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Master Thesis

"Oil price shock on the Norwegian mainland economy and various sectors"

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Master of Science in Business – Major in Economics

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Acknowledgement

We would like to express our sincere gratitude to BI Norwegian Business School and professors of the Department of Economics for two challenging, but educational and interesting years. We have grown a lot in these two years, both educationally and personally, and hope this thesis is a testament of that. Finally, we would like to give a special appreciation to our supervisor Hilde C. Bjørnland for the helpful guidance and advice along the way of our master thesis.

Abstract

In this paper, we compare the effects of two demand shocks to macroeconomic variables for the mainland economy and five different sectors of Norway, by using a Structural Vector Autoregressive (SVAR) model. The two structural shocks are identified as an aggregate demand shock and an oil-specific demand shock. Economic activity is measured in mainland and sector-specific gross domestic product (GDP), employment and real wage. One of the main findings is that the oil price shock appears to be the most important shock for mainland GDP and all sector-specific gdp. While most of the responses of employment and real wage are similar, both in magnitude and persistence. The majority of the sectors appear to have close indirect links to the petroleum industry, while other sectors seem to have little to none link to the petroleum industry. The findings also suggest a fairly stable but oil-dependent mainland economy. The key take-away is that the oil prices do have influence on the Norwegian mainland economy and the different sectors of this paper.

In the latter part of our paper, we include a robustness check where we create four alternative oil price measures on a basis of the real oil price. The four alternative oil price measures are inspired by Mork (1989) and Hamilton (1996), where they look at increases and decreases of oil prices separately. We used this to evaluate the correlation between the alternative oil price measures and the real oil price. The results show that the real oil price has the highest correlation to the alternative oil price measure, related to decrease, inspired by Mork (1989). Finally, as an extension, we conduct an asymmetry test, to investigate the linearity and symmetry of mainland and sector-specific gdp, and the alternative oil price measures. The results indicate a linear relationship with the mainland GDP and most of the sector-specific gdp, and the alternative oil price measures.

1.0. Introduction

The effects of macroeconomic variables to oil price shocks have been debated for many decades and is an interesting topic for both economists and policymakers. There is a great amount of literature suggesting that there are significant macroeconomic effects of change in energy supply and oil prices (Hamilton, 2003). However, the majority of the research is based on oil-importing countries such as the United States and other oil-importing countries in Asia and Europe. There is also a larger focus on how oil price shocks affect the aggregate economy, in comparison to how it affects the economy on a sectoral level. We therefore find it highly relevant to investigate how oil price shocks affect Norway, a net oil exporting country, on a sectoral level. By distinguishing between sectors, we will be able to gain a better understanding of how oil price shocks pass through the economy of a net oil exporting country, both directly and indirectly. We also find it interesting to investigate the mainland of Norway, as several in modern times crises have passed, such as the financial crisis, oil price collapse and the covid pandemic. We measure economic activity by mainland and sector-specific gross domestic product (gdp), employment and real wage. The following sections present our motivation and specification of research questions for this paper.

1.1. The Norwegian oil adventure and the resource curse

The discovery of the Ekofisk oil field in 1969 was the beginning of a new era in Norway. The oil extraction in the 70s marked the start of a Norwegian oil adventure, which led Norway to be one of the wealthiest countries in the world today (Petroleum and Energy department, 2023). At that time, exploration of oil and gas, and development of extraction platforms on the Norwegian Continental Shelf (NCS) was dominated by foreign companies. The Norwegian Government (Stortinget) was determined to develop a Norwegian oil environment at that time. An important contributor for this was the establishment of Statoil in 1972, known as Equinor today (Ryggvik, 2023). The core goal of the establishment of Statoil was to ensure property rights of the Norwegian resources would never go out of the hands of the Norwegian people. In addition, to ensure that the revenue from the oil and gas would benefit the future generations of Norway, the Government Pension fund of Norway, also known as the Norwegian oil fund, was established in 1990. The fund was also intended to buffer the finances of the government. The fund is estimated to be worth more than 15 trillion NOK at market value today. Much has happened since the establishment of Statoil and the oil fund, but these two establishments are important factors to the wealthiness of Norway.

Natural resources, both renewable and non-renewable, are part of the real wealth of a nation. They are important contributors to a nation's fiscal revenue, income, poverty reduction and opportunity to grow (OECD, 2011). But if they are not managed sustainability, an opportunity to grow can simply turn into a curse. Such a curse is often referred to as the resource curse, or more known as Dutch disease in economic theory. According to the Natural Resource Governance Institute (NRGI), the resource curse refers to the failure of resource-rich countries to benefit fully from their natural resource wealth, and for governments in these countries to respond effectively to meet the public welfare needs (NRGI, 2015). There are several causes of the resource curse. One of them is a country being too dependent on natural resources, weakening the robustness of the country's economy to significant changes, such as the subsequent consequences of a crisis.

Recent events have tested the robustness of the Norwegian economy. The financial crisis in 2007/08, the oil price collapse in 2014/2015 and the covid pandemic in 2020. And through three modern times crises the Norwegian economy has continued to recover. An important contributing factor is the oil fund, which has created a form of security for the Norwegian government, households, and markets.

1.2. The importance of studying a resource-rich country

Natural resources can bring prosperity, comparative advantages, and growth in a resource-rich country through production and exclusive trade. However, prosperity and growth can quickly turn into a curse, as mentioned in the previous section. The empirical evidence about resource-rich countries is vast and divided. A study by Bjørnland et al (2019) on reconsideration of the Dutch disease (resource curse) by using the major oil producing country, Norway, suggests that growth effects of natural resources are likely to be positive. Furthermore, studies on other resource-rich countries presented by Alexeev & Conrad (2011) and Cavalcati et al (2011) suggest that natural resources have helped long-run economic performance. On the contrary, research on resource-rich countries written by Sachs & Warner (2001), Mehlum et al (2006) and Arzeki & van der Ploeg (2011) found a negative relationship between natural resources and economic growth. The divided empirical literature calls for some important aspects of studying a resource-rich country. The first one is about differentiating between resource dependency and resource abundance. Countries with high resource abundance are not necessarily dependent on natural resources. Countries such as Australia, New Zealand and Canada are examples of that. The second one is about the type of natural resources. Some have argued that resources such as oil are more subject to authoritarian regimes and rent seeking activities than different resources (e.g., agricultural land), and therefore the economic performance would not be the same. Norway, as a democratic oil nation, is a clear exception to this statement. And the third one concerns the institutions which might negatively affect the relationship between natural resources and economic growth, with poor natural resource management (Moshiri, 2016).

By studying Norway, as a resource rich country, we might be able to identify important aspects about how natural resources, such as oil, may affect the Norwegian economy. Furthermore, as the petroleum industry has been a significant contributor for the Norwegian economy, it will be interesting to investigate how the effects in the petroleum industry, caused by an oil price shock, would potentially spillover in other industries and sectors.

1.3. Research question and specification

The two preceding sections have been our main motivation and inspiration to investigate how oil price shock affects the Norwegian mainland economy and different sectors. And we identify the following research question; *''what is the impact of an oil price shock on the Norwegian mainland economy and different sectors of Norway?''*

The stated research question is without doubt a broad question that would require a vast amount of research on multiple levels of economic analysis. To make our paper specific and more interesting we choose to identify and address three sub-questions as the overall objective of this thesis. The three sub-questions are as follows:

1. How do the mainland economy and sector-specific activities react to oil price shocks?
2. To what extent do the reactions differ in terms of magnitude and persistence?
3. Does an asymmetric relationship between real oil price and Norwegian macroeconomic variables exist?

The remainder of this paper follows the following structure: In section 2, a thorough literature review on the research topic is presented. Section 3 consists of information regarding variable description, time period of analysis, and sectoral background. Section 4 specifies the methodology applied in this paper. Section 5 presents the final empirical results and an analysis of the results. Section 6 investigates the correlation between the real oil price and four alternative oil price measures. In section 7, an extension is presented, where the macroeconomic variables are tested for asymmetric relationship with the oil price. And section 8 presents the conclusion.

2.0. Literature review

In this section we will present existing literature on the topic of our thesis. There is a high number of related research, and the literature review given below is from the ones considered most relevant. We will present papers from the last 40 years discussing the effect of oil price shocks on economic activity.

2.1. Oil price shocks

There has been extensive research on the relationship between oil price shocks and economic activity for the last 40 years. Hamilton (1983) investigated the relationship between increases in oil prices and US recessions since World War II. He found some interesting statistically significant results on the relationship. Even though oil price shocks did not cause the recessions alone, it seems to have a contributing factor to all except one of the US recessions prior to 1972 (Hamilton, 1983).

Hamilton's paper got wide acceptance among several researchers who built their paper on Hamilton (1983) to test the results. Burbidge and Harrison (1984) studied Organizations for Economic Co-operation and Development (OECD) countries. They studied the US, Japan, Germany, the United Kingdom, and Canada to test effects of oil price rises in an unrestricted system of equations estimated for the five countries (Burbidge & Harrison, 1984). Gisser and Goodwin (1986) investigated popular notions to test crude oil on macroeconomic effects. They tested to see if there is any difference in the relationship of oil prices and the economic activity in the US after 1973. Gisser and Goodwin seemed to find a remarkably stable effect of oil prices in the post war. They found no difference after 1973 (Gisser & Goodwin, 1986).

Hamilton (1996) states that research presented since his article in 1983, has only strengthened his earlier conviction, even though many have expressed disagreement. He ensures that oil price shocks are still important contributions to recessions, even after 1973. An important point is that the Iraq invasion of Kuwait in 1990 led to an oil shock. This was a key factor of the later recession (Hamilton, 1996). Hooker (1996), published later that year, disagreed with Hamilton (1996). He stated that oil prices are no longer Granger-cause of many US macroeconomic variables in data after 1973. He tested several hypotheses for this, like oil prices are now endogenous, or a misspecification of the relationships that is caused by the linear VAR. None of these were supported by data, but Hooker emphasizes that when using oil prices as an instrumental or explanatory variable for macroeconomic indicators, care should be considered (Hooker, 1996).

Continuing from Hooker (1996), a more recent study from Barsky and Kilian (2004) also questions the relationship between oil prices and macroeconomic performance. A common belief was that political events in the Middle East were linked to changes in oil prices which then changed macroeconomic performance in the US. This is the same as what Hamilton (1996) claimed. Barsky and Kilian found that political events in the Middle East are one of several factors driving oil prices. What seems to be similar political events may differ greatly from one episode to another, which is in accordance with global macroeconomic conditions and variation in the demand conditions for the oil market. Also, the timing of oil price increases and recessions complies with the notion that oil price shocks may contribute to recessions without being central. They conclude that disturbances in the oil market matter less to the US macroeconomic performance than commonly thought (Barsky & Kilian, 2004).

Blanchard and Gali (2007) presented a study where they investigate changes in how oil price shocks affect the US economy. Most important results were that major oil price shocks must coincide with large shocks of different nature. Also, oil price shocks have changed over time giving a stable smaller effect on prices, wages, output and employment (Blanchard & Gali, 2007). A more recent article by Hamilton, Hamilton (2011), presents that the correlation between oil price shocks and the US economic recessions was too strong to be a coincidence. In his previous articles he agrees that the oil price shocks are not the main reason for a recession, but an important contributing factor (Hamilton, 2011).

The papers presented above are of the most cited within the research of oil price. They are mostly related to oil importing countries. Therefore, we find it important to include papers targeting oil exporting countries, as we are doing in our paper. The paper from Peersman and Robays (2012) investigated countries with a different role in both oil and energy in the economy. They found that the results crucially depend on the underlying source of the oil price shock, in line with Kilian (2009), which will be presented in the next section. When the oil price increase is caused by an increase in economic activity, almost every country experiences an increase in gdp. When there is an exogenous oil price shock, the net importing countries face a permanent fall in economic activity, while the net exporting countries face an insignificant or positive effect in economic activity. The paper by Bjørnland, Thorsrud and Torvik (2019) is another research focusing on an oil exporting country, here Norway. They showed that an increase in oil activity resulting in a resource boom also increases productivity significantly in other industries, including manufacturing.

2.2. The Kilian-index

Kilian (2009) developed an index of global real economic activity using dry cargo single voyage ocean freight rates, which is designed to capture shifts in demand for industrial commodities in global business markets (Kilian, 2009). After Kilian published his paper in 2009, this index has become a popular choice in later research, particularly in oil price studies (Ravazzolo & Vespignani, 2016, p. 3). The common approach until 2009 was to evaluate the response of macroeconomic aggregates to exogenous changes in the price of oil. This approach is not well defined because of two reasons. Firstly, the related changes in the real oil price of macroeconomic causes and effects, are no longer well defined with reverse causality from macroaggregates to oil prices, as shown in Barsky and Kilian (2002). Secondly, the price of oil is driven by distinct demand and supply shocks. Supply and demand shocks are having different effects on the real price of oil. Demand shocks also have a direct effect on the economy in addition to the indirect effect through the oil prices. Kilian (2009) made the Kilian-index to disentangling supply and demand shocks in the global crude oil market (Kilian, 2009).

The measure of global real economic activity from Kilian (2009) has been a popular choice among researchers since 2009. Apergis and Miller (2009) used the Kilian index to see how oil price changes affect stock-market returns in different countries (Apergis & Miller, 2009). Basher, Haug and Sadorsky (2012) used the index to investigate the relationship between oil prices on both stock markets and exchange rates (Basher, Haug, & Sadorsky, 2012). Bjørnland, Larsen and Maih (2018) used Killian (2009) when analyzing the role of price volatility in reducing US macroeconomic instability (Bjørnland, Larsen, & Maih, 2018).

Hamilton (2018) critiques Kilian (2009) and says his index of global real economic activity is misleading and suggests that there should be used alternative methods. Kilian (2019) is therefore a correction of Kilian (2009). Kilian claims that the problems documented by Hamilton were a consequence of a coding error. He found that the nominal freight rates which are underlying in the index were by accident logged twice, and by correcting this error none of the concerns remains valid. With the correction the index only differs slightly from the old index and will not have any impact on the empirical results (Kilian, 2019).

2.3. Global Economic Conditions Indicator

Baumeister, Korobilis and Lee (2020) introduced an alternative index to the Kilian-index from Kilian (2009). They saw that tremendous turbulence in the shipping index, which impacted the dry cargo single voyage ocean freight rates which Kilian used in his index, may not reflect changes in the world economy today. They checked alternative conditions to measure global economic activity and created a new index known as Global Economic Conditions Indicator, hereafter GECON. GECON consists of many components. The components are in a monthly frequency, and are the Kilian index, real shipping factor costs, world industrial production, real commodity price factor and global steel production factor. The Kilian index used as a component in the new GECON, is the index with the nominal shipping cost index calculated as in Hamilton (2019) (Baumeister, Korobilis, & Lee, 2020). This index has become more popular among researchers today. Bjørnland and Skretting (2022) uses GECON as a measure of global demand when studying if the effect of oil price shocks on the US economy has changed with the shale oil boom (Bjørnland & Skretting, 2022).

3.0. Data description

The following section presents a detailed description of macroeconomic variables, domestic variables, time period of analysis and sectoral background.

3.1. Variable description

There are six different variables in the analysis that are measures of the following: global crude oil production ***gcop***, global economic conditions indicator ***gecon***, real oil prices ***rop***, gross domestic product ***gdp***, employment ***empl*** and real wage ***rw***. The variables can be divided into two different blocks, a global block and a domestic block. In the global block we find the variables global crude oil production, global economic condition indicator and real oil prices. In the domestic block we find variables such as gdp, employment and real wage. We also divide between mainland and sector-specific variables, i.e., mainland GDP and sector-specific gdp.

Global crude oil production ***gcop*** is collected from YCharts and is measured in the number of barrels that are produced each day in the world (YCharts, 2023). The ***gecon*** indicator is a fairly recent index of economic conditions introduced by Baumeister, Lee and Korobilis in 2020, as mentioned above in section **2.3**. The indicator gives new measures for assessing future tightness of energy demand and expected oil price pressures (Baumeister, Korobilis, & Lee, 2020). The Kilian index, explained in section **2.2.**, was commonly used as the global real economic activity index, and is still used today. As the ***gecon*** indicator is an extension of the original Kilian index, it may be more relevant to use today. Therefore, the ***gecon*** indicator is the one we are using in this paper. The last variable in the global block is the real oil price, ***rop***. This is given by the Europe Brent spot price (U.S. Energy Information Administration, 2023), dollars per barrel, and is adjusted with the consumer price index for All Urban Consumers in the U.S. (St. Louis FED, 2023) to get the oil price in real values[1].

Gross domestic product, ***gdp***, is downloaded from Statistics Norway. Mainland (Statistics Norway, 2023a) and sector-specific GDP (Statistics Norway, 2023b) is adjusted for the consumer price index in Norway (Statistics Norway, 2023c). Employment ***empl*** (Statistics Norway, 2023d) and wage (Statistics Norway, 2023e) are downloaded from Statistics

[1] Plots of global data sets are presented in Appendix **A.3**

Norway. Both are given by seasonally adjusted numbers and the wage we adjust for CPI Norway (Statistics Norway, 2023c) to get the real wage ***rw***.

Furthermore, all the variables except ***gecon*** are transformed into their natural logarithms to avoid extreme values of the time series. In addition, all variables, except ***gecon*** and ***rop***, are detrended such that only the fluctuations of the variables are included. This is necessary as we are interested in how an oil price shock affects the macroeconomic variables related to the mainland economy and the different sectors.

3.2. Time period of analysis

The time period of our analysis is from the first quarter of 1995 to the last quarter of 2022, which yields 112 observations. The data is analyzed on a quarterly basis, which allows us to use the gdp measure. Most of the data is collected on a quarterly basis. The monthly data was transformed to a quarterly basis. This was applied to ***gcop***, ***gecon*** and ***rop***.

3.3. Sectoral background

In this paper, both data on aggregated and sectoral level are investigated. On the aggregate level we have the Norwegian *Mainland Economy*, here shortened to **ME**. On the sectoral level we have **1)** *Extraction of Oil and Gas including Services* (**EOGS**), **2)** *Fishing, Catching and Aquaculture* (**FCA**), **3)** *Building and Construction* (**BC**), **4)** *Maintenance and Installation of Machines and Equipments* (**MIME**) and **5)** *Shipyard (**SY**)*. *The Manufacturing* sector on an aggregate level was included in the initial stage of this papers' analysis, but due to inconclusive results with the SVAR model it was excluded. Furthermore, the **MIME** sector and the **SY** sector are both subgroups of the *Manufacturing* industry and were added as a replacement of the aggregate *Manufacturing* industry. The data is collected from Statistic Norway, and we will analyze mainland and sector-specific gross domestic product **(*gdp*)**, employment (***empl***) and real wage (***rw***).

Extraction of Oil and Gas including Services is the sector that has the closest link to the supply side of the petroleum industry that is part of this paper. (Statistics Norway, 2023f). The supply side of any petroleum industry is quite firm as substantial changes often lead to substantially high costs. The petroleum industry is a huge benefactor to technological progress in Norway (Norwegian Petroleum, 2022). In addition, the last five to eight years have been eventful for the petroleum industry, especially because of the oil price collapse in 2014/15. After the oil price collapse many workers in the petroleum industry lost their job, and according to a report from DNB markets at the end of 2016, 40 000 petroleum-dependent jobs had disappeared from the Norwegian oil industry from January the 1st of 2015 (Sagmoen, 2023). The likelihood of some of these petroleum-dependent jobs to be in the sector of interest in this paragraph is quite high. By investigating this sector, we will be able to see how the sector reacts to an oil price shock and find out whether the changes are substantial. We expect a positive reaction to the oil price shock for employment and the real wage of this sector.

Fishing, Catching and Aquaculture is another sector with a long tradition in Norway. With a long coastline, fishing and aquaculture naturally becomes an important source. In addition, the seafood industry, alongside the petroleum and energy industry, is considered one of the biggest industries in Norway. Recent data shows a new export record of seafood in Norway in 2022, to a total of 150 billion NOK. This is still below 1/5 of the total petroleum export, but export of seafood is one of the greatest export goods of Norway (Amundsen & Grønningen, 2023). Mowi ASA and SalMar ASA are two of the largest companies in the seafood industry, not only in Norway but also in the world (Aksje Norge, 2023). Both companies export seafood with a primary interest in fish farming. Furthermore, this sector is an important factor for the high level of progression in technology, much like the petroleum industry, and sustainability in Norway. By investigating this sector, we will be able to see how a sector with a close link to one of the biggest industries in Norway reacts to an oil price shock. We find it difficult to predict how this sector would react to an oil price shock, as there are arguments for both positive and negative reactions expectancy. This makes it even more interesting to include this sector in our analysis.

Building and Construction is a sector with a high labor force. An analysis on this sector shows at the end of 2022 and first quarter 2023 that the building and construction sector is one of the sectors with a high increase in unemployment. Increasing interest rates in the last half a year because of the high inflation makes investing in new construction projects less attractive. It is assumed that unemployment will increase further (Aga, 2023). The first thing that comes to mind when talking about this sector is construction and maintenance of houses and commercial buildings, but that is not all. This sector has a close linkage to building and construction of important infrastructure such as developments of roadways, airports and train lines and facilities related to petroleum and energy industries (Byggenærings Landsforening, n.d.). The petroleum industry being one of the biggest industries in Norway, one can only imagine how much building and constructions are needed for oil-platforms, infrastructure for transport of oil, and more. Although this sector obviously is wide and important for several industries across Norway, we find it to be also somewhat important for the petroleum industry. We assume that a higher oil price will have a positive effect on sector-specific variables.

Maintenance and Installation of Machines and Equipment is a subgroup sector within the *Manufacturing* industry. This sector is not the biggest subgroup sector in terms of the number of employees. We find this sector interesting as it is indirectly important to the petroleum industry. That is because the petroleum industry is highly dependent on usage of advanced machinery and equipment, and therefore installation and maintenance. We also find it logical to assume that new investments in the case of repair and installations is something a company does more of, in periods with stable economic and financial conditions. High oil prices often lead to better economic conditions in Norway, because of Norway being an oil exporting country. By studying this sector, we will be able to assess how a small sector with an indirect link to the petroleum industry reacts to an oil price shock. We expect a positive reaction across all sector-specific variables to an oil price shock.

*The Shipyard (**SY**)* is another subgroup sector within the *Manufacturing* industry. This sector has a lot of history and tradition in Norway that stretches all the way back to the Viking Age. Today the Shipyard sector is well established in the west-coast of Norway (Rabbevåg, 2022). The Shipyard sector is a fundamental sector for many industries. One of such industries is the petroleum industry, as ships are essential for transportation of oil, gas, services and workforce back-and-forth of the oil platforms and mainland. By investigating this sector, we will be able to illustrate how a fundamental sector with an indirect link to the petroleum industry reacts to an oil price shock. We expect a positive reaction of sector-specific variables to an oil price shock[2][3].

2 The descriptive statistics of all the variables are reported in Appendix **A.2**
3 Definitions and explanation of statistics used, are given in Appendix **A.1**

4.0. Methodology

This section provides the theoretical framework of this paper. The theoretical framework is mainly based on Bjørnland and Thorsrud (2015).

4.1. Vector Autoregressive (VAR) model

Vector Autoregressive models, often shortened to VAR models, is an economic tool which is widely used in macroeconomics analysis. The VAR model extends the univariate AR models to a vector of many variables (Bjørnland, 2015, s.190). We follow Bjørnland and Thorsrud (2015) for the following notation:

We have a *(K x 1)* vector of random variables.

$$z_t = (z_{1,t}, z_{2,t}, \ldots, z_{K,t})' \quad \textbf{\textit{(1)}}$$

Then, a VAR model of order p can be written as:

$$z_t = \mu + A_1 z_{t-1} + A_2 z_{t-2} + \ldots + A_p z_{t-p} + e_t \quad \textbf{\textit{(2)}}$$

The VAR*(p)* stated in equation *(2)* is called reduced form representation. z_t is a *(5 x 1)* vector, which includes the variables:

$$z_t = (gcop_t, gecon_t, rop_t, gdp_t, empl_t, rw_t) \quad \textbf{\textit{(3)}}$$

μ denotes a *(5 x 1)* vector of intercept terms and e_t is a *(5 x 1)* vector of error terms, which is assumed is white noise with the following properties:

$$e_t \sim i.i.d.\ N(0, \Sigma_e)$$

where Σ_e is the covariance matrix.

4.2. Structural Vector Autoregressive (SVAR) model

The structural vector autoregressive (SVAR) model was introduced by Sims (1980) in the 1980's. It was introduced as an alternative to large-scale macroeconomic models used in academic and policy work at the time. The model is widely used today as a tool to study causal relations in macroeconomics (Bjørnland, 2015, p.213). In order to estimate and analyze the effect of an oil price shock on the different sectors, a SVAR model based on the basis of the previous section will be used for each sector.

Any VAR*(p)* can be reformulated into a VAR (1) process by expressing the VAR in the companion form. By doing so, we can reformulate the VAR (1) process into an infinite moving average process (MA(∞)) using the method of recursive substitution or lags operators

(Bjørnland, 2015, p.194). We express the reduced form MA (∞) representation of the VAR as following:

$$z_t = v + \sum_{i=0}^{\infty} C_j e_{t-j} \tag{4}$$

Before expressing the model in MA (∞) representation, we need to make sure that the VAR*(p)* is stable, and thus invertible. The model is stable if the eigenvalues of the companion form matrix are less than one in absolute value. Granted that the conditions of stability are met, the VAR model is then covariance-stationary, and the effect of the shock in a variable in the system will eventually die out.

A shock in one variable is most likely accompanied by a shock in another variable. This can cause misleading results when doing structural analysis. To perform a structural analysis and assess the causal effects of the shock, we need to make the residuals uncorrelated, i.e., orthogonal. Hence, our analysis will be carried out with the MA (∞) representation, where the residuals are orthogonal. The most common approach to achieve uncorrelated residuals is through Cholesky decomposition. The Cholesky decomposition is a popular identification scheme to obtain orthogonal shocks and a short-run contemporaneous restriction. We can apply it to equation *(4)*, with the assumption that $\Sigma_e = PP'$, where P is the Cholesky decomposition of Σ_e. In addition, P is a lower triangular matrix with positive values on the diagonal, while P' is its conjugate transpose. (Bjørnland, 2015, p.215). With a stable VAR and Cholesky decomposition being sufficiently in accordance with economic theory, we can finally perform an analysis and assess the causal effects of the shock.

4.3. Model specification

This section will give an overview of lag length selection, stationarity of the time series, and the stability of the model.

The appropriate length of lags for the model can be determined by several types of statistical information criterions or by economic reasoning. We have applied the use of Akaike (AIC) and Bayes (BIC) information criterions[4]. The results from the BIC related to both employment and real wage (for the different sectors), and real oil prices suggest a short

[4] Details and results regarding the information criterions is described in Appendix **D**

number of lags, spanning from 1 to 3. This is also the case for all sector-specific gdp except one. However, the results related to global crude oil production, GECON and mainland GDP suggest a larger number of lags, stretching from 4 to 6. The results from AIC suggest a higher number of lags for all the variables than the BIC. This is in accordance with economic theory, as the BIC gives a harder penalty on the size of the model, and therefore often suggests fewer lags. As we are most interested in the effect of oil price shock on the Norwegian economy on a sector level, we find it most appropriate to choose the suggested lag length from the BIC related to real oil price. In addition, most of the variables related to the mainland economy and the multiple sectors suggest a low number of lags. We therefore choose to work with 1 lag as the lag-length.

Stationarity is an important concept in time series analysis. It is useful to determine whether the time series properties are stationary, or if it contains a unit root. The Augmented Dickey-Fuller (ADF) test is used to evaluate the stationarity of a time series property[5]. The results are provided in Appendix **B.2**. If the null hypothesis is rejected, the series does not contain a unit root, and thus stationary. The results show all the variables, except ***gcop*** and ***gecon***, follow a unit root process at one, five and ten percent significance level with log levels, constant and a trend. That is also the case for with detrended variables with a constant. Stationarity is something that is desirable in econometrics and economic analysis. Therefore, it is used to determine whether one needs to transform non-stationary variables into stationary variables, to then get correct estimates in regressions. However, in VAR models this could lead to loss of information and in some cases misspecification of the model, especially if a cointegrating relationship exists between the variables. According to Sim, Stock and Watson (1990), transforming variables to stationary form by imposing cointegration restrictions is unnecessary when there is most likely a cointegrating relationship in the data.

Stability of the VAR model is a necessary economic condition. For the VAR model to be stable, or covariance stationary, the effects of shocks must eventually die out. That is the case if all the eigenvalues of the companion matrix are less than one in absolute value[6]. Plots of the eigenvalues of the companion matrix are presented in Appendix **C.2**. The plots show that

[5] The theory behind stationary and nonstationary processes are provided in Appendix **B**
[6] The theory behind stability of the VAR model is explained in Appendix **C**

the eigenvalues are less than one in absolute value, for all sectors, which implies that the stability requirement for the VAR is fulfilled.

4.4. Cholesky decomposition

All the variables are transformed in line with section **3.1.** The SVAR does not include the constant term. The ordering system of economic arguments is a crucial feature in the identification scheme. The system has a recursive structure which implies that the variable in the first system will not react contemporaneously to any shocks in the remaining variables. The variable in the second system will not react contemporaneously to any shocks but the first. And the variable in the third system will only react contemporaneously to the first and second shock, and so forth. Ordering the variables as

$$z_t = [gcop_t, geocn_t, rop_t, gdp_{t,} empl_t, rw_t]'$$

, implies the following restriction, which summarizes the contemporaneous effects of the shocks:

$$\begin{bmatrix} gcop_t \\ gecon_t \\ rop_t \\ gdp_t \\ empl_t \\ rw_t \end{bmatrix} = \begin{bmatrix} C_{11} & 0 & 0 & 0 & 0 & 0 \\ C_{21} & C_{22} & 0 & 0 & 0 & 0 \\ C_{31} & C_{32} & C_{32} & 0 & 0 & 0 \\ C_{41} & C_{42} & C_{43} & C_{44} & 0 & 0 \\ C_{51} & C_{52} & C_{53} & C_{54} & C_{55} & 0 \\ C_{61} & C_{62} & C_{63} & C_{64} & C_{65} & C_{66} \end{bmatrix} \times \begin{bmatrix} \varepsilon^{oil\ supply} \\ \varepsilon^{aggregate\ demand} \\ \varepsilon_t^{oil-specific\ demand} \\ \varepsilon_t^{gdp} \\ \varepsilon_t^{empl} \\ \varepsilon_t^{rw} \end{bmatrix} + \sum_{i=1}^{1} C_i \varepsilon_{t-i} \qquad (5)$$

The ordering is partially inspired by Kilian (2009) and the motivation of the ordering is as follows:

The global variables:

1. First, we assume that crude oil supply cannot respond to innovations to the global demand or other oil specific price movements within the same quarter. That assumption is plausible because, in practice, the cost of adjusting oil production, and the uncertainty about the state of the crude oil market, causes oil-producing countries to respond slowly to demand shocks.

2. Secondly, innovations to the global activity that are not captured by the oil supply shock will be explained by the global activity (aggregate demand) shock. The restriction imposes a restriction that increases in the real oil price driven by shocks

that are specific to the oil market, will not lower real global economic conditions contemporaneously, but with a delay of at least a quarter.

3. Thirdly, fluctuations in the real oil price that is not due to aggregate demand for industrial commodities is then because of shocks to the oil market. Real oil prices are allowed to react contemporaneously to global aggregate demand shocks. And finally, the domestic activity of a small and open economy like Norway, does not affect global activity. This validates placing the global variables at the top of the ordering system.

Domestic variables

4. The domestic variables, GDP, employment and real wage, are placed at the bottom of the ordering system as Norway is a small and open economy that takes oil prices as given.

5. The ordering of the domestic variables itself may be arbitrary whatsoever since it will mostly give the same impulse responses. The argument that places GDP above employment and real wage is the fact that production level reacts more sluggishly to employment and real wage due to irreversible investments and signed contracts. However, that is worth little to nothing as there are other valid arguments for placing employment and real wage over GDP. A such argument is that the labor unions in Norway are substantially powerful. This would make instant and large fluctuations in employment and real wages a rare phenomenon. We choose to proceed with the initial argument, placing GDP over employment and real wage.

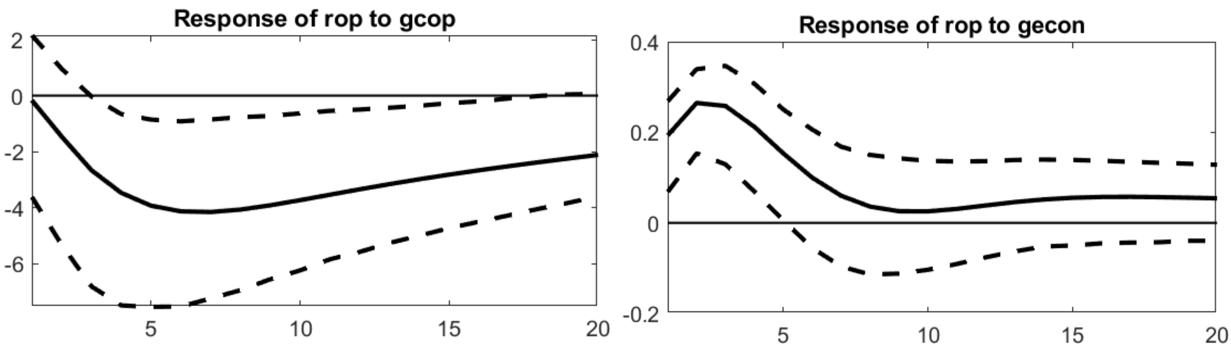
6. The real wage is placed such that it is allowed to respond immediately to all variables.

5.0. Empirical results

The following section presents discussion of the empirical results of this paper. All the global shocks are identified as explained in section **4.4**. The section is split into six subsections, each subsection with results and discussion of the mainland economy and each sector. All impulse response functions (IRFs) are presented in Appendix **E**[7].

Before presenting sector-specific impulse responses on the domestic variables, it might be useful to elaborate on how the real oil prices react to oil supply shock and aggregate demand shock. The following figure illustrates the response of the real oil prices to the oil supply shock (left) and the aggregate demand shock (right).

Figure 1: Response of real oil price to oil supply shock and aggregate demand shock



A standard one shock to oil supply decreases real oil price on impact, and continues to decrease until the sixth quarter, before slowly returning to its steady level. An aggregate demand shock increases real oil prices by 20 percent on impact. It continues to move upwards until the fourth quarter to the peak point at 29.8 percent, before it starts to revert to its initial level. We see a clear difference in pattern of how the real oil price responds to the two different shocks. Similar patterns are likely to be shown in sectors that are dependent on the real oil price. The oil-specific demand shock is likely to have a somewhat similar pattern to the aggregate demand shock. In addition, if we look at the variance decomposition for mainland economy, provided in Appendix **F.1**, we see that the variance of real oil price is more explained by the aggregate demand shock than the oil supply shock. The aggregate demand shock explains 13.77 percent of the variance, while the oil supply shock only explains .98 percent of the variance in the first quarter. In addition, the responses of the variables to an oil supply shock are either insignificant or extremely small in magnitude.

[7] The IRFs are displayed with two striped lines representing two-standard error bands that are equivalent to 95 percent confidence intervals. Formally we can refer to the IRFs as Responses to Cholesky One S.D +/- 2 S.E

As we are most interested in how the real oil prices affect the Norwegian economy, we find the results from the aggregate demand shocks and the oil-specific demand shock to be most relevant to focus on the following sections below.

5.1. Mainland Economy

The responses for all variables in the model for mainland economy are provided in Appendix **E.1**. The figure below displays the responses of mainland gross domestic product (1st column), employment (2nd column) and real wage (3rd column) of the mainland economy to an aggregate demand shock (1st row) and an oil-specific demand shock (2nd row).

Figure 2: Responses of macroeconomic variables in Mainland Economy

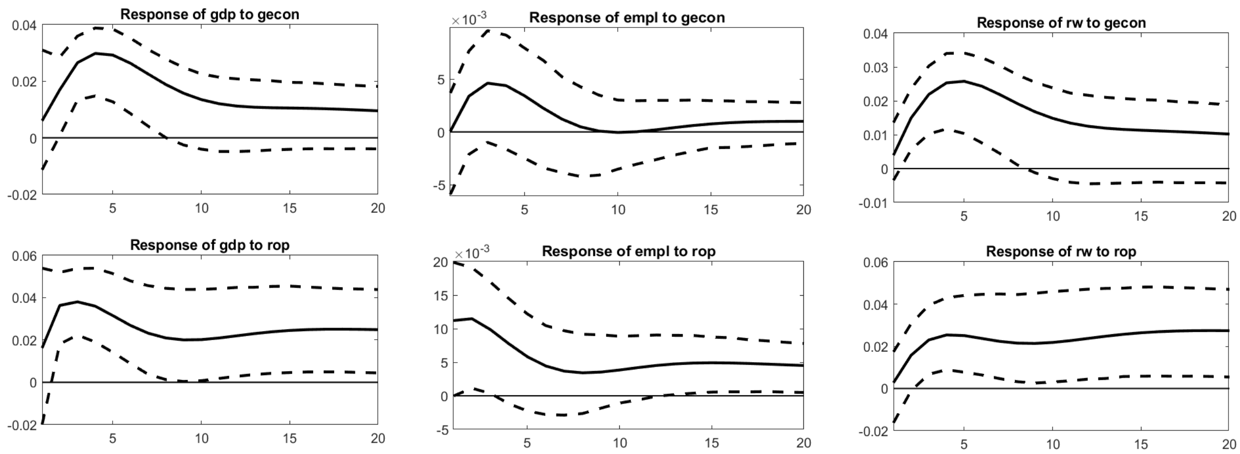


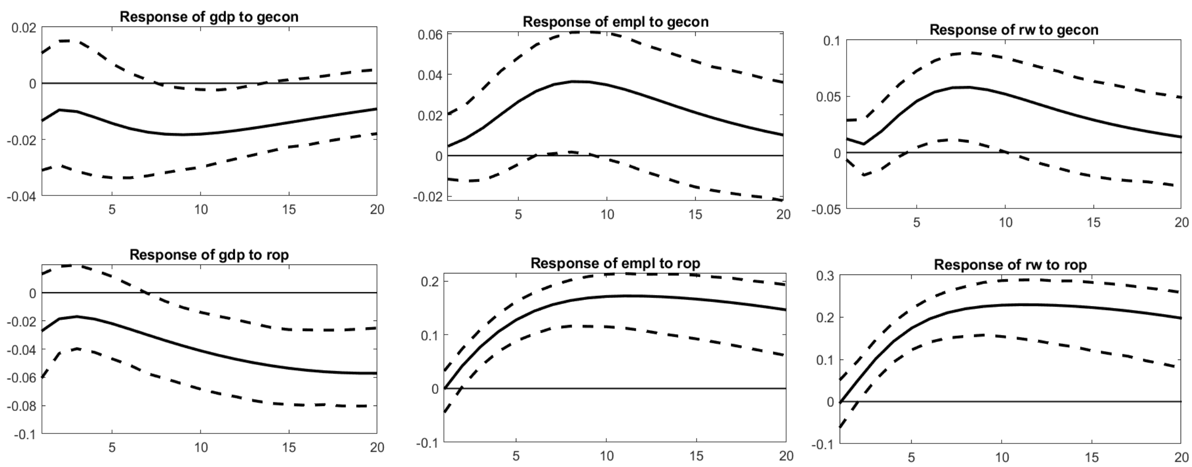
Figure 2 show similarity in implication on the domestic economy in terms of persistence and magnitude. The responses of mainland GDP and real wage hold similar magnitude to both shocks, while the responses of employment to both shocks are significantly small and close to zero. The aggregate demand shock leashes a small reaction to mainland GDP of .6 percent on impact and continues to peak at 2.9 percent before reverting to its initial state. To the oil-specific demand shock the reaction of GDP is 1.6 percent on impact, which is the largest contemporaneous increase. The GDP continues to move upwards to peak point 3.8 percent after three quarters, before the response begins its path to its initial state. The response of real wages is somewhat like the response of GDP.

The findings of IRFs signal towards an oil-dependent mainland economy, however only to a small degree. The response to the shock in the oil price is bigger than the shock in aggregate demand, although the difference is small. The fact that all three domestic variables are positively stimulated is consistent with economic theory. The variance decomposition for the mainland economy is provided in Appendix **F.1**. It shows that both shocks have negligible effects on employment. For mainland GDP, aggregate demand shock and oil-specific demand shock accounts for the biggest portion of the variance in GDP in the first, second and third quarters. After a year, we observe that aggregate demand shock explains the biggest variance in GDP. In the fourth and eighth quarters it explains 11.02 percent and 17 percent of the variance, while oil-specific demand shock only explains 5.74 percent and 6.36 percent of the variance, for the respective quarters.

5.2. Extraction of Oil and Gas incl. Services

The sector of Extraction of Oil and Gas including Services, hereafter EOGS, is the closest link to the petroleum industry, both in terms of production and employment. The responses for all variables in the model for EOGS sector are provided in Appendix **E.2**. The figure below displays the responses of sector-specific gross domestic product (1st column), employment (2nd column) and real wage (3rd column) of the EOGS sector to an aggregate demand shock (1st row) and an oil-specific demand shock (2nd row).

Figure 3:Responses of sector-specific activities in EOGS sector



An aggregate demand shock and an oil-specific demand shock increases the employment and real wage, while both shocks give small negative reactions to sector-specific gdp in the EOGS sector. We observe that the magnitude and the persistence of the responses seem somewhat different, between the two shocks. Both responses to the two shocks to sector-specific gdp are quite small in magnitude, but evidently the response to oil-specific demand shocks is more persistent. An aggregate demand shock leashes a modest reaction to employment on impact of .4 percent. The reaction continues to a peak of 3.6 percent before it begins its path back to its initial level. An aggregate demand shock increases real wage by 1.2

percent on impact and continues to increase it to its peak point of 5.7 percent, before reverting to its initial state. The response of employment and real wage to an oil-specific demand shock is quite interesting. The impact response of both variables is extremely modest, in fact almost equal to zero, while it continues to move upwards for almost three years (11 quarters). The response of employment and real wage peak at 17.56 percent and 23.42 percent, respectively. Both responses of the variables are quite persistent and move slowly to their initial state. The responses show that both employment and real wage of the EOGS sector respond late to an oil-specific demand shock. It also shows that the effect of an oil-specific demand shock lasts a long time on the two variables for the EOGS sector. The preceding findings, related to oil-specific demand shock, are not extremely surprising as the EOGS sector has a close link to the petroleum industry, and thus an influential relationship with the real oil price.

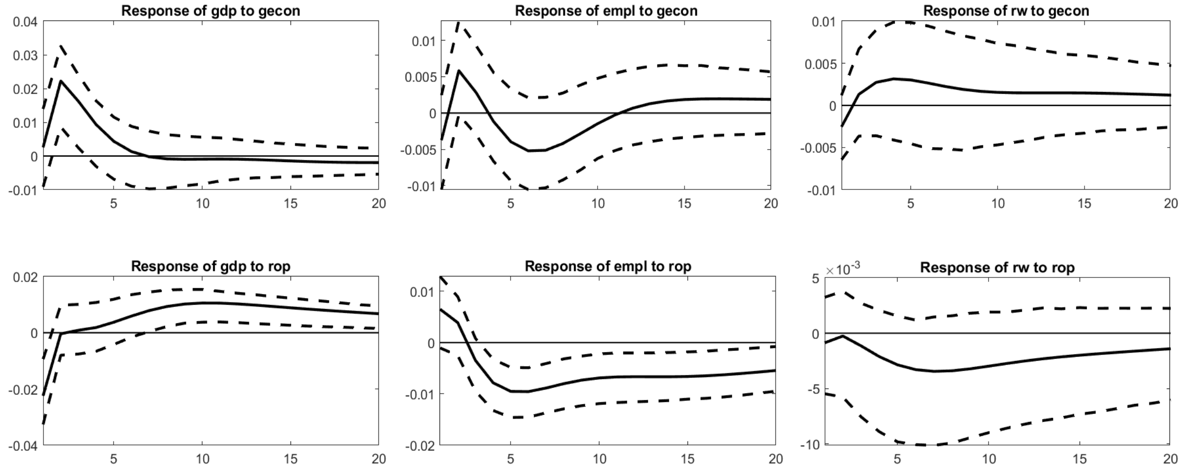
The general findings suggest that an oil-specific demand shock has a larger influence on this sector and is more important than the aggregate demand shock. We find especially that the response to an oil-specific demand shock of employment and real wage is large. We also find that both shocks have negative effects on sector-specific gdp. The negative responses may be because production in the petroleum industry is quite independent of the real oil price in general. That is because to shift supply towards demand is quite costly and therefore undesirable. Another reason may be that the sample used in his thesis, might be heavily affected by the recent Ukraine-Russia war, where both energy prices have heavily fluctuated, because of impaired energy supply.

The variance decomposition is reported in Appendix **F.2**. The results for all three variables show clearly that it is oil-specific demand shock that explains the variation the most over time. While the results for the three variables are not extremely different at the beginning, the difference becomes larger and larger over the horizon. Aggregate demand shock explains 1.49 percent, 3.75 percent, and 6.94 percent of the variance in sector-specific gdp for first, second and fourth year, respectively. For the same periods, an oil-specific demand shock explains a larger amount of variance of .99 percent, 2.27 percent, and 8.65 percent, respectively. For employment and real wages, the oil-specific demand shock is clearly the most important shock to explain variation over time. It explains around 40.50 percent of all variation in employment and approximately 40.20 percent of all variation in the real wages after four years.

5.3. Fishing, Catching and Aquaculture

The responses of variables in the model for *Fishing, Catching and Aquaculture,* hereafter FCA, sector is provided in Appendix **E.3**. The figures below display the responses of the three sector-specific variables: gross domestic product (1st column), employment (2nd column) and real wage (3rd column) of the FCA sector to an aggregate demand shock (1st row) and an oil-specific demand shock (2nd row).

Figure 4: Responses of sector-specific activities in FCA sector



The magnitude and persistence of the responses of sector-specific gdp to the two shocks are quite different at origin of the shocks. The response of sector-specific gdp to aggregate demand shock is a modest but positive reaction of .2 percent, while the response to oil-specific demand shock is of -2.2 percent in the origin of the shocks. The response of sector-specific gdp to aggregate demand shock continues to increase 2.2 percent after two quarters, before almost immediately reverting to zero and continuing to hover around zero. The response of sector-specific gdp to oil-specific demand shock increases to positive values of 1.05 percent before slowly reverting to zero.

The magnitude of response of gdp to oil-specific demand shock is quite small in comparison to the response to aggregate demand shock. However, the strength in persistence is clearly stronger for the response of gdp to oil-specific demand shock. The reaction in employment to a shock in aggregate demand is negligible. However, the reaction in employment to a shock in oil-specific demand shock is significant and quite interesting. Its initial response to an oil-specific demand shock is of .65 percent, which is modest and positive. The response continues to decrease into negative values until it reaches its minimum value at -0.9 percent, before gradually reverting to its initial level. The responses of real wage to both shocks are insignificant.

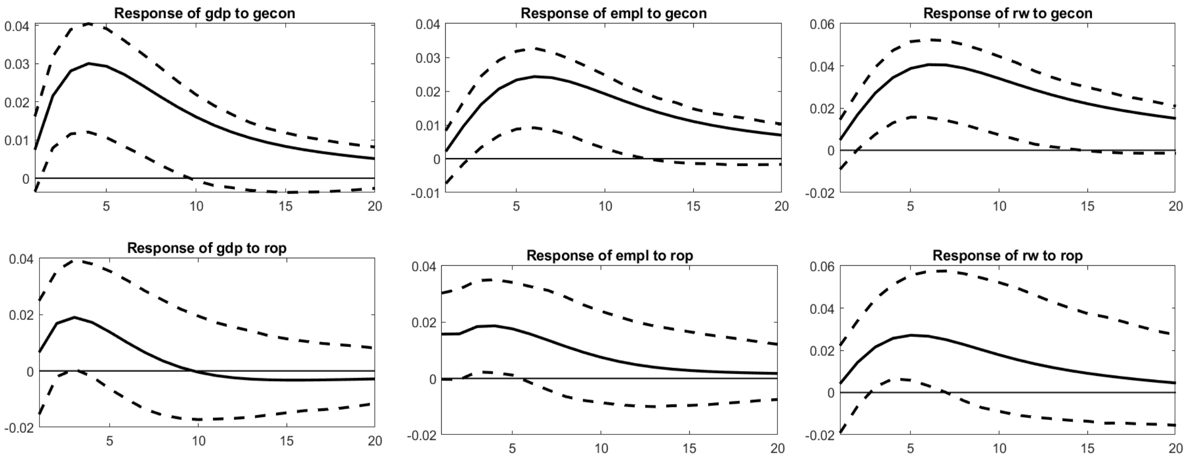
The general findings of the IRFs suggest that the FCA sector is not dependent on aggregate demand shock. The shock revealed a somewhat modest reaction to sector-specific gdp, and the reaction for employment and real wage are negligible. The findings suggest a somewhat different relationship with the oil-specific demand shock. While the shock revealed a much more modest reaction to gdp as for an aggregate demand shock, it also revealed an interesting response in employment. Oil-specific demand shock leashes a small positive reaction on impact and quickly travels to negative values before continuing its path to its initial level. This might suggest that the FCA sector is negatively influenced by the oil-specific demand shock. However, keeping in mind that the response is quite small, one can also argue that the oil-specific demand shock does not have much influence over this sector. If we consider the latter argument to be the case, both shocks suggest a small or no influence over the FCA sector, meaning that there are little to no spillovers from the petroleum industry and global demand in this sector.

The variance decomposition of this sector is reported in Appendix **F.3**. The results show that both shocks explain little of the variance in sector-specific gdp for the initial quarters, while oil-specific demand shock explains more as time goes by. Aggregate demand shock explains 5.75 percent, 4.89 percent, and 4.37 percent of the variance of gdp for the first, second and fourth year, respectively. Oil-specific demand explains 3.42 percent, 3.95 percent, and 7.28 percent, for the same periods. The results show that the two shocks explain about the same amount of variance in employment within the first year, while oil-specific demand shock explains increasingly over the horizon of the time. The aggregate demand shock explains 1.3 percent after the first year and 2.3 percent after the second year. The oil-specific demand shock explains 2.96 percent after the first year and around 7 percent after the second year. This shows that it is the oil-specific demand shocks that explain the variance in employment the most over time. For real wages, both shocks explain a significantly small part of the variance.

5.4. Building and Construction

The responses of variables in the model for *Building and Construction,* hereafter BC, sector is provided in Appendix **E.4**. The figures below display the responses of the three sector-specific variables: gross domestic product (1st column), employment (2nd column) and real wage (3rd column) of the BC sector to an aggregate demand shock (1st row) and an oil-specific demand shock (2nd row).

Figure 5: Responses of sector-specific activities in BC sector



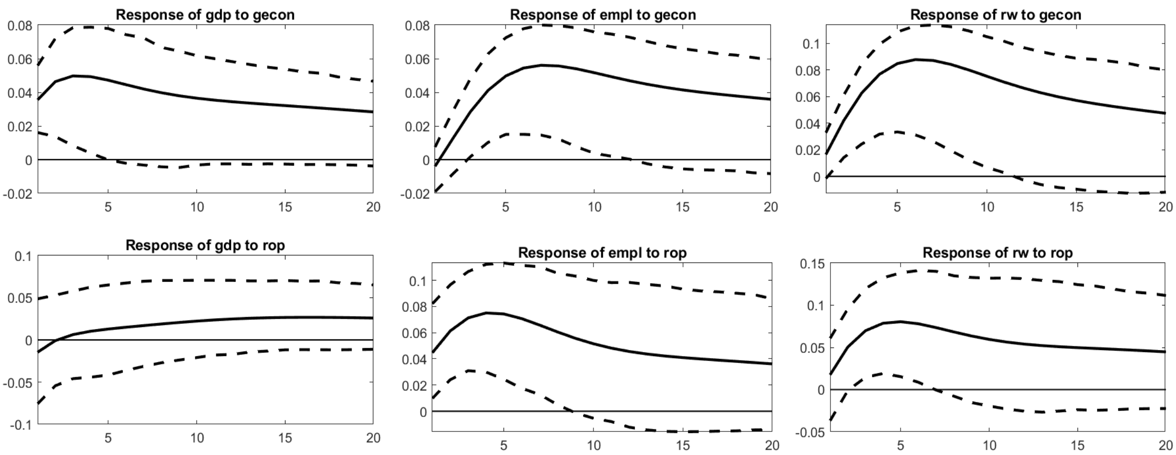
All the three domestic variables are positively affected by the two shocks, and the changes are statistically significant. While the reactions to an aggregate demand shock are hump-shaped, the reaction to an oil-specific demand shock is evidently flatter. The response of sector-specific gdp to an aggregate demand shock is .7 percent on impact. The response continues to increase and reaches its maximum point of 3 percent after a year, before reverting slowly to its initial state. The response of employment and real wage to an aggregate demand shock has almost an identical strength in persistence and somewhat similar magnitude. While on impact the response of employment is .2 percent, the response of real wage is .4 percent. Both responses peak after one and a half years at around 2.4 percent and approximately 4.1 percent, for employment and real wage, respectively. The response of gdp to an oil-specific demand shock is around .6 percent on impact before it increases and reaches its peak after only three quarters. Its peak point is 1.9 percent, and when it is reached, the response falls to its initial state, after one and a half years. The reaction of employment to an oil-specific demand shock is of approximately 1.7 on impact and reaches its peak point of 1.9 percent before a year. The reaction reverts gradually and reaches its initial state after three years. The response of real wage on impact is .4 percent and after that continues to increase to similar peak in magnitude and reverts to its initial state in a slightly stronger persistence.

The findings of the IRFs indicate a large positive relationship between global demand and the BC sector. In addition, a modest and positive relationship between the petroleum industry and the BC sector is identified. The variance decomposition of this sector is provided in Appendix **F.4**. Aggregate demand shock is the most important shock to explain variation in all three domestic variables. To highlight, it explains 1.38 percent, 7.44 percent, 13.47 percent, and 18.22 percent of the variation in sector-specific gdp for the first four quarters, respectively. In comparison, oil-specific demand shock only explains .21 percent, .93 percent, 1.41 percent, and 1.61 percent of the variation in gdp for the same four quarters. After a year, an aggregate demand shock explains 11.83 percent of variation in employment and 15.24 percent of variation in real wage. While oil-specific demand shock only explains 4.24 percent of variation in employment and 1.82 percent of variation in real wage after a year.

5.5. Maintenance and Installation of Machines and Equipments

The responses of variables in the model for *Maintenance and Installation of Machines and Equipments*, hereafter MIME, sector is provided in Appendix **E.5**. The figures below display the responses of sector specific gross domestic product (1st column), employment (2nd column) and real wage (3rd column) of the MIME sector to an aggregate demand shock (1st row) and an oil-specific demand shock (2nd row).

Figure 6: Responses of sector-specific activities in MIME sector



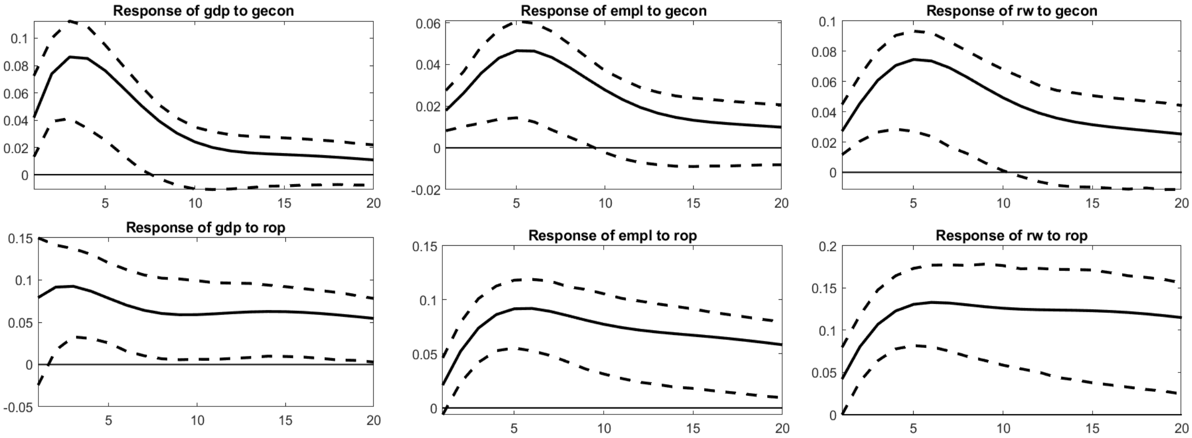
An aggregate demand shock and an oil-specific demand shock increases employment and real wage, while showing insignificant or modest reactions of sector-specific gdp in the MIME sector. The effect from an aggregate demand shock to sector-specific gdp is insignificant, while the effect from an oil-specific demand shock is quite modest. On impact, an oil-specific demand shock leashes a reaction of -1.4 percent to gdp. It immediately increases to zero after one period and stays in positive value without any clear maximum points, before gradually reverting back to its initial state. The responses of employment and real wage, for both shocks, are hump-shaped and show a noticeable similarity in persistence. While the response to the shocks on impact are modest, there are some differences in magnitude. The effects of employment to an aggregate demand shock are close to zero at the origin of the shock and continue to increase to its peak point at 5.6 percent after seven quarters. The effect of real wage to the same shock is 1.6 percent on impact and continues to its peak point at 8.7 percent after one and a half years. Both the responses of employment and real wage revert to their initial state gradually after reaching their peak. The response of employment and oil-specific demand shock is 4.4 percent on impact. The response continues to increase to its maximum point at 7.5 percent before reverting gradually back to zero. The reaction of real wage to the same shock is 1.7 percent on impact, and around 8 percent at its peak after five quarters. The reaction follows its path to its steady state gradually. The responses of employment and real wage to the oil-specific demand shock are larger in magnitude on impact, compared to the responses of aggregate demand shock on impact. However, apart from the impact, the responses to an aggregate demand shock are clearly larger.

The findings of IRFs indicate a positive relationship between the petroleum industry and the MIME sector. This may be related to the fact that the petroleum industry is based on the usage of machinery, and therefore is dependent on repairs and installation, which increases its demand for such services. The variance decomposition of the MIME sector is reported in Appendix **F.5**. The results show clearly that the aggregate demand shock explains the variance in all three variables most. To illustrate, it explains around 15.8 percent of the variation of sector-specific gdp, approximately 18.6 percent of the variance of employment and 23.5 percent of variation of real wage after four years. While oil-specific demand shock only explains approximately 1.8 percent of variation in gdp, around 4.9 percent of variation in employment and 3.1 percent after the same number of years.

5.6. Shipyard

The responses of variables in the model for the Shipyard sector are provided in Appendix **E.6**. The figures below display the responses of sector-specific gross domestic product (1st column), employment (2nd column) and real wage (3rd column) of the Shipyard sector to an aggregate demand shock (1st row) and an oil-specific demand shock (2nd row).

Figure 7: Responses of sector-specific activities in Shipyard sector



All three sector-specific variables are positively affected by the two demand shocks in the Shipyard sector. The responses show a clear difference in both magnitude and persistence as an effect of the two different shocks. An aggregate demand shock leashes a reaction of 4.1 percent to sector-specific gdp on impact. The reaction continues to increase briefly to 8.6 percent after three quarters, before reverting to its initial state. The response of employment to an aggregate demand shock is of 1.7 percent on impact. It reaches its peak of 4.6 percent after five quarters before it begins its path back to its steady level. The response of real wage is similar in persistence to the response of employment, but slightly larger in magnitude. The reaction on impact is 2.7 percent, and peaks after five quarters at 7.4 percent. The response of sector-specific gdp to an oil-specific demand shock is insignificant, but it is noteworthy that the response is positive and quite persistent. The response of employment and real wage are quite similar in persistence. The response of employment to an oil-specific demand shock is 2.1 percent on impact and continues to increase to its peak of 9.2 percent after one and a half years, before it slowly reverts to its initial state. The response of real wage to an oil-specific demand shock is 4.2 percent on impact. The response peaked after one and a half years at 13.36 percent, before gradually returning to its initial state.

The findings of the IRFs indicate a large positive relationship between the shipyard sector, and both the global demand and petroleum industry. The relationship for the Shipyard sector seems to be stronger and more persistent with the petroleum industry. Keeping in mind that the Shipyard sector is much reliant on the petroleum industry, the results are not overly surprising. The variance decomposition of the Shipyard sector is reported in Appendix **F.6**. The results show that aggregate demand shock explains most of the variance for the initial periods, while oil-specific demand shock explains most of the variance for the later periods of employment and real wage. Aggregate demand shock explains 14.43 percent, 21.94 percent, and 19.70 of the variances in employment after the first, second and fourth year, while oil-specific demand shock explains 12.80 percent, 20.43 percent, and 26.24 percent of the variance in employment after the same respective periods. The results show that aggregate demand shock explains 25.70 percent and 21.87 percent of the variance after two and four years, respectively. While oil-specific demand shock represents 19.57 percent and 25.62 percent, after the same respective periods.

6.0. Robustness check - Alternative oil price measures

The VAR model has some limitations, as mentioned in section **2.0**, that we are now going to present. Hamilton (1983) is a paper showing that oil price shocks were a contributing factor to all but one of the US recessions from World War II until 1972. Mork (1989) wanted to build on Hamilton's paper and found that oil price increases have a larger effect than an oil price decrease on the US macroeconomy. In this section we are going to create four alternative oil price measures inspired by Hamilton (1996) and Mork (1989). We will distinguish between oil price increase and oil price decrease, and respectively create four alternative oil price measures, two for oil price increase and two for oil price decrease. We will elaborate on this later in this section.

There exists a lot of empirical studies on how changes in the oil price affect the economy. Many of the studies are analyzing oil importing countries, while we in this thesis are analyzing Norway, an oil exporting country. We have therefore found inspiration in the article of Bjørnland (2009) who studied oil price shock in Norway. By testing the correlation between the real oil price and the alternative oil price measures, we will be able to get an indication of how comparable the alternative oil price measures are to the real oil price.

Mork's study (1989) was the first study really investigating oil price decreases and oil price increases separately. As we touched upon above, Mork found important evidence in the US economy for asymmetric effects on oil price changes. He was the first to propose the original oil price proxies for oil price decreases and increases. Hamilton (1996) followed Mork's paper and suggested another oil price proxy. He suggested a net oil price measure, and this is considered to be one of the most successful oil price transformations. This measure is motivated by the radical changes he observed in oil prices after 1986. There was a much higher fluctuation in the oil price after this period and was nothing like they had observed before. Hamilton (1996) suggested that the increases in the price of oil were corrections from the decreases in the price of oil, and not due to a stable environment. Hamilton also suggests that you compare the current oil price with the level from the previous year and not only from the previous quarter as Mork (1989) suggested.

It is important to note that Hamilton (1996) uses the nominal price of oil. This is because he argues that consumers respond to the nominal price of oil because of its visibility. However, this argument has gained little empirical support. In the following analysis, the real oil price is used to define the nominal oil price increase to ensure consistency. This is also because using the real oil price is a more empirically supported and relevant measure using the theoretical models of transmission mechanisms of oil price shocks (Kilian & Vigfusson, 2011).

1) Hamilton (1996): The net oil price (*npo*) increases and the net oil price decrease:

$$npo_t^{increase} = \max[0, rpo_t - \max[rpo_{t-1}, rpo_{t-2}, rpo_{t-3}, rpo_{t-4}]] \quad (6)$$

$$npo_t^{decrease} = \min[0, rpo_t - \min[rpo_{t-1}, rpo_{t-2}, rpo_{t-3}, rpo_{t-4}]] \quad (7)$$

rpo_t is the real price of oil in time period t.

The net price of oil decrease is created by the same idea as the net price of oil increase, where npo_t is constructed by comparing the real price of oil each quarter, with the lowest value of the real price of oil in the previous four quarters. This is as mentioned above, where Hamilton (1996) suggested that you compare it with the previous year and not only the previous quarter as Mork (1989) did. This is shown below.

2) Mork (1989) separated change in real oil price decreases $\Delta rpo_t^{decrease}$ and change in real oil price increases $\Delta rpo_t^{increase}$:

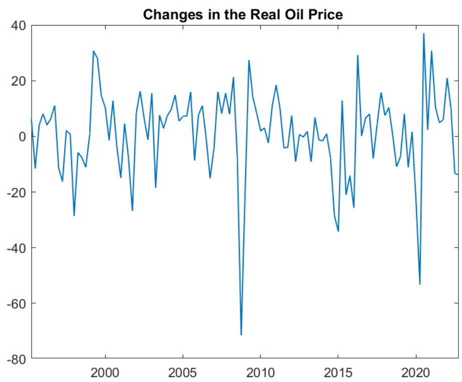
$$\Delta rpo_t^{increase} = \max[0, \Delta rpo_t] \tag{8}$$

$$\Delta rpo_t^{decrease} = \min[0, \Delta rpo_t] \tag{9}$$

rpo_t is also here the real price of oil in time period t.

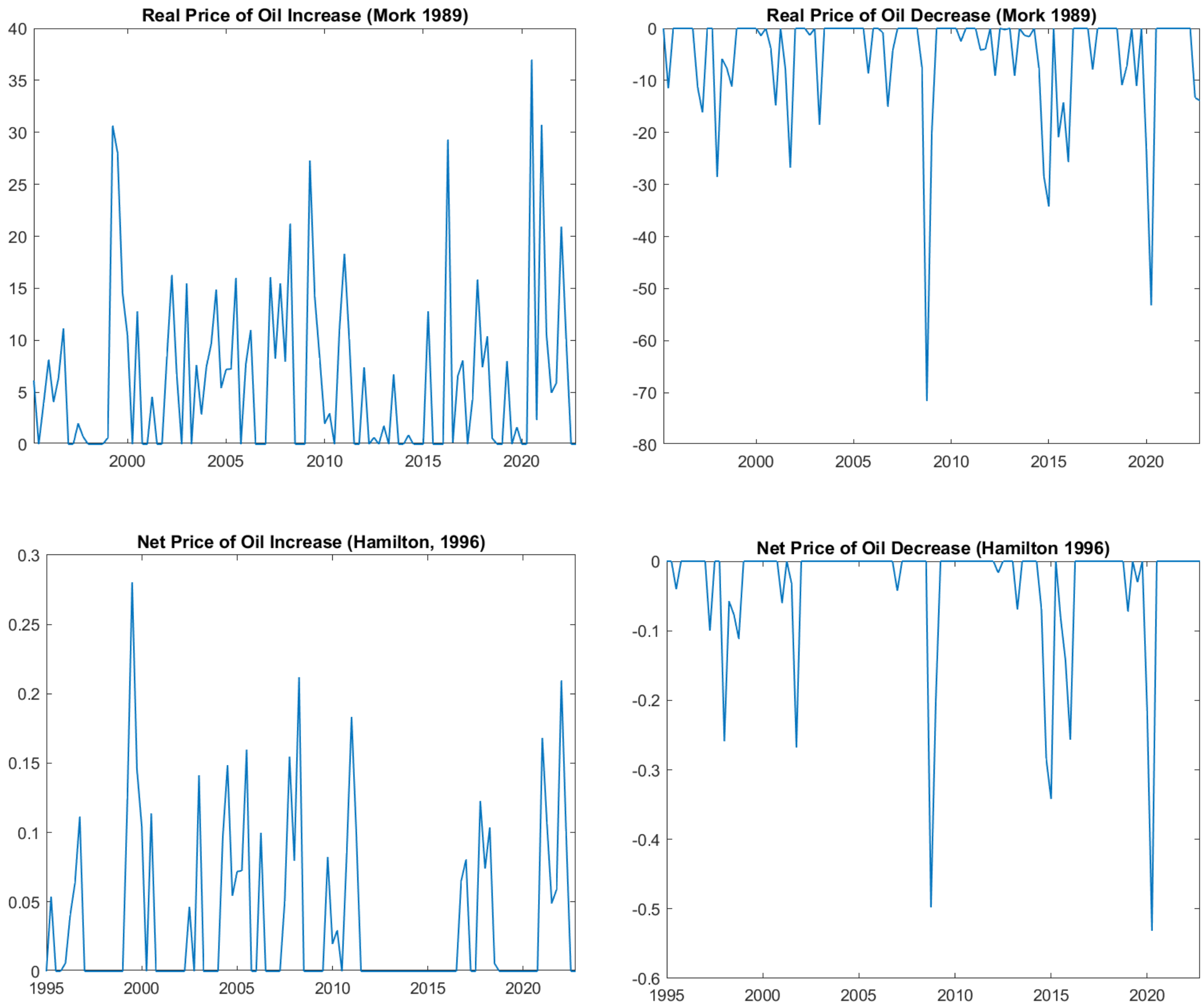
This is a simple oil price proxy where the first equation ***(8)*** is a filter for an oil price increase while the second equation ***(9)*** is a filter for an oil price decrease. The real oil price increase in period t is a function of the max change in the real oil price in period t. Also, the real oil price decrease in period t is a function of the min change in the real oil price in period t.

Figure 8: Changes in the Real Oil Price 1995-2022



Note: The figure above shows the changes in the real price of oil from 1995-2022. This will make it easier to compare to the alternative oil price measures as they are formulated in percentage changes.

Figure 9: Alternative oil price measures



Note: The upper two graphs are based on Mork (1989) showing $\Delta rpo_t^{increase}$ and $\Delta rpo_t^{decrease}$from left to right, while the lower two graphs are based on Hamilton (1996) showing $npo_t^{increase}$ and $npo_t^{decrease}$. The graphs inspired by Mork are expressed in percentage change, while the graphs inspired by Hamilton are expressed in logs. The figure shows quarterly data in the time period from 1995 - 2022.

Table A: Correlation between changes in the real oil price and alternative oil price measures

	Alternative Oil Price Measures			
	Mork (1989)		Hamilton (1996)	
Time Period	$\Delta rpo_t^{increase}$	$\Delta rpo_t^{decrease}$	$npo_t^{increase}$	$npo_t^{decrease}$
1995 Q1 - 2022 Q4	0.7708	0.8822	0.5397	0.7822

Table A above shows the correlation between alternative oil price measures, inspired by Mork (1989) and Hamilton (1996), and changes the real oil price. We clearly see in the table that Mork's oil price measures are highly correlated with the real oil price. As we can see, the decrease is also higher correlated than the increase. The net oil price increase by Hamilton is not highly correlated, but the net oil price decrease is. Furthermore, the alternative oil price measures inspired by Mork (1989) are more correlated with the real oil price, than the two alternative oil price measures inspired by Hamilton (1996). The alternative oil price measure with the highest correlation to the real oil price is $\Delta rpo_t^{decrease}$, which makes it the best alternative measure for the real oil price.

7.0. Extensions

To further investigate the relationship between the oil price and the macroeconomic variables we will perform an asymmetry test. This is to investigate whether there exists asymmetry, or linearity, and therefore a linear relationship between the oil price and the macroeconomic variables. We have prioritized investigating mainland economy GDP and sector-specific gdp. We find the most interesting and important, because there is already data showing no linearity between the oil price and, e.g., the real wage (Keane & Prasad, 1996). In this section we are performing a test to see if the alternative oil price measures and macroeconomic variables have the same variance in their normal distribution. If the variance is similar, it indicates a linear relationship.

Kilian and Vigfusson (2011) suggest that there are two different tests to assess the nonlinear relationship given in the literature. These two tests are the slope-based test and the impulse response-based test. The slope-based test is the traditional way to test for symmetry in the transmission mechanism of oil price shocks (Mork, 1989). This test is used to check the symmetry of the slope parameters of the single equation regression model. But, as Kilian and Vigfusson (2011) presents, the slope test is not appropriate to find the degree of symmetry, and here the impulse-response based test enters the picture as it performs better. As we are going to test the linear relationship between the macroeconomic variables and the oil price, the slope-based test is being used. The formulas below are inspired by Kilian and Vigfusson (2011) as mentioned, but also Bjørnland (2009). Our macroeconomic variables are the gross domestic product, $\boldsymbol{gdp_t}$, the sector employment, $\boldsymbol{empl}_t$, and the sector real wage, $\boldsymbol{rw_t}$, which we are going to check if they have a linear relationship to the oil price. Following test equations for Mork (1989) and Hamilton (1996):

Mork (1989):

$$\Delta Y_t = \mu + \sum_{t=1}^{1} \beta_i \Delta Y_{t-i} + \sum_{t=0}^{1} \gamma_i \Delta rpo_t^{increase} + \epsilon_t \tag{10}$$

$$\Delta Y_t = \mu + \sum_{t=1}^{1} \beta_i \Delta Y_{t-i} + \sum_{t=0}^{1} \gamma_i \Delta rpo_t^{decrease} + \epsilon_t \tag{11}$$

$Y_t \in \{gdp_t, empl_t, rw_t\}$

Hamilton (1996):

$$\Delta Y_t = \mu + \sum_{t=1}^{1} \beta_i \Delta Y_{t-i} + \sum_{t=0}^{1} \gamma_i npo_t^{increase} + \epsilon_t \quad \textit{(12)}$$

$$\Delta Y_t = \mu + \sum_{t=1}^{1} \beta_i \Delta Y_{t-i} + \sum_{t=0}^{1} \gamma_i \Delta rpo_t^{decrease} + \epsilon_t \quad \textit{(13)}$$

$$Y_t \in \{gdp_t, empl_t, rw_t\}$$

The null hypothesis of symmetry and linearity is: H_0: $\gamma_i = 0$ for i = 0, 1. Bjørnland (2009) chose the lag length of six operating in monthly data. Compared to our estimate in the quarterly data this is equal to two quarters. As we described in section **4.3**, we decided a lag length of one. The equations above are made to test for a linear relationship between the variables in the different sectors and the alternative oil price measures.

We are testing in Matlab whether the two variables have the same variance in their normal distribution, or not. The null hypothesis indicates similar variance, while the alternative hypothesis argues that the variance is different. The results of the hypothesis test are shown in *Table B* for mainland GDP and sector-specific gdp. We can also test employment and real wages, but we find it the most important as we already know the real wage is not lowered when the oil price is decreasing (Keane & Prasad, 1996). We are focusing on F-stat with one lag in the table below, and a general rule of thumb states that with a F value > 2.5 we can reject the null hypothesis, but with a significance level of 1 %, we can reject the null hypothesis with a F value larger than the critical F value of 5.013 (Freund, Wilson, & Mohr, 2010).

Table B: Test results of GDP for the different sectors

Sector		Variable			
		$npo_t^{increase}$	$npo_t^{decrease}$	$\Delta rpo_t^{increase}$	$\Delta rpo_t^{decrease}$
ME	F-stat (1 lag)	0.8808	0.3562	0.2591	0.1415
EOGS	F-stat (1 lag)	0.9383	0.7839	0.2363	0.1291
FCA	F-stat (1 lag)	6.51180**	2.63330*	2.23080	1.21890
BC	F-stat (1 lag)	0.716	0.28950	0.07020	0.03830
MIME	F-stat (1 lag)	5.33450**	2.15720	0.44980	0.24580
SY	F-stat (1 lag)	0.7160	0.2895	0.5781	0.3159

*Note: The F-stat testing for sector-specific gdp and alternative oil price measures. *F value higher than rule of thumb > 2.5 **1% significance level.*

In *Table B*, we see overall that we have no significant result. The F-value is very low, except the F-value for the $npo_t^{increase}$ which is very significant in both the *Fishing, Catching and Aquaculture sector* and for the *Maintenance and Installation of Machines and Equipments sector.* We also see $npo_t^{decrease}$ is significant by the rule of thumb, but not by the 1% significance level for the *Fishing, Catching and Aquaculture sector.* Even though this tests the variance between the oil price and the gdp for the chosen sectors, it also helps give some indicators of symmetry or asymmetry. Being statistically insignificant for almost every sector, it suggests linearity and symmetry in the relationship between the oil price and gdp. The results only indicate a weak asymmetric effect between the $npo_t^{increase}$ in both *Fishing, Catching and Aquaculture sector* and *Maintenance and Installation of Machines and Equipments sector*, and for $npo_t^{decrease}$ and the *Fishing, Catching and Aquaculture sector*.

8.0. Conclusion

The objective of this paper has been to assess the effects of oil price on the Norwegian economy on a sectoral level. Using a structural autoregressive model, an impulse response analysis was performed for the mainland economy and five different sectors. By performing impulse response analysis of oil price shocks on these sectors, it is possible to identify effect mechanisms that may differentiate both in magnitude and persistence.

On the aggregate level, we investigated the *Mainland Economy*. On the sectoral level *Extraction of Oil and Gas incl. Services, Fishing, Catching and Aquaculture, Building and Construction, Maintenance and Installation of Machines and Equipments* and *Shipyard* was investigated. *Maintenance and Installation of Machines and Equipments* and *Shipyard* are sub sectors of the *Manufacturing* sector. Economic activity was measured in mainland and sector-specific gdp, employment and real wage. The main finding is that oil-specific demand shock has the greatest influence on mainland GDP and all sector-specific gdp, and strong influence on employment and real wage for most part. The oil-specific demand shock generates responses in gdp, that are of higher magnitude, stronger persistence and of larger statistical significance, than the responses of an aggregate demand shock in general. While the oil-specific demand shock generates similar responses for employment and real wage only for some sectors, the aggregate demand shock does generate some responses on employment and real wage that are of higher magnitude, stronger persistence and of larger statistical significance. That is the case for employment and real wage in the *Building and Construction* and *Fishing, Catching and Aquaculture* sectors. However, some of the sectors are more exposed than others. The *Mainland Economy* responds modestly to the shocks, which implies a fairly stable but oil-dependent aggregate Norwegian economy.

Extraction of Oil and Gas including Services was the sector with largest magnitude and strongest persistence when subjected to an oil-specific demand shock. Given the close link this sector has to the petroleum industry, the results are not too surprising. Other sectors that are positively affected by the oil-specific demand shock are *Maintenance and Installation of Machines and Equipment* and *Shipyard* sectors. This might be explained by an existing link between the respective sectors and the petroleum industry. An increase in real oil price makes investments in the petroleum industry increase. The industry will then demand more goods and services from the oil service-supplying sectors and the effect will begin mainly in sectors that have close links to the petroleum industry. However, the effect will also spread to other parts of the economy with a more obscure link to the petroleum industry as the demand for services not directly related to the oil service-supplying sector also increases, like the sectors *Maintenance and Installation of Machines and Equipments* and *Shipyard*. The *Building and Construction* sector is also positively affected by the oil-specific demand shock, but the explanation is not similar to the preceding sector. The *Building and Construction* sector has no clear link to the petroleum industry. We find the positive effects to purely be a side effect of economic conditions in the Norwegian economy to be improved by the oil-specific demand shock. *Fishing, Catching and Aquaculture* is the only sector that shows a clear difference in effect to an oil specific demand shock for employment and real wage. While the effects for the other sectors are positive, the effects for *Fishing, Catching and Aquaculture* are extremely modest and negative. Which would suggest that there are little to no spillovers to the *Fishing, Catching and Aquaculture sector* from the petroleum industry.

In the latter part of this paper, we compare alternative oil price measures with the real oil price. There is a high amount of research in the field focusing on oil importing countries, while we in this paper focus on Norway, an oil exporting country. By making alternative oil price measures inspired by Mork (1989) and Hamilton (1996), on the basis of the real oil price, we found that measures inspired by Mork (1989) were the highest correlated with the real oil price. And, thus the best alternative measure. Finally, we include an extension of our paper that investigates linear relationships with the alternative oil price measures and gdp, in our model. By testing for linearity, we found almost no significant results of any of the variables, except for in the *Fishing, Catching and Aquaculture* sector and in the *Maintenance and Installation of Machines and Equipments* sector. The rest of the results indicated a symmetric linear relationship between the oil price and the gdp for all the chosen sectors. This indicates that an oil price shift will lead to an immediate response in mainland and sector-specific gdp.

Our present paper contributes to a debate on the Norwegian oil dependency to aggregate demand and oil price. Changes in demand from the petroleum industry create impulses through the rest of the economy that make closely linked sectors to this industry vulnerable to shocks. The paper reveals that demand for goods and services from the petroleum industry works as a key transmission channel for oil price shocks in Norway. An interesting topic for future research is to see whether the dependency of Norwegian oil today is similar to what it was before the financial crisis. Keeping in mind that the Norwegian economy has recovered through three modern time crises; the financial crisis, the oil price collapse and the covid pandemic, we can clearly assume that much has changed in the Norwegian economy since then. The time has given the Norwegian government and people the experience and knowledge to further improve and strengthen the Norwegian economy. Another interesting study could be to investigate how the macroeconomic variables in this paper respond to an aggregate demand shock and oil-specific demand shock with higher magnitude than the magnitude used in this paper and see whether the responses get more significant.

9.0. Reference list

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10.0. Appendix

Appendix A: Descriptive statistics and plots of data

A.1 Descriptive statistics: definitions and explanation of statistics

In this section follows definitions of descriptive statistics used in **Appendix A.2.**

Mean - "Mean is the simplest mathematical average of a set of two or more numbers" (Hayes, 2023).

Median **-** "The median is the value of the middle item when all the data items are ranked in order" (Goldie, 2012 p.16).

Maximum **-** Maximum is the largest value in the dataset.

Minimum **-** Minimum is the lowest value in the dataset.

Std. dev. **-** Standard deviation measures the dispersion of datasets relative to its meaning (Hargrave, 2023).

MAD (Mean absolute deviation) **- "**MAD ignores the signs and adds together the absolute deviations" (Golde, 2012, p.35).

Skewness **-** if the distribution of a dataset is off to one side it is said to be skewed. If skewness is larger than 1 in absolute value, the distribution is significantly skewed. If skewness is lower than 0.5 in absolute value, the distribution is approximately symmetric (Goldie, 2012, p.6).

Kurtosis **-** "Kurtosis is a measure of the combined weight of a distribution's tails relative to the center of the distribution curve" (Kenton, 2023).

Jarque-Bera (test) - Jarque-Bera test, evaluates the null hypothesis that the dataset comes from a normal distribution. If it is rejected the alternative hypothesis implies that the dataset does not come from a normal distribution. The test statistics are always nonnegative. A higher number indicates that the data series does not have a normal distribution. (MathWorks, n.d.).

Correlation rop **-** Correlation shows the strength of a relationship between two variables. The correlation spans from -1 to 1. Correlation equals -1 implies perfect negative correlation, and equal to 1 implies perfect positive correlation (Hayes, 2022). Correlation with ***rop*** illustrates the respective variables' relationship with real oil prices.

Observations **-** Observations are the number of units in a dataset.

A.2 Descriptive statistics: description and results

Descriptive statistics are stated to give an overall understanding of the data series with the sample period from 1995 to 2022. The variables are transformed in line with section **3.1**. The abbreviation of the global variables follows from section **3.1**. The abbreviation for the sectoral gdp, employment and real wage are **ME:** Mainland Economy, EOGS**:** Extraction of Oil and Gas incl. Services, **FCA:** Fishing, Catching and Aquaculture, **BC:** Building and Construction, **MIME:** Maintenance and Installation of Machines and Equipments, and **SY:** Shipyard.

The mean averages of all the variables (but ***gecon*** and ***rop***) are extremely small. This is caused by the fact that the vector of variables is first logged and then detrended. This means they are extremely small, both in positive and negative values, which makes the means less idle for measure of averages. We can use the median as a better measure for averages.

Table C: Descriptive statistics of global variables (1995-2022)

	gcop	*gecon*	*rop*
Mean	-3.2807e-16	-0.0289	3.1150
Median	0.0035	0.0335	3.1622
Maximum	0.0510	0.9745	4.0311
Minimum	-0.1189	-2.1185	jan.92
Std.dev	0.0302	0.4011	0.5266
MAD	0.0227	0.2763	0.4443
Skewness	-1.1935	-1.8242	-0.1806
Kurtosis	5.1301	9.4429	2.1572
Jarque-Bera	47.3366	255.8352	3.9238
Probability	0.001	0.001	0.0918
Observations	111	112	112

The skewness of the global variables is negative, which means the distribution of the respective variables shifts more towards the right. The skewness is especially significantly negative for the global variables ***gcop*** and ***gecon***, and that is also the case for kurtosis. Which might indicate that the distribution of variables is not similar to a normal distribution. This is proven by the Jarque-Bera test as both of the Jarque-Bera (JB) statistics are extremely high in value. However, the ***rop*** has small JB statistics, which indicates a distribution similar to a normal distribution.

Table D: Descriptive statistics of mainland and sector-specific gdp (1995-2022)

gdp	ME	EOGS	FCA	BC	MIME	SY
Mean	2.3790e-16	-3.2989e-15	-1.0468e-15	-1.8081e-15	-4.7581e-16	-5.7097e-16
Median	0.0024	0.0023	-0.0161	0.0002	0.0054	-0.0151
Maximum	0.1454	0.2016	0.4357	0.1778	0.2774	0.2596
Minimum	-0.1133	-0.2489	-0.3029	-0.1222	-0.3156	-0.3106
Std.dev	0.0558	0.0828	0.1517	0.0503	0.1373	0.1267
MAD	0.0463	0.0673	0.1216	0.0369	0.1083	0.1039
Skewness	0.0654	-0.1017	0.4245	0.7796	-0.2846	-0.0855
Kurtosis	2.4660	2.8215	2.7695	4.6673	2.4039	2.4771
Jarque-Bera	1.4109	0.3417	3.6116	24.3194	3.1702	1.4124
Probability	0.4158	0.5000	0.1067	0.0020	0.1356	0.4153
Correlation with rop	0.5552	-0.1908	0.4529	0.2820	0.1358	0.3791
Observations	112	112	112	112	112	112

The descriptive statistics of sector-specific gdp shows that the skewness in each sector is lower than one in absolute value. That shows that there is no indication of significant skewness for gdp in all sectors. The kurtosis of gdp for all sectors, except the **BC** sector, is not too big. This might indicate that gdp for all sectors, but **BC**, has a distribution similar to a normal distribution. This is further proven by the JB-test, as only sector-specific gdp for **BC** has a high JB-stat. What is quite interesting from the descriptive statistics of sector specific gdp is the respective sectors' correlation with the real oil price. The results show that all the sectors have a positive relationship with real oil prices except EOGS sector. The **EOGS** sector is the closest sector to the petroleum industry in this thesis. One can therefore say that the sector-specific gdp of the **EOGS** sector has a close link to the domestic oil supply. Such a link might explain the low but negative correlation between gdp from **EOGS** and real oil price.

Table E: Descriptive statistics of mainland and sector-specific employment (1995-2022)

empl	ME	EOGS	FCA	BC	MIME	SY
Mean	-2.2522e-15	-9.2783e16	3.5686e17	-3.1721e17	-3.8461e16	3.3307e-16
Median	0.0023	-0.0486	-0.0189	-0.0013	-0.0152	-0.0093
Maximum	0.0323	0.2716	0.3248	0.1435	0.2671	0.1931
Minimum	-0.0389	-0.2069	-0.2432	-0.1290	-0.2740	-0.2035
Std.dev	0.0168	0.1436	0.1526	0.0479	0.1377	0.0981
MAD	0.0137	0.1228	0.1342	0.0315	0.1210	0.0810
Skewness	-0.4143	0.5547	0.2919	0.3444	-0.1794	0.0141
Kurtosis	2.4071	1.9395	1.8628	4.6798	1.9376	2.2435
Jarque-Bera	4.8450	10.9911	7.6255	15.3816	5.8685	2.6746
Probability	0.0627	0.0131	0.0273	0.0062	0.0443	0.1829
Correlation with rop	0.1903	0.5429	-0.5295	0.3470	0.3915	0.4509
Observations	112	112	112	112	112	112

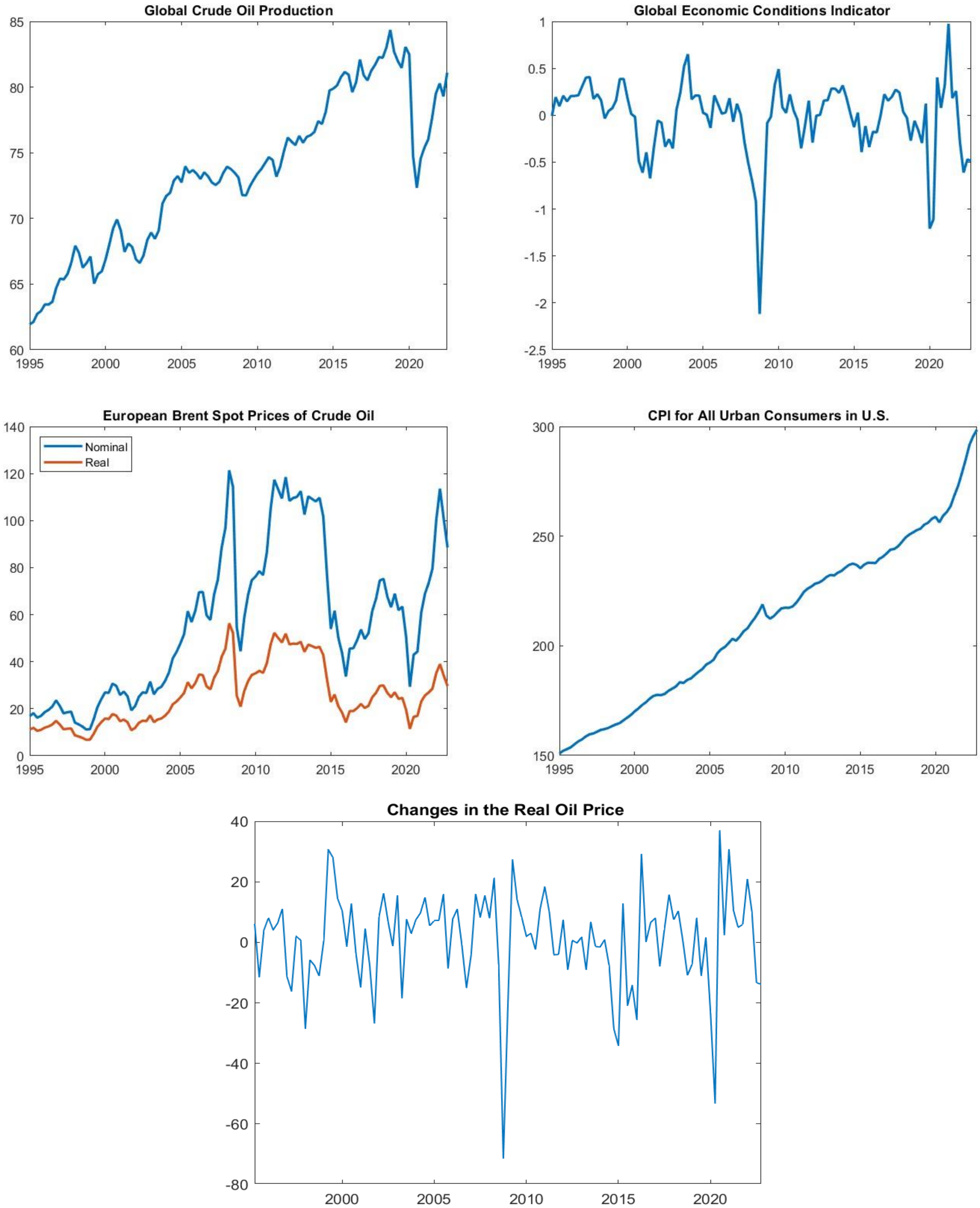
Table F: Descriptive statistics of mainland and sector-specific real wage (1995-2022)

rw	ME	EOGS	FCA	BC	MIME	SY
Mean	1.9825e15	-1.6019e15	-1.1578e15	4.9167e-6	-3.9492e15	6.1062e-16
Median	-0.0085	-0.0629	0.0217	0.0023	-0.0400	-0.0081
Maximum	0.0958	0.3684	0.3672	0.2182	0.3530	0.2878
Minimum	-0.1082	-0.3321	-0.3581	-0.1961	-0.3124	-0.2837
Std.dev	0.0543	0.1943	0.1679	0.0798	0.1798	0.1631
MAD	0.0453	0.1651	0.1330	0.0562	0.1583	0.1368
Skewness	0.0830	0.4843	-0.3418	-0.2918	0.2219	0.0463
Kurtosis	2.0335	2.0083	2.6799	3.7185	1.7917	1.9290
Jarque-Bera	4.4878	8.9678	2.6595	3.9990	7.7330	5.3931
Probability	0.0724	0.0199	0.1847	0.0887	0.0266	0.0515
Correlation with rop	0.5266	0.5516	-0.3888	0.4173	0.5238	0.5436
Observations	112	112	112	112	112	112

The most interesting statistics of sector-specific employment and real wage are the respective sectors' correlation with the real oil price. **ME** and the sectors **EOGS**, **BC MIME** and **SY** have positive correlation with real oil prices, for both the employment and the real wage data. The correlation is slightly higher for sectoral real wages, and therefore it is expected to have a slightly larger response to an oil price shock. On the contrary, the **FCA** sector has a negative correlation with real oil prices. The negative correlation is larger for the employment data and is therefore expected to have a larger negative response to the oil price shock.

A.3 Plotted figures of global variables

Figure 10: Plots of global variables



Appendix B: Stationary and nonstationary processes

Stationarity is a fundamental and essential concept in time series analysis. It is essential as non-stationary variables are problematic as they generate spurious regressions. Spurious regression shows evidence of statistical relationships between variables that, in reality, do not exist (Kenton, 2021). The economic interpretation of this statistical problem is that in the presence of a unit root (non-stationarity) process a shock will persist forever, and the series will not have the fundamental mean reverting properties (Bjørnland, 2015, p.111-117).

Consider the following AR (1) process:

$$y_t = \phi y_{t-1} + \varepsilon_t \qquad \textbf{\textit{(14)}}$$

where

$$\varepsilon_t \sim i.i.d.\ N(0, \sigma^2).$$

The critical question is whether ϕ=1 or ϕ<1. If equal to 1, equation ***(14)*** diminishes to a random walk. If less than one, then the AR (1) process is stationary. Equation ***(14)*** can be rewritten as the following:

$$\Delta y_t = \mu y_{t-1} + \varepsilon_t \qquad \textbf{\textit{(15)}}$$

where

$$\mu = \phi - 1$$

B.1 Augmented Dickey-Fuller Test: Theory

Several tests have been developed to determine the presence of a unit root process. The most popular method to assess a unit root is to use Augmented Dickey-fuller test. The test is a one-sided test, since the relative alternative to the null hypothesis is that the process is stationary. To test for unit root on equation ***(15)*** is to test the null hypothesis:

$$H_0 : \mu = 0$$

If kept, the null hypothesis suggests the process to be non-stationarity, i.e., that the process contains a unit root. This is against the alternative hypothesis:

$$H_a : \mu < 0$$

If the null-hypothesis is rejected in support of the alternative-hypothesis the process is implied to be stationary (Bjørnland, 2015, p.118).

B.2 Augmented Dickey-Fuller Test: Results

Table G: ADF-test results of global variables

	Log- level constant, and trend	Log-level and constant	Detrended and Constant
	t-stat	*t-stat*	*t-stat*
gcop	-3.633659	-1.765887	-3.614807
gecon	-5.289960	-5.194607	-5.315364
rop	-2.336865	-2.106952	-2.349259

Table H: ADF-test results of domestic variables as/with log levels, 1 lag, constant and trend

	Sector-specific rgdp	*Employment*	*Real wage*
	t-stat	*t-stat*	*t-stat*
ME	-2.507043	-3.284442	-0.969901
EOGS	-2.907655	-0.946663	-0.385872
FCA	-2.689239	-0.906668	-2.091166
BC	-2.622604	-2.354465	-1.998125
MIME	-2.246992	-1.453915	-0.763635
SY	-3.149905	-2.605222	-1.489757

Table I: ADF-test results of domestic variables as/with detrended, 1 lag and a constant

	Sector-specific rgdp	*Employment*	*Real wage*
	t-stat	*t-stat*	*t-stat*
ME	-2.529502	-3.276867	-1.061904
EOGS	-2.864079	-0.981295	-0.470733
FCA	-2.710014	-0.966375	-1.975155
BC	-2.632285	-2.299430	-1.986818
MIME	-2.235896	-1.460937	-0.803464
SY	-3.146247	-2.591476	-1.506141

Table J: Critical values for ADF-test

Critical values	Constant and trend	Constant
1 %	-4.005	-3.439
5 %	-3.461	-2.915
10 %	-3.155	-2.584

Appendix C: Stable VAR

C.1 Stability of the VAR: Theory

For a VAR model to be covariance-stationary, the effect of the shocks, ε, must eventually die out. That will be the case if all the eigenvalues of the companion matrix are less than one in absolute value. The eigenvalues of the companion matrix $\Gamma = A_1$ are those number λ for which:

$$|\Gamma_1 - \lambda I| = 0 \qquad \textbf{\textit{(16)}}$$

A VAR of any order can be reformulated to VAR (1), using the companion matrix. We can therefore give an illustration of how to derive these eigenvalues using a simple numerical VAR (1) example. The theoretical explanation and notation follow Bjørnland and Thorsrud (2015).

Consider a VAR (1) process as follows:

$$z_t = \mu + A_1 z_{t-1} + u_t$$

where

$$A_1 = \begin{bmatrix} 0.4 & 0 \\ 1 & 0.7 \end{bmatrix}$$

Plugging in A_1 into the equation ***(16)*** yields:

$$\det\left[\begin{bmatrix} 0.4 & 0 \\ 1 & 0.7 \end{bmatrix} - \lambda \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}\right] = \det\left[\begin{bmatrix} 0.4-\lambda & 0 \\ 1 & 0.7-\lambda \end{bmatrix}\right]$$

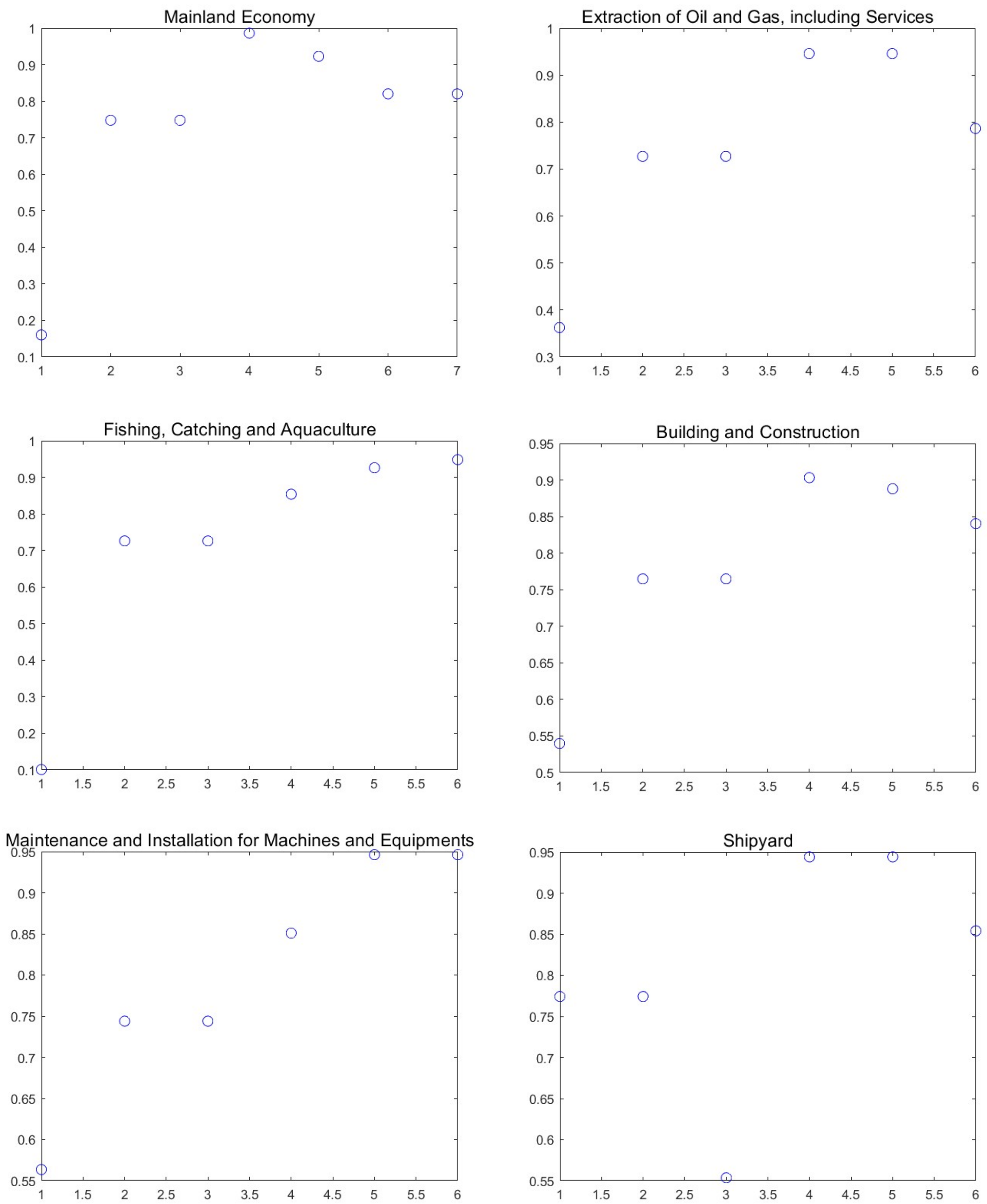
$$= (0.4-\lambda)(0.7-\lambda) = 0 \qquad \textbf{\textit{(17)}}$$

The eigenvalues in this case are $\lambda_1 = 0.4, \lambda_2 = 0.7$, and both are less than one, which makes the VAR (1) a stable process. One can also use the *roots* rather than the eigenvalues to check the stability of a VAR. In this case we will be looking for the opposite results to verify if the VAR is stable, as a stable stochastic VAR has roots that are larger than one. In the more general case of the VAR(p) process, the eigenvalues or roots are easily computed using standard statistical software. In our case, we use Matlab to find the eigenvalues of the VAR to illustrate its stability.

C.2 Stability of the VAR: Results

In this section follows plots of the eigenvalues of the companion form matrix, for mainland economy and each sector. The eigenvalues are derived and plotted in absolute values. The plots illustrate the stability of the VAR models, as the eigenvalues are smaller than one (the vertical axis illustrates the value of the eigenvalue).

Figure 11: Eigenvalues in absolute values of mainland economy and each sector



Appendix D: Lag selection

D.1 Lag selection: Theory

When using a VAR(p) model for real world data analysis, we need to determine what the correct size of p is, i.e., the number of lags we include in the vector autoregression. Including too few lags might lead to valuable information being omitted, and thus the residuals easily being autocorrelated. If we on the other hand include too many lags, we estimate more coefficient than necessary, which in turn leads to additional estimation error in the model (Bjørnland, 2015, p.68).

There are many ways to determine the number of lags. A common method in time series analysis is based on minimizing an information criterion. Two widely used information criterions for lag selection are the Bayes and the Akaike information criterion (BIC and AIC). The notation for derivation is:

$$BIC(p) = \ln\left(SSR(p)/T\right) + (p+1)\cdot \ln\left(T\right)/T \qquad \textit{(18)}$$

and

$$AIC(p) = \ln\left(SSR(p)/T\right) + (p+1)\cdot 2/T \qquad \textit{(29)}$$

The BIC and AIC will most likely not provide us with one answer. The difference between the information criterions is the last term, making the BIC give a harder penalty on the size of the model. The BIC will, therefore, more often suggest fewer lags than the AIC (Bjørnland, 2015, p.69).

D.2 Lag selection: Results

Table K: Results from information criterions for the global variables gcop, gecon and rop

gcop	Lags	AIC	BIC
	1	-583.9368	-581.2828
	2	-591.4061	-586.0981
	3	-595.9614	-587.9995
	4	-601.2962	-590.6804
	5	-599.8398	-586.5700
	6	-599.4113	-583.4875

gecon	Lags	AIC	BIC
	1	59.5748	62.2383
	2	61.2238	66.5507
	3	63.1412	71.1315
	4	48.8574	59.5112
	5	50.4509	63.7681
	6	52.4303	68.4110

rop	Lags	AIC	BIC
	1	-83.3772	-80.7137
	2	-84.9735	-79.6466
	3	-83.9786	-75.9883
	4	-82.0549	-71.4011
	5	-80.0846	-66.7674
	6	-79.2987	-63.3181

Table L: Results from information criterion for mainland and sector-specific gdp

ME	Lags	AIC	BIC
	1	-390.4736	-387.8102
	2	-410.7427	-405.4158
	3	-412.2557	-404.2654
	4	-457.5817	-446.9280
	5	-462.9643	-449.6471
	6	-468.6793	-452.6987

EOGS	Lags	AIC	BIC
	1	-391.8445	-389.1811
	2	-395.3841	-390.0572
	3	-393.6317	-385.6414
	4	-392.7717	-382.1179
	5	-395.4399	-382.1227
	6	-396.3130	-380.3324

FCA	Lags	AIC	BIC
	1	-161.9271	-159.2637
	2	-173.8384	-168.5116
	3	-173.9402	-165.9499
	4	-181.1921	-170.5383
	5	-180.1491	-166.8319
	6	-178.5212	-162.5406

BC	Lags	AIC	BIC
	1	-524.8851	-522.2217
	2	-525.4080	-520.0811
	3	-524.0386	-516.0483
	4	-522.4143	-511.7605
	5	-524.4942	-511.1770
	6	-522.5175	-506.5369

MIME	Lags	AIC	BIC
	1	-318.8807	-316.2173
	2	-317.9796	-312.6527
	3	-316.3160	-308.3257
	4	-314.3214	-303.6677
	5	-313.1867	-299.8695
	6	-312.5461	-296.5654

SY	Lags	AIC	BIC
	1	-298.2167	-295.5533
	2	-298.1980	-292.8711
	3	-296.2169	-288.2265
	4	-294.5444	-283.8907
	5	-294.4436	-281.1265
	6	-292.4438	-276.4632

Table M: Results from information criterion for mainland and sector-specific employment

ME	Lags	AIC	BIC
	1	-727.2850	-724.6216
	2	-727.7832	-722.4563
	3	-743.5835	-735.5931
	4	-745.4123	-734.7586
	5	-791.1489	-777.8317
	6	-790.0500	-774.0694

EOGS	Lags	AIC	BIC
	1	-417.6407	-414.9772
	2	-415.8611	-410.5342
	3	-414.5961	-406.6058
	4	-413.6950	-403.0412
	5	-427.7242	-414.4070
	6	-426.3835	-410.4029

FCA	Lags	AIC	BIC
	1	-315.8720	-313.2086
	2	-335.4912	-330.1643
	3	-337.3893	-329.3990
	4	-337.3510	-326.6972
	5	-335.3555	-322.0383
	6	-338.4525	-322.4719

BC	Lags	AIC	BIC
	1	-622.3600	-619.6966
	2	-628.3823	-623.0554
	3	-634.2681	-626.2778
	4	-633.5709	-622.9172
	5	-635.6893	-622.3721
	6	-634.6239	-618.6432

MIME	Lags	AIC	BIC
	1	-403.9767	-401.3133
	2	-403.1398	-397.8129
	3	-402.2098	-394.2195
	4	-401.3244	-390.6706
	5	-403.7785	-390.4614
	6	-402.5610	-386.5803

SY	Lags	AIC	BIC
	1	-476.4352	-473.7717
	2	-501.5227	-496.1958
	3	-503.1465	-495.1562
	4	-503.6923	-493.0386
	5	-503.5186	-490.2014
	6	-504.7484	-488.7677

Table N: Results from information criterions for mainland and sector-specific real wage

ME	Lags	AIC	BIC
	1	-618.5023	-615.8389
	2	-617.3666	-612.0397
	3	-615.5612	-607.5708
	4	-614.6925	-604.0387
	5	-621.6276	-608.3104
	6	-619.8055	-603.8249

EOGS	Lags	AIC	BIC
	1	-359.4976	-356.8342
	2	-358.7956	-353.4687
	3	-357.9834	-349.9931
	4	-356.3749	-345.7211
	5	-362.6879	-349.3707
	6	-362.6424	-346.6618

FCA	Lags	AIC	BIC
	1	-415.9211	-413.2577
	2	-414.8424	-409.5155
	3	-413.3913	-405.4009
	4	-411.6391	-400.9853
	5	-418.6044	-405.2872
	6	-416.9112	-400.9306

BC	Lags	AIC	BIC
	1	-524.0310	-521.3676
	2	-525.8330	-520.5061
	3	-523.8448	-515.8545
	4	-533.2018	-522.5480
	5	-532.9804	-519.6632
	6	-531.9587	-515.9781

MIME	Lags	AIC	BIC
	1	-386.1999	-383.5365
	2	-385.8570	-380.5301
	3	-386.6583	-378.6680
	4	-387.5842	-376.9304
	5	-387.6260	-374.3088
	6	-386.4614	-370.4808

SY	Lags	AIC	BIC
	1	-397.7594	-395.1936
	2	-398.4493	-393.1224
	3	-403.1840	-395.0960
	4	-401.6995	-391.0457
	5	-399.9563	-386.6391
	6	-398.6253	-382.6447

Appendix E: Impulse Response Functions

E.1 Mainland Economy (ME)

Figure 12: Response of macroeconomic variables of ME to an oil supply shock

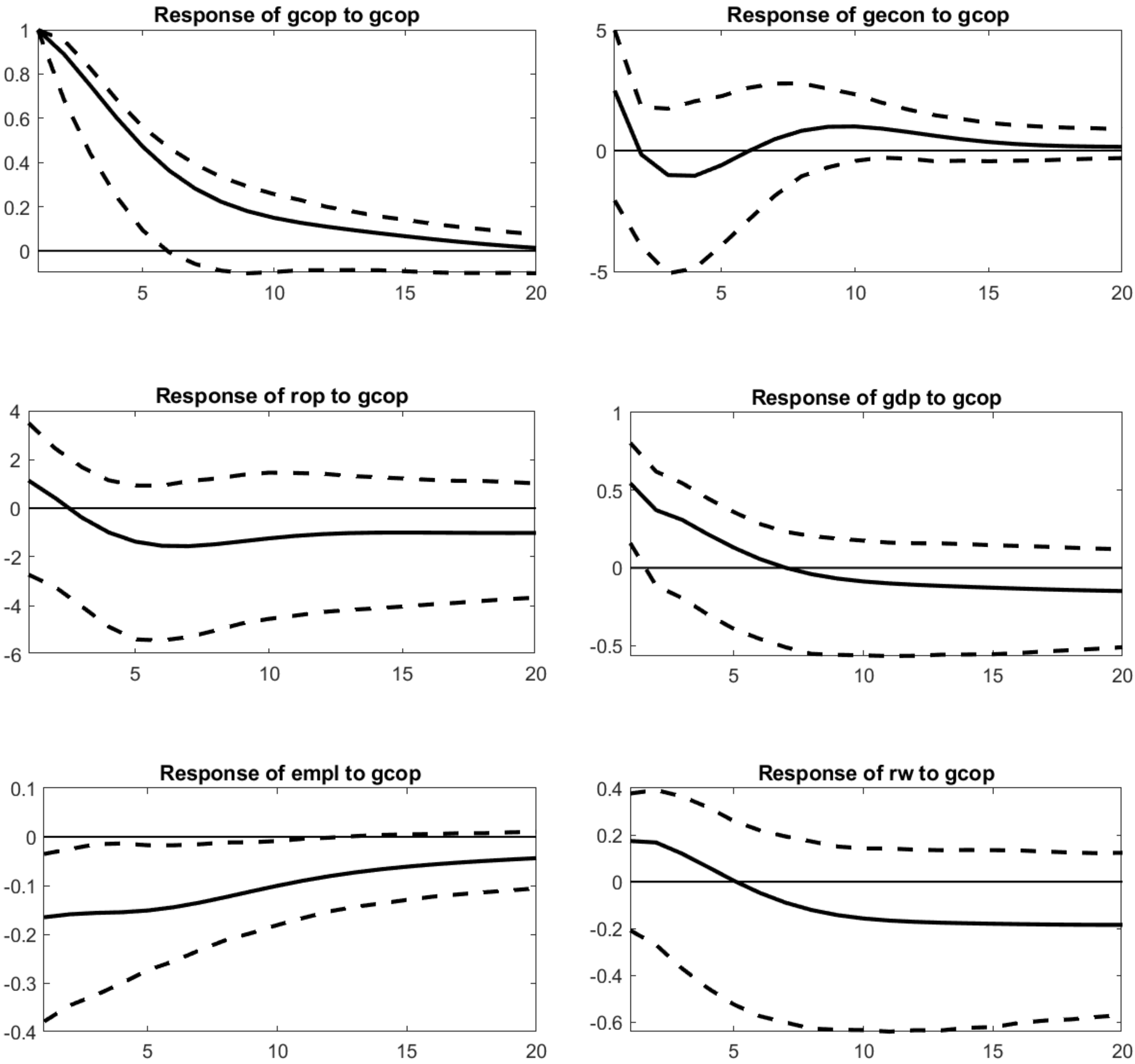


Figure 13: Response of macroeconomic variables of ME to an aggregate demand shock

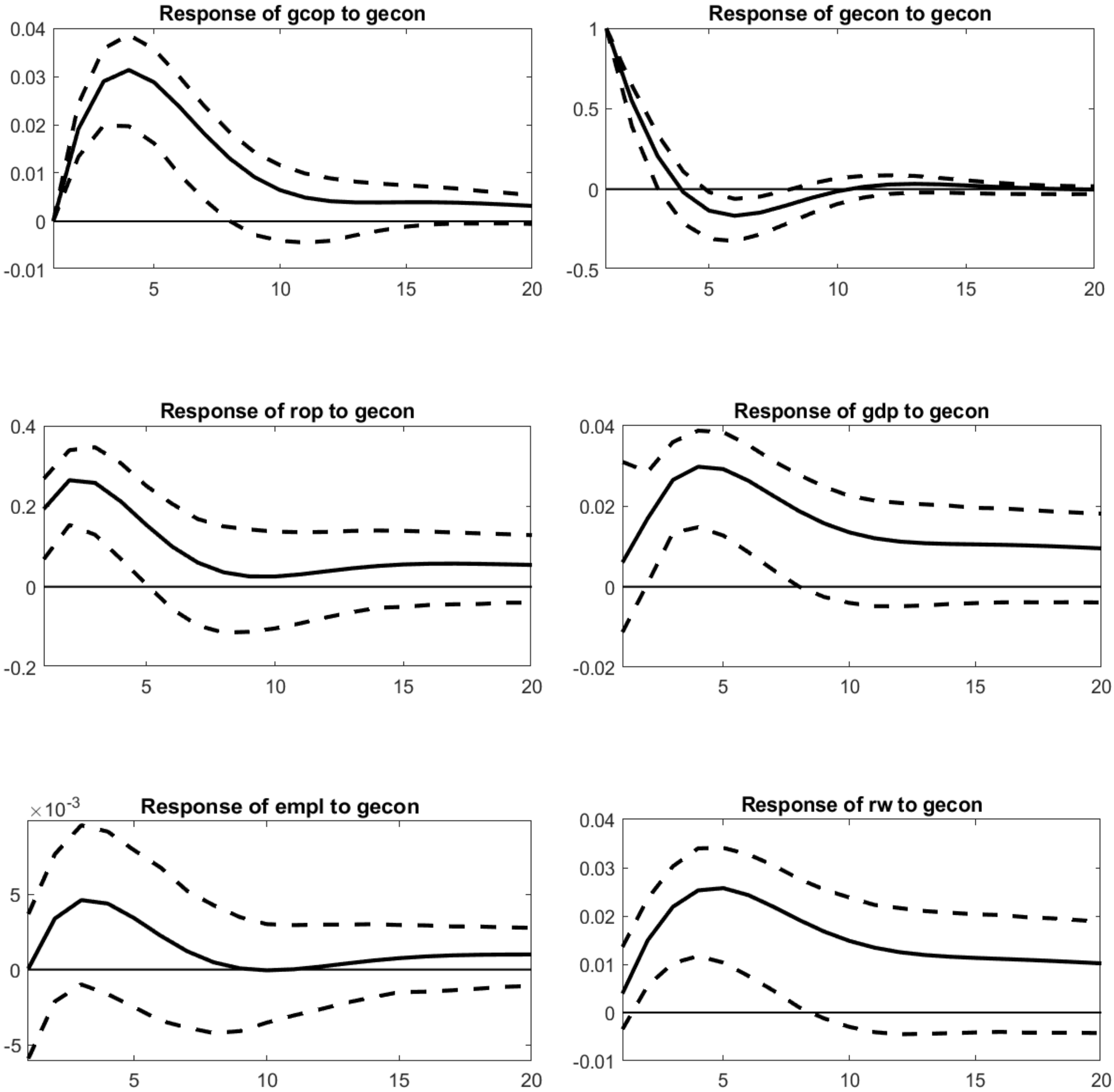
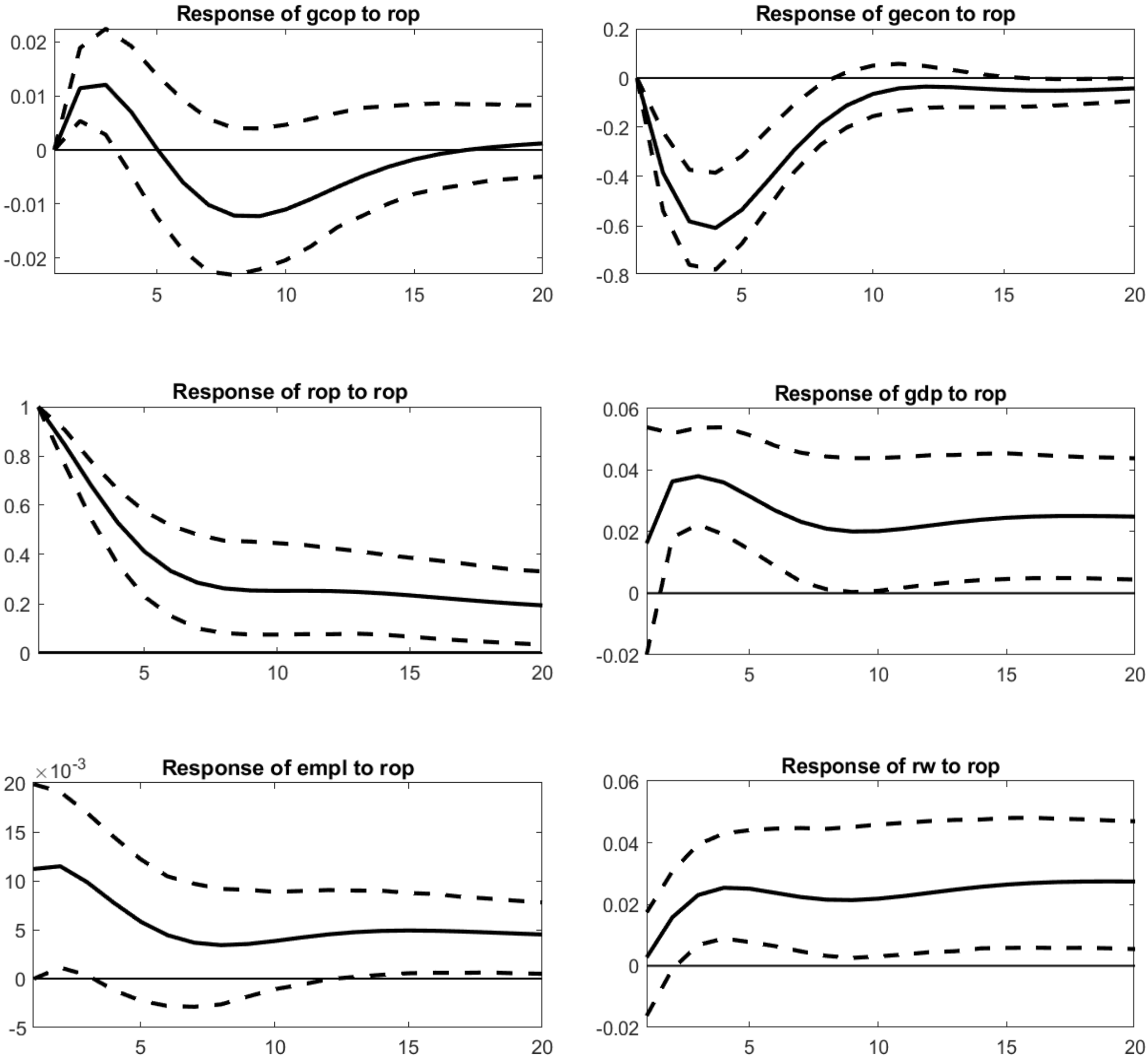


Figure 14: Response of macroeconomic variables of ME to an oil-specific demand shock



E.2 Extraction of Oil and Gas incl. Services (EOGS)

Figure 15: Response of macroeconomic variables of EOGS sector to an oil supply shock

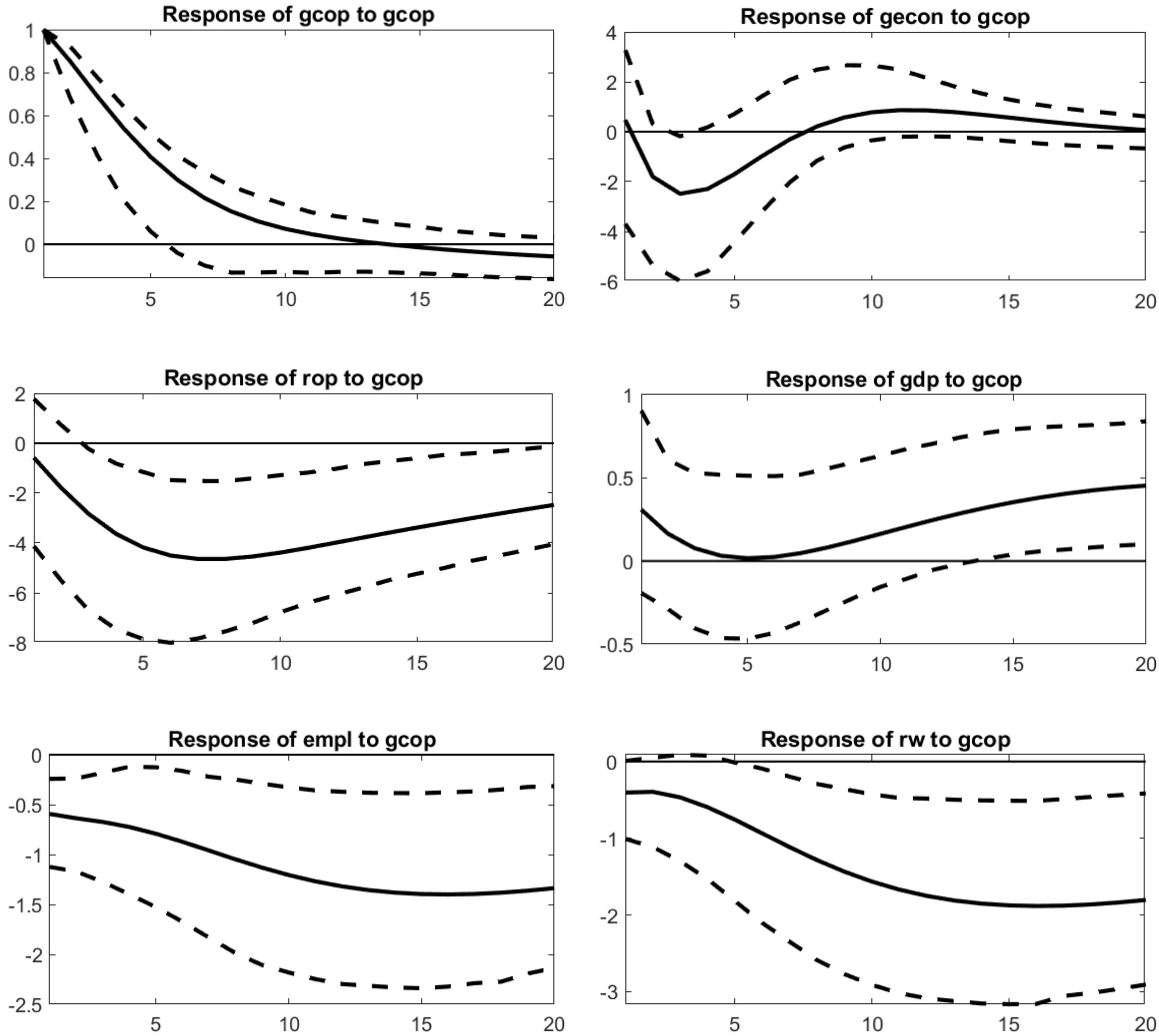


Figure 16: Response of macroeconomic variables of EOGS sector to an aggregate demand shock

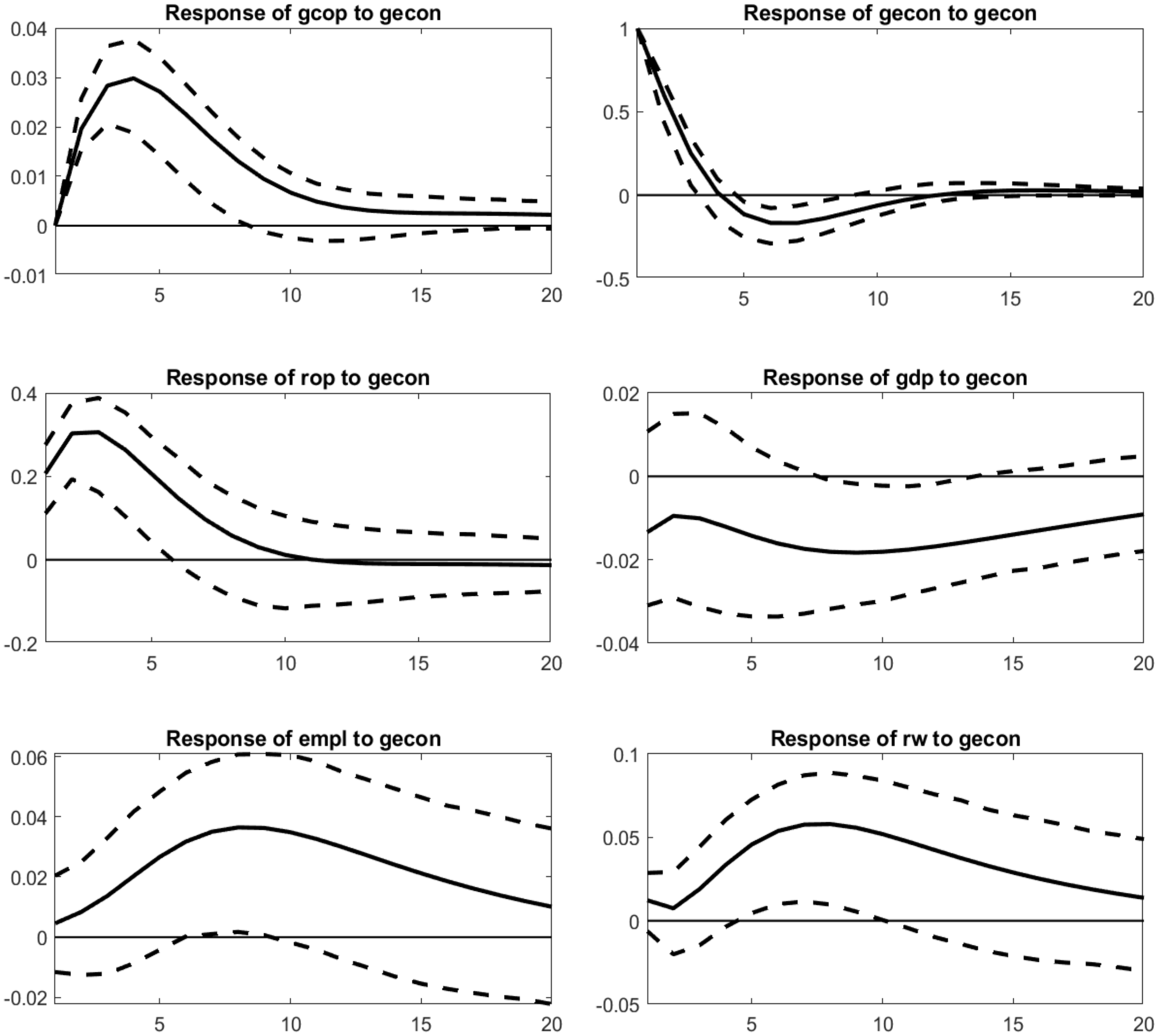
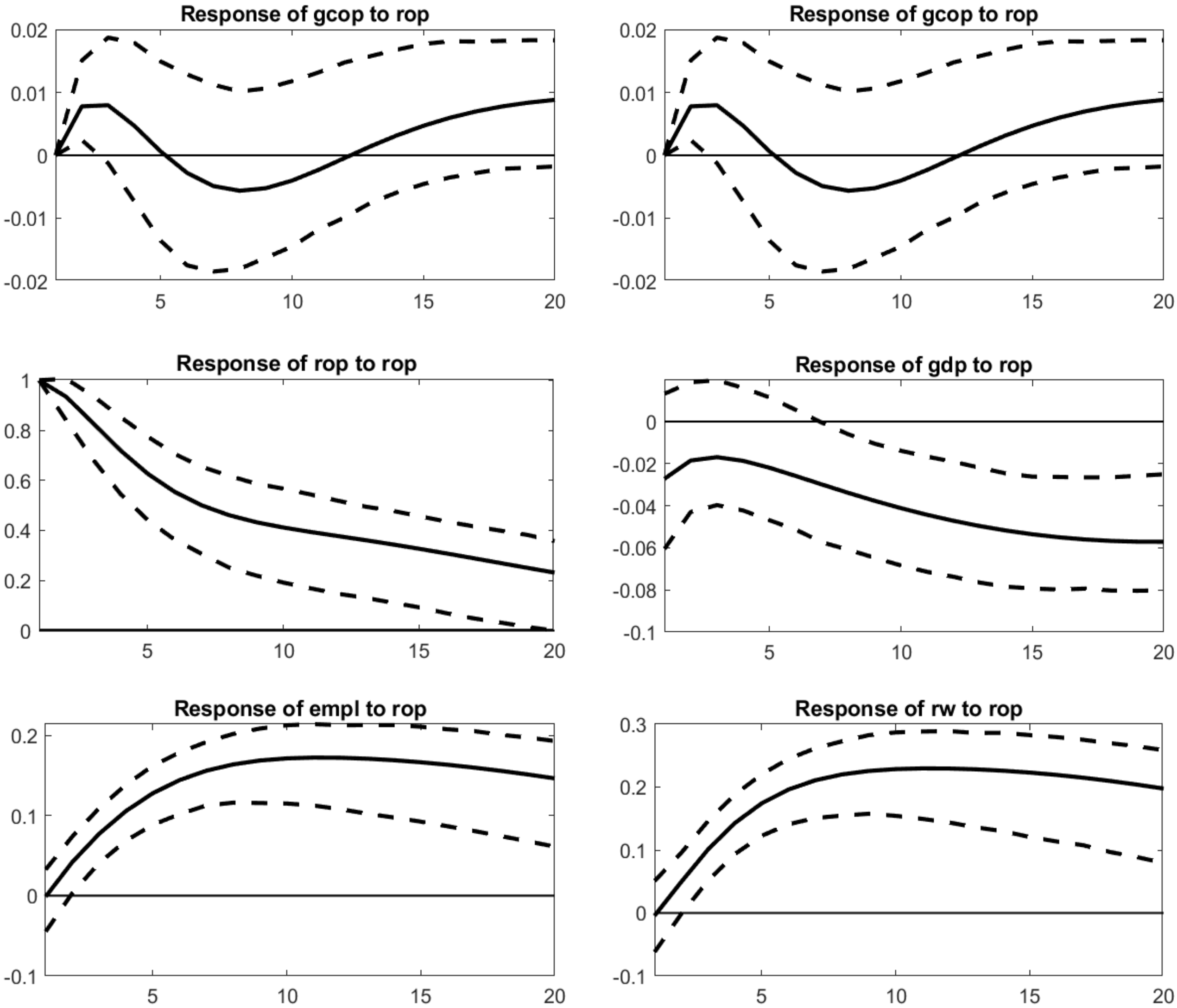


Figure 17: Response of macroeconomic variables of EOGS sector to an oil-specific demand shock



E.3 Fishing, Catching and Aquaculture (FCA)

Figure 18: Response of macroeconomic variables of FCA sector to an oil supply shock

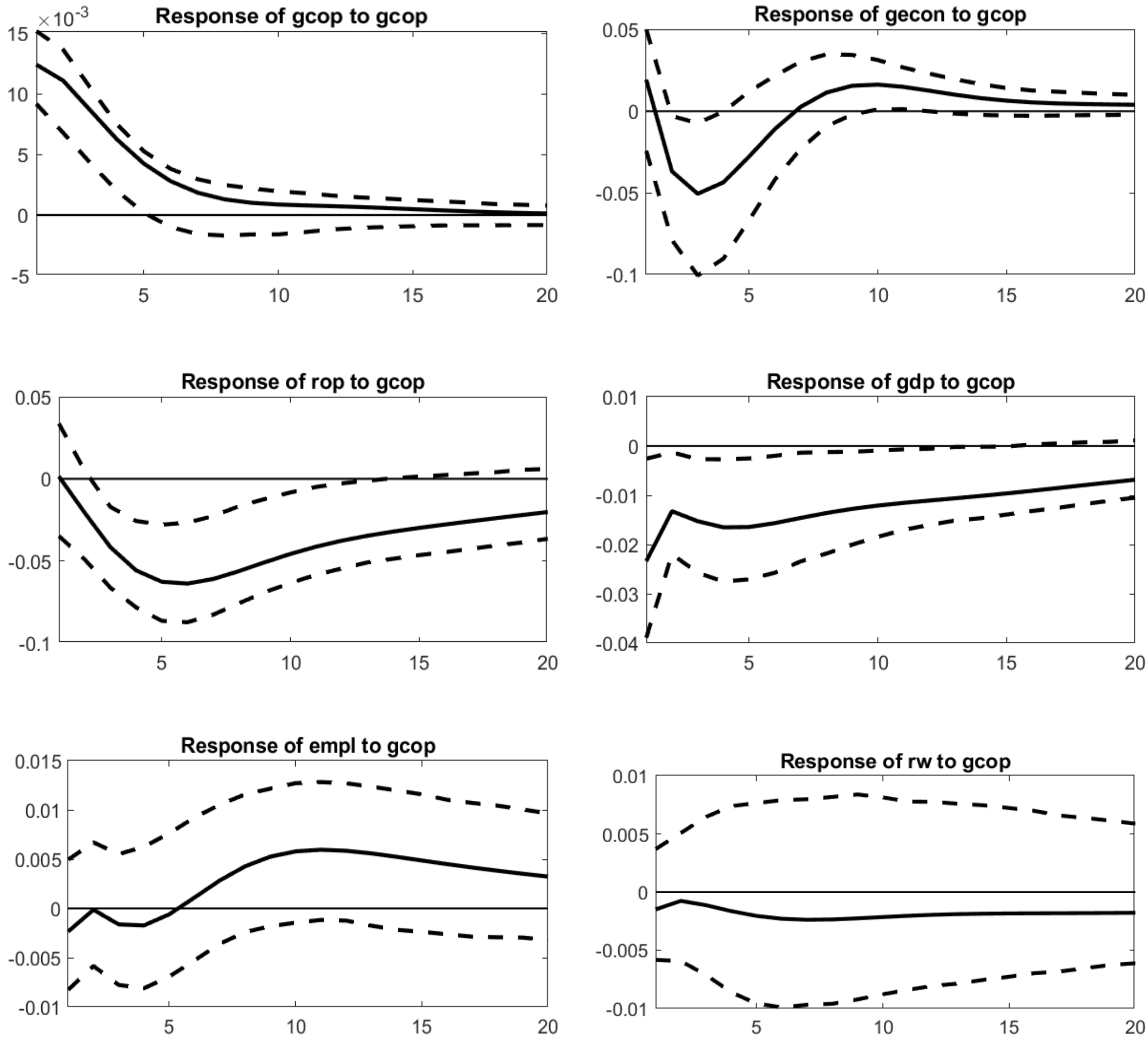


Figure 19: Response of macroeconomic variables of FCA sector to an aggregate demand shock

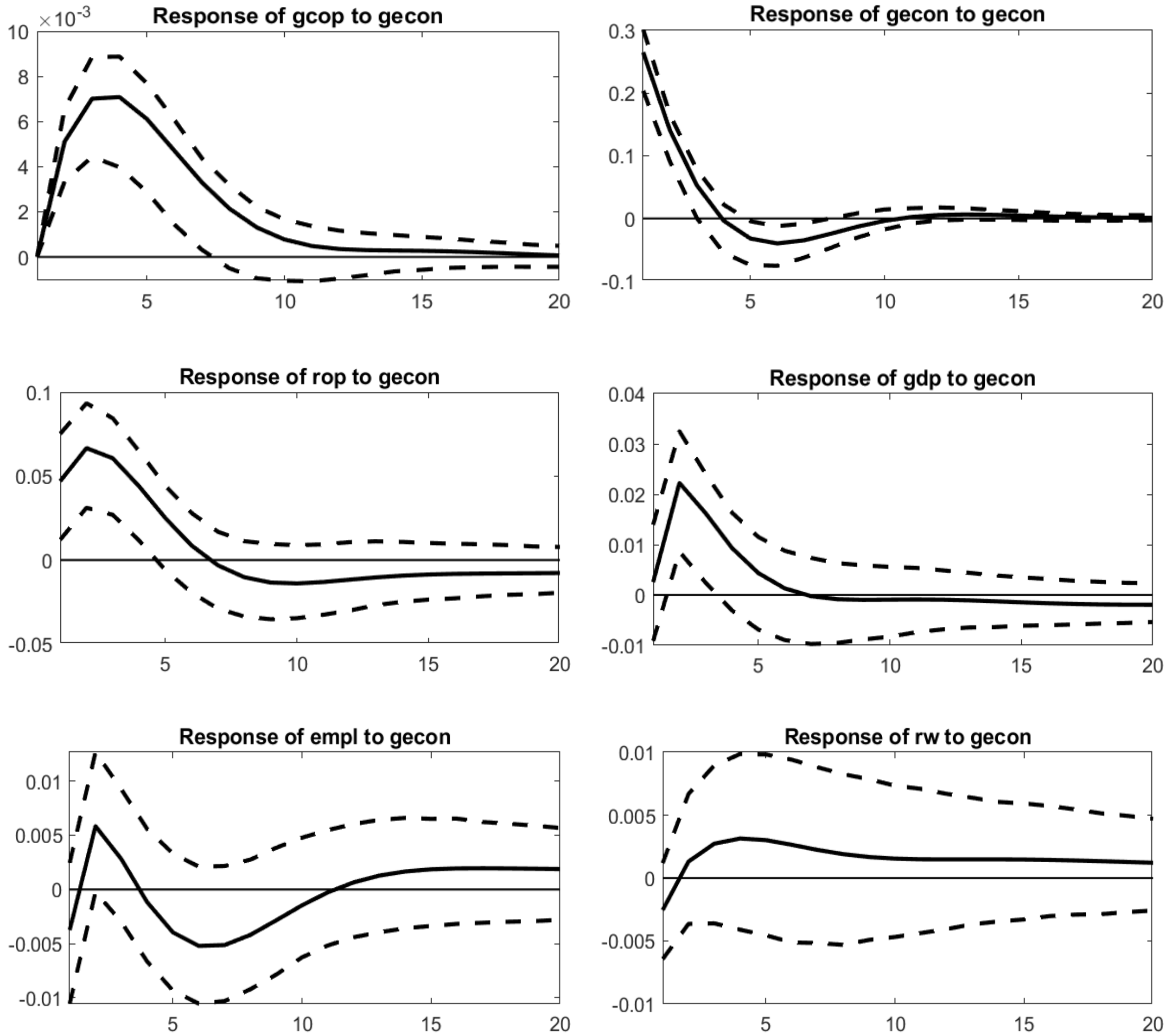
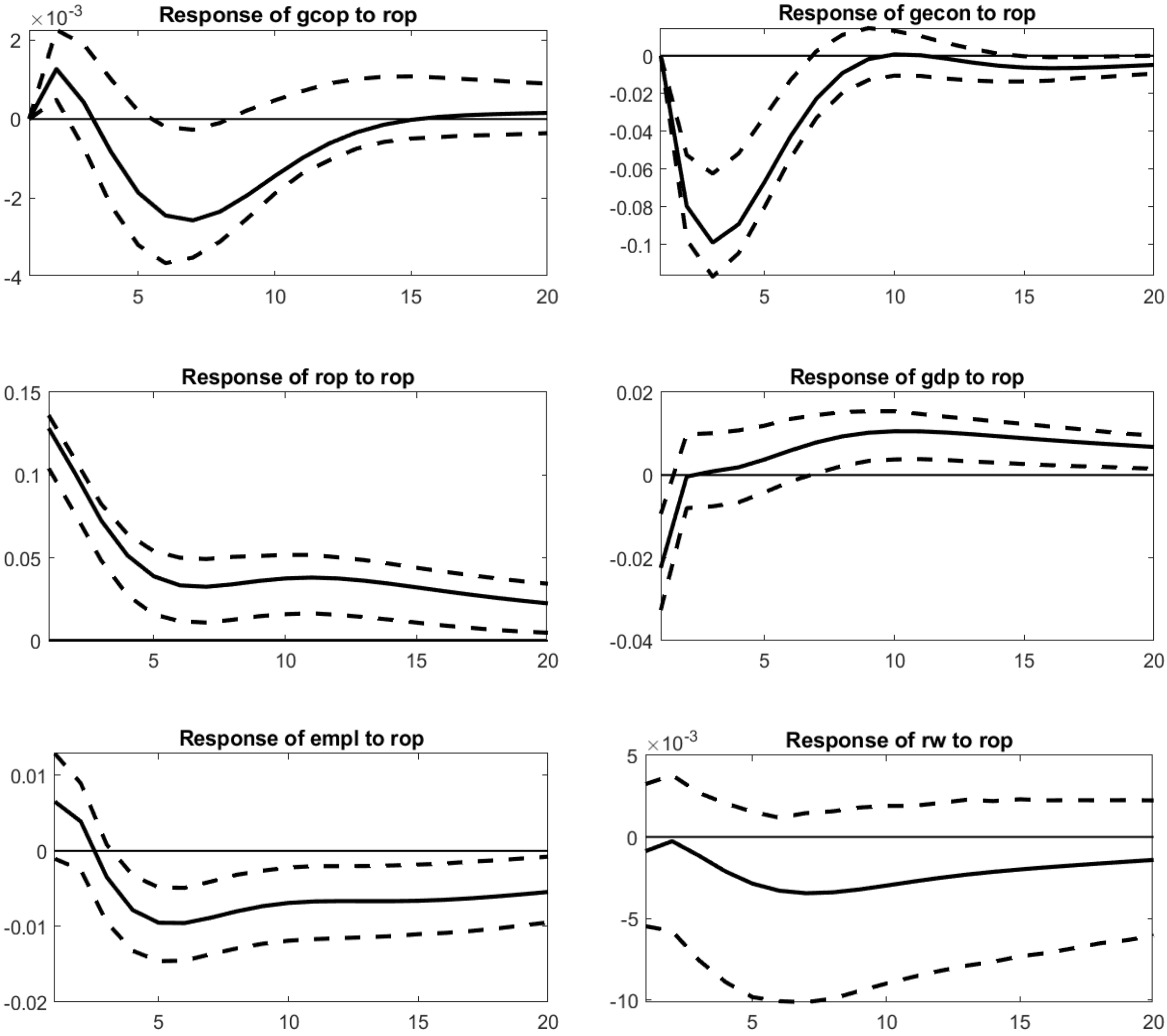


Figure 20: Response of macroeconomic variables of FCA sector to an oil-specific demand shock



E.4 Building and Construction (BC)

Figure 21: Response of macroeconomic variables of BC sector to an oil supply shock

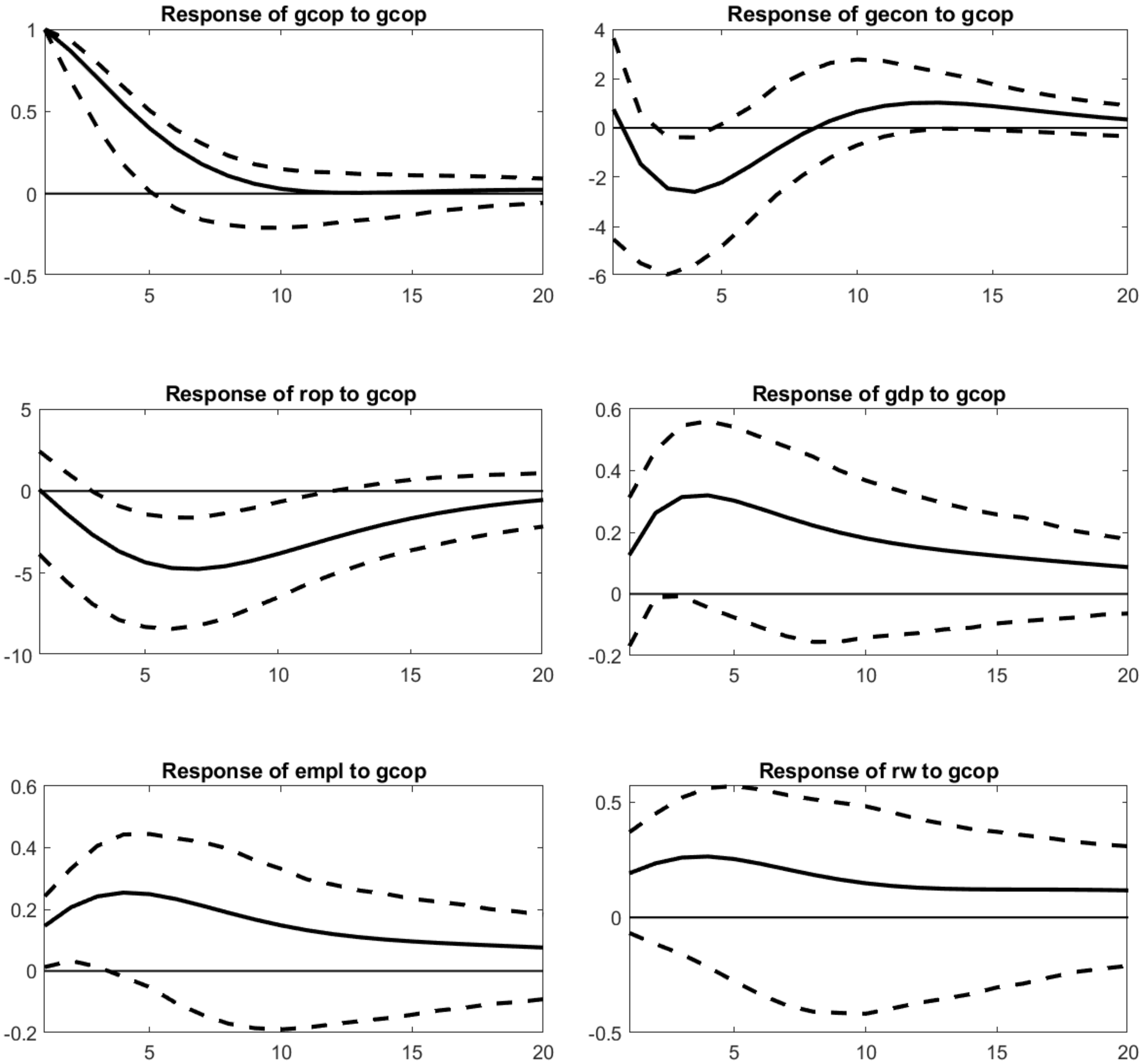


Figure 22: Response of macroeconomic variables of BC sector to an aggregate demand shock

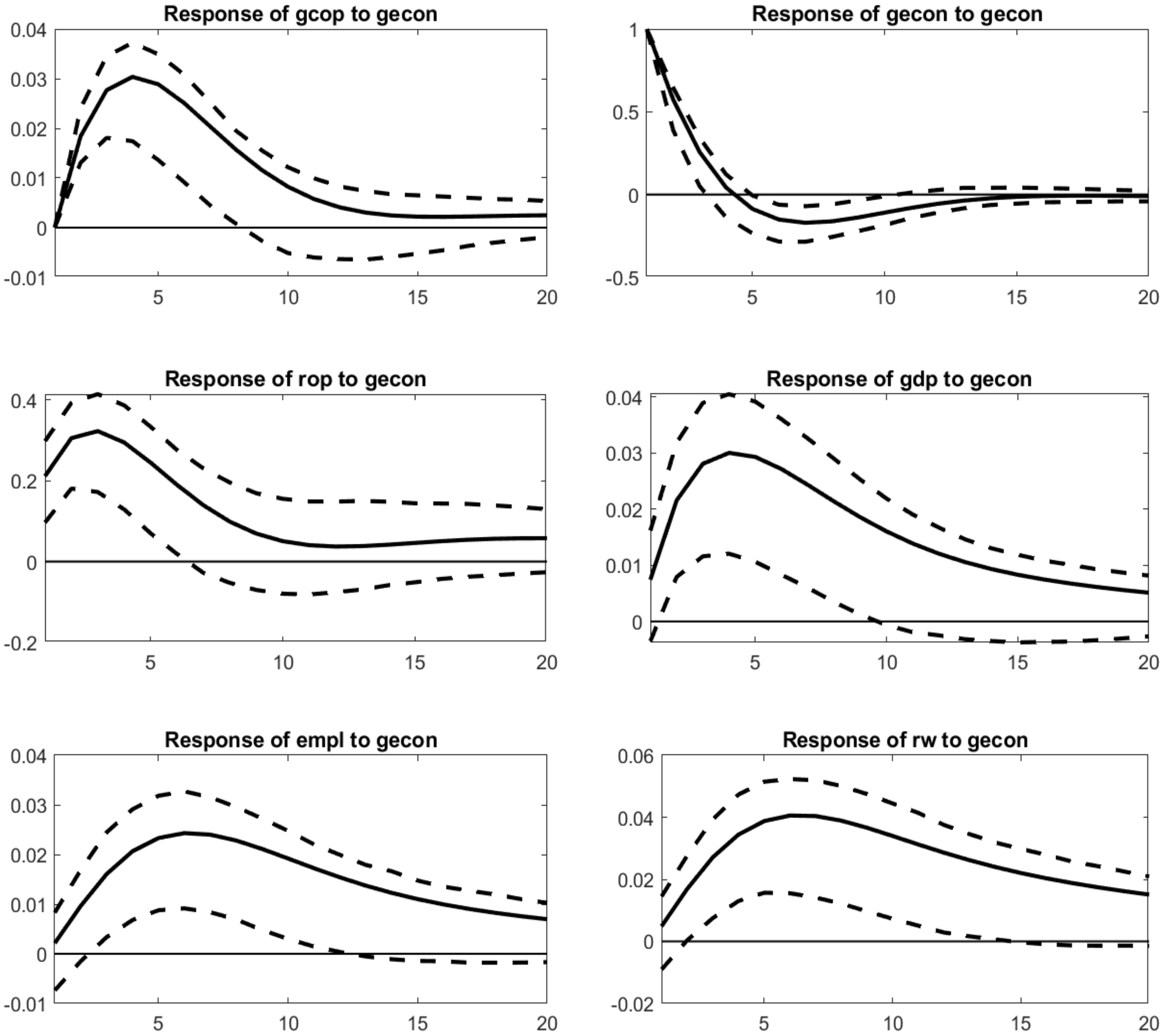
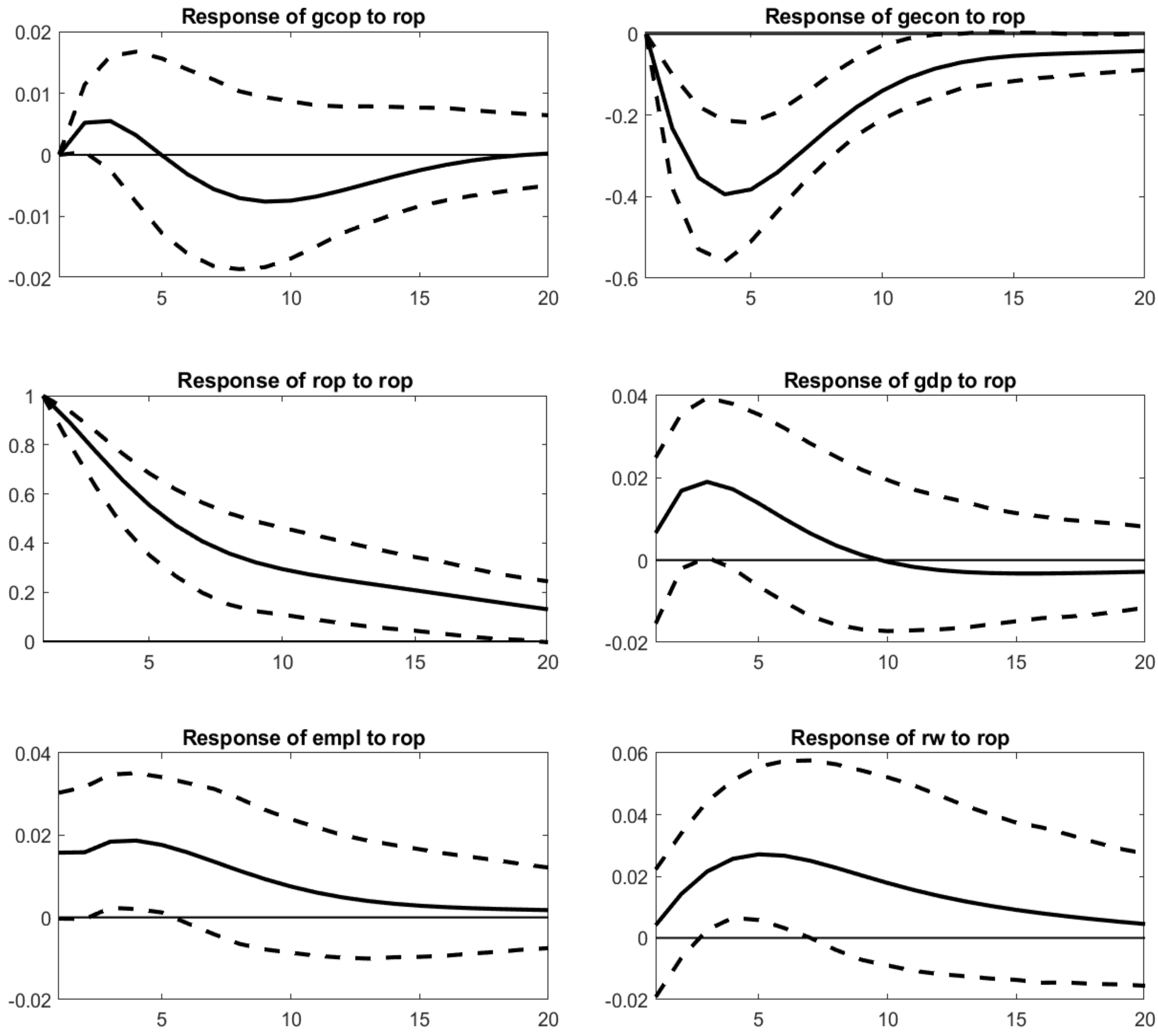


Figure 23: Response of macroeconomic variables of BC sector to an oil-specific demand shock



E.5 Maintenance and Installation of Machines and Equipments (MIME)

Figure 24: Response of macroeconomic variables of MIME sector to an oil supply shock

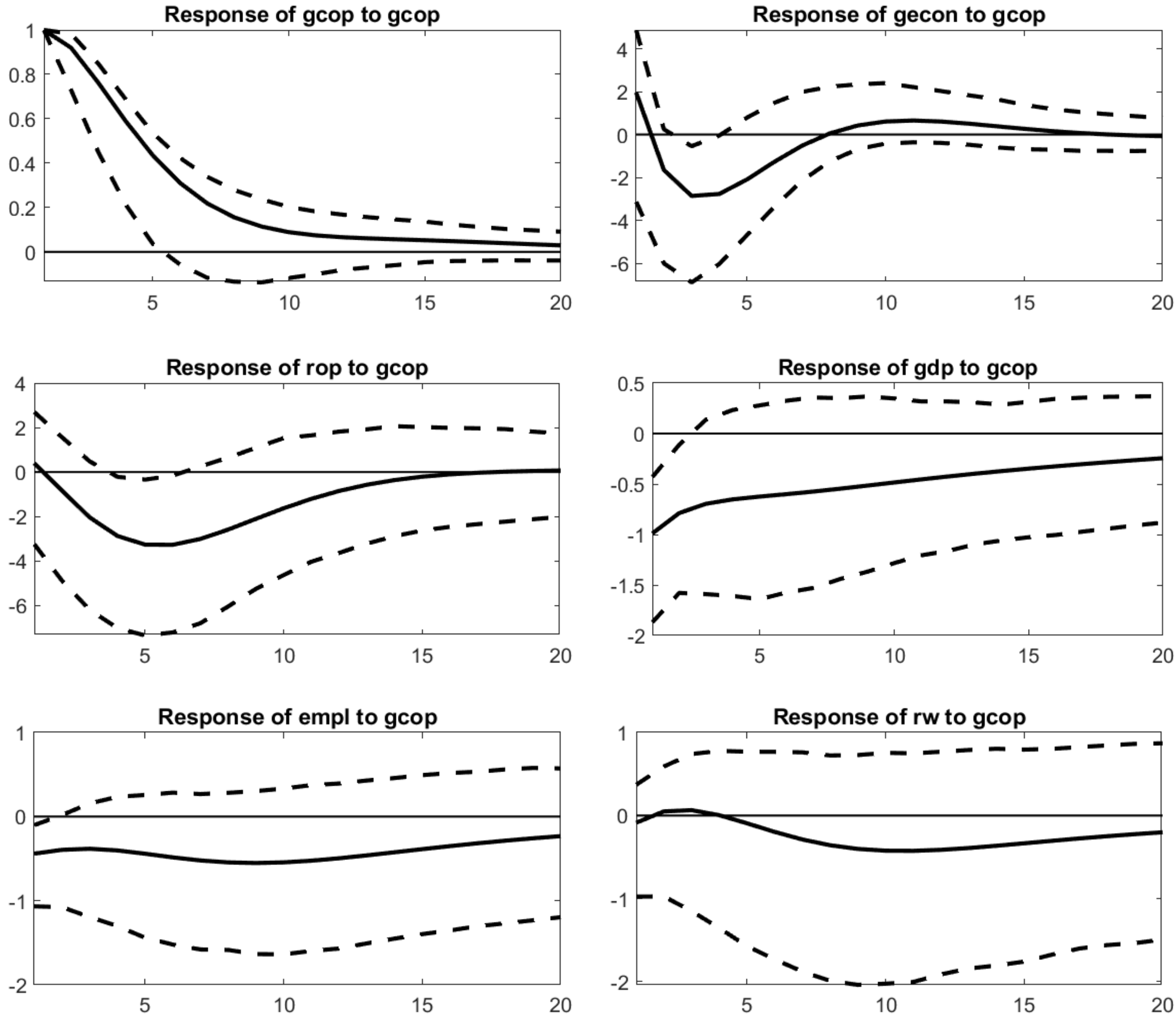


Figure 25: Response of macroeconomic variables of MIME sector to an aggregate demand shock

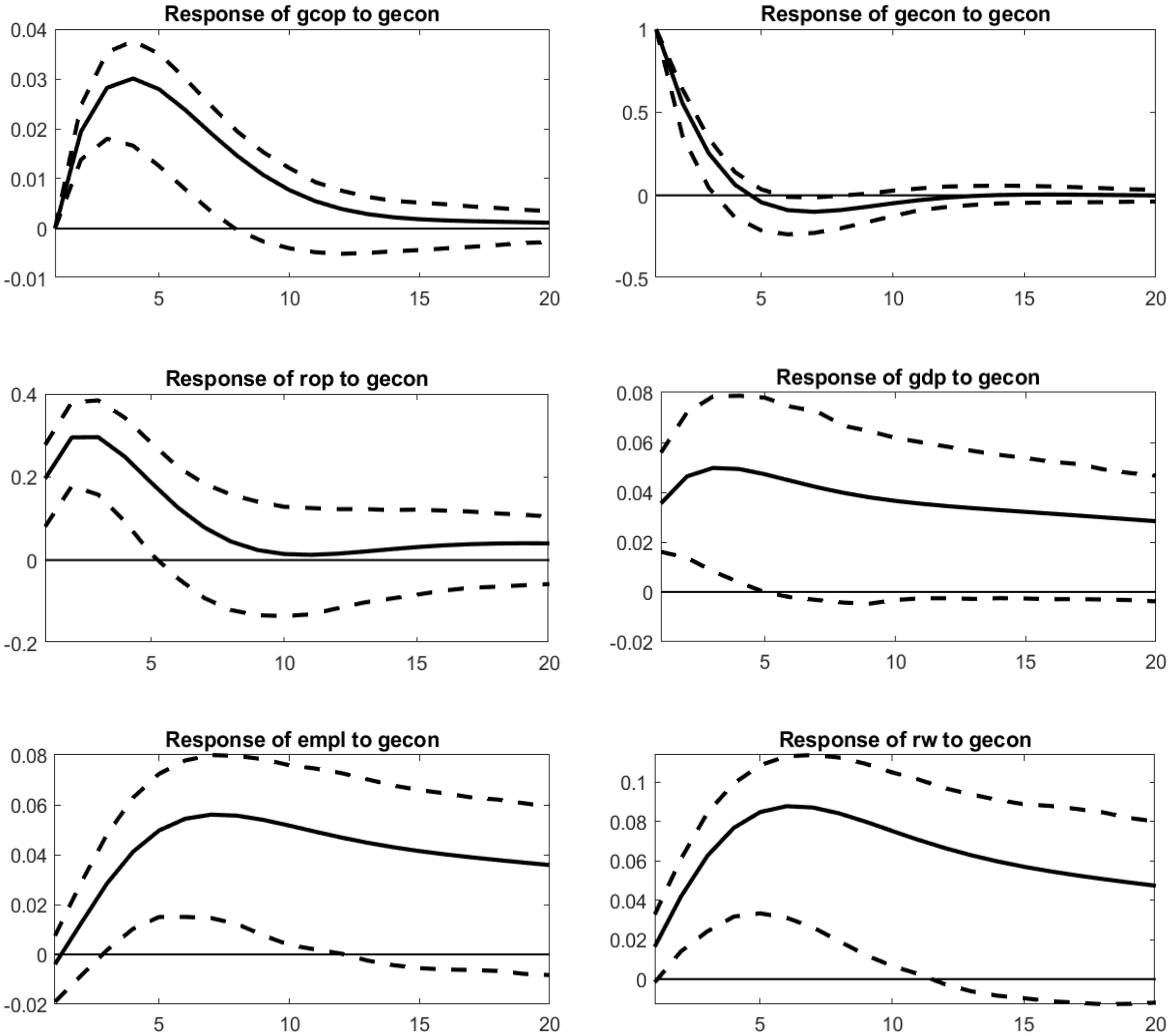
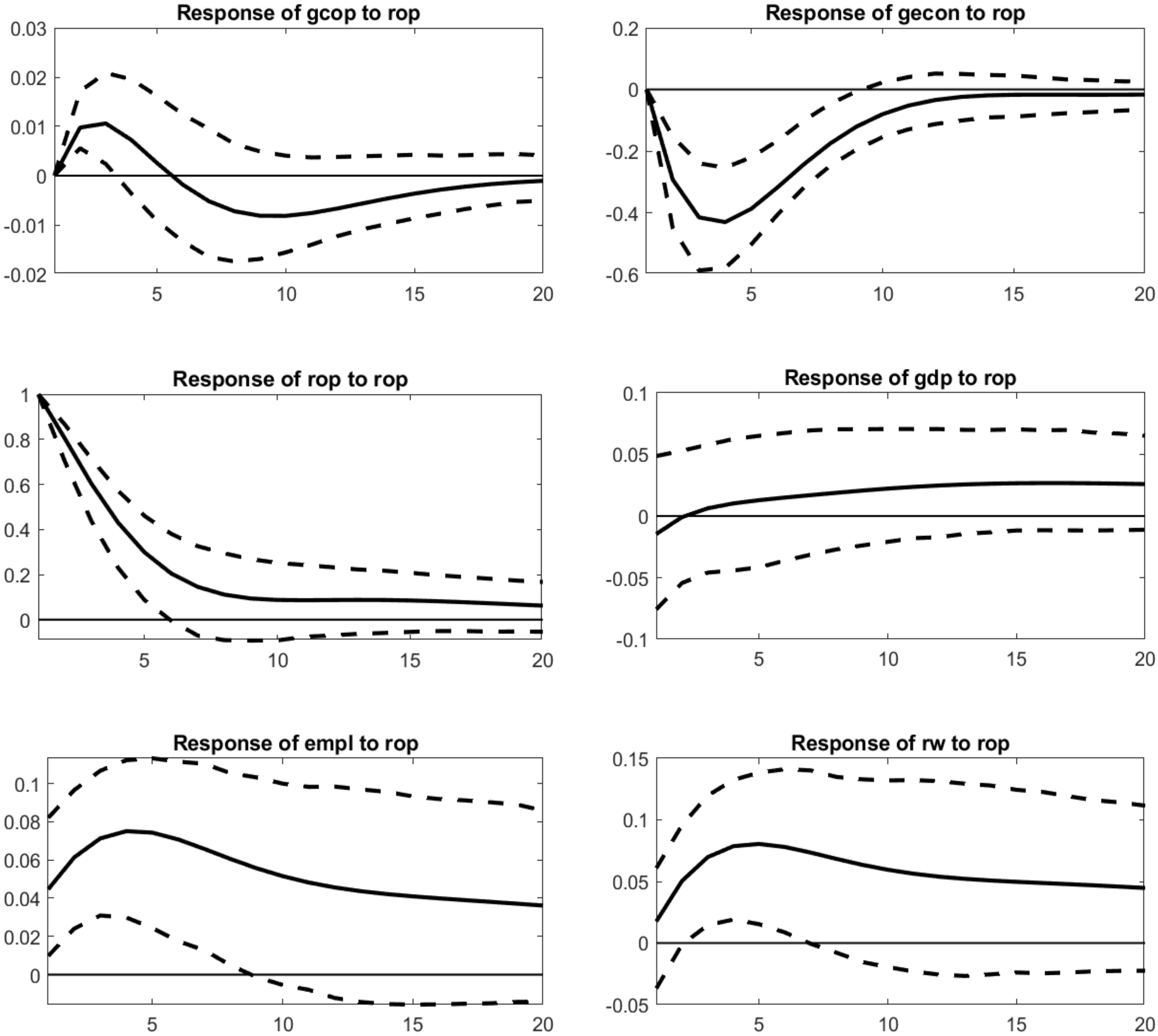


Figure 26: Response of macroeconomic variables of MIME sector to an oil-specific demand shock



E.6 Shipyard (SY)

Figure 27: Response of macroeconomic variables of SY sector to an oil supply shock

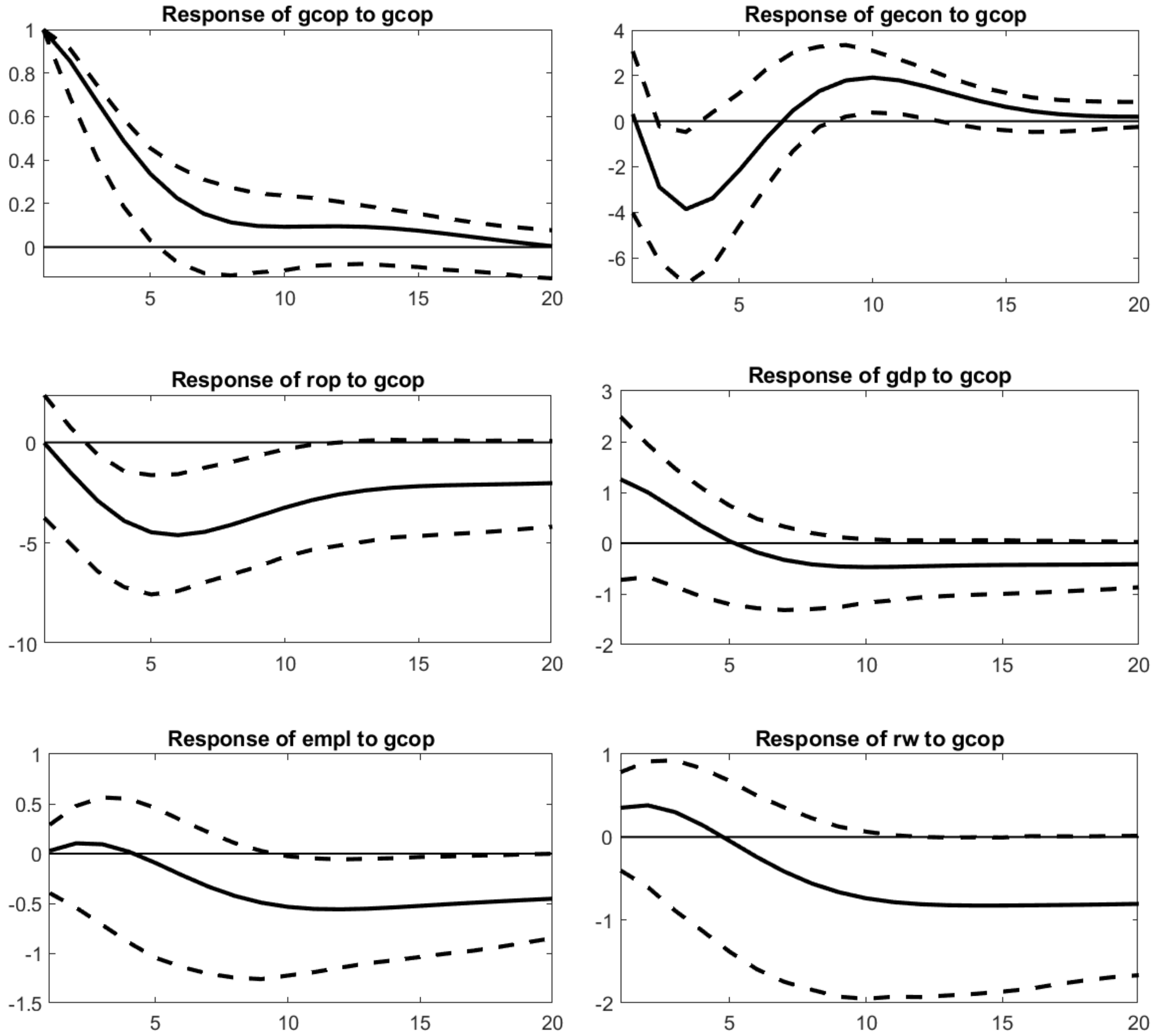


Figure 28: Response of macroeconomic variables of SY sector to an aggregate demand shock

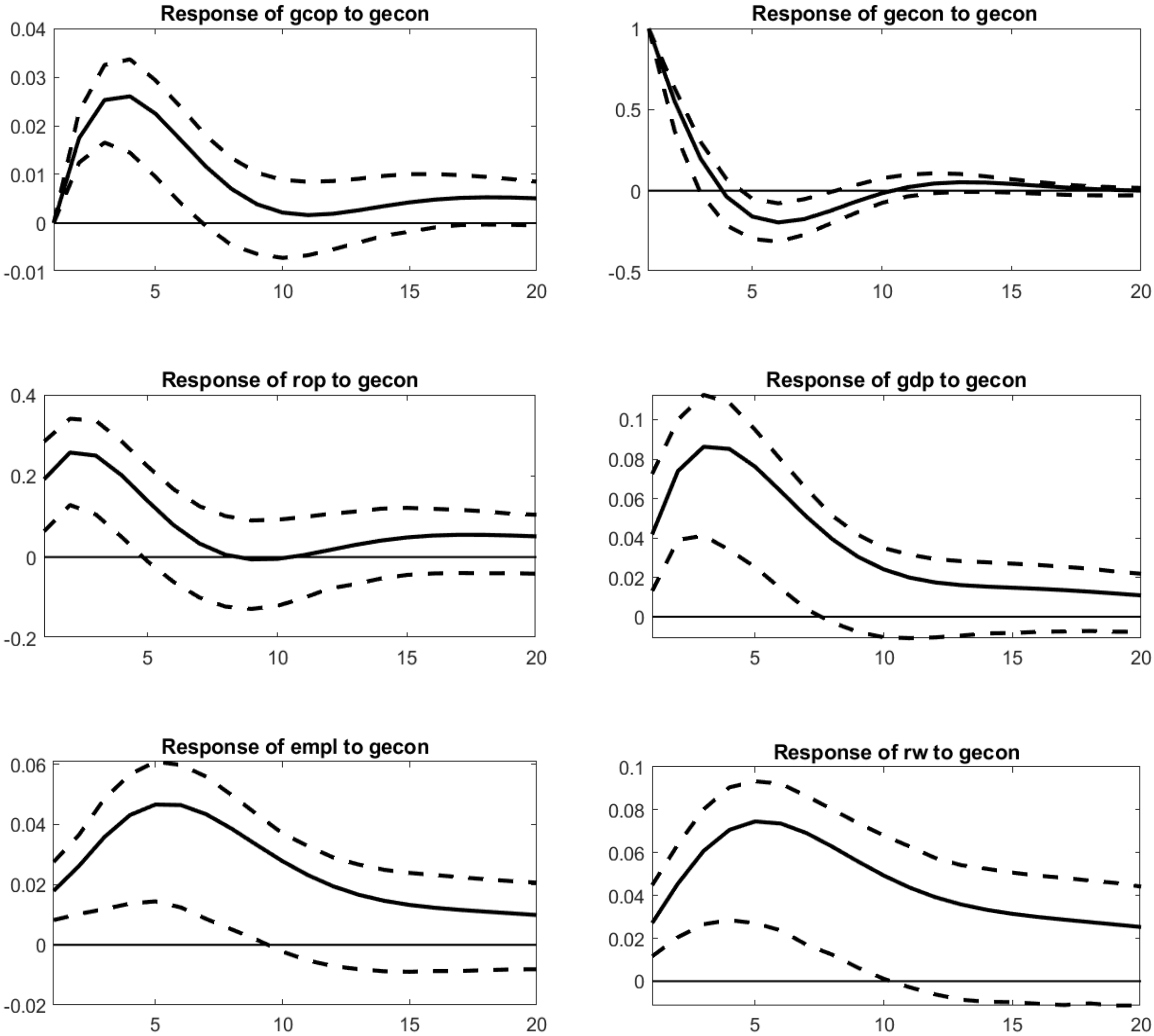
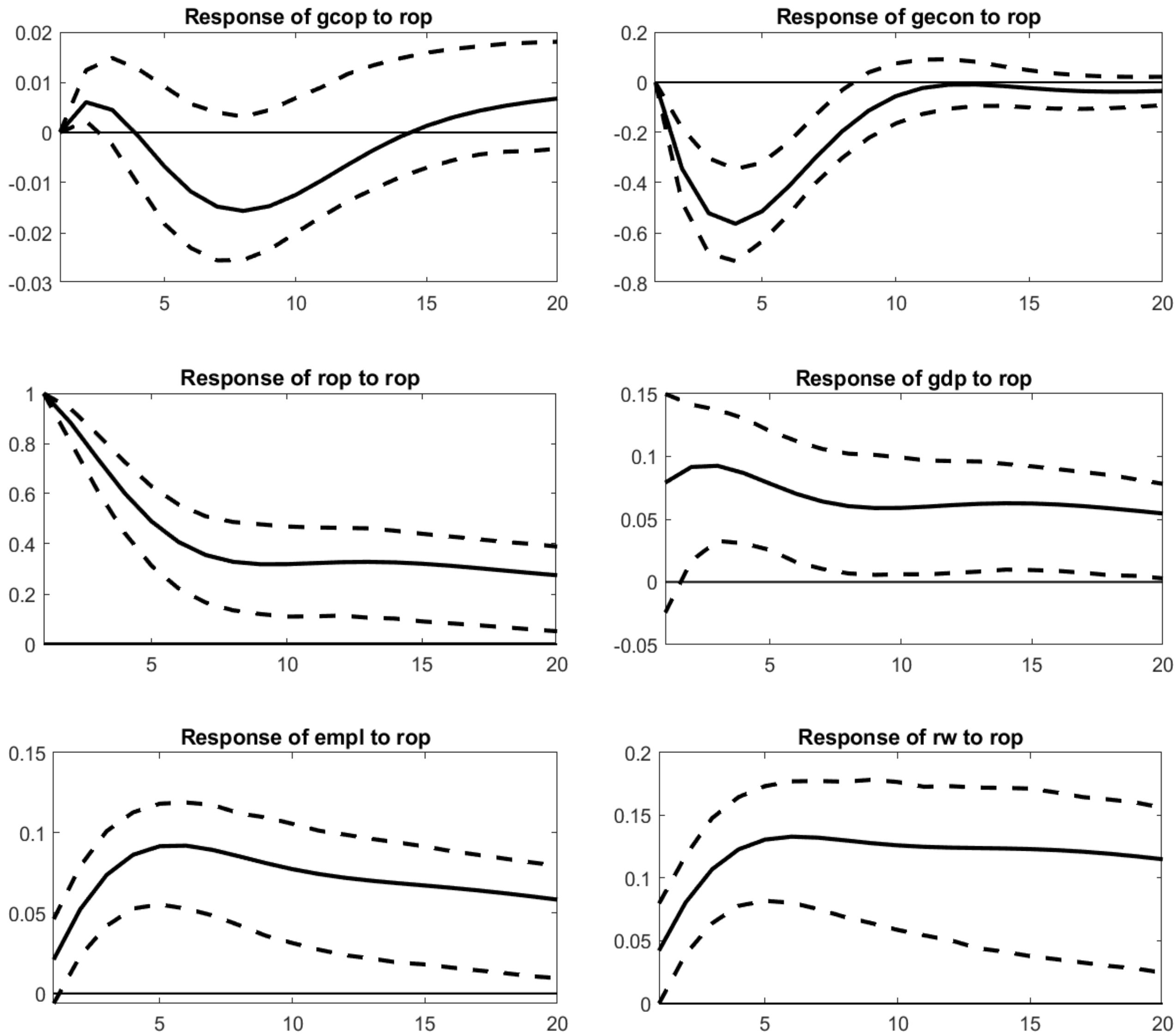


Figure 29: Response of macroeconomic variables of SY sector to an oil-specific demand shock



Appendix F: Variance Decomposition

F.1 Mainland Economy (ME)

Table O: Variance decomposition of macroeconomic variables in ME

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
ROP	1	0.0098	0.1377	0.8525	0	0	0
	2	0.057	0.2055	0.7577	0.0190	0.0101	0.0020
	3	0.0044	0.2335	0.6747	0.0409	0.0359	0.0105
	4	0.0056	0.2311	0.5986	0.0716	0.0702	0.0229
	8	0.0146	0.1593	0.4127	0.1860	0.1583	0.0692
	16	0.0193	0.1196	0.3419	0.2511	0.1558	0.1123
	20	0.0210	0.1142	0.3274	0.2622	0.1478	0.1274

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
GDP	1	0.0524	0.0031	0.0052	0.9393	0	0
	2	0.0674	0.0246	0.0277	0.8274	0.0000	0.0530
	3	0.0712	0.0675	0.0458	0.7361	0.0001	0.0793
	4	0.0679	0.1102	0.0574	0.6606	0.0002	0.1037
	8	0.0481	0.1700	0.0636	0.5264	0.0103	0.1816
	16	0.0387	0.1487	0.0693	0.4757	0.0167	0.2510
	20	0.0386	0.1421	0.0758	0.4619	0.0164	0.2653

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
EMPL	1	0.0680	0.0000	0.0353	0.0641	0.8327	0
	2	0.0742	0.0079	0.0410	0.0813	0.7944	0.0013
	3	0.0840	0.0174	0.0437	0.0800	0.7716	0.0033
	4	0.0961	0.0241	0.0445	0.0754	0.7531	0.0068
	8	0.1393	0.0268	0.0435	0.0643	0.6989	0.0271
	16	0.1612	0.0244	0.0511	0.0712	0.6389	0.0531
	20	0.1618	0.0249	0.0559	0.0777	0.6173	0.0624

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
RW	1	0.0368	0.0092	0.0010	0.1319	0.0378	0.7834
	2	0.0345	0.0689	0.0170	0.1701	0.0645	0.6450
	3	0.0278	0.1339	0.0337	0.1542	0.0712	0.5792
	4	0.0213	0.1842	0.0447	0.1460	0.0662	0.5376
	8	0.0137	0.2278	0.0544	0.1753	0.0367	0.4921
	16	0.0243	0.1733	0.0686	0.2430	0.0209	0.4699
	20	0.0288	0.1590	0.0784	0.2579	0.0182	0.4577

F.2 Extraction of Oil and Gas incl. Services (EOGS)

Table P: Variance decomposition of macroeconomic variables in EOGS sector

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
ROP	1	0.0025	0.1763	0.8212	0	0	0
	2	0.0120	0.2536	0.7011	0.0002	0.0044	0.0287
	3	0.0258	0.2839	0.6320	0.0016	0.0058	0.0510
	4	0.0431	0.2894	0.5937	0.0043	0.0054	0.0640
	8	0.1221	0.2414	0.5428	0.0183	0.0043	0.0712
	16	0.2013	0.1852	0.5231	0.0282	0.0045	0.0576
	20	0.2157	0.1755	0.5203	0.0295	0.0043	0.0546

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
GDP	1	0.0113	0.0118	0.0097	0.9673	0	0
	2	0.0090	0.0110	0.0088	0.9653	0.0047	0.0012
	3	0.0076	0.0121	0.0089	0.9585	0.0114	0.0015
	4	0.0067	0.0149	0.0099	0.9487	0.0184	0.0013
	8	0.0058	0.0375	0.0227	0.8841	0.0434	0.0065
	16	0.0249	0.0694	0.0865	0.7239	0.0665	0.0288
	20	0.0455	0.0708	0.1224	0.6600	0.0673	0.0339

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
EMPL	1	0.0584	0.0020	0.0000	0.0007	0.9389	0
	2	0.0717	0.0048	0.0185	0.0040	0.8864	0.0146
	3	0.0818	0.0106	0.0578	0.0060	0.8126	0.0313
	4	0.0901	0.0200	0.1086	0.0065	0.7285	0.0463
	8	0.1236	0.0665	0.2846	0.0037	0.4410	0.0805
	16	0.2055	0.0701	0.4048	0.0095	0.2316	0.0785
	20	0.2357	0.0611	0.4251	0.0133	0.1938	0.0710

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
RW	1	0.0166	0.0085	0.0002	0.0015	0.4648	0.5084
	2	0.0185	0.0067	0.0158	0.0009	0.5666	0.3916
	3	0.0221	0.0129	0.0574	0.0006	0.5804	0.3266
	4	0.0277	0.0293	0.1138	0.0005	0.5436	0.2852
	8	0.0705	0.1001	0.2900	0.0014	0.3338	0.2042
	16	0.1764	0.0909	0.4019	0.0110	0.1815	0.1383
	20	0.2117	0.0781	0.4225	0.0149	0.1527	0.1202

F.3 Fishing, Catching and Aquaculture (FCA)

Table Q: Variance decomposition of macroeconomic variables in FCA sector

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
ROP	1	0.0001	0.1181	0.8817	0	0	0
	2	0.0124	0.1942	0.7794	0.0043	0.0092	0.0005
	3	0.0460	0.2208	0.6836	0.0203	0.0268	0.0023
	4	0.0914	0.2130	0.6015	0.0410	0.0480	0.0052
	8	0.2236	0.1452	0.4383	0.0762	0.0909	0.0258
	16	0.2577	0.1141	0.4006	0.0622	0.0762	0.0891
	20	0.2551	0.1077	0.3906	0.0579	0.0707	0.1180

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
GDP	1	0.0607	0.0007	0.0558	0.8828	0	0
	2	0.0631	0.0438	0.0439	0.7794	0.0592	0.0107
	3	0.0715	0.0572	0.0377	0.7108	0.1066	0.0162
	4	0.0829	0.0575	0.0342	0.6691	0.1382	0.0181
	8	0.1200	0.0489	0.0395	0.5939	0.1806	0.0170
	16	0.1530	0.0437	0.0728	0.5321	0.1746	0.0239
	20	0.1594	0.0429	0.0808	0.5152	0.1695	0.0322

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
EMPL	1	0.0023	0.0059	0.0179	0.0006	0.9734	0
	2	0.0016	0.0141	0.0169	0.0605	0.8864	0.0205
	3	0.0020	0.0141	0.0175	0.0797	0.8378	0.0490
	4	0.0025	0.0130	0.0296	0.0846	0.7881	0.0823
	8	0.0063	0.0232	0.0733	0.0833	0.5983	0.2156
	16	0.0294	0.0179	0.0882	0.0662	0.4086	0.3897
	20	0.0313	0.0173	0.0915	0.0588	0.3626	0.4385

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
RW	1	0.0021	0.0061	0.0007	0.0000	0.0006	0.9904
	2	0.0013	0.0039	0.0004	0.0014	0.0008	0.9921
	3	0.0013	0.0051	0.0007	0.0011	0.0019	0.9898
	4	0.0017	0.0064	0.0017	0.0009	0.0036	0.9857
	8	0.0039	0.0071	0.0069	0.0018	0.0115	0.9688
	16	0.0053	0.0062	0.0090	0.0031	0.0191	0.9573
	20	0.0059	0.0062	0.0089	0.0035	0.0210	0.9545

F.4 Building and Construction (BC)

Table R: Variance decomposition of macroeconomic variables in BC sector

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
ROP	1	0.0001	0.1837	0.8163	0	0	0
	2	0.0068	0.2760	0.7123	0.0007	0.0000	0.0042
	3	0.0221	0.3258	0.6378	0.0018	0.0000	0.0125
	4	0.0433	0.3446	0.5858	0.0031	0.0001	0.0230
	8	0.1334	0.3062	0.4874	0.0148	0.0041	0.0542
	16	0.1719	0.2520	0.4400	0.0518	0.0329	0.0514
	20	0.1668	0.2472	0.4299	0.0623	0.0444	0.0494

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
GDP	1	0.0073	0.0138	0.0021	0.9767	0	0
	2	0.0225	0.0744	0.0093	0.8533	0.0294	0.0111
	3	0.0350	0.1347	0.0141	0.7335	0.0619	0.0209
	4	0.0436	0.1822	0.0161	0.6463	0.0859	0.0258
	8	0.0584	0.2716	0.0148	0.5048	0.1250	0.0254
	16	0.0677	0.2972	0.0133	0.4631	0.1364	0.0223
	20	0.0699	0.2991	0.0134	0.4585	0.1369	0.0221

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
EMPL	1	0.0230	0.0026	0.0314	0.2124	0.7306	0
	2	0.0355	0.0291	0.0372	0.2562	0.6414	0.0005
	3	0.0456	0.0714	0.0409	0.2742	0.5666	0.0013
	4	0.0524	0.1183	0.0424	0.2772	0.5079	0.0018
	8	0.0595	0.2518	0.0385	0.2583	0.3905	0.0014
	16	0.0589	0.3096	0.0312	0.2500	0.3472	0.0031
	20	0.0597	0.3139	0.0300	0.2500	0.3428	0.0035

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
RW	1	0.0183	0.0064	0.0009	0.0996	0.2862	0.5886
	2	0.0238	0.0432	0.0061	0.1637	0.2615	0.5017
	3	0.0274	0.0969	0.0126	0.2056	0.2420	0.4154
	4	0.0290	0.1524	0.0182	0.2280	0.2272	0.3452
	8	0.0269	0.2909	0.0266	0.2453	0.2022	0.2082
	16	0.0241	0.3421	0.0248	0.2523	0.2057	0.1511
	20	0.0249	0.3461	0.0239	0.2540	0.2083	0.1428

F.5 Maintenance and Installation of Machines and Equipments (MIME)

Table S: Variance decomposition of macroeconomic variables in MIME sector

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
ROP	1	0.0014	0.1757	0.8229	0	0	0
	2	0.0036	0.2868	0.6772	0.0031	0.0037	0.0255
	3	0.0145	0.3292	0.5596	0.0064	0.0132	0.0771
	4	0.0294	0.3261	0.4694	0.0095	0.0253	0.1403
	8	0.0642	0.2278	0.2904	0.0245	0.0548	0.3382
	16	0.0549	0.1652	0.2132	0.0592	0.0559	0.4516
	20	0.0509	0.1562	0.1995	0.0689	0.0551	0.4694

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
GDP	1	0.0566	0.0389	0.0012	0.9033	0	0
	2	0.0531	0.0604	0.0007	0.8828	0.0030	0.0000
	3	0.0517	0.0780	0.0006	0.8630	0.0066	0.0001
	4	0.0516	0.0915	0.0007	0.8457	0.0096	0.0009
	8	0.0553	0.1207	0.0019	0.7917	0.0154	0.0149
	16	0.0572	0.1460	0.0065	0.6856	0.0147	0.0901
	20	0.0553	0.1521	0.0086	0.6338	0.0135	0.1366

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
EMPL	1	0.0299	0.0013	0.0296	0.3148	0.6243	0
	2	0.0292	0.0076	0.0462	0.3616	0.5510	0.0044
	3	0.0289	0.0305	0.0608	0.3847	0.4789	0.0161
	4	0.0294	0.0639	0.0709	0.3886	0.4112	0.0359
	8	0.0369	0.1709	0.0751	0.3205	0.2280	0.1686
	16	0.0390	0.1921	0.0569	0.1911	0.1171	0.4038
	20	0.0351	0.1868	0.0521	0.1581	0.0984	0.4694

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
RW	1	0.0010	0.0187	0.0038	0.3028	0.2095	0.4642
	2	0.0006	0.0697	0.0176	0.2801	0.1838	0.4482
	3	0.0006	0.1301	0.0304	0.2500	0.1517	0.4372
	4	0.0004	0.1838	0.0389	0.2203	0.1217	0.4349
	8	0.0034	0.2716	0.0432	0.1370	0.0554	0.4894
	16	0.0086	0.2424	0.0344	0.0718	0.0303	0.6125
	20	0.0083	0.2272	0.0326	0.0605	0.0277	0.6438

F.6 Shipyard (SY)

Table T: Variance decomposition of macroeconomic variables in SY sector

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
ROP	1	0.0000	0.1389	0.8611	0	0	0
	2	0.0090	0.1984	0.7814	0.0006	0.0004	0.0102
	3	0.0291	0.2220	0.7116	0.0028	0.0006	0.0339
	4	0.0560	0.2188	0.6515	0.0064	0.0005	0.0668
	8	0.1406	0.1551	0.5068	0.0135	0.0011	0.1830
	16	0.1652	0.1202	0.4742	0.0132	0.0076	0.2196
	20	0.1684	0.1161	0.4727	0.0150	0.0105	0.2173

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
GDP	1	0.0811	0.0439	0.0359	0.8391	0	0
	2	0.0777	0.1061	0.0493	0.7577	0.0061	0.0031
	3	0.0691	0.1639	0.0594	0.6884	0.0141	0.0051
	4	0.0607	0.2078	0.0667	0.6379	0.0216	0.0054
	8	0.0519	0.2643	0.0835	0.5527	0.0423	0.0053
	16	0.0660	0.2490	0.1159	0.5067	0.0549	0.0075
	20	0.0722	0.2426	0.1298	0.4921	0.0556	0.0078

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
EMPL	1	0.0002	0.0473	0.0150	0.1834	0.7541	0
	2	0.0017	0.0740	0.0534	0.2522	0.6169	0.0018
	3	0.0020	0.1088	0.0938	0.2851	0.5066	0.0038
	4	0.0015	0.1443	0.1280	0.2943	0.4274	0.0046
	8	0.0138	0.2194	0.2043	0.2679	0.2911	0.0035
	16	0.0689	0.1970	0.2624	0.2306	0.2300	0.0111
	20	0.0843	0.1857	0.2805	0.2213	0.2158	0.0124

Variable	Period	GCOP	GECON	ROP	GDP	EMPL	RW
RW	1	0.0178	0.0517	0.0286	0.2052	0.3227	0.3741
	2	0.0192	0.0978	0.0656	0.2179	0.2974	0.3021
	3	0.0166	0.1469	0.1015	0.2154	0.2686	0.2509
	4	0.0128	0.1896	0.1310	0.2054	0.2433	0.2178
	8	0.0156	0.2570	0.1957	0.1614	0.1877	0.1827
	16	0.0592	0.2187	0.2562	0.1284	0.1531	0.1844
	20	0.0748	0.2034	0.2784	0.1224	0.1433	0.1778