Resource revenue management and wealth neutrality[1]

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Abstract
An important idea behind the Norwegian oil fund mechanism and the fiscal spending rule is to protect the non-oil economy from the adverse effects of excessive spending of resource revenues over the Government budget. A critical assumption in this respect is that public sector saving is not being offset by private sector dis-saving, which is at stake with the hypothesis of Ricardian equivalence. Based on a framework of co-integrating saving rates, this model provides an empirical test of the Ricardian equivalence hypothesis on Norwegian time series data. Although the model rejects the strong-form presence of Ricardian equivalence, results indicate that the Norwegian approach does not fully succeed in separating spending of resource revenues from the accrual of the same revenues.

Key words: Resource wealth, saving, fiscal policy
JEL classification: D91, E21, E61, Q33

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1. Introduction

Economic research on the macroeconomics of resource wealth typically sorts the effects on the non-oil economy in two main groups. The first group relates to *resource movement* effects, which stem from the allocation of domestic resources out of traditional manufacturing and into (booming) resource-based industries. The second group relates to *spending* effects, which is linked to expenditures based on resource revenues, and especially over government budgets (cf. Corden og Neary, 1982; Corden, 1984).

A common line of defense against the spending effects is to promote policy guidelines and rules to separate the spending of resource revenues over government budgets from the accrual of the same revenues. This is also the main idea behind the Norwegian oil fund mechanism and the fiscal policy rule. The Government Pension Fund (GPF) represents a floodgate behind which resource revenues accumulate, and the fiscal policy rule represents a flexible valve, where the flow-rate is tuned to restrict the annual inflow of oil revenues on the government budget to 4% of total capital on the GPF.

A premise for the Norwegian oil fund mechanism is that spending decisions among households and businesses in the mainland economy do not respond to changes in the net wealth position of the government. Such a premise is at stake with the Ricardian Equivalence Hypothesis (REH), which implies that the net wealth position of the government enters directly into decisions on consumption and investment spending in the private sector.

In its strongest form Ricardian equivalence implies that any change in the net financial position of the government will be fully offset by a compensating adjustment in household saving, due to consumption smoothing preferences. However, empirical research has so far failed to produce support for such a strong and direct link between government and private saving (Ricciuti, 2003). Still, elements of forward-looking optimisation in the private sector will imply a partial adjustment of household saving to changes in the government net financial position.

A discrepancy between government and households in the pattern of consumption and saving may stem from differences in view when it comes to spending of petroleum

revenues. Such a variance in perspective may reflect a lack of credibility and transparency in resource management policies, which in turn has the potential of reducing the efficiency of monetary and fiscal policies (Medina and Soto, 2014).

Assessing the relationship between wealth accumulation in government and households, this study adds insight to the literature on macroeconomic effects of resource wealth (cf. Arezki and Brückner, 2010; van der Ploeg 2011, Harding and van der Ploeg, 2011, van der Ploeg and Venables, 2011). So far, empirical studies of Ricardian equivalence have been linked to countries characterised by budget deficits and debt dynamics in the public sector (e.g., Ricciuti, 2003; Galí, Valléz and Salido, 2004; de Mello, Kongsrud and Price, 2004; Coenen and Straub, 2005; Röhn, 2010). The aim of this study is to investigate corresponding mechanisms for a country where the government runs substantial budget surpluses, and also accumulate financial wealth on behalf of the private sector.

Based on 33 years of time series data from the Norwegian economy, the REH is tested through the estimation of a dynamic single-equation econometric model. In this model, the strong form of REH should imply perfect substitution between government saving and household saving. According to the estimated model, an increase in the saving rate for the government of one percentage point will reduce the household savings rate by 0.2 percentage points. Consequently, the strong form of REH is not supported by this study. However, the results still suggest that some of the accumulation of petroleum revenues in the Government Pension Fund – Global (GPF) will be offset by reduced saving in the household sector. The implication is that the Norwegian model of revenue management does not fully succeed in separating the accumulation of oil and gas revneues from the expenditures of the same revenues. For policy design, these results would call for an even higher degree of prudence in fiscal policies than implied by the current spending rule,[2] possibly combined with policies to stimulate wealth accumulation in the private sector. Both these elements are reflected in today's economic policies.[3]

[2] According to the homepage of the Norwegian Ministry of Finance (http://www.fin.dep.no), "fiscal policy shall be geared towards a gradual and sustainable increase in the use of petroleum revenues. Over time, the structural, non-oil budget deficit shall correspond to the expected real return on the Government Pension Fund Global, estimated at 4 per cent. This rule should not be used mechanically, however, and considerable emphasis should be placed on stabilising economic fluctuations."

[3] The first is catered for by the practice that has developed in the application of the fiscal spending rule, where the structural, non-oil budget deficit consistently has been limited to 3 per cent of the

Based on developments over the last 10 years, transmission mechanisms of oil-related impulses to the Norwegian mainland economy are reviewed in Chapter 2. To illustrate key mechanisms behind the REH, a simple dynamic optimisation model of consumption is sketched out in Chapter 3, as a background for the subsequent review of previous theoretical and empirical research. Chapter 4 presents the specification, estimation and testing of an econometric model of private saving, followed by presentation and discussion of results, before some concluding remarks are offered in Chapter 5.

2. Oil in the Norwegian economy

Oil and gas activity in Norway is approaching its 50th anniversary. From a sober start in the mid-1960s, oil and offshore activities have gradual assumed the role of a growth engine for the Norwegian economy, and an important source of income and wealth accumulation both for the government and for the private sector. As opposed to resource-rich countries elsewhere in the world, Norway was blessed with the institutional quality of an industrialised western democracy already at the outset. Consequently, politicians were early in grasping the strategic opportunities and challenges of resource wealth for the wider development in economics, welfare and social conditions.

National control of the oil and gas resources formed the basis for law and regulation. Industrial policies were designed to secure domestic industrial activity and employment, so that resources activity and revenues could benefit the broader requirements of economic and social development. Economists were offered a key role in the plans and policies for the new industry. A white paper submitted to the parliament in 1973 [4] points out a range of mechanisms which were studied in the academic literature at the time. Examples include resource revenue management on the government budget, a shift of input demand from traditional manufacturing to the oil and gas sector, as well as additional challenges related to structural adjustment and competitiveness both in the ramp-up phase and in an eventual reversion phase.

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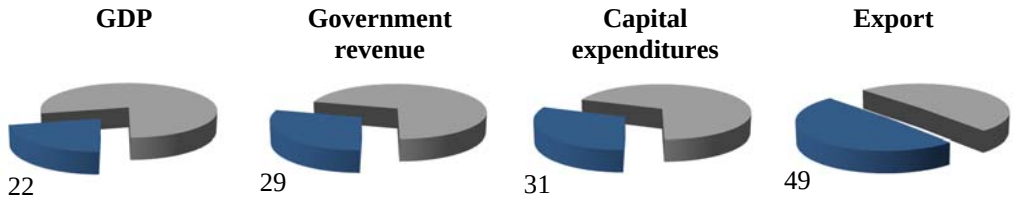
market value of the GPF. The second concern is covered by supportive measures for private property investment, as well policy efforts to support saving among young adults for housing investments.

[4] Stortingsmelding 25, 1973-1974; «Petroleumsvirksomhetens plass i det norsk samfunn» («The position of the petroleum activity in the Norwegian society»).

In 2013, value-added from petroleum activities in Norway made up 22 per cent of mainland GDP and export of oil and natural gas totalled 49 per cent of total exports. Nearly 30 per cent of government revenues originate in oil and gas activities, and nearly every third NOK of total capital expenditures finds its way into oil and gas activities.

Figure 1. Macroeconomic indicators for the Norwegian petroleum sector (2013)
Oil and gas activities' percentage share in…



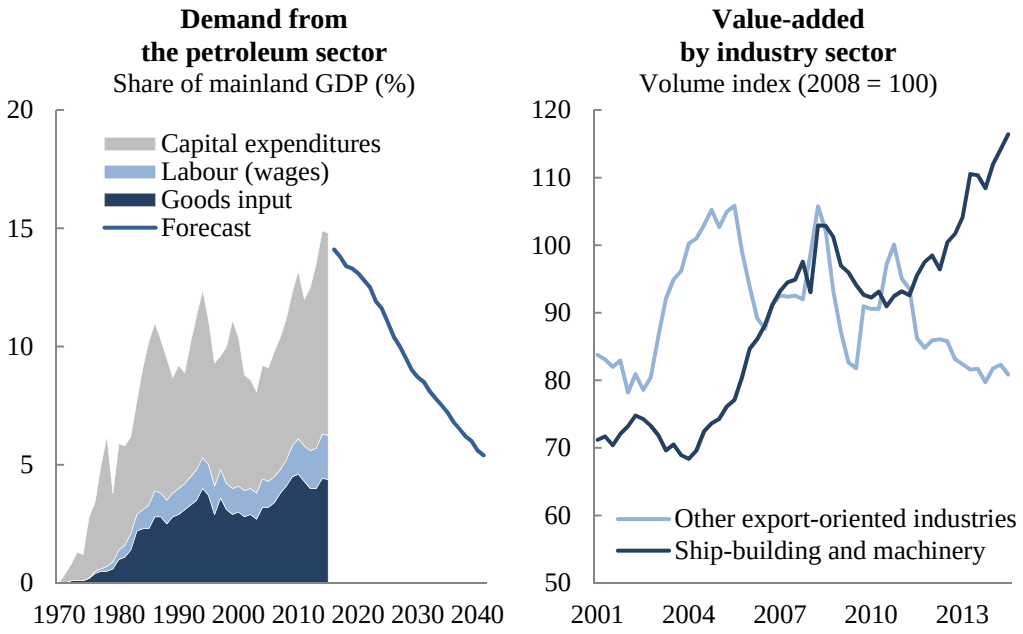
Source: Norwegian Petroleum Directorate (2014).

The research literature on transmission mechanisms for resource activities typically sorts the main effects in two channels, namely *resource movement* effects and *spending* effects. This mindset originates in the early academic research which was inspired by the experience from the Netherlands during the 1960s, when large revenues from natural gas contributed to an erosion of general competitiveness (real appreciation), and a crowd-out of traditional exports. Corden and Neary (1984) provides a survey of the early literature on booming sectors and Dutch Disease, whereas Frankel (2010) and van der Ploeg (2011) represent broader overviews of recent research on macroeconomic challenges related to resource wealth.

Resource movement

In the booming phase, the oil and gas sector attracts resources that would otherwise have served as input in non-oil industries and activities. The implied effects on prices, income and competitiveness are referred to as resource-movement effects, and are triggered when oil and gas companies demand labour, goods, and services from the mainland economy for real investment and operations on the Norwegian Continental Shelf (NCS). Spending effects are directly relevant for petroleum-specific supplier industries, but indirectly also for traditional manufacturing and service industries who market their products and services to companies within the oil and gas industry (e.g., Eika and Martinussen, 2013).

Figure 2. Supplier industry: Demand and production indicators



Source: Ministry of Finance (National Budget 2014), Statistics Norway.

The left-hand panel of Figure 2 illustrates that demand from the petroleum sector has increased from 9.1 per cent of mainland GDP in 2004 to 14.8 per cent in 2014. In terms of manufacturing value-added, the surge in oil and gas activity has offered substantial support to the ship-building and machinery industries, at the expense of other export-oriented industries – as illustrated in the right-hand panel of Figure 2. The implied migration of resources from traditional manufacturing towards production of supplies to the oil and gas sector, illustrates an important transmission channel for oil-related shocks to the mainland economy. This resource movement effect entails a stimulus to mainland GDP, higher employment and labour market pressures, wage and cost inflation, higher income for companies and households, and increased consumption and investment expenditures. Note that with the late internationalisation of the Norwegian oil and offshore industry, these resource movement effects are not limited to activity shocks from the NCS, but may also stem from global oil-related shocks, as roughly 50 per cent of Norwegian oil supplies are currently exported (Rystad Energy, 2014).

Already at the beginning in the early 1970s, an important aim of strategic industrial policies was the conscious development of a domestic petroleum-related industry base,

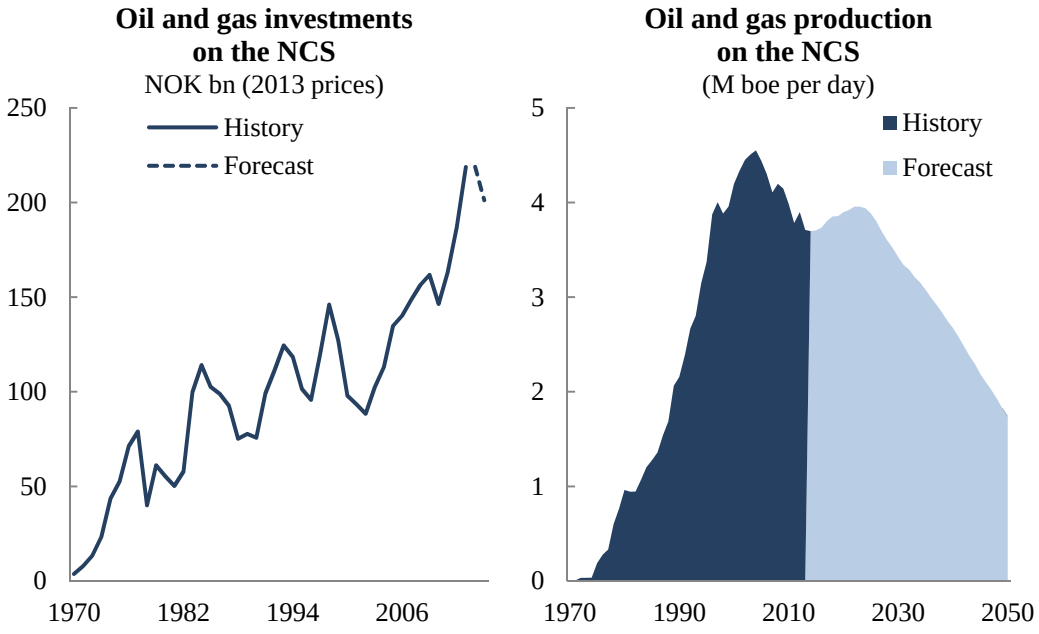
including employment, and associated skills and competence. Political decisions formed the basis for the establishment of Norwegian private and national oil companies. These Norwegian oil companies entered into partnerships with international oil companies to develop oil and gas fields on the NCS. Through contract awards that included a mix of Norwegian and international supplier companies, the partnerships between Norwegian and international oil companies in turn also fostered the gradual development of a domestic supplier industry.

This development of a Norwegian industry base proved helpful in reducing the production gap at the time and laid the basis for a relatively low level of unemployment in Norway during the 1970s and 1980s. However, the high local content in supplies to NCS activity also added strength to the resource movement effect of oil-related shocks. As investment and production activities increased and foreign suppliers were substituted with domestic supplies, fluctuations in NCS investment gained an increasingly important role in Norwegian business cycles. In some periods, oil and gas activities have behaved as a pro-cyclical amplifier in the business cycle (e.g., 1998-1999). In other periods, oil and gas activities have moved counter-cyclically, with a consequent stabilising effect on the mainland economy (e.g., 2008-2009). Both private and public sector forecasters now point to a reduction in capital expenditures starting in 2015, which will also cause a reversion in demand impulses to the mainland economy over the coming years.

Without tools to fine-tune oil exploration and development activities, the resource movement effects have been difficult to regulate. A long period of gradual de-regulation preceded the process of partial privatisation and listing of the national oil company Statoil in 2001. The Statoil IPO completed the formal shift of responsibility for decisions on investment and operations from the public to the private sector. Licensing policies were the only instrument left to regulated activities, because once a license has been granted, the progress in terms of exploration and development is all in the hands of the oil companies. From 2003 and onwards, NCS activity was stimulated by aggressive policies to speed up exploration activity, and by the subsequeent increase in the oil price, which made companies pick previous discoveries off the shelf for review and development at supportive market conditions. The result was a sharp increase in investment activity on the NCS, with accelerating employment and consequent escalation of wages and other input prices.

Traditional manufacturing industries took the opportunity to shift their product menu to exploit the surge in demand from the high-margin markets for oil and gas supplies. Employment figures therefore show no indication of loss in overall manufacturing employment, and the Norwegian economy thefore fails in demonstrating the most classical symptom of the Dutch Disease (Bjørnland and Thorsrud, 2014). However, the resource movement effect has still given rise to a substantial appreciation of the real exchange rate and a deterioriation of competitiveness for the Norwegian economy. Having increased by 50 per cent over the period 2004-2013, hourly wages for Norwegian manufacturing currently hover some 55 per cent above the average of Norway's trading partners. A more appropriate measure of competiveness is relative wages corrected for exchange rate changes, which has increased by 20 per cent over the last ten years (Ministry of labour and social affairs, 2014).

Figure 3. Petroleum investment and production



Source: Ministry of Finance (National Budget 2015).

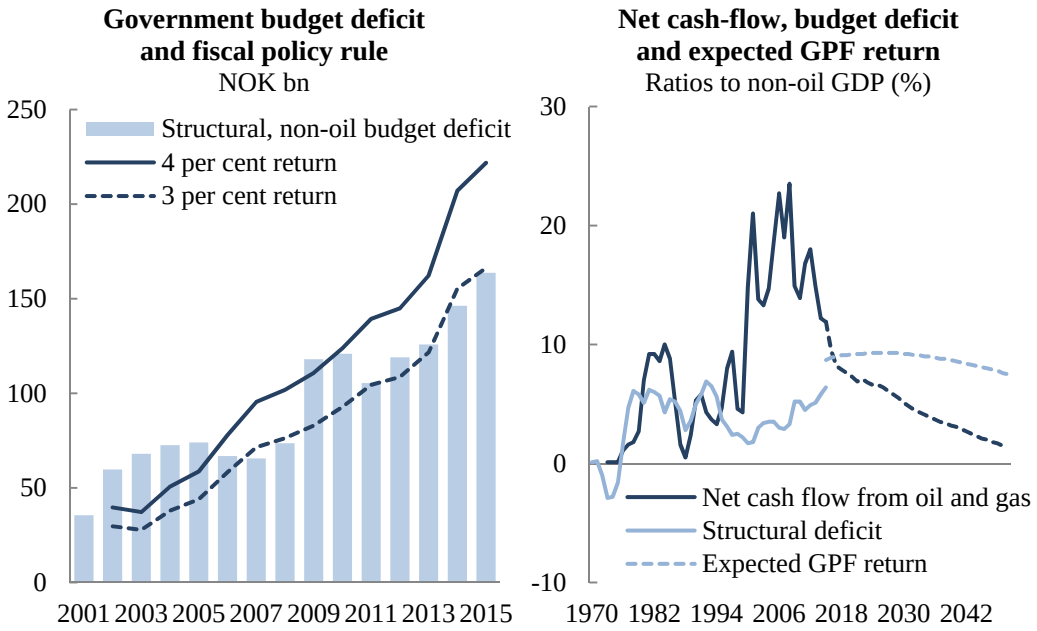
When a booming resource sector requires more resources from the rest of the economy, the danger is that the consequent industrial re-structuring will crowd out traditional manufacturing industries, increase the future costs of re-adjustment when oil and gas activity pass their peak, and reduce the potential for long-term economic growth. The

logic of such a line of arguments implies that the oil-related boom over the last 10 years has left the Norwegian economy more vulnerable to oil-related shocks.

Management of resource revenues

A general perception is still that the Norwegian model of resource management has been successful, and that countries rich in natural resources could take fruitful inspiration from the Norwegian experience. This impression is most probably due to the way in which Norwegian authorities have met the challenges relating to *spending effects* from petroleum extraction. A key concern behind fiscal policy design has been to stem the expansionary and inflationary impulses that potentially could arise from government spending of oil and gas revenues.

Figure 4. Fiscal policy indicators



Source: Ministry of Finance (National Budget 2015).

From the mid-1990s, the Norwegian government faced a significant escalation in their net cash-flow from oil and gas activities, as illustrated in Figure 4. This development accentuated the requirement of a more predictable and transparent mechanism to guide a long-term plan for absorption of oil and gas revenues in the Norwegian economy. As a response, adjusted guidelines for monetary and fiscal policies were adopted in 2001. The

new model implied that the net cash flow from oil and gas activities goes directly to the GPF. Politicians will then have to decide on annual withdrawing from the GPF to finance non-oil Government budget deficit, according to the conclusion of budget negotiation every fall. The 2001 model of fiscal policies also introduced a guideline for long-term absorption of oil and gas revenues in the Norwegian economy. Specifically, the new spending rule implied that over time, annual withdrawing from the GPF to finance non-oil budget deficits should match the expected annual return from the fund, estimated at 4 per cent at the time.

With the oil fund mechanism and the fiscal policy rule as key constituents, the intention behind Norwegian model of resource revenue management is to assure the separation between accumulation of resource revenues on the one hand, and government spending of the same revenues on the other. At the same time, the management model leaves ample room for flexibility for fiscal policies to counter temporary business-cycle shocks. In line with the Hartwick (1977) rule, this policy model also assures a relatively conservative long-term absorption rate for oil and gas revenues in the Norwegian economy, where annual expenditures are limited by the expected return on financial wealth, neglecting the value of remaining resources in the ground.

In a long-term perspective, the Norwegian model of resource revenue management represents a more cautious and conservative path of consumption than implied by standard economic theory, which would suggest that expenditure and consumption should be based on the permanent income from total wealth, and not limited to accumulated financial wealth. Inclusion of the value of oil and gas resources in the ground to the relevant wealth concept would produce a higher rate of government expenditures than the current “bird-in-hand” principle (van der Ploeg and Venables, 2011; van den Bremer, van der Ploeg, and Wills, 2013). Textbook models of dynamic optimisation of consumption therefore suggest that the Norwegian model of resource management so far has entailed a slower absorption of oil and gas revenues in the Norwegian economy than the pace implied by a categorical approach based on the permanent income hypothesis (PIH).

On the other hand, empirically based model studies with more weight on challenges relating to ageing and pension obligations still conclude that government saving is hardly higher that it needs to be meet future challenges of public finance (e.g., Heide, Holmøy,

Solli og Strøm, 2006; Harding and van der Ploeg, 2011). Moreover, an expansion of scope to open for uncertainty, caution, and prudence renders support to the Norwegian strategy of aggressive extraction and prudent consumption even in theoretical studies (e.g., van der Ploeg, 2010). Bems and Carvalho Filho (2011) argue specifically that precautionary saving has potentially large implications for the optimal level of saving for resource-rich nations. A more cautious path of spending than prescribed by straightforward PIH rules would also be justified if government saving is directly offset by forward-looking Ricardian consumers (cf. van der Ploeg and Venables, 2011). The below econometric exercise will explore the relevance of this issue based on Norwegian data.

In summary, a credible commitment to the fund mechanism and the fiscal policy rule of the Norwegian resource revenue management model will protect the non-oil economy against direct *spending effects* from the Government budget. However, this protection is hardly perfect, as oil-related shocks will add to both total capital and absolute returns of the GPF, leaving a link between resource revenues and government spending, even if the government complies with the fiscal spending rule.

This latter mechanism paves the mind a role for wealth accumulation in the transmission of oil-related shocks to the Norwegian economy. Since the mid-1990s, net cash flows from petroleum-related activities have contributed to the accumulation of substantial financial wealth both for the government and in the private sector. The role of shocks in oil and asset prices for consumption, investment and saving in Norwegian companies and households is therefore an area that deserves analytical attention.

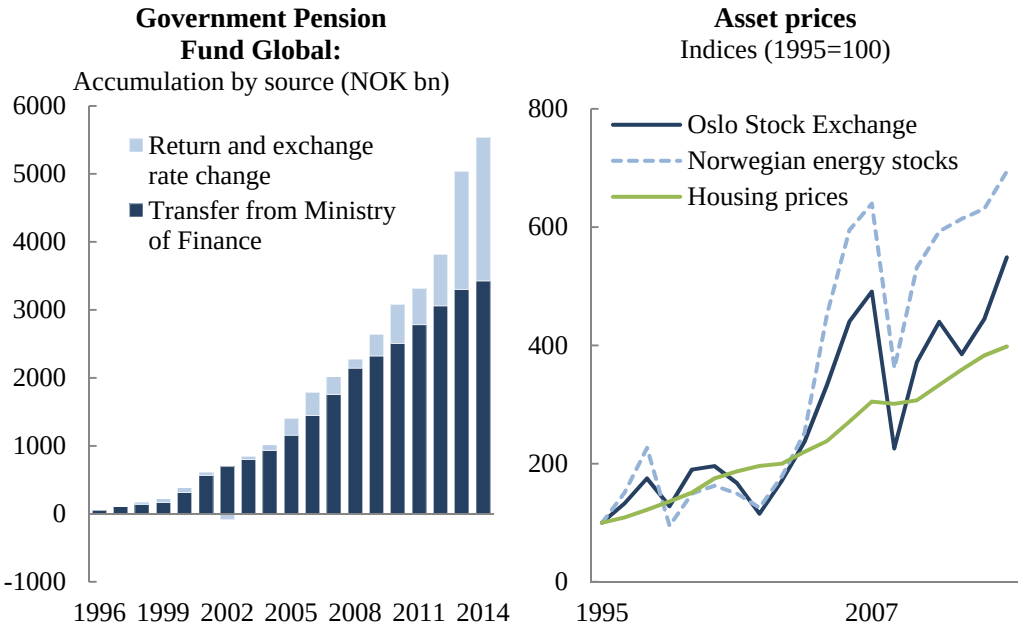
The role of asset prices and wealth

A positive oil price shock will obviously increase the value of oil and gas resources on the NCS.[5] This appreciation in the value of oil and gas resources in the ground will imply a corresponding appreciation in oil-related asset prices. A positive oil price shock will

[5] Not only will an oil price increase influence the path of production for a given reserve volume, but it will also inflate the volume of recoverable reserves. The reason is that a higher oil price will justify higher investments in exploration activities (Mohn, 2008), field development, and efforts to increase oil and gas recovery. Thus the relationship between recoverable reserves and Hydrocarbons Initially In Place (HCIIP) is therefore a function of the oil price. Many studies fail to acknowledge this elasticity (Mohn, 2009), and the implication is that they also underrate most effects on industry and macroeconomic activity from oil price changes, including wealth effects.

also lift expectations for future activity and returns in the oil and gas sector, which again will boost expectations for the future value of private wealth and the size of the GPF.

Figure 5. Government and private wealth indicators



Source: Norges Bank, Oslo Stock Exchange, Statistics Norway.

Figure 5 illustrates how net cash flows from the oil and gas industry has increased government saving. The GPF has increased 6 times over the last 10 years. Roughly 60 percent of the growth can be attributed to "deposits" implied by net cash flows to the government from oil and gas activities, whereas the remaining 40 per cent is due to accumulated returns and exchange rate changes. The increase in the oil price over the same period has also spurred asset prices through equity market appreciation and real estate price inflation. Average annual returns at the Oslo Stock Exchange were 12 per cent over the period 2003-2013, whereas corresponding returns for oil-related stocks were nearly 15 per cent. This development is very different from the rest of Europe, and the return differential is largely driven by superior earnings growth for Norwegian companies, which again relates to the booming Norwegian oil sector. Due to historical factors and strong tax incentives, households in Norway are underweight stocks and overweight in the housing market. Their purchasing power have been fuelled by the

escalation in housing prices, which increased by an annual average of 7 per cent over the last decade.

Wealth effects on private consumption has attracted extensive attention in empirical research over the last years, with a particular focus on shocks in asset prices (e.g., 2008 financial crisis; Jansen, 2010) and changes in economic policies (e.g., financial market regulation; Barrell and Davidson, 2007). Previous research also suggests that housing wealth plays a more prominent role than stock market wealth in explanations of aggregate consumption and saving behaviour (Case, Quigley and Schiller 2011; Davis, 2010).

Figure 5 suggests that the accumulation of wealth in government and households has been influenced by the oil sector boom. An interesting question in this respect is whether government net financial investments serves as a substitute for private saving. If this is the case, the GPF is less efficient in stemming the spending effects of oil-related shocks. Macroeconomic theory of debt neutrality (Barro, 1974) and Ricardian equivalence offers an interesting perspective on consumption and saving in resource-rich economies that so far remains under-explored. At the end of the day, the GPF accumulates tax payers' money. Forward-looking households will know that re-distribution is only a matter of timing. A relevant hypothesis in this respect is that net financial investment by government will stimulate the propensity to borrow in households. This gives rise to a "leakage" in the barrier against spending effects, which is the main motivation for the Norwegian fund mechanism and the fiscal policy rule. Support for the REH would open a transmission channel for oil-related shocks which is yet to be examined through empirical research. A predominance of Ricardian consumer behaviour could potentially reflect a contrast in opinion between government and households on the optimal paths for government net financial investment, fiscal policies, private consumption, and saving. Such a divergence in perspective could also suggest a perceived lack of confidence and transparency of the resource revenue management model, which in turn has the potential of reducing the efficiency of monetary and fiscal policies (Medina and Soto, 2014).

With an annual growth of 9 per cent over the last 10-year period, the strong growth in credit to Norwegian households is indicative of some sort of substitution between government and private saving. Comparing this to the pace of government net financial investment (cf. Figure 5), a suspicion could be raised that government saving is offset by

borrowing in the private sector. Based on a framework of dynamic optimisation, this study goes on with an econometric exercise to model and test the relationship between household saving and government saving in Norway. To motivate this study, we first illustrate the key mechanisms in a simple theoretical model and review previous research in the area.

3. Ricardian equivalence

Original idea: A simple theoretical model

The following exposition presents the REH in a simplified dynamic optimisation model for private and government consumption. Assumptions of quadratic utility, deterministic return, and perfect substitution between government consumption and household consumption may seem strong, but are adopted to keep the formal explanation as simple as possible. Note that the REH remains robust in more advanced models where these assumptions are relaxed.

The point of departure is a representative consumer who lives forever, faces a lump-sum taxes and well-functioning capital market. Per capita consumption is given by $c_t^* = c_t + g_t$, where c_t is total consumption of goods and services supplied by private producers and g_t is the exogenously given consumption of goods and services produced by the government. With separable preferences, the consumer will maximise her consumption plan according to:

$$\underset{\{c_{t+j}^*\}}{Max}\, E_t \sum_{j=0}^{\infty} p^j u(c_{t+j}^*), \qquad (1)$$

where $p = 1/(1+\rho)$ is the discount factor for the consumer and the time preference rate is assumed equal to the interest rate ($\rho = r$). With b_t as per capita private wealth, w_t as wage income, and tx_t as net taxes, the consumer faces the following budget constraint:

$$\sum_{j=0}^{\infty} p^j c_{t+j} = \sum_{j=0}^{\infty} p^j (w_{t+j} - tx_{t+j}) + b_t . \qquad (2)$$

Standard models with government borrowing usual apply standard solvency requirements to impose boundaries on the growth in government debt. To underline the angle of this study, the government is presented as a net saver. However, corresponding boundaries on the growth of government wealth are still essential. We therefore assume that the growth in both private and government wealth (b_t, a_t) are bounded by the interest rate: $\lim_{j\to\infty} p^j b_{t+j} = 0$, $\lim_{j\to\infty} p^j a_{t+j} = 0$. For the development over time in private and government wealth, this implies:

$$b_{t+1} = (1+r)\left[b_t + w_t - tx_t - c_t\right] \tag{3}$$

$$a_{t+1} = (1+r)\left[a_t + tx_t - g_t\right], \tag{4}$$

It follows that the budget constraint of the government can be written as:

$$\sum_{j=0}^{\infty} p^j tx_{t+j} + a_t = \sum_{j=0}^{\infty} p^j g_{t+j}. \tag{5}$$

Combination of the budget constraints in (2) and (5) now yields:

$$\sum_{j=0}^{\infty} p^j c^*_{t+j} = \sum_{j=0}^{\infty} p^j w_{t+j} + a_t + b_t. \tag{6}$$

Equation (6) illustrates that the present value of consumption is bounded by the present value of labour income and initial private and government wealth.[6] A standard optimality condition of dynamic consumption models is that the marginal utility of consumption in period *t* will be equal to the marginal utility of consumption in period *t+1*, scaled by the ratio of the interest rate (*1+r*) and the time preference rate (1+ρ). This is the core of the Euler equation:

$$\frac{\partial u}{\partial c^*_t} = E_t\left[\left(\frac{1+r}{1+\rho}\right)\left(\frac{\partial u}{\partial c^*_{t+1}}\right)\right] \tag{7}$$

[6] In equilibrium, the sum of *a* and *b* will equal the sum of the country's real capital and its net claims on the rest of the world (i.e., national wealth).

Taking expectations on both sides of Euation (6) now yields:

$$E_t\left[\sum_{j=0}^{\infty} p^j c^*_{t+j}\right] = E_t\left[\sum_{j=0}^{\infty} p^j w_{t+j} + a_t + b_t\right]. \qquad (8)$$

With quadratic utility and equality between the interest rate and the time preference rate, the Euler equation (7) implies that expected consumption in the next period always will be equal to current consumption: $E_t(c^*_{t+j}) = c^*_t$.[7] For the left-hand side of Equation (8) this yields:

$$E_t\left[\sum_{j=0}^{\infty} p^j c^*_{t+j}\right] = E_t\left[\frac{c^*_t}{1-p}\right] = \frac{1+r}{r} c^*_t \equiv \frac{c^*_t}{p \cdot r}. \qquad (9)$$

Since the consumption aggregate of this model is the simple sum of private and public goods ($c^*_t = c_t + g_t$), the combination of Equations (8) and (9) now produces the following household consumption function:

$$c_t = p \cdot r \cdot E_t\left[\sum_{j=0}^{\infty} p^j w_{t+j} + a_t + b_t\right] - g_t. \qquad (10)$$

Equation (10) states that private consumption in period *t* is determined by the expected present value of labour income and total wealth, with a simple subtraction for consumption of the publicly provided consumption aggregate in the same period. With perfect substitution between private and publicly provided consumption goods, Equation (10) implies that an increase in government consumption will lead to a corresponding reduction in private consumption, leaving total consumption ($c^*_t = c_t + g_t$) unchanged.[8]

[7] Note that quadratic utility implies linear marginal utility. Without a strictly convex utility function, this simplified model excludes the possibility of precautionary saving. This saving motive may still have empirical relevance in resource-rich nations (van der Ploeg, 2010; Bems og de Carvalho Filho, 2011), and will therefore not be excluded as a saving motive in the empirical assessment below.

[8] Note that perfect substitution between the private and the public consumption good is not assumed in the original formulation of the REH. In Barro's (1974) model, a debt-financed increase in government consumption will therefore not necessarily produce a fully off-setting adjustment in

Household saving is given by the difference between real disposable income and consumption: $s_t \equiv w_t - tx_t - c_t$. Adding returns on the wealth of the previous period leads us to the following relationship for accumulation of private wealth:

$$b_{t+1} - b_t = rb_t + (1+r)s_t \ . \tag{11}$$

With an exogenous interest rate and pre-determined private wealth, the compensating adjustment in private households will be channelled through private saving. For saving in the private sector, the REH will therefore mean that forward-looking consumers will realise that an increase in the government's tax income (and/or a resource revenue windfall) will lead to lower taxes in the future. A government tax windfall will therefore lead to a compensating reduction in private savings, leaving private consumption and total saving independent of the timing of taxes. This form of substitution between government saving and private saving is the key prediction which will be tested in an econometric exercise on Norwegian data in in Chapter 4 below. But before diving into the data, we present a brief review of previous empirical and theoretical literature on the subject.

Testing and theoretical evolution

The potency of fiscal policies is impaired if changes in the net financial position of the government are compensated by off-setting adjustments in expenditures and saving in the private sector. This insight attracted vast attention at its introduction to modern economic research some 40 years ago (Barro, 1974). A range of empirical studies were carried out to test the REH. Preliminary surveys include Bernheim (1987) and Seater (1993). Early results are mixed, and consensus has not been achieved even in contemporary empirical research. In a late survey, Ricciuti (2003) concludes that the REH finds partial support in macroeconomic data, but in a milder form than implied by the original formulation of the theorem.

Based on heterogeneity in consumer preferences, Mankiw (2000) proposes a model that opens for a milder variant of Ricardian equivalence that still could comply with economic

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private consumption and saving. However, with exogenous government consumption will still mean that a change in the tax rate in period *t* will bring about a compensating change in private consumption, leaving the sum of private saving and government saving unchanged.

theory. Mankiw's model introduces to groups of consumers, were one of them (*savers*) are forward-looking optimisers of intertemporal utility, whereas private consumption for another household groups (*spenders*) is linked more closely to contemporaneous income.

The mindset of Mankiw (2000) is reflected in later theoretical and empirical studies. One example is Galí, Vallez, and Lopez-Salido (2004), who build a Keynesian dynamic, stochastic general equilibrium (DSGE) model with two groups of consumers corresponding to Mankiw's (2000) *savers* and *spenders*. Within this framework, Galí et al (2004) argue that an increase in government expenditure will lead to a response in private consumption that depends on the prevalence of *spenders*, or specifically the ratio of *spenders'* consumption to total consumption. Coenen and Stroeb (2005) calibrate a corresponding model on data for the Euro area, and demonstrate that the general results of Galí et al (2004) can be replicated with a relaxation to more realistic assumptions for the fiscal policy framework.

This evolution in theory and empirical modelling strategy may be seen as attempt to bridge a traditional Keynesian approach to fiscal policies with the neo-classical perspective supporting the original REH. With a theoretical foundation that combines these two approaches, the status of contemporaneous research is that the relevance of Ricardian equivalence is an empirical question. Modern empirical studies typically find evidence of substitution in line with Ricardian equivalence, but the vast majority of estimates are less than 1 in absolute value, and typically reside in the [-0,7; -0,2] interval (e.g., de Mello, Kongsrud, and Price, 2004).

The connection between government saving and private saving in resource-rich countries has so far been blessed with limited interest in academic research. Resource-rich countries share a set of characteristics that changes the perspective slightly, when compared to the contributions cited above. First, resource-rich countries are more often than not marked by modest or low income per capita, with households who are not obvious to comply with theories of forward-looking dynamic optimisation. The role of Keynesian consumers (*spenders*) is therefore likely to be more important than for typical industrialised countries. A plausible implication is that Ricardian equivalence is less relevant than among rich and well-educated western consumers (Mankiw, 2000). Moreover, several resource-rich countries have established sovereign wealth funds (SWF)

to separate the domestic absorption of resource revenues from the accumulation of the same revenues.

Consequently, challenges relating to Ricardian equivalence in Western industrialised countries are in many ways turned upside down for typical resource-rich economies, due to substantial windfall tax revenues from resource export and significant net financial investment by government. In a theory-based assessment of optimal policies for resource-rich developing economies, van der Ploeg and Venables (2011) argue that Ricardian consumption behaviour could undermine the ambition of government saving to restrain total consumption, as forward-looking consumers may offset government saving through a credit-financed consumption boom ("Ricardian curse"). However, the empirical relevance of the REH for resource-rich countries is yet to be addressed through econometric research.

The oil fund mechanism and the fiscal policy rule are key elements of the Norwegian model of resource revenue management. If Norwegian households consolidate private and government wealth in their establishment of private consumption and investment, the result will be an undermining of the intentional constraint on the rate of oil revenue absorption which is fundamental to the motivation of the fund mechanism and the fiscal policy rule. A good understanding of the relationship between private and government saving is therefore important both to for forecasting and for policy design. Our next step is therefore to study the relationship between private and government saving in an econometric assessment on Norwegian time series data.

4. Econometric modelling

In his review of previous research on Ricardian equivalence, Ricciuti (2003) distinguishes between two groups of approaches in empirical tests of the REH. The point of departure for one of the approaches is consumption function based directly on intertemporal optimisation. The other approach is based on reduced-form equations of consumption and saving, and usually applies modern methods of time series econometrics. The following empirical analyses will test a key corollary from standard intertemporal consumption models. With no explicit link to the first order conditions of the maximisation problem,

this study will still have to be considered as a reduced-form approach. Building on previous comparable studies (e.g., de Melo et al, 2004; Holmes, 2006; Röhn, 2010), the ambition is to provide an empirical characterisation of the relationship between private and government saving, based on data for a western, industrialised resource-rich country. The estimated model will form the basis for a more rigorous test of the hypothesis that changes in government saving are offset by counteracting changes of in household saving, as predicted by the REH.[9]

Data

This assessment exploits saving rates for Norwegian households (*SRH*) and government (*SRG*) obtained from OECD (2014), in addition to three control variables; Oil price (*OP*), interest rate (*IR*) and unemployment rate (*UR*). The oil price is included to test the relevance of specific impulses from the oil price (and petroleum activity) for household saving in a resource-rich economy. Changes in the interest rate level will obviously have the potential of influencing consumption and saving over time, whereas the unemployment rate is included to account for more general business-cycle effects. An increase in the unemployment rate will dampen household income. If household want to maintain their level of consumption, savings would then have to be reduced. However, an increase in unemployment may also serve as a signal of increased uncertainty around future expected income, which would cause an increase in (precautionary) saving among risk-averse households.

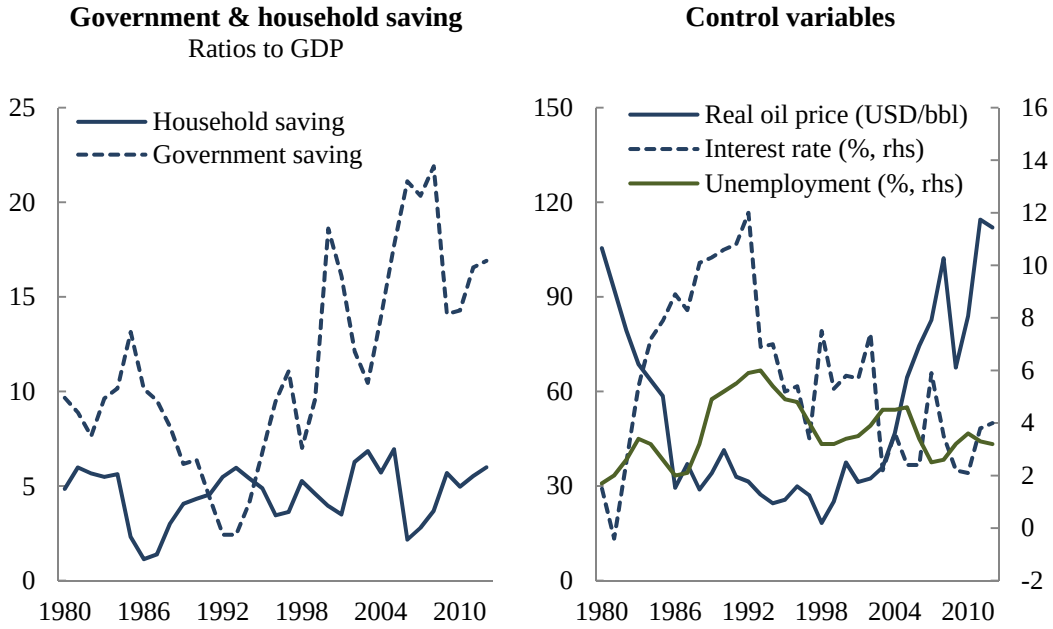
Descriptive statistics are summarised in Table 1. The frequency of our time series data is annual, and the number of observations is limited by the data source, which covers the period 1980-2012. Saving rates for households and (*SRH*) and the government (*SRG*) are retrieved from OECD (2014). The oil price (*OP*) retrieved from Reuters EcoWin is measured in USD/bbl, and deflated (by US CPI) to 2012 prices. The interest-rate variable is an average real borrowing rate among Norwegian banks, retrieved from Statistics Norway.

[9] Note that capital gains are disregarded in National-account definitions of net disposable income, raising the risk of measurement error for savings and capital income data. In many other countries, this type of measurement error would be particularly relevant for the private sector, whereas the substantial Norwegian GPF implies that such measurement errors are potentially larger for government savings data than for corresponding private data. For a discussion on the role of capital gains in empirical studies of saving behaviour, see de Melo et al. (2004).

Table 1. Descriptive statistics

	Observations	*Min*	*Max*	*Average*	*St. dev.*
SRH	33	1.14	6.95	4.58	1.50
SRG	33	2.42	21.9	11.2	5.27
OP	33	18.3	114.5	53.53	29.23
IR	33	-0.4	12.0	5.66	3.11
UR	33	1.7	6.00	3.70	1.18

Figure 6. Saving rates and control variables



Source: OECD (*Economic Survey of Norway* 2014), Norges Bank, Statistisk sentralbyrå.

The evolution over time of key variables in the data set is illustrated in Figure 6. This exposition leaves no conclusive sign of a clear-cut correlation between saving in the private and public sectors. However, some trace of negative interaction is indicated, in particular for the short-term variation from year to year. For the explanatory variables, Figure 6 leaves the impression of slight negative correlation between oil price and unemployment. This should come as no surprise, as oil price and oil-related activity has been important to the patter of Norwegian business cycles over the sample period (cf. Bjørnland and Thorsrud, 2013; Eika and Martinussen, 2013). Moreover, Figure 6 seems

to suggest that government saving is negatively correlated with the unemployment rate. This is also not unexpected, as an increase in unemployment will normally will be met by expansionary fiscal policies and reduced government saving.

Table 2. Correlation matrix for model variables

	SRH	*SRG*	*OP*	*IR*	*UR*
SRH	1.00	-0.19	0.17	-0.33	0.37
SRG		1.00	0.55	-0.50	-0.47
OP			1.00	-0.59	-0.52
IR				1.00	0.39
UR					1.00

Further support for preliminary indications is offered by Table 2, which represents the correlation matrix between all model variables. The most important observation is probably that the pairwise correlation between household saving and government saving is negative, but not very significant in economic terms. This suggests that the relationship between household saving and government saving is not very close. However, more rigorous methods are required to establish and test the validity of this signal. For this purpose we go on to specify a suitable econometric model.

Econometric model

The empirical basis of this study is annual time series data. The variables of time series data are rarely stationary. Direct estimation on non-stationary data is at stake with standard assumptions of econometric methodology, will produce inefficient parameter estimate, with subsequent challenges for statistical inference. At the same time, variable that are integrated of degree 1 (*I(1)*) will produce a stationary time series through simple differentiation: $y_t \sim I(1) \Rightarrow \Delta y_t \sim I(0)$. A corollary from the literature on co-integration also states that a linear combination of co-integrated variables will produce a stationary residual. Moreover, Engle and Granger (1987) demonstrate that all co-integrated vectors have a valid error-correction specification. This set of ideas forms the point of departure for the econometric model specification. Stationarity tests are performed through the

estimation of so-called augmented Dickey-Fuller tests, and test statistics for all model variables are presented in Table 3.

Table 3. Augmented Dickey-Fuller test for stationarity in model variables

	SRH	*SRG*	*OP*	*IR*	*UR*	$\hat{e}$
Level	-2.9	-1.48	-1.15	-2.21	-2.00	4.33**
Change	-5.73**	-5.06**	-5.47**	-7.32**	-3.05*	-8.60**

*) Significant at 95 and **) 99 per cent confidence level, respectively.

The null of non-stationarity is rejected for all *changes* in the model variables, but not for the *levels*. Empirical model specification therefore proceeds under the assumption that the data set consists of *I(1)* variables.

According to the above cited literature on co-integrated time series data, we therefore assume that a long-term equlibrium exists between the private saving rate and the four explanatory variables of our model. This long-term equilibrium relationship is estimated directly on the level variables, in a model including a constant term and a time trend (*t*). The dynamics of the model is then identified by regressing annual *changes* in the household saving rate against *changes* in explanatory variables, including the deviation (estimated residual) from the long-term relationship as one of the explanatory variables. This is essentially the two-step model for estimation of error-correction models, introduced by Engle and Granger (1987). The general form of the long-term relationship may be specified as follows:

$$y_t = \sum_i \beta_i x_{it} + e_t, \qquad (11)$$

where $y_t \equiv SRH_t$, x_{it} = [SRG_t, OP_t, IR_t, UR_t, t] represents the full set of explanatory variables, β_i are respective long-term coefficients and e_t is a residual. In so far as the empirical long-term relationship represents a co-integrating vector, this residual will be well-behaved (i.e., stationary).

OLS estimation of Equation (11) produces the following result (Pc-Give 14; Dornik and Hendry, 2013):

$$
\begin{aligned}
&SRH_t = \underset{(0.007)}{4.21} - \underset{(0.018)}{0.18}\,SRG_t + \underset{(0.040)}{0.02}\,OP_t - \underset{(0.005)}{0.25}\,IR_t + \underset{(0.039)}{0.55}\,UR_t + \underset{(0.223)}{0.043}\,t + \hat{e}_t \\
&\hat{\sigma} = 1.07\ ,\ \overline{R}^2 = 0.49\ \ ,\ \ F(5,27) = \underset{(0.000)}{7.113}\ \ , \\
&Log-likelihood\ = -45.77, \\
&Normality\ test\ (\chi^2(2)) = \underset{(0.614)}{0.974}\ , \\
&Hetero\ test\ (F(10,22)) = \underset{(0.788)}{0.611}, \\
&Hetero\ X\ test\ (F(20,12)) = \underset{(0.823)}{0.633}.
\end{aligned}
\tag{12}
$$

The estimated long-term relationship explains approximately 50 per cent of the total variation of the data set. Estimated coefficients are largely significant in statistical terms (p-values in brackets), and the sign of the coefficients are as expected. These results should be taken with a pinch of salt, as direct estimation on level variables of time series data will produce biased variance estimates. This calls for caution when it comes to statistical inference. Still, model diagnostics do not raise specific challenges for the error term, and therefore leaves further support for the assumption of a co-integrated data set.

Rather than offering an exhaustive explanation of household saving behaviour, the ambition of this study is to provide an empirical assessment of the relationship between saving in Norwegian households and saving by the Norwegian government. The estimated equilibrium equation suggests that an increase of one percentage point in the government saving rate will reduce the private saving rate by 0.18 percentage points, which is fully in line with the simple correlation coefficient of Table 2. Consequently, the estimated long-term relationship suggests a slight substitution between household saving and government saving, but not by far as much as implied by the REH. In its strongest form, Ricardian equivalence would imply that the offset coefficient on government saving was -1. Even though the estimated standard deviations of Equation (12) are not entirely trustworthy, the estimate coefficient is so far from -1 that the REH can most likely be rejected. At the same time, Equation (12) represents econometric evidence that household saving does not develop in total isolation from net financial investments in the government sector. As household saving to some extent will compensate for changes in

government net wealth, the Norwegian oil fund mechanism and the fiscal policy rule do not fully succeed in establishing a the intended watershed between petroleum revenues on the one hand, and expenditures of the same revenues on the other hand.

Note also that the oil price takes a positive and statistical significant coefficient in the long-term relationship. Specifically, an increase in the oil price of 1 USD/bbl will increase the saving rate in Norwegian households by 0.2 percentage points. This may seem modest, but oil price fluctuations are substantial, and may therefore well produce shocks in household saving that are also significant in economic terms. As an example, the estimated model implies that an increase in the oil price of 25 USD/bbl will lift the household saving rates by 0.5 percentage points. One possible interpretation is that parts of the income gain from an oil-related windfall tends to accumulate as financial wealth in Norwegian households, and that consumption is determined by expected returns on total household wealth, as implied by the theoretical model in Chapter 3 above.

Equation (12) also suggests that a permanent increase in the interest rate of 1 percentage point will reduce the household saving rate by roughly 0.25 percentage points. The effects of interest rate changes in dynamic consumption models will depend on the net financial position of the actor in question, and will in general be a result of the interplay of income and substitution effects (cf. Varian, 2006). An increase in the interest rate will depress consumption and increase saving for households with net debt, as the income and substitution effects will pull in the same direction. However, these two effects will pull in opposite directions for households with positive net financial wealth, leaving the sign of the interest effect as an empirical question. This seems to suggest that the estimated interest rate effect on the saving rate for Norwegian households is dominated by households with positive net financial wealth.

The estimated long-term relationship in Equation (12) also indicates that an increase in the unemployment rate of one percentage point will lift the household saving rate by 0.55 percentage points. A likely explanation is that an increase in the rate of unemployment represents a signal of increased uncertainty around expected future income. This may produce an increase in (precautionary) saving among risk-averse households.
The next step is to identify the short-term dynamics of our model, and to estimate the explicit adjustment mechanism. In other words, we want to provide an empirical

characterisation of the way in which household saving responds to transitory and permanent shocks in explanatory variables. For this purpose we specify the change in the household saving rate (SRH_t) as a function of changes in dependent and independent variables, including the deviation from the long-term equilibrium relationship in Equation (12). The general specification of the error-correction model takes the following form:

$$\Delta y_t = \sum_j a_j \Delta y_{t-j} + \sum_j b_j \Delta x_{t-j} + \lambda \hat{e}_{t-1} + u_t , \tag{13}$$

where Δy_t is the change in the dependent variable, Δx_t represent changes in (the vector of) explanatory variables, and $\hat{e}_t$ is the estimated residual from the long-term equilibrium relationship of Equation (12):

$$\hat{e}_t = y_t - \sum_i \hat{\beta}_i x_{it} , \tag{14}$$

Test statistics of Table 3 offer support of stationarity (*I(0)*) in all model variables of Equation (13), and ordinary least squares estimation is therefore justified. A negative and statistically significant coefficient on $\hat{e}_t$ will provide further support of a hypothesis of cointegration, and will also give information about the speed of the adjustment process. The point of departure for estimation of Equation (13) is a model version including all model variables and one lag. The Equation is then reduced step by step through a general-to-specific procedure, whereby non-significant variables are eliminated one by one. The result is the following parsimonious preferred model:

$$\begin{aligned}
&\Delta SRH_t = \underset{(0.020)}{-0.15}\,\Delta SRG_t + \underset{(0.001)}{1.09}\,\Delta UR_t - \underset{(0.001)}{0.66}\,\hat{e}_t \\
&\hat{\sigma} = 0.946 , \quad RSS = 30.96 \\
&Log-likelihood = -42.06, \\
&Normality\ test\ (\chi^2(2)) = \underset{(0.906)}{0.197} , \\
&Hetero\ test\ (F(10, 22)) = \underset{(0.3614)}{1.154}, \\
&Hetero\ X\ test\ (F(20, 12)) = \underset{(0.655)}{0.756}.
\end{aligned} \tag{15}$$

The estimated error-correction model of Equation (15) pass the standard battery of model tests, and provides an acceptable representation of the data-generating process.[10] Among all explanatory variables, only the government saving rate (SRG_t) and the unemployment rate (UR_t) are justified for a position in the preferred error-correction model of Equation (15). However, the error-correction term $\hat{e}_t$ also takes a highly significant parameter estimate of the expected sign. For the response to a shock to the long-term equilibrium, the estimated error-correction model implies that roughly 2/3 of the equlibrium error will be corrected in each period. This suggests a swift adjustment process for shocks to household savings in Norway. Note also that shocks to the unemployment rate are met by larger changes to household savings in the short term than over the longer term (cf Equation (12)).

For the short-term response in household saving to changs in government saving, the estimated error-correction model suggests a response of -0.15, which is only marginally less than the corresponding long-term coefficient of Equation (12). Equation (15) thereby suggests that adjustment of household saving to changes in government saving is quite speedy, and with only a minor deviation between short-term and long-term response.

4. Concluding remarks

The design of the Norwegian model of resource revenue management is motivated by concerns for macroeconomic stability in the short term, and competitiveness, tax and consumption smoothing in the long term. A defining ambition of the oil fund mechanism and the fiscal policy rule is to ensure a separation between the accumulation of oil and gas revenues on the one hand, and the government expenditures of resource-related revenues on the other.

A key assumption for the resource revenue management mechanism in Norway is that households neglect the government net financial position when determining their own

[10] Note that PcGive does not report the determination coefficient (R^2)for models without a constant term, as R^2 is not well defined for such models. However, estimation with an (insignificant; $p=0.96$) constant term produces only marginal changes in coefficient estimates. This model variant produces an adjusted R^2 of 0.60 and an F(3,28) test for joint significance of parameter estimates of 14.04 ($p=0.00$).

consumption and investment expenditures. This assumption is at stake with the neo-classical theorem of Ricardian equivalence, which implies that households will consolidate their own wealth position with the government´s wealth position in their decisions on consumption. With Ricardian consumer behaviour, an increase in government saving will be met by a compensating increase in net borrowing among households, implying that the fund mechanism and the fiscal policy rule will be inefficient in the regulation of aggregate demand in the Norwegian economy. A good understanding of wealth accumulation across various sectors of the economy is therefore important in any evaluation of the Norwegian model of resource revenue management.

The REH is no great empirical success, and the strong form is rejected by the majority of econometric studies. The relevant theory has subsequently been modified to account for heterogeneity in consumer behaviour, including groups of households who are forward-looking optimisers, with other groups who largely consume according to their contemporaneous income. The relevance of the REH has therefore become an empirical question, with observed consumer and saving behaviour that may vary significantly across consumer groups and country groups.

Theoretical and empirical studies of Ricardian equivalence have focused entirely on government borrowing and fiscal policies in indebted nations. With substantial government saving and a sovereign wealth fund of more than USD 1,000 bn, Norway is an interesting example of an entirely different situation, calling for an assessment to test if the relationship is different from more representative industrialised (OECD) countries

The main result of this study is that the relationship between household saving and government saving in Norway is not very different from previous studies of western industrialised countries. The estimated econometric model suggests that an increase in the government´s saving rate of 1 percentage point will reduce the household saving rate by 0.18 percentage points. Although this means that the strong from of the REH most likely is rejected, the results still suggest a partial substitution between government saving and household saving in Norway.

The accumulation of resource revenues is an important factor behind the evolution of both private and public sector wealth in Norway. Insights on the composition, interaction,

and propagation of real and financial wealth is important to understand the development of the Norwegian economy, and to design appropriate policies in the short term and over the longer term. This leaves a range of questions for further empirical research.

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