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PETROLEUM WEALTH AND OIL PRICE EXPOSURE OF EQUITY SECTORS

DISCUSSION NOTE

In this note, we analyse the short- and long-term co-movement of equity sectors with oil prices. We discuss how Norwegian petroleum wealth is exposed to a permanent oil price decline through sectors that co-move with oil prices.

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SUMMARY

- The government petroleum wealth of Norway is sensitive to changes in oil prices, through the present value of government oil and gas revenues and holdings in Statoil. There are additional oil price exposures in the Government Pension Fund Global (GPFG), in particular through holdings of Oil & Gas stocks.
- We analyse the oil price exposure of equities, grouped by sector classification, and show that the Oil & Gas sector intuitively has the largest exposure to oil price changes.
- While Oil & Gas sector total returns co-move strongly with the aggregate market, the sector return *relative to the market* has a high sensitivity to oil price changes, and the inclusion of oil price changes in regression models is important for capturing variation in Oil & Gas sector returns. We do not observe such an additional oil price exposure in other sectors.
- We examine whether oil prices co-move with expected cash flows or expected returns of the Oil & Gas sector relative to the market. We find that the co-movement between Oil & Gas returns and oil prices primarily arises through the correlation between oil price changes and cash flow news of the sector, as opposed to co-movement with discount rate news. This suggests that the short-term oil price exposure of Oil & Gas sector returns is also relevant for longer-term co-movement, and that a permanent shock to the oil price is likely to have a permanent effect on the wealth of investors invested in Oil & Gas stocks.
- We find no significant differences in expected returns for Oil & Gas stocks and the market. Our results hence indicate that it might be beneficial for an investor that already has substantial oil price exposure outside their financial portfolio, not to add to this exposure by investing in Oil & Gas stocks in their financial portfolio.

1. Introduction

It is well-known that an investor should take into consideration their non-financial assets when forming their financial portfolio. This can lead to a different portfolio composition compared to only considering financial assets in isolation.[1] Such advice applies at a national level as well, where the relevant question is whether resource-endowed economies with substantial savings should take into account their (non-tradable) resource wealth, when setting the investment policy for their savings vehicles.[2]

In the case of Norway, oil price exposures within the Government Pension Fund Global (GPFG) lead to a common exposure across financial and non-financial assets, given the nation's large petroleum wealth. The composition of the financial portfolio should potentially be adjusted to account for these common exposures as a result. In this note, we attempt to quantify the exposure of equity sectors to changes in the oil price. We show that there is significant heterogeneity across equity sectors in terms of the sensitivity of returns to oil price changes. Intuitively, we find that Oil & Gas stocks co-move strongly with the price of oil, in particular when considering the performance of the sector *relative* to the market. For the other sectors, we observe less co-movement with oil prices, if at all.

We also consider the co-movement between Oil & Gas stocks and oil prices in a longer-term context, which is naturally of more relevance for a long-term investor. We decompose oil price co-movement, by sector, into co-movement associated with the cash flow news and discount rate news components of returns. We find that Oil & Gas return co-movement is mostly attributable to the correlation between oil price shocks and permanent cash flow news, as opposed to transitory discount rate news. This suggests that the short-term oil price exposure of Oil & Gas sector returns is also relevant for longer-term co-movement, and that a permanent shock to the oil price is likely to have a permanent effect on the wealth of investors invested in Oil & Gas stocks.

We find no significant differences in long-term historical average returns for Oil & Gas stocks and the market, suggesting that there are not positive expected returns on the Oil & Gas sector relative to the market. Taking a broader wealth perspective, for a nation that already has considerable exposure to the oil price, the high oil price exposure of Oil & Gas stocks likely weakens the case for their inclusion in the financial portfolio. In the case of Norway, due to the increase in the size of the GPFG, the amount invested in Oil & Gas stocks in the GPFG is currently at its highest ever level.

[1] See for example, Bodie, Merton, and Samuelson (1992), Heaton and Lucas (2000), Viceira (2001), Benzoni, Collin-Dufresne, and Goldstein (2007), and Cochrane (2014).

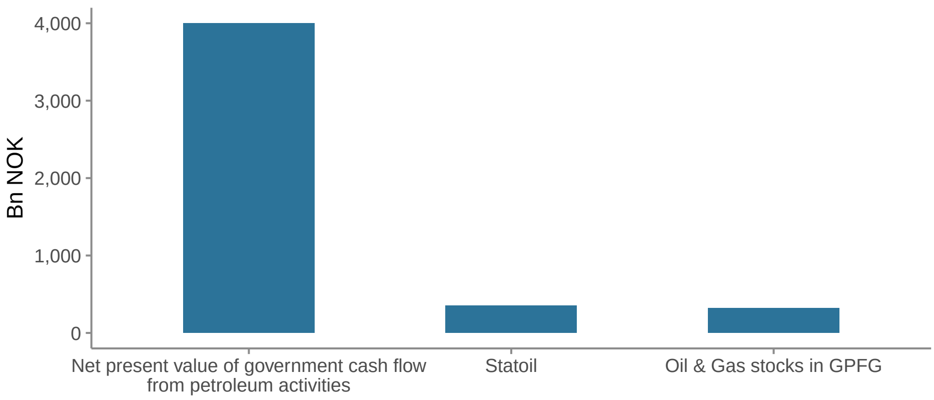
[2] The portfolio choice problem with a natural resource endowment has been studied by, among others, Scherer (2009a,b), Bodie and Brière (2013), van den Bremer, van der Ploeg, and Wills (2016), and Henriksen and Kværner (2016).

The note proceeds as follows. In Section 2, we provide background information on the government petroleum wealth for Norway, and its oil price exposure. In Section 3, we analyse the short- and long-term co-movement between oil prices and equity sector returns, and examine the expected returns of the Oil & Gas sector relative to the market. Section 4 summarises the findings.

2. Norway's Government Petroleum Wealth

The Norwegian government petroleum wealth naturally has significant exposure to oil price risk. The most significant component of petroleum wealth, in terms of oil price risk, is the net present value of government cash flow from petroleum activities. Through the State's Direct Financial Interest (SDFI), the government has a stake in operations on the Norwegian continental shelf. The government also extracts rent from oil reserves through a separate taxation scheme for companies operating in the North Sea. In addition, the government holds a majority stake (67 percent) in the publicly listed petroleum company Statoil, a holding value at around 350 billion kroner, from which dividends contribute to the government petroleum cash flows. In total, the net present value of the government's cash flow from petroleum activities is currently estimated to be around 4,000 billion kroner, see Figure 1.[3]

Figure 1: Norway's petroleum wealth



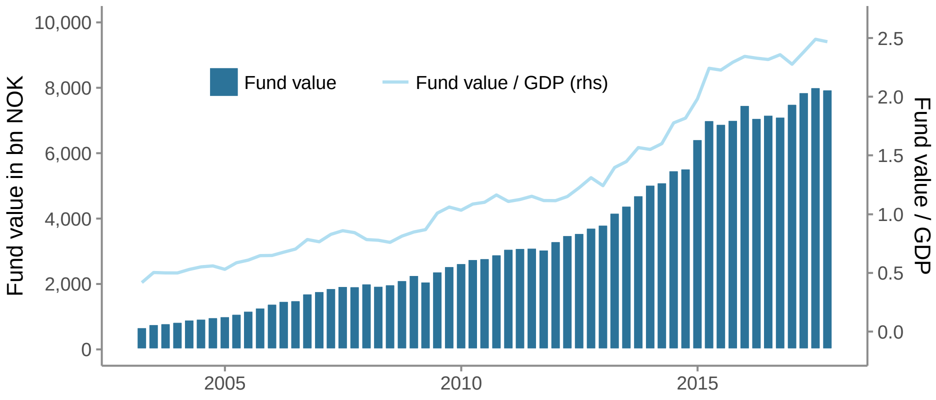
Source: Norwegian Ministry of Finance, NBIM

Oil price exposure also arises through Oil & Gas stock holdings in the GPFG. The fund has experienced rapid growth since its inception in 1998. Today it is worth around 8,000 billion kroner, or around 2.5 times Norway's GDP, see Figure 2. Since the fund has grown rapidly over time, and its benchmark is based on market capitalisation weights (with some regional adjustment factors), the benchmark-implied holdings of Oil & Gas stocks in the fund have also increased rapidly and the value of these companies is currently at its highest ever level, see Figure 3. The holdings are similar in size to the stake in Statoil, at around 320 billion kroner.[4]

[3] See Report to the Storting No. Meld. St. 29 (2016-2017): "Long-term Perspectives on the Norwegian Economy 2017" p. 109.

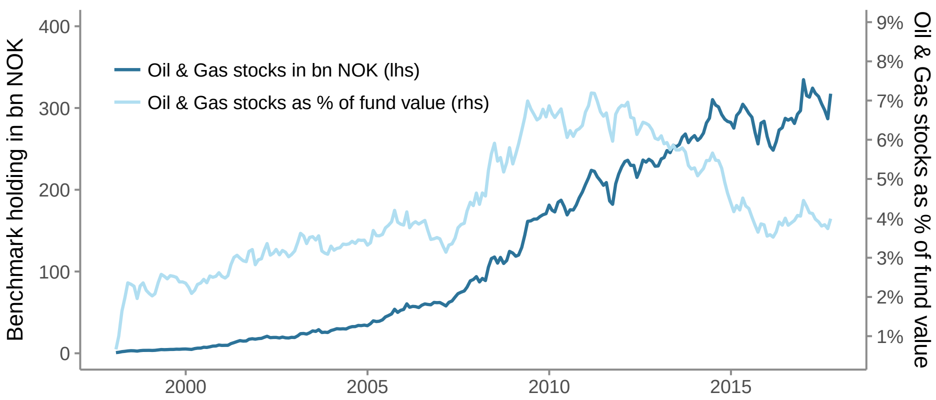
[4] The Oil & Gas stocks in the GPFG are most likely to be exposed to movements in oil prices. Com-

Figure 2: Fund value in billions of kroner and as a share of Norwegian GDP



Source: Statistics Norway, NBIM

Figure 3: Value of Oil & Gas stocks in the fund's benchmark



Source: NBIM

Oil price exposures within the financial portfolio potentially lead to an additional long-term exposure to a large permanent drop in oil prices. In the remainder of this note, limiting the discussion to listed equities, we examine these short- and long-term exposures.

3. The Oil Price Exposure of Equity Sectors

In this section, we assess the co-movement between sector returns and oil prices. We use regression models to analyse the exposure of sector returns *relative* to the aggregate market return. The analysis of the relative return captures the incremental effect on returns and exposures of including (excluding) a given sector in (from) a broad diversified equity portfolio.

panies in this sector tend to be involved in the exploration and production of oil and gas, and their revenues naturally tend to be particularly sensitive to oil price movements.

For the main analysis we use FTSE data and FTSE sector classifications.[5] The sectors are based on the standard FTSE International Classification Benchmark (ICB) system and comprise Basic Materials, Consumer Goods, Consumer Services, Financials, Health Care, Industrials, Oil & Gas, Technology, Telecommunications and Utilities.[6] We use monthly total US dollar returns for the FTSE All Cap and FTSE sectors and oil price changes over the period January 1994 to July 2017.

For each sector, we regress the relative return, defined as long the sector and short the aggregate market, on the aggregate market excess return (in excess of the U.S. Treasury bill rate) and the change in the WTI futures price (i.e. excess return) with 12-months to expiration.[7] The relative return captures the effect of including (excluding) a given sector in (from) a broad diversified equity portfolio. Table 1 shows the estimated coefficients across models, for each of the ten FTSE sectors.

Table 1: Sector relative return regressions

	Oil & Gas	Basic Mat.	Indus-trials	Cons. Gds	Health Care	Cons. Svs	Telecom.	Utilities	Finan-cials	Tech
(Intercept)	0.30	−0.99	−0.38	2.60*	6.17*	0.62	0.28	1.31	−1.36	2.23
	(1.97)	(2.58)	(0.98)	(1.28)	(1.95)	(0.97)	(2.47)	(1.95)	(1.67)	(3.07)
Market	−0.29*	0.08	0.08*	−0.22*	−0.39*	−0.06*	−0.06	−0.45*	0.19*	0.36*
	(0.05)	(0.05)	(0.03)	(0.04)	(0.05)	(0.02)	(0.06)	(0.05)	(0.05)	(0.09)
ΔOil	0.41*	0.19*	0.02	−0.04*	−0.08*	−0.10*	−0.10*	0.04	−0.05*	−0.09*
	(0.04)	(0.04)	(0.01)	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)	(0.03)	(0.04)
N	283	283	283	283	283	283	283	283	283	283
R^2	0.37	0.16	0.08	0.30	0.33	0.23	0.05	0.34	0.12	0.11

*Note: Newey and West (1987) corrected standard errors reported in parentheses (using 3-month lag), * indicates significance at p < 0.05. Intercept annualised and in percent. Source: Bloomberg, FTSE, Ken French, NBIM*

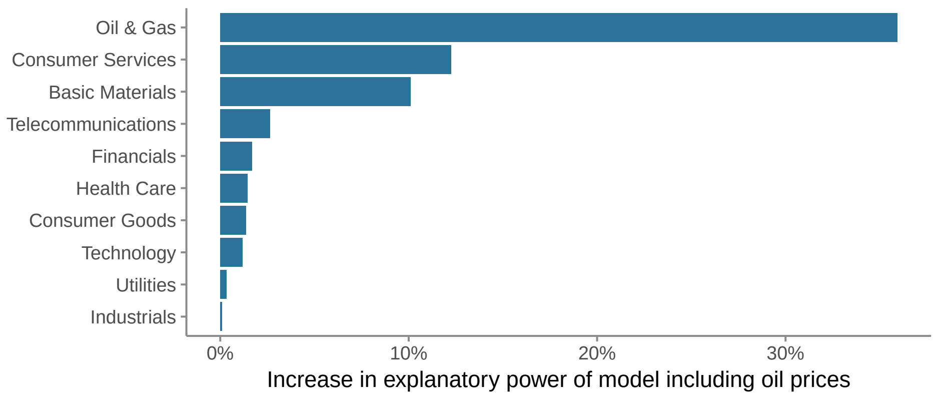
Among the ten top-level FTSE sectors, the regression analysis suggests that two sectors - Oil & Gas and Basic Materials - have positive and statistically significant exposures to changes in the oil price, controlling for exposure to the market. The Oil & Gas sector has the largest estimated oil price coefficient, around twice that for Basic Materials, the second largest.[8] Out of the remaining eight sectors, six have significantly negative loadings to oil price changes, though these are small in absolute value, and two exposures are insignificantly different from zero.[9] As such, the Oil & Gas sector stands

[5]We use FTSE data as the main source since the GPFG's equity benchmark is based on the FTSE Global All Cap.
[6]Before December 2005, we map from the previous Global Classification System (GCS) to the ICB sectors, based primarily upon the mapping information provided by FTSE.
[7]The market is defined as FTSE World until September 2003, and the FTSE Global All Cap thereafter.
[8]We do not account for differences within Oil & Gas sub-sectors, in particular Alternative Energy which contains renewable energy companies with a negative oil coefficient. Since the introduction of this sub-sector in March 2008, it has constituted less than 2 percent of sector capitalisation, however, and has very little impact on our analysis as a result.
[9]Since we are evaluating the sectors relative to the market, the value-weighted sum of the coefficients should be equal to zero.

out in terms of its oil price exposure.[10,11]

The regression-based analysis also allows us to compare model specifications with and without changes in oil prices, to assess whether the inclusion is beneficial for explaining variation in returns. Figure 4 shows the change in explanatory power by sector, for the model specification in Table 1, with and without oil price changes. For the Oil & Gas sector, the explanatory power increases by 36 percentage points, once we include changes to the oil price as one of the explanatory variables in the model. None of the other sectors see as large an increase in explanatory power, again highlighting the importance of oil prices in explaining the relative returns of the Oil & Gas sector.[12]

Figure 4: Change in regression R^2 when adding oil price change, by sector



Source: Bloomberg, FTSE, Ken French, NBIM

To illustrate the nature of the exposure documented in the regression analysis, Figure 5 shows the cumulative real return of the equity market and the Oil & Gas sector, alongside the real price of oil, over the period January 1970 to July 2017.[13] Clearly, the Oil & Gas sector and the overall market have moved closely together over time.[14] There are periods of divergence, however, which tend to coincide with large changes in the price of oil. Over this period, the Oil & Gas sector return has a correlation of 22 percent with oil price changes, substantially higher than that of the equity market and oil prices, which have a 3.7 percent correlation.

[10] The sector oil price betas do not change substantially if we do not control for market exposure. Without controlling for the market, the positive co-movement between the market and oil price changes implies that for sectors with a market beta below (above) one, the estimated oil price exposure will be lower (higher)

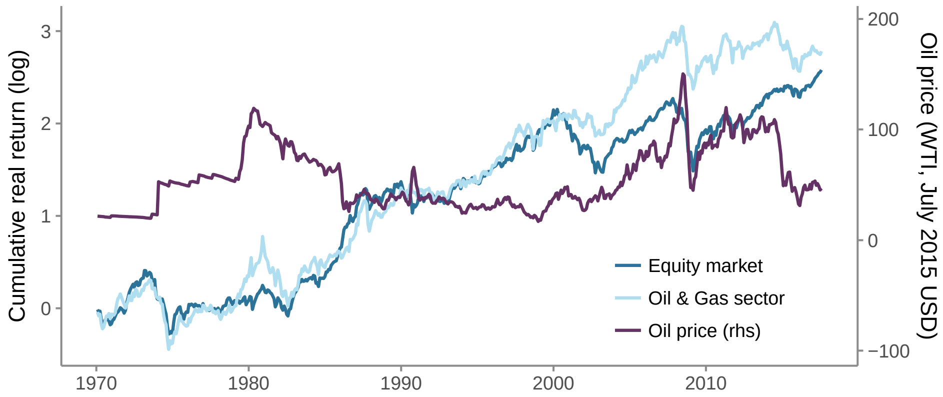
[11] Our findings are robust to using the spot oil price in the model or alternative WTI futures contract maturities, see Appendix A. Shorter maturity contracts tend to be more volatile and lead to a lower oil beta estimate, and longer maturity contracts lead to higher beta estimates. The results are also robust to inclusion of the additional factors from the Fama and French (2015) 5-factor model, as reported in Table A-1 in Appendix A.

[12] The differential oil price exposure of Oil & Gas sector returns has also been documented in previous research such as Huang, Masulis, and Stoll (1996), Nandha and Faff (2008), Gogineni (2010) and Mohanty and Nandha (2011).

[13] In order to obtain a longer history, the Oil & Gas sector is proxied using the MSCI World Energy sector.

[14] The results are unchanged if we use *nominal* rather than real oil prices for Figures 5, 6 and 7, see Appendix C.

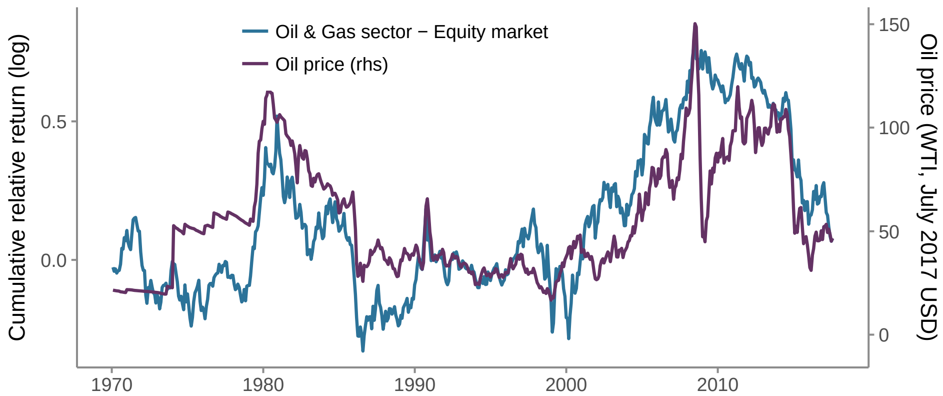
Figure 5: Equity market and Oil & Gas sector cumulative real returns vs. real oil price



Note: Equity market refers to MSCI World, Oil & Gas to MSCI World Energy sector, and oil price to spot WTI price deflated using the U.S. CPI for all urban consumers, all series measured in US dollars. Source: FactSet, MSCI, St. Louis FRED, NBIM

This can be seen more clearly in Figure 6, which shows the cumulative return of the Oil & Gas sector *relative to* the aggregate equity market, alongside the real oil price. There appears to be a close relationship between the oil price and the relative performance of the Oil & Gas sector, which is particularly strong when there are large movements in the oil price. It also seems that large and persistent changes in the oil price lead to large and persistent changes in the cumulative return.

Figure 6: Oil & Gas sector cumulative returns relative to equity market vs. real oil price

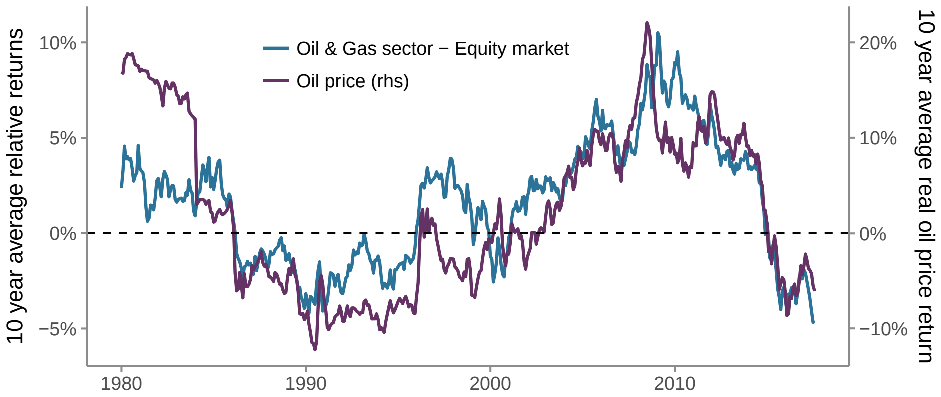


Note: Equity market refers to MSCI World, Oil & Gas to MSCI World Energy sector, and oil price to spot WTI price deflated using the U.S. CPI for all urban consumers, all series measured in US dollars. Source: FactSet, MSCI, St. Louis FRED, NBIM

Oil Price Exposure over Long Horizons

The analysis so far has focused on the short-term co-movement of monthly sector returns and oil prices, albeit using longer-dated futures. Given the long investment horizon of the fund, co-movement over longer horizons is naturally a relevant consideration. Figure 7 shows the rolling ten-year return of the Oil & Gas sector relative to the equity market return, alongside the ten-year change in the oil price. It can be seen that the long-term relative return of the sector co-moves strongly with long-term changes in oil prices. This suggests that oil price changes are also associated with a long-term effect on Oil & Gas sector returns. The implication is that the inclusion of the sector in a diversified equity portfolio leads to long-lasting oil price exposure, and to the long-term risk of a permanent adverse change in the price of oil.

Figure 7: Oil & Gas sector rolling ten-year return relative to equity market vs. ten-year change in real oil price



Note: Equity market refers to MSCI World, Oil & Gas to MSCI World Energy sector, and oil price to spot WTI price deflated using the U.S. CPI for all urban consumers, all series measured in US dollars. Source: FactSet, MSCI, St. Louis FRED, NBIM

We further explore this longer-term co-movement, using a similar exercise to Henriksen and Kværner (2016), where we decompose the oil price sensitivities of sector returns into their cash flow and discount rate components. In a present-value framework, changes to equity prices result from either changes in expected future cash flows or changes in discount rates. Campbell (1991) provides a formalisation of this intuition, where excess unexpected returns $e_{i,t+1} - \mathrm{E}_t\left[e_{i,t+1}\right]$, are a function of changes to expected future cash flows, $\mathrm{N}^{\mathrm{CF}}_{i,t+1}$ (cash flow news), and changes to expected future returns, $\mathrm{N}^{\mathrm{DR}}_{i,t+1}$ (discount rate news):

$$e_{i,t+1} - \mathrm{E}_t\left[e_{i,t+1}\right] = \mathrm{N}^{\mathrm{CF}}_{i,t+1} - \mathrm{N}^{\mathrm{DR}}_{i,t+1} \tag{1}$$

Empirically, the impact of discount rate shocks tends to be transitory, while cash flow shocks have a permanent return impact. This implies that the correlation of oil price changes with sector cash flow news can persist over long horizons, which is naturally of more concern for a long-term investor. This increases the likelihood that a permanent negative oil price shock would lead to long-term Oil & Gas sector underperformance.[15]

For each sector, i, we decompose returns using a VAR model (with a separate model for each sector). Additional detail on the return decomposition and

[15]Alquist, Kilian, and Vigfusson (2013) show that for medium to long horizons, a random-walk model for the price of oil performs well compared to a range of alternative models. If the oil price is well approximated by a random- walk process, this implies that shocks to the oil price are permanent.

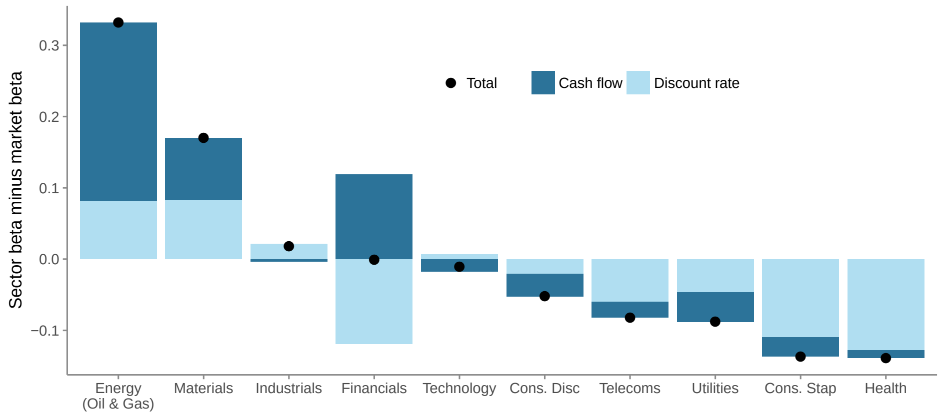
VAR implementation can be found in Appendix B.[16] The implication of the decomposition is that the betas between sector returns and oil price changes estimated in Table 1 can be thought of as being comprised of two separate beta components. One component measures how sensitive discount rate news is to changes in the oil price, and the other component measures the sensitivity of cash flow news, with the sum of the two components totalling the overall oil price beta for the sector. To obtain these betas, we regress the two news components on oil price changes:

$$\mathrm{N}_{i,t}^{\mathrm{CF}} = \alpha_i + \beta_i^{\mathrm{CF}} \Delta \mathrm{Oil}_t + \epsilon_{i,t} \quad (2)$$
$$\mathrm{N}_{i,t}^{\mathrm{DR}} = \alpha_i + \beta_i^{\mathrm{DR}} \Delta \mathrm{Oil}_t + \epsilon_{i,t} \quad (3)$$

where ΔOil is the change to the WTI futures contract with 12 months to expiration.

Figure 8 shows the cash flow and discount rate components of sector oil betas. For each sector, the oil beta of the market-level cash flow news (discount rate news) has been subtracted from the oil beta of the sector cash flow (discount rate) component. This captures the net effect on cash flow and discount rate oil betas of including (excluding) a given sector in (from) a broad diversified equity portfolio (since this approximately implies the reduction of total market exposure for a position in a given sector).[17]

Figure 8: Sector cash flow (discount rate) oil beta minus market cash flow (discount rate) oil beta



Source: Bloomberg, Ken French, MSCI, NBIM

[16] We estimate the VAR and decompose returns using data from January 1970 to July 2017, and estimate betas using data from January 1989 until July 2017 due to availability of 12-month futures prices. In this analysis we use MSCI returns due to the longer data availability. We construct MSCI sector returns that are in general very similar with the FTSE sector return series, including the Oil & Gas sector, though less similar for the consumer sectors.

[17] Strictly speaking, in each case the sector exposure should be removed from the total market betas, but this only leads to a small scaling of market oil betas provided that a sector does not account for a high proportion of total market capitalisation.

For the Oil & Gas sector we find that the total oil beta is around 0.3 higher than the market oil beta, and that most of the increased exposure is due to higher co-movement between Oil & Gas cash flow news and oil price changes.[18] For most of the remaining sectors, the estimated sensitivity is smaller, and the majority of the beta differences are related to sensitivity to discount rate news rather than cash flow news.

The implication of this analysis is that the inclusion of the Oil & Gas sector in a diversified equity portfolio leads to additional long-lasting oil price exposure and that a permanent shock to the oil price is likely to have a permanent effect on the wealth of investors with allocations to Oil & Gas stocks.

Expected Returns of Oil & Gas Stocks vs. the market

Our results so far indicate that it might be benefical for investors that already have substantial oil price exposure outside their financial portfolio, not to add to this exposure by investing in Oil & Gas stocks in their financial portfolio. In order to analyse this further, we also need to look at changes in expected returns. In this section, we examine whether historically the Oil & Gas sector has generated statistically significant returns in excess of the market, and relative to other factors.

We examine the expected return from the inclusion of the Oil & Gas sector, using the regression framework employed in Section 3. The inclusion of the Oil & Gas sector can be thought of as reducing exposure to the overall market in order to fund a position in the sector. As such, similarly to earlier, we analyse the return on the Oil & Gas sector *relative* to the market, in several regression models. First, in Model 1 in Table 2, we regress the sector relative return on a constant only, where the estimated constant is equivalent to the average relative return. We then expand the regression to include additional factors associated with expected returns, where Model 2 includes the market excess return, and Model 3 includes the factors in the Fama and French (2015) five-factor model.

In the table, "Market" refers to the excess return of the aggregate equity market as measured by our FTSE return series, "SMB", "HML", "RMW" and "CMA" refer to returns on Size, Value, Quality and Investment long-short factor portfolios, respectively.[19]

In Model 1, we observe that the estimated average relative return of the sector is positive, but the intercept is not statistically significantly different from zero. The same holds when we control for market exposure, in Model 2, where the estimated exposure to the market is also insignificant. In Model 3, the intercept term is estimated to be negative, though again insignificant, and there are some significant exposures to the Size, Value and Quality factors. Overall, these results indicate no significant differences in historical average

[18] The total oil betas in Figure 8 and Table 1 are estimated from slightly different regressions and differ as a result. The calculation in Figure 8 is equivalent to the regression in Table 1 when not controlling for the market, and in addition is based on unexpected returns, MSCI rather than FTSE sectors, and a longer sample period.

[19] The factor returns and additional detail on their definitions and construction can be found on Ken French's website.

Table 2: Regression analysis of Oil & Gas sector returns relative to market

	Model 1	Model 2	Model 3
(Intercept)	1.32	1.84	−3.42
	(2.67)	(2.62)	(2.55)
Market		−0.08	0.04
		(0.06)	(0.06)
SMB			0.34*
			(0.10)
HML			0.47*
			(0.18)
RMW			0.57*
			(0.21)
CMA			−0.07
			(0.22)
N	283	283	283
R^2	0.00	0.01	0.14

*Note: Newey and West (1987) corrected standard errors reported in parentheses (using 3-month lag), * indicates significance at $p < 0.05$. Intercept annualised and in percent. Source: Bloomberg, FTSE, Ken French, NBIM*

returns for Oil & Gas stocks relative to the market. This suggests that the inclusion of the sector, funded by the market, is not associated with positive expected returns.

4. Concluding Remarks

In this note, we assess the oil price exposure of equity sectors, and show that the Oil & Gas sector intuitively has the largest exposure to oil price changes. We find a significant degree of co-movement between Oil & Gas returns relative to the aggregate market and oil price changes, while the exposure of the other equity sectors is mostly low or negative. In addition, the exposure of the Oil & Gas sector is primarily attributed to co-movement between the cash flows of the sector and the oil price, which implies that permanent shocks to the oil price influence sector returns over long horizons.

We find no significant differences in expected returns for Oil & Gas stocks relative to the market. Our results hence indicate that it might be benefical for investors that already have substantial oil price exposure outside their financial portfolio not to add to this exposure by investing in Oil & Gas stocks in their financial portfolio.

In the case of Norway, the government has considerable exposure to oil through the value of remaining oil reserves. Currently, 4 percent of the financial portfolio, or around 320 billion kroner, is added to this exposure through the GPFG.

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Appendix A: Oil beta robustness

Table A-1 reproduces the analysis in Table 1 when controlling for additional equity factors from the Fama and French (2015) five-factor model. Market refers to the excess return of the aggregate equity market, and SMB, HML, RMW and CMA are the returns on Size, Value, Quality and Investment factor portfolios, respectively, obtained from Ken French's data library.

Table A-1: Regression exposures

	Oil & Gas	Basic Mat.	Indus-trials	Cons. Gds	Health Care	Cons. Svs	Telecom.	Utilities	Finan-cials	Tech
(Intercept)	−4.13*	−5.48*	−1.62	−2.14*	3.42	−0.34	3.24	−3.54	−1.67	11.62*
	(2.10)	(2.57)	(0.87)	(0.97)	(1.99)	(0.98)	(2.20)	(2.02)	(1.01)	(2.37)
Market	−0.15*	0.22*	0.13*	−0.07*	−0.28*	−0.02	−0.14*	−0.28*	0.16*	0.06
	(0.06)	(0.06)	(0.02)	(0.03)	(0.05)	(0.02)	(0.05)	(0.05)	(0.03)	(0.06)
SMB	0.07	0.46*	0.26*	0.14*	−0.23*	0.10*	−0.46*	0.12	−0.16*	−0.19
	(0.09)	(0.10)	(0.06)	(0.05)	(0.09)	(0.04)	(0.15)	(0.09)	(0.05)	(0.13)
HML	0.22	0.43*	0.12*	0.11	−0.30*	−0.08	−0.63*	−0.00	0.72*	−0.69*
	(0.14)	(0.12)	(0.06)	(0.08)	(0.11)	(0.06)	(0.13)	(0.13)	(0.09)	(0.14)
RMW	0.49*	0.45*	0.01	0.62*	0.33*	0.13	−0.09	0.50*	−0.33*	−0.71*
	(0.16)	(0.16)	(0.06)	(0.08)	(0.13)	(0.07)	(0.17)	(0.17)	(0.07)	(0.20)
CMA	0.21	−0.07	0.07	0.22*	0.62*	0.13	0.19	0.49*	−0.19	−0.60*
	(0.17)	(0.15)	(0.08)	(0.09)	(0.18)	(0.08)	(0.19)	(0.18)	(0.12)	(0.23)
ΔOil	0.40*	0.14*	−0.01	−0.06*	−0.04	−0.10*	−0.03	0.04	−0.08*	−0.06
	(0.04)	(0.04)	(0.01)	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)	(0.02)	(0.03)
N	283	283	283	283	283	283	283	283	283	283
R^2	0.45	0.32	0.26	0.57	0.42	0.25	0.28	0.45	0.56	0.53

*Note: Newey and West (1987) corrected standard errors reported in parentheses (using 3-month lag), * indicates significance at p < 0.05. Intercept annualised and in percent. Source: Bloomberg, FTSE, Ken French, NBIM*

Table A-2 reports the results from a constrained version of the model in Table 1, where we do not control for market exposure. The estimated oil price exposure for the Oil & Gas sector is slightly lower than reported in Table 1, while the oil price exposure of Basic Materials is slightly higher. This change is driven by the weak positive correlation between equity market returns and oil prices. As the model specification in the table below does not control explicitly for market beta, the estimated oil price beta contains part of this co-movement. For the Oil & Gas sector, where the market beta is negative in Table 1, the estimated oil price exposure falls once we do not control for the market.

Table A-2: Regression exposures with only oil price changes

	Oil & Gas	Basic Mat.	Indus-trials	Cons. Gds	Health Care	Cons. Svs	Telecom.	Utilities	Finan-cials	Tech
(Intercept)	−1.02	−0.60	0.01	1.60	4.39*	0.33	−0.02	−0.77	−0.50	3.87
	(2.32)	(2.53)	(1.01)	(1.42)	(2.20)	(0.97)	(2.48)	(2.32)	(1.68)	(3.22)
ΔOil	0.34*	0.22*	0.04*	−0.10*	−0.18*	−0.11*	−0.11*	−0.08*	−0.01	−0.00
	(0.05)	(0.04)	(0.01)	(0.02)	(0.03)	(0.01)	(0.03)	(0.04)	(0.03)	(0.03)
N	283	283	283	283	283	283	283	283	283	283
R^2	0.28	0.15	0.03	0.10	0.10	0.20	0.05	0.02	0.00	0.00

*Note: Newey and West (1987) corrected standard errors reported in parentheses (using 3-month lag), * indicates significance at p < 0.05. Intercept annualised and in percent. Source: Bloomberg, FTSE, Ken French, NBIM*

Table A-3 reproduces the results for Oil & Gas in Table 1 using different oil price variables.

Table A-3: Sensitivity to alternative oil prices, monthly USD relative returns for the Oil & Gas sector from January 1994 - July 2017

	Model 1	Model 2	Model 3
Intercept	1.46	0.19	0.30
	(2.26)	(2.15)	(1.97)
Market	-0.14^{*}	-0.22^{*}	-0.29^{*}
	(0.05)	(0.05)	(0.05)
ΔOil - Spot	0.17^{*}		
	(0.03)		
ΔOil - 1M Future		0.25^{*}	
		(0.03)	
ΔOil - 12M Future			0.41^{*}
			(0.04)
N	283	283	283
R^2	0.14	0.31	0.37

*Note: Newey and West (1987) corrected standard errors reported in parentheses (using 3-month lag), * indicates significance at p < 0.05. Intercept annualised and in percent. Source: Bloomberg, FactSet, FTSE, Ken French, St. Louis FRED, NBIM*

Appendix B: Return Decompositions

Below, we present the framework used to decompose the sector returns into cash flow news and discount rate news, which we use to decompose the oil price change beta by sector.

Following Campbell (1991), unexpected equity returns, $e_{t+1} - \mathsf{E}_t\left[e_{t+1}\right]$, can be decomposed into revisions to expected future cash flows and discount rates:

$$e_{t+1} - \mathsf{E}_t\left[e_{t+1}\right] = \left(\mathsf{E}_{t+1} - \mathsf{E}_t\right)\left\{\sum_{j=0}^{\infty} \beta^j \Delta d_{t+1+j} - \sum_{j=1}^{\infty} \beta^j e_{t+1+j}\right\} \tag{4}$$

Unexpected returns arise from changing expectations of future dividends, d_t, commonly referred to as "cash flow news", or from changing expected returns, e_t, commonly referred to as "discount rate news":

$$\mathsf{N}^{\mathsf{CF}}_{t+1} = \left(\mathsf{E}_{t+1} - \mathsf{E}_t\right)\sum_{j=0}^{\infty} \beta^j \Delta d_{t+1+j} \tag{5}$$

$$\mathsf{N}^{\mathsf{DR}}_{t+1} = \left(\mathsf{E}_{t+1} - \mathsf{E}_t\right)\sum_{j=1}^{\infty} \beta^j e_{t+1+j} \tag{6}$$

$$e_{t+1} - \mathsf{E}_t\left[e_{t+1}\right] = \mathsf{N}^{\mathsf{CF}}_{t+1} - \mathsf{N}^{\mathsf{DR}}_{t+1} \tag{7}$$

We follow a large literature that uses VAR models to decompose returns and assume that returns are generated using a first-order VAR:

$$z_{t+1} = \alpha + \Gamma z_t + u_{t+1} \tag{8}$$

z_{t+1} is a state vector including asset returns and variables that help to describe the dynamics of returns.

$$z_t = \{e_t, r_t, pe_t, ty_t, vs_t\} \tag{9}$$

The z_{t+1} vector includes the sector return in excess of the risk free rate, e_t, the real risk free rate, r_t, the smoothed price-earnings ratio for the sector, pe_t, the term spread, ty_t and the small cap value spread, vs_t:

- **Equity sector excess returns**: US dollar return for sectors in excess of U.S. Treasury bill rate
- **Real interest rate**: Monthly Treasury bill rate less realised inflation
- **Smoothed price-earnings ratio**: Real equity price divided by ten-year average of real earnings
- **Term spread**: Yield difference between U.S. ten-year constant-maturity taxable bonds and short-term taxable notes
- **Small cap value spread**: Difference between the log book-to-market ratios of small value and small growth stocks

The z_{t+1} vector is defined by sector, such that we estimate ten different VAR models which are then used to decompose the sector-level returns. We model the excess return and real rate news components separately and combine them to form the total discount rate news term defined above.The news terms can be calculated using the VAR estimates, see Campbell (1991) for details.

Appendix B.1 VAR Robustness

To better understand the sensitivity of the return decompositions, we run a number of alternative models, with the reported oil price beta reported in Table B-1. Panel A illustrates how our selected base case model changes with different return forecasting variables included in the VAR. Panel B shows the impact of switching from a sector-level smoothed price-earnings ratio to a market-level equivalent. Panels C and D show the effect of selecting different time windows for the calculation of the sector-level smoothed price-earnings, using either real or nominal earnings. Panel E shows alternative VAR models where we use the sector-level dividend yield, rather than the smoothed price earnings. The first three specifications in Panel E are based on a dividend yield over the last 12 months, whereas the final specification is based on the ten-year average dividend yield.

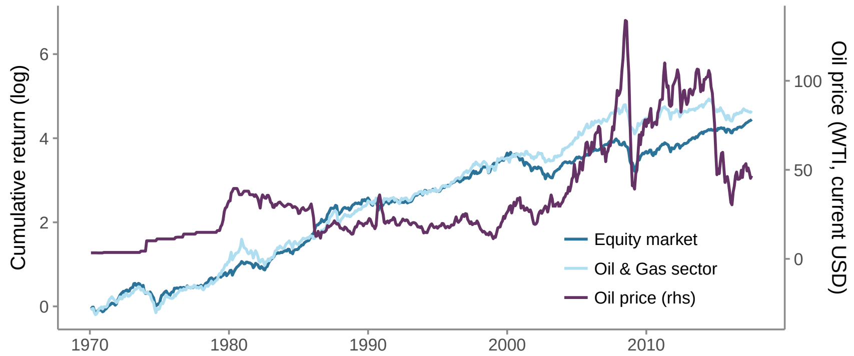
Table B-1: Beta decomposition under different specifications

Model	β^{DR}	β^{CF}
Panel A: Sector-level smoothed real price-earnings		
$z_t = \{e_t, r_t, pe_{t,R,10yr}\}$	-0.05	0.28
$z_t = \{e_t, r_t, pe_{t,R,10yr}, ty_t\}$	-0.05	0.28
$z_t = \{e_t, r_t, pe_{t,R,10yr}, ty_t, vs_t\}$	-0.08	0.25
$z_t = \{e_t, r_t, pe_{t,R,10yr}, \Delta Oil\}$	-0.03	0.28
Panel B: Market-level smoothed real price-earnings		
$z_t = \{e_t, r_t, pe_{t,R,10yr}\}$	0.10	0.43
$z_t = \{e_t, r_t, pe_{t,R,10yr}, ty_t\}$	0.10	0.43
$z_t = \{e_t, r_t, pe_{t,R,10yr}, ty_t, vs_t\}$	0.12	0.44
Panel C: Sector-level horizon for real price-earnings		
$z_t = \{e_t, r_t, pe_{t,1yr}\}$	0.01	0.35
$z_t = \{e_t, r_t, pe_{t,2yr}\}$	0.03	0.36
$z_t = \{e_t, r_t, pe_{t,3yr}\}$	-0.22	0.11
$z_t = \{e_t, r_t, pe_{t,5yr}\}$	-0.06	0.27
$z_t = \{e_t, r_t, pe_{t,7yr}\}$	-0.05	0.28
$z_t = \{e_t, r_t, pe_{t,10yr}\}$	-0.05	0.28
Panel D: Sector-level horizon for nominal price-earnings		
$z_t = \{e_t, r_t, pe_{t,1yr}\}$	0.02	0.36
$z_t = \{e_t, r_t, pe_{t,2yr}\}$	0.04	0.38
$z_t = \{e_t, r_t, pe_{t,3yr}\}$	-0.23	0.11
$z_t = \{e_t, r_t, pe_{t,5yr}\}$	-0.06	0.27
$z_t = \{e_t, r_t, pe_{t,7yr}\}$	-0.05	0.28
$z_t = \{e_t, r_t, pe_{t,10yr}\}$	-0.06	0.27
Panel E: Sector-level dividend yield		
$z_t = \{e_t, r_t, dy_t\}$	-0.17	0.17
$z_t = \{e_t, r_t, dy, ty_t\}$	-0.16	0.18
$z_t = \{e_t, r_t, dy, ty_t, vs_t\}$	-0.18	0.15
$z_t = \{e_t, r_t, dy_{t,10yr}\}$	-0.05	0.29

Source: Bloomberg, Ken French, MSCI, NBIM

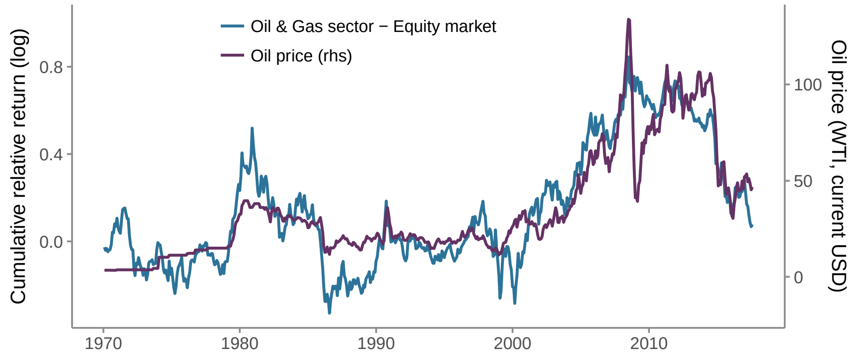
Appendix C: Nominal Oil Price Charts

Figure C-1: Equity market and Oil & Gas sector cumulative returns vs. oil price



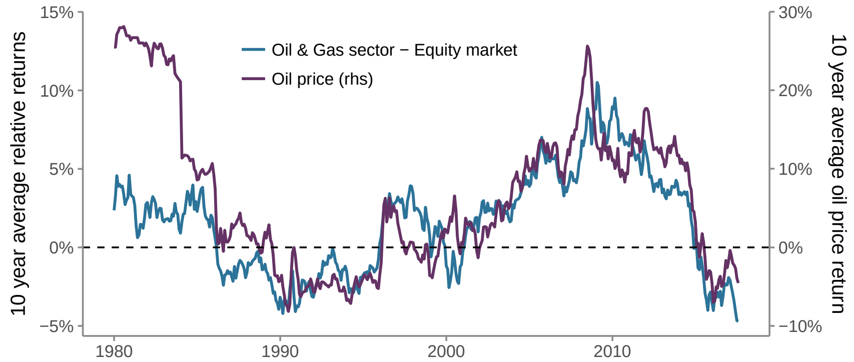
Note: Equity market refers to MSCI World, Oil & Gas to MSCI World Energy sector, and oil price to spot WTI price, all series measured in US dollars. Source: FactSet, MSCI, NBIM

Figure C-2: Oil & Gas sector cumulative returns relative to equity market vs. oil price



Note: Equity market refers to MSCI World, Oil & Gas to MSCI World Energy sector, and oil price to spot WTI price, all series measured in US dollars. Source: FactSet, MSCI, NBIM

Figure C-3: Oil & Gas sector rolling ten-year returns relative to equity market vs. ten-year change in oil price



Note: Equity market refers to MSCI World, Oil & Gas to MSCI World Energy sector, and oil price to spot WTI price, all series measured in US dollars. Source: FactSet, MSCI, NBIM