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Portfolio Choice for a Resource-based Sovereign Wealth Fund: An Analysis of Cash Flows

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ABSTRACT

We consider the portfolio choice of a government with a Sovereign Wealth Fund (SWF) when government revenues depend on exhaustible resources, such as oil and gas. The question is whether the SWF portfolio should underweight shares in the resource industry. Some studies have found that these shares prices correlate more closely with the overall stock market than the resource price, which would seem to weaken the case for underweighting. However, equity price movements depend not only on changes in expectations of future cash flows, but also on time-varying discount factors. Rather than trying to disentangle these effects, we analyze cash flows directly. We have collected cash-flow data for the companies in all the major industries of the FTSE Global All Cap index, the basis for the strategic index of the Norwegian Government Pension Fund Global. We then look at the correlations between each industry's cash flow and the Norwegian government's cash flow from oil and gas. We find a close, statistically significant, and persistent correlation for the oil and gas industry. The correlations for other industries are small and insignificant. We believe our findings can be used to support proposals for SWFs in countries with significant petroleum revenues to underweight shares in this industry.

1. Introduction

Elementary financial analysis warns against concentration risk. Because this kind of risk is idiosyncratic, diversification solves the problem. So, financial investment portfolios should be diversified. However, many investors face risks outside their portfolios. Diversification for these investors should then consider the full spectrum of the risks they face, financial as well as background. When background risks are positively (negatively) correlated with some of the financial assets, investment in these assets should then be underweighted (overweighted) relative to a financial portfolio that is perfectly diversified in the absence of background risks. Discussions of this issue on the literature includes Bodie, Merton, and Samuelson (1992), Heaton and Lucas (2000), Viceira (2001), Benzoni, Collin-Dufresne, and Goldstein (2007), and Cochrane (2014).

Sovereign wealth funds (SWF) are prime examples of financial portfolios held by investors with significant background risks. A quick look at the list of significant such SWFs (e.g. Baldwin, 2012) reveals that a majority of the leading ones are owned by states with significant resource revenues. The reason is, of course, that the funds have been built up from these revenues. Although temporary in a long perspective, the revenues usually last for decades. The continued inflow from resource extraction then raises concerns of concentration risks for the SWFs.

The theoretical literature has been rather clear in its recommendation for the SWF to underweight or to avoid completely financial investments in the industry in question. The dynamic optimization analysis by van den Bremer, van der Ploeg, and Wills (2016) concluded that, as an example, the Norwegian Government Pension Fund Global (GPFG) should underweight or indeed take short positions in oil-industry shares for as long as the country's government continues to receive rent-related revenues from its own oil industry. Henriksen and Kværner (2018) treat unextracted resources as a non-tradeable asset. Like van der Bremer et al., they use the Norwegian GPFG as their prime example. A report from the Norwegian Ministry of Finance (2016a) extends this argument by looking beyond the government's assets to the nation's total capital. Other contributions to this literature include Scherer (2009a, b), and Bodie and Brière (2013).

To be useful for actual decision making, such theoretical arguments must be backed up by empirical facts. The correlation between financial assets and the asset in the ground should be reliably estimated. Such estimation is far from trivial, however. The main problem is that the value of the resources in the ground is unobservable. Markets for such resources may be hard to organize, for example, because problems of dynamic inconsistency, which can make potential buyers doubt assurances about future tax rates or regulations. If a market is nevertheless established, the market price may underestimate the social value of the resource, for the same reasons. Finally, because deposits differ widely in regard to geological conditions, the price of one deposit may be a poor indicator for the value of other deposits that have not yet been taken to the market.

One might think that the market value of the extracted resource could work as a proxy for the asset value. It is, after all, the market price of a similar physical product as the one in the ground. In reality, it falls well short of the target, because it ignores the costs of extraction, which are not only significant, but highly variable depending on a number of geological,

geographical, political, and other factors. Thus, it is hardly surprising that the Norwegian Ministry of Finance (2018) finds that the correlation between oil prices and oil-company stock prices is too low to warrant underweighting of oil and gas shares in the GPFG. In fact, they find that the returns to oil and gas shares are more closely correlated with the overall equity market than with the price of oil.

Norges Bank Investment Management (NBIM, 2017), the agency managing the investment of the GPFG, has looked closer at these correlations. Using the arguments of Campbell and Shiller (1988) and the method of Campbell (1991), they seek to separate stock price movements driven by changes in discount rates from those following from revisions of expectations of company cash flow. They find empirical support for the claim that the close correlation between oil and gas stock returns and the overall stock market is driven mainly by variations in discount rates, which should be common across all industries. After separating out this effect, they find that the component reflecting revisions of cash-flow expectations is much more closely correlated with the world price of oil.

While highly suggestive, this contribution does not settle the issue. Because the price of oil is a highly imperfect proxy for the value of oil in the ground, it compares apples and oranges. Furthermore, Campbell's method is fraught with sampling as well as approximation errors from its reliance of linear approximations and key identifying assumptions.

The main contribution of this paper is to circumvent these problems by looking instead directly at the correlation between oil and gas companies' cash flow and the Norwegian government's cash flow from oil and gas activities. We furthermore compare this correlation with the corresponding correlations for the other major industries represented in the global stock market. By studying cash flows directly, we avoid the complications caused by time-varying discount factors. We also avoid the possible biases from linear approximations and special identifying assumption. On the other hand, by studying realized rather than expected future cash flows, our analysis is subject to expectation errors. If expectations are rational, this should not matter. And even if they are biased, our results should give a reliable guide to the relationship between the company asset prices and the imputed asset price of the government's resource holding, provided only that the biases tend in the same direction. At the very least, we offer an alternative perspective on an issue for which a perfect method of analysis is simply not available.

Another limitation of our study is the relatively young age of the Norwegian GPFG. Although enacted by Parliament in 1990, the first deposit into the fund, corresponding to about USD 300 million, was not made until 1996; and the first equity investments were not made until 1998. Furthermore, the fund's current equity index, based on the FTSE Global All Cap index, was not launched until 2003, which then forms the start of our sample.

The number of observations, though not the sample length in calendar time, could have been increased by using quarterly data. However, data for the Norwegian government's net petroleum cash flow (GPCF) are only available in a meaningful way on the annual frequency. A quarterly breakdown would be dominated by irrelevant details concerning for example the timing of tax payment payments rather than the time profile of the actual earnings. This

limits our sample to the 16 annual observations (15 first differences) between 2003 (2004) and 2018.

These facts obviously limit the power of our statistical tests. On that background, we find it remarkable that we nevertheless find highly significant results.

We find that the cash flows of oil and gas companies are very closely correlated with the Norwegian government's cash flow from oil and gas activities. The corresponding correlations for the other industries are either much weaker or negative. Within the oil and gas industry, we find the strongest correlation for the subsector of integrated oil companies. We also find a significant, but much weaker correlation for the subsector of companies with only upstream operations in oil and gas. For the other oil and gas subsectors, we find no significant correlations with the government's cash flow.

We believe these results to be supportive of the argument that the shares of integrated oil companies as well as upstream companies should be underweighted in the strategic indices of oil-rich countries' SWFs, such as the Norwegian GPFG. Our results are only weakly supportive of the Norwegian government's recent decision[1] to underweight the shares of upstream companies only. That explanation given for that decision was that the integrated oil and gas companies do more than resource extraction. However, by excluding this subgroup, we believe the Norwegian government ignored the dominant actors in the global upstream petroleum industry.

The organization of the rest of the paper is as follows. Sector 2 presents the GPFG. Sector 3 presents the data for the Norwegian government's petroleum cash flow, and Sector 4 the data for the cash flows of the global corporations relevant for the GPFG. Sector 5 presents the main results of our analysis. Sector 6 offers some robustness checks, and Sector 7 concludes.

2. The Government Pension Fund Global

The GPFG is the Norwegian government's vehicle for investing the extraordinary proceeds from the extraction of non-renewable petroleum resources and thus preserving this wealth for future generations. The government's cash flow from oil and gas activity, to be further described in the next section, is the fund's only source of deposits. By statute, all of this cash flow is to deposited each year into the fund. This is also the fund's only source of deposits. The fund is managed by Norges Bank Investment Management (NBIM), a division of the central bank. An Act of Parliament stipulates that the Government, in practice the Ministry of Finance, act as the fund's owner and formulates its investment strategy, subject to Parliamentary approval.

A Fiscal Rule, adopted by Parliament in 2001[2], allows an annual draw from the fund corresponding to its expected real return. At the outset, the expected real rate of return was estimated as 4%. After the ensuing experience of low riskless rates and a lengthy public debate, this rate was officially lowered to 3% in the 2018 budget. Although the rule allows

[1] Norwegian Ministry of Finance (2019)
[2] Norwegian Ministry of Finance (2001)

for considerable flexibility, especially in response to the domestic business cycle, it has mainly been respected[3]. Even so, because of its fast growth to a total AMU exceeding USD 1 trillion, more than 15% of all government spending is currently financed from this source.

The fund is invested in equity, fixed income, and real estate in the global economy, with a certain overweight of European assets. Securities issued by Norwegian entities or in Norwegian kroner are excluded from the fund's universe. The investments are mostly done by index replication, though with a small portion actively managed[4]. The current strategic benchmark issued by the Ministry of Finance specifies an equity share of up to 70% and the rest in fixed income[5]. Investment in unlisted real estate can at most account for 7% of the total AUM. In index terms, however, such investments are considered part of the equity share and evaluated accordingly.

The fund's fixed-income benchmark index is provided by Bloomberg, and consists of the three following three subindices: Global Treasury GDP, Global Inflation-linked and Global Aggregate. It is made up of 70% government bonds in 21 different currencies, and 30% corporate bonds in 7 different currencies. The government bonds are weighted according to each country's GDP, and corporate bonds are weighted based on each company's outstanding debt.

The equity benchmark is based on the FTSE Global All Cap Index (GEISAC). It is market weighted and includes large, mid and small cap stocks in both Developed and Emerging markets. The GEISAC index contains shares of around 8,000 companies in 49 different countries. It was launched by FTSE Russell in 2003 and developed to be used for index tracking funds, derivatives, and as a performance benchmark for funds and such as the GPFG.

As stipulated by the Ministry of Finance, the GPFG actually uses a modified version of the GEISAC. The greatest modification is the overweighting of European corporations and the exclusion of Norwegian ones. Shares by non-Norwegian European corporations are weighted at 2.5 times their actual market cap. For U.S. and Canadian corporations, the corresponding weights are unity; and for the remaining developed and emerging markets the weights are 1.5. Furthermore, the GPFG invests in the equity markets of twenty countries not included in the GEISAC index, such as local Chinese equity (China A), Croatia, Saudi Arabia, and Morocco. Finally, some corporations are excluded for ethical or environmental reasons, such as tobacco, coal and tar-sand companies.

In response to sudden market movements, the GPFG is allowed to deviate from the strategic benchmark with a maximum deviation of an expected relative volatility of 1.25 percentage points. The expected realized volatility is a measure of how much the return on the GPFG is expected to deviate from the benchmark index return in a normal year (NBIM, 2018). The NBIM is required to rebalance the equity allocation whenever the equity share deviates significantly from the strategic benchmark index.

[3] Norwegian Ministry of Finance (2015).
[4] A further discussion can be found in Chambers, Dimson, and Ilmanen (2012).
[5] Norwegian Ministry of Finance (2016b).

Our main interest in this paper is the fund's investment in oil and gas companies. Table 1 displays the overall industry allocation in the FTSE GEISAC index as well as the actual holdings of the GPFG at the end of 2018. The industry classification follows the FTSE Russel Industry Classification Benchmark (ICB). The Oil & Gas industry makes up 5.9% of the fund as well as the FTSE index. Although not an overly large sector compared, e.g. to Financials with a share of 23.7%, it is of special interest because investment in this sector may give rise to a concentration risk for the Norwegian economy.

Table 1: The company count and industry weights for companies in each ICB industry in the GPFG and FTSE GEISAC, as well as their market value in the GPFG, as of Dec. 31, 2018. Sources: NBIM (2017b) and FTSE Russel (2018).

		GPFG equity holdings			*FTSE Global All Cap*	
		Count	NOK mn	Weight %	Count	Weight %
0001	Oil & Gas	341	320,756	5.9	3220	5.9
1000	Basic Materials	659	271,304	5.0	614	4.6
2000	Industrials	1,966	708,762	12.9	1,651	13.4
3000	Consumer Goods	1,204	653,764	11.9	1,009	11.0
4000	Health Care	723	626,847	11.4	544	11.2
5000	Consumer Services	1204	589,709	10.8	1,008	11.5
6000	Telecommunications	130	163,344	3.0	129	2.8
7000	Utilities	252	155,333	2.8	286	3.3
8000	Financials	1,859	1,299,103	23.7	1,659	21.9
9000	Technology	809	689,838	12.6	644	14.4
	Total	9,158	5,478,760	100.0	7,864	100.0

We should note, however, that this industry includes companies not involved in petroleum extraction, such as pipeline companies and renewable-energy companies. For this reason, we also look at a further breakdown into subsectors as displayed in Table 2. As seen there, the Oil & Gas industry is dominated by Integrated Oil and Gas, with a share of almost two thirds. This subsector contains the oil majors such as Royal Dutch Shell, ExxonMobil, BP, and Chevron. These companies are involved in all parts of petroleum production, from exploration and drilling to refining and distribution. They may even be involved in other energy forms, such as renewables. However, we will also be interested in the second-largest subsector, Exploration & Production, which makes up one fifth of the Oil & Gas industry. Here, we find upstream activities like exploration, drilling, production, refining and supply of oil and gas products (FTSE Russell, 2019). *Ex ante* one might expect these activities to be most closely correlated with the activities generating the Norwegian government's petroleum revenues.

Table 2: The company count and industry weights for companies in the Oil & Gas subsectors in the GPFG and FTSE GEISAC, as well as their market value in the GPFG, as of Dec. 31, 2018. Sources as in Table 1.

		GPFG BENCHMARK INDEX			FTSE GLOBAL ALL CAP	
	ICB Subsector	Count	NOK mn	Weight %	Count	Weight %
0533	Exploration & Production	134	70,276	20.52	138	25.08
0537	Integrated Oil & Gas	61	223,066	65.13	62	57.88
0573	Oil Equipment and Services	73	20,227	5.91	78	6.89
0577	Pipelines	16	22,546	6.58	16	8.64
0583	Renewable Energy Equipment	23	6,287	1.84	23	1.39
0587	Alternative Fuels	3	87	0.03	3	0.03
	Total	310	342,489	100.0	320	100.0

The Pipelines subsector was established in 2006 when the industry classification benchmark ICB scheme was introduced. The subsectors Renewable Energy Equipment and Alternative Fuels were created in 2009. We thus do not have data for these subsectors from the earlier years.

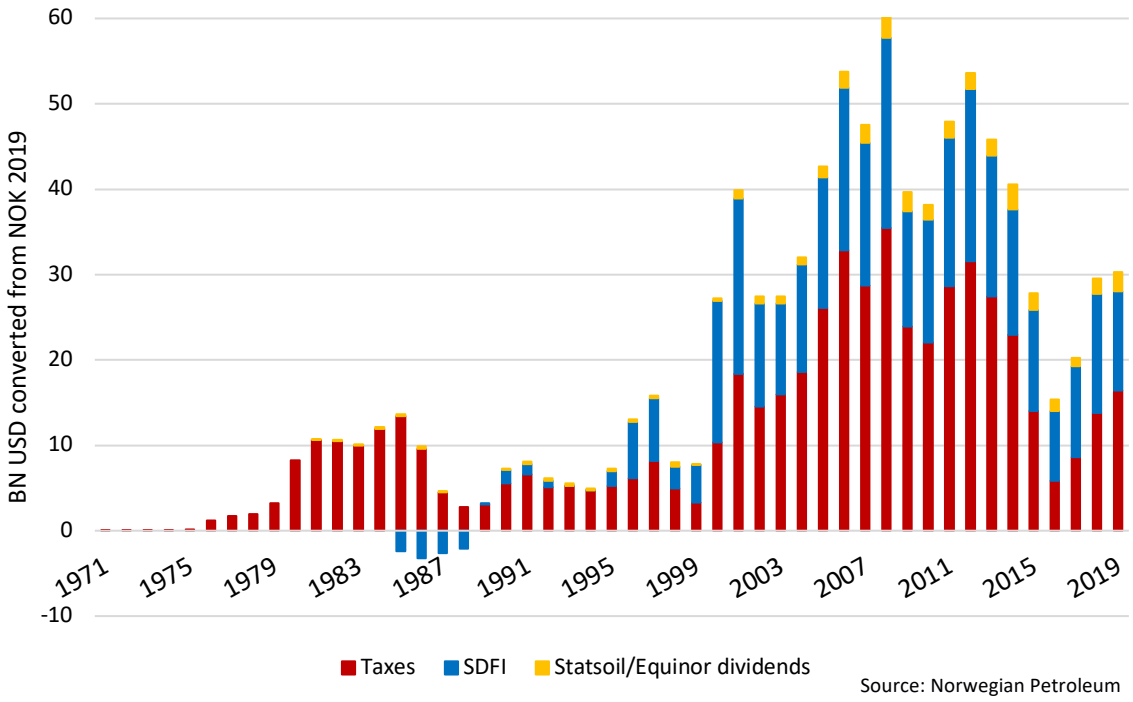
3. The Norwegian Government's petroleum cash flow (GPCF)

The Norwegian government started to collect revenue from oil activity on its continental shelf after the first discovery of oil in December of 1969. Figure 1 shows the time series of these revenues in NOK 2019, converted to U.S. dollars. Although the first revenues started to trickle in shortly after oil was first discovered in Norway in 1969, they remained modest until a huge jump around the turn of the century. For our 2003 – 2018 sample, the annual revenues mainly stayed above USD 30 billion.

Figure 1 also presents the breakdown of this revenue stream into its three main components:

- Oil company taxes, mainly the special corporate income tax for this sector, as explained below. Environmental taxes, area fees, and other fees, are also included, though their contribution is minor.
- The net cash flow from the government's direct participation as a financial partner in oil field development and operation via the State Direct Financial Investment program.
- Dividends from Equinor (formerly Statoil).

Figure 1: Norwegian government's net cash flow from petroleum activitites



For most of the years, the greatest share has come from oil-company taxes, mainly in the form of a special corporate income tax as defined in the Petroleum Taxation Act of 1975. Oil companies do not pay for their production licenses. However, in addition to the normal corporate tax rate, currently at 22%, profits from offshore operations are charged an additional tax which raises the marginal rate on such profits to 78%. This scheme is intended to mimic a rent tax such that, in an approximate sense, the government receives the entire resource rent. A deductible amount is added to take care of the extensive margin, that is, to make projects that are socially beneficial profitable after taxes. In addition, a reimbursement system for exploration costs was introduced in 2005, by which the government reimburses the company for 78% of exploration activities even if the company has no taxable profits.

The State's Direct Financial Interest (SDFI) is the Norwegian government's direct ownership shares in oil and gas fields, onshore facilities and pipelines. This ownership share, which varies from field to field, is determined jointly with the awarding of production licenses. At the end of 2018, the SDFI portfolio consisted of shares in 38 fields, 4 of which are in the development phase, and 15 terminals and pipelines, representing approximately one third of the country's total petroleum reserves. Via this route, the government participates as a financial investor only, contributing to investment expenditures as well as receiving its share of revenues. Since 2001, Petoro, a 100% government owned corporation, has acted as the government's agent for these investments.

Until 2001, the government also owned all the shares of Statoil (now Equinor). Since listing on the Oslo Stock Exchange that year, the government share has been reduced to 67%. As

shown in figure 1, dividends from this company has always represented only a small share of the government's overall petroleum revenues.

In order to make our data for the government's petroleum revenues comparable to the cash flows of global corporations, we converted each year's revenues from Norwegian kroner into U.S. dollars, using the average exchange rate for that year. This makes the data used in our analysis slightly different from the ones in Figure 1, which we find better suited for illustrative purposes.

4. Industry Operating Cash Flow

One of the main contributions of this paper is the data we have collected for the cash flows of companies in the global stock market, sorted by industry. For this purpose, we have combined data from several databases. We define operating cash flow as the sum of net revenue and non-cash expenses, net of changes in working capital. Operating cash flows can be reinvested in the company through fixed asset investments, used to reduce debt, or be paid out directly to owners as dividends. Although shareholders do not receive this cash flow, it forms the basis for how the companies are valued in the stock market.

Company cash flows are reported in local currency, 41 individual currencies in all. We converted these amounts to U.S. dollars using annual averages of daily exchange rates. We used exchange rates from the FRED database for the 23 currencies available there and the rest from Macrobond. Apart from this conversion, we analyze all our cash flows in nominal terms.

The cash-flow data for each company were taken from the S&P database Capital IQ, which we accessed via the Wharton Research Data Services. Each company was identified by means of CUSIP codes for North American companies and CUSIP codes for the rest. We obtained those codes from FTSE Russel for the companies included in the FTSE GEISAC index. This way, we obtained annual USD cash-flow data for 86,622 company-years out of the 121,581 data points from the FTSE, or 71.2% of the total. Table 3 shows the numbers of companies in our data set along with their aggregate weights in the GEISAC index.

In 88 instances we found multiple observations for a company's operating cash flow within the same year. A number of Asian companies have reported annual figures for different time periods than January–December, such as March, February or June. We then chose one of these for our annual observation. As an example, the figure we use for operating cash flow for Keyence Corp in 2017 is the one reported in March 2018. For a few cases, the companies have switched from March to December as the end-of-period, resulting in two separate figures for the same calendar year. In these cases, we have used the figures reported at the same time of the year as in the following years so as to obtain consistent time series. Typically, these companies switched from June to March reporting.

Table 3: The number of companies for which we were able to find cash flow data, their aggregate weights, in all Industries and the Oil & Gas industry. The corresponding numbers for the companies in the FTSE GEISAC are shown for comparison.

	ALL INDUSTRIES				OIL & GAS			
	Our data		GEISAC		Our data		GEISAC	
Year	Count	Weight	Count	Weight	Count	Weight	Count	Weight
2003	4,053	76.1 %	6,959	100 %	130	6.0 %	206	6.6 %
2004	4,806	79.1 %	7,595	100 %	157	6.6 %	231	7.3 %
2005	5,293	79.8 %	8,080	100 %	199	7.7 %	286	8.5 %
2006	5,436	80.5 %	8,116	100 %	246	8.2 %	334	8.8 %
2007	5,743	84.7 %	7,920	100 %	268	9.8 %	343	10.4 %
2008	5,735	87.7 %	7,756	100 %	284	10.0 %	366	10.6 %
2009	5,572	87.5 %	7,304	100 %	316	9.8 %	391	10.4 %
2010	5,615	87.4 %	7,301	100 %	322	9.7 %	393	10.4 %
2011	5,785	89.1 %	7,408	100 %	340	10.5 %	414	11.0 %
2012	5,469	86.6 %	7,197	100 %	328	9.1 %	395	9.7 %
2013	5,535	87.5 %	7,241	100 %	327	8.5 %	384	8.9 %
2014	5,838	87.8 %	7,580	100 %	352	7.1 %	418	7.3 %
2015	6,037	88.9 %	7,747	100 %	335	5.7 %	381	5.8 %
2016	6,088	89.8 %	7,725	100 %	306	6.8 %	336	7.0 %
2017	6,231	90.0 %	7,788	100 %	303	5.8 %	319	6.0 %
2018	3,386	68.5 %	7,864	100 %	219	5.2 %	320	5.9 %
Average	5,414	84.4%	7,599	100%	277	7.9%	345	8.4%

The importance of an industry's cash flow to the GPFG depends on that industry's weight in the fund's index. To capture this importance, and to correct for the missing data, the extent of which varies by industry, we weighted each company's cash flow by its industry's weight in the GPFG's index, according to the formula

$$\text{Weighted } C_{jt} = \sum_{i=1}^{N_j} w_{jt} C_{ijt},$$

where C_{ijt} is the cash flow of company i in industry j for year t, N_j the number of companies within industry j, and w_{jt} the index weight of industry j at time t. The industry weights, which vary slightly from year to year, are shown in Table 4.

Table 4: The weights of ICB industries in the Government Pension Fund Global over time. Source: NBIM (2019a)

Year	Oil & Gas	Basic Mat.	Indus-trials	Cons. Goods	Health Care	Cons. Serv.	Tele-com	Utili-ties	Finan-cials	Tech-nology
2003	7.9 %	4.8 %	10.3 %	10.8 %	10.6 %	11.2 %	6.9 %	3.0 %	25.3 %	9.2 %
2004	8.3 %	4.6 %	10.8 %	9.8 %	9.9 %	11.6 %	7.0 %	3.4 %	26.7 %	7.9 %
2005	9.4 %	5.5 %	10.8 %	9.9 %	9.6 %	10.3 %	5.1 %	3.7 %	27.1 %	8.7 %
2006	8.0 %	5.6 %	11.1 %	10.7 %	8.0 %	9.6 %	4.7 %	4.8 %	29.3 %	8.1 %
2007	10.1 %	7.5 %	12.4 %	11.8 %	7.7 %	8.7 %	5.3 %	5.2 %	23.2 %	8.3 %
2008	11.0 %	6.3 %	11.4 %	12.1 %	10.3 %	8.6 %	6.1 %	6.0 %	21.1 %	7.1 %
2009	10.8 %	8.0 %	12.0 %	11.3 %	8.6 %	8.3 %	5.1 %	4.8 %	22.8 %	8.3 %
2010	10.8 %	9.1 %	13.7 %	11.6 %	7.7 %	8.5 %	4.5 %	4.7 %	21.5 %	7.9 %
2011	11.6 %	7.8 %	13.1 %	12.7 %	9.5 %	9.0 %	4.4 %	4.3 %	19.8 %	7.9 %
2012	9.9 %	7.5 %	13.1 %	13.6 %	8.7 %	9.3 %	3.9 %	3.8 %	23.0 %	7.3 %
2013	8.3 %	6.3 %	14.3 %	13.9 %	8.7 %	10.2 %	3.8 %	3.4 %	23.6 %	7.4 %
2014	6.9 %	5.7 %	13.6 %	13.8 %	9.6 %	10.4 %	3.3 %	3.7 %	24.5 %	8.4 %
2015	5.4 %	5.1 %	13.5 %	14.4 %	10.7 %	10.9 %	3.4 %	3.2 %	24.5 %	9.0 %
2016	6.4 %	5.6 %	14.0 %	13.6 %	10.1 %	10.2 %	3.2 %	3.1 %	24.3 %	9.4 %
2017	5.6 %	6.0 %	14.3 %	13.5 %	9.8 %	10.1 %	2.8 %	2.6 %	24.3 %	11.1 %
2018	5.9 %	5.0 %	12.9 %	11.9 %	11.4 %	10.8 %	3.0 %	2.8 %	23.7 %	12.6 %

Beyond the limited number of years for which we have observations, our data set has two main weaknesses.

Table 5: Operating cash flows for each ICB industry 2003 – 2018, weighted by the GPFG industry weights. USD billions

Year	Oil & Gas	Basic Mat.	Indus-trials	Cons. Goods	Health Care	Cons. Serv.	Tele-com	Utili-ties	Finan-cials	Tech-nology
2003	20.5	6.3	31.6	31.3	13.8	21.9	19.7	4.6	123.4	13.3
2004	27.6	8.7	37.0	31.9	15.1	27.0	22.1	5.8	101.4	14.8
2005	40.7	12.5	42.9	30.8	16.0	24.7	17.1	6.9	38.4	18.4
2006	41.8	14.7	47.1	37.6	14.0	28.9	16.5	10.4	79.7	18.0
2007	57.6	24.2	68.0	49.9	16.2	31.7	21.1	12.4	163.4	22.4
2008	76.3	21.5	59.5	37.9	22.4	31.8	25.4	14.5	231.3	18.7
2009	57.1	26.6	62.3	62.6	19.8	32.7	21.5	15.6	199.8	22.8
2010	70.6	36.5	70.8	59.1	18.5	36.9	20.3	15.3	232.3	26.0
2011	90.9	37.3	65.0	57.1	24.2	41.9	20.5	12.9	268.1	27.4
2012	81.3	31.1	67.1	75.4	21.4	42.5	17.6	11.5	248.0	25.0
2013	73.3	25.1	80.5	84.7	21.8	48.7	16.7	11.4	252.8	27.2
2014	62.5	23.3	80.3	81.1	27.0	53.2	13.7	12.8	250.5	35.1
2015	35.6	19.3	82.3	94.4	31.6	56.7	13.7	11.4	347.0	40.0
2016	33.9	20.8	90.6	93.6	32.3	56.3	13.8	10.4	354.0	45.6
2017	36.9	24.3	89.2	98.1	33.9	61.0	12.1	8.3	336.0	61.0
2018	36.2	13.4	54.8	50.7	34.4	47.3	8.4	5.7	189.1	75.3

1. We find cash flow data based on the FTSE GEISAC constituents, not the GPFG constituents, due to the lack of company codes from the GPFG holding reports. Thus, all companies in the GPFG, not part of the FTSE GEISAC are left out of our analysis.
2. We were not able to find all companies of the FTSE GEISAC index in the Capital IQ database. Furthermore, for some of the companies that we did find, the observations of operating cash flow were not necessarily available. To make up for this problem, we collected cash flows manually for a number of companies from their respective annual reports. In the interest of efficiency, when we did this, we sorted the companies by market capitalization and made sure our resulting data set included all of the 300 largest companies for each year.

5. Analysis

Figure 2 displays the time series for each industry's cash flow along with the Norwegian government's cash flow from petroleum activities, all normalized to 100 in 2003. These graphs suggest a very strong relationship between government's petroleum cash flow and the cash flow for the Oil & Gas industry. A relationship, albeit weaker, appears to be present for Basic Materials as well. For the other industries, the relationships seem weak or non-existent.

The apparent correlations in these graphs may, however, be deceiving because of the presence of unit roots, which are known to give rise to spurious correlations. We thus start our formal analysis by testing for the presence of unit roots. Table 6, which shows the results of Dickey-Fuller tests for all the relevant series, indicates that the unit-root hypothesis cannot be rejected for any of the series. We realize that these tests have low power because of the limited length of the sample. However, unit roots should be expected *ex ante* for these series because, as nominal cash-flow series, they are influenced by trend inflation (however weak in this period) as well as global economic growth. Moreover, for series with near-unit roots, inference in small samples is usually more reliable when conducted on first differences than on the original series. We thus base our analysis on the differenced series.

Figure 2: Time series of weighted operating cash flows for each of the ICB industries as well as the Norwegian government's cash flow from petroleum activities (GPCF), indexed, 2003 – 2018.

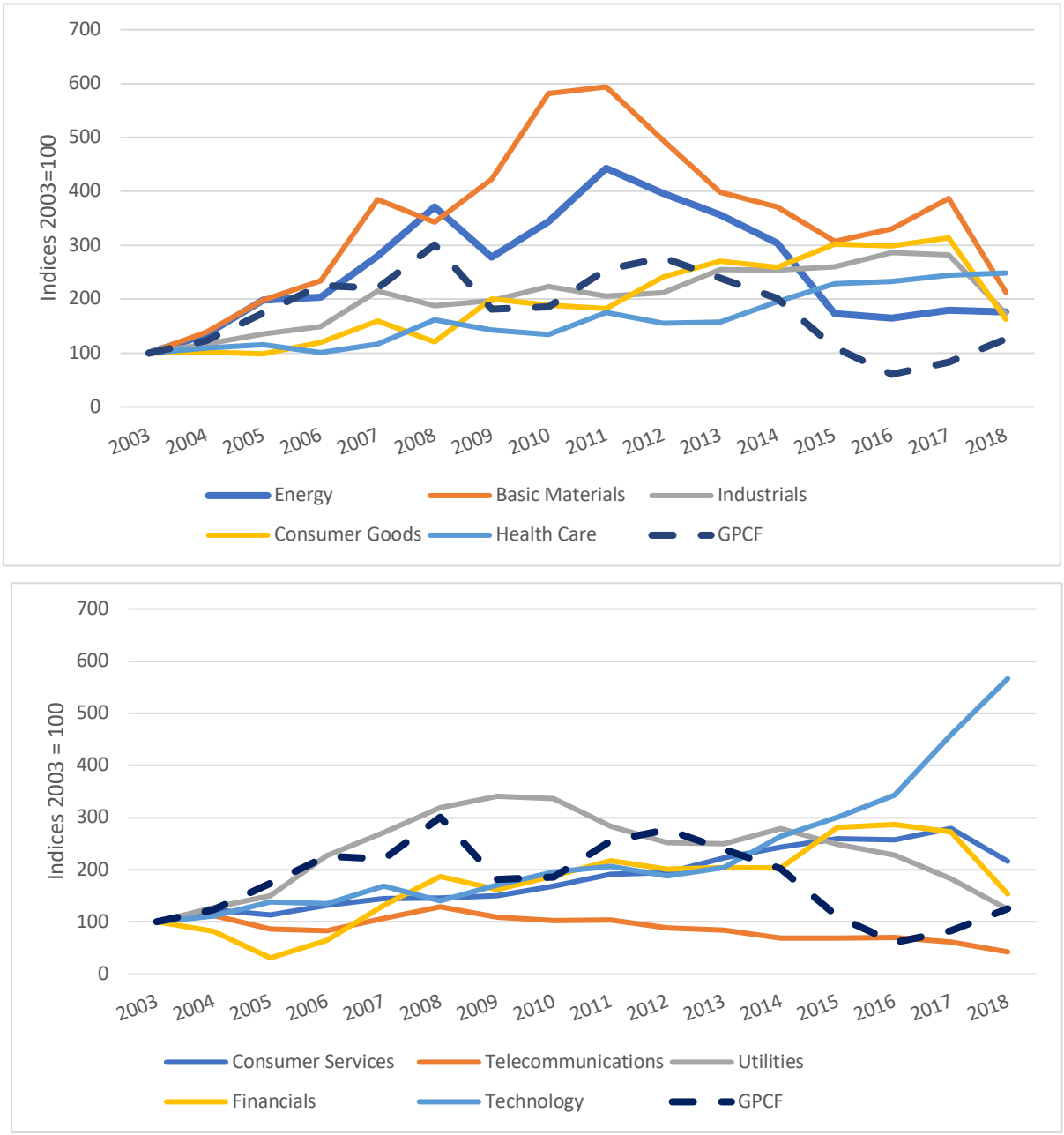


Table 6: *p* values from Dickey-Fuller tests of the GPCF and each of the weighted operating cash flow series for the major ICB industries

Series	I(1)	I(2)
GPCF	0.427	0.021
Oil & Gas	0.443	0.030
Basic Materials	0.393	0.141
Industrials	0.264	0.173
Consumer Goods	0.483	0.015
Health Care	0.914	0.001
Consumer Services	0.576	0.017
Telecommunications	0.916	0.008
Utilities	0.596	0.672
Financials	0.579	0.302
Technology	1.000	0.574
All ICB industries ex Oil & Gas	0.553	0.544
GEISAC	0.500	0.510

For tests of a second unit roots, about half of the series showed rejection on the 5% level. Again considering the low power of these tests, we believe they support our decision to work with first differences.

The series for the subsectors of the Oil & Gas showed similar results, as presented in Table 7.

Table 7: p values from Dickey-Fuller tests of the weighted operating cash flows of the Oil & Gas subsectors

Subsector	I(1)	I(2)
Exploration & Production	0.427	0.021
Integrated Oil & Gas	0.443	0.030
Oil Equipment & Services	0.393	0.141
Pipelines	0.264	0.173
Renewable Energy Equipment	0.483	0.015
Alternative Fuels	0.914	0.001
Oil & Gas ex Exploration & Production	0.553	0.544

Our main results are the correlations, in first differences, between the government's petroleum cash flow on the one hand, and the cash flow for the companies in each of the major industries, respectively. These results are presented in Table 8.

Table 8: Correlations between the GPFG-industry weighted operating cash flow of each industry and the GPCF. All correlations on first-difference data 2004 – 2018.

Industry	Correlation	t-value
Oil & Gas	0.79	4.66***
Basic Materials	-0.08	-0.27
Industrials	-0.34	-1.32
Consumer Goods	-0.50	-2.10*
Health Care	0.19	0.70
Consumer Services	-0.19	-0.68
Utilities	0.05	0.17
Telecommunications	0.20	0.75
Financials	-0.14	-0.49
Technology	-0.19	-0.68
All industries	-0.12	-0.44
All industries ex Oil & Gas	-0.25	-0.93

$*** p < 0.01, ** p < 0.05, * p < 0.1$

Although the shortness of the sample warns against firm conclusions, we find the overall pattern that emerges from Table 8 quite convincing. Only one industry, Oil & Gas, shows a significant, positive correlation with the government's petroleum cash flow. Not only that, this correlation coefficient of 0.8 is four times as high as the second-largest one, which is Telecommunications at 0.2. In fact, all the other correlations seem trivially low except for the marginally significant *negative* correlation for Consumer Goods. The correlation for the total of all industries is insignificantly negative whether or not the Oil & Gas industry is included.

We moreover find the result for Oil & Gas reasonable considering the rules governing the Norwegian government's cash flow. Two parts of it, oil company income taxes and Equinor dividends, are based on oil company profits, and the third part, the net SDIF cash flow, is directly proportional to the cash flow of the government's partners in the oil fields in question.

We believe these results can be interpreted as strong support for underweighting of companies in the Oil & Gas industry in the strategic index for SWFs of oil-rich governments, such as the Norwegian GPFG. However, as the government's cash flow comes mainly from oil companies' upstream activities, it could be argued that the underweighting argument applies only to that part of the Oil & Gas industry.

Table 9 shows the correlations between the Norwegian government's petroleum cash flow and that of the respective Oil & Gas subsectors, again in first differences. Because we were unable to obtain the weights for these subsectors in the GPFG, we used the FTSE GEISAC weights. The Exploration and Production subsector indeed shows a correlation of 0.5, which is marginally significant on the 5% level. However, the sector called Integrated Oil and Gas has a correlation coefficient of almost 0.9, which is comfortably significant on the 1% level.

The coefficients for the remaining subsectors are small and insignificant, with the possible exception of the Renewable Energy Equipment sector, which shows a negative correlation coefficient of 0.59. For this sector, we only had data from 2010 to 2018, however.

Table 9: Correlations between the Oil & Gas subsector operating cash flows and that of the GPCF, in first differences. The subsectors are weighted by the FTSE GEISAC index weights

Subsector	Correlation	t-value
Exploration & Production	0.52	2.18**
Integrated Oil & Gas	0.88	6.67***
Oil Equipment & Services	0.10	0.37
Pipelines	0.21	0.69
Renewable Energy Equipment	-0.59	-1.95
Alternative fuels	-0.09	-0.23
Oil and Gas ex Exploration & Production	0.88	6.60***

$*** p < 0.01, ** p < 0.05, * p < 0.1$

We believe the close correlation for the Integrated Oil & Gas sector is due to the fact that this sector includes the main global players in the oil and gas industry and thus reflects the main global trends of the industry. As shown in Table 2, this sector made up about 60% of the capitalization of the entire Oil & Gas industry for our sample period. The members of the Exploration & Production sector tend to be smaller, which would make their aggregate cash flow more influenced by idiosyncratic factors. As further support of that view, we note that the correlation for the entire Oil & Gas industry except the Exploration & Production subsector is equally high as the one for Integrated Oil & Gas.

6. Robustness

In order to check the robustness of our results, we redid the analysis with different weighting schemes, studied rolling correlations, and looked for evidence of cross correlations at different leads and lags.

6.1. Alternative weighting schemes

As explained in Section 4, we weighted our cash-flow observations by first adding up the cash flows for the companies in each industry and then weighting the sum for each industry according to the respective industry weights in the GPFG strategic index. As our first alternative weighting schemed, we repeated this procedure, but with the FTSE GEISAC industry weights. The difference is mainly that the GPFG index overweights European companies, whereas the FTSE GEISAC does not. The results are reported in Table A1 in the Appendix. The differences from the ones in Table 8 above are trivial.

Our second alternative weighting scheme also used the FTSE GEISAC weights. But instead of adding up the cash flows of all the companies in each industry, we weighted the flows of each company individually. Because of missing information for some companies, we then needed to rescale the company weights to make the implied industry weights equal the ones

in the FTSE GEISAC index. The results, in Table A2 in the appendix, are also very similar to the ones in Table 8.

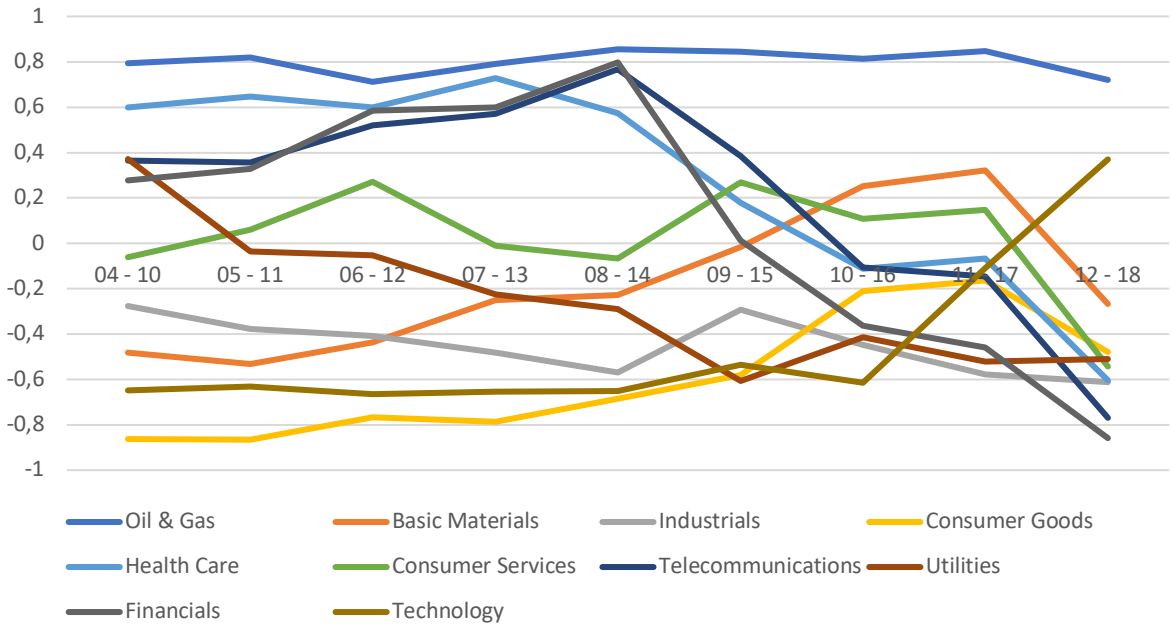
Our third alternative was to ignore weighting altogether and simply add up the cash flows as reported by each company within the ICB industries. Not unexpectedly, these results differed some more from the ones in Table 8. However, the strong correlation for the Oil & Gas industry remains.

For the Oil & Gas subsectors, we were unable to redo the results with the first of the three alternative schemes mentioned above because we could not obtain the GPFG subsector weights for the respective years, only the ones for 2018 displayed in Table 2. However, we were able to repeat the analysis using the second and third alternative weighting schemes. The results, shown in Tables A4 and A5 in the Appendix, are very similar to the ones in Table 9 above. The only difference of interest is that the correlation for the Exploration and Production now is significant on the 1 percent level; however, it remains lower than the one for Integrated Oil & Gas.

6.2. Rolling estimates

Given the short length of our data sample, the scope for studying changing correlations over time is limited. However, we have carried out seven-year rolling correlation estimates for the major industries, again in first differences. The results are displayed graphically in Figure 3. Interestingly, Health Care, and to some extent Telecommunications, show rather high correlations with the government's cash flow from petroleum activity in about the first half of the sample; but the corresponding correlations subsequently seem to collapse. Oil & Gas is the only major industry whose correlation is virtually unchanged during the entire period; and its correlation coefficient lies consistently around 0.8.

Figure 3: Rolling estimates of correlations

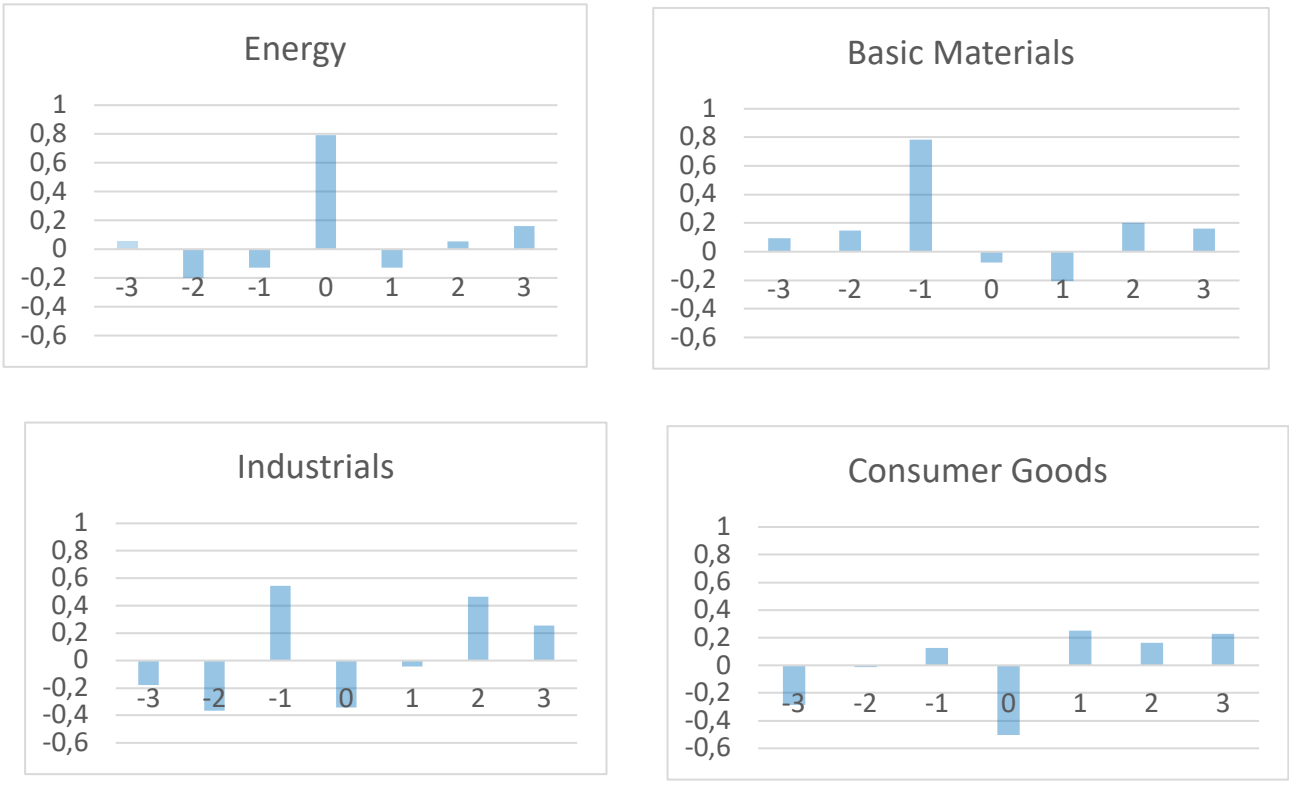


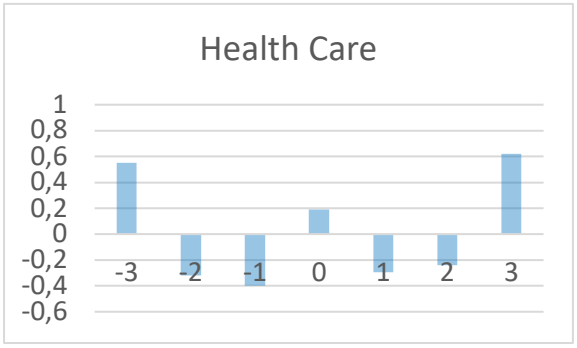
6.3 Cross correlograms

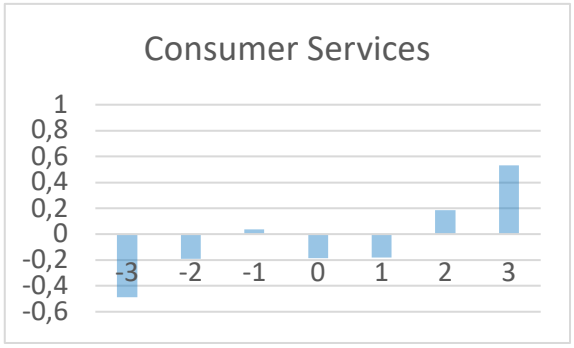
Our final robustness check concerns correlations at various leads and lags. Specifically, for each of the major industries, we computed correlations for the industry cash flow at time $t + k$ with the Norwegian government's petroleum cash flow at time t. The results are presented as a cross correlogram for each industry. Thus, the column labeled "– 3" denotes the correlation between the government's petroleum cash flow and the cash flow of the industry in question three years earlier, and so on.

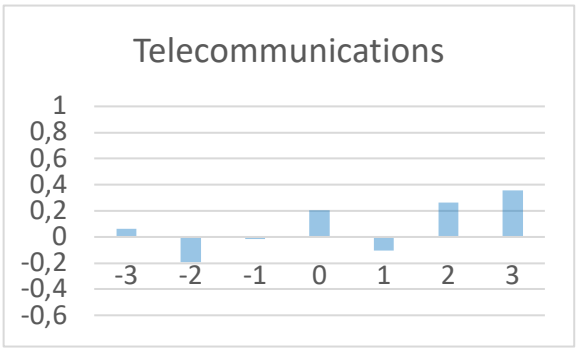
In the results in Figure 4, one item stands out, namely, a correlation of 0.8 between the government's cash flow and the cash flow of the Basic Materials industry one year earlier. We interpret this finding as a supportive of the notion that fossil fuels often move together with other materials. We note it as a possible argument for underweighting shares in the Basic Materials industry as well as Oil & Gas. Given the one-year lag, however, we recognize that this argument is much weaker than for Oil & Gas.

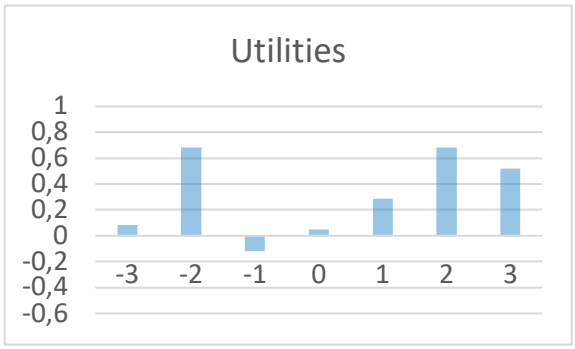
Figure 4: Cross correlograms for leads and lags of industry cash flows





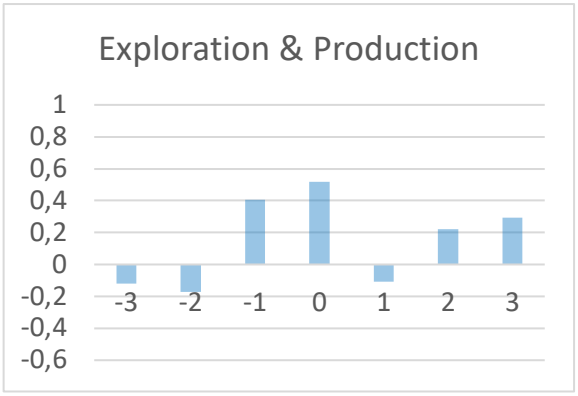


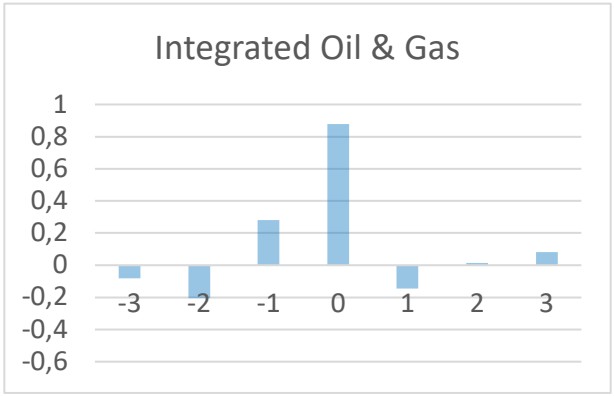


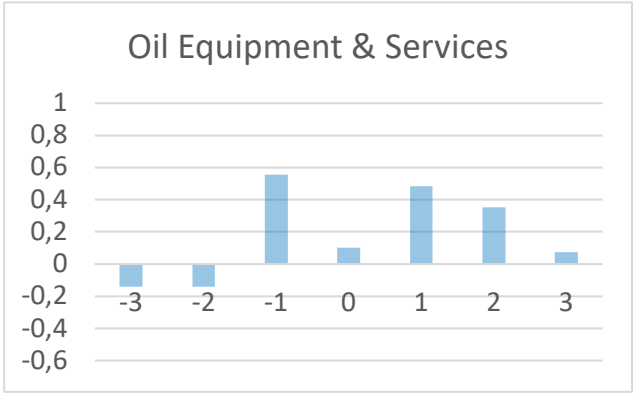


We also constructed similar cross correlograms for the three subsectors of the Oil & Gas industry for which we have data for the entire sample period. The results are shown in Figure 5. There, we note the correlations of around 0.5 for Oil Equipment & Services at both

Figure 5: Cross correlograms for leads and lags of Oil & Gas subsector cash flows







the one-year lag and the one-year lead. These modestly large correlations may perhaps reflect the leads and lags in the industry itself in that higher investment may presage higher government petroleum revenues and also that high government revenues (due, e.g. to higher prices) may signal higher future investments in the industry. The lack of contemporaneous correlation makes such a conclusion tenuous, however.

7. Conclusions

Ultimately, equities are all about cash flows, the right to current and future cash flows, with future cash flows discounted at stochastic rates that may change over time. Cash flows thus form the basis for equity prices. Investors, in turn, choose portfolios that are appropriately diversified so as to minimize risk given the rate of return. However, they also need to keep an eye on background risks to make sure that correlations between those risks and financial risks don't introduce unwanted concentration risks.

Assessing such risks often runs into problems of how to compare the different risks. This paper studies this problem for a government that regularly receives special revenues from extraction of a non-renewable natural resource and at the same time holds a portfolio of equities that includes shares in the companies of that same industry. The comparison problem arises because estimation of the correlation between asset prices in that industry and the government's value of the assets in the ground is infeasible because the value of the asset in the ground is unobservable. Some previous attempts to solve this problem have used the market value of the extracted resource as a proxy for the value of the asset in the ground. Others have sought to econometrically distinguish those movements in the equity prices for companies in the ground that are driven by changing expectations of cash flows from those due to time variations in discount factors. In this paper, we have bypassed this problem by instead comparing directly the government's cash flow from the resource to the aggregated cash flows of the global companies in the resource industry in question.

In particular, we have studied the correlations between the Norwegian government's petroleum cash flow with the cash flows of companies in the global oil and gas industry as well as with companies in other major industries. We find a unique correlation between the government's cash flow and the cash flow of companies in the global oil and gas industry. This correlation is unmatched, by a wide margin, by any other industry. Within oil and gas, we find the greatest correlations for the subsector containing integrated oil and gas companies and a somewhat weaker, though yet significant correlation for the subsector of oil and gas companies with upstream companies only.

For the Norwegian Government Pension Fund Global, we believe our findings strongly support underweighting, perhaps even shorting, of oil and gas shares in particular, and particular for the large, integrating oil and gas companies.

However, we believe our methodology should be relevant to other governments whose revenues come from other kinds of natural resources, such as coal, iron ore, copper, bauxite, lithium, or—in the future—wind or sunshine. Further investigation of such cases would be an interesting extension of our work.

Appendix

Table A1: Correlations between the operating cash flow of each industry and the GPCF. Industry cash flow weighted with FTSE GEISAC industry weights. All correlations on first-difference data 2004 – 2018.

Industry	Correlation	t-value
Oil & Gas	0.80	4.81***
Basic Materials	-0.11	-0.40
Industrials	-0.30	-1.12
Consumer Goods	-0.52	-2.20*
Health Care	0.13	0.48
Consumer Services	-0.04	-0.14
Utilities	0.02	0.05
Telecommunications	0.35	1.33
Financials	-0.15	-0.54
Technology	-0.21	-0.76
All industries	-0.12	-0.43

$*** p < 0.01, ** p < 0.05, * p < 0.1$

Table A2: Correlations between the operating cash flow of each industry and the GPCF. Each company's cash flow weighted individually with the weights in the FTSE GAISAC index, scaled to correct for missing observations.

Industry	Correlation	t-value
Oil & Gas	0.88	6.82***
Basic Materials	0.10	0.38
Industrials	0.29	1.11
Consumer Goods	-0.20	-0.75
Health Care	0.44	1.77
Consumer Services	0.36	1.38
Utilities	0.25	0.91
Telecommunications	0.38	1.50
Financials	-0.33	-1.28
Technology	-0.06	-0.23
All industries	0.26	0.96
All industries ex Oil & Gas	-0.17	-0.63

$*** p < 0.01, ** p < 0.05, * p < 0.1$

Table A3: Correlations between the government's petroleum cash flow and the unweighted operating cash flows of each ICB industry.

Industry	Correlation	t-value
Oil & Gas	0.80	6.82***
Basic Materials	0.20	0.72
Industrials	-0.27	-1.00
Consumer Goods	-0.61	-2.80**
Health Care	-0.27	-1.01
Consumer Services	-0.14	-0.52
Utilities	-0.46	-1.87*
Telecommunications	-0.02	-0.07
Financials	-0.01	-0.03
Technology	-0.13	-0.46
All industries	-0.04	-0.15
All industries ex Oil & Gas	-0.21	-0.79

$*** p < 0.01, ** p < 0.05, * p < 0.1$

Table A4: Correlations between the GPCF and the operating cash flows of the respective subsectors of Oil & Gas. Each company's cash flow weighted individually with the weights in the FTSE GAISAC index, scaled to correct for missing observations.

Subsector	Correlation	t-value
Exploration & Production	0.74	3.94***
Integrated Oil & Gas	0.89	7.11***
Oil Equipment & Services	0.23	0.84
Pipelines	0.37	1.27
Renewable Energy Equipment	-0.74	-2.88**
Alternative fuels	0.19	-0.51
Oil and Gas ex Exploration & Production	0.89	7.16***

$*** p < 0.01, ** p < 0.05, * p < 0.1$

Table A5: Correlations between the unweighted operating cash flows of the Oil & Gas subsector and the GPCF.

Subsector	Correlation	t-value
Exploration & Production	0.69	3.48***
Integrated Oil & Gas	0.83	5.30***
Oil Equipment & Services	0.48	1.99
Pipelines	0.01	0.02
Renewable Energy Equipment	-0.29	-0.81
Alternative fuels	0.04	0.10
Oil and Gas ex Exploration & Production	0.83	5.36***

$*** p < 0.01, ** p < 0.05, * p < 0.1$

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