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Is the price level in Norway determined by fiscal policy?

by

Ragna Alstadheim

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Is the price level in Norway determined by fiscal policy?

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June 2, 2005

Abstract

The Norwegian public sector has net financial assets. The fiscal theory of price determination applies equally to Norway and economies with net public debt: If primary surpluses evolve independently of nominal debt (or assets), the price level has to adjust to satisfy the intertemporal budget constraint of the public sector. In this 'non-Ricardian' regime, monetary policy cannot provide the nominal anchor. In the alternative 'Ricardian' regime, surpluses respond to debt, and monetary policy is the nominal anchor. The plausibility of NR regimes is disputed. I use fiscal data and oil prices to argue that the Norwegian regime is Ricardian.

Key words: *price level determinacy, fiscal policy, Ricardian regime, nominal anchor.*

JEL classification: E60, E63.

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1 Introduction and summary

According to the 'fiscal theory of price level determination'[1], the price level may be determined by the intertemporal budget constraint of the public sector. The alternative and more traditional assumption is that the price level is determined by monetary policy. It is for example often assumed that an interest-rate reaction function pins down the price level. Woodford (1995) calls a monetary-fiscal regime where monetary policy can pin down the price level a 'Ricardian' (R) regime. Woodford's R regime is defined by an endogenous fiscal policy that makes the public sector intertemporal budget constraint hold exactly regardless of the prevailing price path. In a 'Non-Ricardian' (NR) regime on the other hand, the price level has to adjust to assure that the present-value budget constraint of the public sector holds with equality in equilibrium. In an NR regime the path of primary surpluses does not respond enough to real public liabilities to make sure that the intertemporal budget constraint of the public sector holds given any price level. Monetary policy authorities can therefore not pin down the price level. If they tried to, no equilibrium would exist.

The central bank of Norway has an inflation target, and the presence of an R regime is a precondition for the central bank's ability to implement the target[2][3]. It may also be of some general interest to know whether an NR regime is empirically plausible in the case of Norway. Norway is exceptional in the sense that the public sector has large positive financial assets. Tax income from the petroleum sector has enabled the public sector to run budget surpluses. The fiscal theory of the price level applies equally to an economy with net public financial wealth and to one with high net public liabilities. But the empirical relevance of an NR regime might depend on the financial position of the public sector.

I first present impulse-response functions calculated from VARs in the surpluses and the real liabilities of the public sector, following the approach of Canzoneri, Cumby, and Diba (2001b)(CCD). CCD point out that in an R regime, the one-period lagged response in liabilities to a positive shock in the surplus will be negative. In an NR regime the response may be positive, negative or zero depending on the time

[1] Contributions to this literature include among many others Canzoneri, Cumby, and Diba (2001b), Cochrane (1998), Woodford (1995) and Sims (1994). For an overview of this literature and a more complete list of references, see Woodford (2001).

[2] In practice, the traditional conditions for 'Ricardian Equivalence' (e.g. frictionless capital markets) will not hold, and fiscal policy may be assumed to affect the price level via demand for that reason. These effects may feed into the reaction function of monetary authorities in an R regime as defined above. An R regime is a necessary but not sufficient condition for Ricardian Equivalence.

[3] Benhabib, Schmitt-Grohe, and Uribe (2001c), Benhabib, Schmitt-Grohe, and Uribe (2001a) and Benhabib, Schmitt-Grohe, and Uribe (2001b)discuss uniqueness problems when authorities follow interest rate reaction functions. In their work, the interest rate reaction function of the monetary authorities may pin down the price level in a locally R equilibrium, but an NR regime may help ensure global uniqueness. An empirical investigation of the type of regime will necessarily have to be concerned with the forces that ensure uniqueness around the actual historical equilibrium of the economy.

series process of the surplus. If there is no negative autocorrelation in the surplus series, one will be able to distinguish between the regimes based on impulse-response functions. The evidence from my VAR estimations for Norway is inconclusive, since I find negative autocorrelation in the surplus series.

Next I test for Granger causality using the oil tax and the real public liabilities. This approach to the question is new here, and seems to be more informative. If the oil-tax data are exogenous to public liabilities the oil tax should not be Granger caused by public liabilities in an R regime. But in an NR regime the oil-tax income should be Granger caused by public liabilities. The reason is that in the NR case, the direction of causality is from expected future surpluses to liabilities. That is, evidence of Granger causality from the liabilities series to the oil-tax series should appear if and only if the regime is NR (given that the oil tax really is exogenous to liabilities). This is in contrast to the regular surplus, which should respond to liabilities in an R regime, and hence should be Granger caused by liabilities in any regime. I find that real liabilities do not Granger cause oil-tax income. This is evidence of an R regime. One may be worried that oil tax income is not truly exogenous to the level of public debt. I note that the oil price is highly correlated with oil-tax income, and the oil price may be assumed to be exogenous to Norwegian decisions[4]. I find no Granger causality from the liabilities to the oil price. Also, there is no response in the real value of the liabilities to a shock in the oil price calculated from a VAR in the oil price, the surplus and the liabilities. Based on this I find it plausible that an R regime has been in place in Norway rather than an NR regime.

Section 2 below is a brief review of the theory. Estimation results are presented in section 3 and concluding remarks follow in section 4.

2 Theoretical background

2.1 The definition of Ricardian (R) and Non-Ricardian (NR) policy regimes

The terms 'Ricardian' and 'Non-Ricardian' monetary-fiscal regimes were first used by Woodford (1995). I work with CCD's version of the intertemporal public budget constraint, which differs from Woodford's only in that they work with variables relative to nominal GDP. I reproduce their equations here. The present value budget constraint is derived from the period budget constraint of the public sector;

$$B_j = (T_j - G_j) + (M_{j+1} - M_j) + B_{j+1}/(1 + i_j) \tag{1}$$

[4]Even though Norway is the worlds third largest oil exporter, the volume of its production is only about 5 percent of the world market.

where M_j and B_j are stocks of base money and net government liabilities at the beginning of period j, $T_j - G_j$ is the primary surplus during period j, and i_j is the net nominal one period interest rate for period j. The constraint says that expiring bonds have to be financed by the primary surplus, by seigniorage, or they have to be refinanced. The government issues nominal liabilities, $M_j + B_j$. The effect of issuing liabilities in foreign currency (or acquiring assets denominated in foreign currency, as is relevant for Norway) for the reasoning that follows is discussed in appendix B on page 19.

Expressing the government budget constraint in terms of total liabilities, and dividing through by the nominal gross domestic product $P_j y_j$ gives the following difference equation in total real government liabilities:

$$\frac{M_j + B_j}{P_j y_j} = \tag{2}$$
$$\left[\frac{T_j - G_j}{P_j y_j} + \left(\frac{M_{j+1}}{P_j y_j}\right)\left(\frac{i_j}{1+i_j}\right) + \left(\frac{y_{j+1}/y_j}{(1+i_j)(P_j/P_{j+1}}\right)\left(\frac{M_{j+1}+B_{j+1}}{P_{j+1}y_{j+1}}\right)\right]$$

Like CCD, I simplify the notation and replace the above equation by

$$w_j = s_j + \alpha_j w_{j+1} \tag{3}$$

where w_j is the liabilities to $P_j y_j$ ratio, s_j is the surplus to $P_j y_j$ ratio (including transfers from the central bank), and α_j is the discount factor $\frac{y_{j+1}/y_j}{(1+i_j)(P_j/P_{j+1})}$. CCD iterate on (3) to get the following present value budget constraint:

$$w_t = s_t + E_t \Sigma_{j=t+1}^{+\infty} \left(\Pi_{k=t}^{j-1} \alpha_k\right) s_j \tag{4}$$

which holds if and only if the transversality condition

$$\lim_{T\to\infty} E_t \left(\Pi_{k=t}^{T+t-1} \alpha_k\right) w_{t+T} = 0 \tag{5}$$

holds[5].

According to Benhabib, Schmitt-Grohe, and Uribe (2001b), *if fiscal policy makes sure that (4) or equivalently (5) holds regardless of endogenous variables, we have a Ricardian (R) regime*[6]. In the type of model CCD have in mind, the potential endogenous variables are prices, nominal interest rates and real output. Hence, the regime is R if the surplus series s_t responds to innovations in total public liabilities w_t or the series of discount factors α_t to make sure that (4) holds.

[5] The transversality condition follows as an equilibrium condition from a 'No-Ponzi-game' condition in combination with the budget constraint and utility maximization in the private sector. See for example Obstfeld and Rogoff (1996), page 715.

[6] The definition of R and NR regimes in Woodford (1995) are different from Benhabib, Schmitt-Grohe, and Uribe (2001b)'s definition. Woodford (1995) refers to a transversality condition on government debt excluding money. In the discussion of this topic in Woodford (2003), the difference is avoided by referring to a model without money.

On the other hand, *if the path of real primary surpluses including transfers from the central bank s_t is exogenous to the value of real public liabilities w_t, the regime is defined as Non-Ricardian (NR).* In an NR regime, an innovation in the s_t series must imply that either discount factors α_t or w_t have to jump in order to make sure that (4) is satisfied. w_t can jump if the price level or current real output can jump, but the numerator $M_t + B_t$ is a predetermined variable in period t (because it is the beginning of period nominal value of total liabilities). Following CCD, the empirical question I am interested in is therefore the causality between real liabilities w_t and fiscal policy as represented by the expected future path of s_t in the present value budget constraint (4). The regime is NR if causality goes from the net present value of surpluses to total liabilities, while the regime is R if causality goes from total liabilities to the net present value of surpluses.

Nominal values and prices have to enter in equations (4) and (5) in order for the question of an R or NR regime to be meaningful. Without prices entering the equations, the equations have to be satisfied in equilibrium independently of the price level, and the regime is R.

When modelling economic policy, it may be convenient to determine the implied regime by checking whether the implied path of public debt or assets satisfies (5) given any path of prices and nominal interest rates. In the case of a wealthy public sector, the question is whether public assets grow 'too fast' or not. For example, Akram (2005) suggests a policy for Norwegian consumption of petroleum revenues that will minimize disturbances to the sectoral composition of the economy caused by petroleum revenues (via real exchange rate changes). Assuming that all petroleum wealth is publicly owned, that the public sector has no other assets or liabilities, and that petroleum revenues are the only source of public revenues, we may check whether the suggested policy regime is Ricardian: With the notation in Akram (2005), initial real public wealth is W_0, the real interest rate (return on real wealth W_t) is ar and a fraction cr of W_t is consumed each period[7]. The growth rate of real wealth is $ar - cr$. We may furthermore assume a constant growth rate of the economy g for the purpose of this example. We also assume that the consumption rate is not high enough to wipe out wealth completely (that is, $cr < 1 + ar$). Using the definitions of α and w above, the relevant version of equation (5) becomes

$$\lim_{T\to\infty} E_0 \left(\left\{ \frac{1+g}{1+ar} \right\}^{T-1} \frac{(1+ar-cr)^{T-1} W_0}{(1+g)^{T-1}} \right) = 0$$

or, when simplifying,

$$\lim_{T\to\infty} E_0 \left(\left\{ \frac{1}{1+ar} \right\}^{T-1} (1+ar-cr)^{T-1} W_0 \right) = 0$$

[7]Note that in order for the question of a possible NR regime to arise, at least some of public wealth has to be held as nominal assets. In this example, we may assume that a part of the petroleum wealth has been converted to financial assets.

which is true as long as $1 + ar - cr < 1 + ar$ or equivalently $cr > 0$. Hence, as long as the consumption rate cr is positive, the discounted real value of future wealth will approach zero in the limit and the regime is R. In Akram (2005), the 'efficient' consumption rate (the one that minimizes disturbances to the composition of the economy's sectors) depends positively on the real rate of return ar but negatively on growth at home and abroad. Plausible parameter values seem to be consistent with a postive cr and hence with an R regime.

2.2 Potential evidence from a VAR estimation

Regardless how the present value budget constraint (4) gets satisfied, there should be a positive correlation between the ratio of liabilities to GDP and the net present value of surpluses relative to GDP. CCD explore empirical implications of alternative hypotheses regarding how the equation gets satisfied, in order to shed light on the causality question.

Firstly, they consider equation (3) repeated here

$$w_j = s_j + \alpha_j w_{j+1}$$

in the case where the surplus series responds to real liabilities to make sure the present value budget constraint (4) is satisfied. This is the case of an R regime, where w_j may be regarded as predetermined. The empirical implication is what one traditionally would assume: Real liabilities w_{j+1} decline when there is a positive innovation in the surplus. Hence the response in w_{j+1} to a shock in s_j calculated from a VAR in liabilities w_j and surpluses s_j should be negative. The mechanism is that the extra surplus pays off liabilities, and future surpluses will be correspondingly lower. In period $t + 1$, both sides of the present value budget constraint (4) have fallen.

Next CCD consider the case where the surplus series is exogenous and discount factors or nominal GDP adjust to let the present value budget constraint be satisfied. This is the definition of an NR regime. The empirical implication of this is that real liabilities may respond in any way to a shock in the surplus. This means that the impact multiplier calculated from a VAR in surpluses and liabilities may have any sign, depending on the autocorrelation of the surplus. For example, with a positive innovation in the surplus and no autocorrelation in the surplus, real liabilities in the next period remain unaffected in an NR regime. This can be seen by forwarding (4) one period. The right hand side has not changed, and hence the left hand side remains unchanged. The mechanism is that the extra surplus pays off some liabilities (the numerator of w_{t+1}), but there is an offsetting increase in the real value of the liabilities (nominal GDP falls), resulting in no net effect. With positive (negative) autocorrelation in the surplus, the value-effect via the denominator will be stronger (weaker) than the liabilities-pay-off effect, and real liabilities will increase (fall). This means that one can distinguish between the two regimes in all cases except when there is a negative autocorrelation in the surplus series.

2.3 Granger causality between liabilities and exogenous parts of the surplus

Endogenously determined primary surpluses should be Granger caused by liabilities in an R regime, because the surplus responds to the liabilities. Any component of the surplus exogenous to the liabilities should not be Granger caused by liabilities in an R regime, though. By contrast, in an NR regime, all parts of the primary surplus should be Granger caused by real liabilities - even if they are exogenous to liabilities. The reason is that today's liabilities adjust to expected future surpluses. In order to exploit this fact I will distinguish between the oil-tax component of the primary surplus in Norway and the rest of the primary surplus.

The oil-tax component of the primary surplus may not be very responsive to public liabilities even in an R regime. Revenues in the oil and gas sector are determined largely by the world-market price of oil, which is exogenous to Norwegian production decisions. Also, the volume of production may not be very responsive to short term variations in public financial needs. One would therefore expect to find Granger causality from liabilities to oil tax income only if the regime is NR. However, it is possible that tax rates in the petroleum sector respond to public liabilities. The oil price is strongly correlated with the oil-tax income series and therefore useful as an instrument for oil tax income. Again the same logic applies: In an NR regime one should find Granger causality from real liabilities to the oil price, but not in an R regime. Hence, I also test for Granger causality from real liabilities to the oil price.

3 Estimation

3.1 The data

The general government surplus (S), the oil tax (OILTAX) and net public liabilities (W) for the period 1963 to 2003, all figures relative to nominal GDP, are graphed in figure 1. In order to keep the same terminology as CCD, I keep working with negative net public liabilities instead of net assets. For the sources of and the descriptions of the fiscal data, see appendix A. Note that as long as income derived from natural resources is included in the primary surplus, it is correct to work with figures for public assets or liabilities excluding natural resources. Likewise, expected future expenditures related to e.g. pension liabilities should be included in the relevant expected primary surplus as long as those liabilities are not included in the W series.

Table 1 shows correlations between the series. As we would expect, surpluses S and debt W are positively correlated. That is, when the liabilities are high at the beginning of the year, the surplus in the same year is high. But this is consistent both

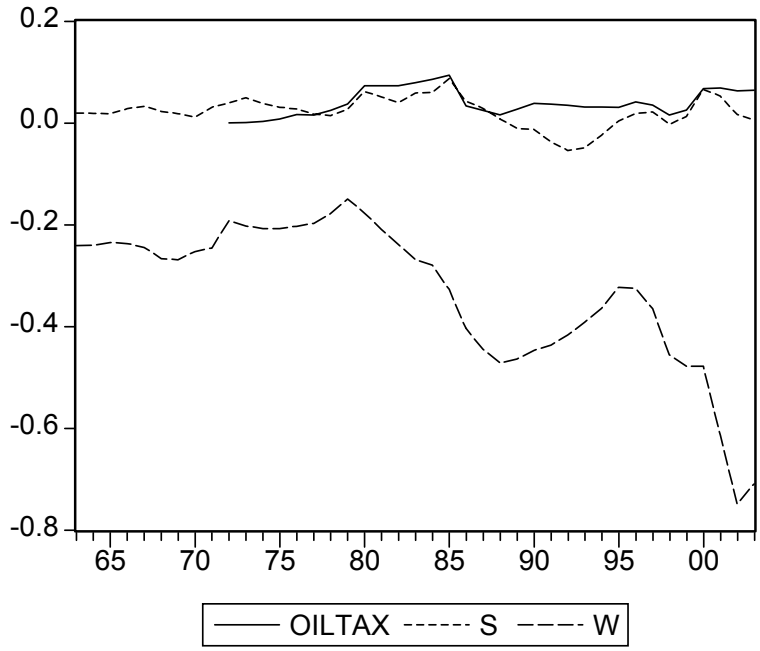

Figure 1: Oil tax income (OILTAX), primary surplus (S) and public liabilities (W). All series relative to nominal GDP.

with an R and an NR regime, causalities going in different directions. Oil-tax income and liabilities are not positively correlated on the other hand. This seems reasonable in an R regime only, where there is no response in the beginning-of-year value of real liabilities to the OILTAX. The series SNET, which is the surplus net of the oiltax, seems to absorb shocks in the OILTAX series. This would also be reasonable in an R regime.

Table 1: Correlations

	1963-2001	1973-2003
S/W	0.30	0.29
S/OILTAX		0.42
SNET/W		0.46
SNET/OILTAX		-0.31
OILTAX/W		-0.18
OILPRICE/OILTAX		0.89
OILPRICE/W		-0.06

The OILPRICE series is the annual average of the spot dollar price of brent blend[8]. Since the exchange rate is endogenous and influenced by the oil price, I chose to use the dollar price. Note the strong positive correlation between the OILTAX series and

[8]Source: Statistics Norway. The brent blend series is from 1978. Before this, the price of 'Iran Light' is used. Annual averages are calculated from published weekly data for 1994 and later.

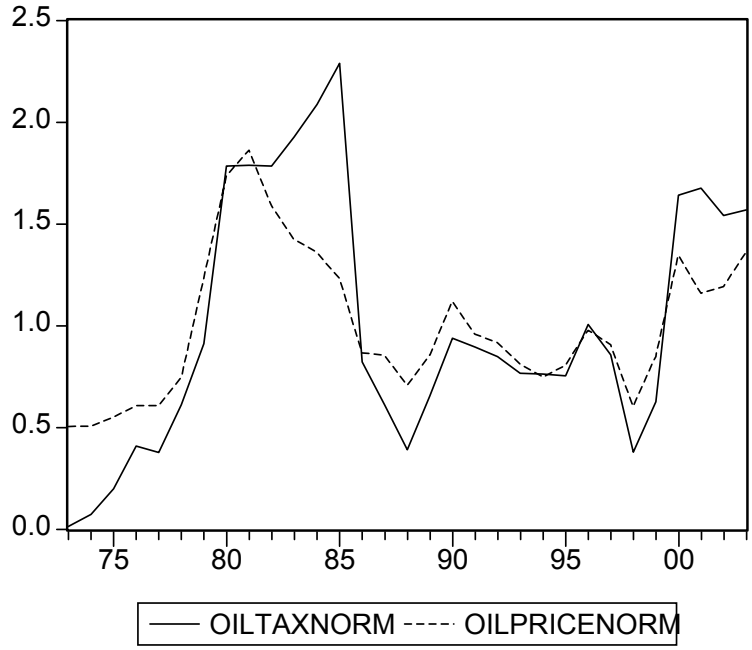

Figure 2: The oil tax income and the oil price are positively correlated.

the OILPRICE series. In figure 2, the OILTAX series and the OILPRICE series are shown together. OILPRICENORM denotes the OILPRICE series relative to its own sample mean while OILTAXNORM denotes the OILTAX series relative to its own sample mean.

I am not able to reject the null hypothesis of a unit root in any of the series debt W, primary surplus S, OILTAX or OILPRICE[9]. Results referred in Hamilton (1994), p. 549 imply that the VARs estimated in levels still may be interpreted as usual when we focus on the lagged effects on real debt from innovations in the other series. However, the standard confidence intervals for the Granger causality tests are not reliable if nonstationary is present.

3.2 The VAR estimation results

First, I estimated a VAR in the primary surplus S and wealth W for the full time period 1963-2003. I used a general-to-specific specification procedure, starting with five lags and checking for significance of the lagged terms. The residuals of the equations did not exhibit significant autocorrelation with three lags and a constant term, and I chose that specification. The correlation of the residuals is 0.15, and hence

[9] I used a general-to-specific augmented Dickey Fuller test for each variable. I included a constant, but no deterministic time trend in the regressions.

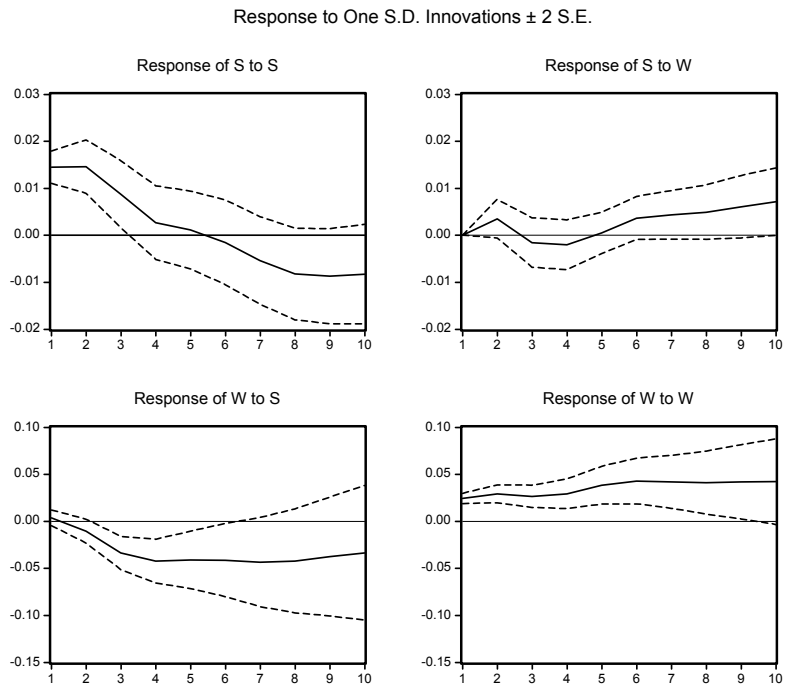

Figure 3: A VAR in S and W, ordering S-W

the ordering of the variables should not be too important for the impulse response functions.

Consider the impulse-response functions calculated with S first. That ordering would be natural in an NR regime, where real liabilities (at the beginning of the period) can jump in response to an innovation in the surplus in the same period. Figure 3 shows that the response in liabilities W after one period is negative (although not significantly so). This is what we would see in an R regime, but not in an NR regime, given non-negative autocorrelation in the surplus series. But the upper left panel of the figure shows that the surplus series responds negatively to an innovation in itself after about six periods. Hence, the data may both have an R regime and NR regime interpretation. Figure 4 below shows the impulse response functions with the reverse ordering.

I also included a time trend, and I tried with more lags and I used shorter time series to avoid the breaks in the fiscal data series. In all cases, I found a similar negative but insignificant response in liabilities to a shock in the surplus. I also found an insignificant but negative response in S to a shock in itself. Table 2 shows that there is a significant and negative autocorrelation in the surplus series from lag 6. Hence I conclude that the possible negative response in liabilities could be the result both of an NR regime and an R regime.

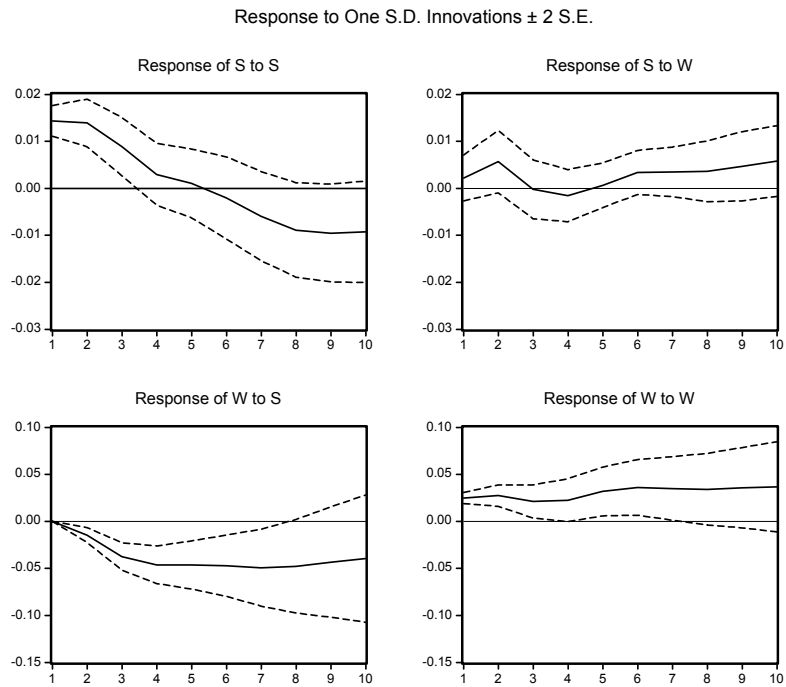

Figure 4: A VAR and S and W, ordering W-S

Table 2: Autocorrelation of S

Lag#	Autocorrelation	Partial autocorrelation	Q statistic	Probability
1	0.791	0.791	27.558	0.0
2	0.515	-0.293	39.560	0.0
3	0.330	0.102	44.608	0.0
4	0.223	−0.001	46.968	0.0
5	0.083	-0.212	47.309	0.0
6	-0.145	-0.313	48.361	0.0
7	-0.314	0.005	53.466	0.0
8	-0.407	-0.158	62.321	0.0
9	-0.359	0.221	69.430	0.0
10	-0.257	0.070	73.178	0.0

Next, I investigated the period 1973-2003. I am interested in whether utilizing the OILTAX series can help me uncover the type of regime in place, and that series exists from 1972 only. That is when oil production started in the Norwegian part of the North Sea. There is a break in the series for fiscal data which I avoid when starting in 1973. I did the same estimation as above, but used the OILTAX series instead of the S series. Again a three lag specification seems appropriate. The residual correlation is 0.20. W shows a zero response to a shock in OILTAX in the next period, as shown in figure 5. This is with the ordering OILTAX-W (natural in an NR regime). With the reverse ordering (W first) the result is a significantly negative response as shown

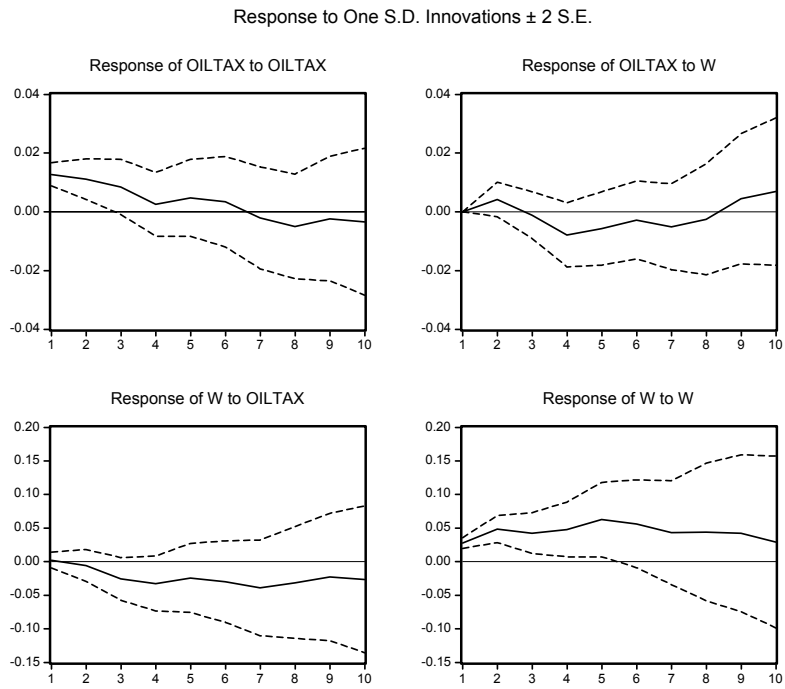

Figure 5: VAR in OILTAX and W, ordering OILTAX-W

in figure 6 below. We know that we would not expect the same one-to-one effect in W to a shock in OILTAX as we would with S within an R regime. In particular, we may note that OILTAX is negatively correlated with SNET, the primary surplus net of OILTAX. The effect of OILTAX on W may therefore be cushioned by counteracting effects from the rest of the surplus. Hence, one interpretation of the result is that the regime is R but that SNET cushions the effect of OILTAX on S. A different interpretation is that on net there is no long run positive or negative autocorrelation in the OILTAX series, and hence a zero response in W is natural if the regime is NR. Table 3 on page 13 shows the autocorrelation in the OILTAX series.

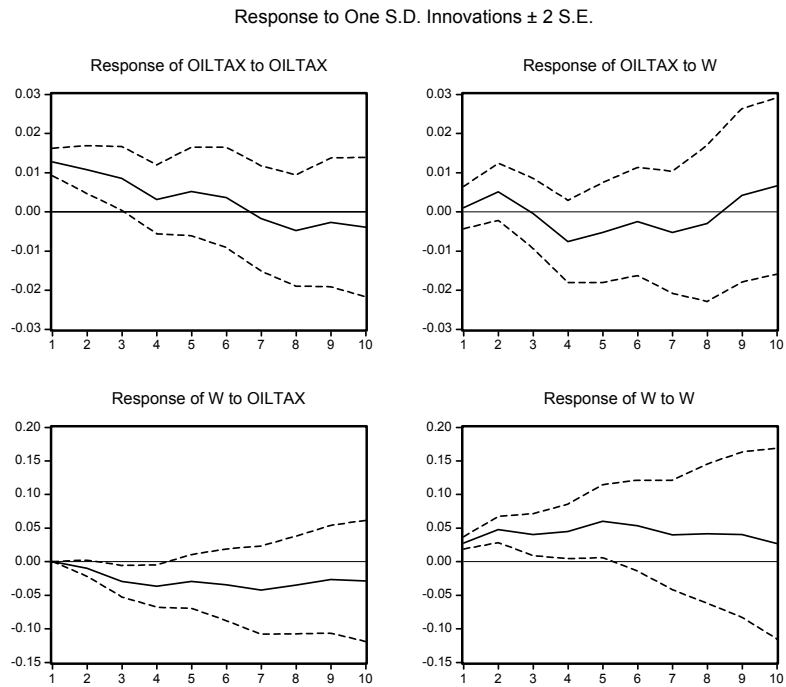

Figure 6: VAR in OILTAX and W, ordering W-OILTAX

Table 3: Autocorrelation of OILTAX

Lag#	Autocorrelation	Partial autocorrelation	Q statistic	Probability
1	0.759	0.759	20.199	0.0
2	0.466	-0.257	28.088	0.0
3	0.218	-0.080	29.869	0.0
4	0.035	-0.058	29.917	0.0
5	-0.109	-0.111	30.392	0.0
6	-0.289	-0.279	33.879	0.0
7	-0.400	-0.042	40.850	0.0
8	-0.461	-0.145	50.498	0.0
9	-0.377	0.148	57.236	0.0
10	-0.302	-0.187	61.761	0.0

To conclude this section, both VAR exercises are inconclusive. Furthermore, given the negative autocorrelation in the S series and the OILTAX series, a refinement of the VAR analysis cannot provide conclusive evidence.

3.3 Granger causality results

Recall that regardless what the regime is, one would expect Granger causality from liabilities to surpluses: In an R regime, this would be because surpluses respond to

previous debt levels. In an NR regime, this would be because expected future changes in the surpluses would influence the real value of debt.

Table 4: Granger causality between S and W.

Null Hypothesis	F-statistic	Probability
S does not Granger cause W	8.84363	0.00006
W does not Granger cause S	3.01256	0.03234

In an R regime, any *exogenous* component of the surplus series would not be Granger caused by debt, however. That would be different in an NR regime, where all components of the surplus would be Granger caused by debt. I exploit this difference in order to figure out the likely regime in place in Norway. As shown in table 5, I find no evidence of Granger causality from W to OILPRICE (sample period 1973-2003). I found it appropriate to estimate equations with four lags, but the result is not sensitive to the number of lags.

Table 5: Granger causality from W to the OILPRICE.

Null Hypothesis	F-statistic	Probability
W does not Granger cause OILPRICE	0.28756	0.88240

With the oil tax (again sample 1973-2003), the result is as given in table 6. Now, two lags seem appropriate.

Table 6: Granger causality from W to the OILTAX.

Null Hypothesis	F-statistic	Probability
W does not Granger cause OILTAX	0.05424	0.81754

To conclude, both the OILTAX data and OILPRICE data support the conclusion that the regime is R rather than NR. The results should be interpreted with caution however, given possibly nonstationary data.

4 Concluding remarks

The evidence from the VARs in surpluses and liabilities and in the oil tax and liabilities is inconclusive. The reason is the negative autocorrelation in the surplus and oil-tax data. However, given no evidence of Granger causality from real liabilities to the oil tax or oil price I find it natural to conclude that the regime is unlikely to be Non-Ricardian, but rather is Ricardian.

An extension of the analysis might be to consider the response in the real value of the liabilities from announcements of revisions of the estimated remaining volume of oil reserves. In a Non-Ricardian regime, the real value of the liabilities should increase - the value of assets should decrease - at each point in time when a discovery of new oil fields or improved technology to extract oil was announced.

Finally, I note that even if one can conclude clearly that real debt does not Granger cause the oil price or tax income from the petroleum industry, and even if there were no detectable response in real debt to discoveries of natural resources that provides the public sector with income, some would still argue that one could not conclude that the regime was R . The reason is that the net present value of surpluses net of public sector oil income in theory could cushion the effect of changed public oil sector income even in an NR regime. For an interpretation of an NR regime that makes this possible, see Cochrane (1998).

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Appendices

A Consolidated liabilities and the primary surplus

I have data for the consolidated government sector (central government and municipalities), but I need the consolidated net liabilities of the central bank and the general government. The general government has e.g. large claims on the central bank, which the central bank invests in foreign assets (the petroleum fund) and hence the consolidation is not trivial. It is convenient to consider the following simplified versions of the central bank and general government's balance sheets:

Table 1: The Balance Sheets of the Central Bank and the Government

Central Bank (CB)		General Government (G)	
Assets	Liabilities	Assets	Liabilities
B^{CB}	A^{CB}	A^{CB}	B^{CB}
DC	D	A	B^P
R	M		B^*
	F		

B^{CB}= CB claims on G, A^{CB}= G claims on the CB,
DC = CB credit to the domestic private sector,
R= foreign reserves, D = private CB deposits,
M=notes and coins, F= the own funds of the CB,
A= G claims on the domestic private sector,
B^P= G debt to the domestic private sector, B^*= foreign G debt

Netting out liabilities and assets between the central bank and the government B^{CB} and A^{CB}, the consolidated total net public liabilities to the domestic and foreign private sector is $(B^P + B^* - A) + (D + M) - (DC + R)$. This is equal to net general government liabilities (to both the private sector and the central bank) minus the central bank's own funds F. For simplicity, I measure consolidated net liabilities in the latter way.

I divide net liabilities with nominal GDP. Also, end-of-year figures are transferred to beginning-of-year figures. That is, the series for total liabilities is forwarded one period. I take the value of the net government liabilities from National Accounts data provided by Statistics Norway , and the data for the Central Bank's own funds from the Central Bank's annual reports[10].

Figure 1 on page 7 illustrates the liabilities series W, together with the oil-tax series (OILTAX) and the surplus series S, all figures relative to nominal GDP. Total government net revenues from oil and gas related activities would in addition to the tax income from the sector's enterprises (as given in the OILTAX series), also include net transfers from publicly owned enterprises doing oil and gas extraction, and dividends from the government's shareownership in the sector. In order to be able to rely on National Accounts data I focus only on the oil and gas tax revenue part.

The surplus concept s that corresponds to the primary surplus plus transfers from the central bank is general government net income plus net expenditure related to assets and liabilities, plus transfers from the central bank. Again, this is divided by the nominal gross domestic product[11].

[10] The net debt series for general government (consolidated data for the central government and municipalities) exists as annual data from 1962. I forward the data, and hence have consolidated data from 1963. There are breaks in the fiscal data series in 1972 and 1978 (1973 and 1979 with forwarding), due to new definitions of sectors and types of income/expenditure, and due to revisions of the series in 1978. GDP figures were also revised from 1978 on, and again from 1991 on. I calculated levels before 1978 using old growth rates for GDP.

[11] In the Norwegian National Accounts, this is measured as the budget surplus, which already includes transfers from the central bank ('offentlig forvaltnings nettofinansinvesteringer'), minus net financial income, minus net transfers from public enterprises. Since investments in public enterprises appear on the balance sheet, the primary surplus should be net of income related to those assets. Working with the standard primary surplus, only adjusting for net interest income, would not change the results significantly.

B Working with liabilities in foreign currency

With assets and liabilities denominated in foreign currency it does not seem correct to assume a common discount rate for all assets and liabilities in the net present value budget constraint (4). However, assuming uncovered interest-rate parity and working with the local currency value of foreign assets and liabilities is enough to justify using a common discount rate. To see this, let net foreign liabilities in terms of local currency be B_t^*. We have $B_t^* = f_t \widetilde{B}_t$, where $\widetilde{B}_t$ is net foreign liabilities in terms of foreign currency and f_t is the nominal exchange rate (units of local currency per unit of foreign currency). In budget constraint (1), borrowing $\frac{f_t \widetilde{B}_t^*}{(1+i_t^*)}$ can contribute to paying down today's liabilities (where i_t^* is the foreign nominal interest rate). We can also think of B_t^* as negative: reducing foreign reserves can be used to pay down liabilities. Uncovered interest parity means that $1 + i_t = (1 + i_t^*)\left(\frac{f_{t+1}}{f_t}\right)$. This implies that the discounted value of foreign liabilities in terms of local currency is $\frac{f_t \widetilde{B}_{t+1}^*}{(1+i_t)(f_t/f_{t+1})} = \frac{f_{t+1}\widetilde{B}_{t+1}^*}{(1+i_t)} = \frac{B_{t+1}^*}{(1+i_t)}$. Hence, I conclude that discounting all assets and liabilities by the same interest rate i_t is justified.

As an aside I note some consequences of assuming that the real exchange rate is constant (purchasing power parity) in addition to uncovered interest-rate parity. If we normalize the foreign price level to one, we get

$$\frac{M_j + B_j}{P_j y_j} + \frac{\widetilde{B}_j^*}{y_j} =$$
$$\left[\frac{T_j - G_j}{P_j y_j} + \left(\frac{M_{j+1}}{P_j y_j}\right)\left(\frac{i_j}{1+i_j}\right) + \left(\frac{y_{j+1}/y_j}{(1+i_j)(P_j/P_{j+1}}\right)\left(\frac{M_{j+1}+B_{j+1}}{P_{j+1}y_{j+1}} + \frac{\widetilde{B}_{j+1}^*}{y_{j+1}}\right)\right]$$

instead of equation (2). As Canzoneri, Cumby, and Diba (2001a) note, foreign liabilities work like indexed liabilities under these assumptions. The price level must jump more for a given innovation in the surplus when part of the liabilities is foreign than when all liabilities are domestic. The fiscal theory of price level determination is still relevant as long as not all net liabilities are denominated in foreign currency.

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