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Abstract:
This paper analyses the sources of business cycles in economies that have an important energy producing sector. Especially, I investigate the effects of oil and gas extractions (energy booms) on the manufacturing sector, and analyse whether there is any evidence of a "Dutch disease", that is whether energy booms have had adverse effects on the manufacturing base. In additions to energy booms, I identify three other types of disturbances in the economy; aggregate demand, supply and oil price shocks. The different structural disturbances are identified by imposing long-run and short-run (zero) restrictions on a vector autoregressive model. The analysis is applied to Norway and United Kingdom, which both discovered huge oil resources in the North Sea in the 1970s. There is no evidence of a Dutch disease in Norway, and manufacturing output has actually benefited from both energy discoveries and higher oil prices. In UK on the other hand, manufacturing output has declined in response to energy booms, although the effect is small compared to the effects of the other shocks that are present at the time.

Keywords: Dutch disease, dynamic restrictions, structural vector autoregression.

JEL classification: C22, C32, E32, L60, Q43

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«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)

1. Introduction

Recent empirical work has demonstrated that oil price increases have had adverse effects on several industrial economies (e.g. Bruno and Sachs 1982, Darby 1982, Hamilton 1983, Burbidge and Harrison 1984 and Ferderer 1996). Especially, it is now believed that the two adverse oil price shocks in the 1970s reduced world manufacturing output drastically. The first major adverse oil price shock in 1973/1974 occurred at a time when both the British and the Norwegian economy had just discovered huge oil resources in the North Sea. Most fields were not profitable before the mid 1970's, but the prospect of increased oil revenues brought about by higher oil prices created a potential for profitable output in both countries. By the end of the 1970's, Norway and UK had turned oil from an importable to an exportable, so when the second oil price rise occurred in 1979/1980, overall national wealth increased further in both countries. This may have confronted Norway and UK with a set of different issues than the other OECD oil importing countries were facing.

First, the real oil price increase and the subsequent higher national wealth, raised income to the factors of production including the government, so that overall demand and production in the economy may actually have increased (although the effects on an exportable like manufacturing can be negative if world demand for manufacturing falls as oil prices rise). Bjørnland (1996), has examined the effects of oil price changes on GDP for some OECD countries including Norway and United Kingdom using a vector autoregression (VAR) model, and essentially I found that for Norway, (non-oil) real output actually increased in response to oil price increases, whereas UK behaved in line with the other oil importing countries, where real output declined after an oil price shock.

Second, the stream of revenues from the North Sea also gave huge investment and business opportunities to the economy, with increased demand for labour and capital. The adjustment period that would follow was expected to affect the individual sectors in the economy to a varying degree. Some sectors would gain, whereas others could actually loose out. This had been emphasised for the Netherlands, where the natural gas discoveries in the 1960's were seen to have had adverse effects on the Dutch manufacturing sector, mainly through a real exchange rate appreciation. The adverse effect on the manufacturing sector from an energy boom, has been termed the 'Dutch disease' in the economic literature. Similar contractions of the manufacturing sector have been observed in Norway and UK in the 1970s and 1980s, a period of which these countries moved from positions as net importers to significant net exporters of oil.

Much theoretical work has been carried out analysing the benefits and costs of energy discoveries, (see e.g. Corden 1984, and the references he states). However, there has been relative few empirical studies, and among those that have been carried out, most have been conducted through simulations of large scale macroeconomic models. Previous empirical (simulation or simple quantification) studies analysing the effects of energy booms on manufacturing production explicitly, include, e.g. Forsyth and Key (1980), Bruno and Sachs (1982), Atkinson et al. (1983) and Bean (1987) about UK, and Bye et al. (1994) and Cappelen et al. (1996) about Norway. Whereas Forsyth and Key (1980) and Bruno and Sachs (1982) find some evidence of a Dutch disease, Atkinson et al. (1983), Bean (1987), Bye et al. (1994) and Cappelen et al. (1996) find little or no evidence of a Dutch disease, and in some cases the manufacturing sector has actually benefited from North Sea oil discoveries.

The complexity of ways that energy shocks can influence the economy, motivates the use of a less theoretical model like a vector autoregression model, instead of a fully specified large scale model, (that is specified through a whole set of relations restrictions). An attempt in that direction is given by Hutchison (1994), who uses a vector error correction model where he imposes cointegration restrictions between the variables. The impulse response functions are thereafter found by assuming exclusion restrictions that follow a recursive structure, as in Sims (1980) original work. Overall, Hutchison (1994) finds no evidence of a Dutch disease in neither the Netherlands, Norway nor the UK, and manufacturing has actually increased in response to oil and gas discoveries. However, the results in Hutchison depend on the cointegration restrictions he has imposed, and for e.g. UK, he finds three cointegration vectors. These vectors are not explicitly identified and the results from the cointegration analysis are therefore not directly interpretable in economic terms. Further the recursive identification structure used to identify the different shocks implies a causal ordering on how the system works, and the results will typically be very sensitive to how identification was achieved.

Below, I instead analyse the effects of energy booms (volume changes due to e.g. a technical improvement or a windfall discovery of new resources) in Norway and United Kingdom, using a VAR model that is identified through both short and long run restrictions, that have intuitive theoretical justifications. In addition to energy booms, I also identify real oil price shocks, to control for a possible decline in manufacturing output induced by real factor price changes, as it 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. Especially, I interpret shocks that have permanent effects on output as supply shocks, whereas shocks that have only temporary effects on output are interpreted as demand shocks. The long run restriction used to identify supply and demand shocks, is similar to that employed by Blanchard and Quah (1989).

Essentially, I find no evidence of a Dutch disease in Norway, and both energy booms and oil price increases stimulate the economy to the extent that manufacturing output increases (temporarily). For UK, there is evidence of a Dutch disease in the long run (six to eight years), although the economy may respond positively to energy booms the first couple of years. However, the effects of energy booms in UK are small compared to the effects of the other shocks present at the time.

The paper is organised as follows. In section two I present some indicators that summarise the importance of the energy sector and the manufacturing sector in Norway and UK over the period examined. Section three reviews the theory of Dutch disease, and thereafter present an economic framework in which one can interpretate the four structural shocks; energy volume, energy price, aggregate demand and aggregate supply shocks. In section four, I present the structural VAR model. Section five reviews the effect of the different shocks on average for manufacturing output, prices and unemployment, and the relative importance of the different shocks in accounting for the forecast errors in the variables is assessed. In section six, the impacts of the different shocks on manufacturing output are analysed in different historical periods. Especially, I decompose movements in manufacturing output in each period as due to each of the four structural shocks. Section seven concludes[1].

2. Oil and gas in the economy

Real output grew at a much faster rate in Norway than in most other OECD countries in the aftermath of the oil price shocks in 1973/1974 and 1979/1980. Unemployment remained almost stable during the 1970s, a period where most countries experienced increasing unemployment. The discovery and use of oil resources from 1970 onwards, stimulated the economy so it grew at a faster rate than otherwise would have been possible. Especially, income from oil production was taken out in advance, and the government followed an expansionary fiscal policy during many periods in the 1970s and early 1980s.

[1] All calculations are performed using GAUSS and RATS, unless otherwise stated.

The macroeconomic performance of the British economy has been less prosperous the last three decades. The 1970s was characterised by increasing inflation rates, which was followed by record high unemployment rates in the 1980s. Although the economy was a net exporter of oil by the time the second oil price shock occurred in 1979, the economy was not stimulated by the prospects of increased oil revenues to any extent as the Norwegian economy experienced. Instead, the record high inflation rates led the government to adopt tight monetary policy from the late 1970s, and tight fiscal policies from the early 1980s.

In both Norway and UK, manufacturing production were stagnant or fell during many periods in the 1970s and early 1980s (for a plot of manufacturing, see e.g. figures 9D and 10D). With positive growth rates in the overall economy, the share of manufacturing in GDP has fallen, and from 1973 to 1993, manufacturing as a pct. of GDP has declined by about 1/3 in both countries (cf. table 1).

Table 1. Oil and manufacturing production (value added) as pct. of GDP, constant prices

	1973	1976	1980	1985	1990	1993
Norway						
Oil and gas	0.4	3.2	8.9	9.0	15.4	20.3
Manufacturing	23.1	22.0	19.5	17.8	17.0	16.6
UK						
Oil and gas	0.1	0.1	4.4	6.1	1.7	2.1
Manufacturing	31.6	30.1	26.6	23.5	23.7	22.7

Sources: Statistics Norway, *Kvarts Database*; UK Central Statistical office, *National Accounts*, various issues.

Oil and gas production has increased its importance in both countries during the same period as manufacturing output has declined as a share of GDP (for a plot of oil and gas production, see appendix A). From virtually zero production in the early seventies, UK produced 4.5 pct. of the total world production of oil in 1985, whereas Norway was responsible for 1.5 pct. of total world production of oil the same year. The picture had turned around by the start of the 1990s, and by 1993, 3.2 pct. of total world production of oil was produced by UK whereas Norway was responsible for 3.6 of total world production of oil. However, with Norway being a much smaller economy than UK, the relative importance of oil and gas has been largest in the Norwegian economy, where the oil and gas sector now amounts to more than 20 pct. of GDP (1993). The share of oil and gas extraction in UK reached a peak in 1984/1985 when it accounted for approximately 6 pct. of GDP. Since then it has fallen, and in 1993, the share of energy production was just above 2 pct. of GDP.

3. Economic effects of North Sea Oil

The harmful consequence for traditional industries of a natural resource discovery, has commonly been referred to as the *Dutch disease* in the economic literature (cf. Rutherford 1992). One of the symptoms of the «disease» is high unemployment rates. This had been experienced in the Netherlands, where the rapid growth of the new gas industries in the 1960s, had led to an overall change in the industry structure. Especially, with the prosperous new gas industry, the exchange rate appreciated, with the consequence that the traditional industries became internationally uncompetitive and declined. This became clearly visible by the end of the 1970s, when the high income from the gas resources declined. By then, the (uncompetitive) traditional industries could not compensate for the loss of revenues from the energy sectors, and the following years, output growth was low and unemployment rose quickly and has remained relatively high since then.

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 Key (1980), Bruno and Sachs (1982), Corden and Neary (1982), Eastwood and Venables (1982), Corden (1984) and Neary and Van Wijnbergen (1984). One of the first known studies of the de-industrialisation effect of a natural resource discovery, was applied to Norway, by Eide (1973). In this study, Eide analyses the effects of the use of oil revenues by the government, either through a reduction in taxes or through increased government spendings. He uses a comparative static model, and concludes that the use of oil revenues will increase prices in the non traded goods and service sector, and induce a change in the overall industry structure, away from the traded goods sector and towards the non traded goods and service sector.

In Eide (1973), there is only an indirect de-industrialisation effect following the oil discoveries, as all reallocations are brought about by the real appreciation, which is induced by the increased government spendings[2]. Corden and Neary (1982) have developed a model where both the direct and the indirect de-industrialisation effect is taken into account. The *direct* impact of oil and gas resources (or any other sectoral boom) come 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 increased demand for goods and services by the energy sector will lead to an *indirect* (secondary) effect of increased demand for resources by the sectors that will produce goods and services for the energy sector. If income in the energy sector has increased, there will also be a further (indirect) effect of increased demand for goods and services. These indirect effects are usually described as the *Spending Effects*, and will lead to a real appreciation that will hurt some sectors and benefit others.

More formally, Corden and Neary (1982), assume that there are three sectors in the economy, a booming sector (B), a tradeable sector (producing primarily manufacturing goods) (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 energy boom is understood as an exogenous technical improvement in B. The resource movement effect will increase demand for labour in B, as the marginal product of labour in B raises from the boom, given constant wages in terms of the tradeables. Hence, there will be a movement of labour out of T and N, into B. The movement of labour from T to B will lower output in T directly, whereas the movement of labour from N to B at constant prices, will reduce the supply of N and create an excess demand for N . In response to the excess demand of N, the price for N in terms of T will raise, which will give a real appreciation and further movements of resources out of T into N.

Second, aggregate income of the factors initially employed in the booming sectors will rise. This will lead to a spending effect, directly by the factor owners in B or indirectly by the government that collects (part of) the income through taxes. With positive income elasticity of demand for N, the price of N relative to the price of T must rise, giving a further real appreciation. Given full employment of all resources, this real appreciation will induce additional movement of labours from T to N. Finally, both the spending effect and the resource movement effect will lower the real rents of the specific factor in T. However, both effects will also increase the demand for labour in the economy, thus raising the nominal wage rate (in terms of tradeables) and reducing the competitiveness of T.

The (core) model described above can be varied in a number of ways. Cordon (1984), summarises several examples of how one can alter the model so the outcome described above may change substantially. Here, I will only focus on a few examples. In the above framework, I assumed that labour was mobile between the three sectors (but there was no capital mobility). By allowing all factors to be mobile, the effects of an energy boom may be ambiguous, and output in the manufacturing sector may or may not fall. A situation where output in the manufacturing industry may actually increase would be when one assume that B has its own specific factor, labour is mobile between the three sectors but capital is mobile only between the N and T sector. This makes up a miniature Heckscher-Ohlin economy, where one sector will be labour intensive whereas the other will be capital intensive. In this case, the resource movement effect will cause the output of the capital intensive industry to expand (as

[2] 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.

labour is moving out of the labour intensive industry and into B during the boom). If T is the capital intensive industry, and the (negative) spending effect on output in the T sector is smaller than the resource movement effects, output in the T sector may actually increase.

Another realistic alteration of the core model is to assume that capital is internationally mobile, (although it is not mobile intersectorally). Assume the rents in B and N rise (as output rises) while the rent in T falls. International capital mobility will induce a flow of capital into B and N, and out of T. This will reduce output in T further, but the effects on the returns to capital in the three sectors will be dampened due to the capital outflow until eventually, a new equilibrium is restored. Although the fall in output in T will be more severe, the adverse effect of the boom on profitability in T will be less due to the capital outflow. In the extreme case of perfect international capital mobility, the rate of return in T will not fall at all, and the price and the rate of profit in T will be fixed internationally. With constant returns to scale in the production technologies, the wage in terms of T will also remain fixed and all adjustments will come through output changes. One can show that in the case of perfect international capital mobility, there will be no real appreciation effect.

Up to now, I have assumed that all factor prices are flexible, so there is no involuntary unemployment. In a situation when there is real wage resistance (and classical unemployment), the effect on unemployment may be ambiguous. Generally, if the energy boom has increased the real wage in the core model, then with a rigid real wage rate, unemployment would have been reduced instead. However, if the energy boom has reduced the real wage in the core model, then with a rigid real wage, unemployment would actually increase. This explains why the typical symptom of a Dutch disease manifests itself in unemployment in the tradeable sector (as it did in the Netherlands in the late 1970s). If the real wage was flexible it would fall in the tradeable sector, (as there is both movement of labour out of T and into other sectors, and the price of N rises). With real wage resistance, the result would instead be increasing unemployment rates. If the labour force in T in addition seek to maintain real wages relative to those employed in the booming sector (where market forces have raised the real wage), unemployment would be further intensified.

On the other hand, 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 stimulative effect on the industries. This typically happened in Norway, where the growth in the public sector in the 1970s provided a stimulus to the female employment opportunities.

To sum up, the core model predicts that the manufacturing sector eventually will contract as the energy sector expands. However, there are several ways the core model may be altered (by changing the underlying assumptions) so that the predicted effects of energy booms on the manufacturing sector may be less severe than in the basic case, and in some cases there may not be a Dutch disease at all. The main focus of this paper, will be to examine empirically through a structural VAR model, if there are any lasting negative effects of energy volume changes (energy booms) on manufacturing output. It is through this effect I will be able to assess the relevance of the Dutch disease hypothesis. To control for other types of shocks that are also present, I will in addition identify real oil price shocks, aggregate demand shocks and aggregate supply shocks, that are uncorrelated with each other and the energy volume shocks. The interpretation of these structural shocks in the VAR analysis, will be motivated by a simple economic model of output fluctuations as discussed below.

3.1. Energy price, demand and supply shocks

In addition to the effects of energy booms discussed above, energy price shocks may also have separate and complex effects on the economy. An energy price disturbance can typically have both demand and supply effects on real output (see e.g. Mork 1994). 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 the production. This may have hurt manufacturing in the oil exporting countries as well as in the oil importing countries. In addition, aggregate demand may also have changed, by transferring income from the oil importing countries to the oil exporting countries, thus inducing the rational consumers in the oil importing countries to hold back on their consumption spendings. On the other hand, the increase in income in the oil exporting countries will increase demand for goods and services domestically as well as from the oil importing countries, thus reducing the net effect of an oil price increase in the world.

In Bjørnland (1996), I proposed a simple economic model where energy price shocks may affect the aggregate economy through several channels. In addition to energy price shocks, I assumed that there were other demand and supply shocks that also hit the economy. The model was a variant of a simple (Keynesian) model of output fluctuations adopted from Blanchard and Quah (1989), which consisted of an aggregate demand function, a production function, a price setting behaviour and a wage setting behaviour. The model was modified by including real oil prices into the system, primarily into the aggregate demand function and the production function. Solving for the level of output, I found that whereas supply and oil price shocks will affect output in the long run (through the production function), demand shocks will have no long run effects on output. However, in the short run, due to nominal and real rigidities, all three disturbances can influence output.

The finding that aggregate demand shocks have only short term effects on output, is also 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 shock (e.g. a monetary expansion) will shift up the (downward sloping) aggregate demand (AD) curve, increasing both output and price. In the long run, the aggregate supply (AS) curve becomes more vertical, hence the economy moves back to its initial output level, where prices have increased to a permanent 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)[3]. The AD/AS framework can also be used to study supply shocks like technology or factor price shocks. For instance, a positive supply shock (e.g. a technological improvement) that shifts both the short run and long run AS schedule to the right, will increase output and reduce prices permanently, whereas following a permanent negative oil price shocks, the reverse will be true.

Although demand and supply shocks can be identified in the price-output space above, a model comprising output and unemployment may essentially contain the same information on the shocks on which we are interested to study. Typically, a positive demand shock that increases output temporarily along the short run supply schedule (where prices increase), will induce a temporary fall in the unemployment rate. 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.

4. Examining the relevance of the Dutch Disease, through a Structural VAR

Analysis of the linkages between energy and the economy is complicated, and it is difficult to capture all the channels of influence without a fully specified model. In a seminal article, Sims (1980) proposed to use VARs as an alternative to the traditional structural econometric models, where too many parameters were identified by excluding variables, most often lagged endogenous variables, without proper theoretical justifications. Sims suggested instead to limit the role of theory to give a set of assumptions necessary to identify the residuals in the VAR model, with shocks in a series of structural models. In Sims' original work, the system was identified recursively. Here I will show how I

[3] For a textbook discussion, see e.g. Dornbusch and Fischer (1994).

instead can use a *combination* of short run and long run restrictions on a VAR model, to identify different types of structural shocks.

I first specify a VAR model that focuses on four variables; *manufacturing output, oil and gas production (extraction), real oil prices* and *inflation*. These variables are a minimum of variables chosen so that they shall capture all the information necessary to identify the four structural shocks defined above; *energy volume shocks (energy booms), real oil prices, aggregate demand,* and *aggregate supply shocks.*

Energy booms and oil price shocks will be identified by imposing a minimum of contemporaneous restrictions on the equation for energy production and real oil prices respectively. Each of these restrictions will be discussed below. As energy booms are identified from the equation for energy extractions, they will be interpreted as volume changes (due to e.g. a technical improvement or a windfall discovery of new resources). Hence, they reflect shocks to a nations income (or wealth). Another aspect of the Dutch Disease would be to analyse the (direct) demand effects from the energy sector explicitly. This is done in simulation studies like Cappelen et al. (1996), where energy booms are identified as changes in investment demand from the petroleum sector. Although these two approaches measure different aspects of the economy (shock to a nations wealth versus demand impulses), I will show by the end of this paper that using either way to identify energy booms in Norway, essentially gives the same results.

To identify demand and supply shocks, I include manufacturing output and inflation in the VAR, so that I can make use of a long run restriction motivated by the findings in the AD/AS analysis above, namely that aggregate demand shocks can have no long run effects on manufacturing output. This restriction is also similar to that applied in Blanchard and Quah (1989) and Bayoumi and Eichengreen (1992). However, whereas Blanchard and Quah (1989) used a bivariate VAR model comprising the first differences of output and the (detrended) unemployment rate to identify demand (transitory) shocks and supply (permanent) shocks, Bayoumi and Eichengreen (1992) estimated a bivariate VAR in the first differences of output and the inflation rate (assuming inflation is stationary), to identify the same shocks[4]. As discussed in section 3.2, these two models essentially contain the same information on the demand and supply shocks[5]. To analyse the robustness of the results, I will therefore also estimate a VAR model where I replace *inflation* with *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*. However, in contrast to Blanchard and Quah (1989) and Bayoumi and Eichengreen (1992) who only identified one type of permanent shock (aggregate supply), I will also allow energy volume and price shocks to affect output in the long run.

4.1. Identifying the Structural VAR

Manufacturing output, oil and gas production and real oil prices are nonstationary integrated, I(1), variables, where stationarity is obtained by taking first differences. Inflation and unemployment are assumed to be stationary, I(0), variables. First, I define z_t as a vector of stationary macroeconomic variables $z_t = (\Delta y_t, \Delta o_t, \Delta s_t, \pi_t)'$, where Δy_t represents the first differences of the log of manufacturing production, Δo_t is the first differences of the log of real oil prices, Δs_t is the first differences of the log of oil and gas extraction and π_t $(=\Delta p_t)$ is the inflation rate[6]. Although the analysis below refers to the core model, it is equally applicable to the Y-U model, as both inflation and unemployment are assumed to be stationary. Formally, the reduced form VAR is estimated as:

[4] Quah (1995) emphasises that the focus in Blanchard and Quah (1989) was not on unemployment itself, any other time series could be used together with output provided it was stationary and had dynamic interactions with output.

[5] In an unpublished manuscript, Faust and Leeper (1994) explore the robustness of the Blanchard and Quah (1989) long run restrictions, by comparing three bivariate models; output-unemployment, output-inflation and output-interest rates. Essentially, they found that the response of output to the different shocks varied somewhat between the models.

[6] The assumption of stationarity will be verified empirically in section five.

(1)
$$z_t = \alpha + A_1 z_{t-1} + \ldots + A_p z_{t-p} + e_t$$
$$A(L) z_t = \alpha + e_t$$

A(L) is the matrix lag operator 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 the Wold Representation Theorem implies that under weak regularity conditions a stationary process can be represented as an invertible distributed lag of serially uncorrelated disturbances. The implied MA representation from (1) can then be found and written as (ignoring the constant term hereafter):

(2)
$$z_t = e_t + C_1 e_{t-1} + C_2 e_{t-2} + \ldots$$
$$z_t = C(L) e_t$$

where $C(L)=A(L)^{-1}$. The C_j matrix refers to the moving average coefficient at lag j and C_0 is the identity matrix. As the elements in e_t are contemporaneously correlated, they can not 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)
$$z_t = D_0 \varepsilon_t + D_1 \varepsilon_{t-1} + D_2 \varepsilon_{t-2} + \ldots$$
$$z_t = D(L) \varepsilon_t$$

where ε_t are orthogonal structural disturbances which for convenience I normalise so they all have unit variance, e.g. $\text{cov}(\varepsilon_t)=I$. The assumption that the underlying structural disturbances are linear combinations of the Wold innovations (e_t) is essential, as without it the economic interpretations of certain VAR models may change, see e.g. Lippo and Reichlin (1993) and Blanchard and Quah (1993) for a discussion of the problem of nonfundamentalness. With C_0 as the identity matrix, from (2) and (3), I can write $e_t = D_0 \varepsilon_t$. Substituting this expression into (2), I find $D_j = C_j D_0$, or:

(4)
$$C(L) D_0 = D(L)$$

The coefficients in the C(L) polynomial can be calculated from the inverse of the A(L) polynomial, that is estimated in (1). If D_0 is identified, I can derive the MA representation in (3). To identify D_0, I will first make use of the fact that from the normalisation of $\text{cov}(\varepsilon_t)$ it follows that:

(5)
$$D_0 D_0' = \Omega$$

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 $\varepsilon_t = (\varepsilon_t^{AD}, \varepsilon_t^{OP}, \varepsilon_t^{ES}, \varepsilon_t^{AS})'$, where ε_t^{AD} is the aggregate demand shock, ε_t^{OP} is the oil price shocks, ε_t^{ES} is the energy boom and ε_t^{AS} is the aggregate supply shock. From (3), the effect of a demand shock (ε_t^{AD}) on Δy_t after j periods can be written as; $D_{11,j}$, whereas the effect of a demand shocks on (the level of) y_t after k periods is; $\sum_{j=0}^{k} D_{11,j}$. Hence, the long run effect of the aggregate demand shock upon the level of y_t is simply found by summing the infinite number of lag coefficients $\sum_{j=0}^{\infty} D_{11,j}$. From (4), the long run expression can be written as: $\sum_{j=0}^{\infty} C_j D_0 = \sum_{j=0}^{\infty} D_j$ or:

(6) $$C(1)D_0 = D(1)$$

where $C(1)=\sum_{j=0}^{\infty} C_j$ and $D(1)=\sum_{j=0}^{\infty} D_j$ indicate the long run matrixes of C(L) and D(L) respectively. C(1) is observable, found by inversion of A(1). The long run identification then implies that D_{11} (1)= 0, (see also Bjørnland 1996). Hence:

(7) $$C_{11}(1)D_{11,0} + C_{12}(1)D_{21,0} + C_{13}(1)D_{31,0} + C_{14}(1)D_{41,0} = 0$$

In the four variable system, five more restrictions are required to identify the system. These are found through contemporaneous restrictions on real oil prices and energy production. In Bjørnland (1996), oil price shocks were identified by assuming that the contemporaneous effects of demand and supply shocks on real oil prices were zero. This is reasonable as oil prices have been dominated by a few large exogenous developments, (e.g. the OPEC embargo in 1973, the Iranian revolution in 1978/1979, the Iran-Iraq War in 1980/1981, the collapse of OPEC in 1986, and most recently the Persian Gulf War in 1990/1991). The oil price is a financial spot price that reacts quickly to news. I therefore assume that if demand shocks 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 UK have been relatively small oil producers compared to the rest of the worlds major producers. However, after a period (one quarter), all three shocks are free to influence real oil prices. The three short term restrictions on real oil prices then imply that:

(8) $$D_{21,0} = D_{23,0} = D_{24,0} = 0$$

The final two restrictions are found by assuming that the contemporaneous effects of aggregate demand and aggregate supply disturbances on extraction of oil and gas are zero. However, I allow oil price shocks to have a contemporaneous effect on oil production, so that the oil producer can determine whether to take out energy production now, or hold back on oil and gas extractions as the price of energy varies. As above, after a period (one quarter), all shocks are free to influence energy production.

(9) $$D_{31,0} = D_{34,0} = 0$$

The system is now just identifiable. It turns out to be linear in its equations and can be solved numerically. By using a minimum of restrictions I have been able to disentangle movements in four endogenous variables; manufacturing output, oil and gas extractions, real oil prices and inflation (unemployment) into parts that are due to four structural shocks; aggregate demand, supply, oil price and energy (volume) booms. Note that I have not imposed any long run restriction on the behaviour of output to energy booms. This is obvious, at as it is through the long run behaviour of manufacturing output to an energy boom that I can assess the evidence of a Dutch disease.

Despite the many advantages of using structural VARs, it is also subject to some limitations. Especially, it is recognised that the results from using 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 instance, demand and supply shocks are identified and distinguished by assuming that only the latter have a permanent effect on output. For these results to be plausible, the simultaneous effects on inflation and prices (or unemployment) should be established. Especially, from the AD/AS analysis above we saw that whereas a positive demand shock shall increase prices permanently, following a positive supply shocks, prices shall fall permanently. This suggests two overidentifying restrictions on prices, which can be tested informally by examining the impulse response analysis below.

Finally, the limited number of variables and the aggregate nature of the shocks, implies that I will not be able to distinguish between different aggregate demand shocks (e.g. increases in money supply or government consumption) and aggregate supply shocks (labour supply and technical improvements). However, by isolating oil prices and energy booms, I have at least separated oil price shocks and energy volume booms (which among other have labour supply effects) from the other supply shocks.

5. Model specifications and empirical results

The VAR model specified above was assumed to be stationary, and the levels of the variables were not cointegrating. Below I perform some preliminary data analysis, to verify whether I have specified the variables according to their time series properties. Several misspecification tests are also carried out. The dynamic effects of the different shocks on the variables are thereafter estimated.

5.1. Data and model specifications

The data used in the core model for both countries are the first differences of the log of manufacturing production, the first differences of the log of oil and gas extraction, the first differences of the log of real oil prices and the inflation rate measured as the first differences of the log of the GDP deflator. Real oil prices are defined as the nominal oil prices in US dollars converted to their national currency and deflated by the consumer price index. I use the consumer price index to deflate oil prices, as in oil producing countries, oil prices may be included in the GDP deflator, (especially in Norway where approximately 20 pct. of GDP is generated in the oil sector). Inflation is measured by the GDP deflator, as I assume the GDP deflator reflects prices of output rather than prices of consumption (see e.g. Bayoumi and Eichengreen 1992). Note that for Norway I use the GDP deflator for the mainland economy, to avoid that oil prices are included in prices. The data are quarterly, seasonally adjusted, and the sample runs from 1976Q1 to 1994Q3 for both countries, to be consistent. The data and their sources are described further in appendix A.

The lag order of the VAR-models are determined using the Schwarz (SC) and Hannan-Quinn (HQ) information criteria and the F-forms of likelihood ratio tests for model reductions as suggested by Doornik and Hendry (1994). Lag lengths between one and eight order are considered. I report two different types of F-tests, one where I reduce the order of the VAR model sequentially and one where the order of the VAR is reduced directly. To investigate whether the models selected are correctly specified, I finally apply a set of misspecification tests.

An initial set of lag reduction tests suggested that a model reduction to three lags could be accepted in Norway and UK at the 1 pct. level[7]. With three lags in the model for Norway, I could reject the hypothesis of autocorrelation and heteroscedasticity at the 5 pct. level for all variables. For UK, four lags were required to reject the hypothesis of autocorrelation and heteroscedasticity at the 5 pct. level. However, using three lags in Norway and (three or) four lags in UK, I could not reject the hypothesis of normality in the equations for Δo_t in both countries and in the equation for Δs_t in Norway even at the 1 pct. level.

To take care of the non-normality in the equations for Δo_t, two dummies are specified. The first dummy is one in 1986Q1 (D86Q1), corresponding to the collapse of OPEC behaviour and the second dummy is one in 1990Q3 (D90Q3), which is the huge increase in oil prices corresponding to the Gulf War. The non-normality in the equation for Δs_t for Norway seems to stem from the exceptionally high growth rates in the late 1977 and early 1978 in oil and gas extractions. I therefore also include a dummy that is

[7] The SC and HQ information criteria are minimised using one lag in both Norway and UK. To avoid a large number of lags, I use the 1 pct. level as a criteria to select the number of lags using the F-tests.

one in 1977Q4 and 1978Q1 (DD77Q4) for Norway. The dummies will be included in all equations in the VAR models[8].

A new set of lag reduction tests, using the three dummies D86Q1, D90Q3 and DD77Q4 for Norway and the two dummies D86Q1, D90Q3 for UK, confirm that a model reduction from eight to three lags in Norway and eight to four lags in UK, can still be accepted at the 1 pct. level. These test results are seen in table B.1 and B.2 in appendix B. Misspecification tests again suggest that there is no evidence of serial correlations or heteroscedasticity in the residuals in any of the two countries. Non-normality tests can now also be rejected at the 10 pct. levels in both countries. The misspecification tests are seen in table B.3 and B.4.

Inflation is taken to be stationary I(0) in the analysis, whereas manufacturing production, oil and gas extractions and real oil prices are taken to be nonstationary integrated I(1) variables. To test whether the time series properties correspond to these assumptions, I use the augmented Dickey Fuller (ADF) test for unit roots. In neither Norway nor UK can I reject the hypothesis that manufacturing production, oil and gas extractions, real oil prices and prices are I(1). Further, I can reject the hypothesis that manufacturing production, oil and gas extractions, real oil prices and prices are I(2). Hence, Δy_t, Δo_t, Δs_t and π_t, are stationary variables over the sample. In the VAR model specified above, there are no cointegration relations. Using the maximum likelihood estimation procedure advocated by Johansen (1988, 1991), I can confirm that the level of manufacturing production, oil and gas production, real oil prices and inflation (y_t, o_t, s_t, π_t) are not cointegrated[9]. Hence, the VAR model is well specified as described in section four. The results from the unit root and cointegrating tests are seen in table C.1 and C.2 in appendix C.

Finally, in the Y-U model I replace inflation with unemployment (again see appendix A for sources). I use three and four lags for Norway and UK respectively to be consistent with the core model. The same dummies that are used in the core model are also included here. Unemployment is treated as stationary in the analysis. However, in Bjørnland (1996), unemployment was found to be stationary only when I had allowed for a structural break in the trend in 1980Q2 for UK, and in 1988Q2 for Norway. I therefore detrend the data and remove the structural break prior to estimation using the break point in 1980 for UK and 1988 for Norway. Finally, a set of cointegrating tests confirmed that the system is not cointegrating. These results are reported in appendix C.3[10].

5.2. Dynamic Responses in the output-inflation (core) model

The cumulative dynamic effects (calculated from equation 3) 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 1 and 2 respectively, whereas the cumulative dynamic effects of the same shocks on the level of manufacturing production and the GDP deflator in UK are reported in figure 3 and 4 respectively. The figures give the responses to each shock, with a one standard deviation band around the point estimates, reflecting uncertainty of estimated coefficients[11]. The horizontal axis indicates time in quarters, whereas the vertical axis denotes percentage change.

[8] However, as will be discussed later, the results will not be very sensitive to the inclusion of these dummies.

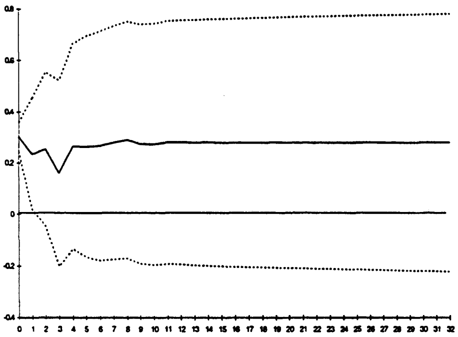
[9] Note that inflation is treated as a stationary variable in the core model, (as unemployment is in the Y-U model), so that when testing for cointegration relations, I use inflation together with the level of manufacturing, energy production and oil prices.

[10] Note that, strictly speaking, the assumptions that π_t and u_t are stationary, nevertheless implies that I should have found one (trivial) cointegrating vector, namely that which has zero coefficients on all variables, except on the stationary variable where it has one, (0,0,0,1). The failure to find this cointegration vector, may be due to the low power of the tests.

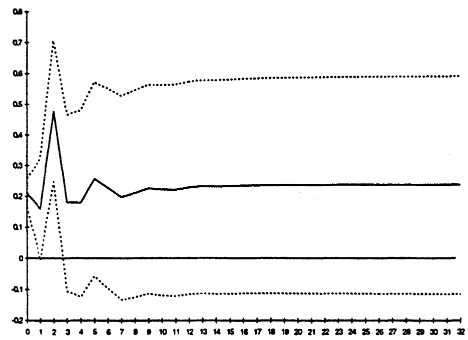
[11] The standard errors reported are calculated using Monte Carlo simulation based on normal random drawings from the distribution of the reduced form VAR. The draws are made directly from the posterior distribution of the VAR coefficients, as suggested in the RATS manual. The standard errors that correspond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

Figure 1. Cumulative impulse response function: Norway Manufacturing Production

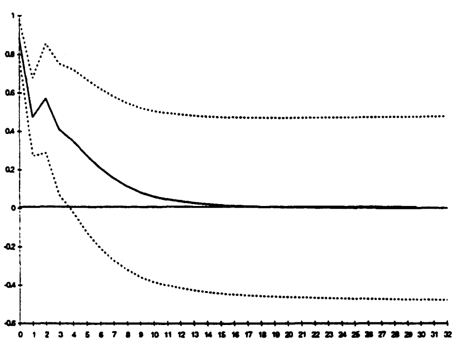
A) Energy Booms



B) Real Oil Price Shock



C) Aggregate Demand Shock



D) Aggregate Supply Shock

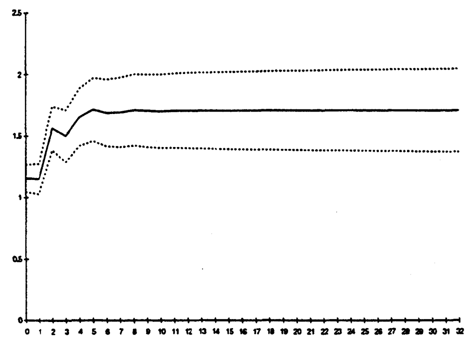
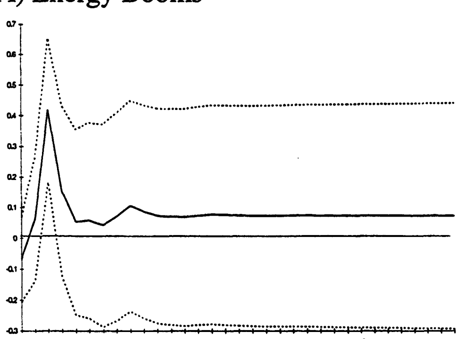
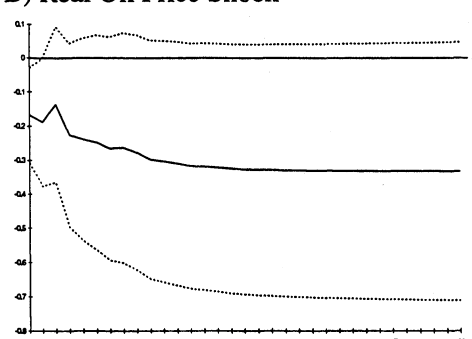


Figure 2. Cumulative impulse response function: Norway price (GDP Deflator)

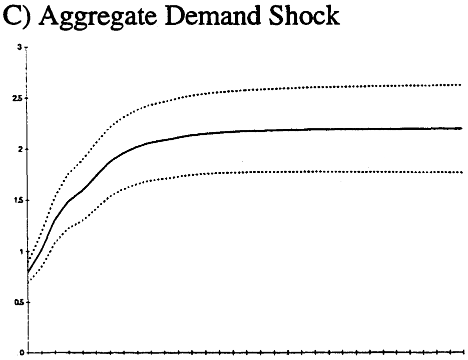
A) Energy Booms



B) Real Oil Price Shock



C) Aggregate Demand Shock



D) Aggregate Supply Shock

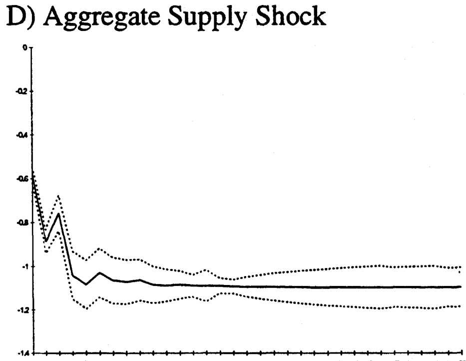


Figure 1 shows that manufacturing production in Norway actually increases in response to a (one unit) energy boom. Similarly, oil price shocks also increase output, and after two years, both shocks have increased manufacturing output with approximately 0.2 pct. However, the wide standard error bands indicate that the response to both types of shocks is not precisely estimated. Nevertheless, the response of output to these two energy shocks indicate that both energy volume and price shocks may actually have benefited the manufacturing sector in Norway, through e.g. increased demand for domestic manufacturing output to the energy sector or through subsidies towards industries (financed by the higher income from the oil sector). Especially, an extensive subsidy programme towards exposed industries was introduced in Norway in the late seventies, to help competitive industries through the international recession, (see e.g. Cappelen et al. 1990 and 1996).

A demand shock increases output in Norway initially as expected, 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. Initially, a unit supply shock increases manufacturing output with 1 pct., but after two years, the effect of a unit shock has stabilised, and manufacturing output has increased by more than 1.5 pct.

In figure 2, an energy volume shock increases the GDP deflator with almost 0.5 pct. for about a year, after which the effect quickly dies out. This is consistent with the Dutch disease where increased demand and production in the economy push inflation and the price level upwards (at least temporarily). A real oil price shock on the other hand, reduces prices with approximately 0.2 pct. However, the standard error band is wide and eventually include zero, indicating that the effect is not precisely estimated after some periods. The negative response of prices to an oil price shock may be due to the fact that the Norwegian currency is a petrocurrency. A petrocurrency is a currency whose value is influenced by the large part oil plays in that country's balance of payments (cf. Rutherford 1992). For Norway whose oil sector is large, the oil price shocks in the 1970s typically led to appreciations of the Norwegian currency. In addition, Norway experienced lower inflation rates than most of her trading partner during the 1970s, and thus experienced a real exchange rate appreciation. An increase in the real price of oil may therefore actually have worked to reduce the price level. Similarly with the huge fall in oil prices in 1986, the Norwegian currency devaluated, thereby pushing the price level upwards.

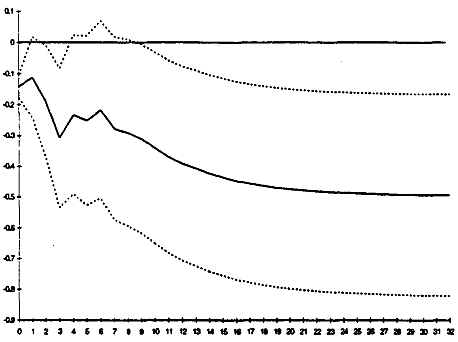
A unit demand shock increases prices permanently with more than 2 pct., whereas a supply shock (that increase output permanently) reduces prices permanently with approximately 1 pct. The overidentifying restrictions suggested by the AD/AS diagram, that demand shocks increase prices permanently whereas supply shocks reduce prices permanently, are therefore supported in the model for Norway.

In figure 3, energy booms reduce manufacturing output in UK in the long run as predicted by the Dutch disease. After eight years, a unit energy volume shock has decreased manufacturing output with approximately 0.5 pct. However, the first two years, the standard error bands include zero, indicating that the effect may be positive or negative initially. A unit oil price shock decreases manufacturing output with about 0.4 pct. after one year, and the effect is stabilised at this point.

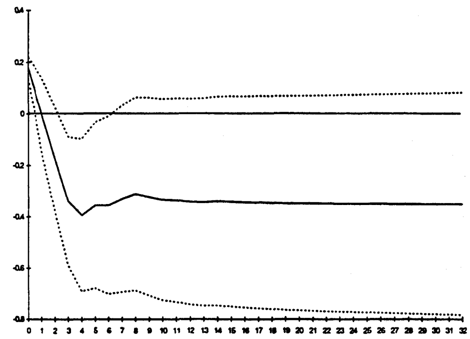
The response of manufacturing output to aggregate demand and supply shocks, mirrors what we saw for Norway. An aggregate demand shock has a positive impact on output, thereafter the effect declines steadily until it vanishes after two to three years. The long run effect of an aggregate supply shock is positive, although the initial impact is much smaller than in Norway. However after four years, manufacturing output has stabilised at a new equilibrium level, 2.5 pct. above its initial level.

Figure 3. Cumulative impulse response function: United Kingdom Manufacturing Production

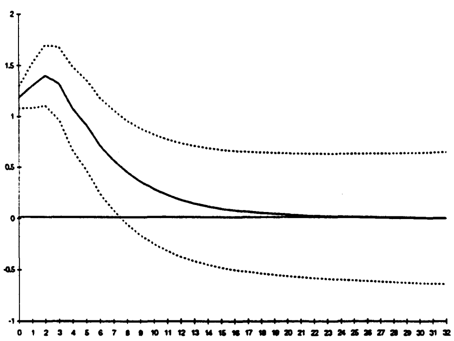
A) Energy Booms



B) Real Oil Price Shock



C) Aggregate Demand Shock



D) Aggregate Supply Shock

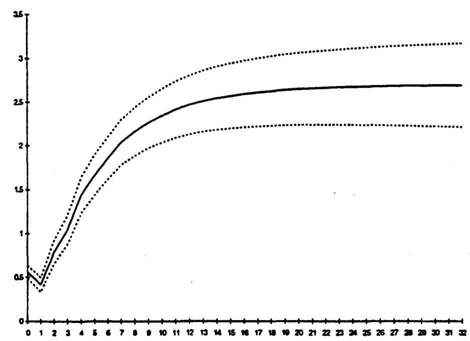
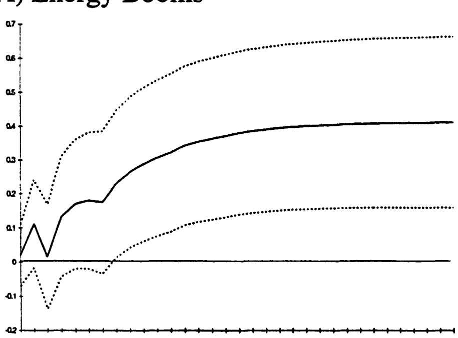
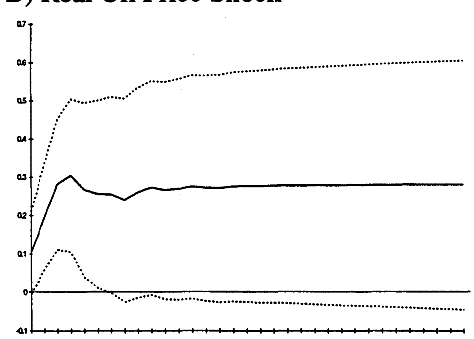


Figure 4. Cumulative impulse response function: United Kingdom price (GDP Deflator)

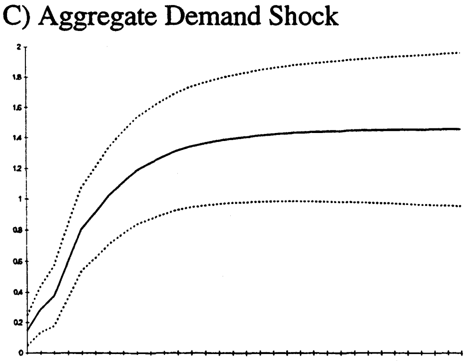
A) Energy Booms



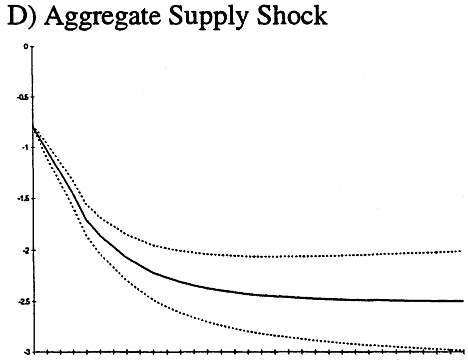
B) Real Oil Price Shock



C) Aggregate Demand Shock



D) Aggregate Supply Shock



In figure 4, energy booms increase the GDP deflator in UK. The effect of an energy boom on prices seems to stabilise around 0.4 pct. after four years. A real oil price shock also increases prices. The effect is largest the first year, where prices have increased with 0.3 pct. Thereafter the effect eventually dies out, and the standard deviation bands include zero after two years. Hence, following an energy boom, prices respond according to the Dutch disease in UK (as in Norway), where the increased activity in the oil sector eventually push the domestic price level upwards. The fact that the oil sector in UK play a relatively small role in the country's balance of payment, may explain why also the price level increased following an oil price shock (whereas in Norway, prices fell as the currency may have appreciated with the higher oil prices).

A unit demand shock increases prices permanently as expected, and after eight years, prices are more than 1 pct. higher. A permanent positive supply shock reduces prices with almost 2.5 pct. after 8 years. Hence, the overidentifying restrictions that positive demand shocks increase prices permanently whereas supply shocks reduce prices permanently, are also supported in the model for UK[12].

The variance decompositions for manufacturing output, inflation and prices are seen in table 2 and 3 for Norway and UK respectively (see Lütkepohl 1993, ch. 2.3.3, for the relevant formulas). Both energy booms and oil price shocks are more important in explaining fluctuations in output, inflation and prices in Norway than in UK, and after two years, the two energy shocks together explain more than 12 pct. of the variance in manufacturing output in Norway, but only 5 pct. of the variance in manufacturing in UK.

In Norway, about 5 pct. of the explained variance in manufacturing is accounted for by energy booms at all horizons. Energy booms explain about 10 pct. of the variation in inflation, although the effect on the price level is virtually zero. Oil price shocks explain more than 7 pct. of the variance in output, but less than 5 pct. of the variation in inflation, and about 2 pct. of the variation in prices. The fact that energy shocks have larger effects on inflation that on prices, emphasises how the volatility in prices are more affected than the price level itself. Demand shocks are less important that supply shocks in explaining variation in manufacturing 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 AD/AS diagram, where wages and prices adjust quickly.

For UK, the negative effects of energy booms on manufacturing output become more important as the horizon increases, although after six years the effect is still small, explaining less than 3 pct. of the variance in manufacturing output. Energy booms have also small effects on inflation and prices, and approximately 3 pct. of the variance in inflation is explained by energy booms. Oil price shocks explain between 2 and 3 pct. 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 also small, explaining between 3 and 4 pct. of the variation the first two years.

In contrast to Norway, demand shocks are more important than supply shocks in explaining output movements the first year in UK, but already after two years, supply movements dominate. The effect on prices (and inflation) in UK are dominated by supply shocks (shocks with permanent effects on output). Hence, in terms of the AD/AS diagram 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.

[12] There is an additional overidentifying restriction that can be tested informally, namely that neither oil and gas extraction nor real oil prices (which are both real variables) should be affected by aggregate demand disturbances in the long run. By examination, the impulse response functions for both Norway and UK show that the effect of demand shocks on oil and gas extraction and real oil prices are not different from zero after some years.

Table 2. 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 3. Variance Decomposition in 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

On the other hand, both Norway and 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, which may have distorted the results reported above. In UK, the 15 pct. increase in VAT on all taxable items in Howe's June budget in 1979, may neither have been captured appropriately by the model, (see Clements and Mizon 1991).

To investigate the sensitivity of the results to these potential structural changes, I constructed a dummy to account for the price controls in Norway (DN), and reestimated the model[13]. The sign and magnitude of the shocks did not change much, except that now demand and supply shocks are almost equally important in explaining output variation initially, but after a year, supply shocks dominate as in the core model. Demand shocks are still the most important factor explaining the variation in price (and inflation). To control for the VAT change in UK, I included a dummy for the third quarter of 1979 (DUK), and reestimated the model. The effects on manufacturing output did not change much, except that initially, demand disturbances are somewhat less important. The largest change were on prices (and inflation), where demand shocks became more important initially, although supply shocks are still the most important factor behind the variation in prices in UK.

Finally, I also tried to leave out all the dummies in the models for Norway and UK, to investigate whether the results are very sensitive to the outliers that was found initially. Overall, the sign and the magnitude of the shocks were virtually unchanged, except for the oil price shocks, which had somewhat less impact on both output and prices after four years in Norway, but somewhat more impact on output and prices in UK at all horizons. However, the signs of the effects of oil price shocks were unchanged. These results implies that although we have included dummies for the outliers in the series for oil prices in both countries and a dummy in the equation for oil and gas extraction in Norway, the results do not essentially change much whether we include these outliers or not[14].

5.3. Dynamic Responses in the output-unemployment model

In figure 5-8 below, I show the impulse responses of energy booms and oil price shocks on manufacturing output and unemployment in Norway and UK, using the *Y-U model.* Note that the vertical axis in the diagram for unemployment measure percentage change. The variance decompositions of all the shocks on manufacturing output and unemployment are thereafter presented[15].

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 impacts on output in Norway. However, the effects of energy booms now decline to zero after approximately three years. Energy booms reduce unemployment temporarily, as demand for labour in the other sectors increase. Real oil price shocks on the other hand, increase unemployment temporarily. This is consistent with Bjørnland (1996), where an adverse oil price shock had positive effects on (non-oil) GDP but increased unemployment temporarily. This may suggest that although the real oil price shock stimulates the economy to the extent that the labour supply and employment increases (as it did in the public sector in Norway in the 1970s), some workers are laid off in other (energy based) sectors, so that total unemployment rises temporarily. However, the effects of both energy booms and oil price shocks on unemployment are small (and not significant).

In UK, energy booms have negative long run effects on output as in the core model, and again the effect may be slightly positive the first year. Oil price shocks have also negative effects on output as in the core model. Both energy booms and oil price shocks increase unemployment in UK. The effects of energy booms is largest the first two years, when unemployment is increased by 0.1 percentage points. The effects of oil price shocks on unemployment are actually negative the first year, but thereafter

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[13] The most important price and wage stops in Norway during the sample I'm investigating, are from September 1978 to December 1979, and from August 1981 to December 1981 (see e.g. Bowitz and Cappelen 1994). I experienced with several dummies to try to capture these price stops, but only the price stop from 1978-1979 turned out to be significant. Eventually, I then constructed a dummy that is 1 in 1978Q3 and 1979Q4, -1 in 1979Q4 and 1980Q1 and 0 otherwise (see appendix A for a further description).

[14] The results using the different dummies (or none), can be obtained from the author on request.

[15] The impulse responses of manufacturing output to demand and supply shocks are not reported, as they are very similar to those reported for the core model, although the magnitude may vary somewhat. As the focus is not on unemployment, the impulse responses of unemployment to demand and supply shocks are neither reported. However, they are consistent with those found in Bjørnland (1996), where demand shocks decreases unemployment (as a mirror response to output) and supply shocks increases unemployment initially, but thereafter unemployment falls.

unemployment increases before it eventually dies out. However as in Norway, the effects of both energy booms and oil price shocks on unemployment are small[16].

The variance decompositions for Norway using the Y-U model indicate that the effects of both energy volume shocks and energy booms are consistent with the core model, although both explain somewhat less of the variation in manufacturing output than in the core model. Supply shocks are the most important factor in explaining output movements after a year, although the first quarter, demand shocks are more important than supply shocks. This is very similar to what I got in the core model, especially when I included a price dummy to account for the price controls in the late 1970s. Supply shocks are the most important factor in explaining unemployment fluctuations initially, but after a while demand shocks become equally important. Only 3 pct. of the variation in unemployment is explained by energy volume shocks after a year, whereas oil price shocks explain only 1-2 pct. of the unemployment variation.

Figure 5. Impulse response functions: Norway Manufacturing Production

A) Energy Booms B) Real Oil Price Shock

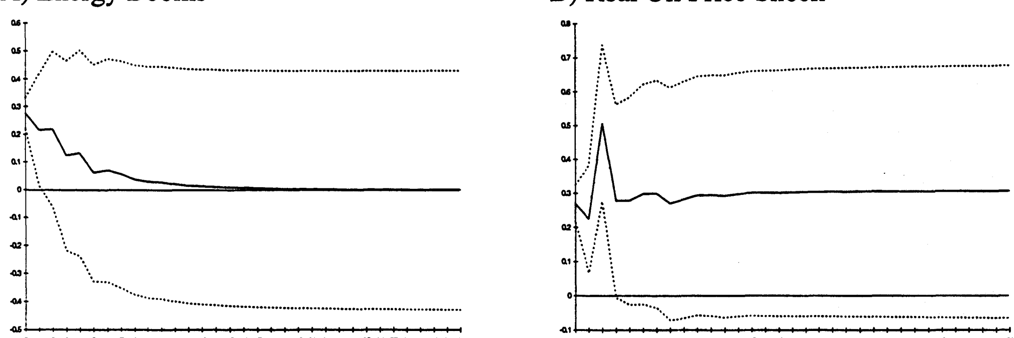
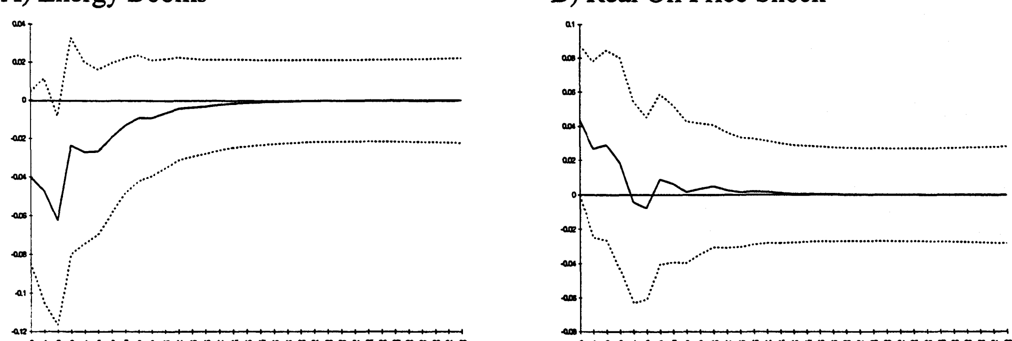


Figure 6. Impulse response functions: Norway Unemployment

A) Energy Booms B) Real Oil Price Shock



For UK, 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 already after one year supply shocks dominate. However, recall that the effect of demand shocks were also reduced somewhat in the core model, when I included a dummy for the VAT change in 1979. Supply shocks are the most important factors behind the variation in unemployment in UK the first year, but thereafter demand shocks dominate, explaining more than 60 pct. of unemployment variation after two years. Energy booms

[16] The reason that unemployment falls initially after an oil price shock, may be due to the fact that we have removed the mean from unemployment in 1980, at the same time as the second oil price shock occurred. In a previous version of this paper, I performed the analysis without removing the mean in unemployment in 1980, and found the effect of oil price shocks on unemployment to be positive already after three quarters (although the effect was still small).

explain about 4 pct. of the variation in unemployment after two years, whereas oil price shocks explain almost 5 pct. of unemployment variation after two years (when oil prices have increased unemployment).

To sum up, there is no evidence of a Dutch disease in Norway using either the output-inflation or the output-unemployment model, and both energy booms and oil price increases stimulate the economy so manufacturing production increases (at least temporarily). Real oil price shocks are the most important (positive) contributors 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. Energy booms also reduce unemployment, although following a real oil price shock, unemployment increases marginally. Although there is no evidence of a Dutch disease in terms of a reduction in the real activity, prices on the other hand, behave more in line with the Dutch disease hypothesis. An energy boom will typically increase prices, whereas following a real oil price shock, prices fall, as the increase in oil prices have appreciated the Norwegian (petroleum) currency, thereby working to reduce the price level.

Figure 7. Impulse response function: United Kingdom Manufacturing Production

A) Energy Booms B) Real Oil Price Shock

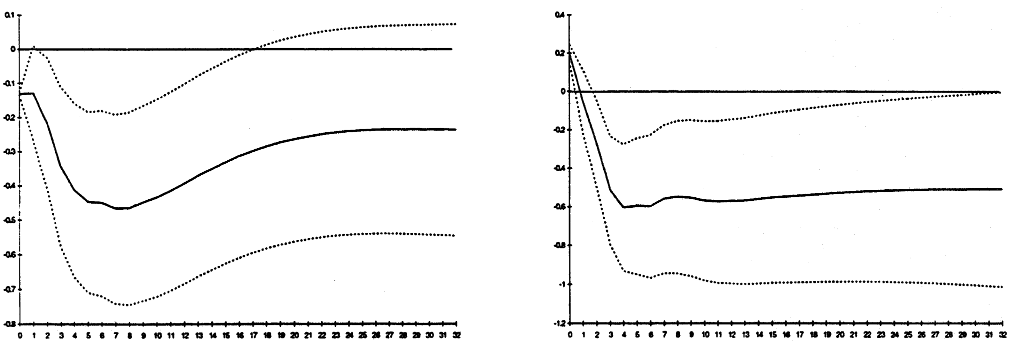
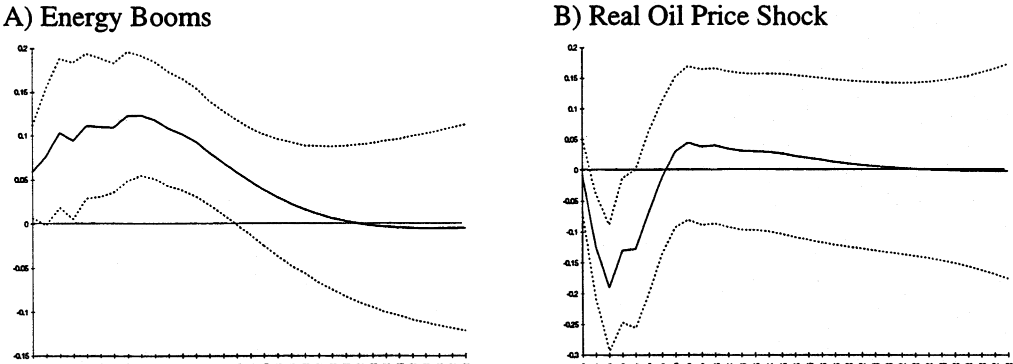


Figure 8. Impulse response functions: United Kingdom Unemployment

A) Energy Booms B) Real Oil Price Shock



For UK, there is evidence of a Dutch disease in the long run (six to eight years), although the economy may respond positively to energy booms the first two years. However, the negative effect on manufacturing is small, and most of the decline in manufacturing in UK, stem probably from factors other than the North Sea oil. Oil price shocks (that increase oil prices) have also negative effects on manufacturing output, and both energy booms and oil price shocks increase prices and unemployment (at least temporarily).

The fact that in UK, manufacturing output decreased, whereas in Norway, manufacturing output 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 UK, macroeconomic policy has also been conducted very differently in light of the two major oil price shocks in Norway and UK. In Norway, there were deliberate subsidies to maintain manufacturing output over the transitional period of North Sea oil, and as a result, unemployment has remained much lower in this period. A similar benefit could probably have been derived in UK, from direct investment of the oil revenues in industries. Instead, with factory closures and rapidly increasing unemployment rates from 1979 in UK, much of the revenues from the North Sea oil went into social security in addition to payment of already existing external debts, (see e.g. the discussions in Mayes and Soteri 1994, pp. 383-386).

Table 4. Variance Decomposition in Norway

Quarters	ES-shock	OP-shock	AD-shock	AS-shock
Manufacturing				
1	3.7	3.5	69.2	23.6
4	2.4	5.8	43.7	48.2
8	1.3	4.8	25.8	77.7
16	0.9	4.3	12.5	82.7
32	0.3	4.0	5.9	89.8
Unemployment				
1	1.4	1.6	31.6	65.4
4	3.0	1.3	38.3	57.6
8	2.9	1.1	45.9	50.1
16	2.9	1.1	47.1	49.0
32	2.9	1.1	47.1	49.0

Table 5. Variance Decomposition in United Kingdom

Quarters	ES-shock	OP-shock	AD-shock	AS-shock
Manufacturing				
1	0.9	2.1	47.3	49.7
4	1.6	3.0	26.9	68.5
8	2.9	5.1	16.3	75.7
16	3.1	5.7	8.5	82.7
32	2.3	6.1	4.5	87.1
Unemployment				
1	1.7	0.0	38.7	59.6
4	2.7	6.5	47.9	42.9
8	4.2	4.7	65.7	25.4
16	6.4	4.1	66.3	23.2
32	6.6	4.2	65.8	23.5

How do these findings correspond to previous empirical studies of the Dutch disease?[17] The results for Norway are consistent with simulation studies in Bye et al. (1994) and Cappelen et al. (1996). Bye et al. (1994) find a positive effect on manufacturing production and employment from energy booms (measured by increases in investment or intermediate input in the energy sector), even in the long run (after 7 years). They also find unemployment to have fallen in response to energy booms, and prices to have risen marginally. This is also supported in Cappelen et al. (1996), although they show in addition that whereas the sheltered industries have increased production over the sample (1973-1993), some export competing industries eventually loose out. Hutchison (1994), also finds positive effects of

[17] Generally, there are some problems in comparing the results from the VAR model with these simulation studies, as the results in the simulation studies will vary with the specifications of the models (as with all empirical studies). Especially, the effect of a Dutch disease is often measured by comparing the historical path (the economy with the oil sector) with the economy without the oil sector, and will thus depend on the assumptions about the appropriate policies and actions when there are no oil sector.

energy booms on manufacturing output, at least in the medium term (1-3 years). He further shows that oil price shocks increase manufacturing output with about 0.3 pct. the first two years[18].

The deflationary (but small) effects on manufacturing output in UK of the oil and gas discoveries, supports the early findings in Forsyth and Key (1980), who using a simple quantification method, was one of the first studies of the Dutch disease in UK to find a negative effect on manufacturing output from energy production. Bruno and Sachs (1982) using a dynamic perfect foresight equilibrium model, also find effects of the Dutch disease in UK. The size of this effect typically depends on the government budget policies concerning the redistribution of oil tax revenues to the private sector. However, as the authors themselves emphasise, the model is not accurately parameterized and may therefore not depict the behavioural relationship in UK exactly.

On the other hand, Atkinson et al. (1983) and Bean (1987), find no negative effects from energy production on manufacturing, and in some cases manufacturing output has actually increased. Hutchison (1994) also finds energy booms to have positive effects on manufacturing in UK in the short to medium term (he does not report any effects after 4-5 years). These results essentially come from the cointegration restrictions he has imposed, but for UK he finds three cointegration vectors, so the point estimates of the cointegrating vectors may not be directly interpretable without further identifying assumptions. Note, however, that the fact that there may be *short term* positive effects on manufacturing production from energy discoveries during a transition period, could be supported in the findings above, (cf. figure 3 and 7), although in the *long run*, the effects were negative. On the other hand, the sample used in Atkinson et al. (1983), Bean (1987) and Hutchison (1994), ended in the middle 1980s, when UK's oil production was at its peak[19]. As seen in table 1, oil production in UK has declined steadily since then, and as expected by the Dutch disease hypothesis, it is first now we will see the symptom of the Dutch disease. Finally, the fact that oil price shocks reduce manufacturing output is widely supported in studies analysing the effects of oil prices on the British economy, (e.g. Bruno and Sachs 1982, Bean 1987, Hutchison 1994, and Bjørnland 1996)[20].

6. Sources of business cycles implied by the VAR model

Until now, I have discussed the responses of manufacturing to the different shocks on average over the whole period. In the remaining part, I focus instead on short term fluctuations in each historical period. This will give us an idea of which shocks are the most important in the different time periods. To focus on specific historical periods, I compute the forecast errors in output. That is, output is decomposed according to (3), using an (eight quarter) weighted average of the estimated shocks, with the weights given by the impulse responses. The decomposition is based on the following partition (cf. Lütkepohl 1993, ch. 2.3.3):

(10) $$z_{t+j} = \sum_{s=0}^{j-1} D_s \varepsilon_{t+j-s} + \sum_{s=j}^{\infty} D_s \varepsilon_{t+j-s}$$

[18] However, Hutchison (1994) is imprecise in some of his statements, as he argues that «the estimated cointegrating vectors...act as long-run constraints on the system dynamics», (see Hutchison, 1994, p.322). This is misleading, as the cointegrating vectors only tell us something about the covariation between the *individual* time series, and do not act as constraints on the *system* in the sense the identifying (long run) restrictions used here do. The LR response of industrial production from energy booms can therefore not be found by interpreting the cointegrating vectors alone. This is clearly illustrated for Norway, where, although the (normalised) cointegrating vector has a positive coefficient between energy booms and industrial production, (see Hutchison, 1994, table 4), the impulse response of manufacturing output to energy booms is both positive and negative the first five years (after which the response is not reported), (see Hutchison, 1994, figure 1).

[19] The sample in Hutchison (1994) ended in 1989.

[20] Bean (1987) shows that the effects of the two oil price shocks in the 1970s *together* with the oil and gas discoveries, work to depress the economy so manufacturing output decreases and unemployment increases.

The first sum represents the part of z_{t+j} that is due to innovations in period t+1 to t+j. The second sum is the dynamic forecast (base projection) of z_{t+j}, based on information given at time t. The gap between each data series and its base projection, can be assessed in terms of the contributions of the innovations of each series in the analysis (the forecast error). The results are presented in figure 9 and 10 for Norway and UK respectively. In panel 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. As the variables are in logarithms, these plots can be interpreted as pct. deviation from a «trend». In 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[21].

Above we have seen that although the responses of manufacturing in the output-inflation and the output-unemployment models are consistent with regard to the sign of the different shocks, they differ somewhat with respect to the magnitude of the shocks, at least for demand and supply shocks. As the demand and supply shocks are aggregate shocks, they will typically vary somewhat when identified using two different models. Especially, the demand and supply shocks identified in the core and the Y-U model may not be exactly the same in the short run, especially if there are structural/regime changes, like the price controls or VAT changes discussed above. As unemployment seems to be a more «unregulated» cyclical variable than inflation, I continue the analysis using the Y-U model. However, the main results are basically the same using either of the two models, although the magnitude of the shocks will differ somewhat in some periods. For comparison, I have graphed the forecast error in manufacturing output due to energy booms and oil price shocks using the core model in appendix D.

To organise the discussion, I divide the sample in Norway into four sub periods, which corresponds approximately to the start and end of two booms and two recessions in the mainland economy (cf. Bjørnland 1995, 1996, and Cappelen et al. 1996). From 1979 to 1981, the economy is booming, thereafter follows a recession from 1982 to 1984, before the economy is again booming in 1985-1987. From 1988 to (1990) 1993, follows a new recession (and a start of a recovery).

1979-1981 Positive energy booms (from increased extractions of oil and gas resources) and higher oil prices due to the adverse oil price shocks, were important contributors towards the boom in manufacturing output in this period. Demand shocks were also positive, as the government pursued accommodating policies in this period. However, the boom in manufacturing is short lived, and from 1981, negative supply shocks hit the economy. This can be seen in figure 9.D, where both manufacturing and the supply potential are on a downward trend from 1981, probably due to a loss of competitiveness.

1982-1984 Energy production is declining in this period, and reaches a trough in 1982 (cf. figure A.1. in appendix A). The negative stimulus from the fall in activity in the energy sector can be seen by a series of negative energy shocks in this period. Oil price shocks play virtually no role in this recession. However, the main contributor later in this recession, is a series of negative demand shocks. The recession is short-lived, which can be seen in figure 9.D, where manufacturing falls below the supply potential only for a short period.

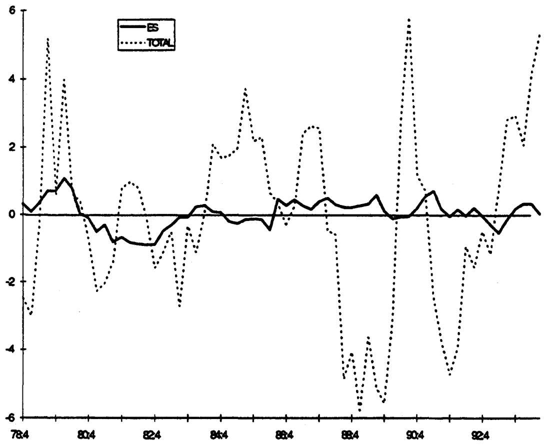
1985-1987 From 1985, the mainland economy in Norway is stimulated from a demand led boom, set off primarily by the financial deregulation in 1984/1985 (see e.g. Bjørnland 1996). The boom in manufacturing in this period is also mainly demand driven, although he supply potential is also increasing. The increase in the supply potential may be due to a series of permanent shocks in the mid 1980s, among other the large investments in the Mognstad refinery. Energy booms are almost

[21] 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.

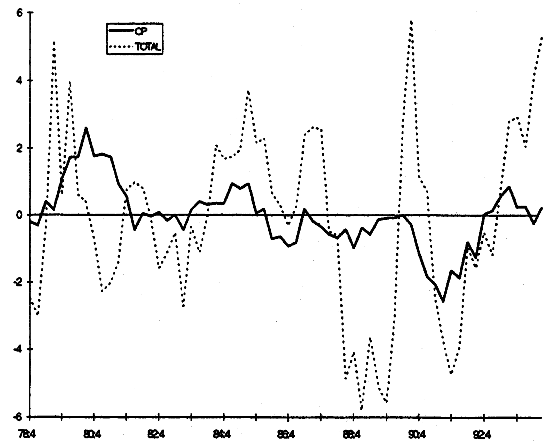
negligible in this period, although using the output-inflation model, energy booms are somewhat more emphasised as positive contributors in this boom (see figure D.1.A in appendix D). From 1986, the fall in oil prices contribute negatively to manufacturing production, and from 1987, the economy slows down.

Figure 9. Forecast error decompositions for Manufacturing production in Norway

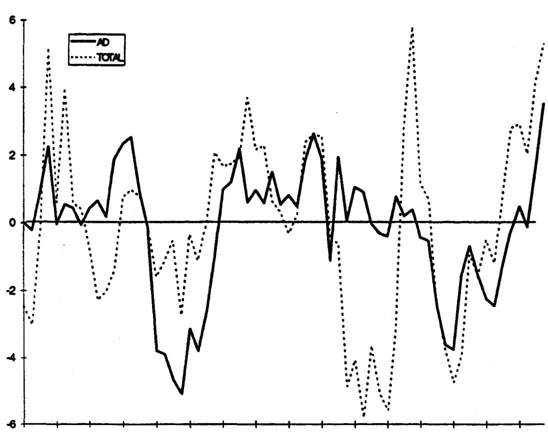
A) Energy boom component, pct. change



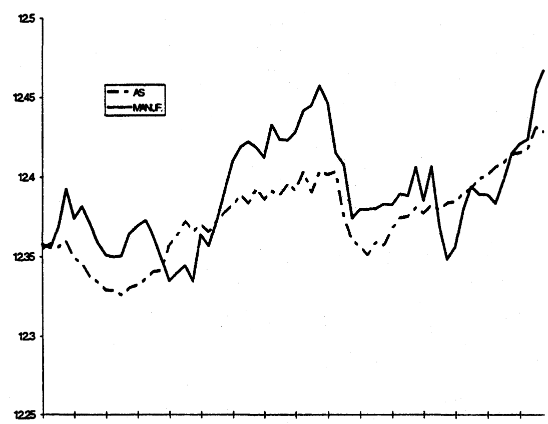
B) Oil price component, pct. change



C) Aggregate demand component, pct. change



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



1988-(1990) 1993 From 1988 to 1990, manufacturing falls drastically. This is driven by an equal severe decline in the supply potential, as a series of negative productivity shocks (accumulating in several shut downs of firms) hit the economy. Demand shocks eventually become negative in this period, but the recession is by far dominated by the negative supply shocks (this is robust using either the output-inflation or the output-unemployment model). The timing of the downwards shift in manufacturing output, corresponds well with the timing of the break upwards in the unemployment rate in 1988Q2 (cf. section 5.1). Energy booms contribute positively during this period, but the effect is very small.

The economy is improving somewhat by 1990, but from 1991, manufacturing output falls again. This time, negative demand shocks (from low international demand) and negative oil prices shocks (from a low oil price) trigger off the recession (again, this is robust using either of the two models, see figure D.1.A in appendix D). From 1993, the economy is improving, with both positive demand and supply shocks hitting the economy.

To sum up, whereas energy booms contribute positively towards the 1979-1981 boom and negatively towards the 1982-1984 recession, they play only small but positive roles in the 1985-1987 boom and the 1988 - (1990) 1993 recession. Oil price shocks are also contributing positively towards the boom in the late 1970s, but in contrast to energy volume shocks, oil price shocks are large negative contributors towards the recession from 1988, (as low oil prices erodes the economy of income).

Until now, I have analysed the effects of energy booms as volume shocks to energy production. As discussed in section four, these booms may have both direct and indirect effects on the economy. The most important direct effects from an energy boom, take the form of increased demand for investment and labour in the energy sector. For Norway, where approximately 20 pct. of GDP are oil and gas extractions, demand effects from the petroleum sector may be important contributors towards the mainland activity. In Cappelen et al. (1996), the effects of energy booms on the cycles in Norway are measured by (among other) comparing a smooth path for (accrued) investment in the petroleum sector, with actual investment[22]. Generally, they find these energy booms to contribute positively with approximately 20 pct., towards the cycles in manufacturing (value added). Especially, they show the recession in 1980-1984 and the boom in 1985-1987 to be highly influenced by the activity in the energy sector, although, consistent with the findings above, energy booms play no role in the recession in the late 1980s (see Cappelen et al. 1996, pp. 71-74).

To compare these findings with mine, I perform a final exercise for Norway, where I replace extraction of oil and gas, (s), with accrued investments, (i), in the VAR model[23]. Generally, I find the results from above to be virtually unchanged, and no more than 5 pct. of the explained variation in manufacturing output is accounted for by energy booms using either the core or the Y-U model. However, when the effect of the shocks are analysed in each time period, I find somewhat more support for the positive contribution of energy booms also in the period 1983-1986 (see figure D.2. in appendix D), indicating that the direct demand effects from increased investment in platforms etc., contribute positively towards the boom in manufacturing industry also in the mid 1980s. However, oil price shocks are still more important contributors than energy booms over the sample, especially in accounting for the recession in the late 1980s. Hence, the direct demand effects from changes in investment in platforms on manufacturing are larger in Cappelen et al. (1996), than what I could find here using an estimated VAR model. On the other hand, as they have not separated out the effects of oil price shocks from energy booms, they may have underestimated the wealth effects following changes in the oil price, on the activity in the manufacturing sector.

The results for UK are seen in figure 10. Again I organise the discussion around four periods, which have characterised the mainland economy; The economy is at a peak in June 1979, thereafter follows a recession in 1980-1983, a recovery in 1984-1986, a boom in 1987-1990, and a recession in 1991-1994 (see e.g. Artis et al. 1995 and Bjørnland 1996)[24].

1979-1983; When the Thatcher government took over in 1979, on of its primary aims was to reduce inflation by tight monetary control. From 1979/1980, the new government announced severe monetary policy tightening, and public expenditure cuts. The economy started to drop from the end of 1979, and with further fiscal tightening from 1981, the effects on the economy were huge. Output fell drastically, especially manufacturing output which decreased by more than 15 pct. during 1980, and unemployment rose by more than 1 million in a year.

[22] Production in the energy sector will depend on capital in that sector, so the activity is fully supply side determined. By determining the level of investment, the capital in the energy sector will also be determined, hence demand for labour and production will be decided.

[23] See appendix A for definitions and a plot of the series. Three lags and the two dummies DD86Q1 and D90Q3 are used in the model to be consistent with the core model. A test for cointegration confirms that the system is not cointegrating.

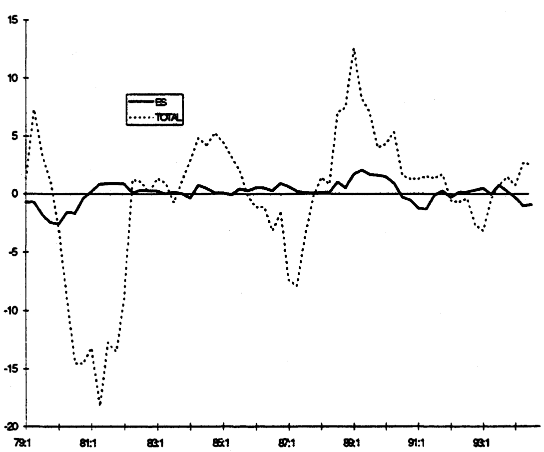
[24] Artis et al. (1995) dates peaks (preceded by recovery) and troughs (preceded by recession) in industrial production in UK.

The effects of these shocks on manufacturing can clearly be seen in figure 10. Adverse supply shocks contribute mostly to the decline in manufacturing output, by shifting down the supply potential (cf. figure 10.D). These negative permanent «supply shocks» have had long lasting negative effects on the economy, and may indicate a loss of competitiveness through a longer term negative trend (see e.g. Flemming 1982, Buiter and Miller 1983 and Mayes and Soteri 1994, for similar arguments). The timing of this downwards shift in output, corresponds well with the timing of the break upwards in the unemployment rate in 1980Q2 (cf. section 5). However, the results reported here are robust using also the output-inflation model.

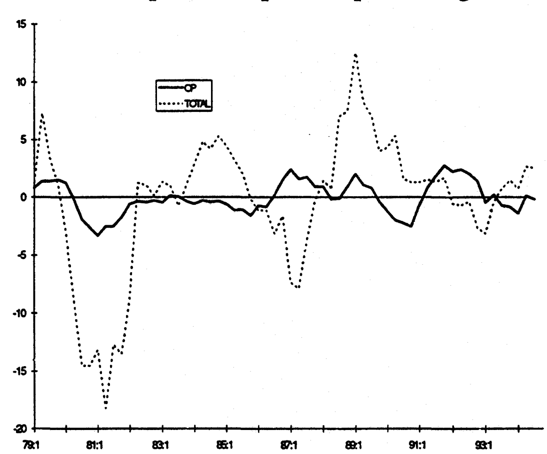
Energy booms are also negative early in this period, as energy production is taken out at a very high speed (cf. figure A.2. appendix A). However as seen in figure 10A, they play only a small role compared to the negative supply shocks that hit the economy from 1980. Higher oil prices due to the adverse oil price shocks from 1980, are also negative contributors in this recession, (see also figure D.1.B in appendix D).

Figure 10. Forecast error decompositions for Manufacturing production in United Kingdom

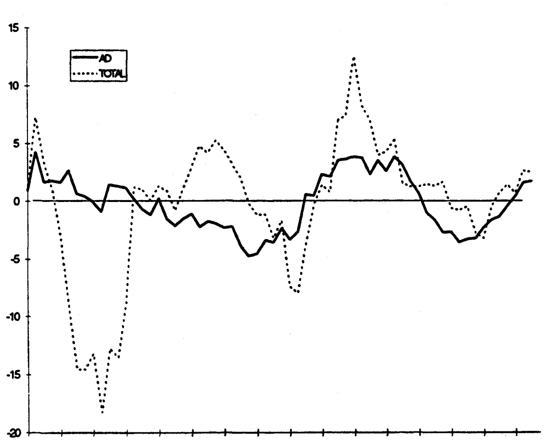
A) Energy boom component, pct. change



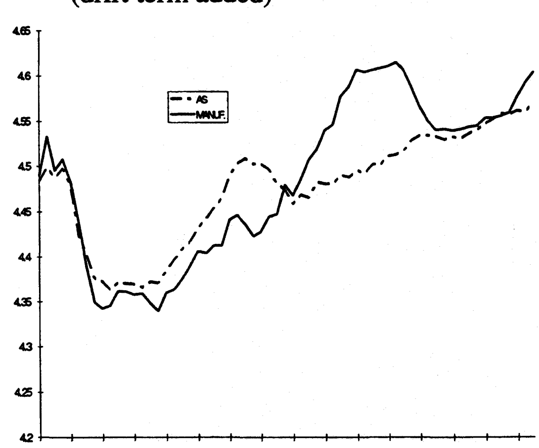
B) Oil price component, pct. change



C) Aggregate demand component, pct. change



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



1984-1986; By 1984, the economy starts to recover. Positive supply shocks (from increased productivity growth) drive the «supply potential» above manufacturing output. However, demand is still slow, and by 1986, the supply potential shifts down again and the economy contracts. Energy booms and oil price shocks play virtually no role in this mid 1980s «recovery» period.

1987-1990; During this period, manufacturing is booming, driven primarily by positive demand shocks, but the fall in oil prices is also a positive contributor towards manufacturing production early in this period. The «supply potential» behaves like a stable (linear) trend from now on (cf. figure 10.D).

1991-1994; From 1990/1991 manufacturing slows down again, primarily due to a series of negative demand shocks as the international economy is slowing down. However, by the end of this period, the economy starts to recover somewhat with positive demand shocks hitting British manufacturing.

Hence, in contrast to Norway, energy booms play little role in short term movements in UK, which is not surprising, as the effects of energy booms are largest in the long run (cf. table 3 and 5). However, the main contributors towards the observed decline in manufacturing, are the negative supply shocks that hit the economy from 1980 and periods of low demand in several periods in the 1980s.

7. Conclusions

There is no evidence of a Dutch disease in Norway, and both energy booms and oil price increases stimulate the economy so manufacturing production increases. 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, as the Norwegian currency appreciates with a high price of oil.

When the impacts of the shocks are analysed in different time periods, energy booms contribute positively towards the 1979-1981 boom and negatively towards the 1982-1984 recession, but play only small roles from the middle 1980s. Oil price shocks also contribute positively towards the boom in the late 1970s, but in contrast to energy volume shocks, they are large negative contributors towards the recession from 1988, (as low oil prices erodes the economy of income).

There is weak evidence of a Dutch disease in the long run in UK, but energy booms play a little role in the short term movements in UK. However, the (long run) negative effect on manufacturing is small, and most of the decline in manufacturing in UK, stem probably from factors other than the North Sea oil. Oil price shocks have also negative effects on manufacturing output in UK.

Demand and supply shocks have the effects as suggested by economic theory in both countries. A demand shock increases output and reduces unemployment temporary, whereas prices increase permanently. Following a supply shock, output increases and prices fall permanently. Supply shocks are the most important contributors towards the variation in manufacturing output (after a year) in both countries, and the severe recessions in the early 1980s in UK and the late 1980s in Norway, are mainly driven by negative supply shocks.

Finally, note that the limited number of variables and the aggregate nature of the shocks, implies that the estimated VAR model should be regarded as an approximation to a larger structural system. Some insight is also lost by treating manufacturing as an aggregate. Although I find manufacturing output in Norway to be benefited from the North Sea oil, the heterogeneity of the manufacturing sector implies that I do not know whether new industries geared towards the oil sector may have been created, at the expense of some of the traditional export oriented industries, (this was supported in Cappelen et al. 1996). In a different study, Klette and Mathiassen (1996) show that the manufacturing sector in Norway is in fact very flexible, and on average (1976-1986), 8.4 pct. of the jobs in the manufacturing industry was destructed each year, whereas 7.1 pct. of manufacturing employment was created each year.

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Appendix A. 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 1976Q1 to 1994Q3. All variables are measured in natural logarithms, except the unemployment rate.

Norway:

(y) GDP Manufacturing sector. *Source: Statistics Norway*
(s) GDP Oil and gas extraction. *Source: Statistics Norway*
(p) GDP deflator mainland Norway. *Source: Statistics Norway*
(o) Real oil prices measured in Norwegian kroner; Nominal oil prices in U.S. dollars per barrel, converted to Norwegian kroner and deflated by the consumer price index in Norway;

Nominal Oil price: 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*
Exchange rate, mth. avg. NOK/USD, (n.s.a.). *Source OECD.*
Consumer Price Index. *Source: Statistics Norway*

(u) Unemployment rate. *Source: Statistics Norway*
(i) Accrued investments in the petroleum sector (investment in the petroleum sector plus the change in the stock of platforms in progress). *Source: Statistics Norway*

(D86q1) Impulse dummy, 1 in 1986Q1, 0 otherwise
(D90q3) Impulse dummy, 1 in 1990Q3, 0 otherwise
(DD77Q4) Impulse dummy, 1 in 1977Q4-1978Q1, 0 otherwise
(DN) Composite dummy, 1 in 1978Q3, 1978Q4, -1 in 1979Q4, 1980Q1, 0 otherwise

United Kingdom:

(y) Industrial production: Manufacturing, (quarterly average from monthly averages), index 1990=100. *Source: Datastream*
(s) Industrial production: Oil and gas extraction, (quarterly average from monthly averages), index 1990=100. *Source: Datastream*
(p) GDP deflator. *Source: Datastream*
(o) Real oil prices measured in GBP; Nominal oil prices in U.S. dollars, converted to GBP and deflated by the consumer price index;

Nominal Oil price: (See above)
Exchange rate, mth. average GBP/USD, (n.s.a.). Source OECD.
Consumer Price Index. *Source: Datastream*

(u) Unemployment rate, total labour force. *Source: OECD*

(D86q1) Impulse dummy, 1 in 1986Q1, 0 otherwise
(D90q3) Impulse dummy, 1 in 1990Q3, 0 otherwise
(DUK) Impulse dummy, 1 in 1979Q3, 0 otherwise

Figure A.1. Norway: Oil and Gas extractions (logarithms)

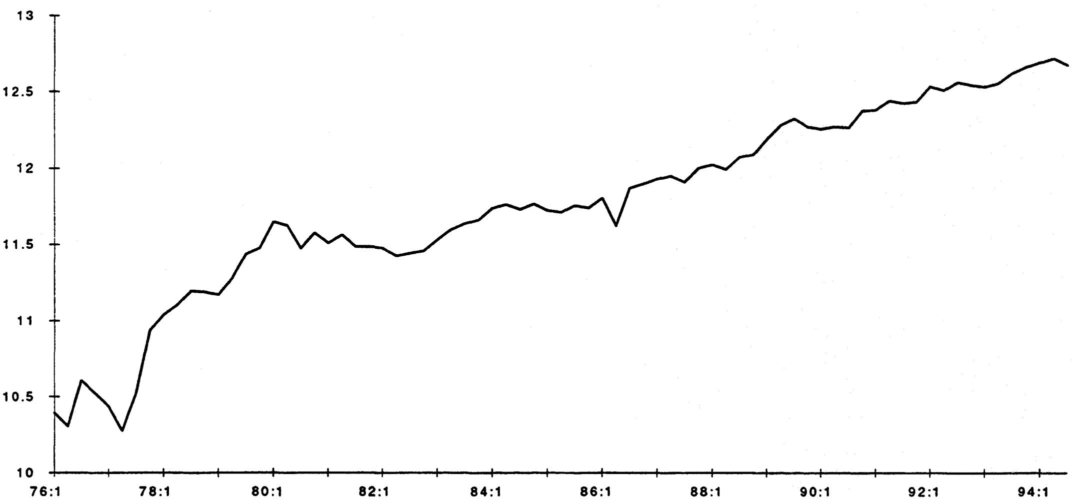


Figure A.2. Norway: Accrued Investment (logarithms)

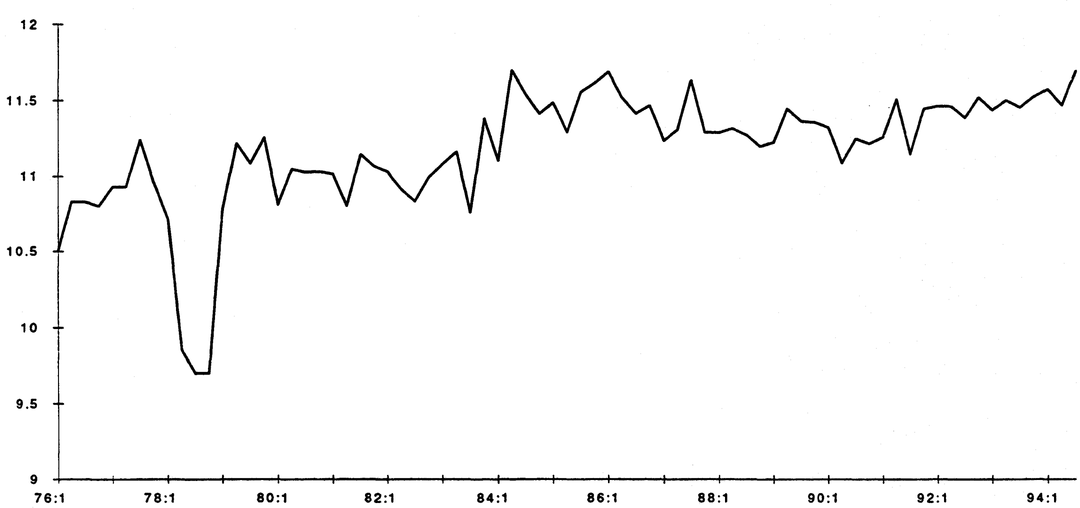
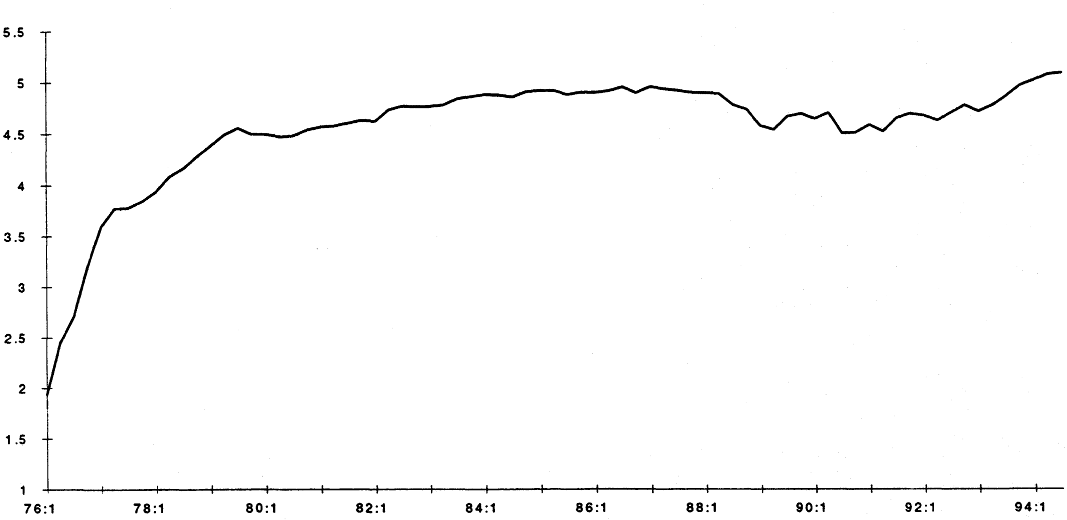


Figure A.3. UK: Oil and Gas extractions (logarithms)



Appendix B. Model specifications - Determination of lag order and misspecification tests

Table B.1. Norway: Information criteria and F-tests for model reductions (core model)[a]

Lags	SC	HQ	Sequential F-tests	p-value	Direct F-tests	p-value
8	-21.75	-24.61				
7	-22.15	-24.70	F(16, 86) = 1.16	0.313	F(16, 86) = 1.16	0.313
6	-22.87	-25.10	F(16, 98) = 0.60	0.874	F(32, 104) = 0.89	0.641
5	-23.34	-25.25	F(16, 110) = 1.32	0.198	F(48, 109) = 1.02	0.458
4	-23.95	-25.54	F(16, 122) = 1.07	0.394	F(64, 111) = 1.03	0.437
3	-24.35	-25.62	F(16, 135) = 1.84	0.032	F(80, 112) = 1.19	0.193
2	-24.62	-25.57	F(16, 147) = 2.51	0.002	F(96, 113) = 1.44	0.032
1	-25.62	-25.65	F(16, 159) = 2.20	0.007	F(112,113) = 1.61	0.006

a) SC reports the Schwarz information criteria, HQ reports the Hannan-Quinn information criteria, sequential F-test with corresponding p-value reports the sequential model reductions (8→7,...,2→1 lags), direct F-test with corresponding p-value reports the direct model reductions (8→7, ..., 8→1 lags). All test-statistics are calculated using PcFiml 8.0 (see Doornik and Hendry 1994).

Table B.2. United Kingdom: Information criteria and F-tests for model reductions (core model)[a]

Lags	SC	HQ	Sequential F-tests	p-value	Direct F-tests	p-value
8	-22.78	-25.59				
7	-23.38	-25.87	F(16, 86) = 0.79	0.691	F(16, 86) = 0.79	0.691
6	-23.41	-25.57	F(16, 98) = 2.34	0.006	F(32, 104) = 1.52	0.060
5	-23.98	-25.82	F(16, 110) = 1.08	0.382	F(48, 109) = 1.41	0.072
4	-24.50	-26.03	F(16, 122) = 1.35	0.181	F(64, 111) = 1.43	0.049
3	-25.18	-26.39	F(16, 135) = 0.98	0.485	F(80, 112) = 1.37	0.062
2	-25.66	-26.54	F(16, 147) = 1.78	0.039	F(96, 113) = 1.48	0.023
1	-26.00	-26.56	F(16, 159) = 2.45	0.003	F(112,113) = 1.69	0.003

a) For a description of the tests, see table B.1

Table B.3. Misspecification tests, Norway [a]

A. Single equations

Test	Statistic	Δy	Δo	Δs	π (=Δp)
AR 1-5[b]	F(5,50)	1.57	2.10	1.14	0.42
		[0.19]	[0.08]	[0.35]	[0.83]
ARCH 4[c]	F(4,47)]	1.06	0.24	0.48	0.31
		[0.39]	[0.91]	[0.75]	[0.87]
White-Het.[d]	F(24,30)	1.14	1.18	0.96	1.62
		[0.37]	[0.33]	[0.54]	[0.10]
Normality [e]	X^2 (2)	1.54	2.80	1.78	1.75
		[0.46]	[0.25]	[0.41]	[0.42]

a) The number in brackets are the p-values of the test statistics. All statistics have been calculated using PcFiml 8.0 (see Doornik and Hendry 1994).

b) LM test for residual autocorrelation of order 5

c) LM test for 4th order ARCH in the residuals

d) Test for residual heteroscedastisity due to White (1980)

e) Test of normality due to Shenton and Bowman (1977), see Doornik and Hansen (1994) for a description.

B. VAR system (core model)[a]

Test	Statistic	VAR
AR 1-5[b]	F(80,128)	1.37
		[0.06]
White-Het.[c]	F(240,219)	1.12
		[0.19]
Normality[d]	X^2 (8)	6.12
		[0.63]

a) The number in brackets are the p-values of the test statistics.
All statistics have been calculated using PcFiml 8.0 (see Doornik and Hendry 1994).
b) LM test for residual autocorrelation of order 5
c) Test for residual heteroscedastisity due to White (1980)
d) Test of normality due to Shenton and Bowman (1977), see Doornik and Hansen (1994) for a description.

Table B.4. Misspecification tests, United Kingdom[a]
A) Single equations

Test	Statistic	Δy	Δo	Δs	π (=Δp)
AR 1-5	F(5,46)	1.20	0.88	0.14	2.42
		[0.32]	[0.50]	[0.98]	[0.05]
ARCH 4	F(4,43)	1.39	0.24	2.01	0.14
		[0.25]	[0.91]	[0.11]	[0.97]
White-Het.	F(32,18)	0.55	0.80	0.85	0.88
		[0.93]	[0.72]	[0.67]	[0.63]
Normality	X^2 (2)	3.45	0.45	2.66	3.01
		[0.18]	[0.80]	[0.26]	[0.22]

a) For a description of the tests, see table B.3.A

B) VAR system (core model)[a]

Test	Statistic	VAR
AR 1-5	F(80,112)	1.59
		[0.02]
White-Het.	F(320,113)	0.48
		[1.00]
Normality	X^2 (8)	12.20
		[0.14]

a) For a description of the tests, see table B.3.B

Appendix C. Test for unit roots and cointegration

Table C.1. Augmented Dickey Fuller unit-root tests (1978:2-1994:3)[a]

	t-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*
π (=Δp)	ADF(2)	-2.91**	ADF(1)	-3.02**

a) The critical values for the full sample Augmented Dickey Fuller statistic was taken from Fuller (1976) table 8.5.2 p 373. A time trend and a constant are included in the regression of the level of y, o, s and p, whereas in the regression using first differences, a constant (but no time trend) is included in the regression. The number of lags used in the ADF tests 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 C.2. Johansen cointegration tests (core model)[a]
Cointegrating vector (y_t, o_t, s_t, π_t)

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≥1	27.07	47.21	24.50	42.78	23.34	46.84
r≤1	r≥2	20.97	29.68	10.69	18.28	14.22	23.49
r≤2	r≥3	14.07	15.41	5.09	7.59	9.02	9.27
r≤3	r=4	3.76	3.76	2.51	2.51	0.25	0.25

a) All test-statistics are calculated using PcFiml 8.0 (see Doornik and Hendry 1994).
Critical values are taken from Table 1 in Osterwald-Lenum (1992).

Table C.3. Johansen cointegration tests (output-unemployment model)[a]
Cointegrating vector (y_t, o_t, s_t, u_t)[b]

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≥1	27.07	47.21	19.83	35.14	20.81	41.19
r≤1	r≥2	20.97	29.68	9.38	15.31	13.50	20.39
r≤2	r≥3	14.07	15.41	4.17	5.93	6.88	6.88
r≤3	r=4	3.76	3.76	1.77	1.77	0.00	0.00

a) All test-statistics are calculated using PcFiml 8.0 (see Doornik and Hendry 1994).
Critical values are taken from Table 1 in Osterwald-Lenum (1992).
b) u_t refers to unemployment adjusted for the structural break (cf. section 5.1).

Appendix D. Forecast error decompositions for Manufacturing output

Figure D.1. Output-inflation model. Energy booms and oil price component; pct. change

A) Norway **B) UK**

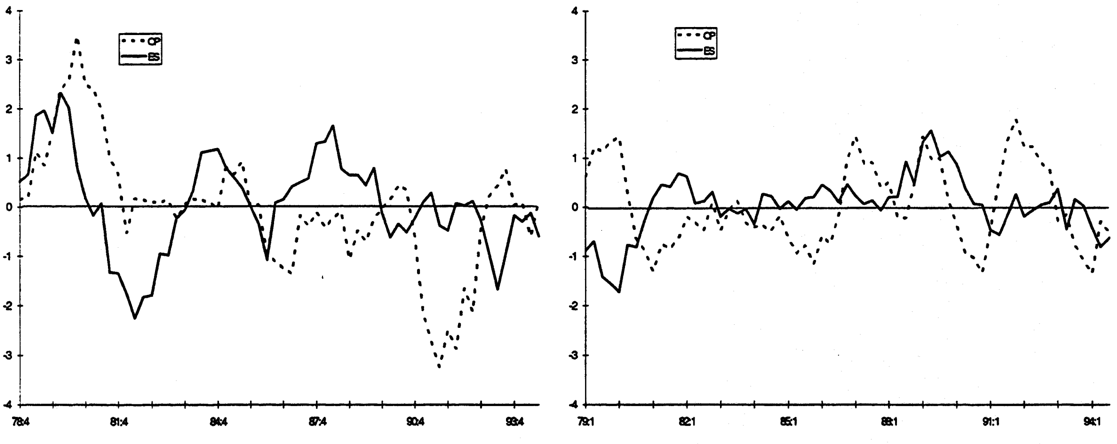
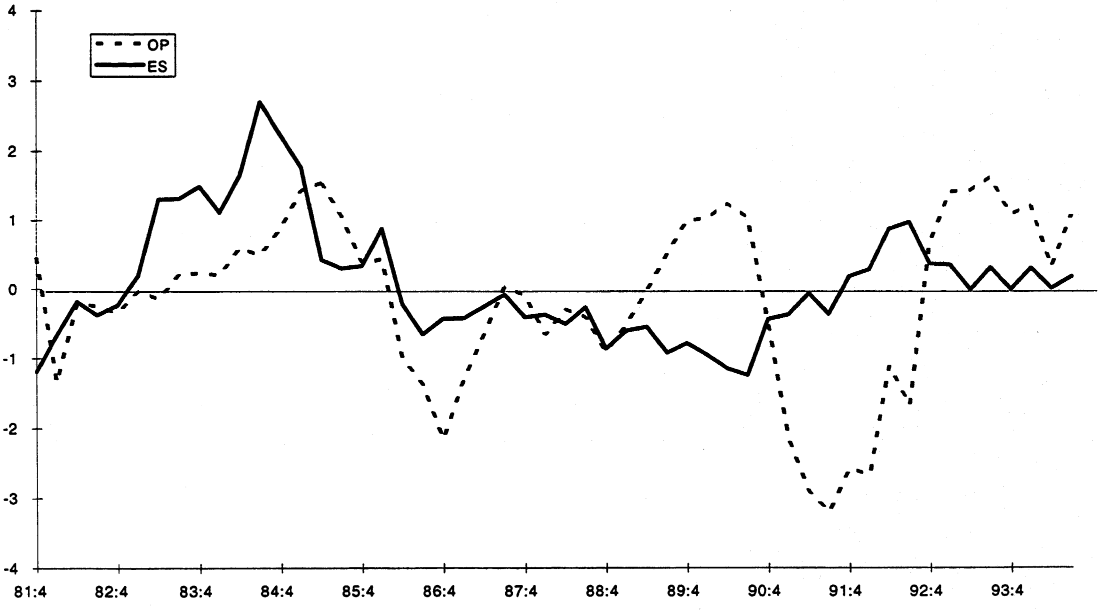


Figure D.2. Norway; Output-inflation model, energy booms identified from accrued investment. Energy booms and oil price component; pct. change[a]



a) The sample used to estimate runs from 1979 to 1994

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