb_t. [8] The government might also have a discretionary transfer h_t from the Fund to the general budget, so the increment in the non-oil primary deficit and the development of the Sovereign Wealth Fund are given by:

(8a) $\Delta b_t = 0.04 f_{t-1} + h_t.$

(8b) $f_t = (1 + r + \nu - 0.04) f_{t-1} + n_t - h_t,$

where f_t denotes the stock of assets in the Fund and ν the premium earned by investment in the Fund over the risk-free interest rate. [9] Net government assets, $-d_t$, are defined as the stock of government assets, f_t. minus gross government debt. The BIH supposes that the government can or does not use future oil revenue as collateral even when it anticipates higher oil and gas production sometime before the higher oil and gas revenue accrue to the government, hence it does not react to n^P.

The BIH rule is inspired by Norwegian policy practice and does not follow from minimizing some welfare loss function. Since the BIH rule precludes borrowing, consumption is too low ahead of the windfall; too high during the windfall, and gradually falls back to its original level after the windfall. The BIH rule thus violates principles of tax and consumption smoothing and is unhelpful if the pension burden is expected to rise, especially if the Fund prevents the government from saving more in response to the rising pension burden. If the return on investments in the sovereign wealth fund is less than 4% *plus* the rate inflation (say, 1.5% per annum) *plus* the real growth rate of the economy (say, 2% per annum), the Fund as a share of GDP gradually falls to zero after the windfall. Else, the Fund grows indefinitely.

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[8] The BIH rule is an ad-hoc way to buffer against future oil and price shocks. Building on the multi-period framework of precautionary saving with income uncertainty (e.g., Sibley, 1975; Zeldes, 1989), one can show that oil price uncertainty induces countries to extract oil more aggressively and establish precautionary buffers (van der Ploeg, 2010), especially if the policy maker is very prudent and oil prices are more volatile. Inevitably, windfalls occur as revenues turn out better than the conservative forecasts of a prudent policy maker, thereby producing the financial leeway a rising non-oil deficit.

[9] The BIH rule does not state how the increment in the non-oil budget deficit is divided into an incremental increase in public spending and an incremental cut in taxes.

Impatient and inconsistent politicians prefer spending hikes and tax cuts now rather than tomorrow and regret them when the time comes to cut the budget and raise taxes to repay accumulated debt plus interest. This can be rationalized with hyperbolic discounting (cf., Laibson, 1997). With targets for the size of the Fund, the government forcefully builds up assets with temporary hikes in taxes and cuts spending. As a result, tax rates decline and public spending shares rise over time. The reaction coefficient of the deficit to public debt is greater than the real interest rate r in this case. With capital scarcity one must use the windfall to bring down debt, stimulate investment at home and speed up economic development rather than accumulate sovereign wealth (Collier, et al., 2010; van der Ploeg and Venables, 2011). With Dutch disease and absorptive capacity problems (van der Ploeg and Venables, 2010), a country may put some of the windfall in sovereign wealth until bottlenecks in the non-traded sectors are alleviated. These issues are more relevant for developing economies.

On the basis of the above, we specify the following time-series model:

(9a) $b_t = \beta_0 + \beta_1 n_t + \beta_2 d_{t-1} + \beta_3 f_{t-1} + \beta_4 y_t + \beta_5 p_t + \beta_6 n_t^P + \beta_7 p_t^P + \varepsilon_t$ and

(9b) $\tau_t = \gamma_0 + \gamma_1 n_t + \gamma_2 d_{t-1} + \gamma_3 f_{t-1} + \gamma_4 y_t + \gamma_5 p_t + \gamma_6 n_t^P + \gamma_7 p_t^P + \theta_t$,

where p_t denotes the number of people in the population aged 67 or older divided by those in the working-age population, $p_t^P \equiv r\sum_{s=0}^{\infty}(1+r)^{-s-1} p_{t+s}$ the permanent value of this dependency ratio, and all other variables are expressed as shares of national income. The econometric specification for the ratio of public spending to GDP follows directly from adding (9a) and (9b). The stochastic error terms ε_t and θ_t are normally distributed with zero mean and are serially uncorrelated. The PIH corresponds to the null hypothesis:

(10) $\beta_1 = 0, \beta_2 = -\beta_3 = r, \beta_4 < 0, \beta_5 = -\beta_7 > 0, \beta_6 = 1$ and
$\gamma_1 = 0, \gamma_2 = -\gamma_3 = r, \gamma_4 = 0, \gamma_5 = 0, \gamma_6 = -1, \gamma_7 > 0.$

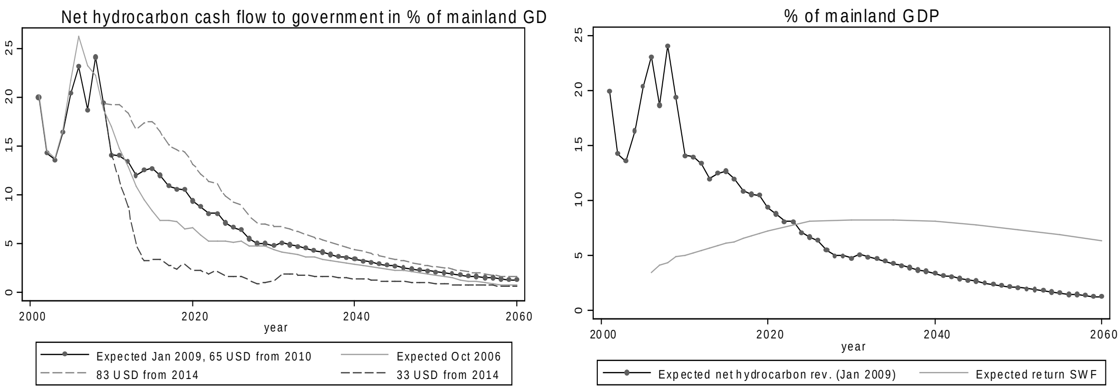
Two reasons for public spending to deviate from its permanent value are the business cycle (picked up by the output gap) and future pension commitments (picked up by the projected fraction of pensioners in the population). Demography proxies future pension and health liabilities. The PIH denies any effect of current oil/gas revenues on the non-oil primary deficit, the tax rate or spending. The PIH may be observationally equivalent to an ad-hoc model without n_t^P or p_t^P. For example, if oil revenue declines at the rate α, we have $n_t^P = \left(\frac{r}{r+\alpha}\right) n_t$ which is equivalent to our null hypothesis if $\beta_1 = r/(r+\alpha) < 1$ if n_t^P is omitted. Bornhorst et al. (2009) find in a panel of 30 oil-producing countries that the non-oil tax take is reduced by 20% of the oil revenue coming in, which is consistent with the PIH if $n_t^p = 0.2 n_t$ or a decline of oil revenues of $\alpha = 4r$, say 8 percent, per annum.

If governments do not adhere to the PIH, the non-oil primary budget deficit may react to actual rather than permanent oil revenue leading to the alternative null hypothesis $\beta_1 > 0$, $0 < \beta_6 < 1$ and $0 < \gamma_1 < 1$, $-1 < \gamma_6 < 0$. Forcefully building up a target Fund size implies $\beta_2 > -r$ and perhaps $\gamma_2 > r$. With habit persistence, the current tax rate is a weighted average of the PIH tax rate and last year's tax rate. Precaution implies buffers and gradual tax cuts, which suggests a negative constant in the rule for the non-oil/gas primary deficit. Since the BIH does not use future oil revenue as collateral, it implies that the relevant null hypothesis is $\beta_6 = \gamma_6 = 0$.

3. Forecasts of future spending needs and oil and gas revenues

Official projections indicate that the expected return on the Fund grows until the 2030s and then tapers off as share of GDP, and primary spending rises from 8% of mainland GDP in 2007 to 15% in 2060.[10] This is due to first rising and then falling contributions to the general budget from the Fund and due to a rising pension bill. Production from proven oil and gas reserves is anticipated to decline substantially during the next twenty five years. Even allowing for improved recovery, discoveries of new fields and undiscovered resources, forecasts show a decline in oil production levels.

Figure 1: Projected net oil and gas cash flow to the government up to 2060



Source: Ministry of Finance January 2009 (Perspektivmeldingen)

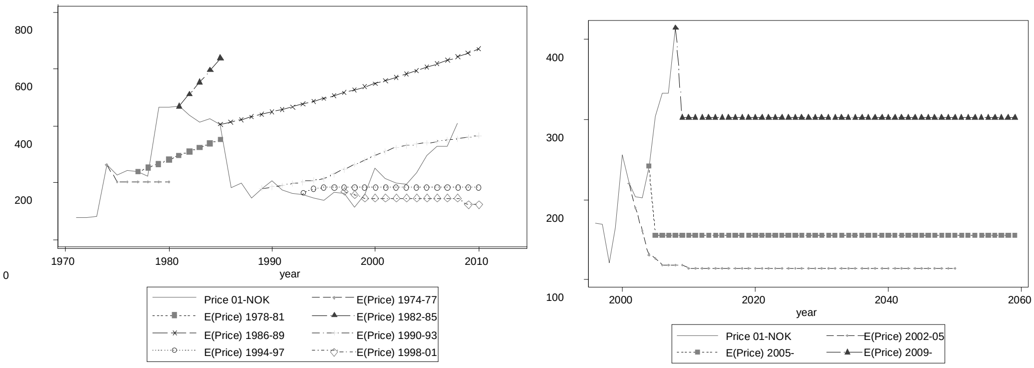
Fig. 1 shows projected net oil and gas cash flows to the government up to 2060. These declining cash flows are sensitive to the projected oil price. Fig. 2(a) gives oil prices together with the values predicted by the Ministry of Finance at various instants of time (measured in fixed 2007 NOK with Norwegian CPI as deflator). As the years pass, the forecasted 'Hotelling' ramps for oil prices have been replaced by forecasts based on random walks with drift in line with empirical evidence (Hamilton, 2009). The production forecasts plotted in fig. 2(b) show a hump-pattern for the next five

[10] These do not include the savings from other pension reforms and the projections of health and old-age expenditures rely on a constant real cost per service user, so it is more a *technical* prediction.

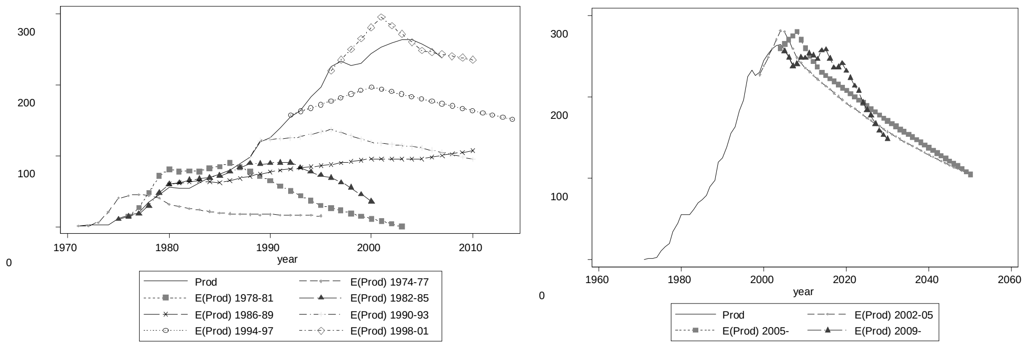
decades and many revisions. Fig. 2(c) shows that, as a result of improved recoveries and discovery of new fields, the declining paths of oil and gas reserves have been continuously revised upwards.

Figure 2: Oil price and oil and gas production and reserve forecasts throughout time

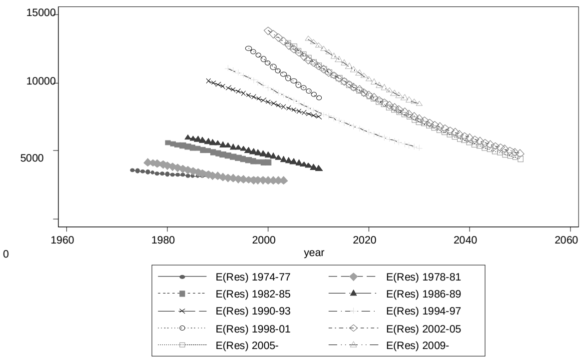
(a) Oil price forecasts



(b) Production forecasts



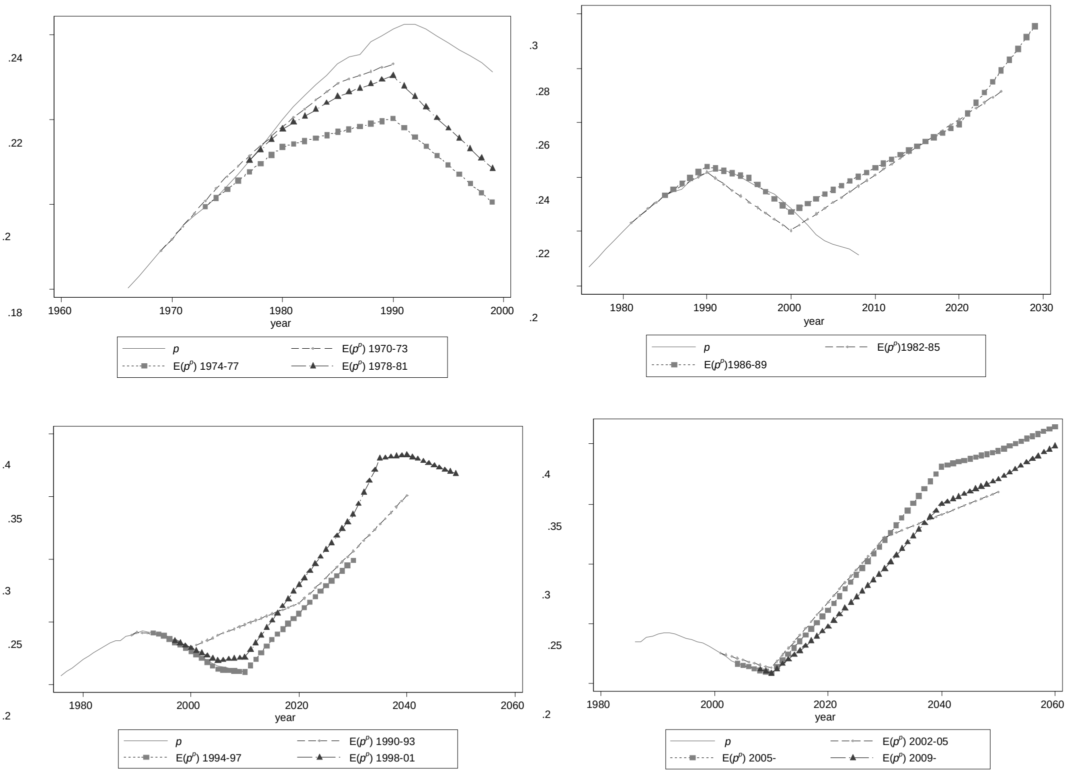
(c) Oil and gas reserves forecasts



Source: Ministry of finance, Statistics Norway and authors calculations

Our estimates of the fiscal reaction coefficients are based on these continuously revised official forecasts of oil reserves and revenue, but also on the changing offical forecasts of the dependency ratio shown in fig. 3. The dependency ratio is a crude measure of pension and health expenditures, but econometrically it will have the advantage of being relatively exogenous to fiscal behavior and is thus more likely to lead to unbiased estimates in section 4. Of course, this is a simplification as there will be other changes (e.g., longevity change, Baumol's cost disease for the care or new medical techniques and medicines) which are not captured by the dependency ratio.

Figure 3: Forecasts of permanent dependency ratio throughout time

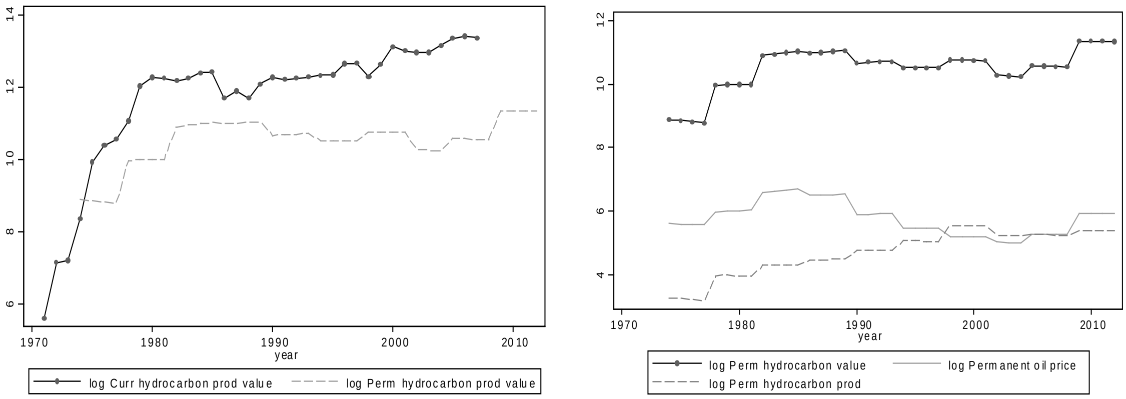


Source: Ministry of finance, Statistics Norway and authors calculations

In the 1970s the Ministry of Finance (correctly) forecasted a turning point in the dependency ratio path around 1990, though the levels of the projected dependency ratios were a bit low (upper left panel). In the 1980s the Ministry forecasted growth to turn positive around 2000 (upper right panel). This turning point was moved ahead in time during the 1990s (lower left panel). By comparing the two lower panels, we see that in the 1998-2001 publication the growth in the dependency ratio was forecasted to turn from positive to close to zero in the late 2020s and later on to negative. This forecast changed subsequently and the three last forecasts presented in the lower right panel show a growing dependency ratio towards 2060. We test whether these changing forecasts of the future dependency ratio impacted fiscal rules.

From a fiscal point of view, the most relevant measure of oil and gas revenue is the present value of the cash flow collected by the Norwegian state. Fig. 4 therefore plots the permanent value of future oil and gas revenues based on official forecasts of the Norwegian Ministry of Finance. The left panel gives current production values (measured as production of oil-equivalents multiplied with the oil price) together with permanent values calculated from official forecasts throughout time. Permanent values are below actual values and show lower growth over time, which reflects relatively rapid depletion of oil and gas reserves. The right panel of fig. 4 decomposes permanent production value into permanent oil price and permanent oil-equivalents of oil and gas production. The permanent oil price decreases from its peak in the mid-1980s. The permanent production path increases steadily from mid-1970s until 1998-2001, when it peaks.

Figure 4: Current and permanent values of oil and gas production



Source: Ministry of finance, Statistics Norway and authors calculations. The two upper panels picture natural logarithms of millions of 2007-NKR.

4. Cointegration and estimation of the fiscal rules

Using Norwegian data for the period 1954-2007 (see appendix 1), we estimate the parameters that identify the fiscal rules (9a)-(9b). The fiscal rule for public spending follows from adding (9a) and (9b).

4.1. Estimates based on official forecasts

Forward-looking behavior, captured by the permanent values of oil and gas revenue and the dependency ratio, is a key aspect. Thanks to a tradition of long-term budgeting since 1953, we can use official forecasts for the expectations on future oil and gas revenue and the dependency ratio to calculate permanent values. The explanatory variables of interest are the transitory component of the dependency ratio, net asset and oil and gas revenue measures.[11] Table 1 presents the estimates.

As testing for unit roots reveals that all variables are non-stationary and I(1), we test for cointegration. Augmented Engle-Granger (AEG) tests are reported in the lower part of table 1. Focusing on the reaction function for the non-oil/gas primary deficit, a unit root in the residuals is rejected if zero lags are included in the test, but not if the test is augmented with 1, 2 or 3 lags (column (a)). However, by using more efficient estimation methods we show in appendix 3 that the estimates of table 1 are stable and spurious correlation is not a big concern.

[11] The Fund was built up only from 1996 and then increased rapidly in size. As our estimates cover a longer period, we focus on net assets in the empirics (i.e. imposing the restriction $\beta_2 = -\beta_3$). For the dependency ratio, we are interested in the transitory component, i.e. the difference between the current and permanent dependency ratio, and impose the restriction $\beta_5 = -\beta_7$, since (7b) indicates that the primary budget deficit is driven by the transitory component of the target level of public spending.

Concentrating on the non-oil/gas primary deficit, the estimated reaction function suggests that a third of each extra Krone of oil and gas revenue is spent on increasing the deficit. For permanent revenue, the effect is 0.3. A percentage point change in the current over permanent dependency ratio increases the non-oil/gas primary deficit by about 1.6 percentage points of GDP, which reflects higher *current* spending needs compared to *future* spending needs. For the previous year's net assets, the coefficient is 0.15; bigger than the relevant interest rate. Based on signs, magnitudes and statistical significance, the estimates of the fiscal responses presented in table 1 are consistent with the theory of section 2.

Table 1: Fiscal responses with permanent oil and gas revenue

	(a)	(b)	(c)
Equation:	(9a)		(9b)
Dependent variable:	Deficit (*b*)	Expenditure (*g*)	Taxes (*t*)
Estimation method:	OLS	OLS	OLS
Oil and gas revenue current (*n*)	0.326^{***}	0.772^{***}	0.446^{***}
	(0.098)	(0.128)	(0.161)
Oil and gas revenue permanent (n^p)	0.313^{**}	-0.660^{***}	-0.974^{***}
	(0.134)	(0.237)	(0.226)
Dependency ratio current - permanent (p - p^p)	1.583^{***}	1.119^{***}	-0.464^{*}
	(0.176)	(0.256)	(0.261)
Last year's net assets ($-d$)	0.150^{***}	0.387^{***}	0.237^{***}
	(0.032)	(0.060)	(0.054)
Output gap (*y*)	-0.514^{***}	-0.148	0.365
	(0.192)	(0.215)	(0.254)
Constant	-0.012^{***}	0.233^{***}	0.244^{***}
	(0.004)	(0.008)	(0.007)
Observations	54	54	54
R-sq	0.72	0.86	0.73
AEG test on residuals from second stage, lags:			
0	**-4.463**	-3.716	-3.139
1	-4.022	-2.643	-2.929
2	-4.146	-2.426	-2.961
3	-3.161	-2.659	-2.562

Critical values: 1% -5.387; 5% -4.685; 10% -4.336.
Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. For the AEG (Augmented Engle-Granger) test, critical values are based on McKinnon (2010) and generated from the Stata program module Schaffer (2010). The optimal lag-length due to the AIC and BIC criteria is 1 period.

The estimates in table 1 may be biased due to endogenous explanatory variables. We argue that this is not a serious concern for the dependency ratios, since they are purely demographic and thus exogenous to fiscal adjustments. Net assets are included with a one year lag, hence are predetermined as far as the fiscal reaction is concerned. Oil and gas revenues, on the other hand, are related to fiscal policy through the tax system and the government's stakes in hydrocarbon enterprises. For example, the government might use its majority stake in StatoilHydro to increase dividends if the deficit is high, inducing an upward bias in the OLS estimates of the effect of current oil and gas revenue on the deficit. To circumvent this, we replace in table 2 current and permanent oil and gas *revenue* by current and permanent oil and gas *production value,* consisting of the production volume and the price. The current production *volume* should be exogenous in our setting, since the Norwegian system of allocating production licenses allows the oil companies to determine the depletion speed. The government only influences the number and distribution of production licenses and these decisions are taken at the earliest stage of an oil field's life cycle. The government could in principle affect depletion speed with the environmental tax, but this tax has in practice been very low. There is thus little feedback from fiscal policy to the oil and gas production volume. The oil *price* is the other component of current production value and is determined on the world market. The government's *prediction* of production value underlies our measure of permanent production value, which is predominantly based on factors such as geological exploration, private search activity for new fields, the speed of depletion in developed fields and assumptions about the oil price.

Table 2: Estimates of fiscal rules with production value directly (v and v^p)

	(a)	(b)	(c)
Equation:	(9a)		(9b)
Dependent variable:	Deficit (b)	Expenditure (g)	Taxes (t)
Estimation method:	OLS	OLS	OLS
Oil and gas production value (v)	0.191***	0.395***	0.204***
	(0.063)	(0.060)	(0.078)
Oil and gas production value permanent (v^p)	0.115**	-0.231***	-0.347***
	(0.049)	(0.063)	(0.060)
Dependency ratio current - permanent ($p - p^p$)	0.919***	1.310***	0.391
	(0.191)	(0.335)	(0.336)
Last year's net assets ($-d$)	0.094***	0.351***	0.257***
	(0.032)	(0.059)	(0.057)
Output gap (y)	-0.534***	-0.172	0.362*
	(0.172)	(0.195)	(0.212)
Constant	-0.022***	0.238***	0.260***
	(0.004)	(0.008)	(0.008)
Observations	54	54	54
R-sq	0.79	0.85	0.75
Re-scaled size corresponding to hydrocarbon revenue#:			
Hydrocarbon production value (v)	0.419	0.866	0.447
Hydrocarbon production value permanent (v^p)	0.252	-0.507	-0.761
AEG test on residuals, lags:			
0	**-5.058**	-4.025	-3.477
1	**-4.931**	-2.868	-3.455
2	**-4.943**	-2.723	-3.348
3	-3.545	-2.455	-2.678

Critical values: 1% -5.387; 5% -4.685; 10% -4.336.

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. For the AEG (Augmented Engle-Granger) test, critical values are based on McKinnon (2010) and generated from the Stata program module Schaffer (2010). The optimal lag-length due to the AIC and BIC criteria is 1 period.
#To make coefficients comparable, coefficients are rescaled by dividing the current and permanent hydrocarbon production value coefficients by 0.456, i.e., the first-stage coefficient in column 1 of the top panel of table A1.

Again focusing on the non-oil/gas primary deficit, we find in table 2 stronger support for cointegration as we reject a unit root in the residuals with the AEG-tests including zero, one and two lags (the AIC and the BIC criteria suggest that one lag is appropriate). Signs and significance are the same for the explanatory variables of tables 1 and 2. To compare the magnitude of the estimated coefficients for current and permanent oil and gas production value with the magnitude found for revenue in table 1, we re-scale the coefficients and find that one extra Krone of oil and gas revenue increases the non-oil/gas primary deficit by 0.42 Krone (see the lower part of table 2).[12]

[12] The conversion factors are from the first stage regression presented in the upper panel of table A1 in appendix 3, which suggest that one extra Krone of current oil and gas revenue is equivalent to 2.2 extra kroner in production value (1/0.456=2.2). For the permanent variables, the conversion factor is 5.0 (1/0.201=5.0). The estimates of table 2 are similar to the IV-estimates presented in appendix 3, table A1, using the current and permanent oil and gas production value as instruments for current and permanent oil and gas revenue: 0.36 and 0.70 for current and permanent oil and gas revenue, respectively. The coefficient on net assets is also similar, but the coefficient on the dependency ratio variable is in table 2 considerably smaller than the IV-estimates (as well as the OLS-estimates of table 1); around 0.9 rather than 1.5.

In appendix 3 we present also IV-estimates using the production value variables as instruments for the revenue variables. In the case that regressors are not strictly exogenous, the OLS-estimates of the cointegrating relationship do not have an asymptotically efficient distribution, thus invalidating standard tests. We therefore also re-estimate the reaction functions with two alternative, asymptotically efficient estimators for robustness: Fully Modified Ordinary Least Squares (FMOLS, Phillips and Hansen, 1990) and Canonical Cointegration Regression (CCR, Park, 1992).

Across all our estimates (including the robustness checks of appendix 3), the estimated effect of *current* oil and gas revenue on the primary non-oil/gas deficit varies between 0.33 and 0.60; the effect of *permanent* oil and gas revenue varies between zero and 0.37.[13] The PIH implies values of 1 and –1 for the coefficients on current and permanent oil and gas revenue (see (10)), which are rejected by the data. The BIH suggests, on the contrary, a zero coefficient on permanent oil and gas income: only already accumulated assets should affect spending decisions. Hence, the relatively larger coefficient on current versus permanent oil and gas revenue is compatible with elements of the BIH rule.

The estimated effect of the difference between the current and permanent dependency ratio on the non-oil/gas primary deficit is between 0.90 and 1.87. The PIH has been imposed for pension needs, so the budget deficit should finance temporary pension needs and provide for future pension commitments in a graying society. The past net asset-GDP ratio has a significant effect on the primary non-oil/gas deficit. The coefficient varies between 0.08 and 0.17 and is larger than the relevant interest rate, which suggests that the fiscal regime is sustainable. The output gap has a negative effect on the non-oil/gas primary deficit, so fiscal policy is anti-cyclical.

We conclude that the fiscal behavior with respect to oil and gas income has been quite close to BIH, while the reactions to the dependency ratios are more in line with the PIH. Since transfers to the Fund were not undertaken until 1996, we have also estimated separate coefficients for the current and permanent oil and gas revenue for the periods 1954-95 and 1996-2007 (Harding and van der Ploeg, 2009). Our findings were that current oil/gas revenue had a reaction coefficient greater than one during the first two decades of the oil era, which suggests that borrowing (also to finance large oil investments) against rising oil and gas revenue took place in line with the PIH. We did not find much variation over time of the dependency ratios. The Fund had a relatively strong effect on budgetary behavior. These estimates reflect the introduction of the fiscal rule of 2001 and lack of formal rules earlier on. Indeed, the non-oil/gas primary deficit jumped upward during the 1970s. Also, as mentioned in section 3, if oil and gas revenue are expected to fall, the PIH implies that estimating a model without permanent oil/gas revenue leads to a coefficient on current oil and gas revenue lower than unity. Zooming in on sub-periods is useful, but our conclusion from our estimates based on the

[13] We treat the IV-estimate of 0.7 reported in table A1 of appendix 3 as an outlier.

full sample period that the Norwegian fiscal stance was dominated by a relatively heavy emphasis on current oil/gas revenue stands. It is also clear that even though Norway did not necessarily get it right for some years, it seems to have learned and reformed in time. Still, our time-invariant estimates of the fiscal reaction functions are useful to examine what would have happened if further reforms would not have taken place.[14]

4.2. Is permanent income based on official forecasts better than based on a time-series model?

To assess whether our measure of permanent oil income derived from official forecasts outperforms, we compare it with a measure derived from a simple AR(1) time series. We first obtain rolling regression estimates of a simple measure of oil income:

$$(11) \qquad n_t = \alpha_{0t} + \alpha_{1t} n_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim IN(0,\sigma^2), \quad |\alpha_{1t}| < 1 + r.$$

Using the law of iterated projections, we obtain the projected time-series forecasts from (11):

$$(12) \qquad E[n_{t+s} / I_t] = \left(\frac{1-\alpha_{1t}{}^{s}}{1-\alpha_{1t}} \right) \alpha_{0t} + \alpha_{1t}{}^{s} n_t, \quad s \geq 1.$$

Substituting the projections (12) into the definition of permanent income (7e), we obtain:

$$(13) \qquad n_t^{P,TS} = \frac{r}{1+r}\left[n_t + \sum_{s=1}^{\infty} \left(\frac{1}{1+r} \right)^s \left\{ \left(\frac{1-\alpha_{1t}{}^{s}}{1-\alpha_{1t}} \right) \alpha_{0t} + \alpha_{1t}{}^{s} n_t \right\} \right] = \left(\frac{1-\alpha_{1t}}{1+r-\alpha_{1t}} \right) \frac{\alpha_{0t}}{1-\alpha_{1t}} + \left(\frac{r}{1+r-\alpha_{1t}} \right) n_t.$$

Historically rising oil revenues imply that $\alpha_{1t} > 1$ in which case the forecasts (12) explode unless $|\alpha_{1t}| < 1 + r.$ If this condition is not satisfied, we calculate our time-series estimate of permanent oil income with a finite horizon of T = 100 years in which case (13) becomes:

$$(13') \quad n_t^{P,TS} = \left(\frac{1-\alpha_{1t}}{1+r-\alpha_{1t}} \right) \left[\frac{ \dfrac{\left(\dfrac{\alpha_{1t}}{1+r} \right)^{T+1}}{1+r-\alpha_{1t}} - \left(\dfrac{1}{1+r} \right)^{T+1} }{1-(1+r)^{-T}} \right] \frac{\alpha_{0t}}{1-\alpha_{1t}} + \left(\frac{r}{1+r-\alpha_{1t}} \right) \left(\frac{1-\left(\dfrac{\alpha_{1t}}{1+r} \right)^{T+1}}{1-(1+r)^{-T}} \right) n_t.$$

This time-series measure of permanent income consistently underestimates the permanent income measure of oil revenue derived from official forecasts (see appendix 3).[15] Regression (b) of table 3 includes our *time-series* measure of permanent income (13′) alongside our measure of permanent

[14] Of course, as is usual in most of economics, we also abstract from time variations in preferences over intertemporal distribution, macroeconomic stabilization, environmental priorities, etc.
[15] The rolling-regression estimates are available on request for the authors. See appendix 3 for more details.

income obtained from the *official forecasts* in regression (a) of table 3. Since the resulting coefficient is statistically insignificant whilst the other coefficients are not much affected, we conclude that the measure of permanent income based on official forecasts outperforms the one based on a time-series model. A similar conclusion is reached if we use production value and the oil and gas measure (column (c) and (d)).

Table 3: Estimates with permanent values from time-series model

	(a) Deficit (b) OLS	(b) Deficit (b) OLS	(c) Deficit (b) OLS	(d) Deficit (b) OLS
Oil and gas revenue current (n)	0.349***	0.426***		
	(0.106)	(0.117)		
Oil and gas revenue permanent (np)	0.287*			
	(0.156)			
Oil and gas production value (v)			0.202***	0.340***
			(0.068)	(0.068)
Oil and gas production value permanent (vp)			0.117**	
			(0.055)	
Oil and gas revenue *TS* permanent		-0.009		
		(0.078)		
Oil and gas production value *TS* permanent				-0.160*
				(0.096)
Dependency ratio current - permanent (p-pp)	1.427***	1.376***	0.919***	0.942***
	(0.320)	(0.365)	(0.247)	(0.315)
Last year's net assets (f-d)	0.117**	0.128**	0.089**	0.083
	(0.047)	(0.054)	(0.045)	(0.052)
Output gap (y)	-0.718***	-0.722***	-0.696***	-0.746***
	(0.246)	(0.246)	(0.216)	(0.239)
Constant	-0.003	0.001	-0.022*	-0.014
	(0.014)	(0.014)	(0.011)	(0.012)
Observations	37	37	37	37
R-sq	0.57	0.54	0.68	0.64
AEG test on residuals from second stage, lags:				
0	-3.613	-3.721	-4.281	-4.375
1	-3.555	-3.603	**-4.487**	-4.305
2	-3.795	-3.726	**-4.546**	-4.248
3	-3.093	-3.004	-3.364	-3.064

Critical values: 1% -5.600; 5% -4.815; 10% -4.433.

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. For the AEG (Augmented Engle-Granger) test, critical values are based on McKinnon (2010) and generated from the Stata program module Schaffer (2010). The optimal lag-length due to the AIC and BIC criteria is 1 period. We start the sample in 1971, as the oil revenue before was zero, making the time-series model inadequate.

5. Short-run dynamics

Given the evidence for cointegration, we estimate an error-correction model where the cointegrating relationship (the stationary residuals from the OLS estimates of the columns (a) in table 1 and table 2) is imposed as the long-run error-correction term and the short-run dynamics are freely estimated (Engel and Granger, 1987). Column (a) and (c) in table 4 present the resulting error-correction models. The coefficient on the residuals is negative and significant, which suggests that there is indeed error correction in the data. Column (b) and (d) present the same models, but with the long-run coefficients estimated rather than imposed. The two approaches generate similar results.

Fig. 5 presents the impulse response functions of the non-oil/gas deficit following permanent shocks in current and permanent oil and gas revenue/production, the transitory component of the dependency ratio and net assets (based on estimates (b) and (d) of table 4. The top-left panel shows a much bigger boost in the deficit from a change in the current compared to the permanent oil and gas revenue. The top-right panel indicates that this also holds for shocks to current and permanent production value. This illustrates the bird-in-hand flavor of the fiscal reaction to oil and gas revenue. However, the error bands show that the difference in the effect is just about statistically significant.

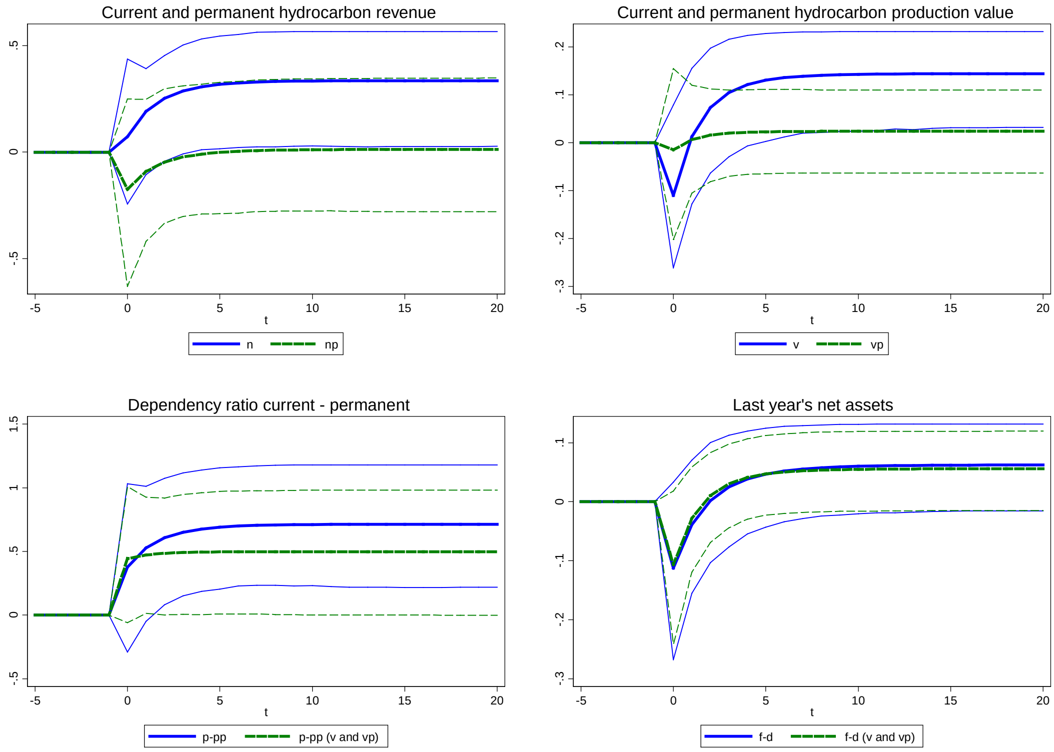
Table 4: Estimates of short-run dynamics of fiscal rules

	(a) ΔDeficit (*b*) OLS	(b) ΔDeficit (*b*) OLS	(c) ΔDeficit (*b*) OLS	(d) ΔDeficit (*b*) OLS
ΔOil and gas revenue current (Δ*n*)	0.025	0.063		
	(0.140)	(0.103)		
ΔOil and gas revenue permanent (Δn^p)	-0.008	-0.174		
	(0.150)	(0.137)		
ΔOil and gas production value (Δ*v*)			-0.116**	-0.113*
			(0.055)	(0.063)
ΔOil and gas production value permanent (Δv^p)			-0.008	-0.022
			(0.044)	(0.047)
ΔDependency ratio current - permanent (Δp - Δp^p)	0.311*	0.400***	0.259**	0.420***
	(0.179)	(0.139)	(0.114)	(0.146)
ΔLast year's net assets (– Δ*d*)	-0.048	-0.097*	-0.067	-0.098**
	(0.050)	(0.051)	(0.046)	(0.043)
ΔOutput gap (Δ*y*)	-0.467***	-0.530***	-0.428***	-0.462***
	(0.137)	(0.145)	(0.132)	(0.133)
Lagged residual	-0.400***		-0.458***	
	(0.092)		(0.095)	
Lagged Deficit (*b*)		-0.437***		-0.491***
		(0.081)		(0.085)
Lagged Oil and gas revenue current (*n*)		0.374***		
		(0.092)		
Lagged Oil and gas revenue permanent (np)		-0.017		
		(0.131)		
Lagged Oil and gas production value (*v*)				0.149***
				(0.037)
Lagged Oil and gas production value permanent (v^p)				0.020
				(0.034)
Lagged Dependency ratio current-permanent (p-p^p)		0.801***		0.565***
		(0.177)		(0.193)
Lagged Last year's net assets (– *d*)		0.070**		0.061**
		(0.032)		(0.029)
Lagged Output gap (*y*)		-0.250***		-0.247***
		(0.092)		(0.089)
Constant	0.002	-0.004	0.003	-0.010***
	(0.002)	(0.003)	(0.002)	(0.004)
Observations	53	53	53	53
R-sq	0.36	0.46	0.46	0.51

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The lower-left panel of fig. 5 gives the responses to a shock in the transitory component of the dependency ratio, the lower-right panel to a shock in net assets. The short run responses are very similar in the two models for both these variables. There is a strong contractionary short-run effect of a shock to net government assets.

Figure 5: Impulse responses non-oil/gas primary deficit (percent of GDP)



Note: Responses of *b* to a 1%-point permanent shift in the listed right-hand side variable. Based on estimates (b) and (d) in table 4. 95%-error-bands are based on non-parametric bootstrapping (1000 replications).

6. Is the fiscal stance sustainable?

A fiscal regime is sustainable if the net debt grows at a pace not higher than the real growth-corrected interest rate (e.g., Hamilton and Flavin, 1986; Bohn 2007). Despite the strong current net asset position of Norway, insolvency might be an issue for Norway.[16] Furthermore, fig. 6 indicates that lack of fiscal reforms implies that the estimated fiscal policy rules, (a) in table 1 and (a) in table 2, leads to a substantial running down of the currently strong net asset position over the next fifty years. Fig. 6 also compares the estimated policy rules with the paths resulting from the prescriptions of the BIH and PIH rules (see appendix 1). Fig. 6 also gives the HC-PIH rule, which is defined as the PIH rule which ignores future public spending obligations arising from the expected increase in the dependency ratio and only takes account of future oil and gas revenue.

The HC-PIH rule leads to a modest increase in sovereign wealth resulting from running a primary non-oil/gas deficit of 5-7% of GDP. If one does take account of the rising burden of a graying population, the PIH rule is relevant and the government should run a much tighter fiscal stance. It then

[16] Estimating $b_t - n_t = -\eta d_t + \varepsilon_t$, $\eta > r$ implies stable and $0 < \eta < r$ explosive (but not violating the no-Ponzi-games condition) paths for net government liabilities where r is the real growth-corrected interest rate. Our OLS estimate of η is -0.086 with standard error 0.026, hence we cannot reject the null hypothesis that $\eta < 0$ at the 5% significance level and thus cannot reject insolvency of the public finances. However, this is a weak test.

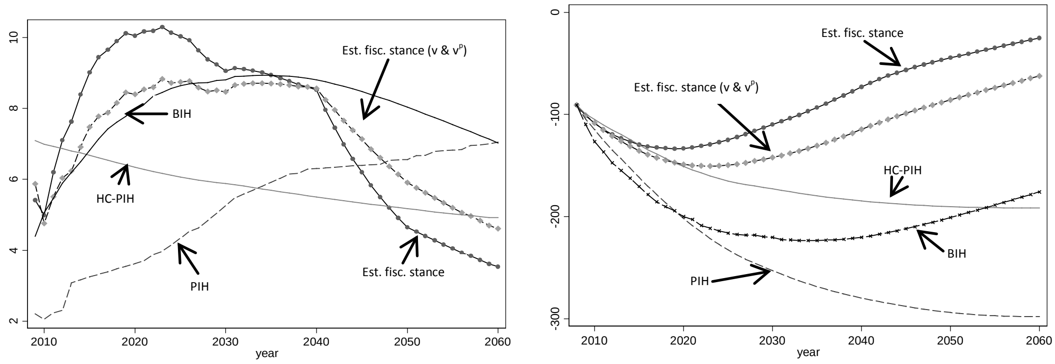
starts out with a primary non-oil/gas deficit which is about 5%-points of GDP less than under the HC-PIH rule. The tighter fiscal stance during the first two decades under the PIH rule leads to a much bigger accumulation of sovereign net wealth (negative net debt), 298 percent of GDP compared to 192 percent of GDP under the HC-PIH rule in 2060, so that its return can pay for future pension obligations without having to cut public spending or raise taxes in the future.

For comparison, the prediction of the Ministry of Finance (in January 2009) for the Fund in 2060 is 176% of GDP, which is based on a large and detailed CGE-model and uses much more information than we can. This prediction also incorporates knowledge about the most recent official fiscal stance which our estimated fiscal stance cannot do as it is estimated from historical data. It happens to generate a Fund of about the same size as the HC-PIH rule which does not take account of the future rise in the burden of a graying population.

The non-oil/gas primary budget deficit under the BIH rule equals 4% of the Fund. The size of the non-oil/gas primary deficit under this rule grows from about 5% of GDP to almost 9% in the 2030s, and then declines to 7% of GDP in 2060. The two estimates of Norway's historical fiscal stance (i.e., (a) in tables 1 and table 2) imply higher non-oil/gas primary deficits in the first decades compared to the other more prudent scenarios. They shrink towards 2060, but lie above the deficits suggested by the PIH or BIH rules for more than three decades and induce accumulation of less net assets, reaching 62% and 25% of GDP in 2060, respectively. The estimated scenarios and the BIH scenario all generate the inverted U-shape of the non-oil/gas primary deficit with relatively steep declines from around 2040. They thus imply less smoothing and more prudence towards the end of the period compared with the PIH-HC and PIH rules. Although sustainability may not be threatened over the next 50 years, there will be a deterioration of the currently admirable sovereign wealth position.

Figure 6: Primary non-oil/gas deficit and net debt under estimated fiscal stance, HC-PIH & PIH

(a) Non-oil/gas primary deficit (b) Net government liabilities

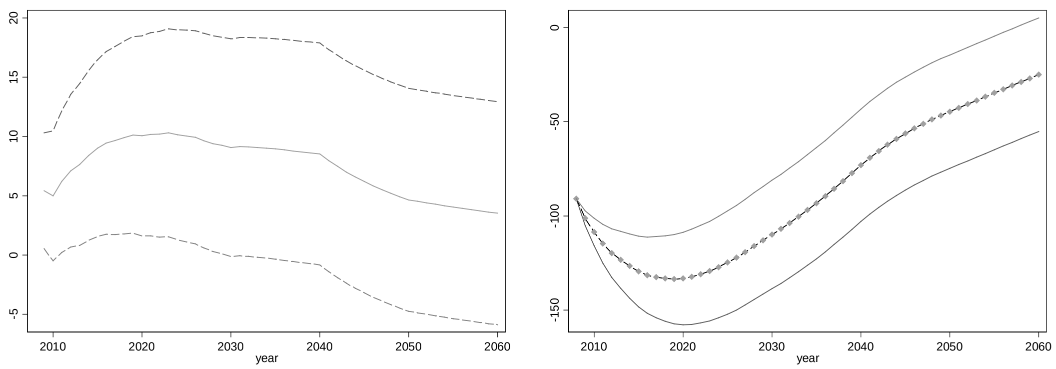


Note: Based on forecasts of Ministry of Finance January-May 2009 (Perspektivmeldingen and Revised National Budget). "Estimated fiscal stance" refers to (a) in table 1 and "Estimated Fiscal stance (v and v_p)" to (a) in table 2. The Fund was about 90% of GDP in 2007 and 2008. Other assets were 25% of GDP in 2007. For simplicity, we set other assets to zero in the simulations.

The projections presented in fig. 6 are uncertain. First, the fiscal reaction functions are uncertain due to the uncertainty of the estimated coefficients. The graphs of the impulse response functions presented in section 5 give a sense of the magnitude of that uncertainty. Second, the projections for the exogenous variables, especially that of the future oil price, are uncertain. To demonstrate the potential magnitude of this source of uncertainty, the solid lines in fig. 7 present the projected net government debt and deficit from our estimated fiscal stance (i.e., the “fiscal stance” projections in fig. 6) and the dashed lines the confidence bands corresponding to the approximate 2.5 percentile value of n and n_p and the 97.5 percentile value of n and n_p.[17] The confidence bands represent lower and upper bounds as suggested by the historical volatility of government oil and gas revenue as share of GDP due to fluctuations in oil prices, oil production, government take and GDP (abstracting from parameter uncertainty. As before, the primary non-oil/gas deficit first rises whilst the oil boom still lasts and then falls rapidly during the following decades in order to provide for the future costs of a graying population. The simulations suggest that the lower band of the deficit varies between -6% and 2% of GDP; the upper band varies between 10% and 19% of GDP. The government’s net debt position is in 2060 between -55% and 5% of GDP and has an expected value of 25% of GDP. The uncertainty is thus considerable. The high uncertainty of oil revenues underlines the need for fiscal reforms. Note that volatile valuation of the assets in the sovereign wealth fund adds to the uncertainty.

Figure 7: Uncertainty due to oil and gas revenue projections

(a) Non-oil/gas primary deficit (b) Net government liabilities



Summing up, our estimates of the historical fiscal stance suggest that the solvability of Norway’s government finances is not in danger but declining oil and gas revenue and the rising gray burden necessitate a gradual tightening of the non-oil/gas primary deficit and a substantial worsening of the net government asset position. Taking account of uncertainty about future oil and gas revenue changes the quantitative but not the qualitative conclusions. In contrast, official projections incorporate the most recent fiscal reforms and suggest that the net government asset position remains strong.

[17] The approximate 2.5 (97.5) percentile was calculated from subtracting (adding) 2 x the variable’s standard deviation of n and n^p over the period 1980-2007.

7. **Concluding remarks**

Our estimates of forward-looking fiscal policy rules for an oil-rich developed economy were inspired by the PIH. To the best of our knowledge, we tested for the first time not only the effect of current oil revenues on the fiscal stance but also that of the present value of future oil and gas revenue. For this purpose, we calculated the permanent value of oil and gas revenues based on official forecasts of reserves and oil prices. In contrast, to our measure of permanent oil revenue based on official forecasts, the measure of permanent revenue derived from rolling time-series estimates of an AR(1)-model was statistically insignificant as a determinant of the fiscal policy rule and thus failed to pick up the forward looking behavior of the government. Furthermore, we corrected for the potential endogeneity of oil and gas government revenue. We also used official projections of the dependency ratio to proxy future spending obligations and estimated a plausible effect of the transitory component of the permanent dependency ratio on the fiscal stance. Our estimates suggest that the fiscal stance does not fully react to oil and gas wealth under the ground, so the estimated fiscal stance has more elements of the bird-in-hand approach than of the PIH. Available government solvency tests indicate that the fiscal stance may not be prudent enough in light of the already declining oil windfall and the looming rise in the pension burden inducing a running down of assets. Official projections have also indicated for some time that the combination of a rising demographic dependency ratio and falling oil and gas revenues and thereby declining inflows into the Sovereign Wealth Fund makes the fiscal future much more problematic than the present fiscal stance may lead politicians and the public to believe.

The analytical and policy implications of the permanent income rule were well understood in the Norwegian policy debate. For example, the 1983 Tempo Committee recommended to convert assets under the ground into a Fund and to decouple oil and gas income from spending and the 1988 Steigum Committee advised that public income should depend on the permanent income of total oil and gas wealth consisting of the value of in-situ oil and gas plus the Fund and also discussed important financial aspects of managing a portfolio consisting of financial assets as well as oil and gas wealth (see appendix 2). Norway wanted a pragmatic, operational and easy-to-understand policy rule, which requires credible, robust estimates of future, unproduced oil and gas revenues and the need to avoid political manipulation of say forecasts of future oil prices. Since smoothing of consumption, public spending and taxes ex ante may require large variations in the net liabilities or asset position in response to changes in the relevant present values, actual policy was more driven by bird-in-hand than permanent-income considerations. It is also important to realize that Norwegian policy might have relied on a different model than the simple one we put forward. In particular, we realize that the strength of Norwegian policy making is that it has learned and adjusted its policy rule over time. This is not captured by our time-invariant estimates of fiscal reaction functions, but our analysis does point to the dangers for solvency of public finances if reforms are not undertaken.

In future work we want to explore the following avenues. First, it is interesting to compare the experience of Norway with other oil- and gas-rich economies. The Netherlands, for example, first squandered their gas revenue and from 1994 onward put it into an economic infrastructure fund and debt reduction while Norway put its oil revenues in a sovereign wealth fund. Second, the estimated fiscal rules can be road-tested with a real DSGE model as has been done for Mexico and Norway (Pieschacon, 2008) or an official full-scale CGE model (e.g., Heide, et al., 2006). Third, the interaction with monetary policy and the issue of the proper division of tasks between the central bank and fiscal authorities of oil-rich economies needs further study. Finally, the portfolio decisions between assets in the ground and assets in the fund need to be analyzed from the finance point of view (Chhaochharia and Laeven, 2008). So far, the evidence suggests that oil-rich countries do diversify their portfolio but hardly hedge against commodity price risks (Avendano, 2011).

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Appendix 1: official forecasts, permanent values and description of other data

The stock of oil at time *t*, S_t, must equal the sum of current and future extractions, R_s, $s \geq t$, that is $S_t = \sum_{i=0}^{\infty} R_{t+i}$. The discounted value of oil revenue is $V_t = \sum_{i=0}^{\infty} \frac{P_{t+i} R_{t+i}}{(1+r)^i}$. We calculate permanent income using only available information. With only projections for income in year *t*+1, *t*+2 and *t*+3, we have:

$$N_t^p = \frac{N_t + \frac{N_{t+1}}{1+r} + \frac{N_{t+2}}{(1+r)^2} + \frac{N_{t+3}}{(1+r)^3}}{1 + \frac{1}{1+r} + \frac{1}{(1+r)^2} + \frac{1}{(1+r)^3}}.$$

An alternative is to suppose that oil revenue stays constant from t+3, which yields:

$$N_t^p = \frac{N_t + \frac{N_{t+1}}{1+r} + \frac{N_{t+2}}{(1+r)^2} + N_{t+3}\left[\frac{1}{(1+r)^3} + \frac{1}{(1+r)^4} + \ldots\right]}{\frac{1+r}{r}} = \frac{r}{1+r}\left(N_t + \frac{N_{t+1}}{1+r} + \frac{N_{t+2}}{(1+r)^2} + \frac{N_{t+3}}{(1+r)^3}\frac{1}{r}\right).$$

Another alternative is to suppose iso-elastic demand and zero extraction costs:

$$P_{t+i} = P_t(1+r)^i,\ V_t = \sum_{i=0}^{\infty}\frac{P_t(1+r)^i R_{t+i}}{(1+r)^i} = P_t\sum_{i=0}^{\infty}R_{t+i} = P_t S_t,$$

$$N_t^p = \frac{N_t + \frac{N_{t+1}}{1+r} + \frac{N_{t+2}}{(1+r)^2} + \frac{V_{t+3}}{(1+r)^3}}{1 + \frac{1}{1+r} + \frac{1}{(1+r)^2} + \frac{1}{(1+r)^3} + \frac{1}{(1+r)^4} + \ldots} = \frac{r}{1+r}V_t \text{ where}$$

$$V_{t+3} = P_{t+3}S_{t+3} = P_{t+3}^e[S_t - N_t - N_{t+1} - N_{t+2}] = (1+r)^3\left[V_t - N_t - \frac{N_{t+1}}{1+r} - \frac{N_{t+2}}{(1+r)^2}\right].$$

X_{t+T}^e is the Ministry of Finance's forecast of X_{t+T} at time t. X_t equals oil income, oil price, oil production, dependency ratio or GDP. T is the year farthest into the future for which a forecast was given. We base our estimates on the first approach, because this seems to be most realistic. The qualitative nature of our estimates does not vary much if either of the two alternatives is used.

Variables measuring permanent values: Permanent values are calculated by the information approach, i.e., we use only published expectations from the authorities and a 2% discount rate. Projections of oil production and reserves are comparable over time, since they are given in volumes and we convert all to standard cubic meters oil equivalents (Sm3 oil equivalents). Oil and gas production value is oil and gas production in oil equivalents multiplied with the oil price. Oil price and production value projections are recalculated to 2007-NOK for consistent comparison over time, and measured as shares of GDP in 2007-NOK. The dependency ratio of interest to the Ministry of Finance has changed over time. The lower age of the labor force has increased over time, while the pension age has varied between 65 and 70. We calculate the growth rate of the predicted dependency ratio at the time and apply this growth rate to the current dependency ratio convention of population aged 67 or more relative to population aged 20-66. We use the actual 67+/20-66 ratio for the year the projection was published as the start of each projection. For GDP, the Ministry's projections focus on growth in real GDP and we apply its projected growth rates to a starting point set by GDP in 2007 prices.

Current oil and gas revenue received by the state is as reported by the Ministry of Oil and Energy, and measured as described above. The current dependency ratio is the population aged 67 and higher divided by the population aged 20-66. Debt (i.e., net debt excluding the petroleum fund, denoted d^g) and the Fund (the state's pension fund abroad – previously called the petroleum fund, denoted f) are measured in current NOK as shares of GDP. The output gap is the logarithmic deviation from GDP trend, which is calculated from the Hodrik-Prescott filter of GDP in 2000 NOK with the smoothing parameter set to 1600 (the standard choice of the Norwegian Ministry of Finance for annual data). The Norwegian CPI serves as deflator to measure variables in 2007-NOK.

Up to 2005 we use long-term budgets (Langtidsprogram) as our source for the Ministry's expectations. The first long-term budget was published in 1953 with budgeting for the succeeding four years (1954-57). The practice of a new long term budget every fourth year was maintained up to 2001, covering 2002-05. Since then long-term budgeting has been replaced by long-run perspectives (Perspektivmelding 2004 and 2009). We have supplemented the long-term budgets and perspectives with detailed information from three parliamentary documents that explicitly address oil and gas issues (Stortingsmelding 25 1973-74, Stortingsmeldig 30 1973-74 and Tempomeldingen NOU 1988:27). The budget documents up to 1998-2001 were from the Library of Statistics Norway. We focus on the fiscal reaction functions for the central government, which is the receiver of public oil rents.

The table below shows data definitions and sources.

Variable definitions and data sources

Variables	**Years**	**Definition**	**Table**	**Publication**	**Inst.**	**www**
Government revenue (including net capital income)	1954-1975	Total revenue -interest payments - transfers from abroad	Table 243	Historical statistics 1978	Statistics Norway	http://www.ssb.no/histstat/hs1978/hs1978.pdf
	1976-1977	Total revenue -interest payments	Table 23-11	Historical statistics 1994	Statistics Norway	http://www.ssb.no/emner/historisk_statistikk/tabeller/23-23-11.txt
	1978-2007	Total revenue -interest payments	Statbank	National accounts, Institutional sector accounts	Statistics Norway	http://www.ssb.no/english/subjects/09/01/
n = Oil and gas revenue current	1954-1970	Set to zero as no production				
	1971-2007	Ordinary tax + Special tax + Production fee + Area fee + Environmental taxes + Net cash flow SDFI + Dividend StatoilHydro	Table 1.1	Facts, The Norwegian Petroleum Sector 2008	Ministry of Petroleum and Energy	http://www.npd.no/en/Publications/Facts/Facts-2008/
n^p = Oil and gas revenue permanent		Calculated based on projections by Ministry of Finance and "information" approach	Calculated			
Government expenditures (excluding capital expenses)	1954-1975	Total expenditure - Increase in net claims - interest payments	Table 243	Historical statistics 1978	Statistics Norway	http://www.ssb.no/histstat/hs1978/hs1978.pdf
	1976-1977	Total expenditure - interest payments	Table 23-11	Historical statistics 1994	Statistics Norway	http://www.ssb.no/emner/historisk_statistikk/tabeller/23-23-11.txt
	1978-2007	Transfers + Government consumption	Statbank	National accounts, Institutional sector accounts	Statistics Norway	http://www.ssb.no/english/subjects/09/01/
Capital income	1954-1969	Capital income	Table 243	Historical statistics 1978	Statistics Norway	http://www.ssb.no/histstat/hs1978/hs1978.pdf
	1970-2007	Capital income		Database of the macroeconomic model Modag	Statistics Norway	http://www.ssb.no/emner/09/90/sos108/sos108.pdf
Capital expenses	1954-1969	Capital expenses	Table 243	Historical statistics 1978	Statistics Norway	http://www.ssb.no/histstat/hs1978/hs1978.pdf
	1970-2007	Capital expenses		Database of the macroeconomic model Modag	Statistics Norway	http://www.ssb.no/emner/09/90/sos108/sos108.pdf
Gross assets	1954-1969		Table 244	Historical statistics 1978	Statistics Norway	http://www.ssb.no/histstat/hs1978/hs1978.pdf
	1970-2007			Database of the macroeconomic model Modag	Statistics Norway	http://www.ssb.no/emner/09/90/sos108/sos108.pdf
Gross debt	1954-1969	Growth rate applied to calculate backwards from level in 1970	Table 242	Historical statistics 1978	Statistics Norway	http://www.ssb.no/histstat/hs1978/hs1978.pdf
	1970-2007			Database of the macroeconomic model Modag	Statistics Norway	http://www.ssb.no/emner/09/90/sos108/sos108.pdf
Gross Domestic Product in current NOK	1954-2007			Historical accounts	Central bank of Norway	http://www.norges-bank.no/templates/article____42332.aspx

GDP deflator (expenditure side)	1954-2007	Index equal to 100 in 2000, but rescaled to 1 in 2007 so all fixed prices measured in 2007 NOK		Historical accounts	Central bank of Norway	http://www.norges-bank.no/templates/article 42 332.aspx
Non-oil/gas government revenue		*Total government revenue – oil and gas revenue*	Calculated			
Net Capital income		*Capital income - Capital expenses*	Calculated			
τ = Non-oil/gas primary government revenue		*Non-oil/gas government revenue - (Net capital income - Net cash flow SDFI - Dividend StatoilHydro)*	Calculated			
g = Government expenditures		*Government expenditures*	Calculated			
b = Non-oil/gas primary government deficit		*Non-oil/gas primary government revenue - Government expenditures*	Calculated			
p = Dependency ratio current	1954-2007	Population aged 67 and higher divided by population aged 20-66	Calculated	Population Statistics	Statistics Norway	http://www.ssb.no/english/subjects/02/befolkning_en/
p^p = Dependency ratio permanent		Calculated based on projections by Ministry of Finance and "information" approach	Calculated			
d^g = debt		Gross debt - (Gross assets - Fund)		National accounts, Institutional sector accounts	Statistics Norway	http://www.ssb.no/english/subjects/09/01/
f = Fund	1954-1995	Set to zero				
	1996-2007	Fund value in current NOK by December 31st		Central bank of Norway		
y = output gap	1954-2007	Gross Domestic Product in 2000 NOK, log of Gross Domestic Product as deviation from HP-trend with smoothing parameter set to 1600. HP-filtering was done by the authors		Historical accounts	Central bank of Norway	http://www.norges-bank.no/templates/article 42 332.aspx

Background data and calculations for fig. 6

The PIH simulations use forecasts of total transfers and suppose that the other components of government spending are a constant share of GDP. In our regressions, we use the dependency ratio. Our estimated coefficient includes in effect a "price", which links the dependency ratio to government expenses, in addition to the behavioural effect of government spending on the fiscal stance. Given the predictions of transfers and the dependency ratio (Perspektivmeldingen 2009) and our calculations of their permanent values, we estimate $g_t = 0.069 + 0.488 p_t$ and $g_t^p = 0.080 + 0.458 p_t^p$. Our estimates of the effect of the current and permanent dependency ratio on the non-oil/gas primary deficit suggest a coefficient of about 1 for the current dependency ratio and a coefficient of about –0.9 for the permanent dependency ratio (Harding and van der Ploeg, 2009). Translated into government transfers, our estimates imply that a 1%-point increase in current government transfers increases the non-oil/gas primary deficit with about 2%-points. A 1%-point increase in permanent government transfers decreases the non-oil/gas primary deficit with about 2%-points. To get values for the predicted value of current and predicted oil production as share of GDP (predicted *n* and n^p), we use the series for the predicted current government oil revenue as share of GDP (predicted *n*) and the coefficients as estimated in the first stage; column (a) upper panel of table 2 (i.e., in the simulations we set $v=n/0.456$ and $v^p=np/0.456$). We assume that government spending *g* equals total transfers, the discount factor is 2%, the return on the fund is 4%, and that total transfers and oil and gas revenue to the state follow the paths presented by Ministry of Finance in January 2009 (Perspektivmeldingen 2009). The estimates are based on percentages of GDP, whereas the projections of Ministry of Finance on mainland GDP. The oil price used in the projections is about 65 USD per barrel. The projected size of the Fund is based on the series for the Fund-to-Mainland GDP and Mainland GDP-to-GDP presented by the Ministry of Finance in Perspektivmeldingen (2009).

Appendix 2: Emergence of the oil and gas windfall in Norway

The **history** of Norway as a oil and gas nation started in 1969. Ten years after the Netherlands found gas in Slochteren, the first oil field within the territory of Norway – Ekofisk – was discovered. This was one of the world's largest offshore oil basins and started production in the summer of 1971. Today there are 57 oil and gas fields in production and Norway is ranked as the fifth largest exporter and the 11th largest producer of oil in the world. Norway was in 2006 the third largest exporter and sixth largest producer of gas. In 2007 the oil- and gas industry constituted 24 and 48 percent of GDP and exports, respectively.[18] The Ministry of Oil and Energy (OED 2008) suggests that about 36 percent of expected total production is currently produced. The peak of oil production was probably passed around the turn of the millennium and the composition of production is tilting away from oil and other liquids towards gas. In 2007 gas contributed 40 percent of production.

Both the time path of oil prices and that of oil and gas production and government revenue have a positive trend over the past four decades. Part of volatility of government income is caused by oil price fluctuations, but the tax regime and government's direct engagements have also contributed substantially to volatility. The implicit tax rate on oil and gas revenues also has an upward trend.

From the late 1970s to mid 1980s, effective **ordinary and special tax rates** on value added saw a volatile but gradual rise followed by a sharp fall in the late eighties and much lower rates during the 1990s. Recent years have seen a sharp rise in these tax rates. Special taxes on oil and gas have since the early 1990s taken over from ordinary taxes in importance. Together they constitute almost 35 percent of value added. The other big chunk of government revenue is net cash flow from the State's Direct Financial Interest in the gas/oil industry (SDFI). After initial investment outlays of up to 20 percent of value added in the mid 1980s, net return on state holdings is now more than one fifth of value added. Production fees used to be an important source of public revenue, but nowadays are almost gone. Dividends from Statoil have recently tracked (with a short lag) the development of oil prices and have now reached about 3 percent of value added. Environmental taxes rose from zero in 1990 to 2.5 percent in 2000 but are a bit over half percent of value added. Area fees contribute even less to government revenue. Total public income from oil and gas revenues is now about 60 percent of value added, most of it being special and ordinary takes and returns from stake holdings.

Government expectations of **future oil and gas revenue** have followed current revenue closely. Current values are lower than permanent values in the beginning of the hydrocarbon area, which is consistent with increasing production soon after oil and gas was discovered. The time path of current oil and gas revenues now lies above the permanent path as oil and gas revenues are expected to fall in the future. This should signal a shift from borrowing to saving oil and gas revenues; something the Norwegian government has started doing for some time.

The 1960s and 1970s saw a gradual rise in both primary **spending** and non-oil/gas **taxes**. After the onset of oil and gas revenue in the early 1980s, taxes and spending first fell and then increased relentlessly, roughly in line with each other. The non-oil/gas primary deficit (b) has fluctuated around two plateaus, with the level shifting in the late 1970s. In the post war, pre-hydrocarbon period the government ran a surplus of about 3 percent of GDP. In the later period the average deficit has been around 4 percent of GDP. Oil revenue has allowed for running a higher non-oil/gas primary deficit. The key question is whether the higher non-hydrocarbon primary deficits in the hydrocarbon era are sustainable in view of the long-term budgetary commitments of the Norwegian government.

The **fiscal rule** backed by the Norwegian parliament in Spring 2001 states that the government on average should keep the structurally adjusted, non-oil/gas deficit in year t to 4 percent of the Fund at the end of the previous year. The deficit relative to the fund was close to 4 percent in 2001, so that the rule may be seen as a formalization of going policy at the time. There has been a gradual increase in net government assets excluding the Fund (negative d) and a switch from a small surplus to a somewhat larger deficit for the non-oil/gas primary budget deficit. The two episodes in the 1980s and 1990s with negative output gaps (high unemployment) are associated with large increases in the non-oil/gas primary budget deficit. The Norwegian Fund started in 1990 and has since then rapidly increased to about 90 percent of GDP. The global financial crisis wiped out a big chunk of the Fund.

We focus on the **primary non-oil/gas deficit,** cleaned for both net capital income and oil revenue and take all lending and borrowing and their associated revenues and costs should be taken into account. In contrast, the non-oil/gas budget deficit used by the Ministry of Finance includes net capital income

[18] For the history of oil and gas as well as the institutional background, we draw on OED (2008, Ministry of Petroleum and Energy/Norwegian Petroleum Directorate, www.npd.no/NR/rdonlyres/24468CE3-30DC-497F-9E43-501FBC48A131/17867/Facts_2008.pdf)

(excluding those from hydrocarbon-related assets). The structural deficit used by the Ministry of Finance corrects the deficit for business cycle adjustments.[19] The biggest deviation in our definition of the deficit and that of the Ministry of Finance occurs in 2000, which is most likely due to different treatment of the state's direct oil engagement (SDFI).[20]

The gradual rise in the 67+ **dependency ratio** in Norway has led to a gradual rise in the need for funding public pension obligations. In the far future, graying of the economy will increase spending needs even further, so that it is sensible to provide for these future needs by having a smaller budget deficit or a surplus. Given the relatively small size of Norway, its sovereign wealth fund is very large.

In response to the oil and gas windfall, the Norwegian government has produced various **policy documents and initiatives**. In chronological order, they can be summarized as follows.

1973-75: Analytical work by the Ministry of Finance and the Ministry of Industry led to three important documents covering Dutch disease issues, size of reserves, likely lifecycles of fields and environmental concerns. There was not much discussion of long-run spending needs.

1983: The Tempo Committee headed by Hermod Skånland, Central Bank Governor 1985-94, produced its report on "The Future of the Petroleum Activity" (NOU 1983: 27). It recommended the bird-in-hand approach, which says that the government should put its oil and gas revenues in a fund and spend only the real return on the assets accumulated in this fund.[21] The Tempo Committee also discussed in detail how such a petroleum fund and spending rule should work in practise. It pointed out the importance of converting oil and gas assets in the ground into financial assets in a fund and of decoupling oil and gas income from spending. Due to political pressures to spend, the Tempo Committee discounted the likelihood of such a Stabilization Fund being implemented and therefore recommended slow extraction of oil and gas as a way to distribute oil and gas wealth to future generations.

1988: The policy Committee headed by Professor Erling Steigum, then NHH Bergen and now at BI Oslo, presented its report "The Norwegian Economy in Change - Prospects for National Wealth and Economic Policy in the 1990s" (NOU 1988: 21). This report suggested that government spending should depend on the permanent income of total oil and gas wealth consisting of the financial fund plus the value of oil and gas reserves in the ground. The calculation of total oil and gas wealth requires the prediction of an optimal depletion path given expected oil/gas prices, technology and interest rates. In contrast to the Tempo Committee, the Steigum Committee did argue for the establishment of a financial hydrocarbon fund. It stressed the importance of regarding such a fund and the value of oil and gas reserves in the ground as part of the same portfolio. It also offered arguments for selling oil before extracting the oil as well as for going short in oil stocks.

2001: The Norwegian government implemented its 4% BIH rule, which allows for a business-cycle corrected deficit equal to 4 percent of the value of the Fund measured in Norwegian kroner at the end of year $t-1$. Hence, 4 percent of the value of the Fund at the end of the previous year is allowed to be extracted from the Fund and to be used to fund the general government deficit. The Fiscal Policy Guideline (Handlingsregelen) interpreted the 4% as the expected future real rate of return of the Government Pension Fund, so non-renewable petroleum wealth had to be invested abroad and transformed into financial wealth (5% of which in property). The basis sustainability rule was inspired by Hartwick (1977) and starts only the expected future rate on return could be used for domestic consumption purposes.

[19] It corresponds on average to 97% of the value difference since 1985. A regression explaining the difference with the business cycle adjustment gives R-squared of 0.87. The structural deficit is net of oil and gas revenue and should over time equal 4% of the fund measured at the end of the previous year. The Ministry also corrects for the business cycle, cyclical variations in transfers from the Central Bank and capital income, and special accounting circumstances (see Revised National Budget for 2004, p. 29).

[20] From 1999 to 2000 the cash flow from this engagement went from 25 billion NOK to 98 billion NOK. We assume that income from SDFI is counted as capital income and exclude it from our definition of the deficit.

[21] See speech (in Norwegian) of research director Ådne Cappelen, Statistics Norway, 2000, for discussion of spending of oil money (www.ssb.no/forskning/foredrag/arkiv/art-2000-10-06-01.html).

2006: The Government Pension Fund of Norway comprises two separately managed funds. The main one is the Government Pension Fund Global renamed 1 January 2006 and part of the Norwegian Central Bank (formerly The Government Petroleum Fund established in 1990 and receiving money since 1996). It manages the surplus wealth produced by Norwegian petroleum income (taxes and licenses) and had a value of NOK 2.385 trillion in August 2009. This made it the largest pension fund in Europe and the second largest in the world. Its objective is to counter the decline of expected petroleum income and to smooth the disrupting effects of highly fluctuating oil prices. Since 1998, the fund was allowed to invest up to 40 percent of its assets in the international stock market, but this was increased to 60 percent in 2007. Much of the debate surrounding the fund is on how to contain the risks in investing in the international stock market, ensure ethically sound investments (away from arms and tobacco) and avoid inflation when its return is spent. The other fund is the Government Pension Fund Norway renamed 1 January 2006 (formerly The National Insurance Scheme Fund established in 1967) has value of NOK 106.9 billion at end of 2006.

2006: The Norwegian government undertook reforms to trim pension rights. Pensions are no longer indexed to wage growth but indexed to the average of wage growth and inflation (typically, less). Furthermore, the lifetime value of the pension is a fixed amount calculated around age 60 and is based on expected *average* life expectancy for the cohort of 60-year olds. The focus is on keeping people in work longer and to retire later whilst allowing for some freedom of choice. The individual can decide whether to work long and enjoy a higher pension pay per retirement year or enjoy more retirement years with a lower pension. The average de facto retirement age (including early retirement and partly disabled) is currently ("pre-reform") around 59 years, but is expected to rise a little. Compared with most OECD countries, Norway's pension system is still very generous.

Appendix 3: Econometric robustness checks

A3.1 Instrumenting current and permanent hydrocarbon income with production values

Given that the variables in (9a)-(9b) are I(1) and our fiscal reaction functions will be cointegration relationships between the variables b (or g or t), n, n^p, p-p^p, f-d^g and y, instruments can be used to achieve consistent estimates (Phillip and Hansen, 1990).[22] We use current and permanent oil and gas *production value* as instruments for current and permanent hydrocarbon *income* (see the main text for a discussion of exogeneity).

Panel A of table A1 shows the first-stage IV regression for our econometric time-series model (9a)-(9b) in panel B. Current oil and gas production value predicts current oil and gas revenue with a coefficient of 0.46. For permanent production value, we find a robust positive coefficient of 0.2. Partial R-squared and F-tests indicate that predictive power of the instruments is good.

Test statistics of the Augmented Engle-Granger test for cointegration in the first stage are shown in the bottom rows of panel A. We reject a unit root in the residuals from the current oil and gas revenue equation (see statistics in bold), but the evidence against a unit root is weaker for permanent oil and gas revenue. The non-stationarity in the endogenous variables should be driven by the non-stationarity of the exogenous variables through a cointegration relationship for 2SLS to be valid for non-stationary data, so we must interpret our 2SLS results with caution (Hsiao, 1997, 2006).[23]

Turning to the second stage, the unit root tests of the residuals from the estimated fiscal reaction functions reported in panel B of table A1 indicate that a unit root cannot be rejected in the residuals. However, the estimates are similar to what we obtain with our other estimators and spurious correlation does not seem to be a big concern.

The IV-estimate of the reaction for the non-oil/gas primary deficit suggests that a third of each extra

[22] Even irrelevant or spurious instruments can be used for consistent estimation in a cointegrating system as the spurious correlation is enough for the instrument to meet the relevance condition (Phillip and Hansen, 1990; Phillips, 2006). We prefer to use relevant instruments (cf., Bårdsen and Haldrup, 2006).

[23] However, if our assumption of strictly exogenous explanatory variables/instruments does not hold, the OLS and 2SLS estimates of the cointegration relationship are inefficient and can also produce biased estimates in our finite sample (Bårdsen and Haldrup, 2006; Banerjee et al., 1986; Montalvo, 1995; Gonzalo, 1994).

Krone of oil and gas revenue is spent on increasing the deficit. For permanent revenue, the effect is 0.7, compared to 0.3 under OLS. The IV-estimate of the effect of the current over permanent dependency ratio is the same as the OLS-estimate. For the previous year's net assets, the coefficient is now 0.08. Comparing with table 1 in the main text, the OLS bias seems only severe for permanent oil and gas revenue and net assets. Based on signs, magnitudes and statistical significance, the estimates of the fiscal responses presented in table A1 are thus consistent with the theory put forward in section 2 and the OLS-estimates presented in Table 1.

Table A1: Fiscal responses with permanent oil and gas revenue - IV-estimates

Panel A: First stage		
	Oil and gas revenue current (n) OLS	Oil and gas revenue permanent (n^p) OLS
Dependency ratio current - permanent (p - p^p)	-0.355**	-0.628***
	(0.152)	(0.180)
Last year's net assets ($-d$)	-0.009	0.024
	(0.023)	(0.031)
Output gap (y)	0.059	0.061
	(0.093)	(0.092)
Oil and gas production value (v)	0.456***	0.041
	(0.051)	(0.042)
Oil and gas production value permanent (v^p)	-0.075**	0.201***
	(0.035)	(0.032)
Constant	-0.007***	-0.014***
	(0.002)	(0.002)
Observations	54	54
R-sq	0.92	0.87
AEG test on residuals form first stage, lags:		
0	**-5.327**	-3.605
1	**-5.997**	-3.814
2	**-5.159**	-3.451
3	-4.097	**-4.482**

Critical values: 1% -5.387; 5% -4.685; 10% -4.336.

Panel B: Second stage			
	(a)	(b)	(c)
Equation:	(9a)		(9b)
Dependent variable:	Deficit (b)	Expenditure (g)	Taxes (t)
Estimation method:	IV	IV	IV
Oil and gas revenue current (n)	0.356**	0.939***	0.583***
	(0.142)	(0.150)	(0.224)
Oil and gas revenue permanent (n^p)	0.709***	-0.800***	-1.509***
	(0.255)	(0.305)	(0.367)
Dependency ratio current - permanent (p - p^p)	1.491***	1.142***	-0.349
	(0.171)	(0.265)	(0.275)
Last year's net assets ($-d$)	0.081*	0.378***	0.298***
	(0.044)	(0.066)	(0.076)
Output gap (y)	-0.598***	-0.179	0.419
	(0.220)	(0.221)	(0.294)
Constant	-0.010*	0.234***	0.244***
	(0.005)	(0.008)	(0.008)
Observations	54	54	54
R-sq	0.68	0.86	0.70
Shea n	0.69	0.69	0.69
Shea n^p	0.56	0.56	0.56
F instr. N	52.30	52.30	52.30
F instr. n^p	21.54	21.54	21.54
AEG test on residuals from second stage, lags:			
0	-4.018	-3.946	-3.732
1	-4.047	-2.861	-3.300
2	-4.277	-2.490	-3.120
3	-3.426	-2.630	-2.977

Critical values: 1% -5.387; 5% -4.685; 10% -4.336.

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. For the AEG (Augmented Engle-Granger) test, critical values are based on McKinnon (2010) and generated from the Stata program module Schaffer (2010) for the first stage. For the second stage, test statistics are obtained with the dfuller-test in Stata. The optimal lag-length due to the AIC and BIC criteria is 1 period.

A3.2 FMOLS and CCR estimates

If regressors are not strictly exogenous, the OLS estimates of the cointegrating relationship do not have an asymptotically efficient distribution, thus invalidating standard tests. As a robustness test we re-estimate in table A2 the reaction functions with Fully Modified Ordinary Least Squares (FMOLS, Phillips and Hansen, 1990) and Canonical Cointegration Regression (CCR, Park, 1992). We now also offer additional tests on cointegration next to the Engle-Granger test. As shown in the lower panel of table A2, the Engle-Granger and Phillips-Ouliaris tests do not reject a unit root for the formulation with oil and gas revenue, but do reject a unit root in the formulation with oil and gas production value (consistent with tables 1 and 2). The Hansen Parameter Instability and Park Added Variables tests do not reject cointegration for either specification. Not rejecting a unit root in the residuals of table 1 with the Augmented Engle-Granger tests might thus be due to low power of the tests rather than lack of cointegration.

Table A2: Estimates of non-oil/gas primary deficit (*b*) with permanent oil and gas revenue

	(a)	(b)	(c)	(d)
Equation:	(9a)	(9a)	(9a)	(9a)
Dependent variable:	Deficit (*b*)	Deficit (*b*)	Deficit (*b*)	Deficit (*b*)
Estimation method:	FMOLS	CCR	FMOLS	CCR
Oil and gas revenue current (*n*)	0.404***	0.424**		
	0.148	0.165		
Oil and gas revenue permanent (n^p)	0.368*	0.339		
	0.192	0.208		
Oil and gas production value (*v*)			0.235***	0.233***
			0.058	0.058
Oil and gas production value permanent (v^p)			0.120***	0.122**
			0.044	0.046
Dependency ratio current - permanent ($p - p^p$)	1.869***	1.835***	0.949***	0.905***
	0.232	0.260	0.225	0.267
Last year's net assets ($-d$)	0.172***	0.169***	0.089**	0.087**
	0.045	0.047	0.036	0.038
Output gap (*y*)	-0.629***	-0.608***	-0.611***	-0.598***
	0.179	0.171	0.132	0.126
Constant	-0.013**	-0.013*	-0.023***	-0.024***
	0.006	0.007	0.005	0.005
Observations	53	53	53	53
R-squared	0.70	0.70	0.78	0.78
Re-calculated size corresponding to Hydrocarbon revenue# :				
Oil and gas production value (*v*)			0.515	0.511
Oil and gas production value permanent (v^p)			0.263	0.268

Cointegration tests on residuals			*n* and *np*			*v* and *vp*		
	Null hypothesis		Test statistic	Probability		Test statistic	Probability	
Engle-Granger	Not cointegrated	Engle-Granger tau	-4.463	0.145	§	-5.058	**0.047**	§
		Engle-Granger z	-28.396	0.160	§	-33.503	**0.058**	§
Phillips-Ouliaris	Not cointegrated	Phillips-Ouliaris tau	-4.459	0.146	§	-4.963	**0.058**	§
		Phillips-Ouliaris z	-28.301	0.162	§	-30.449	**0.109**	§
Hansen Parameter Inst.	Cointegrated	Lc statistic	0.056	**> 0.2**	¤	0.598	**> 0.2**	¤
Park Added Variables	Cointegrated	Chi-square	3.319	**0.190**		3.178	**0.204**	

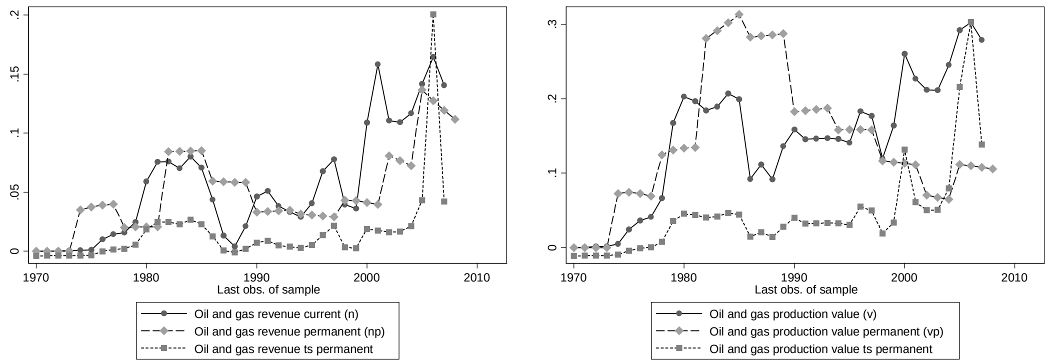
Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The sample is adjusted in accordance with the estimation methods FMOLS (Fully Modified OLS) and CCR (Canonical Cointegrating Regression) to 1955-2007. Long-run variances are computed using the Bartlett kernel with Newey-West fixed bandwidth of 4.0000. # To make coefficients comparable, coefficients are rescaled by dividing the current and permanent oil and gas production value coefficients by 0.456, i.e. the first stage coefficient in column 1 of the top panel of table A1. Cointegration tests on residuals: Bold p-values indicate support for cointegration. §MacKinnon (1996) p-values. ¤Hansen (1992) p-values. Tests performed in EViews 7 and default options are chosen.

Regardless of the estimation method, current oil and gas revenue/production is quantitatively and statistically more important than their permanent value. As before, using oil and gas revenue rather than the more exogenous oil and gas production decreases the coefficients on the dependency ratio measure and net assets dramatically. We prefer the latter estimates in view that dealing with identification is essential also under non-stationarity and cointegration (Hsiao, 2006).

A3.3. Permanent values based on time-series model

The left-hand panel of figure A1 shows the two alternative measures of the permanent value of oil and gas revenue – based on official forecasts and a time-series model – together with the series for the current values. The right hand side panel does the same for the production value. The series based on the time series models under-predict both the official and the current ones, except for in the end of the sample.

Figure A1: Permanent values from time-series estimates compared to permanent values based on official forecasts



Note: "ts" indicates permanent value series based on estimates of (11) and calculated by (13) in the main text. T=100. a_0 and a_1 in (11) before 1986 are set to the 1986 values, as a_1 >1 before 1986. The value of "Oil and gas revenue ts permanent" for year 2001 was an outlier and was replaced by the average of the 2000 and 2002 value.