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THE ECONOMIC EFFECTS OF NORTH SEA OIL ON THE MANUFACTURING SECTOR

*Hilde Christiane Bjørnland**

ABSTRACT

This paper analyses the economic effects of the oil and gas sector (energy booms) on manufacturing output in two energy producing countries: Norway and the UK. In particular, I investigate whether there is evidence of a 'Dutch disease', that is whether energy booms have had adverse effects on manufactures. In addition to energy booms, three other types of structural disturbances are identified; demand, supply and oil price shocks. The different disturbances are identified by imposing dynamic restrictions on a vector autoregressive model. Overall, there is only weak evidence of a Dutch disease in the UK, whereas manufacturing output in Norway has actually benefited from energy discoveries and higher oil prices.

> A new paradigm emerged: of a country whose wealth would henceforth be dependent on services, on profits remitted from overseas investment, and on North Sea oil. Manufacturing was seen as a balancing item, which, if temporary eclipsed by the impact of oil, would automatically revive as oil declined … (Chandler, 1994, p. 12).

I INTRODUCTION

From the early 1970s, Norway and the UK experienced an intensive exploitation of North Sea oil and gas fields, turning both countries from oil importers to significant net oil exporters by the end of that decade. The high oil prices from the middle 1970s induced a stream of revenues from the North Sea, increasing overall national wealth and demand in both countries. The potential for profitable output from the energy sector gave huge investment and business opportunities to the overall economy, with increased demand for labour and capital.

* Statistics Norway

However, the introduction of a new energy producing sector was expected to affect the individual sectors in the economy to a varying degree. Especially, there was concern that the manufacturing sector, prone as it is to international competition, would lose out in the adjustment process that followed. This had been experienced in the Netherlands, where the natural gas discoveries in the 1960s had adverse effects on the Dutch manufacturing sector, mainly through a real exchange rate appreciation. This became clearly visible by the end of the 1970s, when the high income from the gas resources fell. By then, the (uncompetitive) traditional industries could not compensate for the loss of revenues from the energy sector, and in the following years, unemployment rose quickly. For this reason, the harmful consequence for traditional industries of a natural resource discovery, has commonly been referred to as the *Dutch disease* in the economic literature (see Rutherford, 1992).

Much theoretical work has been carried out analysing the benefits and costs of energy discoveries, but there have been relatively few empirical studies, and most have been conducted through simulations of large scale macroeconomic models. However, the complexity of ways that energy shocks can influence the economy motivates the use of a less theoretical model than a fully specified large scale model. Here I analyse instead the effects of energy booms (volume changes due to e.g. a technical improvement or a windfall discovery of new resources) in Norway and the United Kingdom, using a structural vector autoregression (VAR) model that is identified through short and long run restrictions that have intuitive theoretical economic justifications. In addition to energy booms, I identify real oil price shocks, to control for a possible decline in manufacturing output induced by real factor price changes, as occurred in many industrial countries in the 1970s. Finally, I assume that there are demand and supply shocks present, that are defined and distinguished from each other by imposing long run restrictions on the VAR model.

The paper is organised as follows. In Section II I briefly review the theory of Dutch disease, and thereafter present some descriptive statistics comparing Norway and the UK with some other industrial countries. Section III presents the structural VAR. In Section IV I review the effect of the different shocks on average for manufacturing output, prices and the rate of unemployment. The main focus will be to examine whether there are any negative effects of energy booms on manufacturing output, as it is through this effect we can assess the relevance of the Dutch disease hypothesis. In Section V, the impacts of the different shocks on manufacturing output are analysed in different historical periods. Section VI summarises the conclusions.

II Economic Effects of North Sea Oil

A large amount of theoretical literature analysing the macroeconomic impacts of a natural (energy) resource discovery has been developed, for instance Eide (1973), Forsyth and Kay (1980), Bruno and Sachs (1982), Corden and Neary (1982), Eastwood and Venables (1982), Corden (1984) and Neary and Van Wijnbergen (1984). Corden and Neary (1982) develop a model where there are both direct and indirect de-industrialisation effects of energy discoveries. They assume that there are three sectors in the economy, a booming sector (B), a tradeable sector (T) and a non-tradeable sector (N). The first two sectors produce tradeables given world prices, whereas prices for non-tradeables are given by domestic factors. The direct impact of oil and gas resources comes through an increased demand for resources and goods and services to the energy producing sector. This is usually referred to as a the *Resource Movement Effect*. The movement of labour from T to B will lower output in T directly. In addition, the movement of labour from N to B (at constant prices), will reduce the supply of N and create an excess demand for N, so that the price for N in terms of T will raise, giving way to a real appreciation and further movements of resources out of T into N.[1]

The increased demand for goods and services by the booming sector will also lead to an *indirect (spending)* effect through increased demand for resources by the sectors that produce goods and services for the energy sector. With positive income elasticity of demand for N, the price of N relative to the price of T must rise, inducing a further real appreciation and additional movements of resources out of T.

Although the simple model described above predicts that manufacturing will eventually contract as the energy sector expands, there are several ways the core model may be altered. By changing some of the underlying assumptions, the predicted effects of energy booms on the manufacturing sector may be less severe, and in fact, in some cases there may not be a Dutch disease at all (see Cordon, 1984). For instance, if one is initially in a situation where all domestic resources are not fully employed before the energy boom, the boom may actually provide a stimulating effect on the industries.

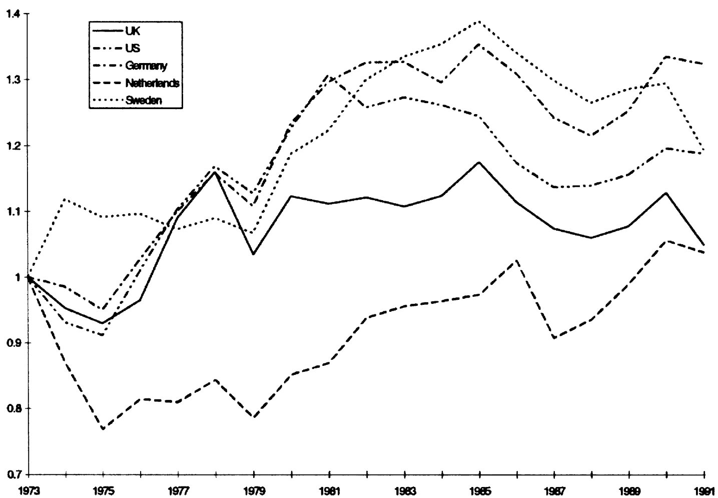
Descriptive statistics: an international comparison

It was suggested above that a country which experiences an energy boom will observe a shift of resources away from the tradeable sector towards the booming sector. As the energy sector employs very few people compared to the tradeable sector, unemployment is likely to increase. However, with growing wealth and demand, consumption (private and government) will increase and there may be an expansion of the non-tradeable (service) sector. Below I compare the economic structure of Norway and the United Kingdom with that of the United States, Germany, the Netherlands and Sweden. Of these, only the Netherlands has experienced an energy boom, with the development of gas fields from the 1960s.

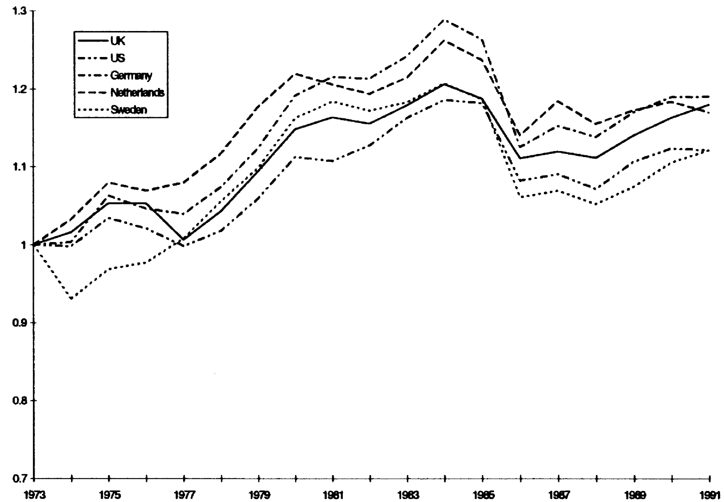
From zero production in the early 1970s, Norway and the UK each produced approximately 4% of total world production of oil by 1993. However, with Norway being a much smaller economy than the UK, the relative importance of

[1] The increase in the relative prices of non-traded goods in terms of traded (manufacturing) goods is equal to a real exchange rate appreciation if the terms of trade in manufacturing is fixed, which is a plausible small country assumption.

A) Value added in manufacturing as a pct. of GDP, relative to that of Norway



B) Value added in services as a pct. of GDP, relative to that of Norway



C) Real government consumption expenditure, relative to that of Norway

D) Standardised unemployment rates

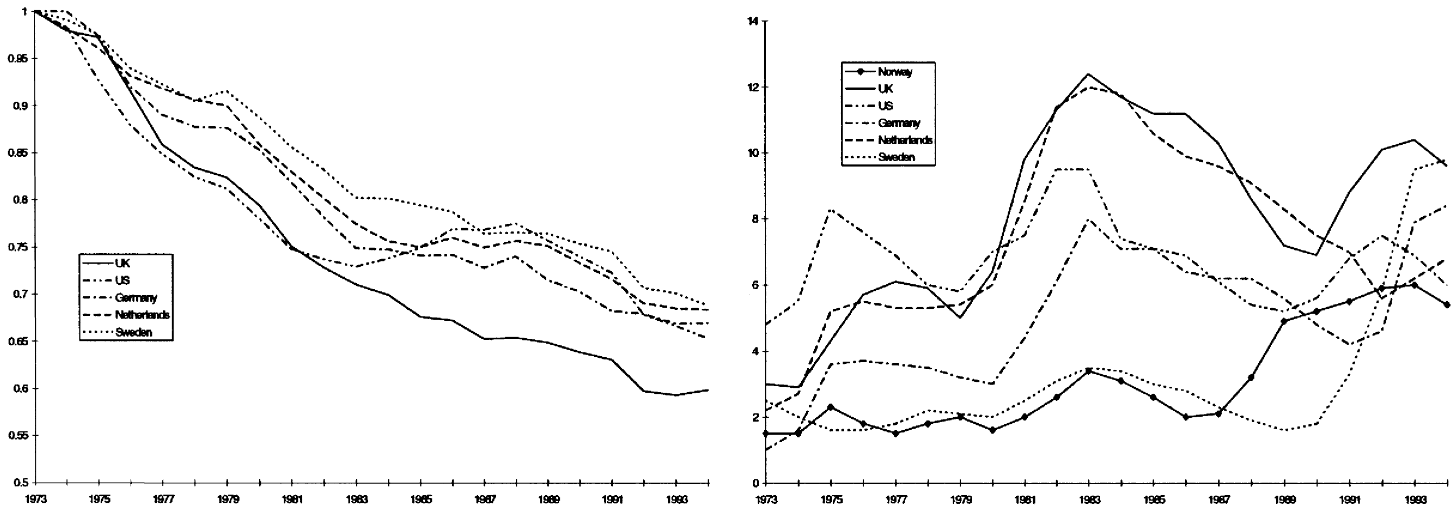


Figure 1. Macroeconomic indicators.
Source: OECD Historical Statistics, various issues.

energy has been larger in Norway, where the oil and gas sector amounts to more than 20% of GDP (1993). The share of oil and gas extractions in the UK reached a peak in 1984/1985 when it accounted for 6% of GDP, but since then has fallen, to 3% of GDP in 1993.

Consistent with the Dutch disease hypothesis, as energy has increased its importance in Norway and the UK, value added in manufacturing as a percentage of GDP has fallen, by about one third from the 1970s to the 1990s in both countries. However, similar contractions have also been experienced in most other OECD countries. Nevertheless, Figure 1a shows that except for the Netherlands, manufacturing as a percentage of GDP in all countries has increased slightly *relative* to that of Norway. Manufacturing in the UK behaves closest to that of Norway. In the Netherlands, there has been a contraction in manufacturing relative to most other OECD countries already from the early 1970s.

At the same time as the share of manufacturing in GDP has declined in the OECD countries, value added in services as a percentage of GDP has increased steadily. However, in Norway, the share of services has remained almost constant over the last three decades. Figure 1b emphasises that the share of services in all countries *relative* to that of Norway have increased, most so in Germany and the Netherlands. Hence, there is no evidence that there has been a pronounced shift of resources in Norway and the UK into the service sector.[2]

On the other hand, government consumption has increased relatively more in Norway than in the other OECD countries (cf. Figure lc). The increase in the public sector in the 1970s and 1980s (financed by among other things, the higher oil revenues), provided a stimulus to female employment opportunities, and may be among the factors that have explained the low unemployment rates in Norway compared to the other OECD countries (cf. Figure ld). Clearly, government consumption in the UK has remained tight, and of the countries examined here, unemployment in the UK has been among the highest since the late 1970s.

III EXAMINING THE DUTCH DISEASE, THROUGH A STRUCTURAL VAR

The VAR model comprises manufacturing production (y_t), oil and gas extractions (s_t), real oil prices (o_t), and the inflation rate (calculated from the GDP deflator) (π_t). The data used and their sources are described in the Appendix. Below I show how estimation of this reduced form VAR model will be sufficient to identify the four (uncorrelated) structural shocks; energy booms (ε_t^{ES}), real oil price shocks (ε_t^{OP}), aggregate demand shocks (ε_t^{AD}), and aggregate supply shocks (ε_t^{AS}).

[2] Although not shown here, there is some evidence that in some periods, employment in the service sector as a percentage of total civilian employment in both Norway and the UK, has increased somewhat more than in the OECD.

Identifying the structural VAR

Manufacturing output, oil and gas production and real oil prices are nonstationary integrated variables, where stationarity is obtained by taking first differences. Inflation is assumed to be stationary. The assumption of stationarity will be verified below. First, I define z_t as a vector of stationary macroeconomic variables $z_t = (\Delta s_t, \Delta o_t, \Delta y_t, \pi_t)'$. Formally, the reduced form VAR is estimated as:

$$z_t = \alpha + A_1 z_{t-1} + \cdots + A_p z_{t-p} + e_t, \qquad A(L) z_t = \alpha + e_t. \tag{1}$$

The A_j matrix refers to the autoregressive coefficient at lag j, and $A_0 = I$ is the identity matrix. The residual vector e_t is serially uncorrelated with covariance matrix Ω. As the VAR contains only stationary variables, it is itself stationary and following the Wold Representation theorem, it can be represented as an invertible distributed lag of serially uncorrelated disturbances (ignoring the constant term hereafter):

$$z_t = C(L) e_t \tag{2}$$

where $C(L) = A(L)^{-1}$ and C_0 is the identity matrix. As the elements in e_t are contemporaneously correlated, they cannot be interpreted as structural shocks. The elements in e_t are orthogonalized by imposing restrictions. A (restricted) form of the moving average containing the vector of original disturbances as linear combinations of the Wold innovations can be expressed as:[3]

$$z_t = D(L) \varepsilon_t \tag{3}$$

where ε_t is the vector of the orthogonal structural disturbances, which for convenience are normalised so that they have unit variance, e.g. $\text{cov}(\varepsilon_t) = I$. (2) and (3) imply that $e_t = D_0 \varepsilon_t$, hence:

$$C(L) D_0 = D(L). \tag{4}$$

Clearly, if D_0 is identified, I can derive the MA representation in (3). To identify D_0, note that from the normalisation of $\text{cov}(\varepsilon_t)$ it follows that $D_0 D_0' = \Omega$. With a four variable system, this imposes ten restrictions on the elements in D_0. However, as the D_0 matrix contains sixteen elements, to orthogonalise the different innovations, six more restrictions are needed. One will come from a restriction on the long run multipliers of the $D(L)$ matrix, whereas the other five will come from restrictions on the contemporaneous matrix D_0 directly.

I first order the four uncorrelated structural shocks as $\varepsilon_t = (\varepsilon_t^{AD}, \varepsilon_t^{AS}, \varepsilon_t^{ES}, \varepsilon_t^{OP})'$. Energy booms will be identified from the equation for energy extractions, and are thus interpreted as volume changes (due to e.g. a technical improvement or a windfall discovery of new resources). Hence, they reflect shocks to a nation's

[3] The assumption that the underlying structural disturbances are linear combinations of the Wold innovations is essential, as without it the economic interpretations of certain VAR models may change (see Lippi and Reichlin, 1993; Blanchard and Quah, 1993; for a discussion of the problem of nonfundamentalness).

potential income (or wealth). To identify energy booms, I impose the restriction that the contemporaneous effects of aggregate demand and aggregate supply disturbances on extraction of oil and gas are zero. However, after one period (one quarter), all shocks are free to influence energy production. Note that oil price shocks can have a contemporaneous effect on oil production, so that the oil producer can determine whether to take out energy production now, or hold back as the price of energy varies. Rewriting (3) in terms of the equation of energy production, the two contemporaneous restrictions imply that $D_{11,0} = D_{12,0} = 0$:

$$\Delta s_t = D_{11}(L)\varepsilon_t^{AD} + D_{12}(L)\varepsilon_t^{AS} + D_{13}(L)\varepsilon_t^{ES} + D_{14}(L)\varepsilon_t^{OP}. \tag{5}$$

Real oil prices are included in the model as energy price disturbances may have separate and complex effects on the economy. For instance, the two adverse oil price shocks in the 1970s are believed to have reduced world manufacturing output drastically, mainly by reducing the net amount of energy used in production. In addition, aggregate demand may have changed, by transferring income from the oil importing countries to the oil exporting countries. To be able to focus on both the adverse effects on industrial production, as well as the potential positive real income effects for the energy exporting countries of a higher price of oil, I use real (as opposed to nominal) oil prices in the VAR model.[4]

Oil price shocks are identified by assuming that the contemporaneous effects of demand and supply shocks on real oil prices are zero. This is reasonable as the oil price is a financial spot price that reacts quickly to news, and has been dominated by a few large exogenous developments (e.g. the OPEC embargo in 1973, the Iran–Iraq War in 1980/1981, the collapse of OPEC in 1986 and recently the Persian Gulf War in 1990/1991). I therefore assume that if demand and supply shocks influence real oil prices, they do so with a lag. In addition I also assume that energy booms will affect real oil prices with a lag, as both Norway and the UK are relatively small oil producers compared to the rest of the worlds major producers. Hence, from (3), the contemporaneous restrictions in the equation for real oil prices imply that $D_{21,0} = D_{22,0} = D_{23,0} = 0$:

$$\Delta o_t = D_{21}(L)\varepsilon_t^{AD} + D_{22}(L)\varepsilon_t^{AS} + D_{23}(L)\varepsilon_t^{ES} + D_{24}(L)\varepsilon_t^{OP}. \tag{6}$$

Finally, manufacturing will also be affected by demand and supply shocks. To identify these shocks, I include inflation together with manufacturing output in the model. Demand and supply shocks are then distinguished from each other by assuming that aggregate demand shocks can have no long run effects on output (cf. Blanchard and Quah, 1989). The long run restriction is consistent with the interpretation of an upward sloping short run supply schedule, but a vertical long run supply schedule in the price-output space. A positive demand

[4] Some studies argue that it is more plausible to specify commodity price equations in nominal terms in the short run while real terms is plausible in the long run (see e.g. Gilbert, 1989). However, here I follow the idea in e.g. Rasche and Tatom (1981) and Darby (1982), who use the real price of oil in the production function instead of an energy quantity, as the competitive producers treat the real price of oil as parametric.

shock (e.g. a monetary expansion) will shift up the (downward sloping) aggregate demand curve, increasing both output and price. In the long run, the aggregate supply curve is vertical in correspondence to the full employment level of output, hence the economy moves back to its initial output level, where prices have increased to a permanently higher level.

However, the speed of adjustment to a demand shock is unrestricted and may be instantaneous (as in the New Classical School) or slow (as in the Keynesian models with a relatively flat short run supply schedule). From (3), the growth rate of output and the inflation rate can be described as:

$$\Delta y_t = D_{31}(L)\varepsilon_t^{AD} + D_{32}(L)\varepsilon_t^{AS} + D_{33}(L)\varepsilon_t^{ES} + D_{34}(L)\varepsilon_t^{OP}, \tag{7}$$

$$\pi_t = D_{41}(L)\varepsilon_t^{AD} + D_{42}(L)\varepsilon_t^{AS} + D_{43}(L)\varepsilon_t^{ES} + D_{44}(L)\varepsilon_t^{OP}. \tag{8}$$

The long run effect of the demand shock upon the level of y_t is simply found by summing the infinite number of lag coefficients, $\sum_{j=0}^{\infty} D_{31,j}$. Writing (4) as $C(1)D_0 = D(1)$, where $C(1)$ and $D(1)$ indicate the long run matrixes of $C(L)$ and $D(L)$ respectively, the long run restriction implies that $D_{31}(1) = 0$ or:

$$C_{31}(1)D_{11,0} + C_{32}(1)D_{21,0} + C_{33}(1)D_{31,0} + C_{34}(1)D_{41,0} = 0. \tag{9}$$

The system is now just identifiable, and can be solved numerically. However, despite the many advantages of using structural VARs, it is also subject to some limitations. Especially, it is recognised that the results from a VAR model will be sensitive to the way the model is identified. The identifying restrictions should therefore have plausible interpretations and the credibility of the results could be tested, using for instance any overidentifying restrictions. For example, demand and supply shocks are identified by assuming that only the latter has a permanent effect on output. For these results to be plausible, the simultaneous effects on inflation (or prices) should be established. Especially, the standard aggregate demand/supply diagram suggests that whereas a positive demand shock shall increase prices permanently, following a positive supply shock, prices shall fall permanently. This suggests two overidentifying restrictions on prices, which can be tested informally by examining the impulse response analysis.

In this analysis, inflation was assumed to be stationary and used together with manufacturing output to identify demand and supply shocks. The same idea was also used in Bayoumi and Eichengreen (1992). However, there are other variables that are stationary on which this analysis could be based. In Blanchard and Quah (1989), output and unemployment were used together to identify demand and supply shocks. Typically, a positive demand shock that increases output and prices temporarily along the short run supply schedule, will induce a temporary fall in the rate of unemployment. However, over time, when the economy has adjusted to the higher prices, the short run supply schedule shifts backwards to its long run equilibrium, consistent with a natural rate of unemployment. As a final check on the robustness of the results using the VAR model, I therefore estimate a model where I replace *inflation* with the *rate of unemployment*. I will refer to the *output-inflation* (Y-π) model as the *core* model, whereas the model replacing inflation with unemployment is referred to as the *output-unemployment* (*Y-U*) model.

IV MODEL SPECIFICATIONS AND EMPIRICAL RESULTS

The lag orders of the VAR-models are determined using the Schwarz and Hannan-Quinn information criteria and the *F*-forms of likelihood ratio tests for model reductions as suggested by Doornik and Hendry (1994). A lag reduction to three lags in Norway and four lags in the UK could be accepted at the 1% level by all tests. Using three lags in Norway and four lags in the UK, there is no evidence of autocorrelation and heteroscedasticity in the models. On the other hand, non-normality is only rejected when I include a dummy that is one in 1986:1(corresponding to the collapse of OPEC), and a dummy that is one in 1990:3 (corresponding to the huge increase in oil prices during the Gulf War) in the VAR model in both countries. In addition, a dummy that is one in 1977:4 and 1978:1 (corresponding to exceptionally high growth rates in energy production), is required to reject non-normality in Norway. Unit root tests confirm that Δs_t, Δo_t, Δy_t and ($\Delta p_t =$) π_t, are stationary variables over the sample (cf. Table A1) and the level of manufacturing production, oil and gas production, real oil prices and inflation (s_t, o_t, y_t, π_t) are not cointegrated (cf. Table A2).[5]

Dynamic responses in the output-inflation (core) model

The cumulative effects of energy booms, oil price shocks, demand shocks and supply shocks on the level of manufacturing production and the level of the GDP deflator in Norway are reported in Figures 2 and 3 respectively, whereas the cumulative dynamic effects of the same shocks on the level of manufacturing production and the GDP deflator in the UK are reported in Figures 4 and 5 respectively. The figures give the responses to each shock, with a one standard deviation band around the point estimates, reflecting uncertainty of estimated coefficients.[6]

Figure 2 shows that manufacturing production in Norway actually increases in response to a (one unit) energy boom and an oil price shock. However, the wide standard error bands indicate that the responses to both types of shocks are not precisely estimated and may not be significantly different from zero in the long run. Nevertheless, the results indicate that both energy shocks may actually have benefited the manufacturing sector in Norway in the short run, for example

[5] Note that inflation is treated as a stationary variable in the core model (as unemployment is in the Y-U model), so that when testing for cointegration relations, I use inflation together with the level of the other variables. However, replacing the inflation rate with the price level in the cointegrating vector in both countries, gives no additional evidence of cointegration.

[6] The standard errors reported are calculated using Monte Carlo simulation based on normal random drawings from the distribution of the reduced form VAR. The draws are made directly from the posterior distribution of the VAR coefficients, as suggested in Doan (1992). The standard errors that correspond to the distributions in the D(L) matrix are then calculated using the estimate of D_0.

through increased demand for domestic manufacturing output to the energy sector or through subsidies towards industries financed by the higher income from the oil sector. As expected, a demand shock increases output in Norway initially, but after a few years, the positive effect dies out as the zero long run restriction bites. A supply shock has a positive permanent effect on manufacturing output, that is stabilised after two years.

An energy volume shock increases the GDP deflator for a year, after which the effect quickly dies out (cf. Figure 3). This is consistent with the Dutch disease where increased demand and production in the economy push prices upwards (at least temporarily). A real oil price shock on the other hand, reduces prices. However, the standard error band is wide and eventually includes zero. The negative response of prices to a real oil price shock may be due to the fact that the Norwegian currency is a petrocurrency, which appreciated when oil prices were high (1970s) and depreciated (devaluated) when oil prices were low (1986), (see Rutherford, 1992). A demand shock increases prices permanently, whereas a positive supply shock reduces prices permanently. Hence, the overidentifying restrictions suggested above, namely that demand (supply) shocks increase (reduce) prices, are supported in Norway.

Energy booms reduce manufacturing output significantly in the UK in the long run as predicted by the Dutch disease theory (cf. Figure 4). However, in the first two years, the standard error bands include zero, indicating that the effect may as well be positive. A unit oil price shock decreases manufacturing output, and the effect is stabilised after one year. Hence, in contrast to the results for Norway, both energy (price and volume) shocks work to depress manufacturing in the UK. An aggregate demand shock has a positive impact on output that dies out after two to three years. The long run effect of an aggregate supply shock is positive, although the initial impact is much smaller than in Norway.

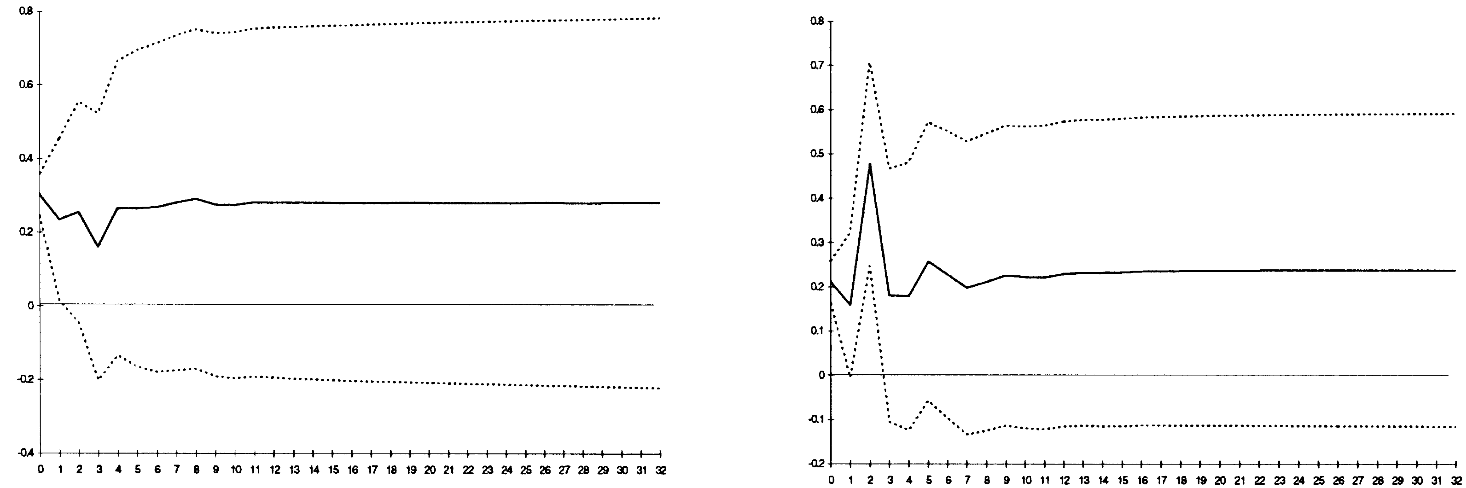
In Figure 5, both energy booms and real oil price shocks increase the GDP deflator in the UK. Hence, following an energy boom, prices respond according to the Dutch disease in the UK (as in Norway), where the increased activity in the oil sector eventually pushes the domestic price level upwards. A unit demand shock increases prices whereas following a permanent positive supply shock, prices are reduced. Hence, the overidentifying restrictions are also supported in the model for the UK.

The variance decompositions for manufacturing output, inflation and prices are seen in Tables 1 and 2 for Norway and the UK respectively. Both energy booms and oil price shocks explain more of the variation in the variables in Norway than in the UK, and after one year, the two energy shocks together explain more than 13% of the variance in manufacturing output in Norway, but less than 5% of the variance in manufacturing in the UK.

In Norway, about 5% of the explained variance in manufacturing is accounted for by energy booms at all horizons. Energy booms explain about 10% of the variation in inflation, although the effect on the price level is virtually zero. Oil price shocks explain more than 7% of the variance in output, but less than 5% of the variation in inflation (and prices). Demand shocks are less important than supply shocks in explaining variation in manufacturing

A) Energy booms

B) Real oil price shock



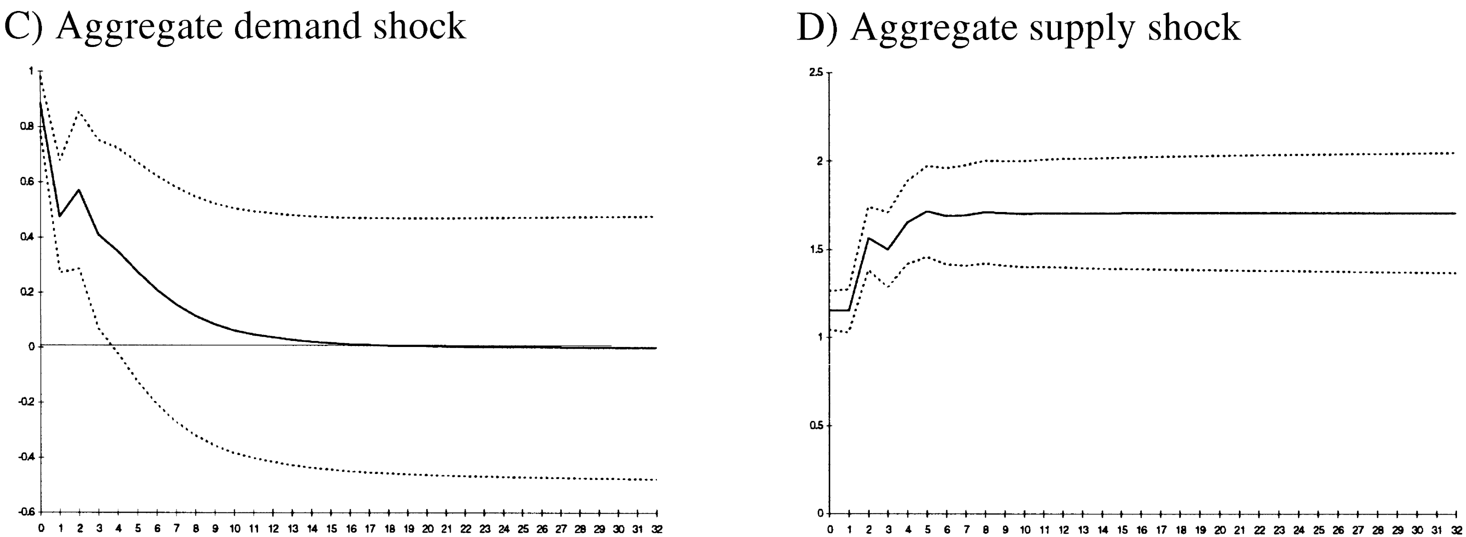
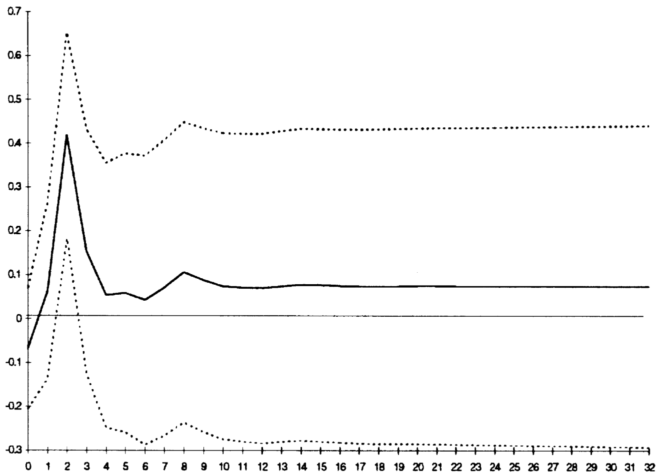
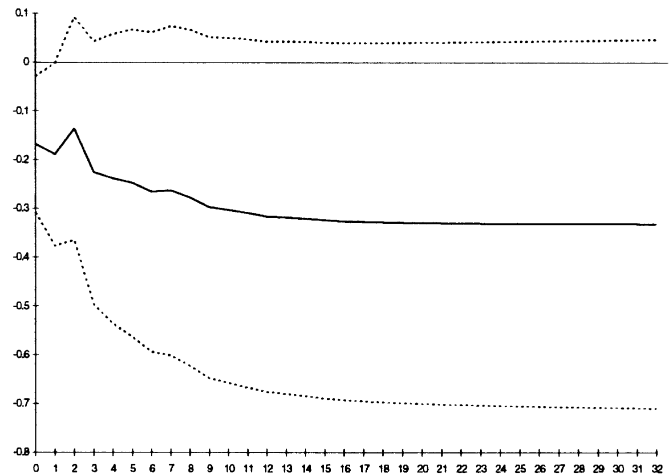


Figure 2. Cumulative impulse response function: Norway manufacturing production.

A) Energy booms



B) Real oil price shock



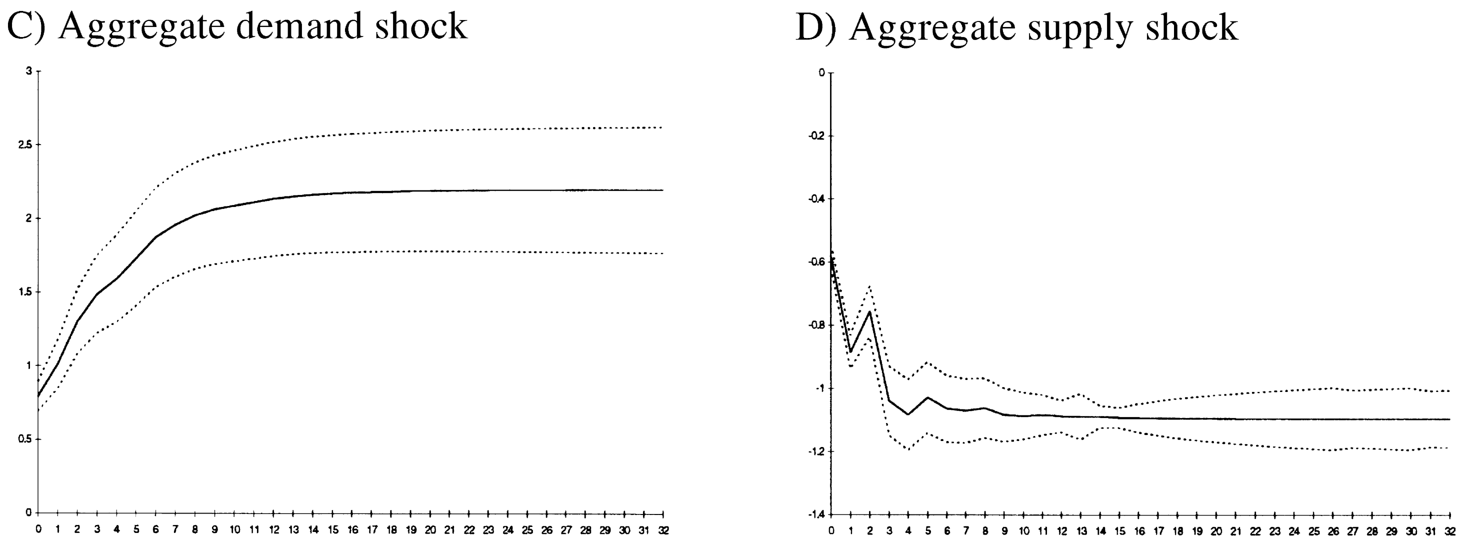
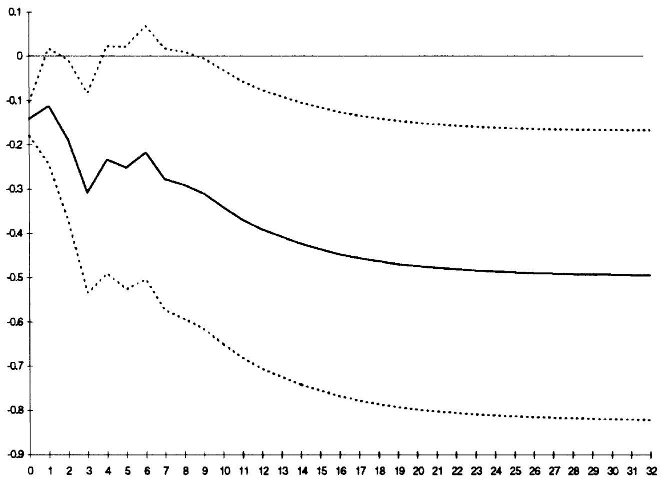
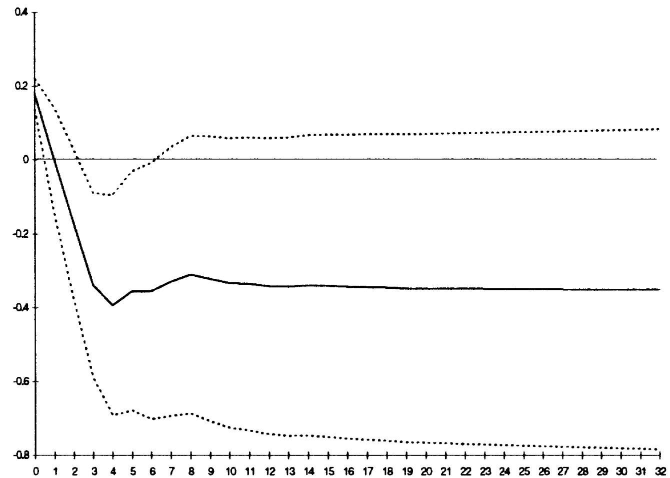


Figure 3. Cumulative impulse response function: Norway price (GDP deflator).

A) Energy booms



B) Real oil price shock



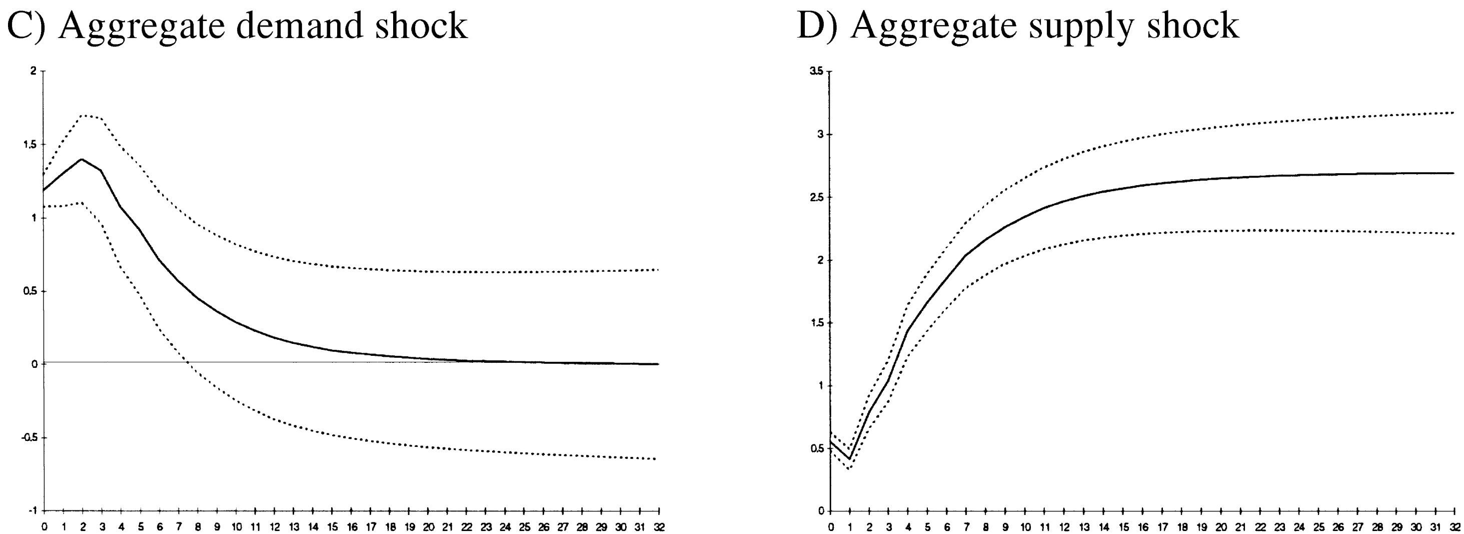
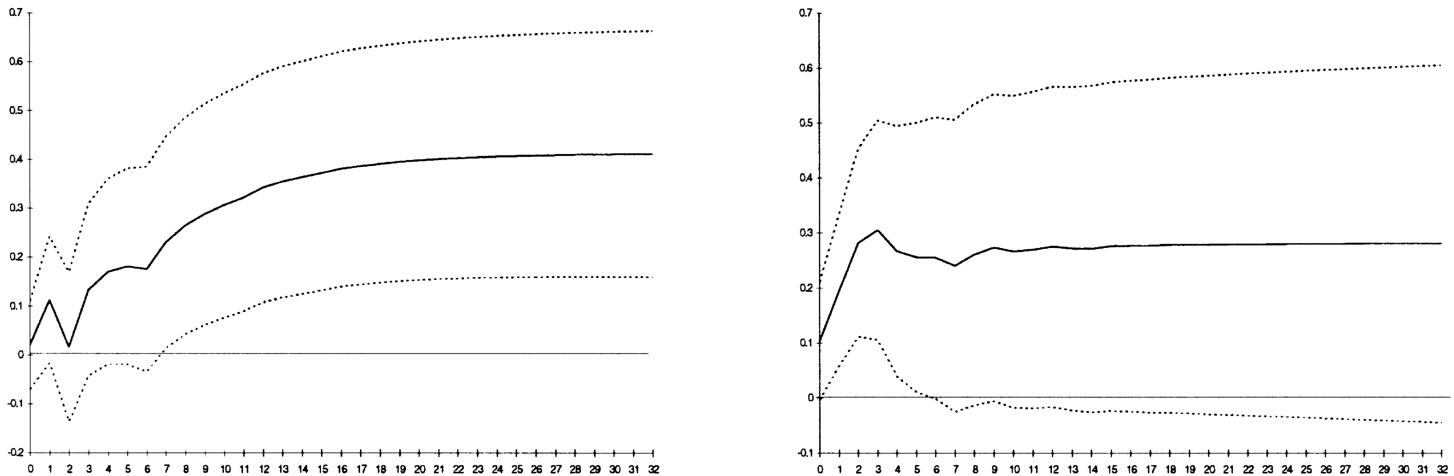


Figure 4. Cumulative impulse response function: United Kingdom manufacturing production.

A) Energy booms B) Real oil price shock



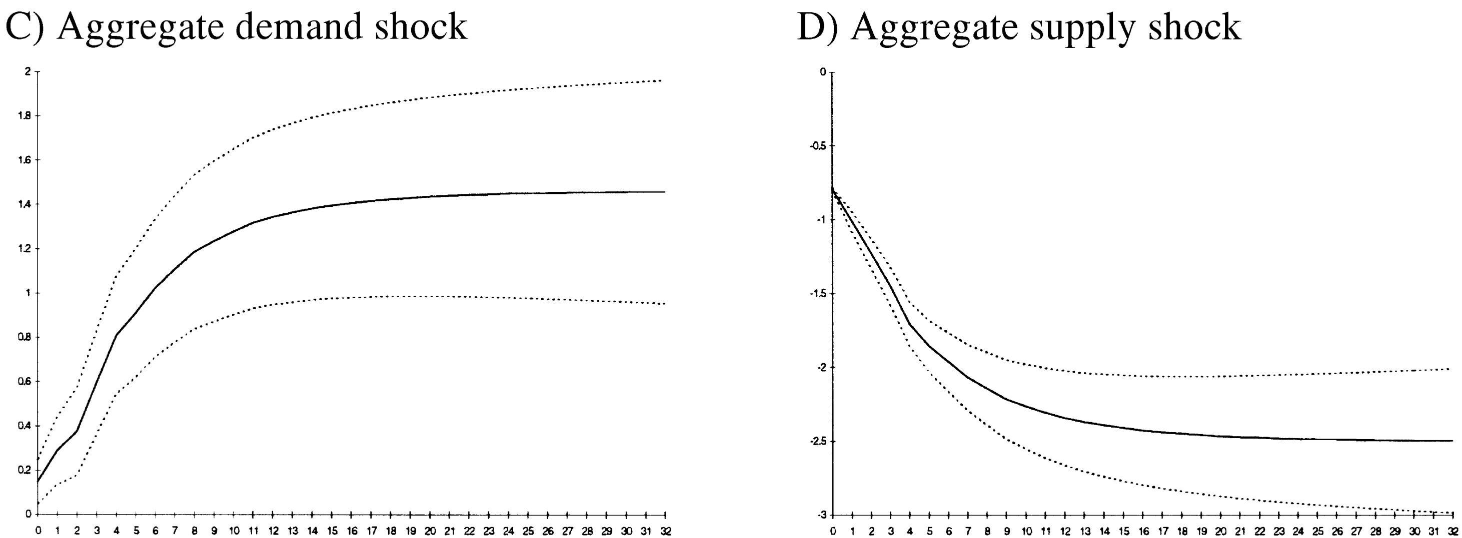


Figure 5. Cumulative impulse response function: United Kingdom price (GDP deflator).

TABLE 1
Variance decomposition in Norway

Quarters	ES-shock	OP-shock	AD-shock	AS-shock
Manufacturing				
1	5·8	4·5	32·4	57·4
4	5·5	7·7	14·9	72·0
8	5·3	7·2	7·9	79·6
16	5·1	7·2	3·8	83·9
32	4·9	7·3	1·9	85·9
Inflation				
1	0·3	4·6	63·7	31·5
4	10·5	5·0	53·5	31·0
8	10·4	4·9	54·7	30·1
16	10·4	4·9	54·9	29·9
32	10·4	4·9	54·9	29·9
Price				
1	0·3	4·6	63·7	31·5
4	1·3	2·5	67·5	28·7
8	0·6	2·3	73·8	23·3
16	0·4	2·2	77·8	19·6
32	0·3	2·2	79·5	18·0

TABLE 2
Variance decomposition in the United Kingdom

Quarters	ES-shock	OP-shock	AD-shock	AS-shock
Manufacturing				
1	1·1	1·8	79·6	17·5
4	1·8	1·9	73·1	23·2
8	1·6	2·7	38·2	57·5
16	2·0	2·1	13·7	82·1
32	2·7	1·8	5·3	90·2
Inflation				
1	0·1	1·6	3·3	95·0
4	3·3	2·9	10·5	83·2
8	3·2	2·6	15·4	78·8
16	3·4	2·6	16·1	77·9
32	3·4	2·6	16·1	77·9
Price				
1	0·1	1·6	3·3	95·0
4	0·5	3·6	9·8	86·1
8	0·7	1·9	17·6	79·8
16	1·3	1·3	21·9	75·5
32	1·7	1·1	23·6	73·7

output, whereas demand shocks explain most of the variation in inflation and prices. The fact that demand shocks have less impact on output than on prices (and inflation) may indicate a relatively steep short run supply schedule in terms of a standard aggregate demand and supply diagram, where wages and prices adjust quickly.

For the UK, the negative effects of an energy boom on manufacturing output become more important as the horizon increases, although after six years the effect is still small, explaining less than 3% of the variance in manufacturing output. Energy booms have also a small effect on inflation and prices. Oil price shocks explain between 2 and 3% of the variation in manufacturing output, and the effect is largest after two years. The effect on inflation and prices of an oil price shock is equally small. In contrast to Norway, demand shocks are more important than supply shocks in explaining output movements the first year, but already after two years, supply shocks dominate. Prices (and inflation) in UK are dominated by supply shocks. Hence, in terms of the analysis above, the short run supply schedule is relatively flat with wages and prices slowly adjusting, implying important effects on output in the short run from demand shocks, but less effects on the price level.

Dynamic responses in the output-unemployment (Y-U) model

The results from the Y-U model are consistent with the core model in Norway, as both energy booms and oil price shocks have positive effects on manufacturing, although the long run impact may be somewhat smaller using the Y-U model than the core mode.[7] In contrast to the core model, demand shocks are more important than supply shocks in explaining output movements initially, but after two quarters, supply shocks dominate. Energy booms reduce the rate of unemployment temporarily, as demand for labour in the economy increases. Real oil price shocks, on the other hand, increase the rate of unemployment temporarily. However, the effects of these two shocks on unemployment are small.

In the UK, energy booms have significant negative long run effects on manufacturing as in the core model, but again the effect may be positive in the first year. Oil price shocks also reduce output as in the core model. The variance decompositions indicate that the two energy shocks play the same role in the Y-U model as in the core model, although now oil price shocks are somewhat more important in the long run. Demand shocks on the other hand, play a less important role in the Y-U model than in the core model, and after one year, supply shocks dominate. Consistent with the hypothesis of Dutch disease, both energy booms and oil price shocks increase the rate of unemployment. The effects on unemployment of these shocks are also much larger than in Norway.

[7] The same number of lags and dummies used in the core model are included in the Y-U model for consistency. Using Zivot and Andrew's (1992) test for unit roots, the rate of unemployment was found to be stationary only when I had allowed for a structural break in the trend in 1980:2 for the UK, and in 1988:2 for Norway. I therefore detrend the unemployment rata and remove these structural breaks prior to estimation. A set of cointegrating tests confirmed that the systems are not cointegrating.

The results using the output-inflation model or the output-unemployment model seem therefore to be consistent in terms of generating the same manufacturing output response to the two energy shocks. However, the importance of demand and supply shocks varied somewhat between the two models. In particular, demand shocks were less important in explaining variation in the manufacturing output in the core model than in the Y-U model in Norway, whereas in the UK, the opposite was found. One of the reasons for this divergence may be the fact that both Norway and the UK may have experienced several structural breaks/regime shifts that the models may not have captured appropriately. For instance, during the late 1970s and early 1980s, Norway pursued strict price and wage controls, whereas in the UK, there was a 15% VAT increase on all taxable items in Howe's June budget in 1979. This may have been misinterpreted by the core models, so the output-inflation relation has been incorrectly specified.

To investigate the sensitivity of the results to these potential structural changes, I constructed a dummy to account for the price controls in 1978–1979 in Norway, and a dummy to control for the VAT change in the third quarter of 1979 in the UK, and re-estimated the core models (see Bjørnland, 1996). Now, demand and supply shocks are almost equally important in explaining manufacturing output variation initially in Norway, but after a year, supply shocks dominate. By including a dummy in the core model in the UK, the effects of demand disturbances on manufacturing output become less important initially. Hence, by including dummies to account for possible structural breaks in the core models for Norway and the UK, the results using the core and the Y-U model become more consistent.

Faust and Leeper (1994) have explored the robustness of the Blanchard and Quah long-run identifying restriction and argued that for the identification scheme to be robust, it has to be tied to a restriction on finite horizon dynamics. However, the joint use of long run and short run constraints in this paper should be sufficient to side-step the criticism of Faust and Leeper (1994). In fact, I have demonstrated that their criticism did not turn out to be important here, as the results using the two different models turned out to be very similar, especially when I corrected for some possible structural breaks in the relations.

Comparison with previous studies

How do the findings reported above correspond to other empirical studies of the Dutch disease? Previous empirical (simple quantification or simulation) studies analysing the effects of energy booms on manufacturing output include Forsyth and Kay (1980), Bruno and Sachs (1982), Atkinson *et al.* (1983) and Bean (1987) about the UK, and Bye *et al.* (1994) and Cappelen *et al.* (1996) about Norway.

Bye *et al.* (1994) and Cappelen *et al.* (1996) also find the manufacturing sector in Norway to have benefited from energy booms. However, the positive effects reported in these studies are much larger than in the present paper. This may be due to the fact that they have not explicitly separated the effects of energy price changes in the analysis, hence the (positive) effects from the energy booms may have been exaggerated. Note also that Cappelen *et al.* identify energy booms from changes in investment demand from the petroleum sector, rather than from energy extractions. This may suggest that they have emphasised more of the demand effects than what I have captured here. However, in Bjørnland (1996), I showed that whichever method was used to identify energy booms in the VAR, essentially the same results were achieved.

The deflationary (but small) effects on manufacturing output in the UK of the oil and gas discoveries supports the early findings in Forsyth and Kay (1980) who, using a simple quantification method, provided one of the first studies to report any evidence of Dutch disease in the UK. Bruno and Sachs (1982) also found negative effects of energy production on manufacturing, with the size of the effect depending on the government budget policies concerning the redistribution of oil tax revenues to the private sector.

On the other hand, Atkinson *et al.* (1983) and Bean (1987), found no negative effects from energy production, and in some cases manufacturing output had actually increased (although Bean also shows that the effects of the two oil price shocks in the 1970s together with the oil and gas discoveries, reduce manufacturing output). However, the sample used in Atkinson *et al.* (1983) and Bean (1987) ended in the mid 1980s, when the UK's oil production was at its peak. Oil production in the UK has declined steadily since then, and as expected by the Dutch disease hypothesis, it is only now that one will expect to see the symptoms of the Dutch disease. Hence, the present results, namely that there may be short run positive effects of energy booms on manufacturing although in the long run the effects are negative, (cf. Figure 4), may therefore be consistent with the results in Atkinson *et al.* (1983) and Bean (1987).

In general, it is problematic to compare the results from the VAR model with these simulation studies, as the effect of a Dutch disease in the simulation studies is measured by comparing the historical path of the economy with the economy without the oil sector, and will thus depend on the assumptions about the appropriate policies when there is no oil sector. A less theoretical study and more in line with the present paper is given by Hutchison (1994), who uses a vector error correction model, where he imposes cointegration restrictions between the variables. The cointegration vectors work as long-run constraints imposed on the estimated system. Variance decompositions and impulse responses are thereafter found by assuming exclusion restrictions that follow a recursive structure, as in Sims' (1980) original work. In addition to energy volume and real oil price shocks, a money/credit shock is identified whereas the remaining variability in the variables is attributed to other (unidentified) factors. In an extended model, he also includes the real exchange rate.

Overall, Hutchison (1994) finds positive effects of real oil price shocks and energy booms on manufacturing output in Norway the first two to three years (although initially the effect of an energy boom is negative), but thereafter the effect fluctuates around zero. However, the magnitude of the positive (short run) effects of an energy boom is more in line with the results reported here than with the simulation studies of for instance Cappelen *et al.* (1996). Consistent with the present analysis, Hutchison also finds the effects of an energy price shock on manufacturing in the UK to be negative. On the other hand, energy booms have positive effects on manufacturing in the UK the first four years (after which he does not report impulse responses).

What are the reasons for the divergence between the results reported here and those in Hutchison with respect to the response of manufacturing output in the UK to energy booms? First, the results in Hutchison depend on the cointegration restrictions he has imposed, and for the UK he finds two or three cointegration vectors. However, the estimated vectors are not explicitly identified and the results from the cointegration analysis are therefore not directly interpretable in economic terms without further identifying assumptions.[8]

Secondly, the sample used in Hutchison ends early in 1989, after which I have almost six years of observations. This may again suggest why the long run (negative) effects of energy booms are more clearly seen now. By re-estimating the core and Y-U models for the UK using the same sample as in Hutchison (1994), I find some evidence that there is one cointegrating vector in the UK. The Y-U model suggests that there is a positive long run relationship between manufacturing and energy production, (as the coefficient on the cointegrating vector is positive), although using the core model, a negative long run relationship is still supported. However, adjusting for degrees of freedom as the sample is small (cf. Reimers, 1992), there is essentially no evidence of cointegration using any model.

Finally, the recursive identification structure used to identify the different shocks implies a causal ordering on how the system works, and the results will be very sensitive to how identification was achieved (see e.g. Cooley and LeRoy, 1985). New orderings will typically imply differing degrees of importance for each shock. This has been demonstrated by among others Ahmed *et al.* (1988), who using a VAR model, showed how the contribution of money and energy prices in the variance decomposition of industrial production in OECD changed substantially as a result of variation in the ordering of these variables. However, as Hutchison only reports the impulse responses of the two energy shocks on manufacturing, I cannot compare his model with mine in terms of the other (money/credit) shocks.

V Sources of Business Cycles in Manufacturing

In this section I focus on the short term fluctuations in each historical period, by computing the forecast errors in manufacturing output, using an (eight quarters) weighted average of the estimated shocks from (7). The results are presented in Figures 6 and 7 for Norway and the UK respectively. In Panels A-C in each figure, I plot the total forecast error in output together with the forecast error that is due to energy booms, oil price shocks and demand shocks respectively. In

[8] That cointegration analysis without a strong link to economic theory makes interpretation of the cointegrating vectors a dubious exercise has also been emphasised recently in many studies (see e.g. Søderlind and Vredin, 1996).

Panel D, the log of manufacturing output is graphed together with the forecast error in manufacturing output that is associated with the supply shock when the drift term in the model is added. I will refer to this as the supply potential.[9] As the demand and supply shocks identified in the core model were somewhat different from the output-unemployment model in the short run, I continue the analysis using the Y-U model as the rate of unemployment seems to be a more 'unregulated' cyclical variable than inflation. However, the main results are basically the same using either of the two models.

Positive energy booms (from increased extractions of oil and gas resources) and a higher oil price were among the main contributors towards the boom in manufacturing output in Norway in the late 1970s. Especially, the increased oil revenues allowed the government to follow expansionary fiscal polices, and demand shocks contributed positively in this period. Negative energy volume shocks (due to a fall in activity in the energy sector) together with a series of negative demand shocks, contributed towards the slowdown of manufacturing in the early 1980s. However, from 1985, manufacturing output was stimulated by a demand led boom (set off primarily by the financial deregulation in 1984/1985). In this period, the supply potential was also increasing, due to a series of permanent shocks, among others the large investments in the Mognstad refinery.

By the late 1980s, Norway experienced one of its worst recessions. Manufacturing fell drastically, mainly due to a severe decline in the supply potential, as a series of negative productivity shocks hit the economy (cf. Figure 6D). In addition, the low oil price from the late 1980s deprived the country of income, and was an important factor behind the slowdown in manufacturing production.

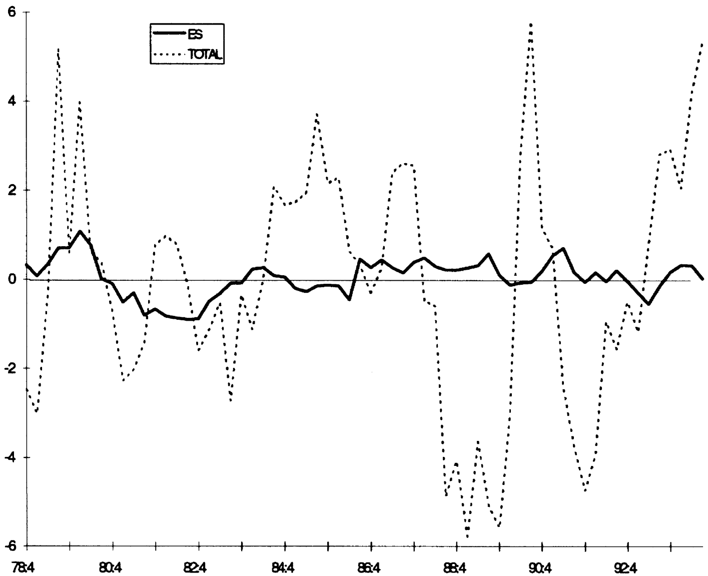
In the UK, energy booms (from a high energy production) were negative contributors towards manufacturing in the early 1980s. Higher oil prices contributed also negatively in this period. However, as seen in Figure 7D, the energy shocks played only small roles compared to the negative supply shocks that hit the economy in this severe recession. These negative permanent supply shocks may indicate a loss of competitiveness through a longer term negative trend (see e.g. Mayes and Soteri, 1994). By 1984, the economy started to recover. Positive supply shocks (from increased productivity growth) drove the supply potential above manufacturing output. However, with low demand, manufacturing was not pushed above the supply potential before late in the 1980s. The fall in oil prices was also a positive contributor towards manufacturing production from 1986/1987.

VI Conclusions

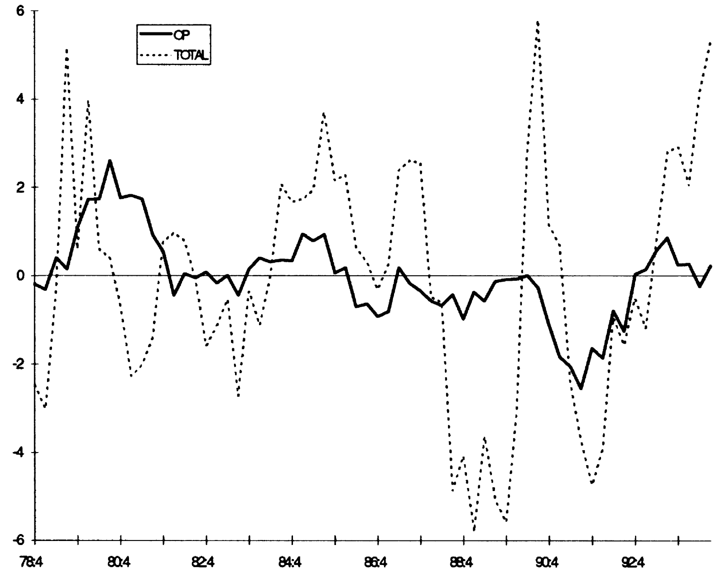
There is no evidence of a Dutch disease in Norway, and both energy booms and oil price increases stimulate the economy so that manufacturing production

[9] Note that, the total forecast error in manufacturing output reported in panel A-C also include the contribution of the aggregate supply shocks (without the drift term) in addition to the three other shocks.

A) Energy boom component, pct. change



B) Oil price component, pct. change



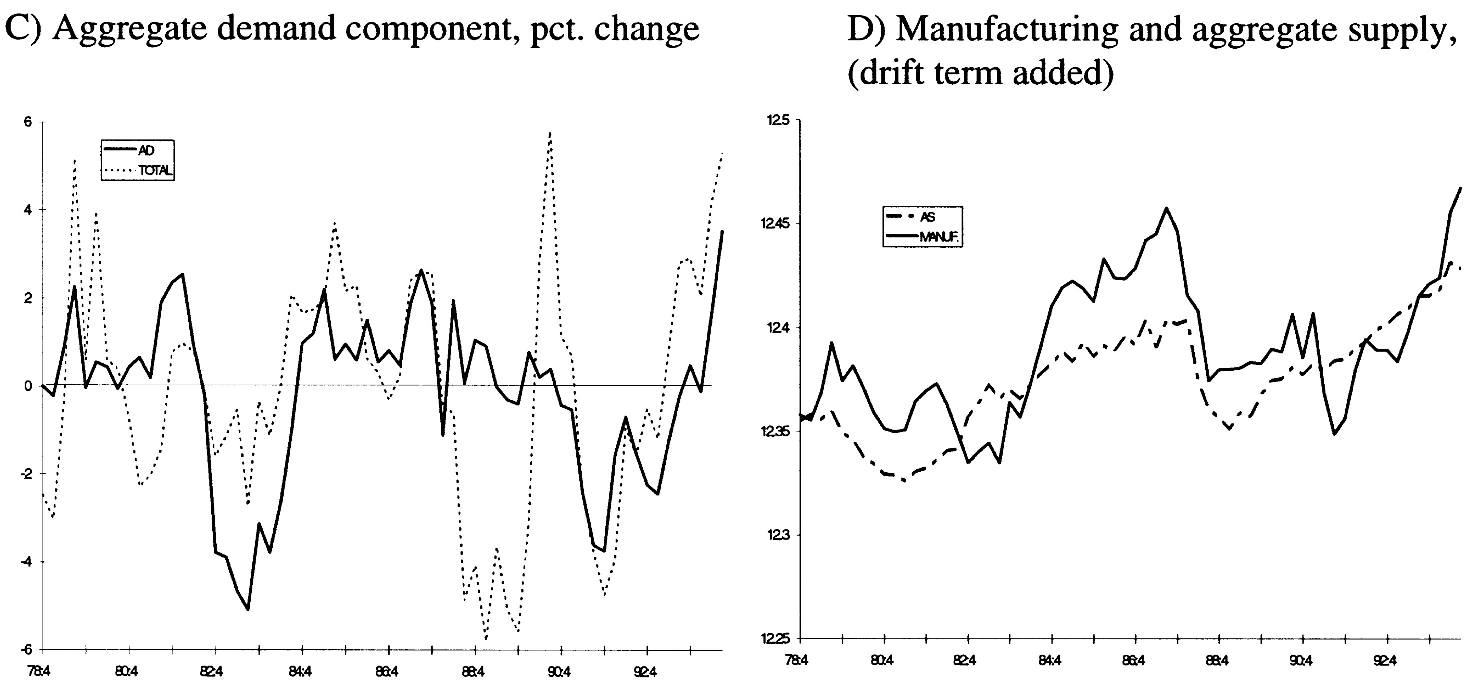
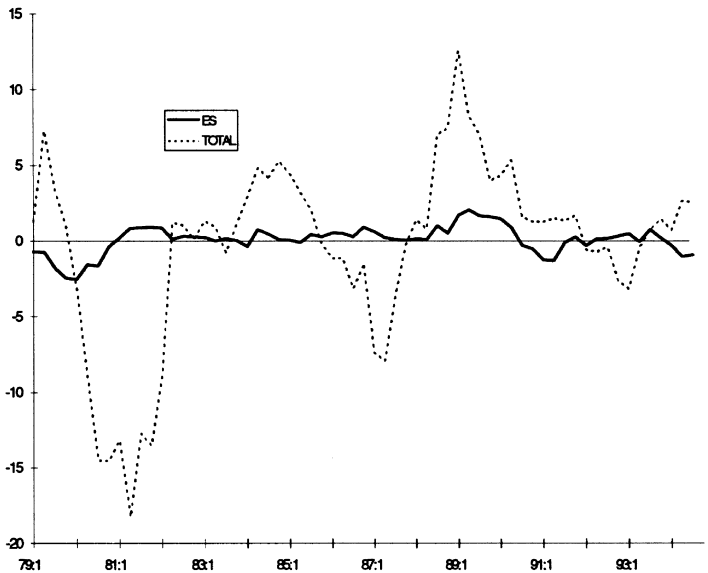
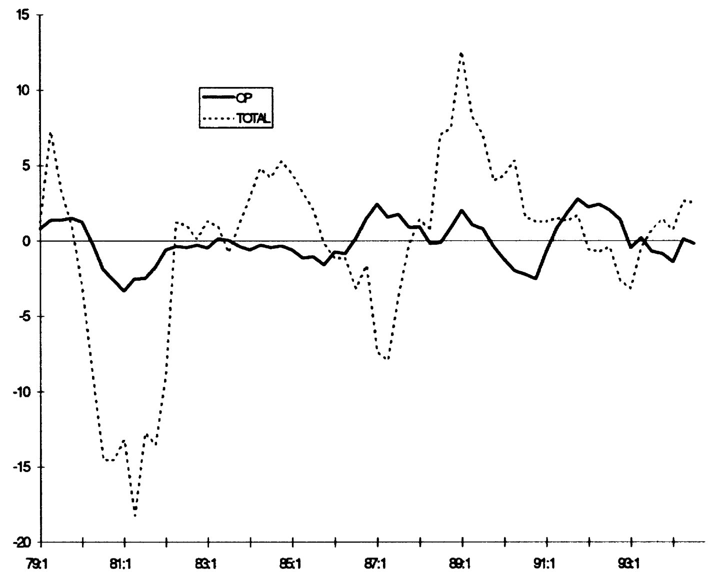


Figure 6. Forecast error decompositions for manufacturing production in Norway.

A) Energy boom component, pct. change



B) Oil price component, pct. change



C) Aggregate demand component, pct. change

D) Manufacturing and aggregate supply, (drift term added)

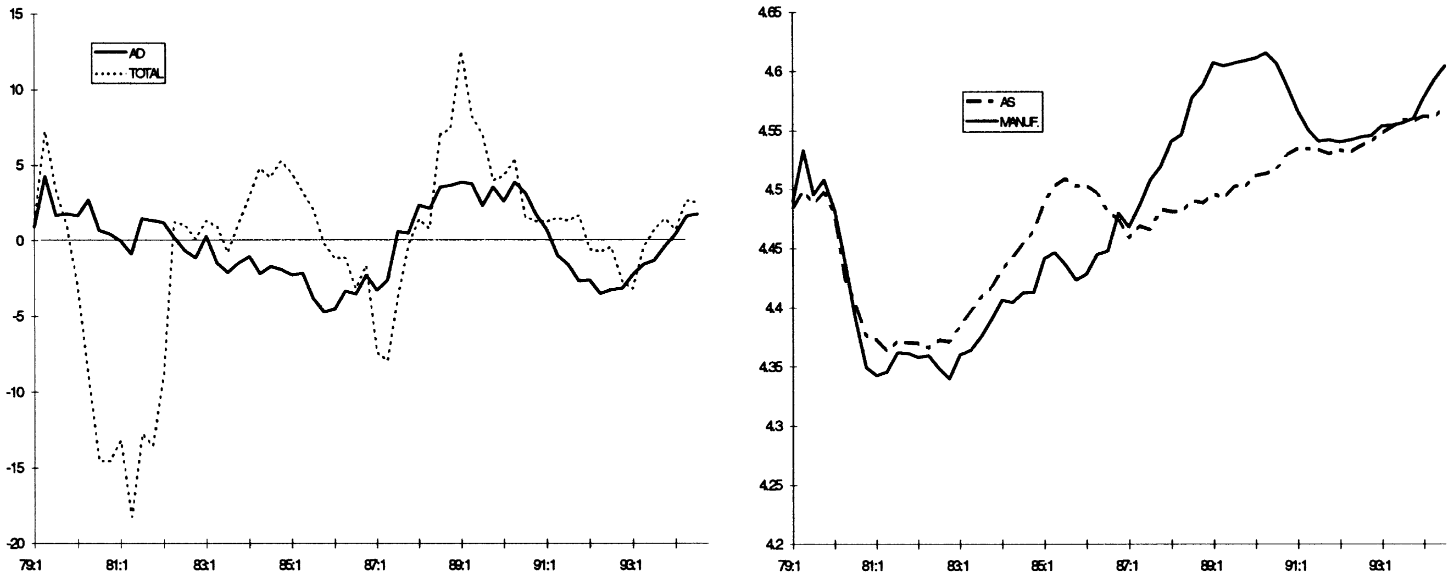


Figure 7. Forecast error decompositions for manufacturing production in the United Kingdom.

increases (at least temporarily). Real oil price shocks are the most important (positive) contributor towards the variation in manufacturing output of the two energy shocks, indicating that the value of the petroleum wealth is an important contributor towards the activity in the mainland economy. Prices, on the other hand, respond according to the Dutch disease in Norway, as energy booms increase prices (as activity increases), whereas a real oil price shock reduces prices (temporarily), probably as the exchange rate appreciates with a high price of oil.

For the UK, there is evidence of a Dutch disease in the long run, although the economy may respond positively to energy booms the first few years. However, the (long run) negative effect on manufacturing is small, and most of the decline in manufacturing in the UK probably stems from factors other than the North Sea. Oil price shocks have had negative effects on manufacturing output in the UK, especially the oil price shock in the 1970s. Both energy shocks work to increase the price level and the rate of unemployment temporarily.

Demand and supply shocks have the effects suggested by economic theory in both countries. Supply shocks are the most important contributors towards the variation in manufacturing output (after a year), and the severe recessions in the early 1980s in the UK and the late 1980s in Norway are mainly driven by negative productivity (supply) shocks.

The fact that in the UK, manufacturing decreased, whereas in Norway, manufacturing actually increased in response to energy volume and price shocks, emphasises how two countries that are self sufficient with oil resources can react very differently to external energy shocks. Although the oil sector plays a much larger role in Norway than in the UK, macroeconomic policy has also been conducted very differently in light of the two major oil price shocks in Norway and the UK. In Norway, there were deliberate subsidies to maintain manufacturing output over the transitional period of North Sea oil, and as a result, the rate of unemployment has remained much lower in this period. A similar benefit could maybe have been derived in the UK, from direct investment of the oil revenues in industries. Instead, with factory closures and rapidly increasing unemployment rates, much of the revenue from the North Sea in the UK went instead into social security in addition to paying off already existing external debts.

Despite the fact that manufacturing responded positively to energy shocks in Norway, the analysis has also demonstrated how vulnerable Norway is to any changes in oil prices. This was clearly seen in the late 1980s, when the fall in oil prices hurt mainland industries, not only by reducing investment demand from the energy sector, but by inducing a tightening of fiscal polices as government income fell. With a continuing variation in oil prices, the task of maintaining economic stability through a careful operation of economic policies will continue to be a challenge.

APPENDIX

Data sources and descriptions

All series are seasonally adjusted quarterly data, unless otherwise stated. The series are seasonally adjusted by their respective sources. The periodicity is from 1976:1 to 1994:3. All variables are measured in natural logarithms, except the rate of unemployment.

(n) Nominal oil prices in US dollars: Saudi Arabian Light-34, USD per barrel, fob-(n.s.a.). Prior to 1980, posted prices, thereafter spot prices. *Source: OPEC BULLETIN and Statistics Norway*.

Norway:
(y) GDP Manufacturing sector;
(s) GDP Oil and gas extraction;
(π) First differences of (the log of) the GDP deflator mainland Norway;
(u) Unemployment rate; *Source: Statistics Norway*;
(o) Real oil prices measured in Norwegian kroner; (n × e/cpi):
    (e) Exchange rate, mth. average NOK/USD (n.s.a.). *Source OECD*;
    (cpi) Consumer Price Index. *Source: Statistics Norway*.

United Kingdom:
(y) Industrial production: Manufacturing (quarterly average from monthly averages);
(s) Industrial production: Oil and gas extraction (quarterly average from monthly averages);
(π) First differences of (the log of) the GDP deflator; *Source: Datastream*;
(u) Unemployment rate, total labour force; *Source: OECD*;
(o) Real oil prices measured in GBP; (n × e/cpi):
    (e) Exchange rate, mth. average GBP/USD (n.s.a.); *Source OECD*;
    (cpi) Consumer Price Index; *Source: Datastream*.

TABLE A1
Augmented Dickey Fuller unit-root tests (1978:2–1994:3)[a]

	ADF-test	Norway	ADF-test	United Kingdom
y	ADF(2)	−2·44	ADF(2)	−2·31
o	ADF(3)	−2·65	ADF(3)	−2·71
s	ADF(7)	−2·98	ADF(3)	−2·95
p	ADF(3)	−0·33	ADF(2)	−1·92
Δy	ADF(3)	−4·82***	ADF(1)	−3·38**
Δo	ADF(2)	−4·05***	ADF(1)	−7·58***
Δs	ADF(6)	−3·62***	ADF(4)	−2·81*
$\pi(=\Delta p)$	ADF(2)	−2·91**	ADF(1)	−3·02**

Notes:
[a] Critical values were taken from Fuller (1976). A time trend and a constant are included in the regressions using the levels, whereas only a constant is included in the regression using first differences. The number of lags used are determined by selecting the highest lag with a significant t value on the last lag, as suggested by Doornik and Hendry (1994).
***Rejection of the unit-root hypothesis at the 1% level.
**Rejection of the unit-root hypothesis at the 5% level.
*Rejection of the unit-root hypothesis at the 10% level.

TABLE A2
Johansen cointegration tests; cointegrating vector (y_t, o_t, s_t, π_t)[a]

H_0	H_1	Critical value 5%	Critical value 5%	Norway		UK	
		λ_{max}	λ_{trace}	λ_{max}	λ_{trace}	λ_{max}	λ_{trace}
$r = 0$	$r \geqslant 1$	27·07	47·21	24·50	42·78	23·34	46·84
$r \leqslant 1$	$r \geqslant 2$	20·97	29·68	1·69	18·28	14·22	23·49
$r \leqslant 2$	$r \geqslant 3$	14·07	15·41	5·09	7·59	9·02	9·27
$r \leqslant 3$	$r = 4$	3·73	3·76	2·51	2·51	0·25	0·25

Notes:
[a] All test-statistics are calculated using PcFiml 8.0 (see Doornik and Hendry, 1994). Critical values are taken from Table I in Osterwald-Lenum (1992).

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