Is Norway's Bird-in-Hand Stabilization Fund Prudent Enough?

Fiscal Reactions to Hydrocarbon Windfalls and Graying Populations

Torfinn Harding

Frederick van der Ploeg

CESIFO WORKING PAPER NO. 2830

CATEGORY 1: PUBLIC FINANCE

OCTOBER 2009

CESifo *Working Paper No. 2830*

Is Norway's Bird-in-Hand Stabilization Fund Prudent Enough?

Fiscal Reactions to Hydrocarbon Windfalls and Graying Populations

Abstract

We estimate fiscal reaction functions for non-hydrocarbon tax and public spending shares of national income and for debt management strategies adopted by Norway and compare these with rules that would prevail under the permanent income hypothesis and bird-in-hand rule. We conclude that the fiscal reaction functions adopted by Norway have to some extent been forward-looking when it comes to the rising pension bill, but backward-looking when it comes to hydrocarbon revenues. Still, our results suggest that the imminent costs of a rapidly graying population are not sufficiently taken into account in the current fiscal rules, since Norway is on a trajectory of turning a current net asset-GDP-ratio close to one into a net debt-GDP-ratio of two in 2060. Something needs to give in the holy trinity: either the rules of the Stabilization fund have to be tightened, or civil servant salaries, benefits and pensions will no longer have to be fully indexed to market wages, or the retirement age has to be increased.

JEL Code: H20, H63, Q33.

Keywords: permanent income hypothesis, oil windfall, sovereign wealth fund, graying population, pension bill, unsustainable public finances.

Torfinn Harding
Department of Economics
University of Oxford
Manor Road Building
Oxford OX1 3UQ
United Kingdom
torfinn.harding@economics.at.uk

Frederick van der Ploeg
Department of Economics
University of Oxford
Manor Road Building
Oxford OX1 3UQ
United Kingdom
rick.vanderploeg@economics.ox.ac.uk

7 October 2009
This research was supported by the BP funded Oxford Centre for the Analysis of Resource Rich Economies. Harding is also affiliated with Statistics Norway and van der Ploeg with the University of Amsterdam and CEPR. We have benefited from comments of Facundo Alvaredo, Maarten Bosker, Ådne Cappelen, Erling Holmøy, Rocco Macchiavello, Egil Matsen, Joakim Prestmo, Jørn Rattsø, Guido Schotten, Ragnar Torvik, Tony Venables, Peter Wierts and seminar participants at the University of Trondheim and Statistics Norway.

1. Introduction

Norway puts its oil and gas revenues in a Stabilization Fund and only draws 4 percent per annum from this Fund to finance public spending or tax cuts. This way Norway should be able to spread the benefits of its hydrocarbon revenues to future generations. Its way of managing resource revenues is generally regarded as a good example for other resource-rich countries to follow. But does Norway really follow a conservative bird-in-hand (BIH) by consuming only already received hydrocarbon revenues? Does Norway implement the hydrocarbon permanent income hypothesis (HC-PIH) in the sense that it borrows against future hikes in hydrocarbon revenues and that public consumption reacts to permanent hydrocarbon revenues? However, a key challenge for Norway is its rapidly graying population and the increase in pension and health care costs that go with that and, unfortunately, neither the HC-PIH nor the BIH rules take account of these rising costs. We therefore argue that HC-PIH and BIH policy rules may not be prudent in light of the rising pension commitments. It is preferable to use a permanent income hypothesis rule which takes account of future pension obligations as well as future hydrocarbon revenues (the PIH rule). Our empirical results suggest that the current fiscal rules imply a too small asset build up to cover for the future costs of Norway's graying population. Consequently, we argue that Norway is locked in a vicious policy dilemma unless tough policy choices are faced. However, currently, Norway does not seem prepared to dismantle its holy trinity of indexed pensions (and civil servant salaries), an average actual retirement age of 59 years[2] and the rules of the Stabilization Fund. To make Norway's fiscal stance sustainable, something in this holy trinity has to give.

We depart from previous empirical cross-country studies on fiscal reactions to hydrocarbon windfalls (e.g., Bornhorst, 2008; Ossowski et al., 2008) in five ways. First, we focus on the intertemporal aspects of the fiscal stance for one particular country, Norway. This has the advantage that one can test the time-series hypotheses of the HC-PIH, PIH and BIH rules and analyze the optimal management of public debt and sovereign wealth. Second, the empirical tests of whether countries follow the HC-PIH, PIH or BIH rule are not confounded by differences in institutional quality, rule of law, degree of corruption, etcetera across countries. Third, we take account of the endogeneity of oil/gas windfalls by using instrumental variables. Fourth, thanks to long-term budgeting in Norway since the 1950s we are able to calculate time series of forecasted future and thus of permanent hydrocarbon revenue and of the ratio of pensioners to the work force. When these series are included in our empirical model, they eliminate an important omitted variable bias and allow identification of separate effects of *current* and *permanent* values, of hydrocarbon revenue and the old-age dependency ratio consistent with the theory. Fifth, we provide a theoretical underpinning of the fiscal reactions to a windfall of foreign exchange. Our normative theoretical framework is based on the theory of tax smoothing and public debt management (Barro, 1979) which is also familiar from studies on aggregate consumption (e.g., Deaton, 1992) and on how to apply the PIH to the macroeconomic management of natural resource revenues (e.g., Ossowski et al., 1979; Barnett and Ossowski, 2003; Medas and Zakharova, 2009). We conduct our analysis by expressing all variables as proportions of the national income and find that the optimal long-run size of the Stabilization Fund as a fraction of the national income generates sufficient interest income to

[2] Including retirement due to disability (www.regjeringen.no/nb/dep/fin/dok/nouer/2004/nou-2004-1/5/2.html?id=383409).

ensure a permanent increase in private and public consumption also after the hydrocarbon revenue has ceased to flow. For the Norwegian government, the development of a substantial Fund is itself probably seen to be an achievement and something to be proud of. Also, there is no reason to quickly pay off a large initial debt as the hike in taxes required to achieve this would violate the principle of tax smoothinq. But the Norwegian government may adopt a bird-in-hand rule and have a declining interest revenue from the Fund as percentage of the national income. We briefly discuss extensions such as Fund or debt convergence targets, habit persistence (cf. Leigh and Olters, 2006; Olters, 2007), hyperbolic discounting (cf., Laibson, 1997) and precautionary buffers (cf., Sibley, 1975; Zeldes, 1989). Our model allows for unemployment and business cycle variations, but we abstract from behavioral relationships and general equilibrium effects. Instead, we take prices as given and focus on social welfare and intertemporal government budget constraints.[3][4]

Although existing work on fiscal rules for Norway pays due regard to old-age demographics and the rising cost of the pension bill (Jafarov and Leigh, 2007), we hope that our estimated fiscal reaction functions for Norway provide valuable insights whence simply imposing the rule that targets a non-hydrocarbon deficit equal to 4% of the Fund ignores any offsetting budgetary reactions the Norwegian government might engage in. To address the issue of fungibility head on, it is important to *estimate* fiscal reaction functions to allow for possible offsetting changes in government spending or non-oil tax revenues that are not covered by the 4% rule. We can thus compare our empirically estimated rule with the 4% rule and other more stringent rules that imply higher savings rates. Norway's fiscal sustainability has also been studied in general equilibrium models (e.g., Heide, et al., 2006; Holmøy and Stensnes, 2008). These suggest that the current fiscal regime violates tax smoothing, since there is evidence for a short-term tax reduction requiring a tax increase in the long run. In a model with overlapping generations, one obtains a long-term tax rate of 60 percent (Galaasen, 2009). We deviate from these calibration exercises by basing projected future government reactions on its reactions over the past 50 years and thus anchoring our simulations in reality. However, a shortcoming of our analysis is that it is partial equilibrium in that it treats wages, prices and interest rates as exogenous variables. Our results confirm that Norway's fiscal position is sound in the medium run, but that the mix of a higher pension burden and lower hydrocarbon income eventually will lead to a buildup of net debt unless there is a structural change in policies regarding the welfare state, the Fund or the fiscal rule. This coincides with the analysis of the Ministry of Finance, which also projects a rising gap between the pension burden and the return on the pension fund. There thus seems to be consensus that sustainability requires tightening of the current fiscal regime, adjusting the rules of the Fund or trimming pension rights in the longer run.[5]

Section 2 presents stylized facts on the emergence and development of Norway's hydrocarbon revenues, and gives some institutional details that are relevant for fiscal management in Norway. Section 3 discusses relevant policy initiatives that have been taken by Norway to manage the

---

[3] An alternative is to evaluate fiscal policy rules in a DSGE framework (Pieschacon, 2008).

[4] We thus also 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). One reason for this is that a recent study casts doubt on whether the curse really exists (Brunnschweiler and Bulte, 2008).

[5] See Yngvar Tveit, 2006 (logting.elektron.fo/Nevndargerdabokur/Nevgerdb06/Figgjarnevndin/DK-Nor-ferd/Myndir/Tilfar/Yngvar.pdf).

hydrocarbon windfall. Section 4 presents our analytical framework for optimal setting of the tax rate as well as the share of government spending, the non-hydrocarbon deficit and public debt as fractions of national income. We offer some testable hypotheses on how the non-hydrocarbon primary budget balance and the tax rate should respond to permanent and transitory shocks. We then briefly discuss how our hypotheses must be modified when there is a target for the size of the Fund, habit persistence, hyperbolic discounting, a BIH motive, and precautionary saving. Section 5 discusses our empirical specification and section 6 explains how the permanent values of future hydrocarbon revenues and pension spending needs are calculated. Section 7 takes our hypotheses to Norwegian data and tests for the PIH and its modifications. A novel feature is that we explicitly allow for the effects of a return on prospective oil/gas wealth (i.e., the permanent value of future oil/gas revenues) and for the effects of anticipated graying of the population on the non-hydrocarbon primary budget deficit and the national income share of public revenues. Section 8 simulates our estimated fiscal reaction rules, compares them with the HC-PIH and the PIH rules, and suggests that the current fiscal stance of Norway is unsustainable unless tough and unpopular policy choices are made. Section 9 concludes and offers policy conclusions.

2. Emergence of the hydrocarbon windfall in Norway

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.[6] 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.

The historical paths for the crude oil price as well as Norway's oil production and net government cash flow from petroleum activities are presented in the left panel of Figure 1. Both the time path of oil prices and that of hydrocarbon 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 direct engagements have also contributed substantially to volatility as may be seen from the implicit tax rate – the government share of value added – in the right panel of Figure 1. Furthermore, the implicit tax rate on hydrocarbon revenues also has an upward trend.

[6] 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)

Figure 1: Oil production and general government's oil revenues, 1945-2030

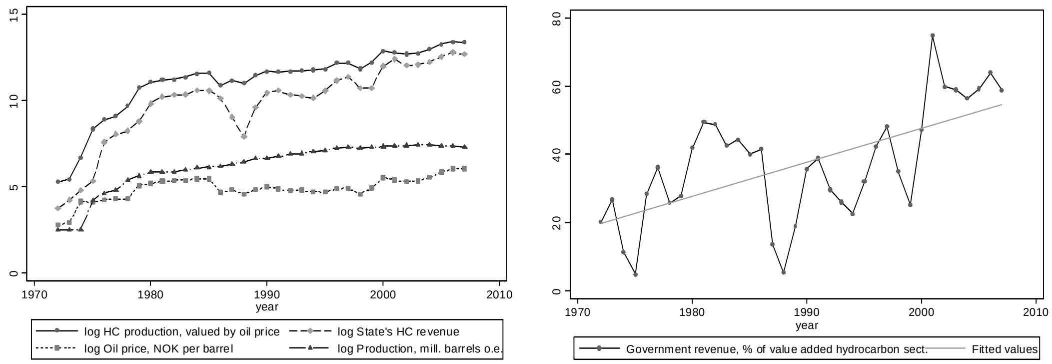
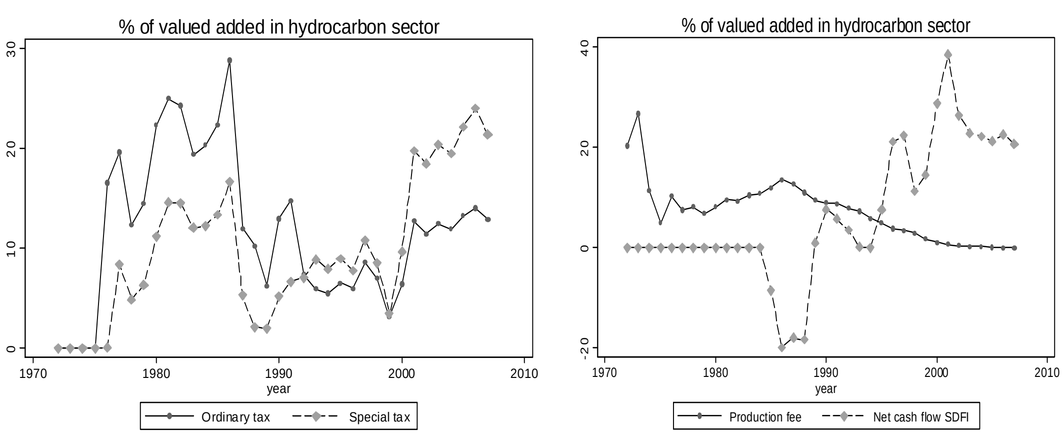


Figure 2 decomposes government income from hydrocarbons into seven components. From the late 1970s to mid 1980s, effective ordinary and special tax rates on value added saw a volatile but gradual rise followed by a sharp fall in the late eighties and much lower rates during the 1990s. Recent years have seen a sharp rise in these tax rates. Special taxes on hydrocarbons 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 hydrocarbon revenues is now about 60 percent of value added, most of it being special and ordinary takes and returns from stake holdings.

Figure 2: Components of government hydrocarbon revenues



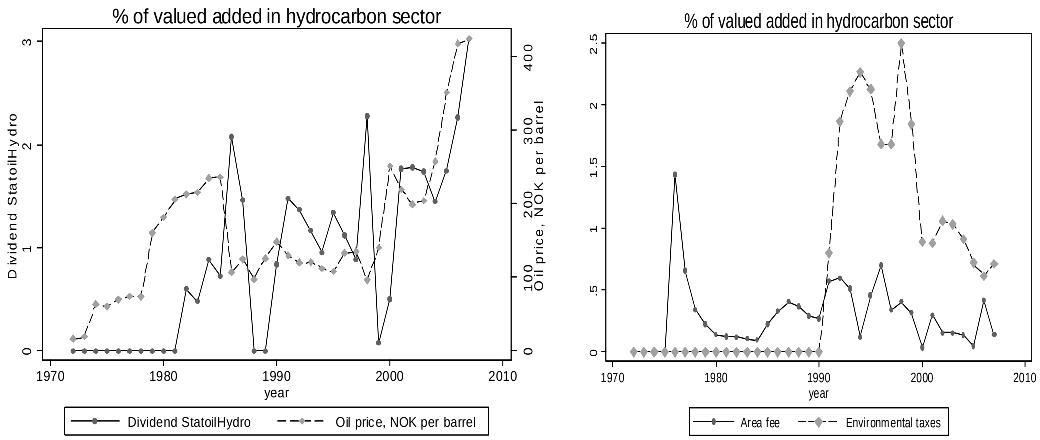
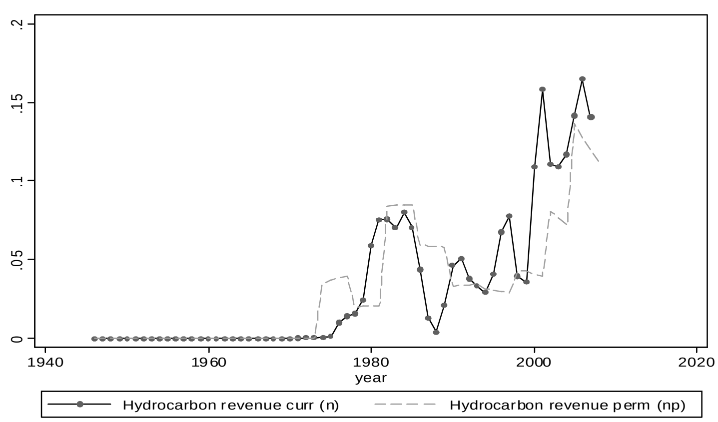


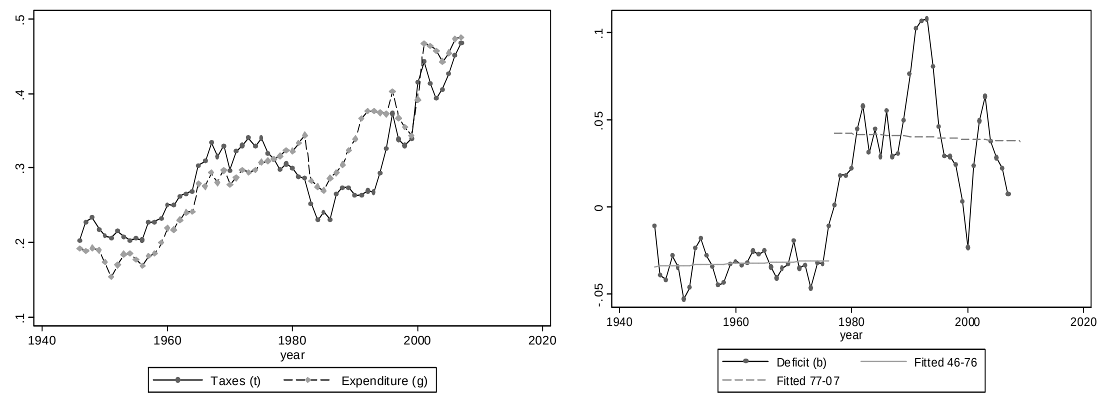
Figure 3 gives net government hydrocarbon revenues as fraction of national income and also the permanent value of this series (calculated as the annuity value of the present value of expected future hydrocarbon revenues, as reported by the Ministry of Finance since early 1970s and using a discount rate of 2 % per year; for more details, see section 6 and appendix 1). This figure indicates that government expectations of future hydrocarbon 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 hydrocarbon revenues now lies above the permanent path as hydrocarbon revenues are expected to fall in the future. This should signal a shift from borrowing to saving hydrocarbon revenues; something the Norwegian government has started doing for some time.

Figure 3: Actual and permanent paths for national income fractions of hydrocarbon revenues



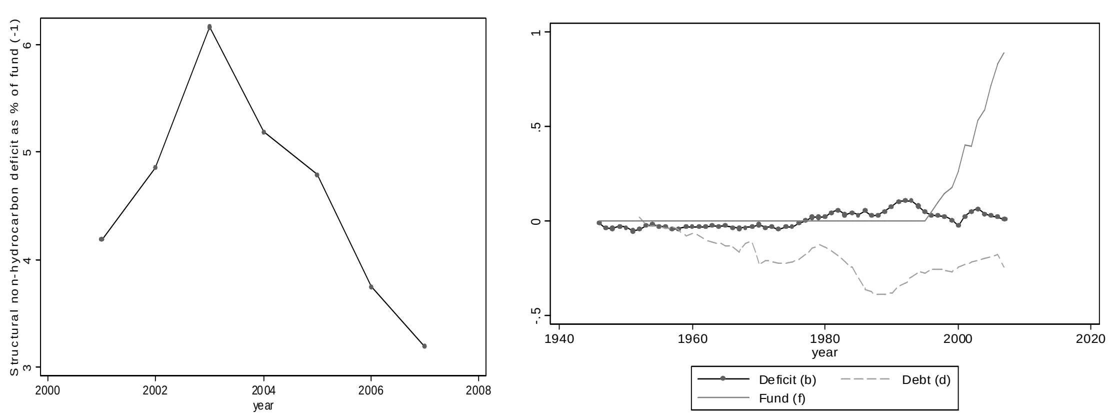
The left panel of Figure 4 gives central government expenditure (*g*) and non-hydrocarbon, non-net capital government revenue (τ) as fraction of GDP. The 1960s and 1970s saw a gradual rise in both primary spending and non-hydrocarbon taxes. Interestingly, after the onset of hydrocarbon revenue in the early 1980s, taxes and spending first fell and then increased relentlessly, roughly in line with each other. The right panel of Figure 4 shows the difference between expenditure and taxes, i.e., the non-hydrocarbon primary deficit (*b*). This deficit 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-hydrocarbon primary deficit. The key question is whether the higher non-hydrocarbon primary deficits in hydrocarbon era are sustainable in view of the long-term budgetary commitments of the Norwegian government.

Figure 4: Central government primary spending and non-hydrocarbon revenue paths



The fiscal rule supported by the Norwegian parliament in Spring 2001 suggests that the government on average should keep the structurally adjusted, non-hydrocarbon deficit in year t equal to 4 percent of the petroleum fund in (end of) year t-1. As can be gleaned from the left panel of Figure 5, the level of 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. The right panel of Figure 5 shows the 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-hydrocarbon 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-hydrocarbon 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 has wiped out a big chunk of the Fund.

Figure 5: Hydrocarbon wealth spent, deficit and development of the Stabilization Fund



Since we are interested in the intertemporal allocation of hydrocarbon revenue, all lending and borrowing and their associated revenues and costs should be taken into account. We therefore use a deficit definition cleaned for both net capital income and oil revenue. In contrast, the non-hydrocarbon budget deficit used by the Ministry of Finance includes net capital income (excluding those from hydrocarbon-related assets). The left panel of Figure 6 shows our measure of the non-hydrocarbon primary deficit together with the non-hydrocarbon deficit and the structural non-hydrocarbon deficit as defined by the Ministry of Finance (MF). The structural deficit used by the Ministry of Finance corrects the deficit for business cycle adjustments.[7] 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).[8]

Figure 6: Central government non-hydrocarbon primary deficit and output gap

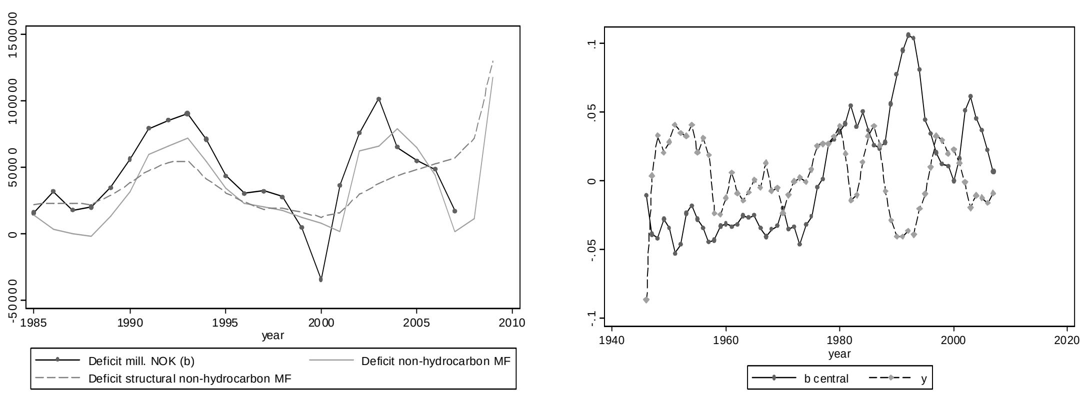
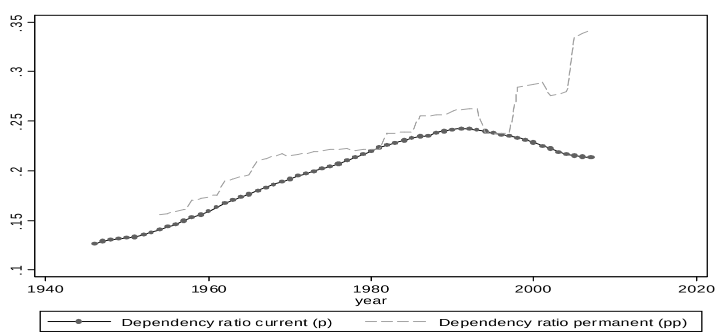


Figure 7: Actual & permanent levels of old-age (67+) dependency ratio



[7] 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 hydrocarbon revenenue 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).

[8] 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.

Figure 7 shows the gradual rise in the 67+ dependency ratio in Norway. This 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 (see sections 4 and 6).

Given the relatively small size of Norway, its sovereign wealth fund is very large. Table 1 indicates that only two sovereign wealth funds dwarf the Norwegian fund.

Table 1: Sovereign wealth funds – proved oil reserves at end of 2007

UAE - Abu Dhabi	Abu Dhabi Investment Authority	$627	1976	Oil	29.5	3
Saudi Arabia	SAMA Foreign Holdings	$431	n/a	Oil	12.7	2
Norway	Government Pension Fund – Global	$396.6	1990	Oil	7.1	10
China	SAFE Investment Company	$347.1		Non-Commodity	0.2	2
China	China Investment Corporation	$288.8	2007	Non-Commodity	0.1	6
Singapore	Government of Singapore Investment Corporation	$247.5	1981	Non-Commodity	1.9	6
Kuwait	Kuwait Investment Authority	$202.8	1953	Oil	12.7	6
China - Hong Kong	Hong Kong Monetary Authority Investment Portfolio	$193.4	1998	Non-Commodity	1	8
Russia	National Welfare Fund	$178.5	2008	Oil	0.4	5
Singapore	Temasek Holdings	$122	1974	Non-Commodity	0.8	10

Source: Updated August 2009, Sovereign Wealth Fund Institute, largest funds by assets under management (see www.swfinstitute.org/funds.php).

3. Norwegian policy initiatives

In response to the hydrocarbon 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, which 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 hydrocarbon revenues in a fund and spend only the real return on the assets accumulated in this fund.[9] 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 hydrocarbon 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.

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

1988: Policy Committee headed by Professor Erling Steigum, then NHH Bergen, now 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 hydrocarbon wealth consisting of the financial fund plus the value of oil and gas reserves in the ground. The calculation of total hydrocarbon 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 this 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.

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). It manages the surplus wealth produced by Norwegian petroleum income (taxes and licenses) and has a value of NOK2.385 trillion in August 2009. This makes 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 is how to contain the risks in investing in the international stock market, ensure ethically sound investments (away from arms and tobacco) and avoid inflation. 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.

4. Managing windfall revenue, government debt and the non-hydrocarbon fiscal stance

We put forward a very stark model focused at government policy and meant to illustrate the principles of tax smoothing and optimal debt management. We assume that the government has access to international capital markets but that private sector agents are credit constrained.

Although we allow for unemployment and business cycle variations, we abstract from behavioral relationships and focus on social welfare, efficiency losses from taxation and intertemporal budget constraints. Let the government budget constraint be given by:

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

where d_t is net government debt (liabilities minus assets) at the end of period t, and g_t denotes government spending (excluding net interest payments), τ_t the non-hydrocarbon tax rate, y_t the output gap (logarithmic deviation of output from its long-run trend value), and n_t hydrocarbon revenues (direct and indirect taxes, license fees, environmental taxes, return on government stakes in oil and gas fields, dividends) accruing to the government in period t. The government deficit depends negatively on the output gap to reflect that expenditures on unemployment benefits and, in as far as the tax system is progressive, tax revenues vary with the business cycle. The parameter ϕ represents the strengths of these automatic stabilizers. All variables are expressed as fractions of national income, so that r indicates the growth-corrected real rate of interest. One can use (1) and the no-Ponzi condition that the present value of net government debt as time tends to infinity should go to zero ($\lim_{s\to\infty} (1+r)^{-s} d_{t+s} = 0$) to obtain the present-value budget constraint for the government:

(1′) $$\sum_{s=0}^{\infty}(1+r)^{-s}\left(n_{t+s}+\tau_{t+s}\right) \geq (1+r)d_{t-1} + \sum_{s=0}^{\infty}(1+r)^{-s}\left(g_{t+s}-\phi y_{t+s}\right) \text{ or}$$
$$\sum_{s=0}^{\infty}(1+r)^{-s} n_{t+s} \geq (1+r)d_{t-1} + \sum_{s=0}^{\infty}(1+r)^{-s} b_{t+s},$$

where $b_t \equiv g_t - \tau_t - \phi y_t$ stands for the non-hydrocarbon primary deficit. Equation (1′) says that the present value of future hydrocarbon and non-hydrocarbon revenues should not be less than government commitments consisting of outstanding net government debt plus the present value of future government spending. Alternatively, (1′) says that the present value of future hydrocarbon revenues should be sufficient to cover outstanding net debt plus the present value of future non-hydrocarbon primary deficits.

To get a benchmark for optimal fiscal policy and debt management, we specify a social welfare function. Let private consumption be given by what is left of output after paying taxes and incurring quadratic costs of tax rates due to collection and tax distortions, that is $c_t = 1 + \phi y_t - \tau_t - ½\, \theta\, \tau_t^{\,2}$ where $\theta > 0$. Let social felicity be given by the quasi-linear specification $c_t - ½\psi(g_t^* - g_t)^2$, where $\psi > 0$ is the priority given to the public spending target g_t^*. The government thus minimizes the social welfare loss function

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

subject to (1′), where we set the social rate of discount to the growth-corrected real interest rate, $\beta(1+r) = 1$. The BIH rule and other ad-hoc rules are not based on an explicit social welfare criterion.

4.1. Permanent income hypothesis (PIH and HC-PIH)

The permanent income hypothesis (PIH) follows from minimizing (2) subject to (1′). This yields

$$\psi\left(g_{t+s}^{*}-g_{t+s}\right)=1+\theta\tau_{t+s}=\eta_{t}>1,\quad \forall s\geq 0, \tag{3}$$

where η_t indicates the marginal cost of public funds at time *t*. Hence, a higher tax rate pushes up the cost of funds and thus lowers demand for public goods. Furthermore, all expected future tax rates equal the current tax rate and similarly for all expected future shortfalls of public spending from target. This is the tax smoothing principle. Upon substitution of (3) into (1′), we solve for the cost of funds and thus for the optimal tax rate, public spending and non-hydrocarbon primary deficit:

$$\eta_{t}=\frac{rd_{t-1}+\phi^{-1}+g_{t}^{*P}-n_{t}^{P}}{\phi^{-1}+\psi^{-1}},\quad \tau_{t}=\frac{rd_{t-1}-\psi^{-1}+g_{t}^{*P}-n_{t}^{P}}{\theta\left(\phi^{-1}+\psi^{-1}\right)},\quad g_{t}=g_{t}^{*}-\frac{\eta_{t}}{\psi},$$
$$b_{t}=g_{t}^{*}-g_{t}^{*P}-\phi y_{t}-rd_{t-1}+n_{t}^{P}\ \text{ and }\ d_{t}-d_{t-1}=g_{t}^{*}-g_{t}^{*P}-\phi y_{t}+n_{t}^{P}-n_{t}, \tag{4}$$

where permanent hydrocarbon revenues are the annuity value of current and future hydrocarbon revenues, $n_{t}^{P}\equiv r\sum_{s=0}^{\infty}(1+r)^{-s-1}n_{t+s}$ (i.e., return on hydrocarbon wealth in the ground) and the permanent target spending share equals $g_{t}^{*P}\equiv r\sum_{s=0}^{\infty}(1+r)^{-s-1}g_{t+s}^{*}$. If meeting spending targets is of overriding importance, $\psi = 0$ and $g_t = g_t^*$ regardless of windfalls, recessions or public debt. Solvency must then be attained by variations in taxes rather than spending. The permanent value of the output gap is set to zero. The PIH summarized by the fiscal reaction functions (4) has the following implications:

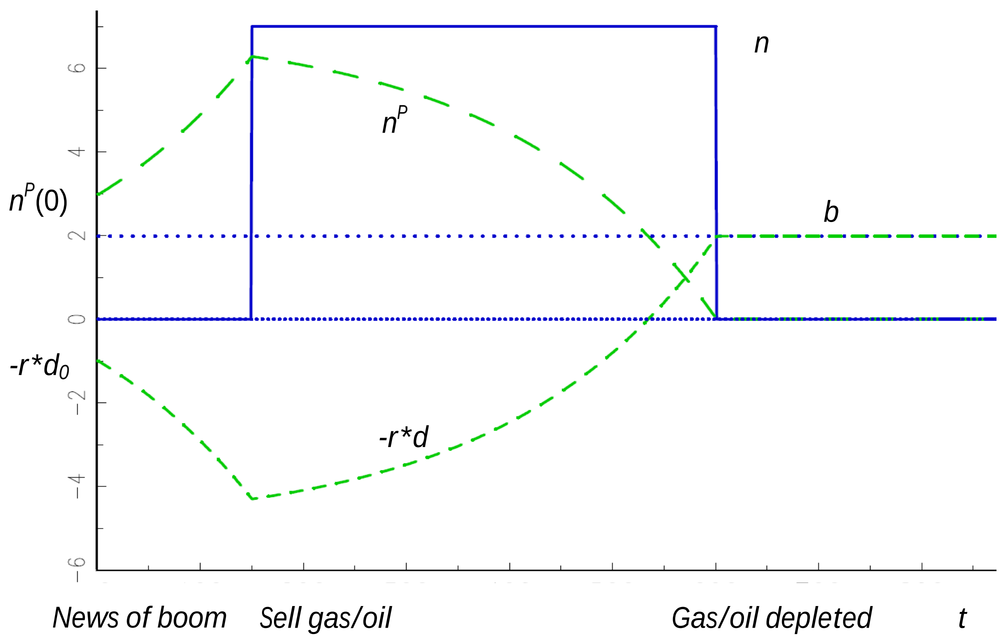
1. The mere presence of a high net government debt does not warrant debt reduction. The temporary hike in tax rates and temporary cuts in public spending needed to achieve this violate the principles of tax and consumption smoothing.
2. The non-hydrocarbon deficit should be loosened (tightened) in economic recessions (booms).
3. The cost of funds is high if the present value of future spending needs is high and low if the return on hydrocarbon wealth is low. Public funds thus become scarcer as future pension needs are expected to increase and hydrocarbon revenues run out. As a result, the government must raise the tax rate and cut spending.
4. Neither the cost of funds nor the tax rate nor the shortfall of spending form target should react to current hydrocarbon revenues or current spending needs.
5. If current spending targets are lower than future expected spending targets, there should be a non-hydrocarbon surplus and government saving to provide for future spending needs. The PIH thus requires saving in anticipation of graying of the population, so future costs can

be paid out of the return on those savings. One should thus save more than permanent hydrocarbon rents to provide for future pension obligations (i.e., $b_t > n_t^P$).

6. The non-hydrocarbon deficit should react one-for-one with permanent hydrocarbon revenues. Borrowing is called for ahead of a hydrocarbon 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/gas boom, so that the increase in public consumption and (via lower tax rates) private consumption can be sustained after the windfall of hydrocarbon revenue has ceased to flow. Falling hydrocarbon wealth is thus gradually replaced by fund assets.
7. The size of the sovereign wealth fund that has been accumulated at the end of the windfall exactly equals the permanent value of the stream of hydrocarbon 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 pay for the increase in the non-hydrocarbon primary deficit. The post-windfall deficit including interest as fraction of GDP is $g_t^* - g_t^{*P} - \phi y_t + \upsilon d_{t-1}$, where υ denotes the growth rate in nominal GDP.

Figure 8 illustrates this way of managing a sovereign wealth fund to sustain permanent increases in private and public consumption.

Figure 8: Use of sovereign wealth fund to manage temporary windfall revenue



The PIH requires that the government fully takes account of future spending obligations. If the government is myopic and reacts only to future hydrocarbon revenues, the PIH becomes:

(4′)
$$\eta_t = \frac{rd_{t-1} + \phi^{-1} + g_t^* - n_t^P}{\phi^{-1} + \psi^{-1}}, \quad \tau_t = \frac{rd_{t-1} - \psi^{-1} + g_t^* - n_t^P}{\theta\left(\phi^{-1} + \psi^{-1}\right)}, \quad g_t = g_t^* - \frac{\eta_t}{\psi},$$
$$b_t = -\phi y_t - rd_{t-1} + n_t^P \text{ and } d_t - d_{t-1} = -\phi y_t + n_t^P - n_t,$$

This will be referred to as the HC-PIH rule, since it does not react to future spending needs such as a rising pension bill. As a result, the country saves less, and has a bigger budget deficit, a lower cost of funds, lower tax rate and higher spending share.

4.2. Bird-in-Hand rule (BIH)

Norway adopts a BIH rule although the government leaves plenty of room for discretion when necessary. The BIH rule states that the government puts all hydrocarbon revenues in the Fund and only takes out 4% of the value of the Fund in the previous year for the general budget. This 4% corresponds to the supposed real rate of return on the fund (e.g., 5.5% nominal return minus 1.5% expected inflation per annum). If real growth is 2% per annum, the growth-corrected real return on the Fund r^F would equal 2%. In reality, the equity fund premium over the risk-free growth-corrected real interest rate r equals ν, so that $r^F = r + \nu$. Governments have discretion to deviate from the 4%-rule, which is captured by the discretionary transfer h_t from the Fund to the general budget. The development of the Fund f_t, government net liabilities (excluding the Fund) l_t and net government debt $d_t \equiv l_t - f_t$ follow from:

(5)
$$f_t = (1 + r + \nu - 0.04) f_{t-1} + n_t - h_t, \;\; l_t = (1+r) l_{t-1} + b_t - 0.04 f_{t-1} - h_t \text{ and}$$
$$d_t = (1+r) d_{t-1} + b_t - n_t - \nu f_{t-1}.$$

If the return on investments in the Fund (say, at most 7.5% per annum) 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 gradually falls to zero after the windfall has ceased. If as nowadays seems unlikely, the return on investments in the Fund is greater (than 7.5% per annum), the Fund will grow indefinitely in size.

The BIH rule is inefficient, since the government spends oil/gas revenues and reacts only to financial wealth in the Fund but not to hydrocarbon wealth in the ground. Precluding borrowing implies that consumption is too low ahead of the windfall while consumption is first to low and then to high during the windfall, and once the windfall has ceased consumption gradually falls back to its original level. Hence, the BIH rule violates the principles of tax and consumption smoothing (e.g., Collier, et al., 2009). Also, the BIH rule is unhelpful if the pension burden is expected to rise and the rules of the Fund prevent the government from saving more in response to the rising pension burden.

4.3. Precautionary saving

Although there is uncertainty about oil and gas reserves and extraction technology, the main source of uncertainty is future oil prices. The BIH rule can be seen as an ad-hoc way to buffer against future oil and price shocks. It implies precaution and a very conservative policy (provided there is no pension bill lurking in the future). It seems preferable, however, to extend the principles of tax and consumption smoothing exposited in section 4.1 (as well as the Hotelling principle of optimal oil and gas extraction) to allow for the effects of a very volatile stream of hydrocarbon revenues on fiscal policy and debt management. Building on the multi-period framework of precautionary saving by households with income uncertainty (e.g., Sibley, 1975; Zeldes, 1989), one can show that oil price uncertainty induces countries to extract oil and gas more aggressively than suggested by the Hotelling rule and to establish precautionary buffers (van der Ploeg, 2009). The magnitudes of these effects are stronger the bigger the prudence of the policy maker and the bigger the variance of oil price shocks. An inevitable consequence of precautionary buffers is that over time windfalls are likely to occur as hydrocarbon revenues turn out better than the conservative forecasts of a prudent policy maker, thus producing the financial leeway to have a declining path for the tax rate, rising consumption paths, and a rising path for the non-hydrocarbon deficit. Prudence thus implies that less oil and gas is left in the ground to avoid a high cost of future oil price fluctuations.

Temporary oil price hikes give rise to temporary windfalls which are mostly saved and there is not much action on taxes, public spending or the non-hydrocarbon budget deficit. However, the empirical evidence suggests that oil prices follow a near-random walk (Hamilton, 2009). In that case, oil price shocks are much more permanent whence positive (negative) oil price shocks permit tax cuts (hikes) and boosts to (cuts in) private and public consumption and there should be no saving (borrowing) response.

4.4. *Extensions: habit persistence, hyperbolic discounting, Fund targets and capital scarcity*

The IMF has extended the PIH with habit persistence (Leigh and Olters, 2006; Olters, 2007). The idea is that one may be hooked on high levels of consumption during a temporary windfall, but it is tough to cut back consumption after the windfall. One way to model this is to replace $\frac{1}{2}\psi\left(g_{s+t}^{*}-g_{s+t}\right)^{2}$ by $\frac{1}{2}\psi\left(g_{s+t}^{*}-(g_{s+t}-\xi g_{s+t-1})\right)$ in the social welfare function, where $0 < \xi < 1$ indicates the degree of habit persistence. The PIH is modified by adding $\xi^{*}(b_{t-1}-g_{t-1}-rd_{t-1})$ to the expression for the optimal non-hydrocarbon primary deficit. An estimated value of $0 < \xi^{*} < 1$ suggests evidence of habit persistence. No habit persistence corresponds to $\xi^{*} = 0$. With ever-lasting habits $\xi^{*} = 1$, we have $b_t = g_t - g_{t-1} + b_{t-1}$ so that the non-hydrocarbon primary deficit follows a random walk if public spending does not change.

Politicians are often impatient and inconsistent. They prefer spending hikes and tax cuts today rather than tomorrow, but regret these policies in the future when they have to face up to budget cuts and tax increases to finance repayment of the accumulated debt plus interest. This can be rationalized with theories of hyperbolic discounting (cf., Laibson, 1997). This seems less important for an established democracy like Norway than for more corrupt countries and we therefore abstract from these issues.

Resource-rich countries such as Norway may have targets for the optimal size of the Fund.[10] In that case, tax and consumption smoothing is no longer opportune and it can be shown that it is optimal to forcefully build up assets in the Fund with a temporary hikes in taxes and cuts spending. As a result, tax rates are expected to decline over time and public spending shares to rise over time. The reaction coefficient of the deficit to public debt is greater than the real interest rate r in this case.

Finally, we abstract from capital scarcity which seems to be more relevant in resource-rich developing countries. For those countries it pays not to use the windfall to accumulate sovereign wealth but to use it to bring down debt, lower interest rates, stimulate investment domestically and bring forward the path of economic development (Collier, et al., 2009; van der Ploeg and Venables, 2009a).[11] We also abstract from Dutch disease effects (declining traded and booming non-traded and construction sectors) and problems of absorptive capacity (van der Ploeg and Venables, 2009b), since these also seem more relevant for developing economies.[12]

5. Econometric specification and hypotheses

In our empirical work we allow for the effects of oil/gas income, expectations about future oil/gas income, the output gap and actual and expected burden of old age pensioners on the budget deficit. Public spending is projected to change over time due to graying of the population. Projections of future oil/gas revenue are also available. We assume a growth-corrected real interest rate of 2% (assuming an average annual rate of return of 5.5% on the fund *minus* 1.5% inflation *minus* 2% real growth), which corresponds to the 4% withdrawal rate of the Norwegian fund uncorrected for growth. We might distinguish between the growth-corrected real return on investments in the Fund r^F and the r to be used for the present-value calculations with net government debt. We contrast the HC-PIH with the PIH, BIH rule and the estimated fiscal rules using Norwegian post-WWII data (section 7), and simulate these four policy rules over the next four decades to assess the sustainability of Norway's fiscal stance (section 8).

The PIH (4) requires that the non-hydrocarbon deficit must equal the return on prospective wealth *plus* the differences between actual and permanent spending *minus* a term depending on the output

---

[10] Governments may also have explicit criteria for debt reduction even though it is hard to rationalize them. For example, the Maastricht criteria for the EMU specify an ad-hoc debt-GDP target of 60% in which case it is optimal to forcefully bring down government debt.

[11] A low initial capital stock can induce governments to spend all their oil revenue rather than maintaining a stable level of spending out of oil wealth as shown within the context of a neoclassical growth model with positive external effects of public spending on consumption and productivity (Takizawa, Gardner and Ueda, 2004). Effectively, benefits of faster convergence to the steady state dominate losses of lower public spending in steady state in economies that start off with a low capital stock.

[12] Of course, a major motivation of the 4% rule was to avoid sharp appreciations of the real exchange rate and the accompanying Dutch disease effects. The arguments made in Norway around 2001 highlighted the importance of gradual phasing in of hydrocarbon revenues, also to avoid absorption problems and capacity bottlenecks especially in the non-traded sector. These arguments reinforce the intertemporal allocation arguments sketched in section 4.

gap. The deficit is increased if there are temporary public spending needs (e.g., due to a recession) or temporary downturns in tax revenues, but the deficit is reduced if there are future spending needs (e.g., for pension obligations). It follows that the growth-corrected deficit must equal temporary public spending minus temporary oil revenue. The optimal tax rate and the shortfall of public spending from its bliss level should respond to permanent changes in public spending and oil revenues and be independent of the output gap and the cycle.

If hydrocarbon revenue declines at the rate α, the return on prospective hydrocarbon wealth is less than the current stream of hydrocarbon income, especially if the rate of decay α is large, $n_t^P = \left(\frac{r}{r+\alpha} \right) n_t$. This implies a coefficient smaller than one on the actual revenues in regressions for the non-hydrocarbon primary deficit.

5.1. Core hypotheses

With exogenous public spending ($\psi \rightarrow \infty$), we estimate the following time-series regression for the non-hydrocarbon primary budget deficit and national income share of government tax revenues:

(6) $$b_t = \beta_0 + \beta_1 n_t + \beta_2 l_{t-1} + \beta_3 f_{t-1} + \beta_4 y_t + \beta_5 g_t + \beta_6 p_t + \beta_7 n_t^P + \beta_8 p_t^P + \varepsilon_t \text{ and}$$

(7) $$\tau_t = \gamma_0 + \gamma_1 n_t + \gamma_2 l_{t-1} + \gamma_3 f_{t-1} + \gamma_4 y_t + \gamma_5 g_t + \gamma_6 p_t + \gamma_7 n_t^P + \gamma_8 p_t^P + \theta_t ,$$

where p_t denotes the share of the number of people in the population older than 65 years divided by those in the working-age population, l_t the net government fund (excluding the Fund) expressed as a fraction of national income, and f_t the accumulated reserves in the Fund as a fraction of national income. Two main 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 is only a good indicator of future pension liabilities if pensions are indexed to nominal national income.[13] The share of primary public spending directly follows from $g_t = b_t + \tau_t$. Equation (6) deals with the intertemporal and (7) with the intratemporal allocation. The PIH implies the following null hypothesis:

(8) $$\begin{gathered} \beta_1 = 0, \beta_2 = -\beta_3 = r, \beta_4 < 0, \beta_5 = 0, \beta_6 = -\beta_8 > 0, \beta_7 = 1 \text{ and} \\ \gamma_1 = 0, \gamma_2 = -\gamma_3 = r, \gamma_4 = 0, \gamma_5 = 1, \gamma_6 = 0, \gamma_7 = -1, \gamma_8 > 0. \end{gathered}$$

Note that the PIH denies a role for actual oil/gas revenues on the non-hydrocarbon primary deficit or on the tax rate. Actual oil/gas revenues do affect the normal deficit and should feed straight into accumulation of assets (in as far as they exceed the permanent value of oil revenues).

Bornhorst et al. (2008) find in a panel of 30 hydrocarbon-producing countries that the offset between hydrocarbon revenues and other revenues is about 20%, but is invariant to other

[13] We could introduce a dummy to allow for the effects of changes in indexation laws.

governance indicators. This suggests that oil-rich countries reduce their non-oil tax take by 20% of the oil revenue coming in. The problem with this empirical study is that no attempt is made to calculate permanent oil revenue or to correct for the past debt-GNI ratio or permanent projected public spending. However, it may be compatible with the PIH (8) if permanent hydrocarbon revenue is twenty percent of actual revenue, which is compatible with a rate of decline of hydrocarbon revenues α of 8 percent per annum.

With endogenous public spending, it makes more sense to include projected targets of public spending:

(6′) $$b_t = \beta_0 + \beta_1 n_t + \beta_2 d_{t-1} + \beta_3 f_{t-1} + \beta_4 y_t + \beta_6 p_t + \beta_7 n_t^P + \beta_8 p_t^P + \varepsilon_t \text{ and}$$

(7′) $$\tau_t = \gamma_0 + \gamma_1 n_t + \gamma_2 d_{t-1} + \gamma_3 f_{t-1} + \gamma_4 y_t + \gamma_6 p_t + \gamma_7 n_t^P + \gamma_8 p_t^P + \theta_t.$$

The relevant null hypothesis is now:

(8′) $$\begin{gathered}\beta_1 = 0, \beta_2 = -\beta_3 = r, \beta_4 < 0, \beta_6 = -\beta_8 > 0, \beta_7 = 1 \text{ and} \\ \gamma_1 = 0, \gamma_2 = -\gamma_3 = r, \gamma_4 = 0, \gamma_6 = 0, 0 > \gamma_7 > -1, \gamma_8 > 0.\end{gathered}$$

5.2. Competing hypotheses

Various competing hypotheses are summed up in Table 1. If governments do not adhere to the PIH, the non-hydrocarbon primary budget deficit may react to actual rather than permanent oil/gas revenue. This leads to the alternative hypothesis $\beta_1 > 0$, $0 < \beta_7 < 1$ and $0 < \gamma_1 < 1$, $-1 < \gamma_7 < 0$. Governments may also attempt to stabilize escalating public debt or forcefully build up towards a target size of the Fund in which case one has $\beta_2 > -r$ and perhaps $\gamma_2 > r$ as well. Note that this should not affect the coefficient on the Fund. With habit persistence, the current tax rate is a weighted average of the PIH tax rate and last year's tax rate.

If the government has a precautionary motive, it has a tendency to accumulate buffers and gradually cut tax rates. This suggests a negative constant in the equation for the non-hydrocarbon primary deficit. Ideally, one should allow for the volatility of oil/gas revenues but it is not clear how to measure that.

The BIH rule implies that the government bases spending decisions only on the assets already in hand, so it does not borrow against future oil/gas revenue and the non-hydrocarbon deficit is driven by the return on existing assets. The BIH amounts to $n^P = 0$ so the corresponding tax rate $\tau = rd + g^P$ is higher and the non-hydrocarbon primary deficit $b = g - g^P - rd$ is less than under the PIH. As the government accumulates assets and *d* falls or goes more negative, the tax rate can fall (but only then).

Table 2: Hypotheses about the non-hydrocarbon primary budget deficit and tax share

	Non-hydrocarbon primary deficit	Tax share
Current oil/gas income	0, but + with Fund targets	0, but + with Fund targets
Permanent oil/gas income	1, but <1 with Fund targets and dropped under the BIH	(–1,0), but dropped under the BIH
Output gap	–	0, perhaps + if there some counter-cyclical response
Share of pensioners	+	0
Permanent share of pensioners	–	>0
Past debt-GDP ratio	–*r*, but >*r* with Fund targets	*r*, but >r with Fund targes
Past Fund-GDP ratio	*R*	–*r*
Past tax share	0, but – with habit persistence*	0, but (0,1) with habit persistence (all other coefficients should be less)
Public spending	0	0

* With habit persistence the non-hydrocarbon primary deficit ratio reacts less strongly to the permanent share of pensioners, permanent oil/gas income and the past debt-GDP ratio. One could test instead whether the term $\left[\tau_{t-1} + n_t^P - rd_{t-1}\right]$ has a negative effect on the non-hydrocarbon primary deficit ratio. The regression coefficients for the public spending share should follow directly from adding those for these two equations.

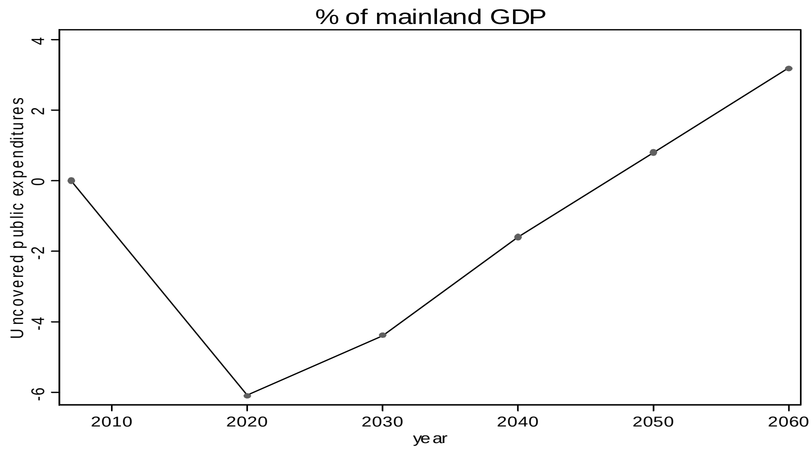
6. Projections of future spending needs and hydrocarbon revenues needs for Norway

6.1. Future pension obligations and projected deficits

The holy trinity dilemma, implicitly described by the Ministry of Finance (Perspektivmeldingen 2009, p. 133), can be summarized by the following three statements:

- With the 4%-rule, the contribution from the Fund to the finance of public welfare spending is expected to increase during the coming years. The structural, hydrocarbon-corrected deficit is expected to increase from 3.5% of mainland GDP in 2007 to 9.5% in 2025. Towards 2060 this deficit will, however, decrease to an estimated 7% in 2060 due to declining growth of the Fund and positive growth in mainland GDP.
- The gradual decrease in the contribution from hydrocarbon revenues to the government budget sets in when demographical changes increase public spending needs.
- Increases in private sector productivity do not considerably benefit public finances. Although they boost the tax base, they also increases wage and transfer bills given that private and public sector wages, benefits and public pensions follow private sector pay.

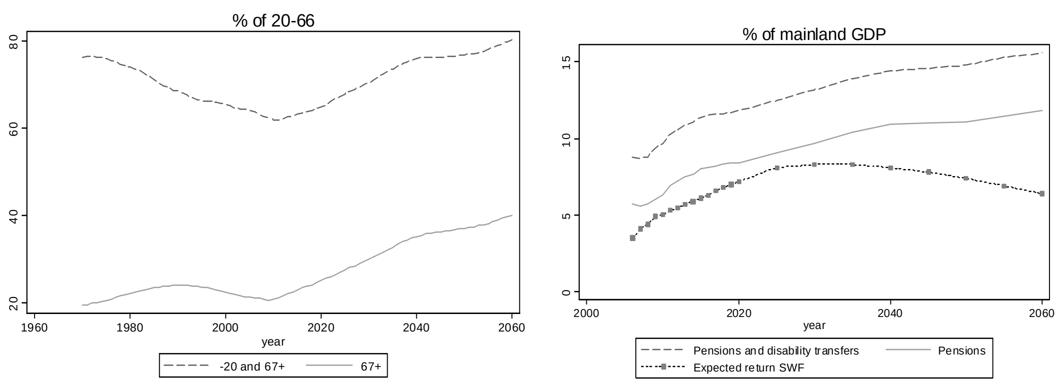
Figure 9: Projected uncovered government spending up to 2060



Source: Maintaining the "welfare programs" as today. Source, Ministry of Finance January 2009 (Perspektivmeldingen)

Even though some reforms have been made (e.g., from 2006 onwards public pension pay is indexed only for 50% to wages),[14] the public finances are unsustainable unless the holy trinity is further dismantled. Indeed, Figure 9 indicates that uncovered public spending is projected to first fall to –6% of mainland GDP in 2020 and then rise to +3% by 2060. Such a volatile path of non-hydrocarbon tax rates is according to the PIH-logic very sub-optimal. It would be better to use debt to smooth tax rates.

Figure 10: Projected demographic dependency ratios, transfers and pensions up to 2060



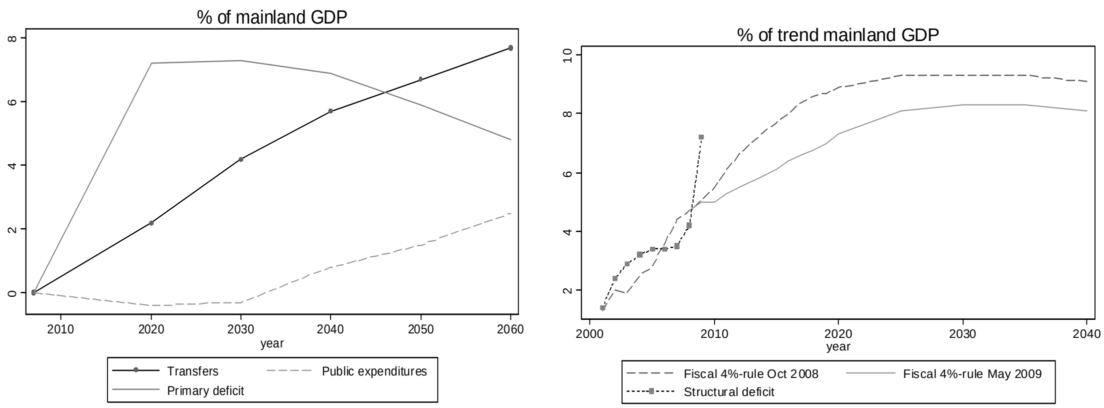
Source: Ministry of Finance January 2009 (Perspektivmeldingen) and May 2009 (Revised National Budget).

To get an idea of how this profile of uncovered government spending comes about, Figures 10 shows that including children the dependency ratio is projected to increase to 80% in 2060 while pensions and disability transfers are projected to rise to about 15% of mainland GDP by 2060. From about

[14] Rights during working years are fully indexed to wages, but individual payments *during* retirement grow at a rate equal to the simple average of inflation and wages.

2030 revenue from the Fund is expected to decline. The left panel of Figure 11 confirms the inexorable rise in both public expenditures and transfers, together rising from about 8 % of mainland GDP in 2007 to about 15 % in 2060. Hence, the primary deficit first rises strongly until 2020, then stays flat for the next decade, and then falls gradually all the way to 2060. The right panel of Figure 11 shows how the 4% rule led to downward adjustment of the sustainable deficit after the global financial crisis wiped out large part of the Fund.

Figure 11: Projected transfers, public spending and deficits up to 2060

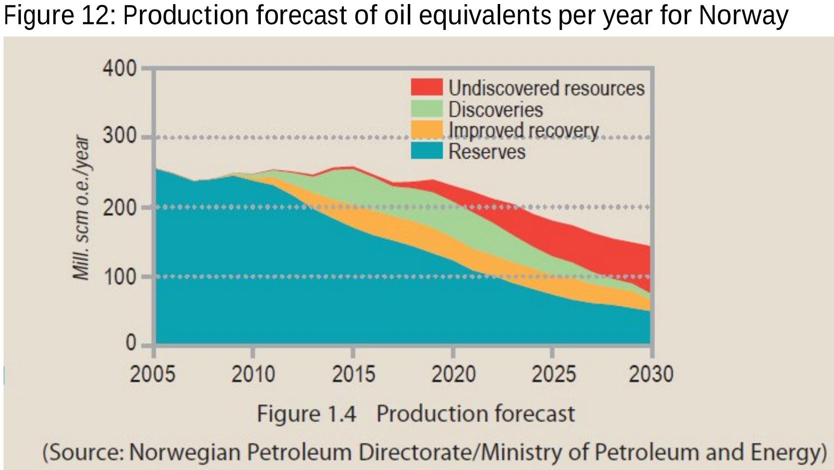


Source: Ministry of Finance January 2009 (Perspektivmeldingen) and May 2009 (Revised National Budget). Left panel shows percentage points change (of mainland GDP).

6.2. Projected hydrocarbon revenues

Figure 12 presents production forecasts of annual hydrocarbon production up to 2030. From 2007 onwards production levels resulting from proven reserves are anticipated to decline substantially in the following twenty five years. Even allowing for improved recovery, discoveries of new fields and undiscovered resources, production forecasts show a decline in hydrocarbon production levels. This highlights the temporary nature of Norway's hydrocarbon windfall.

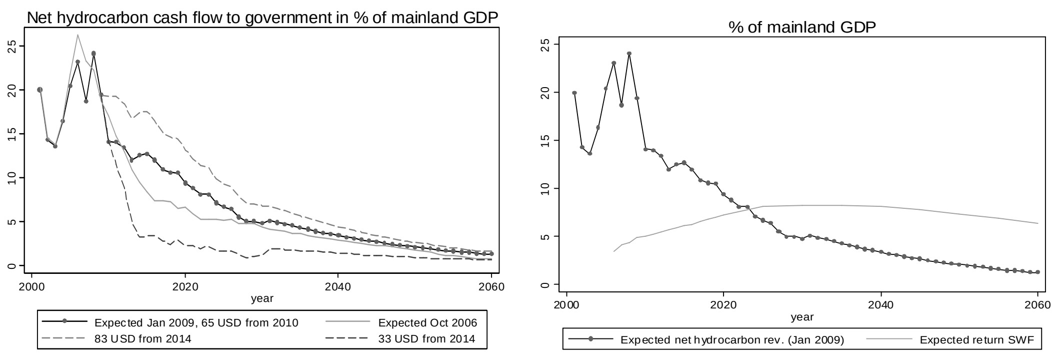
Figure 12: Production forecast of oil equivalents per year for Norway



Source: Norwegian Petroleum Directorate/Ministry of Petroleum and Energy.

Figure 13 shows how the production forecasts give rise to projected net hydrocarbon cash flows to the government up to 2060. Obviously, these cash flows are sensitive to the projected oil price. More important is that the net cash flow is expected to fall over time. The expected return on the Fund is therefore expected to grow until the 2030s and then to taper off.

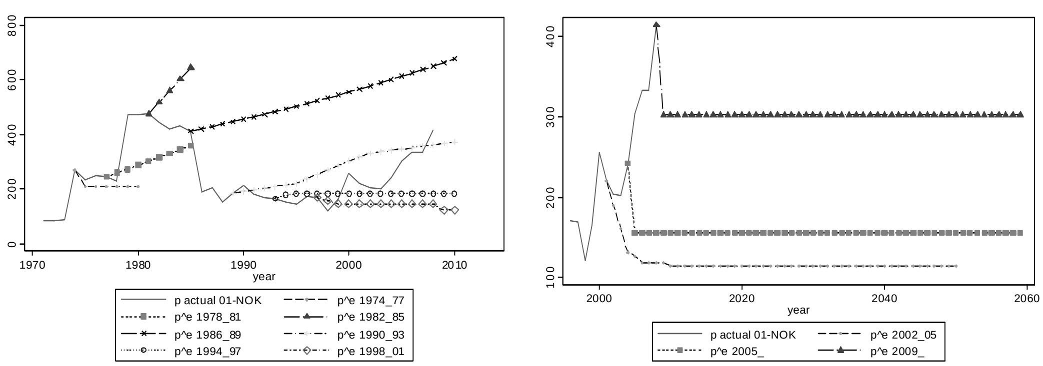
Figure 13: Projected net hydrocarbon cash flow to the government up to 2060



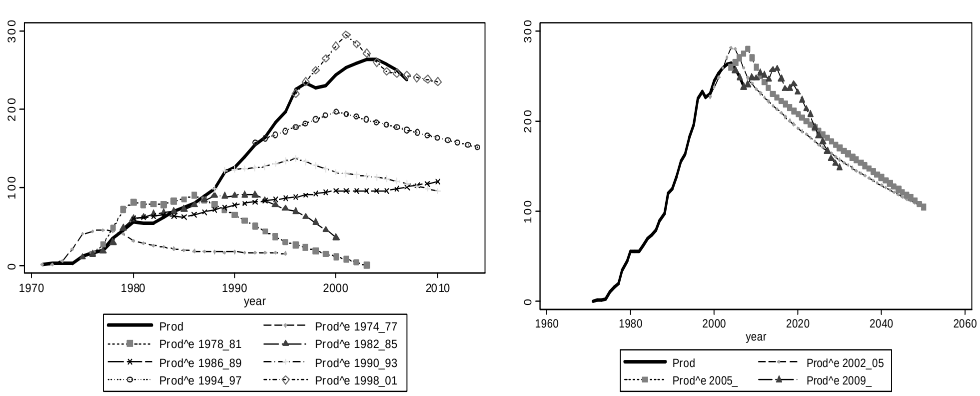
Source: Ministry of Finance January 2009 (Perspektivmeldingen)

Figure 14: Oil price and hydrocarbon production and reserve projections throughout time

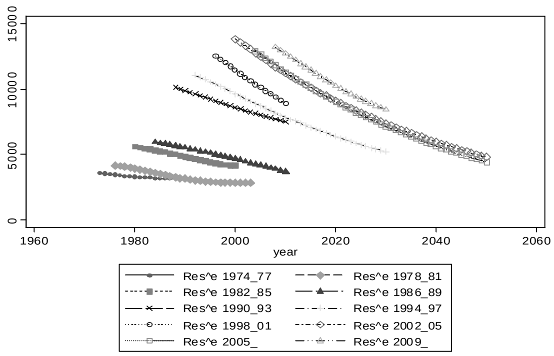
(a) Oil price projections



(b) Production projections



(c) Hydrocarbon reserves projections



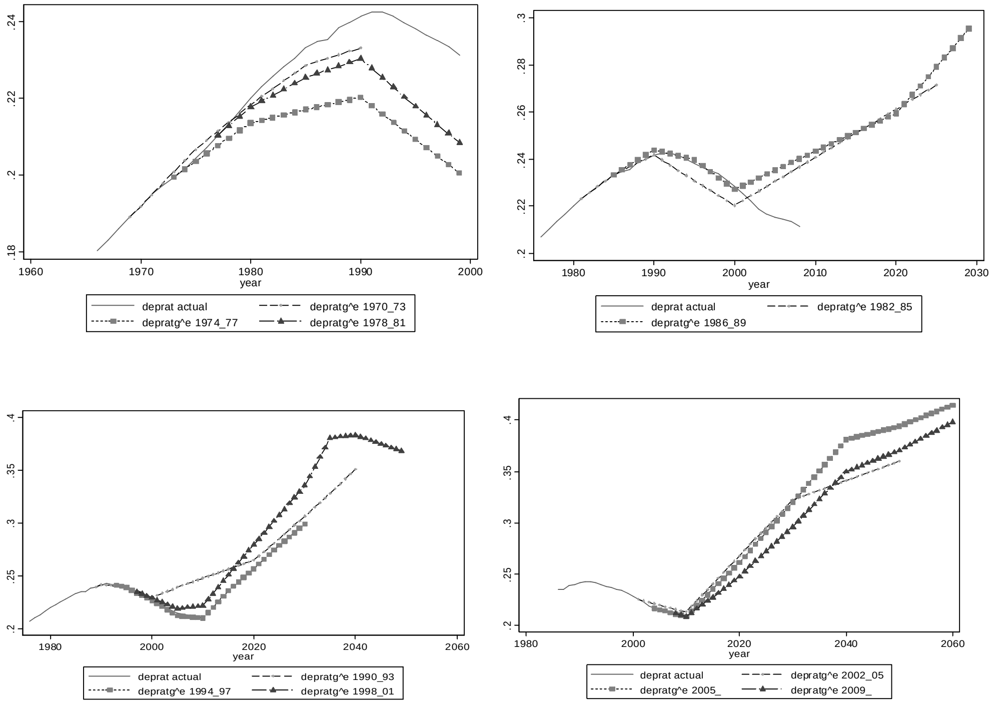
Source: Ministry of finance, Statistics Norway and authors calculations

The projected hydrocarbon cash flow to the government depicted in Figure 13 depends on projected oil prices and projected oil/gas production levels. They also depend on projected tax/dividend regimes, which we assume to be unchanged. Figure 14(a) gives actual oil prices together with the oil prices predicted by the Ministry of Finance. Both are measured in fixed 2007 NOK, using Norwegian CPI as deflator. Note that forecasts of oil prices have often been revised. In particular, as the years progressed, the forecasted 'Hotelling' ramps for oil prices have been replaced by forecasts based on random walks with drift in line with the empirical evidence (e.g., Hamilton, 2009). The production projections of the Norwegian government presented in Figure 14(b) show the hump-pattern for the next five decades familiar from Figure 12. They also indicate a large number of revisions. Figure 14(c) shows that, as a result, the declining paths of hydrocarbon reserves have been continuously revised upwards due to improved recoveries and discovery of new fields as already indicated in Figure 12.

6.3. Projected dependency ratios

Figure 15 gives examples of the Ministry of Finance's expectations for dependency ratios througout time. In the 1970s a turning point in the dependency ratio growth was correctly expected around 1990, though the levels of the projected dependency ratios were a bit low (upper left panel). In the 1980s the Ministry expected growth to turn positive around 2000 (upper right panel). This turning point was moved ahead in time during the 1990s (lower left panel), but it has yet to happen. By comparing the two lower panels, we also see that in the 1998-2001 publication Norway expected the growth in the dependency ratio to turn from positive to close to zero in the late 2020s and later on to negative. This expectation changed subsequently and the three last projections presented in the lower right panel show a growing dependency ratio towards 2060. We aim to test whether these expectations of the costs of future dependency have affect budgetary decisions of successive Norwegian governments.

Figure 15: Projections of permanent dependency ratio throughout time



Source: Ministry of finance, Statistics Norway and authors calculations

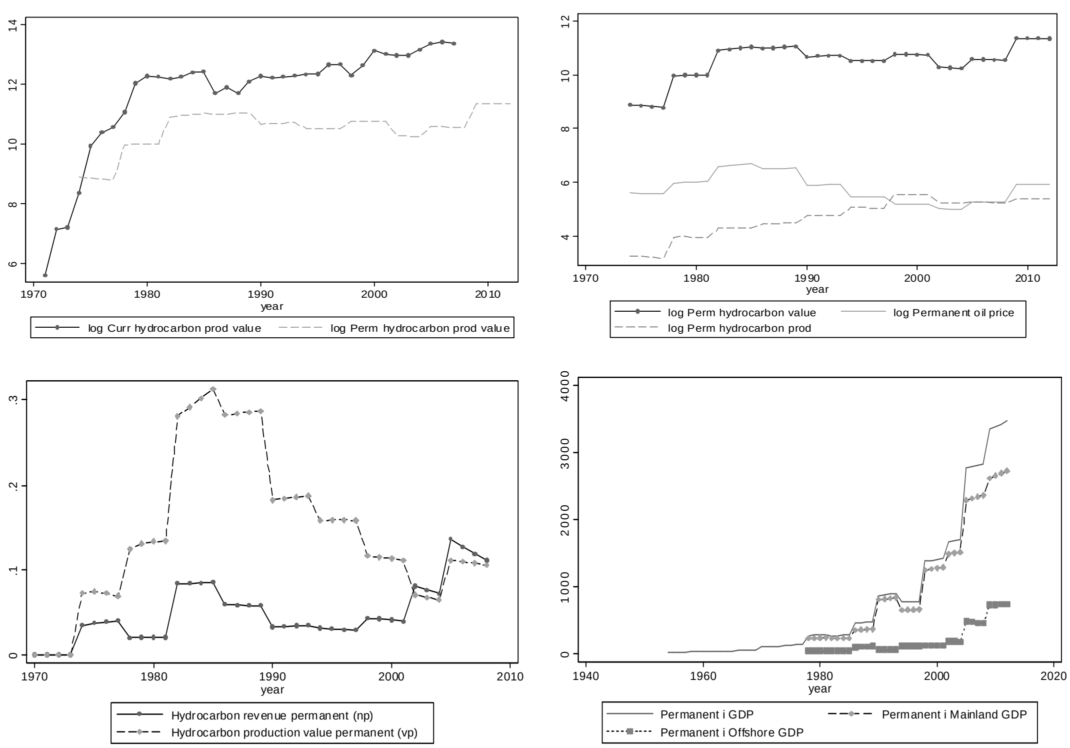
6.4. Calculating permanent values

Usually, (6)-(7) or (6′)-(7′) are estimated without data on permanent oil/gas revenues accruing to the government. In that case, if government believes oil/gas revenue to lasts forever, one has $n_t^P = n_t$ and thus $\beta_1 = 1$ and $\gamma_1 = -1$. If the government perceives changes to oil/gas revenues to be temporary, $n_t^{\ P} = 0$ and thus $\beta_1 = 0$ and $\gamma_1 = 0$ must hold. If oil/gas revenues are expected to decline exponentially at a rate α, using n_t rather than $n_t^{\ P}$, implies $n_t^P = \left(\frac{r}{r+\alpha}\right) n_t$ and thus $0 < \beta_1 = -\gamma_1 = \frac{r}{r+\alpha} < 1.$ With declining hydrocarbon revenues and no correction for permanent revenues, one should thus expect a coefficient smaller than unity for the effect of hydrocarbon revenues on the non-hydrocarbon deficit. Better is to use published forecasts of the Norwegian Ministry of Finance and use these to calculate the permanent value of future hydrocarbon revenues.[15] Figure 18 presents selected permanent values. The upper left panel gives actual

[15] An alternative is to approximate historical and projected oil/gas revenues with an estimated ARMA-model and extract the permanent component using this DGP. Yet another alternative is to use the value of oil/gas reserves in the ground evaluated at current oil prices as an approximation for the present value of the stream of present and future hydrocarbon income to the economy, which is accurate with iso-elastic oil/gas demand, zero extraction costs and no new discoveries. If S_t denotes hydrocarbon reserves at time t,

production values (measured both as production of oil-equivalents multiplied with the oil price and as the value added of the hydrocarbon sector) together with the calculated permanent values, which are based on the Ministry of Finance's expectations throughout time. Permanent values are below actual values and show a lower growth over time, both features indicating falling and temporary hydrocarbon production. The upper right panel of figure 16 decomposes permanent production value into permanent oil-equivalents of hydrocarbon production and permanent oil price. The permanent production path decreases from its peak in the mid-1980s towards the long-term budget of 2002-05. The permanent oil price increases steadily from mid-1970s until 1998-2001, when it peaks. In the last three forecasts the level of the price is still high, albeit somewhat lower than around 2000. The overall picture is declining permanent oil production and increasing permanent oil price.

Figure 16: Actual and permanent values of hydrocarbon production



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

$\sum_{s=0}^{\infty}(1+r)^{-s} p_{t+s}q_{t+s} = p_t\sum_{s=0}^{\infty}q_{t+s} = p_tS_t$ provided that oil prices satisfy $p_{t+s} = (1+r)^s p_t$. The Hotelling rule says that marginal hydrocarbon revenue minus marginal extraction costs should rise at the market rate of interest, but with iso-elastic demand and zero extraction costs this implies that oil prices should increase at the market rate of interest. To get n_t^P, one needs to multiply the value of hydrocarbon reserves and multiply it with a postulated government tax cum dividend rate on hydrocarbon wealth.

The Ministry of Finance has also published its expectations for State hydrocarbon income directly. The lower left panel of figure 16 compares the permanent values of State hydrocarbon income and permanent production values as shares of GDP. Given that the Ministry is consistent, the difference between the two should be due to the tax scheme. The two series seem to follow each other quite closely, with the exception of 1978-81 and 1998-2001, where we see them moving in opposite directions. Figure 1 confirms that over time the state has captured a higher share of the production value. The lower right panel decomposes permanent GDP into mainland and offshore GDP, the latter including the entire hydrocarbon sector. We can see that the relative contribution of offshore GDP declines over time as mainland GDP experiences higher growth rates. Figure 7 in section 2 presents the permanent dependency ratio together with the current one.

7. Estimation of fiscal reaction functions

We estimate equations (6′) and (7′). Identification requires that the regressors are uncorrelated with the error term. The dependency ratios, measured as population aged 67 or more relative to population aged 20-66, should be exogenous to fiscal adjustments. The debt and the fund are included with a one year lag and are predetermined from the point of view of the fiscal reaction in year *t*. However, hydrocarbon revenue can be directly influenced by fiscal policy and may thus be endogenous. For instance, the government may be tempted to use its majority stake in StatoilHydro to increase dividends if spending is high. A positive correlation between spending and hydrocarbon income due to endogenous dividends would bias the OLS estimates of the effect of current hydrocarbon revenue on public expenses upwards. To avoid such biases, we use current and permanent hydrocarbon production value as instruments for current and permanent hydrocarbon income. We instrument also permanent hydrocarbon income, because predictions of future income may be influenced by current fiscal stance and incomes. Production value and government hydrocarbon income are directly related through the tax system and the government's stakes in hydrocarbon enterprises and the empirical results confirm high predictive power of the instruments. The exclusion restriction requires that the production value relates to the non-oil primary deficit, taxes and expenses through hydrocarbon income only, given the controls included. The output gap controls for potential effects of hydrocarbon production value via general macroeconomic activity. Furthermore, the institutional framework allows for the possibility of political influence on the number of licenses issued on each potential field and the allocation of those between different oil companies. When the licenses are granted, the oil companies are allowed to determine the extraction speed from private economic considerations. The government could in principle influence depletion speed with the environment tax, but this tax has only a minor impact on the budget (see section 2). In addition to the extraction speed, the other component of the production value is the oil price, which is accountable for the larger part of the variation in the production value. It is determined on the world market and exogenous to Norway. The government's *prediction* of production value underlies the permanent production value. It is based on factors that are exogenous to the current fiscal stance, e.g. geological explorations, private search activity for new fields, the speed of depletion in developed fields and assumptions about the oil price. The fiscal stance could have an impact on future licensing and thus on the prediction of future production value, but we argue that this is not a concern for using permanent production value as an instrument.

Table 3 shows the first-stage IV regression (corresponding to our benchmark results of model 3 in Table 5 below). Current hydrocarbon production value predicts current hydrocarbon revenue with a coefficient of 0.4. For the permanent production value we also find a robust positive relation with a coefficient of 0.3. The partial R-squared and the F-tests indicate that predictive power of the instruments is good. As we employ two instruments for two endogenous variables, we cannot test the exclusion restriction with an over-identification test and rely on the assumptions of exogeneity discussed above.

Table 3: First-stage IV estimates with hydrocarbon production value as instrument for revenue

	(1a)	(1b)
	Hydrocarbon revenue current (*n*)	Hydrocarbon revenue permanent (n^P)
Hydrocarbon production value current (*v*)	0.423***	-0.083*
	(0.060)	(0.047)
Hydrocarbon production value permanent (v^P)	-0.035	0.287***
	(0.038)	(0.029)
Dependency ratio current (*p*)	-0.180	0.043
	(0.292)	(0.227)
Dependency ratio permanent (p^P)	0.138	0.182
	(0.196)	(0.152)
Last year's debt (*d*)	0.030	0.085*
	(0.056)	(0.044)
Last year's Fund (*f*)	0.038	0.133***
	(0.036)	(0.028)
Output gap (*y*)	0.030	-0.020
	(0.094)	(0.073)
Constant	0.007	-0.032
	(0.037)	(0.029)
R-squared	0.93	0.92
Observations	54	54
Shea partial R-squared	0.54	0.69
Partial R-squared	0.55	0.70
F-test for instrument's predictive power	28.28	53.32
P-value F-test for instrument's predictive power	0.00	0.00

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Current hydrocarbon revenue current is oil/gas revenue received by the state as reported by the Ministry of Oil and Energy. Hydrocarbon production value is hydrocarbon production in oil equivalents multiplied with the oil price. The dependency ratio is the population aged 67 and higher divided by the population aged 20-66. Permanent values are calculated by the information approach, i.e., we use only published expectations from the Ministry of Finance and a 2% discount rate. Hydrocarbon monetary variables are measured in 2007 NOK as share of GDP Debt (i.e., net debt) and the Fund (the state's pension fund – previously called the petroleum fund) are measured in current NOK as shares of GDP The output gap is the logarithmic deviations from GDP trend, as estimated by 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).

Table 4 reports conventional estimates of fiscal reaction functions excluding permanent values of hydrocarbon income. Only two of the three regressions for the primary non-hydrocarbon deficit, taxes and expenditure need to be estimated, since the third one follows from adding the first two. Current hydrocarbon production value is used as instrument for current hydrocarbon revenue, which has not been taken account in previous studies.

If permanent variables are omitted, the coefficient on current hydrocarbon revenues will generally reflect effects of both current and permanent values. Current hydrocarbon revenue increases the non-hydrocarbon primary deficit with a coefficient of about 0.7, so that on the margin roughly 30% of hydrocarbon revenue is saved. This is compatible with the HC-PIH if the government believes hydrocarbon revenue declines at a rate of α = 1% per annum, which follows from $n_t^P = \left(\frac{r}{r+\alpha}\right) n_t = 0.7 n_t$ if *r* = 0.02. Interestingly, expected hydrocarbon revenue as percentage of mainland of GDP published by the Ministry of Finance in January 2009 (shown in Figure 13 based on an oil price of 65 USD from 2010) implies an average annual decline in this ratio over the period 2010-2060 of 4.9 percent, which suggests that only 30% of current hydrocarbon revenue should be used to raise spending or cut taxes and 70% should be saved. This suggests that spending out of current hydrocarbon revenue has been too high. The positive effect of current hydrocarbon revenue on the non-oil primary deficit is reflected in the negative relationship between current hydrocarbon income and non-oil taxes. The coefficient of -1 indicates that one extra Norwegian Krone of current hydrocarbon revenue has reduced taxes with one Krone.

Table 4: IV Estimates of fiscal rules ignoring future hydrocarbon revenues and pension obligations

	(2a) Deficit (*b*) IV	(2b) Taxes (τ) IV	(2c) Expenditure (*g*) IV
Hydrocarbon revenue current (*n*)	0.729***	-1.084***	-0.355
	(0.229)	(0.408)	(0.288)
Dependency ratio current (*p*)	0.386	1.941***	2.327***
	(0.393)	(0.701)	(0.496)
Last year's debt (*d*)	-0.082	0.246	0.164
	(0.095)	(0.169)	(0.120)
Last year's Fund (*f*)	-0.127***	0.428***	0.301***
	(0.042)	(0.075)	(0.053)
Output gap (*y*)	-0.512***	0.248	-0.264
	(0.159)	(0.283)	(0.200)
Constant	-0.103*	-0.038	-0.141*
	(0.060)	(0.106)	(0.075)
R-squared	0.69	0.57	0.86
Observations	54	54	54

Hydrocarbon revenue is oil revenue received by the state as reported by the Ministry of Oil and Energy. Current and permanent hydrocarbon production value - calculated as hydrocarbon production in oil equivalents multiplied with the oil price – are used as instruments for current and permanent hydrocarbon revenue. The first-stage regressions are shown in Table 3. The dependency ratio is population aged 67 and higher divided by the population aged 20-66. Hydrocarbon monetary variables are measured in 2007 NOK as share of GDP in 2007 NOK. Debt (i.e., net debt) and the Fund, the state's pension fund (previously called the petroleum fund) are measured in current NOK as shares of GDP. The output gap is the logarithmic deviation from GDP trend, as estimated by 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).

Wierts and Schotten (2008) estimate fiscal reaction functions for the Dutch budget deficit similar to the ones in Table 4, i.e., they suppose that the budget surplus depends on current gas revenues, lagged debt and the output gap. Their coefficient on current gas revenue of 0.78 is close to our estimate of 0.73. Furthermore, they find that lagged debt has a significant negative effect on the deficit with a coefficient equal to –0.06. This is similar in magnitude to our (insignificant) estimate of the effect of debt on the deficit. Their estimate for the coefficient on the output gap, -0.6, is similar to ours -0.5.

The coefficients on the output gap in Table 4 also indicate that anti-cyclical demand management mainly operates via the budget deficit, not via taxes or public spending. Furthermore, Table 4 suggests that a higher current dependency ratio is associated with a higher level on current public spending and a higher tax rate, but not with a higher deficit. A bigger Fund is associated with higher spending, but somewhat surprisingly also to higher taxes and even a higher primary non-hydrocarbon deficit.

The estimates presented in Table 4 suffer from omitted variables bias, since permanent hydrocarbon revenue and permanent pension burden are excluded. In Table 5 we therefore re–estimate our fiscal reaction functions allowing for the effects of time-varying permanent values for hydrocarbon income and the dependency ratio (see section 6 and appendix 1 for details on the construction of these variables). This allows us to compare the estimated coefficients with the theoretical predictions summarized in Table 2. Regressions (3) presented in Table 5 are our core IV-estimates.

For hydrocarbon revenue and taxes the evidence seems to support the PIH, since there is no significant effect of *current* hydrocarbon revenue on taxes while the coefficient for the effect of *permanent* revenues on taxes is significant and estimated at –1.8. This seems, however, high given that the PIH suggests a zero coefficient for current revenue and a coefficient between -1 and 0 for permanent revenue. The estimated effects of *current* and *permanent* hydrocarbon revenue on the primary non-hydrocarbon deficit are 0.52 and 0.35, respectively. This is in line with the PIH with debt criteria. The PIH suggests a coefficient equal to one on permanent hydrocarbon revenue and a zero coefficient on current hydrocarbon revenue, i.e., only permanent changes should affect consumption. The BIH suggests, on the contrary, a zero coefficient on permanent hydrocarbon income and only already accumulated assets should affect spending decisions. The positive coefficient of 0.52 on current hydrocarbon revenue violates the PIH, but is compatible with the BIH.

The estimated effects of the current and permanent dependency ratios on the non-hydrocarbon primary deficit are consistent with the PIH. The positive effect of the current dependency ratio on the non-hydrocarbon primary deficit reflects higher spending needs when the dependency ratio is high. The negative effect of the permanent dependency ratio on the non-hydrocarbon primary deficit suggests that Norway is making provisions for future spending needs arising from the graying of the population. The current dependency ratio is positively associated with both taxes and expenses, but the coefficient on taxes is smaller than the one on expenses. The pay-as-you go system of financing pensions seems to increase taxes, but not sufficiently to cover the transfers and necessary negative saving turns up as a higher non-hydrocarbon primary deficit.

The past debt-GDP and fund-GDP ratios have no significant effect on the primary non-hydrocarbon deficit. Still, the debt reaction coefficient is negative and larger than the interest rate, which suggests presence of debt criteria. Debt has to have a positive effect on taxes, but the size of 0.25 seems implausibly high. The Fund seems to have a positive effect on taxes, which is at variance with the theory. We return to the effect of the Fund-GDP ratio below. Finally, the output gap has a negative effect on the non-hydrocarbon primary deficit and no effect on taxes and expenses.

Regressions (3′) in Table 5 are the OLS estimates corresponding to regressions (3). OLS estimates of the effect of current and permanent hydrocarbon revenue are biased towards zero in OLS. Judged from magnitudes, the bias for the non-hydrocarbon primary deficit is driven by the tax equation. Low tax revenue may lead politicians to be overly optimistic on future hydrocarbon revenue in order to avoid tax increases. This would create a partial positive correlation between permanent hydrocarbon revenue and taxes, so the OLS estimate of the negative effect of permanent hydrocarbon revenue on taxes would be biased towards zero. The OLS-bias in the coefficient for current hydrocarbon income and taxes is harder to explain. Since the positive coefficient on the current dependency ratio in the tax equation is also biased towards zero under OLS, these contemporary variables should been seen together. One possibility is that a high current dependency ratio makes the government seek extra revenue from the hydrocarbon sector to avoid tax increases. The current hydrocarbon income would then be a function of the dependency ratio, which may lead to biased OLS coefficients on both the current dependency ratio and current hydrocarbon income.

Table 5: IV Estimates of fiscal rules with permanent hydrocarbon revenue and dependency ratio

	(3a) Deficit (*b*) IV	(3b) Taxes (τ) IV	(3c) Expenditure (*g*) IV	(3a′) Deficit (*b*) OLS	(3b′) Taxes (τ) OLS	(3c′) Expenditure (*g*) OLS
Hydrocarbon revenue current (*n*)	0.516**	-0.404	0.112	0.299*	0.043	0.342**
	(0.206)	(0.327)	(0.227)	(0.159)	(0.235)	(0.166)
Hydrocarbon revenue permanent (n^p)	0.354*	-1.782***	-1.428***	0.203	-1.203***	-1.000***
	(0.193)	(0.306)	(0.213)	(0.168)	(0.248)	(0.175)
Dependency ratio current (*p*)	1.018**	1.699**	2.716***	1.426***	0.668	2.094***
	(0.421)	(0.668)	(0.465)	(0.395)	(0.583)	(0.411)
Dependency ratio permanent (p^p)	-0.873***	0.927**	0.054	-0.887***	0.946**	0.059
	(0.294)	(0.466)	(0.324)	(0.308)	(0.455)	(0.320)
Last year's debt (*d*)	-0.122	0.252*	0.130	-0.064	0.118	0.054
	(0.087)	(0.138)	(0.096)	(0.085)	(0.126)	(0.089)
Last year's Fund (*f*)	-0.006	0.386***	0.380***	0.050	0.242***	0.292***
	(0.060)	(0.095)	(0.066)	(0.057)	(0.085)	(0.060)
Output gap (*y*)	-0.529***	0.324	-0.205	-0.509***	0.266	-0.243
	(0.142)	(0.226)	(0.157)	(0.149)	(0.220)	(0.155)
Constant	-0.051	-0.164*	-0.216***	-0.112**	-0.008	-0.120**
	(0.057)	(0.091)	(0.063)	(0.053)	(0.078)	(0.055)
R-squared	0.75	0.73	0.91	0.77	0.78	0.93
Observations	54	54	54	54	54	54

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. First-stage regressions are shown in Table 3.

In Table 6 we investigate the role of current and permanent hydrocarbon revenue for the non-hydrocarbon primary deficit during 1954-95 and 1996-2007. This choice of periods is motivated by the start of the Fund in 1996. Regression (4a) thus extends regression (3a) in this way, but finds no significant effects. Regressions (4b)-(4g) include current hydrocarbon revenue with a separate coefficient for the first period. Current hydrocarbon revenue was fully spent, and more so during this first part of the Norwegian hydrocarbon area, with a coefficient of about 1.4. Permanent hydrocarbon revenue is in none of these regressions significant. We do find, however, that the Fund is positively significant in regressions (4b), (4e) and (4g). This occurs if permanent hydrocarbon revenue is assumed to have the same coefficient over the whole sample or if permanent hydrocarbon revenue for the later period is excluded. The coefficient on the Fund in these regressions seems large, 0.10 to 0.17, and it may be that the Fund picks up some of the effect of the permanent hydrocarbon revenue from 1996 onwards. Regression (1b) in Table 3, the first stage for permanent hydrocarbon revenue, shows a strong correlation between the Fund and permanent hydrocarbon revenue. Such a correlation makes it econometrically hard to pick up effects of both. Furthermore, as hydrocarbons are depleted and transformed into financial wealth, the permanent hydrocarbon revenue is gradually being replaced by a permanent return on the Fund. The government is therefore expected to focus more attention on the Fund and less on permanent hydrocarbon revenue.

For the permanent dependency ratio we find little variation of the effect throughout our period. In separate estimations we estimated this coefficient for different early and late periods with cut offs in 1980/81, 1985/86, 1990/91, 1995/96 and 2000/01, and it was stable at around -0.8 (the estimates varied between -0.75 in the period 1953-95 to -0.99 in the period 1953-90). The Norwegian Ministry of Finance has a long tradition of employing fairly sophisticated models in their budget and population projections have clearly been available during the whole of our sample period. It therefore seems plausible that the Ministry of Finance has steadily kept an eye on the development of the future dependency ratio.

Table 6: Changing emphasis on hydrocarbon revenue measures over time

	(4a) Deficit (*b*) IV	(4b) Deficit (*b*) IV	(4c) Deficit (*b*) IV	(4d) Deficit (*b*) IV	(4e) Deficit (*b*) IV	(4f) Deficit (*b*) IV	(4g) Deficit (*b*) IV
Hydrocarbon revenue current (n)	0.711**						
	(0.344)						
Hydrocarbon revenue permanent (n^p)		-0.163					
		(0.253)					
Hydrocarbon revenue current (n) ->1995		1.429***	1.450***	1.441***	1.403***	1.357***	1.288***
		(0.355)	(0.388)	(0.406)	(0.346)	(0.339)	(0.277)
Hydrocarbon revenue current (n) 1996->		-0.457	-0.414		-0.465		
		(0.302)	(0.330)		(0.300)		
Hydrocarbon revenue permanent (n^p) ->1995	0.278		-0.137	-0.131	-0.133		
	(0.316)		(0.271)	(0.284)	(0.250)		
Hydrocarbon revenue permanent (n^p) 1996->	-2.137		-0.937	-1.365		-1.329	
	(2.657)		(2.013)	(2.062)		(2.063)	
Dependency ratio current (p)	0.463	0.049	-0.108	-0.147	0.084	-0.133	0.149
	(0.793)	(0.517)	(0.680)	(0.711)	(0.503)	(0.708)	(0.484)
Dependency ratio permanent (p^p)	-0.254	-0.635**	-0.456	-0.356	-0.673**	-0.366	-0.673**
	(0.732)	(0.296)	(0.559)	(0.576)	(0.287)	(0.576)	(0.278)
Last year's debt (d)	-0.105	-0.328***	-0.314***	-0.297**	-0.326***	-0.281**	-0.297***
	(0.126)	(0.106)	(0.119)	(0.123)	(0.107)	(0.115)	(0.096)
Last year's Fund (f)	0.235	0.173***	0.245	0.239	0.157***	0.232	0.099**
	(0.263)	(0.066)	(0.204)	(0.214)	(0.059)	(0.213)	(0.045)
Output gap (y)	-0.494**	-0.361**	-0.376**	-0.381**	-0.366**	-0.409**	-0.392***
	(0.214)	(0.155)	(0.169)	(0.177)	(0.154)	(0.165)	(0.139)
Dummy=1 ->1995	-0.072	0.049	0.043	0.033	0.050	0.033	0.042
	(0.078)	(0.066)	(0.073)	(0.075)	(0.065)	(0.075)	(0.063)
Dummy=1 1996->	-0.035	0.122	0.134	0.106	0.121	0.109	0.084
	(0.089)	(0.082)	(0.092)	(0.094)	(0.081)	(0.094)	(0.074)
R-squared	0.58	0.78	0.75	0.72	0.78	0.72	0.80
Observations	54	54	54	54	54	54	54
Chi2 np	0.82		0.16	0.35			
P-value np	0.37		0.69	0.55			
Chi2 n		15.44	13.21		15.52		
P-value n		0.00	0.00		0.00		

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Chi2 np reports the Chi-squared statistics for the test n^p ->1995 = n^p 1996 -> and the P-value n^p the corresponding p-value. The analogous is reported for n. We find significant different effects across time of n but not n^p.

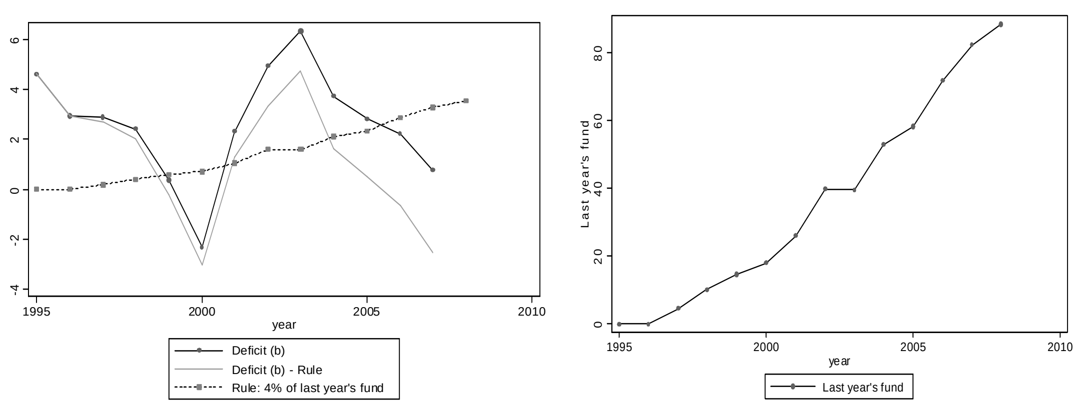
Table 7: Restricting coefficients on net debt and Fund in accordance with current stated fiscal rule

	(5a) Deficit (b) IV	(5b) Deficit (b) IV	(5c) Deficit (b) IV	(5d) Deficit (b) IV	(5c′) Deficit (b) IV
Hydrocarbon revenue current (n)	0.429**	0.414**	0.340**	0.342**	0.516**
	(0.169)	(0.174)	(0.137)	(0.140)	(0.206)
Hydrocarbon revenue permanent (np)	0.319*	0.351*	0.319*	0.321*	0.354*
	(0.184)	(0.191)	(0.183)	(0.187)	(0.193)
Dependency ratio current (p)	1.259***	1.258***	1.466***	1.459***	1.018**
	(0.273)	(0.332)	(0.148)	(0.184)	(0.421)
Dependency ratio permanent (pp)	-1.038***	-0.804***	-0.958***	-0.944***	-0.873***
	(0.196)	(0.282)	(0.174)	(0.282)	(0.294)
Last year's Debt(d)	-0.118	-0.040	-0.040***	-0.037	-0.122
	(0.086)	(0.000)	(0.000)	(0.047)	(0.087)
Last year's Fund (f)	0.040	-0.002	0.040***	0.037	-0.006
	.	(0.059)	(0.000)	(0.047)	(0.060)
Output gap (y)	-0.518***	-0.561***	-0.549***	-0.551***	-0.529***
	(0.139)	(0.137)	(0.134)	(0.138)	(0.142)
Constant	-0.061	-0.097***	-0.103***	-0.105***	-0.051
	(0.055)	(0.030)	(0.028)	(0.034)	(0.057)
R-squared					0.75
Observations	54	54	54	54	54
Chi2 Last year's Fund (f)=0.04					0.58
P-value Last year's Fund (f)=0.04					0.45
Chi2 Last year's Debt (d)=-0.04					0.89
P-value Last year's Debt (d)=-0.04					0.34
Chi2 Last year's Fund (f)=0.04 & Last year's Debt (d)=-0.04					0.89
P-value Last year's Fund (f)=0.04 & Last year's Debt (d)=-0.04					0.34

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Bold coefficients are imposed.

Table 7 restricts the coefficients in the estimated fiscal reaction functions to correspond to Norway's fiscal rule of running a structural non-hydrocarbon deficit equal to 4% of last year's value of the Fund. This rule implies a reaction coefficient for the effect of the Fund-GDP ratio on the non-hydrocarbon deficit as share of GDP of 0.04. In regression (5a), the coefficient on the Fund is thus set to 0.04; in regression (5b) the debt coefficient is set to 0.04; and in regression (5c) both of them are set to 0.04. In regression (5d) the restriction is that net debt and the Fund are treated symmetrically, i.e. their coefficients should be of the same size, but its exact size is estimated. Qualitatively, these restrictions do not make a difference compared to our benchmark model (3a). Regression (5c′) reproduces the benchmark model; p-values well above 0.10 indicate that we cannot reject the coefficients on the net debt and the Fund to equal -0.04 and 0.04, respectively. Figure 17 shows how the rule has only recently started to cover a considerable share of the non-hydrocarbon primary deficit. It may be too early to test compliance with the rule. Appendix 2 offers some robustness checks.

Figure 17: Discretionary part of non-hydrocarbon primary deficit and Fund



Note: the figure shows the non-hydrocarbon primary deficit and the Fund as percentage of GDP.

8. Dynamic simulation of estimated fiscal policy, HC-PIH, PIH and BIH rule

We now investigate the sustainability of the fiscal stance given our core regressions (3a) and (5c). We use the coefficients obtained by re-estimating (3a) by excluding the insignificant net debt and Fund variables (see regression (3A) in Table A.2.3). We compare its implications for the deficit and the net debt with the fiscal stance that would result from either the HC-PIH or the PIH. Table 8 gives the expressions for the deficit and net debt level under these three policy regimes and figure 18 presents the dynamic simulations.[16]

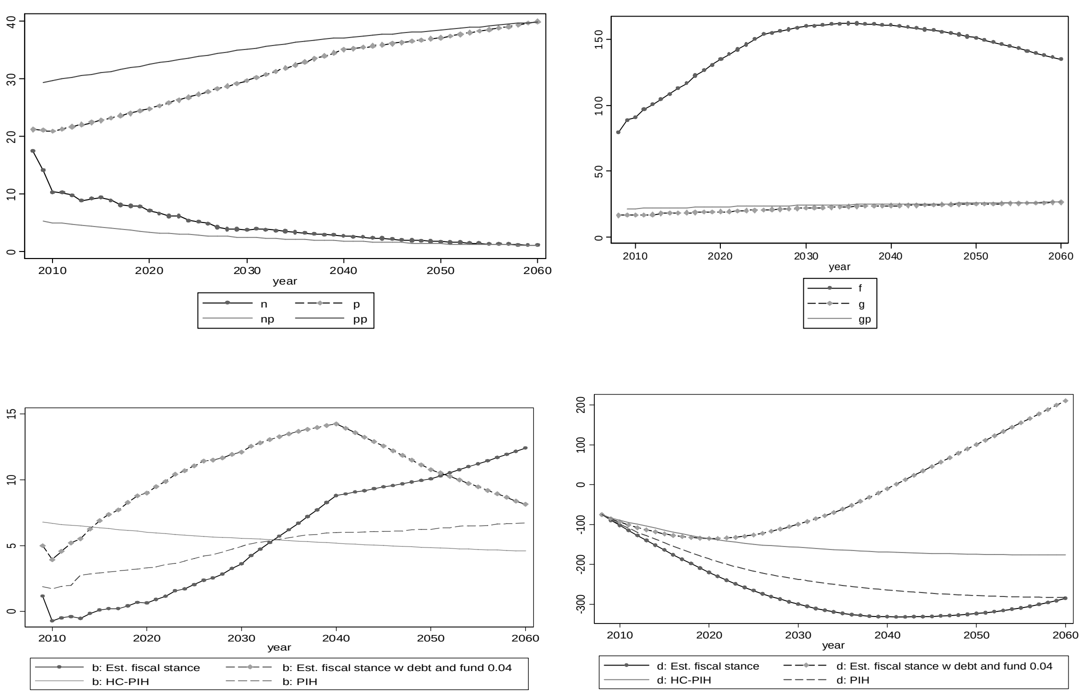
[16] We use predictions of total transfers to represent government spending in the PIH simulations (implicitly assuming that other components of government spending will be a constant fraction of GDP). In our regressions, on the other hand, we use the dependency ratio. Our estimated coefficient includes in effect a price, which links the dependency ratio to government expenses, in addition to the behavioural effect of government spending on the non-hydrocarbon primary deficit, taxes and spending. Given the predictions of transfers and the dependency ratio of the Ministry of Finance (Perspektivmeldingen 2009) and our calculations

Table 8: Simulated Fiscal Reaction Functions

Rule	Estimated fiscal reaction function	HC-PIH	PIH
Primary non-HC deficit	$b_t^{3A} = 0.355 n_t + 0.403 n_t^p + 1.373 p - 0.796 p^p - 0.11$ $b_t^{5c} = 0.340 n_t + 0.319 n_t^p + 1.466 p - 0.958 p^p$ $- 0.040 d_{-1} + 0.040 f_{-1} - 0.103$	$b_t = n_t^p - r d_{t-1}$	$b_t = g_t - g_t^p + n_t^p - r d_{t-1}$
Net debt	$d_t = (1+r) d_{t-1} + b_t - n_t$	$d_t = d_{t-1} + (n_t^p - n_t)$	$d_t = d_{t-1} + (n_t^p - n_t) - (g_t^p - g_t)$

Note: We assume that government spending *g* equals total transfers, the discount factor is 2%, the return on the fund is 4%, the ratio of net debt to GDP in 2008 was 0.75, and that total transfers and hydrocarbon revenue to the state follow the paths presented in by Ministry of Finance January 2009 (Perspektivmeldingen 2009). The estimates are based on percentages of GDP, whereas the projections of Ministry of Finance on Mainland GDP. The projected size of the Fund is calculated from expected fund return as published by the Ministry of Finance in the Revised Budget of May 2009 (RNB 09). The return is expressed in percentage of Mainland GDP and we have recalculated to GDP using consistent GDP and Mainland GDP series.

Figure 18: Primary non-hydrocarbon deficit and net debt under estimated fiscal stance, HC-PIH and PIH



Note: The two upper panels present the data for exogenous variables needed for the simulations. These are based on projections of the Ministry of Finance from January and May 2009 (Perspektivmeldingen and Revised National Budget). The permanent values are calculated by the authors, applying the information approach explained in the appendix. The two lower panels show the simulations of the non-hydrocarbon primary deficit (b) and the net debt (d) under four alternative fiscal reaction functions. "Estimated fiscal stance" refers to our econometric model (3A) and "Estimated Fiscal stance w debt and fund 0.04" to our econometric model (5c)

---

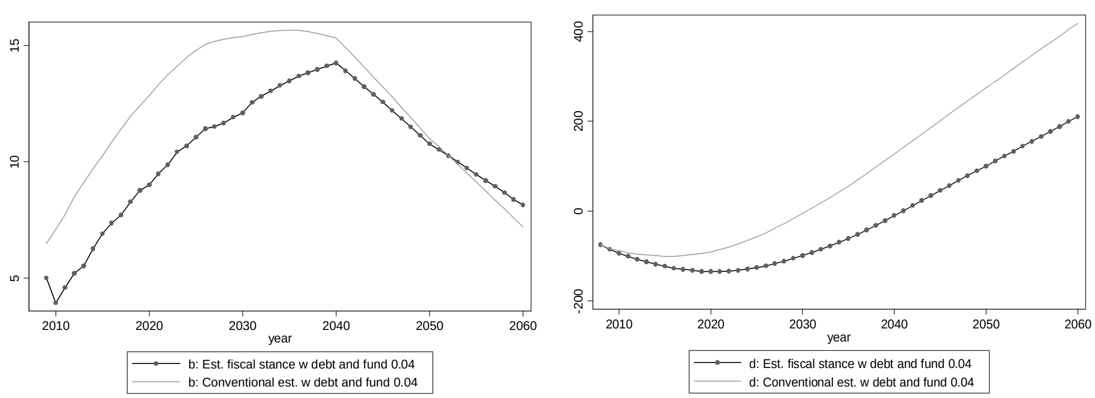
of permanent values of the two, we estimate $g_t = 0.069 + 0.488 p_t$ and $g_t^p = 0.080 + 0.458 p_t^p$. Our benchmark estimates of the effect of the current and permanent dependency ratio on the non-hydrocarbon primary deficit suggest a coefficient of about 1 for the current dependency ratio and a coefficient of about -0.9 for the permanent dependency ratio. Translated into government transfers, our estimates imply that a one percentage point increase in current government transfers increases the non-hydrocarbon primary deficit with about 2 percentage points. A one percentage point increase in permanent government transfers decreases the non-hydrocarbon primary deficit with about 2 percentage points.

Ignoring future public spending obligations arising from the expected increase in the dependency ratio, we observe that the HC-PIH leads to a modest increase in sovereign wealth resulting from running a primary non- hydrocarbon deficit of 5-7% of GDP. However, if one takes fully account of the rising burden of a graying population, the PIH is appropriate and the government should run a much tighter fiscal stance. It should run during the next few years a much smaller primary hydrocarbon deficit about 5%-points of GDP less than under the HC-PIH and in the decades thereafter a gradually rising primary non-hydrocarbon deficit. This tighter fiscal stance during the first two decades under the PIH leads to a much bigger accumulation of sovereign wealth, 282 percent of GDP compared to 176 percent of GDP under the HC-PIH in 2060, so that its return can pay for future spending obligations without having to cut public spending or raise taxes in the future.

Figure 18 indicates that Norway's estimated fiscal stance, given by b_t^{3A} in Table 8, is sustainable and leads to a maximum net asset accumulation of 332 percent of GDP in 2042, declining to 285 percent in 2060. This is comparable to what is required by the PIH. This estimate misses, however, the effect the Fund will have on the non-hydrocarbon primary deficit. If we impose the 4% rule of the Fund and use b_t^{5c} in Table 8, the outcome is instead a debt accumulation of 210 percent of GDP in 2060. This simulation casts serious doubt on whether the prudent reputation of Norway's fiscal policy is warranted.

Figure 19 demonstrates how conventional estimation of fiscal reaction functions leads to biased projections for the non-hydrocarbon primary deficit and the net debt-GDP ratio. The figure compares the b_t^{5c} equation in Table 8 with a conventional estimate where the coefficients of permanent hydrocarbon revenue and dependency ratio are set to zero. In both cases the current fiscal rule is imposed (the simulation of the conventional estimates is based on column (7) in Table A.2.5). If the government fails to take into account that the permanent pension burden is higher than the current pension burden, it will run a too large non-hydrocarbon primary deficit. The net debt-GDP ratio reaches under such a scenario 418 percent in 2060, compared to 210 percent under the forward looking alternative.

Figure 19: Primary non-hydrocarbon deficit and net debt under fiscal stance and conventional approach



9. Concluding remarks

We have contrasted the estimated fiscal stance of Norway with the PIH with and without taking account of the costs of the rising pension burden and with and without imposing the current fiscal rule governing Norway's sovereign wealth fund. Our main result is that the current fiscal stance of Norway is unsustainable and leads to escalation of net debt rather than accumulation of net assets to provide for the rise in future spending obligations. This means that the holy trinity of Norwegian politics needs to be reassessed. Either the rules of the Stabilization Fund have to be tightened up, so that less goes to finance the general budget. Or the dogma of indexing pensions and civil servant salaries needs to be abandoned. Or the actual average retirement age of 59 years has to be raised. Without reforming this holy trinity, it will not be possible to make Norway's fiscal stance sustainable.

Our estimates of fiscal reaction functions were inspired by PIH and, 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 hydrocarbon revenue. To do this, we offered various ways of calculating the permanent value of hydrocarbon revenues based on either government projections of reserves and oil prices or on the value of oil and gas under the ground. Furthermore, we used instrumental variables to correct for the potential endogeneity of hydrocarbon government revenue. We also used government projections of the dependency ratio as a proxy for future spending obligations and estimated the effect of both the current and the permanent dependency ratio on the fiscal stance. Although our estimates offer evidence that Norway's fiscal stance has features of the bird-in-hand rule in the sense that not full account is taken of hydrocarbon wealth under the ground, they also indicate that the fiscal stance is a far cry from the permanent income hypothesis.

In future work on fiscal policy responses to natural resource windfalls, we want to explore four avenues. First, it is interesting to compare the experience of Norway with another hydrocarbon-rich economy with a stable political environment, reliable institutions and an effective legal system. The Netherlands, for example, has adhered to the Maastricht convergence process and Norway did not. Furthermore, the Netherlands 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. It is interesting to investigate whether the Netherlands investment has gone into 'white elephants' such as freight railways (cf., Robinson and Torvik, 2005). Second, it is worthwhile to road-test analytical and empirically estimated fiscal rules in small-scale macroeconomic models of these countries. Although one could do this within the context of a real DSGE model as has been done for Mexico and Norway (Pieschacon, 2008), it may be more convincing to do this with an official econometric model used by the government paying ample attention to the fiscal burden of a growing pension bill (e.g., Heide, et al., 2006). Third, it is important to study the interaction with monetary policy and Taylor rules for the nominal interest rate and investigate the issue of the proper division of tasks between the central bank and fiscal authorities of oil-rich economies. Finally, the portfolio decisions between assets in the ground and assets in the fund need to be analyzed from the finance point of view. So far, the evidence suggests that sovereign wealth funds perform poorly due to imperfect diversification – e.g., biases towards countries that share the same culture – and poor corporate governance (Chhaochharia and Laeven, 2008).

References

Barnett, S. and R. Ossowski (2003). Operational aspects of fiscal policy in oil-producing countries, in J. Davis, R. Ossowski and A. Fedelino (eds.), Fiscal Policy Formulation and Implementation in Oil-Producing Countries, International Monetary Fund, Washington, D.C.

Barro, R.J. (1979). On the determination of the public debt, Journal of Political Economy, 87, 5, 940-971.

Bornhorst, F., S. Gupta and J. Thornton (2008). Natural resource endowments, governance, and the domestic revenue effort: evidence from a panel of countries, IMF Working Paper WP/08/170, International Monetary Fund, Washington, D.C.

Brunnschweiler, C. and E.H. Bulte (2008). The resource curse revisited and revised: a tale of paradoxes and red herrings, Journal of Environmental Economics and Management, 55, 3, 248-264.

Chhaochharia, V. and L. Laeven, (2008). Sovereign wealth funds: Their investment strategies and performance, Discussion Paper No. 6959, CEPR, London.

Collier, P., F. van der Ploeg, M. Spence, and A.J. Venables (2009). Managing resource revenues in developing economies, IMF Staff Papers, to appear.

Deaton, A. (1992). Understanding consumption, Oxford University Press, Oxford.

Galaasen, Sigurd (2009), Managing government wealth in an aging society - The implications of fiscal rules, Document 2009/13, Statistics Norway, www.ssb.no/emner/12/01/doc_200913/doc_200913.pdf

Hamilton, J.D. (2009). Understanding crude oil prices, Energy Journal, 30, 2, 179-206.

Heide, K.M., E. Holmøy, I.F. Solli and B. Strøm (2006). A welfare state funded by nature and OPEC. A guided tour on Norway's path from an exceptionally impressive to an exceptionally strained fiscal position, Discussion Paper No. 464, Statistics Norway, Research Department, Oslo.

Holmøy, E. and K. Stensnes (2008), Will the Norwegian pension reform reach it goals? An integrated micro-macro assessment, Statistics Norway Discussion Paper 557.

Jafarov, E. and D. Leigh (2007). Alternative fiscal rules for Norway, IMF Working Paper WP/07/241, International Monetary Fund, Washington, D.C.

Laibson, D. (1997). Golden eggs and hyperbolic discounting, Quarterly Journal of Economics, 62, 2, 443-477.

Leigh, D. And J.-P. Olters (2006). Natural resource depletion, habit formation, and sustainable fiscal policy: Lessons from Gabon, IMF Working Paper 06/193, International Monetary Fund, Washington, D.C.

Olters, J.-P. (2007). Old curses, new approaches? Fiscal benchmarks for oil-producing countries in sub-Saharan Africa, IMF Working Paper 07/107, International Monetary Fund, Washington, D.C.

Medas, P. and D. Zakharova (2009). A primer on fiscal analysis in oil-producing countries, IMF Working Paper 09/56, International Monetary Fund, Washington, D.C.

Ossowski, R., M. Villafuerte, P.A. Medas and Th. Tomas (2008). Managing the Oil Revenue Boom: The Role of Fiscal Institutions, Occasional Paper 260, International Monetary Fund, Washington, D.C.

Pieschacon, A. (2008). Oil booms and their impact through fiscal policy, mimeo., Stanford University.

Ploeg, F. van der (2009). Aggressive oil extraction and precautionary saving: coping with volatility, Research Paper 21, OxCarre, University of Oxford.

Ploeg, F. van der and A. J. Venables (2009a). Harnessing windfall revenue: optimal policy for resource-rich developing economies, Research Paper 9, OxCarre, University of Oxford.

Ploeg, F. van der and A.J. Venables (2009b). Absorbing a windfall of foreign exchange, OxCarre, University of Oxford.

Robinson, J.A. and R. Torvik (2005). White elephants, Journal of Public Economics, 89, 2-3, 197-210.Sachs, J.D. and A.M. Warner (1997). Natural resource abundance and economic growth, in G. Meier and J. Rauch (eds.), Leading Issues in Economic Development, Oxford University Press, Oxford.

Sibley, D.S. (1975). Permanent and transitory effects of optimal consumption with wage income uncertainty, Journal of Economic Theory, 68-82.

Sachs, J.D. and A.M. Warner (1997). Natural resource abundance and economic growth, in G. Meier and J. Rauch (eds.), Leading Issues in Economic Development, Oxford University Press, Oxford.

Takizawa, H., E.H. Gardner and K. Ueda (2004). Are developing countries better off spending their oil wealth up front, IMF Working Paper WP/04/141, International Monetary Fund, Washington, D.C.

Wierts, P. and G. Schotten (2008). De Nederlandse gasbaten en het begrotingsbeleid: theorie versus praktijk, Occasional Studies, Vol/6/No.5, De Nederlandsche Bank, Amsterdam.

Zeldes, S.P. (1989). Optimal consumption with stochastic income: deviations from certainty equivalence, Quarterly Journal of Economics, 104, 2, 275-298.

Appendix 1: Calculation of permanent values and data appendix

The stock of natural resources at time t, S_t, must equal the sum of current and all future extractions, R_s, $s \geq t$, that is $S_t = \sum_{i=0}^{\infty} R_{t+i}$. The discounted value of the resource equals $V_t = \sum_{i=0}^{\infty} \frac{P_{t+i} R_{t+i}}{(1+r)^i}$. There are various ways to calculate permanent income if, say, forecasts are available three years ahead:

1) "Information": If we only have projections for income in year t+1, t+2 and t+3, we have

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

2) "Forever ": If we assume that hydrocarbon income stays constant after $N_{t+3+j} = N_{t+3}$, $j > 0$,

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

3) Hotelling rule: If demand is iso-elastic and marginal extraction costs are zero, the Hotelling rule is $P_{t+i} = P_t(1+r)^i$, so that $V_t = \sum_{i=0}^{\infty} \frac{P_t(1+r)^i R_{t+i}}{(1+r)^i} = P_t \sum_{i=0}^{\infty} R_{t+i} = P_t S_t$. With only projections of say three periods ahead, the permanent income from the resource is given by

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

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

It is easy to generalize these expressions to the general case with *T* years ahead projections.

Our benchmark permanent values follow the “information approach”. X_{t+T}^e is the Ministry of Finance’s (MF) expected value of X_{t+T} at time t. In our context X_t equals hydrocarbon income, oil price, hydrocarbon production, dependency ratio or GDP. *T* is the year farthest into the future for which a projection was given. X_{t+i}^e is based on forecasts of the Ministry of Finance at time t. 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 hydrocarbon-issues (Stortingsmelding 25 1973-74, Stortingsmeldig 30 1973-74 and Tempomeldingen NOU 1988:27).[17]

Projections of hydrocarbon 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 price and production value projections are recalculated to 2007-NOK for consistent comparison over time.

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

[17] The budget documents up to 1998-2001 were found in the Library of Statistics Norway. The later documents are to be found at the internet:
http://www.regjeringen.no/Rpub/STM/20002001/030/PDFA/STM200020010030000DDDPDFA.pdf
http://www.regjeringen.no/Rpub/STM/20042005/008/PDFS/STM200420050008000DDDPDFS.pdf
http://www.regjeringen.no/en/dep/fin/press-center/Press-releases/2009/long-term-perspectives-for-the-norwegian.html?id=542381

of each projection. For GDP, the Ministry's projections focus on growth in fixed price GDP and we apply its projected growth rates to a starting point set by GDP in 2007 prices. We focus on the fiscal reaction functions for the central government, which is the receiver of public hydrocarbon rents, and the following therefore refers to the central government. Table A.1.1 presents the data and variables employed in this paper.

Table A.1.1: 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 = Hydrocarbon 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 = Hydrocarbon 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____42332.aspx
Non-hydrocarbon government revenue		*Total government revenue - Hydrocarbon revenue*	Calculated			
Net Capital income		*Capital income - Capital expenses*	Calculated			
τ = Non-hydrocarbon primary government revenue		*Non-hydrocarbon government revenue - (Net capital income - Net cash flow SDFI - Dividend StatoilHydro)*	Calculated			
g = Government expenditures		*Government expenditures*	Calculated			
b = Non-hydrocarbon primary government deficit		*Non-hydrocarbon 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 = 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____42332.aspx

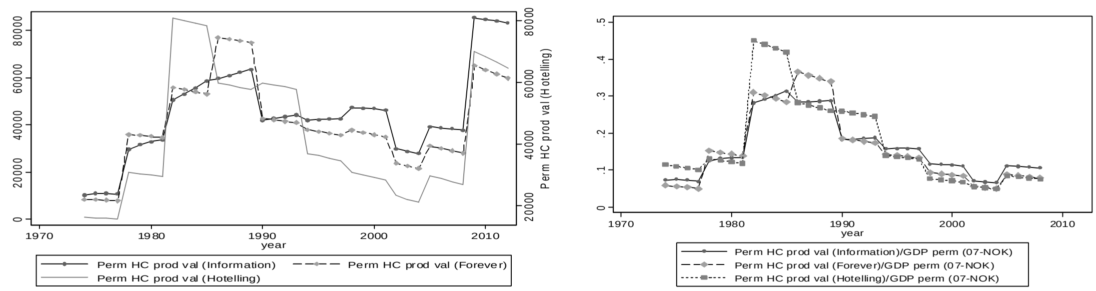
Appendix 2: Robustness checks

Predictions of hydrocarbon production and hydrocarbon revenue may be influenced by the state of the hydrocarbon sector, thus creating a high correlation between the two. For instance, high oil prices may create optimistic projections of future hydrocarbon revenue. This could make it hard identify the effect of current and permanent hydrocarbon revenue at the same time due to multicolinearity. Regressions (5a)-(5c) and (5a′)-(5c′) in Table A.2.1 re-estimates Table 5 with permanent and current hydrocarbon revenue excluded. The estimates are in general stable. The largest difference seems to be the estimated effect on taxes of current hydrocarbon income, which becomes significantly negative if permanent hydrocarbon revenue is excluded. This can be seen as omitted variables bias; current hydrocarbon income picks up some of the effect of permanent hydrocarbon income if the latter is omitted.

Table A.2.1: Excluding either permanent or current hydrocarbon revenue

	(5a)	(5b)	(5c)	(5a′)	(5b′)	(5c′)
	Deficit (*b*)	Taxes (τ)	Expenditure (*g*)	Deficit (*b*)	Taxes (τ)	Expenditure (*g*)
Hydrocarbon revenue current (*n*)	0.633***	-0.992**	-0.360			
	(0.208)	(0.392)	(0.288)			
Hydrocarbon revenue permanent (n^p)				0.526***	-1.917***	-1.390***
				(0.198)	(0.300)	(0.215)
Dependency ratio current (*p*)	1.105***	1.259	2.364***	1.614***	1.232**	2.846***
	(0.423)	(0.798)	(0.586)	(0.342)	(0.517)	(0.371)
Dependency ratio permanent (p^p)	-0.849***	0.806	-0.043	-0.927***	0.969**	0.043
	(0.300)	(0.565)	(0.415)	(0.303)	(0.457)	(0.328)
Last year’s Debt (*d*)	-0.130	0.292*	0.162	-0.012	0.166	0.154*
	(0.089)	(0.168)	(0.123)	(0.077)	(0.116)	(0.083)
Last year’s Fund (*f*)	0.012	0.296***	0.308***	0.068	0.328***	0.396***
	(0.060)	(0.112)	(0.083)	(0.052)	(0.078)	(0.056)
Output gap (*y*)	-0.514***	0.250	-0.264	-0.512***	0.310	-0.201
	(0.145)	(0.273)	(0.200)	(0.146)	(0.221)	(0.159)
Constant	-0.070	-0.069	-0.139*	-0.132***	-0.101	-0.233***
	(0.057)	(0.107)	(0.078)	(0.046)	(0.070)	(0.050)
R-squared	0.74	0.60	0.86	0.74	0.74	0.91
Observations	54	54	54	54	54	54

Figure A.2.1: Alternative methods of calculating permanent hydrocarbon revenue



Note: (1) the "Information" series is based only on information found in the publications by the Ministry of Finance and is our preferred method; (2) the "Forever" series assumes that the last observed expectation point holds forever after; and (3) the "Hotelling" series assumes that extraction patterns follow the Hotelling rule corresponding to zero extraction costs and iso-elastic demand. See Appendix 1 for details of the calculations.

Figure A.2.1 shows the three alternative measures for the permanent hydrocarbon production value. To further investigate robustness, regressions (6a)-(6c) in Table A.2.2 present estimates when permanent values of hydrocarbon production value (the instruments for permanent hydrocarbon revenue) are calculated by assuming that the last projected value for each projection period to last forever. Regressions (6a′)-(6c′) assume that depletion of hydrocarbon reserves follows the Hotelling rule. The measure used in Table 5 is, in contrast, calculated by using only the available information avoiding strong assumptions about the future dependency ratio (see Appendix 1 for more on these methods). Compared to the estimates presented in Table 5, the instruments calculated by the "Forever" approach in general push up the coefficient on permanent hydrocarbon revenue, whereas the instruments calculated with the Hotelling approach push down this coefficient. Coefficients on the other variables are not much affected.

Table A.2.2: Instruments for permanent hydrocarbon revenue calculated with alternative methods

	(6a)	(6b)	(6c)	(6a′)	(6b′)	(6c′)
	Forever Approach on Instruments			Hotelling Approach on Instruments		
	Deficit (b)	Taxes (τ)	Expenditure (g)	Deficit (b)	Taxes (τ)	Expenditure (g)
	b/se	b/se	b/se	b/se	b/se	b/se
Hydrocarbon revenue current (n)	0.487**	-0.346	0.141	0.543**	-0.500	0.043
	(0.207)	(0.335)	(0.231)	(0.211)	(0.328)	(0.226)
Hydrocarbon revenue permanent (n^p)	0.442**	-1.957***	-1.515***	0.272	-1.491***	-1.219***
	(0.216)	(0.349)	(0.241)	(0.185)	(0.287)	(0.198)
Dependency ratio current (p)	0.996**	1.742**	2.738***	1.038**	1.627**	2.665***
	(0.427)	(0.690)	(0.477)	(0.416)	(0.645)	(0.446)
Dependency ratio permanent (p^p)	-0.879***	0.939*	0.060	-0.868***	0.907**	0.040
	(0.297)	(0.479)	(0.331)	(0.293)	(0.454)	(0.314)
Last year's Debt (d)	-0.120	0.248*	0.128	-0.124	0.259*	0.134
	(0.088)	(0.142)	(0.098)	(0.087)	(0.135)	(0.093)
Last year's Fund (f)	-0.010	0.395***	0.385***	-0.002	0.371***	0.370***
	(0.061)	(0.099)	(0.068)	(0.059)	(0.092)	(0.063)
Output gap (y)	-0.533***	0.331	-0.202	-0.526***	0.312	-0.214
	(0.144)	(0.232)	(0.160)	(0.142)	(0.219)	(0.152)
Constant	-0.047	-0.174*	-0.221***	-0.056	-0.149*	-0.205***
	(0.058)	(0.094)	(0.065)	(0.056)	(0.087)	(0.060)
R-squared	0.75	0.71	0.91	0.75	0.74	0.92
Observations	54	54	54	54	54	54
Chi2 n vs n^p	0.02	9.31	20.63	0.73	4.07	13.84
P-value n vs n^p	0.89	0.00	0.00	0.39	0.04	0.00

We conclude that our benchmark estimates in Table 5 represent the middle ground. Furthermore, our assumption about hydrocarbon production value beyond the horizon in the public forecasts does not seem crucially important for our results.

In the simulations we use the coefficients from re-estimating the naive regression (2a) of Table 4 and our core regressions (3a) of Table 5 by leaving out the insignificant coefficients. The resulting estimates are reported as regression (2A) and (3A) in Table A.2.3.

Table A.2.3: Re-estimating core regression excluding insignificant coefficients

	(3a) Deficit (*b*)	(3A) Deficit (*b*)
Hydrocarbon revenue current (*n*)	0.516**	0.355**
	(0.206)	(0.141)
Hydrocarbon revenue permanent (n^p)	0.354*	0.403*
	(0.193)	(0.209)
Dependency ratio current (*p*)	1.018**	1.373***
	(0.421)	(0.151)
Dependency ratio permanent (p^p)	-0.873***	-0.796***
	(0.294)	(0.183)
Last year's Debt (*d*)	-0.122	
	(0.087)	
Last year's Fund (*f*)	-0.006	
	(0.060)	
Output gap (*y*)	-0.529***	-0.581***
	(0.142)	(0.137)
Constant	-0.051	-0.114***
	(0.057)	(0.030)
R-squared	0.75	0.75
Observations	54	54

Table A.2.4: Restricting coefficients on net debt and Fund in accordance with current stated fiscal rule under conventional approach

	(1) Deficit (*b*) b/se	(2) Deficit (*b*) b/se	(3) Deficit (*b*) b/se	(4) Deficit (*b*) b/se	(5) Deficit (*b*) b/se	(6) Deficit (*b*) b/se	(7) Deficit (*b*) b/se
Main							
Hydrocarbon revenue current (*n*)	0.729***	0.729***	-0.091	0.671***	-0.025	0.417***	
	(0.229)	(0.229)	(0.102)	(0.185)	(0.090)	(0.138)	
Dependency ratio current (*p*)	0.386	0.386	1.350***	0.543***	0.954***	1.037***	0.934***
	(0.393)	(0.393)	(0.322)	(0.158)	(0.134)	(0.124)	(0.112)
L.Debt (*d*)	-0.082	-0.082	0.080	-0.040	-0.040***	0.076***	-0.040***
	(0.095)	(0.095)	(0.089)	(0.000)	(0.000)	(0.029)	(0.000)
L.fund 1996->	-0.127***	-0.127***	0.040	-0.119***	0.040***	-0.076***	0.040***
	(0.042)	(0.042)	.	(0.038)	(0.000)	(0.029)	(0.000)
Output gap (*y*)	-0.512***	-0.512***	-0.412**	-0.530***	-0.333**	-0.552***	-0.334**
	(0.159)	(0.159)	(0.163)	(0.152)	(0.155)	(0.151)	(0.155)
Constant	-0.103*	-0.103*	-0.252***	-0.126***	-0.196***	-0.198***	-0.193***
	(0.060)	(0.060)	(0.048)	(0.029)	(0.026)	(0.024)	(0.023)
R-squared	0.69						
Observations	54	54	54	54	54	54	54
Chi2 l.f=0.04	15.74						
P-value l.f=0.04	0.00						
Chi2 l.d=-0.04	0.19						
P-value l.d=-0.04	0.66						
Chi2 l.f=0.04 & l.d=-0.04	0.19						
P-value l.f=0.04 & l.d=-0.04	0.66						

Table A.2.5 shows estimates for alternative deficit measures. In column (1) and (2) we use the non-hydrocarbon deficit, i.e. net capital income except returns from the Fund is included on the revenue side. Column (2) differs from (1) by the imposed restrictions of -0.04 and 0.04 on net debt and the fund. The main difference compared to our other estimates is the coefficient on permanent hydrocarbon revenue, which now turns up with a smaller and insignificant coefficient. The coefficient of about 0.55 on current hydrocarbon revenue suggest a bird-in-hand approach in the spending of hydrocarbon rents, whereas the negative coefficient on the permanent dependency ratio suggests forward looking behavior with respect to the pension bill.

Table A.2.5: Estimates with alternative deficit measures

	(1) Deficit non-hydrocarbon IV	(2) Deficit non-hydrocarbon IV
Hydrocarbon revenue current (*n*)	0.533***	0.561***
	(0.172)	(0.118)
Hydrocarbon revenue permanent (n^p)	0.061	0.045
	(0.161)	(0.158)
Dependency ratio current (*p*)	1.137***	1.089***
	(0.351)	(0.128)
Dependency ratio permanent (p^p)	-0.790***	-0.930***
	(0.245)	(0.150)
L.Debt (*d*)	0.018	-0.040
	(0.073)	(.)
Last year's Fund	0.019	0.040***
	(0.050)	(0.000)
Output gap (*y*)	-0.467***	-0.437***
	(0.119)	(0.115)
Constant	-0.072	-0.044*
	(0.048)	(0.025)
R-squared	0.71	0.71
Observations	54	54
Chi2 l.f=0.04	0.18	
P-value l.f=0.04	0.67	
Chi2 l.d=-0.04	0.64	
P-value l.d=-0.04	0.42	
Chi2 l.f=0.04 & l.d=-0.04	0.64	
P-value l.f=0.04 & l.d=-0.04	0.42	

CESifo Working Paper Series

for full list see www.cesifo-group.org/wp
(address: Poschingerstr. 5, 81679 Munich, Germany, office@cesifo.de)

2769 Alessandro Balestrino, Kind of Black: The Musicians' Labour Market in Italy, August 2009

2770 Yosr Abid Fourati and Cathal O'Donoghue, Eliciting Individual Preferences for Pension Reform, August 2009

2771 Christian Breuer and Chang Woon Nam, VAT on Intra-Community Trade and Bilateral Micro Revenue Clearing in the EU, August 2009

2772 Choudhry Tanveer Shehzad, Jakob De Haan and Bert Scholtens, Growth and Earnings Persistence in Banking Firms: A Dynamic Panel Investigation, August 2009

2773 Erdal Yalcin, Uncertain Productivity Growth and the Choice between FDI and Export, August 2009

2774 Klaus Abberger, Wolfgang Nierhaus and Shynar Shaikh, Findings of the Signal Approach for Financial Monitoring in Kazakhstan, September 2009

2775 Sascha O. Becker, Francesco Cinnirella and Ludger Woessmann, The Trade-off between Fertility and Education: Evidence from before the Demographic Transition, September 2009

2776 Thomas Aronsson and Erkki Koskela, Optimal Income Taxation, Outsourcing and Policy Cooperation in a Dynamic Economy, September 2009

2777 Joel Slemrod, Old George Orwell Got it Backward: Some Thoughts on Behavioral Tax Economics, September 2009

2778 Cagri Seda Kumru and Athanasios C. Thanopoulos, Social Security Reform and Temptation, September 2009

2779 Alessandro Bucciol and Roel M. W. J. Beetsma, Inter- and Intra-generational Consequences of Pension Buffer Policy under Demographic, Financial and Economic Shocks, September 2009

2780 Eduardo Strube and Marcelo Resende, Complementarity of Innovation Policies in the Brazilian Industry: An Econometric Study, September 2009

2781 Henry Tulkens and Vincent van Steenberghe, "Mitigation, Adaptation, Suffering": In Search of the Right Mix in the Face of Climate Change, September 2009

2782 Maria L. Loureiro, Anna Sanz-de-Galdeano and Daniela Vuri, Smoking Habits: Like Father, Like Son, Like Mother, Like Daughter, September 2009

2783 Momi Dahan, Tehila Kogut and Moshe Shalem, Do Economic Policymakers Practice what they Preach? The Case of Pension Decisions, September 2009

2784 Eytan Sheshinski, Uncertain Longevity and Investment in Education, September 2009

2785 Nannette Lindenberg and Frank Westermann, How Strong is the Case for Dollarization in Costa Rica? A Note on the Business Cycle Comovements with the United States, September 2009

2786 Leif Danziger, Noncompliance and the Effects of the Minimum Wage on Hours and Welfare in Competitive Labor Markets, September 2009

2787 Gerlinde Fellner, Rupert Sausgruber and Christian Traxler, Testing Enforcement Strategies in the Field: Legal Threat, Moral Appeal and Social Information, September 2009

2788 Gabriel J. Felbermayr, Mario Larch and Wolfgang Lechthaler, Unemployment in an Interdependent World, September 2009

2789 Sebastian G. Kessing, Federalism and Accountability with Distorted Election Choices, September 2009

2790 Daniel Gros, Global Welfare Implications of Carbon Border Taxes, September 2009

2791 Louis N. Christofides, Michael Hoy and Ling Yang, The Gender Imbalance in Participation in Canadian Universities (1977-2005), September 2009

2792 Jan K. Brueckner and Robert W. Helsley, Sprawl and Blight, September 2009

2793 Vidar Christiansen and Stephen Smith, Externality-correcting Taxes and Regulation, September 2009

2794 John Beirne, Guglielmo Maria Caporale, Marianne Schulze-Ghattas and Nicola Spagnolo, Global and Regional Spillovers in Emerging Stock Markets: A Multivariate GARCH-in-mean Analysis, September 2009

2795 Rüdiger Pethig and Frieder Kolleß, Asymmetric Capital-Tax Competition, Unemployment and Losses from Capital Market Integration, September 2009

2796 Ngo Van Long, Horst Raff and Frank Stähler, Innovation and Trade with Heterogeneous Firms, September 2009

2797 Margit Osterloh and Bruno S. Frey, Research Governance in Academia: Are there Alternatives to Academic Rankings?, September 2009

2798 Thiess Buettner and Clemens Fuest, The Role of the Corporate Income Tax as an Automatic Stabilizer, September 2009

2799 Annette Alstadsæter, Measuring the Consumption Value of Higher Education, September 2009

2800 Peter Friedrich, Chang Woon Nam and Janno Reiljan, Local Fiscal Equalization in Estonia: Is a Reform Necessary?, September 2009

2801 Evžen Kočenda and Jan Hanousek, State Ownership and Control in the Czech Republic, September 2009

2802 Michael Stimmelmayr, Wage Inequality in Germany: Disentangling Demand and Supply Effects, September 2009

2803 Biswa N. Bhattacharyay, Towards a Macroprudential Surveillance and Remedial Policy Formulation System for Monitoring Financial Crisis, September 2009

2804 Margarita Katsimi, Sarantis Kalyvitis and Thomas Moutos, "Unwarranted" Wage Changes and the Return on Capital, September 2009

2805 Christian Lessmann and Gunther Markwardt, Aid, Growth and Devolution, September 2009

2806 Bas Jacobs and Dirk Schindler, On the Desirability of Taxing Capital Income to Reduce Moral Hazard in Social Insurance, September 2009

2807 Hans Gersbach and Noemi Hummel, Climate Policy and Development, September 2009

2808 David E. Wildasin, Fiscal Competition for Imperfectly-Mobile Labor and Capital: A Comparative Dynamic Analysis, September 2009

2809 Johan Eyckmans and Cathrine Hagem, The European Union's Potential for Strategic Emissions Trading through Minimal Permit Sale Contracts, September 2009

2810 Ruediger Bachmann and Christian Bayer, The Cross-section of Firms over the Business Cycle: New Facts and a DSGE Exploration, October 2009

2811 Slobodan Djajić and Michael S. Michael, Temporary Migration Policies and Welfare of the Host and Source Countries: A Game-Theoretic Approach, October 2009

2812 Devis Geron, Social Security Incidence under Uncertainty Assessing Italian Reforms, October 2009

2813 Max-Stephan Schulze and Nikolaus Wolf, Economic Nationalism and Economic Integration: The Austro-Hungarian Empire in the Late Nineteenth Century, October 2009

2814 Emilia Simeonova, Out of Sight, Out of Mind? The Impact of Natural Disasters on Pregnancy Outcomes, October 2009

2815 Dan Kovenock and Brian Roberson, Non-Partisan 'Get-Out-the-Vote' Efforts and Policy Outcomes, October 2009

2816 Sascha O. Becker, Erik Hornung and Ludger Woessmann, Catch Me If You Can: Education and Catch-up in the Industrial Revolution, October 2009

2817 Horst Raff and Nicolas Schmitt, Imports, Pass-Through, and the Structure of Retail Markets, October 2009

2818 Paul De Grauwe and Daniel Gros, A New Two-Pillar Strategy for the ECB, October 2009

2819 Guglielmo Maria Caporale, Thouraya Hadj Amor and Christophe Rault, International Financial Integration and Real Exchange Rate Long-Run Dynamics in Emerging Countries: Some Panel Evidence, October 2009

2820 Saša Žiković and Randall K. Filer, Hybrid Historical Simulation VaR and ES: Performance in Developed and Emerging Markets, October 2009

2821 Panu Poutvaara and Andreas Wagener, The Political Economy of Conscription, October 2009

2822 Steinar Holden and Åsa Rosén, Discrimination and Employment Protection, October 2009

2823 David G. Mayes, Banking Crisis Resolution Policy – Lessons from Recent Experience – Which elements are needed for robust and efficient crisis resolution?, October 2009

2824 Christoph A. Schaltegger, Frank Somogyi and Jan-Egbert Sturm, Tax Competition and Income Sorting: Evidence from the Zurich Metropolitan Area, October 2009

2825 Natasa Bilkic, Thomas Gries and Margarethe Pilichowski, Stay in School or Start Working? – The Human Capital Investment Decision under Uncertainty and Irreversibility, October 2009

2826 Hartmut Egger and Udo Kreickemeier, Worker-Specific Effects of Globalisation, October 2009

2827 Alexander Fink and Thomas Stratmann, Institutionalized Bailouts and Fiscal Policy: The Consequences of Soft Budget Constraints, October 2009

2828 Wolfgang Ochel and Anja Rohwer, Reduction of Employment Protection in Europe: A Comparative Fuzzy-Set Analysis, October 2009

2829 Rainald Borck and Martin Wimbersky, Political Economics of Higher Education Finance, October 2009

2830 Torfinn Harding and Frederick van der Ploeg, Is Norway's Bird-in-Hand Stabilization Fund Prudent Enough? Fiscal Reactions to Hydrocarbon Windfalls and Graying Populations, October 2009