Oil Price Shocks and Stock Market Booms in an Oil Exporting Country

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Abstract

This paper analyses the effects of oil price shocks on stock returns in Norway, an oil exporting country, highlighting the transmission channels of oil prices for macroeconomic behaviour. To capture the interaction between the different variables, stock returns are incorporated into a structural VAR model, as stock prices are an important transmission channel of wealth in an oil abundant country. I find that following a 10 percent increase in oil prices, stock returns increase by 2.5 percent, after which the effect eventually dies out. The results are robust to different (linear and non-linear) transformations of oil prices. The effects on the other variables are more modest. However, all variables indicate that the Norwegian economy responds to higher oil prices by increasing aggregate wealth and demand. The results also emphasize the role of other shocks; monetary policy shocks in particular, as important driving forces behind stock price variability in the short term.

Keywords: VAR, oil price shocks, monetary policy, stock market.
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1. Introduction

According to the seminal work of Hamilton (1983), all US recessions but one since World War II were preceded by a spike in oil prices. High oil prices typically lead to a reduction in the supply of oil, a major input to production, decreasing total world output of goods and services. Subsequent to Hamilton's work, a large body of research has suggested that oil price variations have strong and negative consequences for oil importing countries. These results hold independent of whether one uses alternative data and estimation procedures, see for instance, Burbidge and Harrison (1984), Gisser and Goodwin (1986), Cuñado and Pérez de Gracia (2003) and Jiménez-Rodríguez and Sánchez (2005). More recently, research has focused on the role that asymmetric oil price shocks have on the economy. This research has followed the observation that from the mid 1980s, the oil price - macroeconomic relationship seemed to lose its significance. However, by instead assuming various non-linear transformations of oil prices, the negative link between oil price increases and economic activity still prevails; see Hamilton (2003) for evidence and an overview of the literature.

The studies referred to above all concern oil importing countries. For oil exporting countries, the mechanisms may be significantly different. In particular, higher oil prices generate additional income and wealth to oil producers. If this income is transmitted back to the economy, then higher oil prices would be expected to lead to higher levels of economic activity. Yet, empirical studies have provided no consensus on how oil price changes affect the macroeconomic performance of oil exporting countries. For instance, while Norway has benefited from higher oil prices for prolonged periods, countries like Canada and the UK behave more in line with oil importing countries, with higher oil prices leading to lower output (see Bjørnland 1998, 2000 and Jiménez-Rodríguez and Sánchez, 2005).

In sharp contrast to the volume of studies investigating the link between oil price shocks and macroeconomic variables, there have been relatively few analyses on the relationship between oil price shocks and financial markets such as the stock market, with the notable exceptions of Nandha and Faff (2008), Sadorsky (1999), Jones and Kaul (1996) and Huang et al. (1996), whose studies are limited to oil importing countries. With regard to oil exporting countries, the issue has largely been ignored.[1] Yet, asset prices; and stock prices in particular will be affected by the price of oil, through the cash flow of oil related firms. Asset prices may then influence consumption through a wealth channel and investments through the Tobin Q effect and, moreover, increase a firm's ability to fund operations (credit channel). Hence, asset prices may be an important transmission channel of wealth in an oil abundant country.

In this paper, I analyze the effects of oil price shocks on financial markets in Norway, an oil exporting country. Norway is used as a case study, as the country has been a net oil exporter for almost 30 years. However, oil prices do not affect asset prices in isolation, but through the perceived effect on the macroeconomy. An analysis of the linkages between oil and financial markets therefore requires a thorough examination of macroeconomic linkages. Given the pattern of behaviour for the macroeconomy, the hypothesis maintained is that oil price increases not only boost aggregate wealth and stock returns, but overall growth. Furthermore, as most central banks, including the Central Bank of Norway, Norges Bank, regulate monetary policy with the aim of targeting inflation, the analysis of oil prices requires a model that allows policy makers to respond to shocks that result in higher prices. Implicit to the transmission mechanism of oil price shocks is therefore a study of monetary policy responses to curtail any effects that changes in oil prices may have on aggregate demand and inflation.

To capture the full interaction between the different variables, I will specify a model that allows for endogenous responses to the variables. The structural vector autoregression (VAR) is such an approach, first introduced by Sims (1980).

The rest of this paper is organized as follows. Section 2 reviews the existing literature on the macroeconomic effects of oil price shocks, emphasising the consequences for both oil importing and oil exporting countries. In Section 3 I examine oil price data and possible transformations in more detail, by constructing non-linear functions of oil prices. Section 4 presents the model framework used in the analysis; the structural vector autoregression (VAR). Section 5 presents the main results of oil price

[1] El-Sharif et al. (2005) investigate the relationship between the price of crude oil and equity values in the oil and gas sector in the UK, but do not focus on the role of equity as a transmitters of shocks as will be done here.

changes, as well as robustness results for various data and model specifications. Section 6 concludes.

2. The effect of oil price shocks - some background

An analysis of the linkages between energy and the aggregate economy is complex. When the price of oil rises, households and firms which purchase petroleum-based products (i.e. gasoline) have less disposable income to spend on other goods and services. Oil producing countries, on the other hand, experience a positive wealth effect through the income gained from the oil products they sell. The net effect will depend on a series of factors, as discussed below.

2.1. Oil price shocks and economic fluctuations in oil importing countries

Oil price shocks typically have real effects, as higher energy prices affect output via the aggregate production function by reducing the net amount of energy used in production. Consequently, an increase in oil prices leads to a rise in production costs, inducing firms to lower output. This reduction in output and income induces rational consumers in oil importing countries to hold back on consumption (and investment) spending, reducing aggregate demand and output, see e.g. Bohi (1989) for further theoretical discussion.

A large body of empirical research has confirmed that oil price increases have strong and negative consequences for the world economy, see Hamilton (1983), Burbidge and Harrison (1984), Gisser and Goodwin (1986), Bjørnland (2000), Cuñado and Pérez de Gracia (2003) and Hamilton (2003) among others.

From the late 1980s, however, the established view has been challenged. First, following the oil price fall in 1986, there was little evidence to suggest that oil price decreases boost economic activity, in the same way that increases restrain activity. A number of authors therefore re-examined the oil price – macroeconomic relationship, using instead asymmetric or nonlinear methods, see e.g. Mork (1989), Mork et al. (1994), Lee et al. (1995), Hamilton (1996, 2003) and Baumeister and Peersman (2008) among others. Doing so, they found that the negative link between oil price increases and economic activity still prevailed. Hence, it may be rational to adjust differently to oil price increases and decreases.

Second, studies such as Bernanke, Gertler and Watson (1997) have argued that it is not the oil price that is the principal cause of recessions, but the fact that the Federal Reserve has responded to higher oil prices by increasing interest rates in order to control inflation. The confusion between oil shocks and the response of monetary policy explains why oil shocks appear to have an effect that far exceeds what is expected based on a comparison of energy costs to total production costs. This view has, however, been modified more recently, as several studies have shown that oil shocks are in fact more important than monetary contraction, see for instance Hoover and Perez (1994), Davis and Haltiwanger (2001) and Hamilton and Herrera (2004) among others.

Finally, Kilian (2008) has suggested that the implications of higher oil prices for U.S. real GDP and CPI inflation depend on the cause of the oil price increase. In particular, as global growth has been high at the same time as oil prices have increased, oil prices may have been driven by increased demand instead of restrictions on the supply side (as in the 1970s). This may have dampened the otherwise negative effect that the recent surge in oil prices may have had.

2.2. Oil price shocks and economic fluctuations in oil exporting countries

For oil producing countries, higher oil prices may affect the economy in two ways: 1) Through positive income and wealth effects and 2) through negative trade effects. Regarding the first channel, higher oil prices represents an immediate transfer of wealth from oil importers to oil exporters. The effect in the medium to long term will, however, depend on what the oil producers (i.e. governments) do with the additional income. If this income is used to purchase goods and services in their own country, higher oil prices generate a higher level of activity in the domestic economy. Hence, overall national wealth and demand increase. The potential for profitable output from the energy sector can also provide huge investment and business opportunities in the overall economy, with increased demand for labour and capital. However, the high level of activity may put upward pressures on inflation and on the domestic currency, which often appreciates in oil exporting countries (see Haldane, 1997).

Regarding the second channel, the negative trade effect, as the oil importing trading partners will suffer an oil induced recession, they will demand less export of traditional goods and services from the oil exporting countries. To the extent that the oil exporting country has a large export sector, this channel may provide a negative stimulus to the oil exporting countries.

The net effect of the two channels, (positive wealth effect and negative trade effect), therefore remains uncertain. Further, empirical studies of the effects of oil price changes in oil exporting countries are not unequivocal. For instance, Bjørnland (1998, 2000) and Jiménez-Rodríguez and Sánchez (2005) find that whereas Norway, a net oil exporter, has benefited from increased oil prices, displaying temporary higher growth rates and reduced unemployment rates, other oil exporting countries like the UK and Canada have behaved more in line with oil importing countries, showing declining growth rates. Bjørnland (2000) argues that one of the reasons for the positive response in Norway is the activist policy followed in the aftermath of oil price increases, compared to the UK (in particular in the 1980s). Furthermore, Jiménez-Rodríguez and Sánchez (2005) point out that the appreciation of the exchange rate was much less severe in Norway than in the UK, thereby proving less of a dampening effect on the Norwegian economy.

Since 2001, however, Norway's petroleum income has been regulated to be phased into the economy on par with expected returns on the Government Petroleum Fund. This may make the future effect of oil prices less pronounced, an issue we will investigate further in the empirical analysis below.

2.3. Oil price shocks and the stock market

Asset prices are determined on the stock market depending on information about future prospects as well as current economic conditions facing firms. The efficiency with which stock markets process information has been a subject of intense study for several decades. If stock-price or rate-of-return forecasts cannot be improved upon by use of any other information, the case can be made that the stock market is already using all publicly and privately available information in the formation of those prices. It is reasonable to expect that the stock market would absorb information about the consequences of an oil price shock and incorporate it into stock prices very quickly. Since asset prices are the present discounted value of the future net earnings of firms, both the current and the future impacts of such a shock should be absorbed into prices and returns without waiting for those impacts to actually occur.

Previous studies of the impact of oil prices on equities in oil importing and exporting countries have found various results. Sadorsky (1999) estimates a vector autoregression (VAR) model for the US including industrial production, real oil prices, interest rates and aggregate real stock returns over the period 1947-1996 using monthly data. The model set up is the closest to the one I will adopt here. In all cases, he finds an oil price shock to have a negative and statistically significant impact on stock returns. Huang et al. (1996) also use a VAR approach to investigate the relationship between oil futures and stock returns using daily data. They find that although oil futures do lead some individual oil company stock returns, they do not have much impact on broad based stock return indices. More recently, Nandha and Faff (2008) have examined to what extent oil prices influence various global equity prices. They find that oil price rises have a negative impact on equity returns for all sectors except the mining and oil and gas industries. Consistent with this, El-Sharif et al. (2005) find that the price of crude oil affects equity values positively in the oil and gas sector in the UK.

Finally, Jones and Kaul (1996) examine stock market efficiency, focusing on the extent to which stock prices change in response to oil price changes, (i.e. whether changes in stock prices reflect current and future real cash flows). By using a cash-flow/dividend valuation model, they find that oil prices can predict stock returns and output on their own. However, when they use a more comprehensive model that includes cash flows, their findings are not definitive.

3. A first look at oil price data

Following recent research on oil price asymmetries, I specify four oil price proxies in addition to actual oil prices; oil price increases, oil price decreases, net oil price increases and changes in oil prices outside an oil price band. Brent Blend (also known as Brent Crude) is used as the oil price measure (see appendix A). It is the largest of the many major classifications of oil and consists of several measures including Brent Crude, Brent Sweet Light Crude, Oseberg and Forties. I have chosen to focus on Brent Blend because European oil production (as well as African and the Middle Eastern flowing West) tends to be priced relative to this oil. Hence, it forms a benchmark.

3.1. Period of analysis

The main analysis is carried out using monthly data from 1993 to 2005, which is suggested to be a relative stable monetary policy regime. Using an earlier starting period would have made it difficult to identify one policy regime, as the Norwegian krone has been fixed to a series of different currencies; 1978-1990, vis-à-vis a trade weighted currency basket, and 1990-1992, vis-à-vis the ECU exchange rate. At the end of 1992, however, the Norwegian krone was allowed to float. Since then, the krone has had a managed float where monetary policy has been aimed at maintaining a stable krone exchange rate against the ECU exchange rate (and from 1999, the Euro exchange rate), albeit without any fluctuation margins or obligation for the central bank to intervene in the foreign currency exchange market. Eventually, in 2001 Norges Bank was given the mandate to target inflation. Although adopted late, Norges Bank had already been using monetary policy instruments to bring price inflation down towards European levels for some years, in order to achieve exchange rate stability against the Euro exchange rate (Gjedrem, 1999; Norges Bank, 1999). Consistent with this, Olsen et al. (2002) argue that with the exception of the brief period 1996/7-1998 when the interest rate was used to defend the currency, monetary policy has followed a Taylor rule closely since 1993.

Hence, we can treat the period from 1993-2005 as a relatively stable monetary regime. I will therefore estimate the baseline model for the period 1993-2005[2], but test for robustness of results by expanding the sample back to 1983 (the earliest period we

[2] To account for deviations from a Taylor rule, I include a dummy that takes the value 1 in the period 1996M9-1998M3, and 0 otherwise. The is significantly negative in the interest rate equation, implying that the interest rate should have been lower had the rule been followed over the whole period (see Bjørnland, 2008).

have available data for stock prices). In the end we also look at robustness with respect to the recent inflation targeting period; defined broadly as 1999-2005.

3.2. Oil price measures

Investigating oil price increases and decreases separately is motivated by the finding by Mork (1989) that there are important asymmetries between the effects of oil price increases and decreases on the US economy. Defining the log level of nominal oil prices as op_t, and $\Delta op_t = (op_t - op_{t-1})$ as the monthly changes in oil prices, a proxy that considers oil price increases only (Δop_t^+) can be defined as:

$$\Delta op_t^+ = \max(0, \Delta op_t) \tag{1}$$

and equally, a proxy that considers oil price decreases only (Δop_t^-) can be defined as

$$\Delta op_t^- = \min(0, \Delta op_t) \tag{2}$$

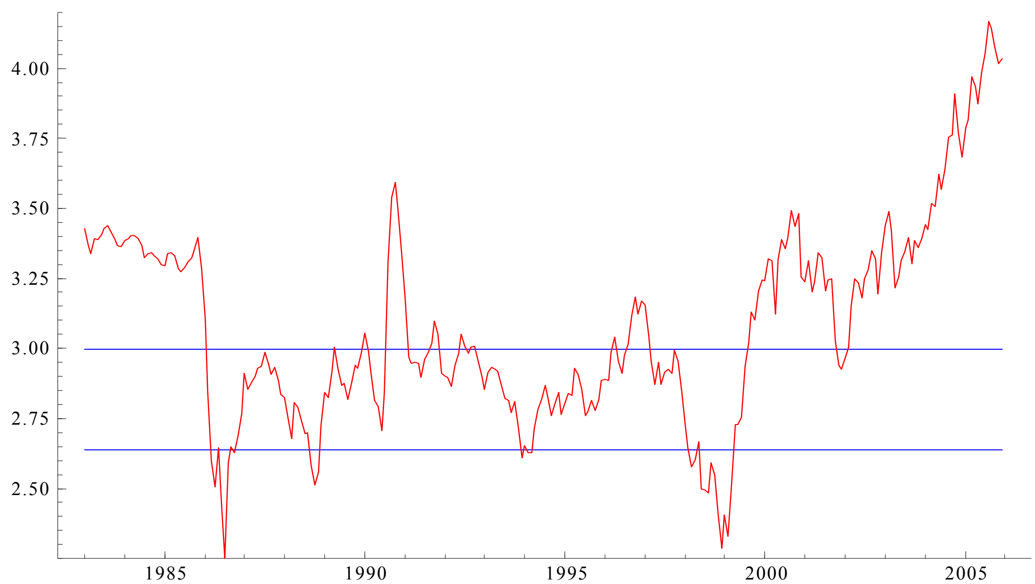
The net oil price measure ($netop_t$) is motivated by Hamilton (1996) who argues that as most of the increases in the price of oil since 1986 have immediately followed even larger decreases, they are corrections to the previous decline rather than increases from a stable environment. To correctly measure the effect of oil price increases on the macroeconomy, he suggests that one should compare the price of oil with where it has been over the previous year, rather than with where it was the previous month alone. By constructing what he refers to as the net oil price (the maximum value of the oil price observed during the preceding year), Hamilton (1996) shows that once one defines oil price in terms of the net oil price, the historical correlation between oil price shocks and the macroeconomy that was found prior to the mid 1980s remains intact. Equation (3) describes how one can construct a net oil price measure as the increase from the previous year's monthly high price if that is positive, and, zero otherwise:

$$netop_t = \max[0, op_t - \max(op_{t-1}, op_{t-2} op_{t-3}, ..., op_{t-12})] \tag{3}$$

The motivation behind the final measure (*opband*$_t$), is the weak support that has been found in empirical studies of the assumed symmetric relationship between oil prices and asset prices. A hypothesis that has been investigated with some success is that asset prices only react to movements in oil prices if they are particularly low or high. That is, the response in the asset price to an oil price shock will depend on the actual (log) level of oil prices, rather than the changes.

This idea fits nicely into the literature on currency crises, where one assumes that a central bank that aims to stabilize the exchange rate, can only stabilize exchange rate fluctuations by adjusting interest rates when the oil price is within a given range. Outside this range, the cost of stabilizing the exchange rate would require setting interest rates too high or low, which might be destabilizing to the overall economy. Hence, outside the band, the exchange rate will potentially respond to oil price shocks, whereas inside the band, there is little response due to expected policy interventions.

Figure 1 (Log) nominal oil price with (log) oil price band [a)]



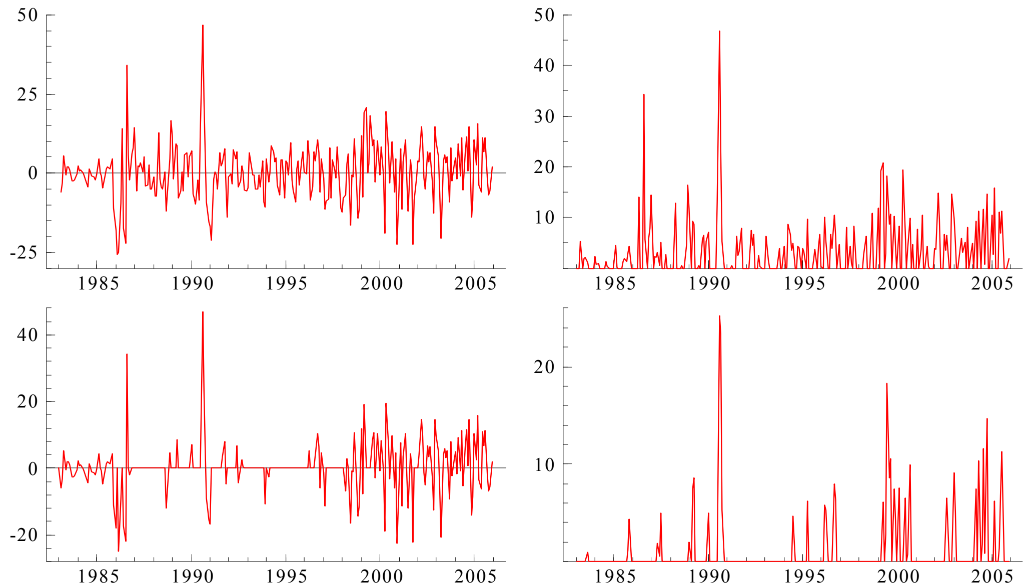
[a)] *The figure displays log nominal oil prices with the log of the oil price band, (14-20 USD).*

In deciding on the range for the oil price change, I build on Akram (2004), who found that the Norwegian exchange rate only responded significantly to oil price changes outside a band. He estimated the lower limit of the band to be 14 USD and the upper limit to be 20 USD. Here I want to examine whether the asymmetric effects on the exchange rate also translates into the stock price, and use the same band. Inside the band, any oil price change will be forced to zero, whereas outside the band, actual values are reported. Formally, the $opband_t$ will then be defined as:

$$opband_t = \begin{cases} 0 & if \ (\log)14 \rangle \ op_t \ \langle (\log)20 \\ \Delta op_t & otherwise \end{cases} \quad (4)$$

Figure 1 graphs the (log) nominal oil price together with the (log) oil price band. Clearly, the oil price has remained inside the band during much of the 1980s and 90s, with a notable exception in the early 1980s. There seems to be a break in 1999, after which the oil price has been on an upward trend.

Figure 2 Different oil price measures, percentage [a)]



[a)] The first figure (top left) displays monthly changes in oil prices, the second the positive monthly oil price changes and the last two figures (bottom left and right), changes in oil prices outside the band and net oil price increases.

In Figure 2, I graph the monthly changes in the oil price together with all the oil price proxies: Δop_t^+, $opband_t$ and $netop_t$.[3] Table 1 then shows the correlation between the monthly oil price changes and the four oil price proxies.

Table 1. Correlation of monthly oil prices Δop_t with alternative oil price proxies[a)]

	$\Delta op+$	Δop^-	*opband*	*netop*
1993-2005	0.86	0.86	0.86	0.49
1983-2005	0.85	0.81	0.83	0.52

a) Δop_t^+ and Δop_t^- are respectively positive and negative oil price changes, Opband is the oil price excluding oil price changes within a certain band, and Netop is the maximum value of the oil price observed during the preceding year. See the text for further explanation.

Clearly all proxies are highly correlated with oil price changes, with the exception of *netop* where the correlation is less than 0.5. Interestingly, there seems to be an equal dispersion of positive and negative changes in the oil price, as both Δop_t^+ and Δop_t^- are highly correlated with Δop_t. The correlation coefficients remain stable when focusing on post 1993 data and the whole sample 1983-2005.

3.3 Testing for significance – predictability of stock prices

Before turning to the structural VAR analysis, I examine whether oil price shocks can predict stock prices. There is reason to believe that oil prices have become a more important driving force for stock price developments. Energy companies accounted for more than half of the total market value on the Oslo Stock Exchange in 2005, compared with 13% at the end of 2000 (Norges Bank, 2005). Foreign investors' ownership share of equity holdings on the Oslo Stock Exchange has also increased over the last few years. Foreign investors' behaviour may therefore have contributed to amplifying price movements. To get a feel for the importance of oil prices in predicting stock prices, I therefore first regress a simple OLS:

$$\Delta sp_t = \mu + \sum_{j=1}^{n} \gamma_j \Delta sp_{t-j} + \sum_{j=0}^{n} \alpha_j \Delta op_{t-j} + \varepsilon_t, \tag{5}$$

[3] Δop_t^- can be read from the graph as the difference between Δop_t and Δop_t^+.

where changes in stock prices (Δsp_t) are explained by contemporaneous[4] and lagged oil price changes and lagged changes in stock prices themselves. The equation seeks to test whether there is an immediate and a delayed reaction to oil price changes. Given that we expect the stock market to be efficient, zero coefficients on all the α_j's and γ_j's would imply that equation (5) reduces to a random walk (with drift) for stock prices. On the other hand, if some of the α_j's are significant, oil price changes can predict future stock returns. By including lags of stock price changes in the regressions, one allows for some persistence in stock prices. However, all the results show that only the first lag (Δsp_{t-1}) is significantly positive in the equations, implying that there is no information in past observations of stock prices, beyond one lag, to predict future stock prices.

Table 2 reports coefficients and corresponding t-values for α_0 in the baseline sample (1993-2005) and in the extended sample (1983-2005). The F-test reports the null hypothesis that all lags (n = 6) on the oil price measures can be excluded.

Table 2. Test of predictability of stock price changes with alternative oil price proxies

	Δop	Δop$^+$	Δop$^-$	Opband	Netop
1993-2005					
α_0 [t-value]	**0.12** [2.52]	**0.18** [2.05]	**0.22** [2.61]	**0.14** [2.38]	-0.00 [-0.28]
F-test op; 6 lags [p-value]	**2.313** [0.0291]	0.778 [0.6064]	**4.4294** [0.0002]	**2.6205** [0.0142]	0.7688 [0.6143]
1983-2005					
α_0 [t-value]	**0.11** [2.81]	0.09 [1.46]	**0.25** [3.75]	0.08 [1.78]	0.00 [0.07]
F-test op; 6 lags [p-value]	**2.2115** [0.0338]	1.283 [0.2593]	**3.6960** [0.0008]	1.8005 [0.0875]	0.4151 [0.8925]

a) Δop_t Δop_t^+ *and* Δop_t^- *are respectively total, positive and negative oil price changes, Opband is the oil price excluding oil price changes within a certain band, and Netop is the maximum value of the oil price observed during the preceding year. See the text for further explanation..*

Focusing on the most recent sample, the coefficient α_0 is statistically significant at the 5 percent level using all oil price proxies but *netop*. The coefficients are positive, indicating that an oil price increase will increase the stock price immediately. Furthermore, judging by the F-test, three of the oil price proxies (*Δop*, *Δop*$^-$ and *opband*) indicate that the

[4] By focusing on contemporaneous effects of oil prices, I implicitly assume that the world oil price is exogenous with respect to (Norwegian) asset prices, which is a plausible small open economy assumption.

additional oil price lags are significant in predicting stock prices. Hence, not only is the current price of oil important, there is also significant delay information, suggesting that investors do react to oil price information. Similar results have also been found in Driesprong et al. (2005) focusing on contemporaneous correlations between oil price changes and stock prices for the oil exporting countries: Norway, Venezuela, Canada and Australia.

Some additional results are worth emphasizing. When including the 1980s (1983-2005) stock prices responded only significantly to oil price decreases, implying a *fall* in equity values when oil prices *decreased*.[5] However, in the final sample (1993-2005), the stock price responded significantly (and symmetrically) to both oil price increases and decreases, implying a fall/rise in equity values when oil prices fell/rose. This may suggest that since the Norwegian krone returned to a free-float in 1993, the Oslo Stock Exchange has gained confidence so that both domestic and foreign investors may use the stock exchange in Norway as a hedge against oil price changes.

4. The structural vector autoregression (VAR) approach

The main focus of the analysis is to examine if and how oil price shocks influence stock returns in Norway. However, to allow for interaction between the identified shocks and monetary policy responses to shocks (the central bank that has an inflation target aims to counteract any stimulus these shocks may have on inflation), the choice of variables must reflect the theoretical set up of a New-Keynesian (inflation targeting) small open economy model, such as that described in Svensson (2000) and Clarida et al. (2001). That is, in addition to oil price and stock return variables, I need to include a variable that captures the monetary policy instrument (i.e. the interest rate), monetary target variable(s) (inflation and possibly a measure of real activity), a foreign interest rate (controlling for foreign monetary policy) and the exchange rate (which is an important transmission channel in an open economy).

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[5] Sadorsky (1999) finds a similar asymmetry in the first part of the eighties analysing oil importing countries, although the response was, of course, the reverse; stock prices fell significantly following an oil price increase, but did not respond to oil price decreases.

Hence, the corresponding variables used in the analysis are the nominal oil price, (op_t),[6] the log of the stock price index of major shares adjusted for dividend payouts, (sp_t), the three month domestic interest rate, (i_t), the (trade weighted) foreign interest rate, (i_t*), the unemployment rate, (u_t), the log of the annual changes in the domestic consumer price index – referred to hereafter as inflation, (π_t) and the log of the real exchange rate against a basket of trading partners, (e_t), (see appendix A for further details). The unemployment rate, inflation and domestic and foreign interest rates are expressed in levels as they are already measured as a ratio. The remaining variables will be expressed in log levels (oil price, exchange rate and stock prices), so that a unit change can be interpreted as percentage. The following VAR model of order *p* can then be estimated:

$$Z_t = \alpha + \sum_{i=1}^{p} A_i Z_{t-i} + v_t \,, \tag{6}$$

where Z_t is the (7x1) vector of endogenous variables discussed above, α is the (7x1) intercept vector, A_i is the i^{th} (7x7) matrix of autoregressive coefficients for i = 1,2,…,p, and v_t is a (7x1) vector of reduced form white noise residuals. Assuming the vector of variables Z_t is stationary[7], the VAR system can be inverted and written in terms of its moving average:

$$Z_t = \gamma + \sum_{i=0}^{\infty} B_i v_{t-i} \tag{7}$$

where $B_i = (I_n - \sum_{i=1}^{p} A_i L^i)^{-1}$, and $\gamma = (I_n - \sum_{i=1}^{p} A_i)^{-1}\alpha$. So far, the residuals are correlated between each equation and can not be interpreted as structural shocks. To orthogonalise the shocks I follow the standard literature (see i.e. Christiano et al., 1999; Hamilton, 1983), and order the vector of shocks recursively using Cholesky decomposition. That is,

[6] The results are independent of whether I use the nominal or the real oil price, since most of the oil price changes are in an order of magnitude larger than the change in prices. Also, oil price changes have preceded price changes in the period examined.
[7] This assumption is discussed further in the empirical analysis below.

I choose an ordering for the variables in the system so that I only allow for a *contemporaneous* correlation between certain series. Recursive (Cholesky) ordering implies that the first variable in the system will not react contemporaneously to any shocks in the remaining variables, but all other variables can react to shocks in the first variable, and so forth. Note that this restriction concerns contemporaneous relations only. After one period (one month in the present analysis), all variables can react to all shocks. This can be specified as follows.

Ordering the variables as: $Z_t = \left[op_t, i_t^*, u_t, \pi_t, i_t, e_t, sp_t \right]'$, implies the following restriction on the B_0 matrix; summarizing the contemporaneous effects of shocks:

$$\begin{bmatrix} op \\ i* \\ u \\ \pi \\ i \\ e \\ sp \end{bmatrix}_t = \begin{bmatrix} B_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ B_{21} & B_{22} & 0 & 0 & 0 & 0 & 0 \\ B_{31} & B_{32} & B_{33} & 0 & 0 & 0 & 0 \\ B_{41} & B_{42} & B_{43} & B_{44} & 0 & 0 & 0 \\ B_{51} & B_{52} & B_{53} & B_{54} & B_{55} & 0 & 0 \\ B_{61} & B_{62} & B_{63} & B_{64} & B_{65} & B_{66} & 0 \\ B_{71} & B_{72} & B_{73} & B_{74} & B_{75} & B_{76} & B_{77} \end{bmatrix}_0 \begin{bmatrix} v^{op} \\ v^{i*} \\ v^{u} \\ v^{\pi} \\ v^{mp} \\ v^{e} \\ v^{sp} \end{bmatrix}_t + \sum_{i=1}^{\infty} B_i v_{t-i} \ . \qquad (8)$$

where $v_t = \left[v^{op}, v^{i*}, v^{u}, v^{\pi}, v^{mp}, v^{e}, v^{sp} \right]_t'$ is the vector of structural shocks. The placement of oil prices on top in the ordering reflects a plausible small country assumption that oil prices are only affected by exogenous oil price shocks, (v^{op}), contemporaneously. Foreign monetary policy is placed after the oil price in the Cholesky ordering, assuming it will only be affected by oil price shocks and foreign monetary policy, (v^{i*}), contemporaneously; another plausible small country assumption. By placing the unemployment rate and inflation above the domestic interest rate in the ordering, monetary policy can react immediately to domestic conditions represented by unemployment shocks (v^{u}) and inflation shocks (v^{π}) (as well as shocks to foreign monetary policy and oil prices), while it takes one period before monetary policy shocks

(v^{mp}) affect these variables. This is a common assumption used in the monetary policy literature (see e.g. Christiano et al., 1999).[8]

The exchange rate and the stock price are placed after the interest rate in the ordering, so that they are allowed to react immediately to monetary policy disturbances. This is consistent with the quick adjustment in asset prices observed in the data following monetary policy surprises (see e.g. Rigobon and Sack, 2004; Zettelmeyer, 2004). However, by placing asset prices after the interest rate in the ordering, monetary policy is restricted from reacting immediately to shocks in the exchange rate (v^e) and the stock price (v^{sp}). The legitimacy of this assumption is more questionable, as there is no reason to expect the monetary policymaker to disregard shocks to these variables for a period. This has been emphasized by Bjørnland (2008) and Bjørnland and Leitemo (2008), who, show respectively that the effects of a monetary policy shock will be biased if monetary policy is restricted from reacting immediately to exchange rates or stock prices. Although this is potentially a problem when using quarterly data, I believe it to be less of a problem with monthly data. The board of Norges Bank only meets every sixth week, thereby making a month delay in asset price news less severe.

Finally, the fact that the stock price is placed after the exchange rate in the ordering implies that the exchange rate will react with a month delay to shocks in stock prices, while stock prices react immediately to all news. Although not necessarily a justified assumption, it is not likely to be a very damaging one, as there is little reason to expect the exchange rate to react to stock price news that is not already reflected in the other variables. Rearranging the order of these two asset prices does not make a significant difference in the results.

4.1. Model specification

Consistent with most recent VAR studies, the variables are specified in levels. This implies that any potential cointegrating (long run equilibrium) relationship between the

[8] A further examination of the B_0 matrix also suggests that as inflation shocks move prices before unemployment (or any other real variable), they can be interpreted as cost push shocks, whereas unemployment shocks are a mixture of demand- and supply shocks. Alternating the order of these two variables has little effect on the results.

variables will be implicitly determined in the model (see Hamilton, 1994). Sims et al. (1990) also argue for using VAR in levels as a modeling strategy, as one avoids the danger of inconsistency in the parameters caused by imposing incorrect cointegrating restrictions; though at the cost of reducing efficiency. However, since monetary policy responds to deviations from the natural rate of unemployment (or output) rather than the level itself, I have included a linear trend in the VAR. The inclusion of a trend also serves as a good approximation for ensuring that the VAR is invertible if the variables are non-stationary, in particular given the short time span of data used. However the results are robust to other forms of transformations, including estimating the VAR in first differences (with no trend).

Finally, the lag order of the VAR-model is determined using the Schwarz and Hannan-Quinn information criteria and the F-forms of likelihood ratio tests for model reductions. A lag reduction to six lags could be accepted at the five percent level by all tests. Using six lags in the VAR, there is no evidence of autocorrelation in the residuals.[9]

5. Effects of oil price shocks

Below I first discuss the responses to oil price shocks in figure 3 and then perform some robustness tests in Figure 4. The effects of all shocks (shown with probability bands) are eventually graphed in Figure 5a and 5b. The responses are graphed with probability bands represented as .16 and .84 fractiles (as suggested by Doan, 2004).[10]

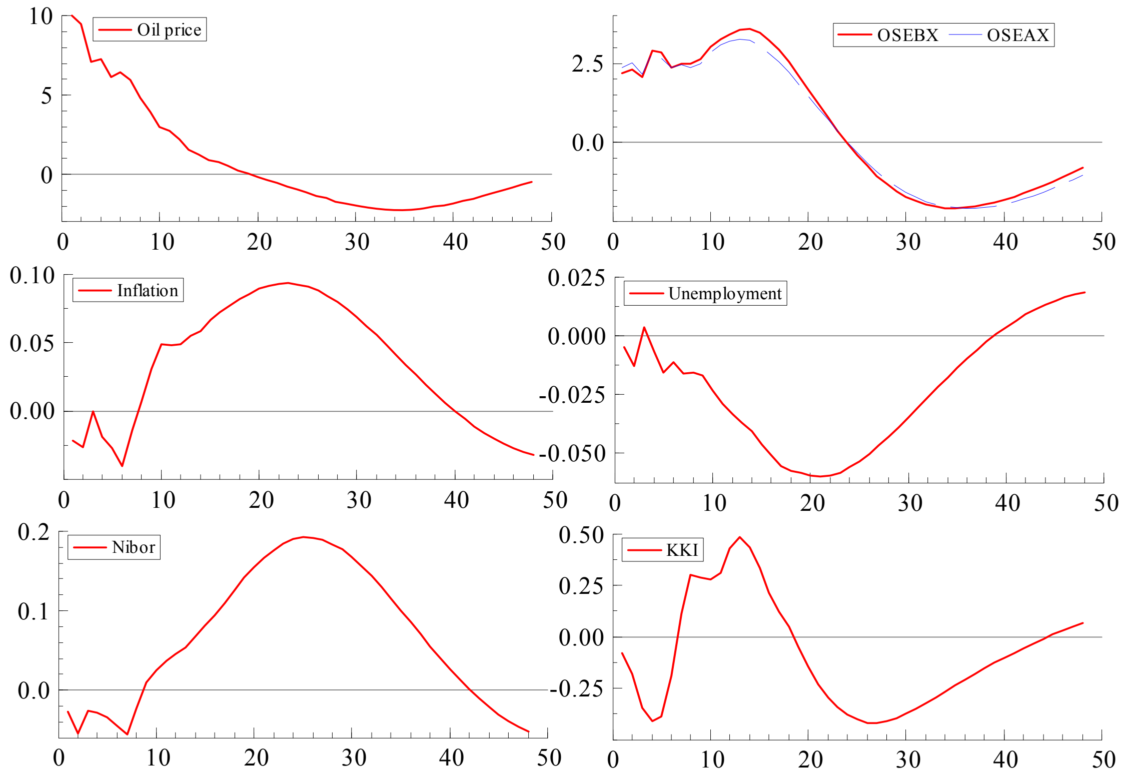
In Figure 3, the impulse responses to the oil price shock using the baseline oil price level are graphed. To compare the different specifications used in the analysis, I have normalized the responses so that in all cases I analyze the effects of an oil price shock that increases oil prices by 10 percent the first month. The figure shows that following an oil price shock that increases oil prices by ten percent, stock returns increase immediately by 2.5 percent. The maximum effect is reached after 14-15 months, when stock prices have increased by 3.6 percent. After that, the effect gradually dies out. These

[9] A further lag reduction is possible, but at the cost of no longer being able to reject the hypothesis of zero auto-correlation in the residuals.

[10] This is the Bayesian simulated distribution obtained by Monte Carlo integration with 2500 replications, using the approach for just-identified systems. The draws are made directly from the posterior distribution of the VAR coefficients (see Doan, 2004).

results remain almost the same whether I focus on OSEBX or OSEAX (see the appendix for definitions), with a slightly stronger response in OSEBX. However, both respond significantly, (see the first column in Figure 5a for standard deviation bands).

Figure 3 Dynamic effects of an oil price shock (v^{op}) [a)]



[a)] The response in the oil price, stock price (measured as OSEBX or OSEAX), and the exchange rate (KKI) are measured in percentage, the remaining variables in percentage points. Nibor refers to the three months interest rate.

The effects on the other variables are more modest. However, all indicate that the Norwegian oil producing economy responds to higher oil prices by increasing aggregate demand and production. As a consequence, the unemployment rate falls by 0.1 percentage points after close to two years.[11] Consistent with the increased activity, inflation gradually picks up and reaches a maximum after 20 months. In response to the increased activity, the interest rate is increased by 20 basis points after two years.

[11] Alternative measures of aggregate activity have also been used in the model, such as industrial production (available on a monthly basis) instead of the unemployment rate. The oil price shocks increase industrial production at first, but the effect is insignificant after just a few periods. The effects on the other variables, on the other hand, remain the same as in the baseline case.

However, the response in domestic interest rates is delayed, in particular compared to foreign interest rates that increase almost immediately (see column one in Figure 5a). As a consequence, the interest rate differential falls initially.

Finally, the effect on the real exchange rate is that of appreciation (a fall in the exchange rate), as expected, but the effect is small and not significantly different from zero (see Figure 5a). The relatively weak response in the exchange rate can partly be understood by the quick monetary policy tightening abroad following the same oil price shock. With a delayed interest rate response in Norway, the interest rate differential will at first fall, which could entail subsequent exchange rate depreciation. The small response in the exchange rate is in line with what has been reported in Jiménez-Rodríguez and Sánchez (2005), explaining why higher oil prices may have such a stimulating effect on the Norwegian economy.

5.1. Robustness of oil price shocks

The above results have been subjected to a series of robustness tests. In particular, Figure 4 displays the implications of an alternative ordering of the variables in the VAR model (interest rates are ordered before the oil price so that oil prices can respond to monetary policy), alternative lag orders in the VAR (4 or 9), alternative measures of the oil price (*opband*)[12], and finally, alternative start dates for the estimations (1983 or 1999).[13]

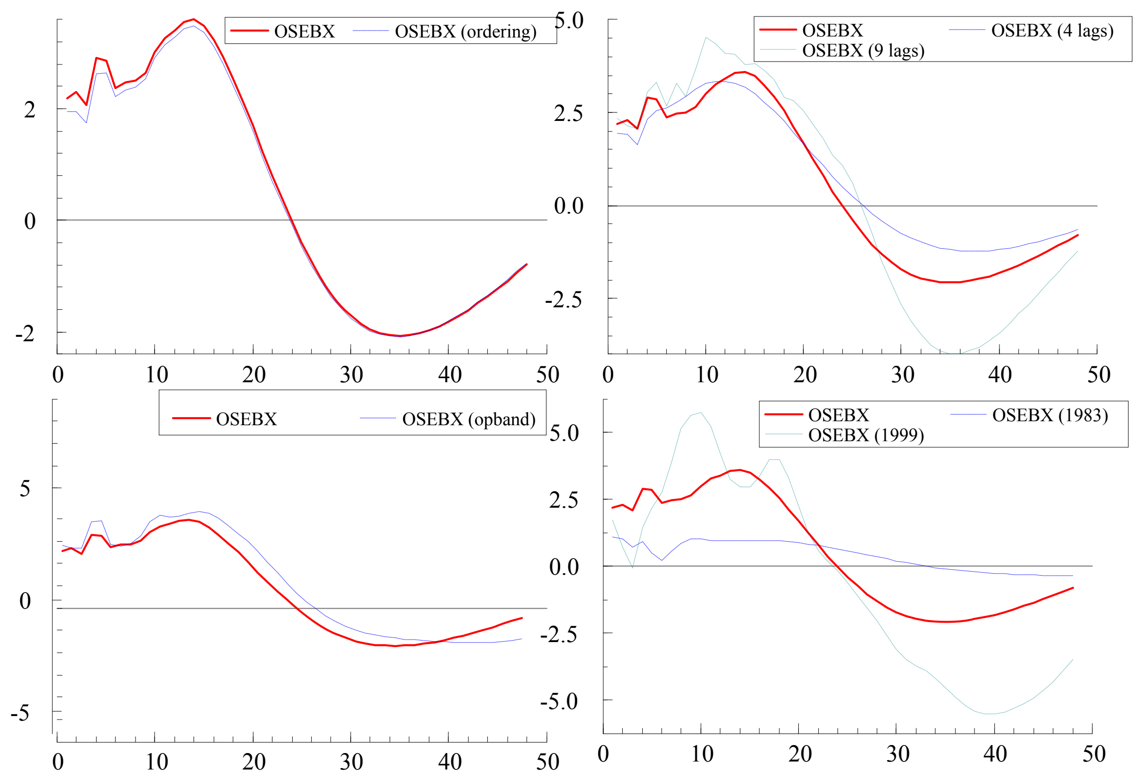
The tests confirm the main results. Stock prices increase on impact in all cases. In particular, testing robustness using the oil price band, alternative orderings or different lags yields very similar results to the baseline case. Investigating different samples, however, provides some interesting results. In the sample starting in 1983, the effect is approximately 1/3 of the baseline case, whereas in the post 1999 (inflation targeting) sample, the results are almost twice as large, as oil prices increase stock prices by close to 6 percent after 10 months. The results are not very surprising and confirm what we found

[12] Since we specify the VAR model in levels, I accumulate *opband* to a level index.

[13] In addition I have also tested robustness with respect to model specifications, by allowing the variables in the VAR to be differenced rather than measured in levels. Using first differences implies that there are no long run equilibrium relationships between the variables. This may imply inconsistency in the parameters if a true relationship exists. Nevertheless, using the first differenced VAR shows that the results are robust to this specification on a 1-2 year horizon, (after which the results are imprecisely estimated).

above. In particular, since stock prices responded more asymmetrically to oil price changes prior to 1993, the response will be less pronounced using the whole sample. The increased reaction from 1999 may also be partly understood based on the increased share of energy companies on the Oslo Stock Exchange. However, due to the relatively short time span investigated, these results should be interpreted with care.

Figure 4 Robustness of responses in stock return (OSEBX) to an oil price shock, percentage[a)]



a) OSEXB from 1990-2005, before that total stock price index (TOTX)

With regard to the effects on the other variables, the main results prevail (these results can be obtained on request). Interestingly, the effect of a higher oil price on the interest rate is quite similar whether the baseline (1993-2005) sample or the post-1999 (inflation-targeting) sample is used, indicating a fairly stable monetary policy response (where a higher oil price increase is followed by modest monetary policy tightening). Furthermore, contrary to the general perception,[14] the data shows no evidence that the effects of oil price shocks on the macroeconomy have become less pronounced over time, a finding also seen in Solheim (2008).

One issue left out for future work is to what extent the effects found here depend on the different causes behind the oil price changes. In a recent paper, Kilian (2008) has suggested that as global growth has been high at the same time as oil prices have increased, oil prices may have been driven by increased demand instead of restrictions on the oil supply side (as in the 1970s). Hence, the recent high oil prices may have had a less pronounced negative effect on the global economy than previously, when oil supply shocks dominated. This would imply that in the main period examined (1993-2005), positive wealth effect may have dominated the negative trade effect. If the world economy experiences lower growth rates ahead, this could curb the expansionary effects associated with higher oil prices than Norway so far has experienced.

5.2. Effects of all shocks

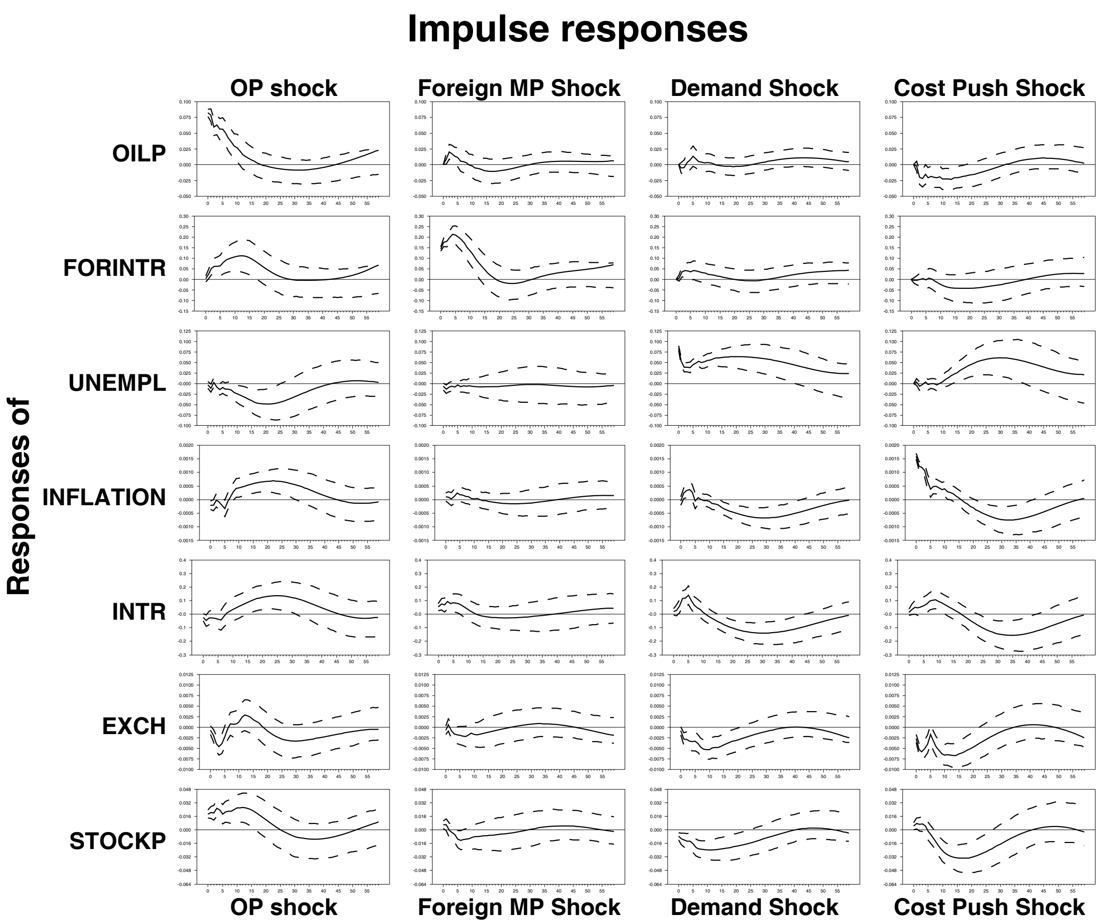
Having studied the effects of the oil price shocks, I now turn to examine briefly the effects of the other shocks identified in the system, monetary policy shocks in particular. Figure 5a graphs the responses of all the variables to the four first shocks, while in Figure 5b the three final shocks are graphed. Hence, in Figure 5a, the first column shows the responses to an oil price (OP) shock, the second column to a foreign monetary policy shock, the third column to the unemployment (demand) shock and the final column to a inflation/cost push shock. Figure 5b then graphs in the first column the responses to a domestic monetary policy (MP) shock, the second column to an exchange rate (ER) shock, and the final column to the stock price (SP) shock. In both figures, the response in stock prices to all the shocks can then be found in the bottom row.

Figure 5b, column one shows that following a contractionary monetary policy shock that increases domestic interest rates (INTR) temporarily, stock prices (STOCKP) respond by far the strongest of all variables, falling immediately. The effect on the

[14] Since 2001, the petroleum income in Norway has been regulated to be phased into the economy on par with developments in the expected returns on the Government Petroleum Fund, leading to more stable income streams from the oil sector.

exchange rate (EXCH) is more delayed, as it appreciates for more than a year before it gradually dies out. Consistent with the subsequent appreciation of the exchange rate, the unemployment rate (UNEMPL) and the inflation rate (INFLATION) also adjust, with unemployment reaching a maximum after 1.5 years and inflation falling to its lowest level after 2.5 years. These responses are broadly consistent with what has been found in a recent analysis of Norwegian monetary policy, see Bjørnland (2008).[15]

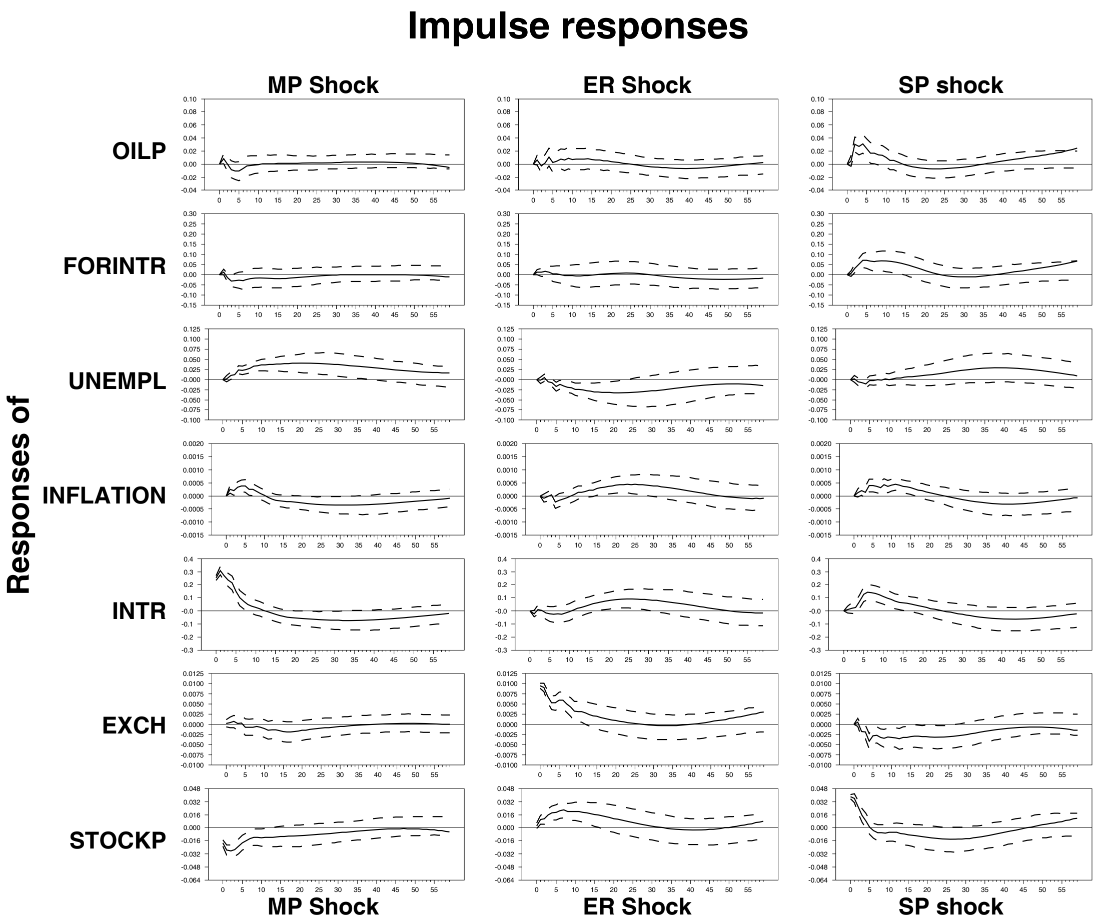
Figure 5a Impulse responses with probability bands[a]



a) The first column gives the responses in various variables to an oil price (OP) shock, the second column to a foreign monetary policy (MP) shock, the third column to an unemployment (demand) shock and the final column to a cost push shock.

[15] However, in contrast to Bjørnland (2008), there is more evidence of delayed reaction in the exchange rate here. As pointed out, the delayed reaction may be due to the ordering of the variables in the VAR and should be interpreted with care.

Figure 5b Impulse responses with probability bands



a) The three columns gives respectively the responses in various variables to a monetary policy (MP) shock, the response to an exchange rate (ER) shock and the response to the stock price (SP) shock.

The effects of the remaining shocks are as expected. Stock prices decrease following shocks that increase inflation (*cost push*) or the unemployment rate (*demand*). Monetary policy (the interest rate) also seems to react in a systematic way by becoming tighter in response to shocks that push up inflation or reduce the unemployment rate, although following the latter, the interest rate response is delayed. In addition, an exchange rate shock that depreciates the exchange rate leads to a temporary increase in the interest rate. Similar results are found for a stock return shock that increases OSEBX.[16]

[16] Note, that although monetary policy responds to exchange rate and stock prices, there is no direct evidence that these variables are stabilized independent of less controversial objectives such as inflation (and unemployment). More likely, stabilization is the result of the policymaker reacting to financial variables due to the monetary policy lag in influencing objectives such as unemployment and inflation.

Table 3. Variance decomposition, (1993-2005)

	Unemployment						
Horizon\Shocks	v^{op}	v^{i*}	v^{u}	v^{π}	v^{mp}	v^{e}	v^{sp}
1	0	1	99	0	0	0	0
6	2	2	83	0	7	3	2
12	6	1	68	0	16	8	1
24	17	1	47	10	15	9	1
48	15	1	40	18	14	7	4
	Inflation						
Horizon\Shocks	v^{op}	v^{i*}	v^{u}	v^{π}	v^{mp}	v^{e}	v^{sp}
1	1	0	0	98	0	0	0
6	3	2	4	78	5	2	7
12	7	2	3	67	5	2	14
24	24	2	13	37	5	10	9
48	21	2	18	36	6	8	9
	Interest rate (Nibor)						
Horizon\Shocks	v^{op}	v^{i*}	v^{u}	v^{π}	v^{mp}	v^{e}	v^{sp}
1	1	4	0	0	95	0	0
6	1	7	10	3	73	1	5
12	2	8	9	8	52	1	20
24	14	6	15	8	34	7	15
48	17	4	20	19	21	8	11
	Exchange rate (KKI)						
Horizon\Shocks	v^{op}	v^{i*}	v^{u}	v^{π}	v^{mp}	v^{e}	v^{sp}
1	0	1	0	7	0	91	0
6	6	2	8	13	1	60	9
12	7	2	15	23	1	40	12
24	11	2	15	28	2	30	12
48	15	3	14	28	2	27	12
	Stock price (OSEBX)						
Horizon\Shocks	v^{op}	v^{i*}	v^{u}	v^{π}	v^{mp}	v^{e}	v^{sp}
1	13	2	2	0	16	0	66
6	19	2	7	1	27	12	33
12	22	4	15	8	16	16	18
24	23	3	15	25	10	12	13
48	26	3	14	24	9	11	13

a) Variance decomposition explaining variation in variables due to oil price shocks, (v^{op}), foreign monetary policy shocks (v^{i*}), unemployment shocks (v^{u}) , inflation (or cost push) shocks (v^{π}), monetary policy shocks (v^{mp}), exchange rate shocks (v^{e}) and stock price shocks (v^{sp}).

Finally, Table 3 gives the variance decomposition of all shocks for the variables of interest. Oil price shocks are important driving forces behind stock return variability, explaining almost 20 percent of the variation in OSEBX in the short run (half a year). In addition, monetary policy and unexplained stock price variation (portfolio shocks) each explain 30 percent of stock price variation. In the long run (more than four years), structural shocks in the unemployment and inflation equations explain more of the stock price variation; close to 15 and 25 percent respectively.

The contribution of the oil price shock to the other variables is more modest, but clearly not negligible. In the short run oil price shocks explain less than 5 percent of the variation in the interest rate, unemployment rate and inflation rate, increasing to 10-15 percent after two years. The effect thereafter dies out.

The contribution of the other shocks is as expected; monetary policy shocks explaining less than 10 percent of the variation in the other nominal and real variables.

6. Conclusion

This paper analyses the effects of oil price shocks on stock returns in Norway, and in so doing highlights the transmission channels of oil price changes for macroeconomic behaviour in an oil exporting country. I find that higher oil prices have a stimulating effect on the Norwegian economy that is consistent with what one would expect for an oil exporting country. In particular, a higher oil price increases stock returns. The results show that following a 10 percent increase in oil prices, stock returns increase immediately by 2-3 percent. The maximum effect is reached after 14-15 months (having increased by 4-5 percent), after which the effect gradually dies out.

The effects on the other variables are more modest. However, all indicate that the Norwegian economy responds to higher oil prices by increasing aggregate wealth and demand. As a consequence, the unemployment rate falls and inflation picks up gradually. In response to increased economic activity, the interest rate is eventually increased. The effect on the real exchange rate is that of appreciation, as expected, but the effect is small. This lack of response in the exchange rate has been found in a series of different studies over time, suggesting why it is possible for Norway to benefit from higher oil prices.

The results are robust to a series of non-linear transformations of oil prices and several additional model variations. The results also emphasize the role of other shocks; monetary policy shocks in particular, as important driving forces behind stock price variability in the short term.

One issue left out for future work is to what extent the effects depend on the different causes behind the oil price changes. Recent research has suggested that as global growth has been high at the same time as oil prices have increased, oil prices may have been driven by increased demand instead of restrictions on the supply side (as in the 1970s). Hence, higher oil prices may have had a less pronounced negative effect on the global economy in recent years than previously. Given lower growth prospects ahead for the world economy, this could now curb the expansionary effects associated with higher oil prices that the oil exporting country Norway so far has experienced. This could imply new challenges for the Norwegian policy makers in the years ahead.

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Appendix A Data

The variables used in the analysis are taken from Norges Banks database, with the exception of the stock price index that is taken from the Oslo Stock Exchange.

(op_t) Oil price: Brent Blend, USD/barrel, spot price.

(sp_t) Stock return: The stock return index of *major* shares at the Oslo Stock Exchange adjusted for dividend payouts (OSEBX). Daily observations averaged to monthly data, 1995-2005. The series is linked to the TOTX (the old equivalent of OSEAX) prior to 1995.

Stock return: The stock return index of *all* shares at the Oslo Stock Exchange adjusted for dividend payouts (OSEAX). Daily observations averaged to monthly data, 1995-2005. The series is linked to TOTX (the old equivalent of OSEAX) prior to 1995.

(i_t) Three month domestic interest rate, (NIBOR).

(i_t*), Trade weighted three month foreign interest rate (SWE, EURO, USD and GBR).

(u_t) The unemployment rate.

(π_t) Log of the annual changes in the domestic Consumer Price Index Adjusted for Taxes and Energy Prices ('CPIATE).

(e_t) Log of the real exchange rate against a basket of trading partners, KKI ("konkuransekursindeksen").