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The Role of Oil Prices in Norwegian Petroleum Investments

An Empirical Study

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Abstract

This paper provides evidence that oil price fluctuations have been an important driver of petroleum investment in Norway. To show this, I utilize a Bayesian vector autoregressive (BVAR) model combined with local projections, using various investment data from national accounts and firms' survey data. I find that a 10 percent increase in real oil prices typically results in about a 4 percent rise in petroleum investment, primarily boosting activities in exploration and existing fields, while field development investments show minimal response. These results contribute to a broader understanding of the role of oil prices in shaping Norwegian business cycles.

Keywords: Oil Prices, VAR model, Investment Dynamics, Macroeconomic Shocks, Bayesian Analysis, Energy Economic

JEL classification: Q43, E22, C32, L71

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Sammendrag

Sammenhengen mellom oljeprisendringer og investeringsbeslutninger varierer mellom land, utvinningsteknologier og økonomisk politikk. I Norge har opprettelsen av oljefondet og innføringen av handlingsregelen bidratt til å redusere koblingen mellom oljeinntekter og offentlig forbruk, men aktiviteten på norsk sokkel forblir en viktig driver av innenlandske konjunkturer.

Denne artikkelen undersøker hvordan oljeprisendringer påvirker ulike typer petroleumsinvesteringer på norsk sokkel, som historisk har skapt betydelige ringvirkninger for fastlandsøkonomien. Ved bruk av en to-trinns estimeringsmetode, som kombinerer en Bayesian Vector Autoregressive (BVAR)-modell og lokale projeksjoner, analyseres effektene av oljeprisendringer på norske oljeinvesteringer. BVAR-modellen brukes til å estimere en oljemarkedsmodell for å fange opp eksogene oljeprissjokk, mens lokale projeksjoner brukes til å beregne hvordan disse sjokkene påvirker innenlandske investeringer. Denne fremgangsmåten gjør det mulig å isolere oljeprissjokk ved å ta hensyn til global økonomisk aktivitet og forstyrrelser i tilbudet. Metoden lar også Norge behandles som en relativt liten oljeeksportør, hvor innenlandske investeringsbeslutninger i liten grad påvirker globale oljepriser.

Resultatene viser at en økning i oljeprisen fører til betydelig økning i investeringsplaner, særlig innen eksisterende felt og leting, mens feltutviklingsinvesteringer reagerer minimalt.

Studien bidrar til en bedre forståelse av økonomisk vekst og konjunktursvingninger i Norge og er den første til direkte å estimere forholdet mellom oljeprisendringer og ulike typer petroleumsinvesteringer i en offshore-økonomi.

1 Introduction

The relationship between oil price fluctuations, investment decisions and oil production, varies across countries and extraction technologies, shaped by the distinct characteristics of conventional, offshore, and unconventional oil sources. Countries like Brazil and Norway, which rely on capital-intensive, long-term offshore production, face substantial lags, spanning several years between investment and production, while shale oil producing states in U.S. have shorter cycles due to flexible fracking methods (see, e.g., Bjørnland et al. (2021); Bjørnland and Skretting (2024)). Investment responses to oil price fluctuations depends also on economic policies and market expectations; for instance, non-OPEC firms generally show a stronger correlation between investment and prices than OPEC firms (see Bornstein et al. (2022)). Additionally, depending on the life-cycle stage of oil fields, various investment types can respond differently to changes in oil prices.

This paper examines how fluctuations in oil prices influence different types of petroleum investment in Norway. Norway provides a unique case study due to its reliance on offshore oil production, the capital-intensive nature of its projects, and its economic policies that decouple public spending from petroleum income. While fiscal policy rules have reduced the direct impact of oil prices on Norwegian business cycles, petroleum activity has played a critical role in driving economic fluctuations. The challenging climate and the need to extract oil from deep beneath the sea have required massive investments in exploration, field development, and transportation infrastructure. The long-term nature and high capital intensity of these offshore projects mean that even modest initiatives become significant industrial undertakings compared to similar efforts on land. However, offshore operations are closely linked to the mainland economy. Developing a new high-tech industry has demanded substantial inputs of equipment and services from other sectors. Currently, more than 50 percent of the petroleum sector's total demand is met by various domestic industries, including manufacturing and services. This integration has created significant spillovers to most mainland industries (see Bjørnland et al. (2019); Hungnes et al. (2022)).

While high oil prices have undoubtedly played a crucial role in the success of Norwegian industrial ventures, the response of petroleum investment to oil price fluctuations—and the resulting spillovers to the broader economy—is complex. First, the responsiveness of investment can be influenced by the volatility of oil and gas prices. Elder and Serletis (2010) demonstrate that uncertainty about oil prices can negatively impact oil and gas extraction. All else being equal, this suggests a generally lower responsiveness to changes in petroleum prices. Additionally, the long-term nature of Norwegian petroleum projects makes it difficult to accurately estimate the profitability of current investments, where, beyond the available oil and gas reserves and extraction costs, future oil prices represent the most uncertain factor in these calculations.

In addition, there is considerable debate regarding the predictability of oil spot prices and the extent to which futures-based forecasts provide more accurate information about future oil prices than standard random-walk forecasts (see Alquist and Kilian (2010); Reeve and Vigfusson (2011); Baumeister and Kilian (2012); Alquist et al. (2013); Baumeister and Kilian (2014); Ellwanger and Snudden (2023)). Despite this, expectations about future oil prices can vary among oil companies and are not always based on random-walk or futures curve predictions. For instance, Rystad Energy offers long-term energy price forecasts to petroleum companies worldwide, which often differ significantly from random-walk forecasts. If oil prices rise today, will it trigger investments that will only begin to yield returns a decade later? This paper explores such questions by examining how fluctuations in oil prices have influenced petroleum investment in Norway.

To do so, I first estimate an oil market model using a Bayesian Vector Autoregressive (BVAR) approach, following Baumeister and Hamilton (2019). I then use local projections (see Jordà (2005)) to estimate the effects of oil price fluctuations on domestic oil investment. This two-step framework allows me to identify exogenous oil price variations by taking into account common knowledge about the oil market and controlling for developments in global economic activity and supply disturbances. Further, by focusing on oil-specific shocks, I consider Norway as a relatively small oil exporter on a global scale—where domestic investment decisions are unlikely to influence global oil prices.

The results show that an unexpected increase in oil prices leads to a substantial rise in firms' future investment plans, which in turn boosts petroleum investments. Specifically, a 10 percent increase in real oil prices results in an approximate four percent increase in total petroleum investment two years after the shock. This surge in investment is primarily driven by increased activity in existing fields and higher investment in exploration and concept studies, while the response of field development investments remains minimal. These findings suggest that most company investments are directed toward technologies and methods to enhance extraction, thereby maximizing returns on initial capital outlay. Furthermore, the results indicate that exploration activities are more flexible and responsive to fluctuations in oil prices, whereas field development projects tend to follow predetermined plans and are less influenced by price changes.

These results contribute to our understanding of the causal effects on Norwegian economic growth and the fluctuations of business cycles. While several studies have analyzed the effects of petroleum investment on the mainland economy (cf. Hungnes et al. (2022); Cappelen et al. (2013); Eika and Martinussen (2013)), to the best of my knowledge, this is the first study that directly estimates the relationship between changes in oil prices and different types of petroleum investment. Understanding how these investments respond to oil price changes aids in refining economic forecasts and policy responses in other resource-rich economies with similar characteristics.

The analysis in this paper contributes to several areas of the literature. First, it relates to studies examining the effects of oil prices and oil activity on the Norwegian economy (cf. Cappelen et al. (2013); Bjørnland and Thorsrud (2016); Bjørnland et al. (2019); Bjørnland and Thorsrud (2019); Bergholt et al. (2019)). However, my analysis delves deeper into the direct effects on petroleum investment, demonstrating that these effects vary depending on the type of activity. Additionally, my analysis employs the identification framework proposed by Baumeister and Hamilton (2019), which allows for the relaxation of short-run restrictions and incorporates common knowledge about the oil market as identification method.

Second, I engage with the extensive literature that analyzes the effects of oil price shocks, focusing on different sources of shocks and identification methods (cf. Bjørnland (2000); Hamilton (2009); Kilian (2009); Kilian and Murphy (2012, 2014); Kilian and Vigfusson (2011); Lippi and Nobili (2012); Peersman and Robays (2012); Cashin et al. (2014); Aastveit (2014); Aastveit et al. (2015); Stock and Watson (2016); Baumeister and Hamilton (2019); Känzig (2021)). Using the Bayesian framework described in Baumeister and Hamilton (2019), I estimate a BVAR including the post pandemic period and incorporating North Sea Brent as a benchmark price of oil.

Third, I contribute to the literature examining the relationship between oil prices and investment. This includes studies on the effects of oil price uncertainty on investment decisions (cf. Elder and Serletis (2009, 2010); Maghyereh and Abdoh (2020)) and theoretical contributions to this topic (cf. Bornstein et al. (2022); Peng and Luo (2022)). I confirm the findings of Bornstein et al. (2022), demonstrating a positive correlation between oil prices and petroleum investment, and further show that this relationship varies depending on the stage in the life cycle of oil activity at which the investment is made.

The remainder of the paper is structured as follows: Section 2 gives a short description of the Norwegian petroleum sector and petroleum investment. In Section 3 I introduce the modeling framework. Section 4 demonstrates my findings. The robustness analysis is presented in Section 5. Section 6 concludes.

2 The Norwegian Petroleum Sector

Norway's petroleum era truly began with the discovery of the Ekofisk field in 1969, which started production in 1971. Major discoveries in the 1970s, such as Statfjord, Oseberg, Gullfaks, and Troll, further solidified Norway's position in the global petroleum industry. As production from these large fields began to decline, smaller fields were developed, increasing the number of active production sites. Exploration expanded northward in 1979, leading to significant activity in the Norwegian and Barents Seas throughout the 1980s and 1990s.

Oil and gas production increased fivefold from the early 1980s to the early 2000s, with exports reaching an all-time high during that period. Since then, oil production has gradually declined, while extraction of natural gas has increased, resulting in relatively stable overall production levels, see Figure 1. In 2007, the Ormen Lange gas field, Europe's third-largest, and Snøhvit began operations. The years 2022 and 2023 have been the most profitable for Norwegian petroleum companies, driven by historically high gas prices due to the war in Ukraine.

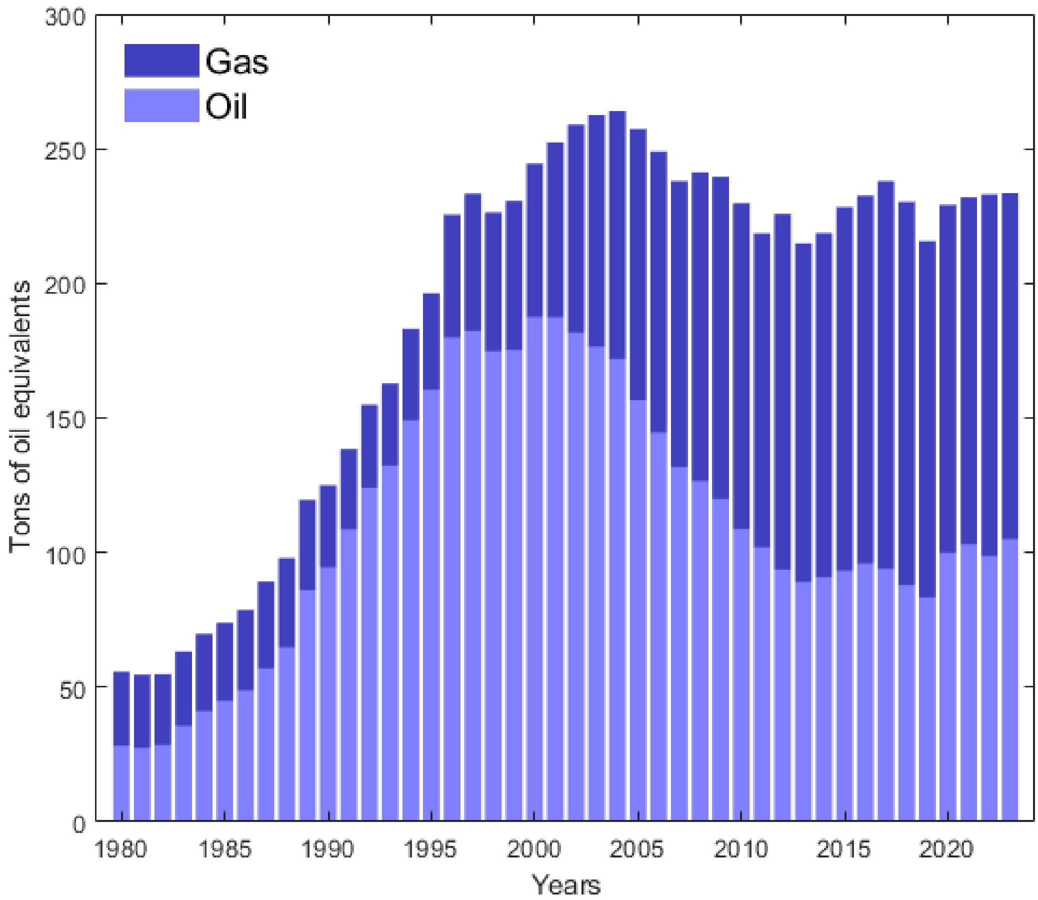


Figure 1. Tons of oil equivalents. Annual values. Sample period 1980-2023.

2.1 The Life Cycle of Petroleum Activities

Petroleum activities begin with the opening of designated areas for exploration, where companies map and assess subsea resources. If discoveries are commercially viable, the next phase involves developing the field and commencing production. Companies can initiate petroleum activities after receiving a production license, which grants exclusive rights to exploration, exploration drilling, and production of petroleum in the designated area. Production licenses are typically awarded through competitive licensing rounds to groups of companies and are valid for an initial period of up to ten years, reserved for geological and geophysical studies, as well as exploration drilling.

If the licensees make a discovery and wish to proceed, they can request an extension of the production license's validity period. The duration of the extension is determined by the Ministry of Energy and is generally set for up to 30 years. To develop the field, companies must submit a Plan for Development and Operation (PDO) for approval by the Ministry. The actual development and operation of the field take place during this extension period. Eventually, when production is no longer profitable, operations are wound down, and the infrastructure is either secured in place or removed.

As the Norwegian oil and gas sector has gained more experience and developed infrastructure on the continental shelf, the time from granting production licenses to the start of production has shortened—from over 20 years in the 1980s to slightly over 10 years in the 2010s (Menon-Notat (2023)).

2.2 Petroleum Investment in Norway

Since production began in 1971, oil and gas have been extracted from a total of 123 fields on the Norwegian shelf, requiring significant investments in exploration, field development, transportation infrastructure, and onshore facilities. Over the last decade, total investments in the petroleum sector, including exploration and decommissioning costs, have accounted for about one-sixth of total capital investments in Norway. In the mid-1990s, this share was as high as 30 percent. No other industry in Norway compares to this. Even smaller projects in the offshore sector would be considered large industrial projects if carried out on the mainland. Compared to other demand components, such as product input and employment, investment is both the largest and most volatile, typically seen as an important driver of Norwegian business cycles.

Depending on where in the life cycle of petroleum activity investments are made, they can be divided into three main categories: (i) exploration and concept studies, (ii) field development, and (iii) fields in production, which together account for around 90 percent of total investment. The remaining investments include pipelines, construction and civil engineering, cars, machinery, and equipment.

As shown in Figure 2, investments associated with fields in production are the largest category. Additionally, investments in field development have increased substantially over time, partly due to the advancement of more complex fields. Most of the pipeline investments occurred in the 1980s and 1990s when the network of installations and pipelines

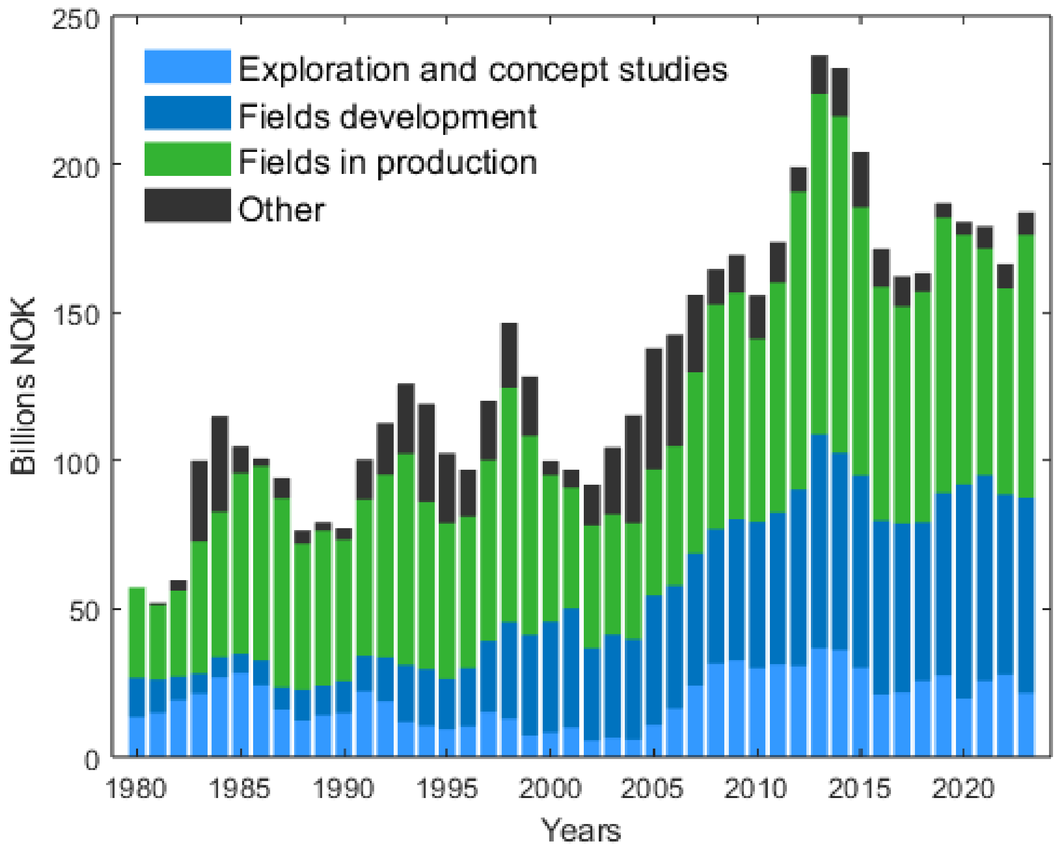


Figure 2. Petroleum investment by type. Constant prices. Annual values. Sample period 1980 to 2023.

connected to onshore facilities was being built. Exploration investments were low at the beginning of the 2000s but have increased steadily since then.

As discussed in the previous subsection, the investment phase comes early in a field's lifespan. Initially, there are geological pre-surveys, followed by exploratory drilling and planning within oil companies, with these costs registered as exploration investments. Then comes the investment in new or existing fields. Substantial real capital must be in place before extraction and production can commence. The production profile of a typical oil field shows a rapid increase to a maximum production rate, followed by a stable period (the plateau phase), and then a gradual decline. Without further investments, oil production will decline rapidly, and even with considerable investment to improve recovery, maintaining production levels can be challenging.

During the lifespan of a field, various factors can affect companies' investment plans. These include assessments of future oil prices, the availability of potential projects, shifts in government policies concerning taxation, concession decisions, and the issuance of exploration permits or the opening of new areas.

3 The Oil Market Model

The main question in this paper is to what extent oil prices have influenced petroleum investment in Norway. To answer this question, I need to: (i) identify exogenous changes in oil prices, ensuring that these changes are not influenced by other factors affecting petroleum investments apart from the oil price itself; and (ii) estimate the effects of these exogenous changes on petroleum investment in Norway

To that end, I proceed in two steps. First, I follow Baumeister and Hamilton (2019) and apply insights about the oil market in a structural vector autoregression model with Bayesian inference. This approach allows me to identify different oil market shocks and determine whether changes in oil prices are due to (i) innovations in oil supply, (ii) innovations in aggregate demand, or (iii) oil-specific demand disturbances, see Kilian (2009); Kilian and Murphy (2012).

In the second step, I use the estimated structural shocks from the VAR in a Local Projection model (see Jordà (2005)) to estimate the effects on petroleum investments.

This two-step framework is advantageous for several reasons. First, it allows the use of monthly data to identify oil market shocks, even though investment series are available only at a quarterly frequency. Second, given Norway's relatively small role in the global oil market, it is reasonable to assume that domestic oil activities do not influence global oil prices. Third, this approach enables an in-depth analysis of how different types of investment—aligned with various stages of the oil activity life cycle—respond to oil price fluctuations, including future investment plans.

More generally, it is worth noting that, as shown in Plagborg-Møller and Wolf (2021), LP and VAR yield equivalent impulse responses under correct specification, meaning they estimate the same dynamic responses in many settings. However, as Jordà (2023) points out, the main difference lies in their practical application: LPs are more flexible for directly estimating impulse responses without needing to specify the entire system, whereas VAR tends to be more efficient when complete system modeling is feasible.

I start by introducing Bayesian VAR model in Section 3.1 and thereafter discuss identification in Section 3.2. In Section 3.3 I describe Local Projection framework. The data is described in Appendix A.

3.1 Bayesian VAR model

Assume a 3-variable oil model that describe the global oil market:

$$q_t = \alpha_{qg} g_t + \alpha_{qp} p_t + b_q' x_{t-1} + u_{qt} \tag{1}$$

$$g_t = \alpha_{gq} q_t + \alpha_{gp} p_t + b_g' x_{t-1} + u_{gt} \tag{2}$$

$$p_t = \alpha_{pq} q_t + \alpha_{pg} g_t + b_p' x_{t-1} + u_{pt} \tag{3}$$

where q_t is the log difference in global oil production, g_t is a measure of the log difference in real economic activity, and p_t is the log difference between the North Sea Brent crude oil price and the U.S. CPI.[1] Assume

$$y_t = [q_t,\, g_t,\, p_t]',$$

then

$$x_{t-1} = (y_{t-1}', y_{t-2}', \ldots, y_{t-n}', 1)$$

where the number of lags n is set to 12 consistent with Hamilton and Herrera (2004).[2]

Equations 1 and 3 represent the oil supply and demand relationships. α_{qp} is the short-run price elasticity of supply, while α_{pq} is the reciprocal of short-run price elasticity of demand. Notice, that real economic activity enters both equations, allowing for the possibility to affect supply decisions as well as the oil price fluctuation.

Let

$$u_t = (u_{qt},\, u_{gt},\, u_{pt}),$$

where u_t represents structural disturbances to oil supply (u_{qt}), economic activity (u_{gt}), and oil demand (u_{pt}), respectively.

The main interest is to determine the effect of these structural disturbances in u_t on y_t.

The above model can then be represented in the traditional VAR form:

$$Ay_t = Bx_{t-1} + u_t \tag{4}$$

where A is an 3×3 matrix that summarize the contemporanios relationship between the variables in y_t. By definition, the structural shocks are mutually uncorrelated, and

[1] The three-variable model does not take into account the effects of oil inventory demand, as analyzed in Kilian and Murphy (2014); Baumeister and Hamilton (2019). However, as shown in Baumeister and Hamilton (2019), inventory demand shocks have played only a small role in oil price fluctuations, and the measure of world inventories contains considerable error. Given that my analysis focuses on the effects of oil price fluctuations on Norwegian petroleum investment, the impact of inventory demand shocks can be reasonably disregarded.

[2] Hamilton and Herrera (2004) show that a too restrictive lag length can produce misleading results, while increasing the lag length above one year has negligible effects.

the variance matrix of u_t, D is assumed to be diagonal. I follow the common assumption in the literature and treat u_t as Gaussian, see e.g. Kilian (2009); Kilian and Murphy (2014); Baumeister and Hamilton (2019); Känzig (2021).

3.2 Identification and Estimation

To estimate the model I need to specify my prior information about parameters A, D, and B in the form of densities: $p(A)$, $p(D|A)$, $p(B|D,A)$. The prior about contemporaneous relationship between the variables in the model, $p(A)$, can be related to identification schemes in the traditional VAR approach, where the goal is to identify the structural disturbances. However, in Bayesian approach these restrictions can be specified in term of priors that reflect the knowledge about the oil market model specified in Equations 1 - 3.

I follow Kilian and Murphy (2012, 2014); Baumeister and Hamilton (2019) and make several economically intuitive assumptions: (i) upward sloping supply curve, (ii) an increase in oil price reduces economic activity, (iii) downward sloping demand curve, and (iv) higher income increases oil demand. Further, I assume that there is no feedback effects arising from a possible direct response of oil production to economic activity or economic activity to oil production. This imply that within the month an increase in global activity can only affect oil production through the oil prices and vice versa. As it is shown in Baumeister and Hamilton (2019), these conventional assumptions assure that sign restrictions used by Kilian and Murphy (2012) holds.

After setting the priors, I can draw from the posterior distribution, $p(A, D, B|Y_T)$, using the same estimation procedure as Baumeister and Hamilton (2019) where I use observations in $Y_T = (y_1', y_1', ..., y_T')$ to revise my prior beliefs. A more detailed description of priors and estimation procedure is described in Appendix B.

3.3 Local Projection

Once I have estimated the structural disturbances in the global oil market, these can be used in the second step of my framework, where I trace out the effects of these shocks on Norwegian petroleum investment series. For this purpose I use local projection, see Jordà (2005).

Each of the series of interest are regressed on the structural shocks according to:

$$\psi_{i,t+h} = c_{i,h} + \beta_{i,h}\hat{U}_{jt} + \Psi_{i,t-1} + e_{i,t+h}, \quad \text{for } h \in [0, H] \tag{5}$$

where $\psi_{i,t+h}$ is series i in time period h, $\Psi_{i,t-1} = (\psi_{t-1}', \psi_{t-2}', \ldots, \psi_{t-12}')$, $c_{i,h}$ is a constant, and $\beta_{i,h}$ is the estimated parameter that yields the impulse response function for the $\psi_{i,t:t+h}$ at horizon h. $e_{i,t+h}$ is the error term assumed to be Gaussian. $\hat{U}_{jt}$ is the structural shock of interest accumulated to the quarterly frequency according to:

$$\hat{U}_{jt} = \sum_{m=1}^{3} \hat{u}_{jtm}, for j = 1, 2, 3 \tag{6}$$

where $\hat{u}_{jtm}$ refers to the estimated residual from Equation 4 for the j-th structural shock on the m-th month in the t-th quarter of the sample.

Estimation is performed separately for each series. Since the shocks $\hat{U}_{jt}$ are purely exogenous, there is no need to include additional control variables in the regression. For each time period h, the regression in Equation 5 is estimated using standard OLS. The number of lags is set to three years; however, in Section 5, I demonstrate that the results are robust to alternative lag specifications. Appendix B provides more details about the estimation procedure.

In Sections 4 and 5, I present the results based on Equation 5, where ψ_t varies across different investment series, as well as other series such as oil and gas prices, economic activity, and oil production. As described in Appendix A, all investment series are transformed to log differences, hence $\beta_{i,h}$ can be interpreted as the effect of an oil shock in period t on the growth rate of investment series i, h periods ahead.

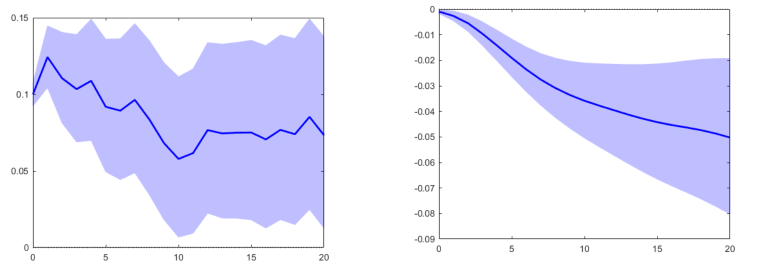
4 Empirical Results

This section presents impulse responses for a number of investment variables focusing on the oil-specific demand shock. This shock reflects oil price fluctuations that are not driven by oil supply disturbances or changes in global demand and can therefore be interpreted as an oil-specific demand shock, see Section 3. The effect of oil-supply and aggregate demand shocks are discussed in Section 5. The figures presented in this Section show effects of an increase in the real price of oil that is normalized to increase the oil price with 10 percent in the first quarter. All estimated responses are accumulated and shown in levels.

4.1 Real oil price and economic activity for Norwegian trading partners

I start by establishing some facts about the oil-specific demand shock. While in the estimated VAR model described in Section 3, the oil price is represented by spot prices, oil companies may base their decision on the future expectations about the oil prices and hence focus on the forward contracts. As panel (a) in Figure 3 shows the increase in oil price is also associated with strong and persistent increase in markets expectation about the future real oil prices.[3]

In Section 3 I also emphasized the importance of controlling for developments in global activity when analyzing the effects of oil prices on the economy. While oil demand is driven by global economic activity, the most relevant measure for non-domestic economic activity in Norway is the activity level of its trading partners. If an increase in oil prices is driven by an increase in economic activity for Norway's trading partners, the subsequent rise in petroleum investment might also be due to increased demand, making it challenging to isolate the effects directly attributable to changes in oil prices. However, as most of Norway's main trading partners are oil importers, I expect to see a reduction in their activity after an oil-specific demand shock. Pabel (b) in Figure 3 confirms this, showing fall in export indicator for Norway's main trading partners.[4]



(a) Forward Oil price

(b) Export demand for Norway's main trading partners

Figure 3. The effect of an oil-specific demand shock: Impulse responses from Local Projection model (see Section 3.3) for (a) forward oil price and (b) volume indicator for export demand for Norway's main trading partners. The initial shock is normalized to increase forward oil prices by 10%. The responses are reported in levels. Quarterly frequency. Sample period 1987:Q4-2023:Q2. Point estimate (solid line) and 90% confidence intervals (shadowed area).

[3]There is extensive literature discussing the predictability of oil spot prices and the extent to which futures-based forecasts contain more information about future oil prices, see jf Alquist and Kilian (2010); Reeve and Vigfusson (2011); Baumeister and Kilian (2012); Alquist et al. (2013); Baumeister and Kilian (2014). A recent study by Ellwanger and Snudden (2023) conclude that future-based forecasts have always been useful for short-horizon forecasts of the average spot price of crude oil and are now also accurate at longer horizons.

[4]While the main concern regarding identification of oil specific demand shock is that increase in oil prices can be driven by other factors than oil specific demand, the concern can also go other way around. As an increase in oil prices is associated with decrease in trading partners activity, one could argue that this could affects the estimates of the importance of the oil price for the economy. The possible issue is then that the effect of oil price on investment series can be underestimated.

4.2 Effects of Oil Price on Actual Investment

Having established that the oil-specific shock leads to increased expected oil prices, while not being driven by increased activity among Norway's main trading partners, I now turn to analyze the effects on petroleum investment.

Figure 4 shows that higher oil prices result in a significant increase in total petroleum investment. This effect is positive from the first quarter, with the greatest impact occurring approximately two years after the shock, raising total petroleum investments by nearly four percent. The effect remains significant for three years after the shock. These results are in line with historical developments, and evidences that the majority of fall in the oil activity after 2014 can be explained by the fall in real oil prices. [5]

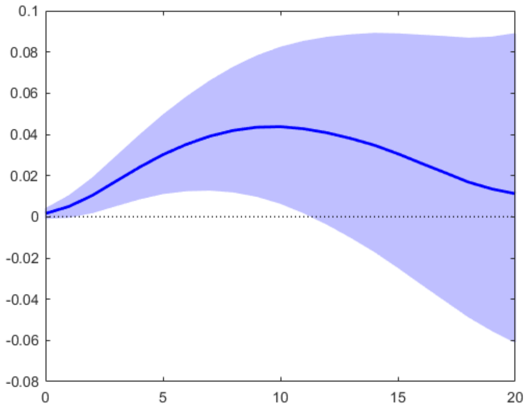


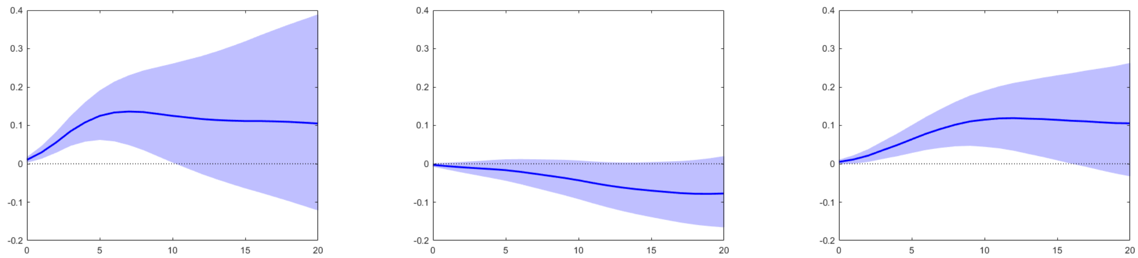
Figure 4. The effect of an oil-specific demand shock: Impulse responses from Local Projection model (see Section 3.3) for total petroleum investment. The initial shock is normalized to increase forward oil prices by 10%. The responses are reported in levels. Quarterly frequency. Sample period 1987:Q4-2023:Q2. Point estimate (solid line) and 90% confidence intervals (shadowed area).

An increase in oil prices may affect oil companies investment decisions through several channels. First, higher income from existing production enhances their ability to invest. Additionally, expectations of higher future oil prices create incentives to accelerate production in current fields. Furthermore, projects that were previously unprofitable may become viable due to the improved present value of future cash flows. However, increased activity in the petroleum sector can also lead to rising costs for equipment and labor, which may, in turn, dampen overall activity.

As discussed in Section 2, the life cycle of petroleum activity involves many steps. More than ninety percent of total petroleum investment is allocated to exploration and concept studies, field development, and fields in production. Panels (a), (b), and (c) in

[5] From 2014 to 2016 the real price of oil dropped by around than 55 percent. During the same period petroleum investment were reduced by more than 25 percent.

Figure 5 illustrate how each of these sub-categories of investment responds to an increase in oil prices. Several key observations stand out. First, an increase in real oil prices significantly boosts investment in exploration and concept studies, as well as investments related to existing fields, while the effect on field development is small and insignificant. Second, investment in exploration and concept studies increases at a similar rate as investment in fields in production, rising by approximately 12-14 percent after 2-3 years, however the confidence intervals are much wider. Third, the increase in investment in fields in production is more enduring than in exploration and concept studies, remaining significant after five years. Lastly, it is important to highlight that although both fields in production and exploration and concept studies see similar percentage increases in investment following a price surge, historically, the actual amount invested in fields in production has been more than four times greater than in exploration and concept studies. This shows that a major portion of capital is directed towards activities in existing fields.



(a) Exploration and concept studies **(b)** Field development **(c)** Fields in production

Figure 5. The effect of an oil-specific demand shock: Impulse responses from from Local Projection model (see Section 3.3) for (a) exploration and concept studies, (b) field development, and (c) fields in production. The initial shock is normalized to increase forward oil prices by 10%. The responses are reported in levels. Quarterly frequency. Sample period 1987:Q4-2023:Q2. Point estimate (solid line) and 90% confidence intervals (shadowed area).

An increase in investments related to fields in production suggests that companies are focusing on technologies and methods to enhance extraction, thereby extending the productive life of the field and maximizing returns on the initial capital outlay. The time it takes for production to actually increase after an investment in an already developed oil field can vary from several months to several years. In Section 5 I show that it takes around three years before significant increase in production.

Investment in field development does not respond significantly to changes in oil prices. As discussed in Section 2, companies must develop a Plan for Development and Operation (PDO) and obtain the necessary regulatory approvals before beginning field development, a process that can take 1-3 years. Field development involves constructing and installing essential infrastructure, which can take 2-5 years or more, depending on the field's size and complexity. Consequently, the uncertainty regarding profitability is generally higher for new field development investments compared to investments in existing fields. The timing of field development investments also depends on PDOs that have already been approved, limiting the ability to postpone these investments in the case of lower oil prices. Additionally, the expectation of increased costs can dampen the willingness to initiate new fields.

The median time from the start of exploration drilling to the first barrels of oil being produced ranges from 8 to 14 years. Additionally, it typically takes 1-2 years from the granting of permission to the actual start of drilling. While the uncertainty about oil prices at the time production begins is higher for exploration projects than for field development projects, the effect of oil price increases is evident only in the former. This difference can be attributed to the greater flexibility and ability of exploration and concept studies to rapidly adjust to changing market conditions, compared to field development projects, which require long-term planning, regulatory approvals, and significant capital. Once a field development project is initiated, it typically follows a set schedule, making it less responsive to price fluctuations.

To sum up, higher oil prices have a positive and significant effect on petroleum investment. A ten percent increase in oil prices leads, on average, to a four percent increase in petroleum investment two years later. This surge in investment is primarily driven by increased activity in existing fields. The results also indicate that increase in oil prices leads to higher investment in exploration and concept studies, while the response of field development investments remains minimal. This can be attributed to the flexibility and lower immediate costs of exploration activities, in contrast to the structured, long-term nature of field development projects.

4.3 Effects of Oil Price on Planned Investment

So far, I have examined the effects of oil prices on actual investments. In this section, we analyze how changes in oil prices affect future investment plans reported by oil companies.

Statistics Norway conducts a quarterly survey of petroleum companies' investment plans for the reporting year and the following year, known as the Quarterly Investment Intentions Survey (KIS). The survey is carried out four times a year and published in February, May, August, and November. Companies report their business plans, which can include both approved plans and preliminary assumptions. Investment plans are published quarterly for the reporting year, while plans for the following year are released only in May, August, and November. This schedule is due to the fact that first-quarter reports are considered too uncertain and often require significant revisions.

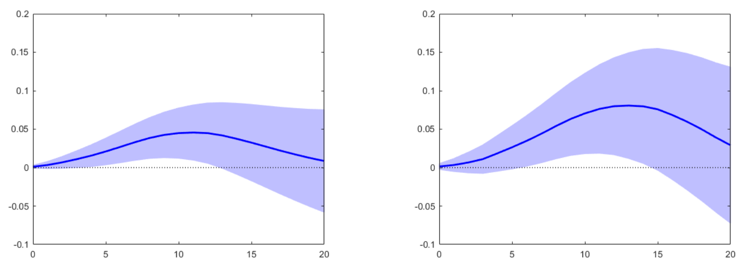
Because reported investments must meet a certain probability threshold to be included, there is strong seasonality in the reported plans. As more information becomes available throughout the year and more plans receive approval, these investment plans are updated. Therefore, it is important to compare reported investment plans with corresponding observations from the previous year. To estimate changes in firms' investment plans, the focus should be on year-on-year changes. For more details, see Appendix A.

The uncertainty around these investment plans is illustrated in Table 1, which shows how well reported investment predict actual investment growth rates at different times. The $R2$ value indicates the proportion of the variance in actual investment growth rates that can be explained by the reported growth rates.

	February	May	August	November
Previous Year	-	-1.36	-0.22	0.24
Same Year	0.55	0.77	0.86	0.95

Table 1. Calculated values of R^2 for different months, presenting the accuracy of investment predictions based on reported annual investment plans. The values represent R^2, calculated as 1 minus the ratio of the residual sum of squares to the total sum of squares.

The results show that, as expected, the reported plans become more certain as the actual investment time approaches. The reported plans from November of the same year are the most accurate, with an R^2 of 0.95. August of the same year also shows strong predictive accuracy with an R^2 of 0.86. In contrast, reported plans from May and August of the previous year perform poorly, with negative R^2 values.[6] Additionally, there is an underestimation bias across all predictors suggests a systematic tendency for reported investment to be lower than the actual values.



(a) Same year plans **(b)** Next year plans

Figure 6. The effect of an oil-specific demand shock: Impulse responses from from Local Projection model (see Section 3.3) for (a) investment plans in the same year, and (b) investment plans in the next year. The initial shock is normalized to increase forward oil prices by 10%. The responses are reported in levels. Quarterly frequency. Sample period 1992Q2-2023:Q2. Point estimate (solid line) and 90% confidence intervals (shadowed area).

[6]Negative R^2 values suggest that the model performs worse than using the mean of the actual values as a predictor.

Now I turn to examine how changes in oil prices affect companies' plans. It is worth noting that while the results presented in the previous section show the effect on actual investments accrued throughout the year, the planned investments are reported in annual values. Hence, there is no direct mapping between these two results. Still, I expect similarities between these responses since the actual increase in accrued investments should be reflected in companies' annual plans. Figure 6 confirms this view, showing that an increase in oil prices leads to an upward shift in firms investment plans. Several key findings stand out. First, an increase in oil prices leads to an increase in firms' investment plans both in the same and for the next year. Second, firms seem to revise their next-year plans somewhat more than their current-year plans following changes in oil prices. Third, similar to actual investment, the effect on firms' plans increases over time, indicating that it takes time for the increase in oil prices to be fully incorporated into firms' investment plans.

To sum up, an increase in oil prices has a clear effect on firms' future investment plans. The analysis indicates that reported investments for the next year increase somewhat more than for the current year following an increase in oil prices. However, it is worth noting that next year's plans are much more uncertain and tend to be less representative for actual investments.

5 Additional Results and Robustness

The analysis presented so far has demonstrated that an oil-specific demand shock significantly increases both expected and actual petroleum investment. This Section further investigates these results and confirm the robustness of the main findings. Section 5.1 extends the analysis by examining the effects of oil-specific demand shocks on oil production and gas prices, and compares the impacts of oil-specific demand shocks with other types of oil market shocks. Section 5.2 conducts several sensitivity analyses to evaluate the chosen modeling framework.

5.1 Additional Results

In Section 4 I showed that an increase in oil prices leads to a significant increase in investments related to fields in production. Based on this, it is reasonable to expect an increase in oil production. Figure 7 in Appendix C.1 confirms this: production begins to increase five quarters after the shock, with the effect becoming significant three years after the shock. These results align well with an immediate increase in investments directed toward technologies and methods that enhance production. However, considering that investments increase gradually and reach their peak effect after about two years, along with the time required for production to respond following an investment, the delayed response in oil production appears reasonable.

Gas currently makes up about half of the total production in oil equivalents. In contrast, in 2004, gas accounted for approximately 30 percent of Norwegian petroleum production. Given the growing significance of gas prices, it is pertinent to examine to what extent fluctuations in oil prices also influence gas prices. Historically, there has been a robust correlation between oil and gas prices. For instance, Villar and Joutz (2006) identified a co-integrated relationship between these two commodities. The significant rise in European natural gas prices between late 2021 and mid 2022 prompts an inquiry into whether European gas prices have begun to decouple from crude oil prices. Nonetheless, Szafranek and Rubaszek (2024) have shown that while oil price shocks have a limited impact on U.S. natural gas prices, in Europe, gas prices are predominantly influenced by oil price shocks over extended periods. Appendix C.2 demonstrates that increases in oil prices due to oil-specific shocks are strongly correlated with rises in gas prices, see Figure 8.

While the primary analysis in this paper focuses on oil-specific shocks, variations in oil prices can also arise from other market shocks that may impact petroleum investment. Appendix C.3 compares oil-specific demand shock to oil supply and aggregate demand shock. Posterior structural impulse-response functions from BVAR model outlined in Section 3 are plotted in Figure 9. An oil supply shock lowers oil production and raises oil price on impact, whereas a shock to oil consumption demand raises production, although insignificantly. An aggregate demand shock results in an increase in real activity, impacting real oil prices. Increase in demand and oil prices lead to higher oil production. Real activity falls on impact after an oil-specific demand shock, however after around three months there is a temporary increase in activity similar to Kilian (2009).

Figures 10 and 11 provide an examination of how oil supply and aggregate demand shocks affect forward oil prices, economic activities of Norway's main trading partners, and petroleum investment. The results indicate that the impacts of these shocks on forward oil prices are generally more short-term, that is in line with Figure 9. Oil supply shocks exert a minimal influence on the economic activities of Norway's trading partners, whereas global demand shocks appear to enhance their activities. Nonetheless, the influence on petroleum investment is limited, primarily due to the temporary nature of the price changes caused by these shocks. Moreover, supply disturbances have a negative effect on investment, likely due to increased uncertainty about future oil prices, as discussed in Elder and Serletis (2010).

5.2 Robustness

In Appendix D.1 I investigate to what extend the increase in real economic activity followed an oil specific demand shock drives the main results in this paper. As discussed in Section 3, possible issue could be that the increase in petroleum investment may be correlated with a measured real economic activity. To investigate this potential correlation, I have re-estimated the model using an alternative measure of global economic activity using the Global Economic Conditions Indicator (GECON), proposed by Baumeister et al. (2020). This index of global economic conditions and measures for assessing future energy demand and oil price pressures. Figure 12 shows posterior structural impulse-response functions with this new measure. While the primary outcomes of the benchmark model are preserved, the real activity responds significantly negative to an oil-specific demand shock. Figure 13 illustrates that the response of petroleum investment to an oil-specific demand shock obtained with the new measure of real activity is nearly identical to benchmark model. This confirm that the results in this paper are not driven by the choice of real economic activity variable.

Given the dynamic nature of the global oil and gas markets, it may be argued that the findings of this paper are influenced by specific events, such as the investment behaviors during the COVID-19 pandemic, the 2014 Oil Crisis, or the 2009 Financial Crisis. Appendix D.2 explores how the impacts have evolved over time. As demonstrated in Figure 14, the positive response of petroleum investment to increases in the real oil price has remained significant throughout the period analyzed, and becomes even more pronounced when the aforementioned events are excluded from the sample.

Finally, in Appendix D.3, it is demonstrated that the primary findings of this study remain robust regardless of variations in the number of lags employed within the local projection regression framework.

6 Conclusion

In this paper, I investigate how offshore activities are influenced by oil prices. Norway's fiscal policy framework, designed to minimize the direct impact of oil price fluctuations on domestic business cycles, makes Norway an ideal case for studying the effects of oil prices on petroleum investment.

To do so, I employ Bayesian vector autoregressive (BVAR) model followed by local projections to examine how exogenous oil price fluctuations impact petroleum investments. This method allows for the identification of oil-specific demand shocks and considers the broader effects of global economic activities and supply disturbances.

Findings indicate that a ten percent increase in real oil prices results in a four percent rise in petroleum investment within two years, primarily enhancing activities in existing field operations, but also in exploration and concept studies. Higher activity in the existing fields results in increased crude oil production approximately three years after the shock. These results are in line with historical developments, and evidences that the majority of fall in the oil activity after 2014 can be explained by the fall in real oil prices.

By examining the varied impacts of oil price changes on different investment types, this paper adds depth to the literature on economic responses to energy prices and aids in refining economic forecasts and policy responses in resource-rich economies.

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The Role of Oil Prices in Norwegian Petroleum Investment

Julia Skretting

— Appendix—

A Data Description

To investigate the effects of oil price shocks on Norwegian petroleum investment, I employ a set if domestic and international series. A detailed breakdownnof these series can be found in Table 2. The benchmark VAR model described in Section 3.1 include world crude oil production, global activity and real price of oil. I include an estimate of industrial production in the OECD plus other major countries published by OECD Main Economic Indicators, and extended from November 2011 by Baumeister and Hamilton (2019) (see also Hamilton (2019)). However, I also analyze the robustness of real activity measure using Global Economic Conditions Indicator (GECON) proposed by Baumeister et al. (2020). For the real oil price, I use spot Brent prices as this is the benchmark price for Norwegian oil. I deflate the oil price by U.S. CPI.

I use a broad range of investment series including total petroleum investment, as well as investment allocated to exploration and concept studies, field development, and fields in production. Finally, I use data from quarterly survey of petroleum companies' investment plans for the reporting year and the following year, known as the Quarterly Investment Intentions Survey (KIS). All investment data are deflated by corresponding PPI series.

To ensure stationarity while preserving economic interpretability, I employ year-on-year growth using the log difference of the data. Oil and gas prices are transformed by taking the log difference between the prices and the U.S. Consumer Price Index (CPI). n

Variable	Data series	Transformation
1	World, EIA, Oil & Gas, Total Oil Supply, Crude Oil & Petroleum Products, Petroleum & Other Liquids, Production, Crude Oil Including Lease Condensate, Barrels per Day	Δ log
2*	World, Crude Oil, Brent, Spot, FOB North Sea, ICE, Close, USD	log
3	World Industrial Production Index, see *Baumeister and Hamilton (2019)*	Δ log
4	Monthly Global Economic Conditions (GECON) indicator see Baumeister et al. (2020)	none
5	Norway, Expenditure Approach, Gross Fixed Capital Formation, Extraction & Transport via Pipelines, Total, Constant Prices, NOK	Δ log
6	Norway, Expenditure Approach, Gross Fixed Capital Formation, Extraction & Transport via Pipelines, Exploration and concept studies, Constant Prices, NOK	Δ log
7	Norway, Expenditure Approach, Gross Fixed Capital Formation, Extraction & Transport via Pipelines, Field development, Constant Prices, NOK	Δ log
8	Norway, Expenditure Approach, Gross Fixed Capital Formation, Extraction & Transport via Pipelines, Field on stream, Constant Prices, NOK	Δ log
9**	Norway, Estimates, Investment costs, Extraction of oil and natural gas, Current prices, NOK	Δ log
10	Natural Gas, Dutch TTF Natural Gas (TTFI), Index, EUR	log
11	Crude Oil, Future, ICE Brent Crude, 6th Position, Close, USD	log
12***	Export weighted volume indicator for export demand	Δ log
13	Crude oil production, Norway, Millions of ton equivalents	Δ log

Table 2. Description of the variables and their data sources and transformations. * Deflated by U.S. Total CPI. ** Deflated by PPI, Extraction of oil and natural gas. ***Constructed as weighted sum of foreign trade with Euro Area, U.S., China, Denmark, U.K., Sweden, Japan, South Korea, Poland, and Russia.

B Estimation and Prior Specification

B.1 BVAR Identification

Recall that the oil market model described in Section 3.1 can be represented in the traditional VAR form:

$$Ay_t = Bx_{t-1} + u_t \tag{7}$$

where $y_t = [q_t\, g_t\, p_t]'$; A is an 3×3 matrix that summarize the contemporanios relationship between the variables in y_t; x_{t-1} is the lagged matrix of y_t; u_t is the structural disturbances. By definition, the structural shocks are mutually uncorrelated, and the variance matrix of u_t, D is assumed to be diagonal. I follow the common assumption in the literature and treat u_t as Gaussian, see e.g. Kilian (2009); Kilian and Murphy (2014); Baumeister and Hamilton (2019); Känzig (2021).

As in the traditional VAR approach, in order to identify the structural disturbances we need to put some restrictions on the contemporaneous relationship between the variables. First I follow the literature and assume that there is no feedback effects arising from a possible direct response of oil production to economic activity or economic activity to oil production. This imply that within the month an increase in global activity can only affect oil production through the oil prices and vice versa.

$$A = \begin{bmatrix} 1 & 0 & -\alpha_{qp} \\ 0 & 1 & -\alpha_{yp} \\ -\alpha_{pq} & \alpha_{py} & 1 \end{bmatrix} \tag{8}$$

Given the above assumption the impact matrix can be written as:

$$A^{-1} = \frac{1}{1 - \alpha_{qp}\alpha_{pq} - \alpha_{py}\alpha_{yp}} = \begin{bmatrix} 1 - \alpha_{py}\alpha_{yp} & \alpha_{qp}\alpha_{py} & \alpha_{qp} \\ \alpha_{pq}\alpha_{yp} & 1 - \alpha_{qp}\alpha_{pq} & \alpha_{yp} \\ \alpha_{pq} & \alpha_{py} & 1 \end{bmatrix} \tag{9}$$

I further assume, in line with the literature, that the supply curve is upward sloping, an increase in oil prices reduces economic activity, the demand curve is downward sloping, and higher income increases oil demand. As it is shown in Baumeister and Hamilton (2019), these conventional assumption in the literature assures that sign restriction used by Kilian and Murphy (2012) holds, i.e.

$$A^{-1} = \begin{bmatrix} + & + & + \\ + & + & - \\ - & + & + \end{bmatrix} \tag{10}$$

The identification assumptions discussed so far mainly impose restrictions on the sign of the responses and do not say anything about the magnitude. The Bayesian framework, however, allows a researcher to specify all relevant information in the prior, before testing how this information is allighned with the actual data. The prior densities are specified in the next subsection.

B.2 Priors and Posterior Probabilities

The prior information about A is specified in the form of density $p(A)$. For the non zero elements of A matrix, in line with Baumeister and Hamilton (2019) I use Student t-distribution:

$$p(\alpha_{xx}) = \frac{\Gamma(\frac{\nu_{xx}+1}{2})}{\Gamma(\frac{\nu_{xx}}{2})\sqrt{\pi\nu_{xx}\sigma_{xx}}}\left[1+\frac{1}{\nu_{xx}}(\frac{\alpha_{xx}-c}{\sigma_{xx}})^2\right]^{-\frac{\nu_{xx}+1}{2}} \tag{11}$$

where c is the local parameter, σ is the scale parameter, and ν degrees of freedom.

I set the mode for short run supply elasticity α_{qp} to 0 and truncate it to be positive, the scale parameter $\sigma_{qp} = 0.02$ and the degree of freedom is set to $\nu = 3$. This allows for a 9 percent probability that elasticity is above 0.05 and reflects the view that the response of oil production within a month is small. However, contrary to Kilian (2009), I allow for oil production to increase within a month following an increase in oil prices.This is also consistent with Kilian and Murphy (2012), who state that supply elasticity is low. However, in contrast to Kilian and Murphy (2012), I also allow for the possibility that supply elasticity could be greater than 0.0258. The priors for the elements of A are specified in Table 3.

Parameter	Meaning	Sign restriction		
Student t distribution				
			Location	Scale
α_{qp}	short-run price elasticity of oil supply	+	0	0.2
α_{yp}	short-run oil price elasticity of global demand	−	-0.05	0.1
α_{py}	income elasticity of oil demand	+	0.7	0.2
α_{pq}	short-run price elasticity of oil demand	−	-0.1	0.2
Uniform distribution				
			Min	Max
h	effects of economic activity on y	−	-1.5	0

Table 3. Prior distribution for model parameters. Degrees of freedom for Student t distributions are all set to 3.

In line with Baumeister and Hamilton (2019), I use natural conjugate priors for $p(D|A)$ and $p(B|D, A)$, such that diagonals of $D|A$ are independently gamma-distributed and rows of $B|D, A$ are independently normally distributed.

B.3 BVAR Estimation

After having set the priors, I draw from the posterior distribution, $p(A, D, B|Y_T)$, using the same estimation procedure as Baumeister and Hamilton (2019) and use observations in $Y_T = (y_1^{'}, y_1^{'}, ..., y_T^{'})$ to revise my prior beliefs. In total I use one million different draws from this joint posterior distribution:

$$\{A^{(n)}, D^{(n)}, B^{(n)}\}_{n=1}^{N} \tag{12}$$

The structural shocks are estimated as:

$$\hat{u}_t = y_t - \hat{A}^{-1}\hat{B}x_{t-1} \tag{13}$$

where $\hat{A}$ and $\hat{B}$ are the median estimates.

The model is estimated over sample period from 1985:10 to 2023:8 due to data availability. The observation between 2020:3 and 2020:6 are removed from **Y** and the corresponding observations in **X** matrix are removed as well. The observations for these dates are still available in **X** matrix as the model is estimated with 12 lags consistent with Hamilton and Herrera (2004).[7] [8]

B.4 Local Projection Estimation

Recall Local Projection model

$$\psi_{i,t+h} = c_{i,h} + \beta_{i,h}\hat{U}_{jt} + \Psi_{i,t-1} + e_{i,t+h}, \quad \text{for } h \in [0, H] \tag{14}$$

where $\psi_{i,t+h}$ is series i in time period h, $\Psi_{i,t-1} = (\psi_{t-1}^{\prime}, \psi_{t-2}^{\prime}, \ldots, \psi_{t-12}^{\prime})$, $c_{i,h}$ is a constant, and $\beta_{i,h}$ is the estimated parameter that yields the impulse response function for the $\psi_{i,t:t+h}$ at horizon h. $e_{i,t+h}$ is the error term assumed to be Gaussian. $\hat{U}_{jt}$ is the structural shock of interest accumulated to the quarterly frequency

The results in Sections 4.1 and 4.2 are obtained based on the above equation, estimated over a sample period from 1987Q4 to 2023Q2 with 12 lags. I include lags of up to three years to ensure that the model captures the extended adjustment period characteristic

[7] Hamilton and Herrera (2004) show that a too restrictive lag length can produce misleading results, while increasing the lag length above one year has negligible effects.

[8] During this period the developments in oil market is dominated by Russia–Saudi Arabia oil price war. In the current model this event would be interpret as a negative oil demand shock that actually increases oil production. From March to April 2020 the Brent spot price dropped by 29,2 percent, while World production increased by 0,6 brrls/d, that is 0.7 percent, implies elasticity of -0.02. Russian production remained unchanged, OPEC production increased by 2 bbrl/d, that is 6.7 percent, while Rest of the world decreased by 1.5 brrls/d, that is 3,7 percent.

of investment decisions in the oil sector, which often requires multiple quarters to fully reflect the impacts of economic conditions and market signals. In Appendix D.3, I also demonstrate that the results are robust to alternative lag specifications. In Section 4.3, the sample period is from 1992Q2 to 2023Q2. Since the dependent variable is the revisions in firms' investment plans, the LP model is estimated with 4 lags. Observations for estimates in February of the year before the investment year are treated as missing observations.

C Additional Results

C.1 Effects of Oil Price on Oil Production

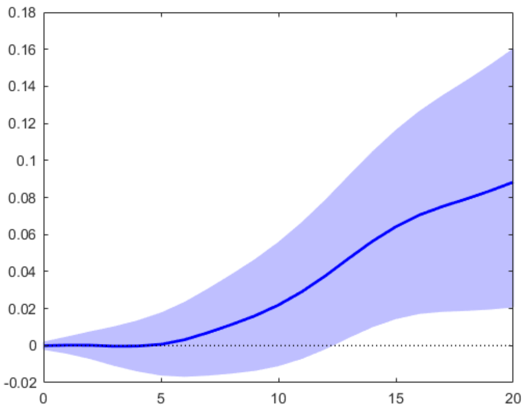
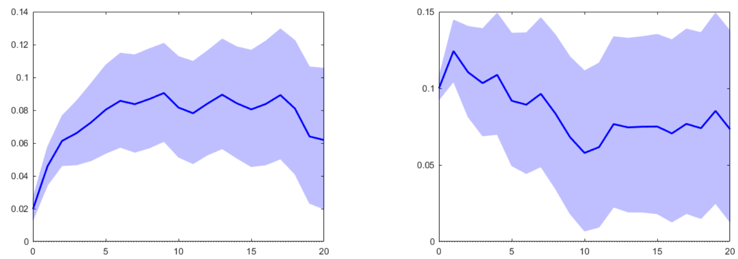


Figure 7. The effect of an oil-specific demand shock: Impulse responses from Local Projection model (see Section 3.3) for crude oil production. The initial shock is normalized to increase forward oil prices by 10%. The responses are reported in levels. Quarterly frequency. Sample period 1987:Q4-2023:Q2. Point estimate (solid line) and 90% confidence intervals (shadowed area).

C.2 Gas prices



(a) Gap prices **(b)** Oil prices

Figure 8. The effect of an oil-specific demand shock: Impulse responses from LP model for (a) spot oil price and (b) gas price. The initial shock is normalized to increase forward oil prices by 10%. The responses are reported in levels. Quarterly frequency. Sample period 1987:Q4-2023:Q2. Point estimate (solid line) and 90% confidence intervals (shadowed area).

C.3 Oil Market Shocks

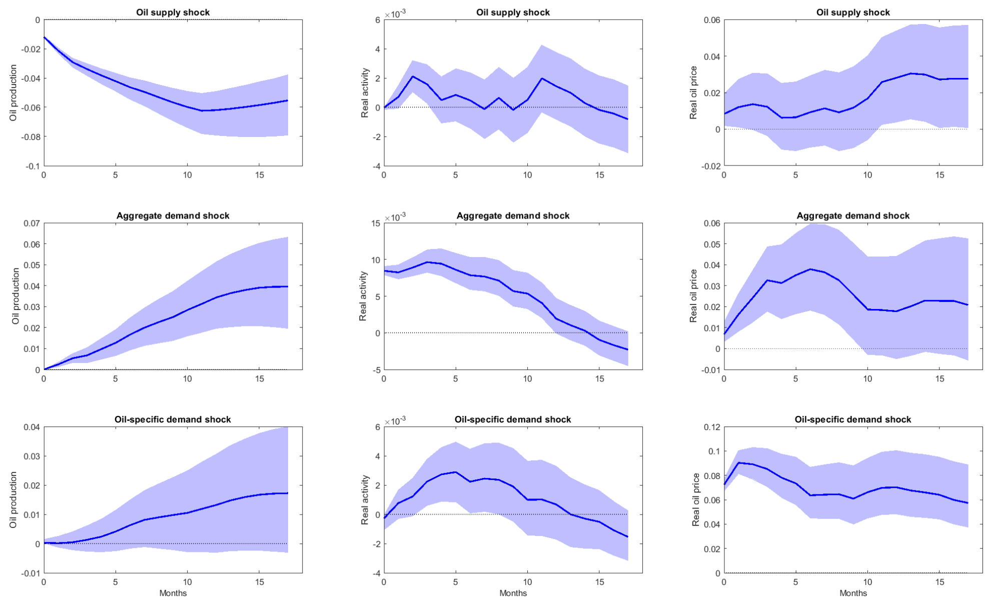
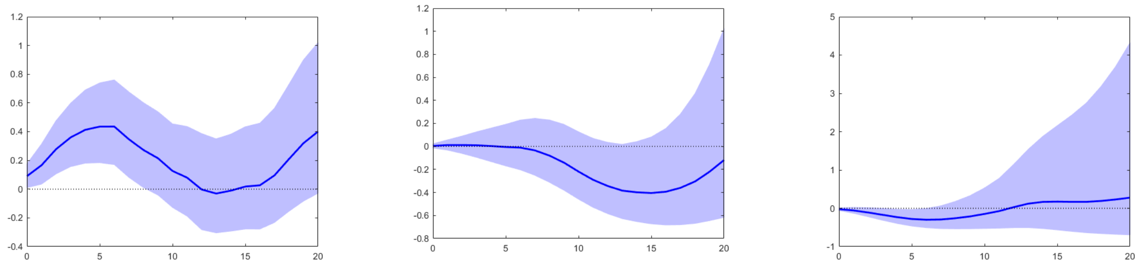


Figure 9. Impulse Responses from benchmark BVAR model. Solid lines: Bayesian posterior median; shaded regions: 68 percent posterior credible sets.

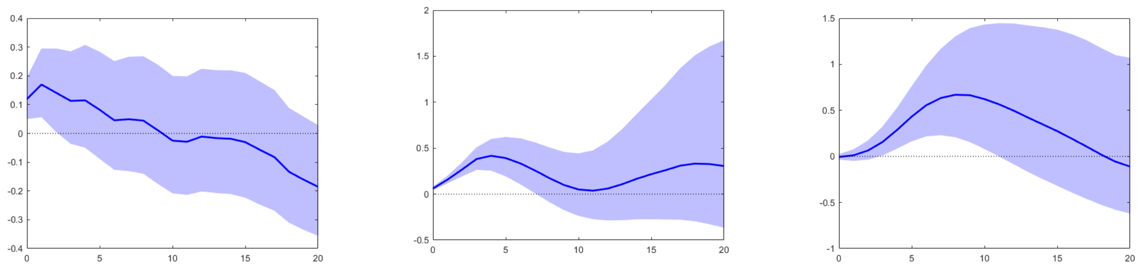


(a) Forward oil price

(b) Export demand for Norway's main trading partners

(c) Petroleum investment

Figure 10. The effect of an oil supply shock: Impulse responses from LP model for (a) forward oil price, (b) volume indicator for export demand for Norway's main trading partners and (c) total petroleum investment. The initial shock is normalized to increase oil prices by 10%. The responses are reported in levels. Quarterly frequency. Sample period 1987:Q4-2023:Q2. Point estimate (solid line) and 90% confidence intervals (shadowed area).



(a) Forward oil price

(b) Export demand for Norway's main trading partners

(c) Petroleum investment

Figure 11. The effect of an aggregate demand shock: Impulse responses from LP model for (a) forward oil price, (b) volume indicator for export demand for Norway's main trading partners and (c) total petroleum investment. The initial shock is normalized to increase oil prices by 10%. The responses are reported in levels. Quarterly frequency. Sample period 1987:Q4-2023:Q2. Point estimate (solid line) and 90% confidence intervals (shadowed area).

D Robustness

D.1 Selection of Real Economic Activity Variable

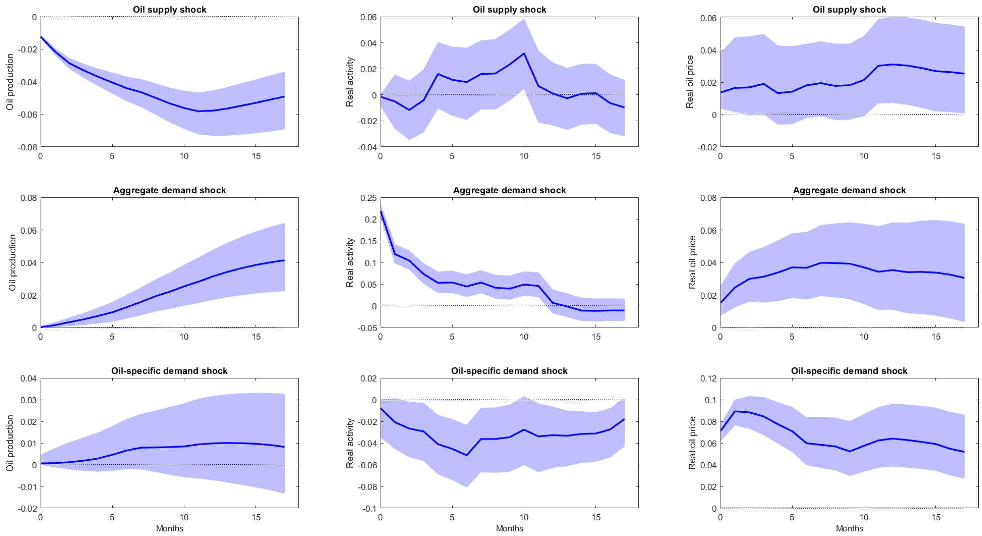
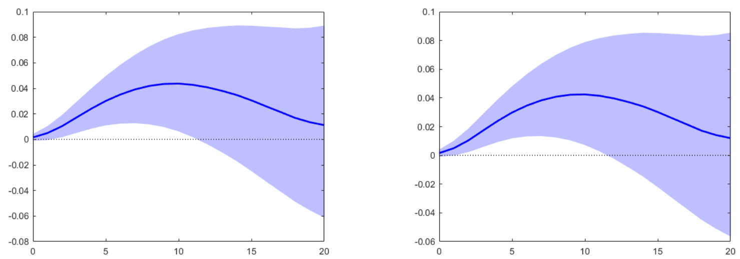


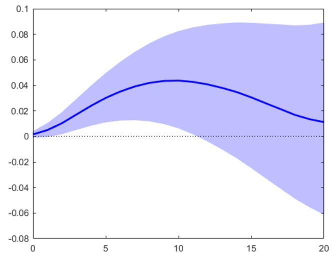
Figure 12. Impulse Responses from alternative BVAR model specification with GECON as measure for real economic activity. Solid lines: Bayesian posterior median; shaded regions: 68 percent posterior credible sets.



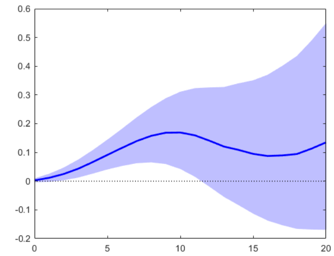
(a) Benchmark **(b)** Alternative Real Activity

Figure 13. The effect of an oil-specific demand shock: Impulse responses from LP model for total petroleum investment in a benchmark model (left panel) and alternative model specification with GECON as measure for real economic activity. The initial shock is normalized to increase forward oil prices by 10%. The responses are reported in levels. Quarterly frequency. Sample period 1987:Q4-2023:Q2. Point estimate (solid line) and 90% confidence intervals (shadowed area).

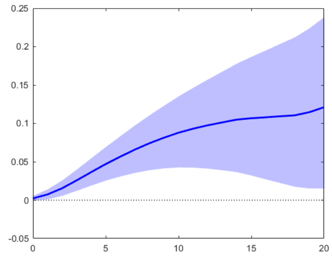
D.2 Local Projection estimated over different time periods



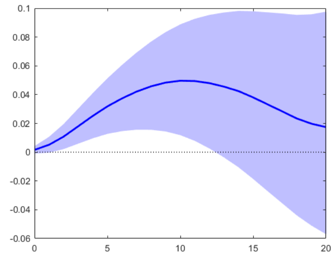
(a) Benchmark



(b) Before 2007



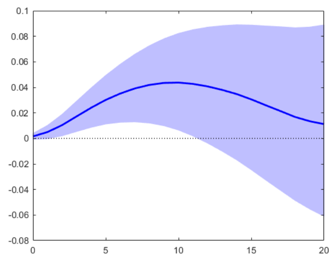
(c) Before 2014



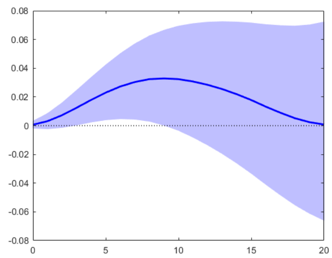
(d) Before 2020

Figure 14. The effect of an oil-specific demand shock: Impulse responses for total petroleum investment from LP model estimated over sample period (a) 1987:Q4-2023:Q2, (b) 2006:Q4-2023:Q2, (c) 2013:Q4-2023:Q2, and (d) 2019:Q4-2023:Q2. The initial shock is normalized to increase forward oil prices by 10%. The responses are reported in levels. Quarterly frequency. Point estimate (solid line) and 90% confidence intervals (shadowed area).

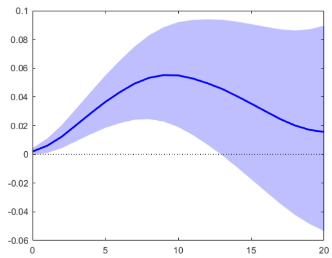
D.3 Number of Lags



(a) Benchmark



(b) 4 lags



(c) 20 lags

Figure 15. The effect of an oil-specific demand shock: Impulse responses for total petroleum investment from LP model estimated with (a) 12 lags, (b) 4 lags, and (c) 20 lags. The initial shock is normalized to increase forward oil prices by 10%. The responses are reported in levels. Quarterly frequency. Sample period 1987:Q4-2023:Q2. Point estimate (solid line) and 90% confidence intervals (shadowed area).