Momina Javaid Butt

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Oil Price Shocks and the Norwegian Economy – A Sector-Specific Study

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Supervisor
Hilde C. Bjørnland

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Abstract

In this paper, I compare the macroeconomic consequences of two types of oil price shocks on different sectors in Norway by the use of a Structural Autoregressive (SVAR) model. The two structural shocks are each identified as global demand shock and oil-specific shock, which is the decomposition of the real oil price proposed by Kilian (2009). Economic activity is measured by changes in sector-specific gross domestic product (GDP), employment and real wage. Based on input-output analysis, the sectors discussed in the paper have the closest linkage to the petroleum industry and are very much likely to be effected by a shift in the oil price. The result crucially depends on the underlying sources of the oil price change, in terms of the magnitude and the persistence of the responses. One of the main findings is that the oil-specific shock appears to be the most important shock for all the sectors. This result is robust for monetary policy adjustments. In addition, asymmetry tests were applied to check for potential non-linearity and asymmetry in the relationship between the real oil price and Norwegian macroeconomic variables. However, findings suggests that there is symmetry and linearity in the relationship.

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Momina J. Butt

Content

1. Introduction

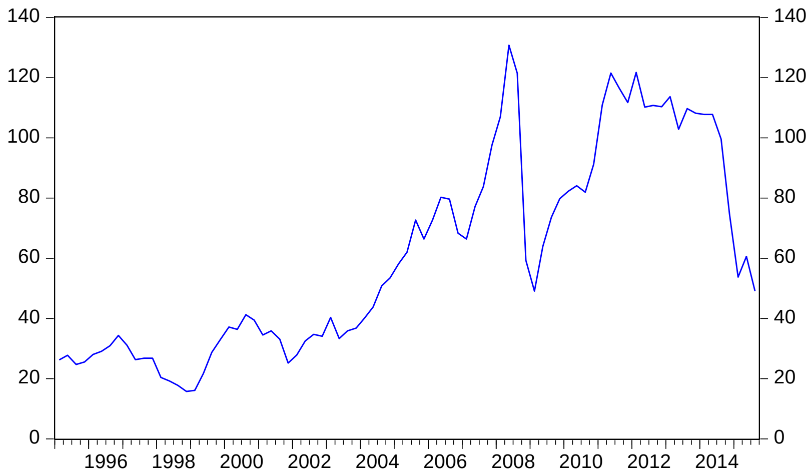
The macroeconomic effects of oil price shocks have been debated on for many decades, and it is a topic of interest for both economists and policymakers. A large body of literature suggests that there are indeed significant macroeconomic effects of changes in energy supply and oil prices (Hamilton 2003). However, majority of the studies focus on oil-importing countries, such as the United States and major oil-importing Asian and European countries. There is also a larger focus on how oil price fluctuations effects the *aggregated* economy and less on how it works on the *sectoral* level. The objective of this paper is to investigate the effects of oil price shocks on the economic activity of different business sectors in Norway, a net oil exporting country. I believe distinguishing between sectors is valuable, as it gives a better foundation to understand how the oil shocks penetrates the Norwegian economy, directly and indirectly. Economic activity is measured by sector-specific gross domestic product (GDP), employment and real wages.

In previous studies, the common approach has been to treat unexpected oil price shifts as an exogenous factor. More recently, the underlying causes of oil price shocks have been reconsidered. Empirical evidence suggests that oil price changes are in theory caused by distinct supply and demand shocks, and that oil supply shocks (disruption of supply capacity) accounts for a smaller fraction of the real oil price variability in recent periods (Kilian 2009). This implies a demand driven oil price, where global economic activity and uncertainty about future oil supply (precautionary savings) are the main contributors to oil price changes (see e.g. Kilian 2009, Aastveit, Bjørnland and Thorsrud 2015 and Kilian and Murphy 2012). Due to distinct origins of the shocks, the way an economy responds is dependent on what fundamentally caused the shock.

In recent years, important contribution to the research on oil exporting countries has come along. Utilizing Kilian's (2009) decomposition method of the oil price, Peersman and Robays (2012) are one of the few studies that distinguishes between oil exporting and oil importing countries. Their study contains evidence that suggests that there are positive economic effects of exogenous oil supply shocks on net energy-exporters such as Norway and Canada. Similar results are found in the study of Aastveit, Bjørnland and Thorsrud (2015), and also in that of Bjørnland and Thorsrud (2016) on Norway and Australia.

However, these papers were published before the significant fall in oil prices since June 2014. This dramatic plunge ended a four-year stability period of the oil price, after the financial crisis, at 105 (USD) per barrel (Baffes, Kose, Ohnsorge and Stocker 2015)[1]. The decline in oil prices and the macroeconomic consequences of it is, therefore, a matter of recent interest. My research topic is inspired by the latest oil price fall and it has made it relevant to revisit the question about the Norwegian oil dependency. The petroleum industry is Norway's largest sector measured in value creation, governmental revenues, investments and exports. It accounted for approximately 15% of the country's total GDP and around 39% of total exports in 2015. The sector also employ around 240.000 people directly and indirectly on the country locally and regionally. There is, therefore, substantial extended influence from this industry on the country, locally and regionally (Norsk Petroleum 2016). The purpose and contribution of this study will be to investigate how sectoral activity in Norway is affected by two distinct oil price shocks.

Figure 1: Price development for Brent Crude Oil over the period 1995-2015



NOTE: The real price of oil.

[1] The average price of $105 per barrel is a monthly average of the period 2011:1-2014:6 where the price fluctuated between $93 and $118 per barrel.

I follow Kilian (2009) and treat the oil price shocks as endogenous. He proposes a structural decomposition of the oil price into the three components: oil supply shocks, shocks to global economic activity and oil-specific demand shocks. As supply shocks (physical disruption in oil production) are suggested to have limited importance in explaining the oil price in the literature, the two latter components will be in focus. This paper also follows Sims (1980), among others, and apply Structural Vector Autoregressive (SVAR) models on both aggregated and sectoral-level data to investigate the transmission mechanism of the shocks. The magnitude and the persistence of the responses of a shock depends on its origin and on the sector characteristics. To my knowledge, this is the first study of its kind to be executed for Norway.

In order to target the overall objective of this thesis, I will address the following questions:

1. How do sector-specific activity respond to distinct oil price shocks?
2. To what extent do the effects differ, in terms of the magnitude and the persistence, when the underlying mechanism of the shock differs?
3. Is there any indication of an asymmetric relationship between the real price of oil and Norwegian macroeconomic variables?

The remainder of this paper is structured as follows: In section 2, a thorough literature review on the research topic is given. In section 3, relevant sector background, data description and time series properties of the variables are presented. Section 4 specifies the methodology applied and section 5 will present the final empirical results and the analysis of the results. Section 6 addresses one of the limitations of unmodified VAR's: non-linear relationship between the oil price and the macroeconomic variables. In section 7, an extension of the baseline model that includes monetary policy adjustments is given, and section 8 presents the conclusion.

2. Research Topic – Literature Review

In this section, a brief overview over the existing literature on the thesis topic is given. The topic is related to many strands of research and the literature reviewed below is considered the most relevant.

2.1 Theory and Empirical Evidence – Oil Price Shocks and The Real Economic Activity

There are extensive researches done on the relationship between the real price of oil and the economic activity in the past five decades. One of the earlier studies is by Hamilton (1983) where he investigates this particular relationship for the U.S. economy during the period of 1948-1972. He finds a statistically significant correlation between the real price of oil and the economic activity, where it was revealed that seven of the eight post-war recessions in the U.S. had been preceded by a dramatic increase in the price of crude petroleum. Substantial evidence indicated that the oil price shocks, if not necessarily causing the recessions, were an important contributing factor for the slowdowns in economic activity in the U.S..

In Hamilton's study, oil price fluctuations were mostly caused by supply shocks (physical disruptions of supply) due to geopolitical events and wars. There is wide acceptance of the results of Hamilton (1983), and earlier references for this topic in the literature are made from Rasch and Tatom (1977). Additional evidence for oil price changes being an important contributor to economic fluctuations is found by Burbidge and Harrison (1984) for the U.S., Japan, Germany, U.K. and Canada, and Gisser and Goodwin (1986), among others. However, the main drivers behind oil price variation and the oil price-macroeconomy relationship has been re-evaluated in later studies.

A later study by Hooker (1996) suggests that the oil price-macroeconomy relationship has changed since 1973. He found that, in the data, the oil price did not Granger cause variety of U.S. macroeconomic indicators after 1973. Several hypotheses were tested as for why this could be, like an endogenous oil price or a misspecification of the relationship caused by the linear VAR. Even though none of these hypotheses were supported by data, the author emphasize that care should be exercised when using oil prices as an instrumental or explanatory variable for macroeconomic indicators.

A more recent study by Barsky and Kilian (2004) also questions the relationship between oil prices and macroeconomic aggregates. They find that exogenous political events in the Middle East, which changes the oil production, are one of several factors contributing to oil price changes. They also find that such events may differ from each other based on the demand in the oil market and global macroeconomic conditions. They conclude that the demand for oil is essential to understand the oil prices, but that does not imply that OPECs market strategy is inconsequential. In parallel with Hooker (1996), they also find that oil prices as explanatory variables for U.S. performance are less sufficient than commonly suggested.

A study by Blanchard and Galí (2007) investigates the apparent changes in how the U.S. economy is effected by oil price shocks and possible reasons for the change. They reached to five concluding remarks. Firstly, major oil price shocks also coincided with other large, explanatory shocks of different nature, giving a partial identification. Secondly, the oil price shocks have gotten less effect on output, employment, wages and prices over time. Thirdly, one reason for the second conclusion could be a decrease in real wage rigidities. Fourthly, another plausible reason for the second conclusion could be increased credibility of monetary policy. The fifth conclusion is also another plausible reason, which is simply the significant decrease in the share of oil in consumption and in production.

The recent paper by Hamilton (2011) emphasizes that the correlation between the oil price shocks and U.S. economic recession is too strong to be a mere coincidence. He highlights that oil price shocks in itself were not the sole reason for the recessions, but a significant contributing factor.

2.2 Oil Price Shocks – Classification

The origins of the oil price shocks are crucial to map out, as the underlying mechanisms of the shock and the magnitude of the effect of it on economic activity is highly dependent on what type of shock it is (Kilian 2009). In previous studies, the common approach has been to treat changes in the oil price as exogenous when evaluating the macroeconomy-oil price relationship. Implicit in this approach is the ceteris paribus assumption (varying the oil price, holding other variables constant), which is inappropriate for two reasons. First, there is a reverse causality problem, implying that global macroeconomic fluctuations also effect the price of crude oil. With this problem prevailing, cause and effect are no longer well defined when relating changes in oil prices to macroeconomic activity. Second, the changes in oil prices are evidently driven by distinct supply and demand shocks. These shocks have different direct and indirect effects on the real price of oil, thus, having different effect on the real economy (Kilian 2009).

A study by Peersman and Robays (2012) compare the macroeconomic effects of different types of oil price shocks across a set of industrialized countries. They find supporting evidence for Kilian (2009) and emphasize that dividing oil price shocks according to their underlying source is crucial. Ignoring this fact could make the analysis suffer from seriously biased estimation when looking at cross-country effects of oil price shocks.

There is an intense debate in the literature on what type of oil price shock is more important in explaining the variation in the oil price. A study by Kilian (2008a) investigates the predictive power of exogenous *supply* shocks on changes in the real price of oil. He concludes that oil production shortfalls had limited importance in explaining the oil price fluctuations since the 1970's, although it was important for some historical events. The analysis is suggestive of other important explanatory variables such as shifts in demand for oil and shifts in the uncertainty about future oil supply shortfalls, which are unrelated to actual production of oil. In another study Kilian (2008b) suggests that while no oil price shock is alike, the majority of all major oil price shocks since the 1970's can be attributed to a combination of strong global demand for oil and shifts in expectation that increases precautionary demand for oil.

A later study of Hamilton (2009) examines the causes and consequences of the oil shocks of 2007-08. His conclusion supports the conventional interpretation: the oil price shocks of past decades were primarily due to significant supply disruptions in production caused by largely exogenous geopolitical events. Hamilton (2011) gives legitimacy to demand pressures to be a contributing factor for the oil price shocks, but conclude that supply disruptions arising from geopolitical events are the prominent causes of a number of the most important oil price shock episodes in history.

Kilian and Baumeister (2016) investigates what could have driven the latest oil price fall. They suggests that more than half of the decline in the price were predictable in real time as of June 2014. They claim adverse demand shocks (because of slowing global economy prior to July 2104) and positive supply shocks and shocks to expected productions (prior to July 2014) are the main causes for half of the price decline. They also consider falling oil price expectation in July 2014 as one of the reasons.

2.3 Oil Price Shocks – Real Macroeconomic Effects on Oil Exporting Countries

The literature presented in section ***2.1*** is mainly on oil importing countries, and subsequent to Hamilton's work (1983) the majority of literature suggest adverse effect of oil price increases on oil importing countries. For oil exporting countries, however, the transmission effect may be more complex. The increase in energy prices in the 1970s led to a significant rise of national wealth in the oil-exporting countries (Bruno and Sachs 1982). Higher oil prices typically generates higher net income. If this positive wealth effect was to be transmitted into the economy, one would expect the economic activity to increase.

However, the increase in wealth from higher oil prices or from resource discoveries have a systematic impact on the allocation of resources between the sectors of an economy (Bruno and Sachs 1982). In the traditional context of the "Dutch Disease", the booming resource sector caused by higher wealth, shrinks and weakens the trade-able sector. However, the way the booming sector effects the rest of the economy depends on how the wealth is distributed and whether the booming sector has potential productivity spillovers to the rest of the economy. In a recent study by Bjørnland and Thorsrud (2016), they find evidence for significant and positive productivity spillovers from the resource sector to non-resource sectors in Norway and Australia. This aspect has not been considered in the traditional studies of the "Dutch Disease".

In an earlier study by Bjørnland (2009) on Norway, the effects of oil price shocks on stock returns is analysed, investigating the transmission channels of oil prices on macroeconomic behaviour. Two ways on how high oil prices may affect the economy were highlighted. One way is through positive income and wealth effect and the second through negative trade effects. The second effect appears through oil induced recession for oil importing trading partners that will demand less of traditional goods and services from the oil exporting countries, due to an exchange rate depreciation. The net effect of the two channels is ambiguous and differs by oil exporting countries. Norway has responded positively from an increase in oil prices with increased economic growth and reduced unemployment rates while other oil exporting countries like Canada and UK experienced have experienced a more adverse effect from the oil price increase. The results for Norway is consistent with economic reasoning for an oil exporting countries. Namely, that there is a stimulating effect of increased oil prices on the economy, with increased aggregate wealth and demand. Bjørnland (2009) also emphasize that understanding different causes behind the oil price changes is important to understand the effect on the Norwegian economy.

The interesting question is how sectoral level activity is effected by oil price changes. Bjørnland and Thorsrud (2016) finds empirical evidence that the petroleum industry has strong extended effect on the rest of the mainland economy. They find that up to 30% of the variation in mainland GDP in Norway can be explained by impulses from the petroleum industry. Variation in the oil prices also explained a significant fraction of the variation in production, employment and investments in the energy sector itself and for subsectors like the construction and business sector.

In a new study by Wee Cian Koh (2015), he investigates the macroeconomic effects of an adverse oil shock under different exchange rates (fixed versus flexible) and under different fiscal policies (no oil fund versus with oil funds) in oil exporting countries. The findings were not surprising. Output and government consumption fall in response to oil price decline, but countries with flexible exchange rates has a significantly smaller and smoother response in output. Real exchange rate depreciation cushions the effect on the real economy. Flexible exchange rate makes the need for contractionary fiscal policy less necessary, in contrast to countries with fixed exchange rate that rely only on fiscal policy to make the macroeconomic adjustments after an oil price fall. In the presence of oil funds, however, countries have smaller fiscal spending and smaller output fall. This illustrates the shock-absorbing property of flexible exchange rates and the economic stabilisation role of oil funds when oil prices fluctuates. These results are applicable and relevant for Norway.

2.4 Transmission Channels of Oil Price Shocks

The issue of *how* oil price shocks effect the real economy has gained more and more attention in business cycle research (Jones, Leiby and Paik 2004). The transmission channels of oil price shocks are the routes by which oil price changes work their way through the economy and create macroeconomic fluctuations. There is a vast debate on what channels are more important than others to explain these fluctuations. An early study by Corden and Neary (1982) develops a model where they suggest both direct and indirect effects of an energy discovery. In their model, the latter works the same way as a price increase, raising the profitability and demand for labor in the energy sector at a given wage. They assume that there are three sectors in the economy; the booming energy sector, the tradeable sector and the non-tradeable sector. The direct effect of oil and gas is through increased demand from the energy sector for resources, goods and services from the rest of the economy. This effect is usually called the "Resource Movement Effect" (Bjørnland 1998).

The increase in profitability will make labor move from the tradable sector into the booming sector, which will result in a lower output level in the tradable sector. Labor will also move from the non-tradeable sector into the booming sector, increasing demand in non-tradable sector that pushes up the domestic prices. This may result in a real appreciation of the exchange rate, as prices for non-tradable goods will increase relatively to those of tradeable goods. The increased demand in the booming energy sector will have an indirect effect on the real economy as well, referred to as the "Spending Effect". The energy sector will demand more goods and services from the sectors that delivers to the booming sector (Bjørnland 1998). This channel will be of particular interest in this paper.

The transmission channels are also essential to explain how macroeconomic variables will behave, and will expectedly be different for oil-exporting and oil-importing countries. For an oil-exporting country, increase in oil prices are typically considered as good news that will generating higher income and will increase investments in the petroleum industry. A fall in oil prices will reversely lead to less profitability, increase in production cost, wage reductions and possibly a reduction in labour force. The literature suggests that oil price changes will mainly influence economic activity through a supply- and demand channel (see Jiménez-Rodríguez and Sanchez 2005 and Tang, Wu and Zhang 2010). The demand-side effects typically applies for the oil exporting countries, and appears through consumption and investment. Increase in oil prices will increase disposal income and therefore increase consumption. It is worth noting that there is an indirect effect through foreign exchange rate markets and inflation on the real activity as well (Jiménez-Rodríguez and Sanchez 2005).

Increased oil prices can additionally affect economic aggregates through "Second-round effects", where employees are more likely to demand higher nominal wages (Peersman and Robays 2009). They find that the transmission channel of an oil price increase on wage and the labour force differs across Euro area countries, depending on different labour market dynamics. They also find that countries with less flexible labour markets experience a stronger rise in nominal wages than countries with a formal automatic wage indexation mechanism due to an oil price increase. The low unemployment rate in Norway can partly be due to high real wage flexibility (Raaum and Wulfsberg 1998, 2).

3. Background and Data description

3.1 Sector Background

Data from both the aggregated level and the sectoral level is investigated in this paper. The aggregated data is for the *Norwegian Mainland Economy* and the *Norwegian Industry*. These are included to get a better understanding of how the transmission mechanism of oil price shocks works on the aggregated level in Norway. The sectoral data is for the following sectors: **1)** *Services related to extraction of oil and gas*, **2)** *Maintenance and installation of machines and equipment*, **3)** *Rubber- and plastic industry, mineral product industry* and **4)** *Professional, scientific and technical services*.

The sectoral data is for specifically chosen sectors, based on input-output analysis from Statistics Norway (SN). According to their reports, these sectors are among those with the highest percentage of deliveries of investment products and services to the petroleum industry out of total deliveries, directly and indirectly. These are also among those with the highest employment level linked to the petroleum industry, directly and indirectly (Hungnes, Kolsrud, Nitter-Hauge, Prestmo, and Strøm 2016, 14-19). Due to this close linkage, the extended effects of an oil price shock from the petroleum industry to other parts of the economy can be studied more closely. The sectors are classified according to the classification system of StatBank Norway. In Appendix **A.1**, a more detailed overview on what type of firms there are in the different sectors is given.

3.2 Time Period of Analysis

Quarterly data from the period 1995Q1-2015Q3 is used. The importance of a stable monetary policy regime was taken into consideration when choosing the time-period. The Norwegian krone has had a managed float since 1993, where the goal has been to keep a stable krone exchange rate against European Currency Unit exchange rate (from 1999, against the Euro exchange rate). Before 1993, the Norwegian krone was fixed. Norway officially adopted inflation targeting in 2001, but Norges Bank had already been using monetary instruments to hold the inflation stable to achieve exchange rate stability since 1999 (Bjørnland 2009).

Hence, the period 1995Q1-2015Q3 can be considerate a relatively stable monetary policy regime, and therefore reasonable for this analysis.

3.3 Variable Description

The variables included in the analysis are measures of the following: global economic activity *($gact_t$)*, the real oil price *(rpo_t)*, real gross domestic product *(gdp_t)*, employment *(emp_t)*, real wage *(rw_t)* and the real exchange rate *($reer_t$)*. Recall from the introduction, this paper will be follow Kilian (2009) and decompose the oil price shock into two components, a global economic activity (aggregated demand shock) shock and an oil-specific shock. The measure for global activity is the Kilian index[2] obtained from Lutz Kilian's homepage[3]. The measure was transformed into quarterly data for this analysis.

As a measure for the oil price, the Brent Crude is used. It is a common measure to use in causal effect analyses as Brent Crude functions as a benchmark measure. This is because European oil production tends to be priced relative to this oil (Bjørnland 2009). In addition, Brent Crude is normally extracted from the North Sea and due to Norway's geological location; this is a natural measure to use for the oil price. The data series is obtained from the database of Federal Reserve Bank of St. Louis. Because we are interested in the real economic effects, the oil price is deflated with the U.S. consumer price index (CPI), which was obtained from the Bureau of Labor Statistics U.S..

The domestic data that is the GDP, employment and real wage is obtained from Statistic Norway. All variables are expressed in real terms and are seasonally adjusted to ensure non-seasonally variation only. The remaining variables, that is the real exchange rate and the three-month domestic interest rate, are included to capture other important transmission channels through which oil price may affect the economic activity. A shock in the oil price may induce economic policy

[2] The Kilian Index of global real economic activity in industrial commodity markets are proposed in "Not all oil price shocks are alike…" (Kilian 2009). The paper discusses both the good properties and the weaknesses of the index as the measure global real economic activity.

[3] Lutz Kilian homepage: http://www-personal.umich.edu/~lkilian/paperlinks.html

interventions that cushions the effects of the shock. A flexible exchange rate can absorb some of the shock as well. The real exchange rate is therefore included in the baseline VAR model, while the interest rate is included in the extension of the model to control for monetary policy intervention. The data for real exchange rate is obtained from the database of Bank for International Settlements[4]. The measure for the three-month domestic interest rate is the Norwegian Interbank Offered Rate (NIBOR) and is obtained from Statistics Norway.

Furthermore, all variables apart from the Kilian index and the interest rate are transformed into their natural logarithms to avoid extreme values of the series. In addition, logarithms have the valuable property of converting first difference data into an approximation of the percentage change of the original series (Stock and Watson 2012, 562). This is inevitable as the analysis is carried out using impulse response functions (IRF). Descriptive statistics with comments on all the macroeconomic variables in focus, for all the sectors, are reported in Appendix **A.2**. This also includes the correlation with the real price of oil.

3.4 Time Series Properties

Before using the variables for modeling in a VAR setting, it is useful to determine the time series properties. More specifically, whether the time series are stationary in levels (integrated of order 0, I ~ (0)) or contains a unit root and is stationary in first difference[5] (integrated of order 1 i.e. I ~ (1)). The Augmented Dickey-Fuller (ADF) test is used to test for stationarity and the results are provided in Appendix **B.2**. If the null hypothesis is not rejected, the series contains a unit root and it is integrated of order 1. The results demonstrates that all variables expressed in levels follow a unit root process at one and five percent significance level. This is the case when an intercept and a linear trend is included. There are a few variables, in some of the sectors that are stationary at ten percent significance level with log levels, constant and a trend. This is the case for the employment series for the Mainland Economy and the Industry, and for the real wage in the Industry.

[4] http://www.bis.org/index.htm

[5] Detailed theory on stationarity and unit root processes is provided in Appendix **B.1**.

The majority of the variables are stationary at ten percent significance level when expressed in 1st difference. Stationarity is a desired property in econometrics and the common approach in regressions is to transform non-stationary variables into stationary in order to get correct estimations. However, in VAR models this could lead to loss of information and even misspecification of the model if a cointegrating relationship exists between the variables. In an established study by Sim, Stock and Watson (1990) it is argued that transforming variables to stationary form by differencing or imposing cointegration restrictions is unnecessary when there is most likely a cointegrating relationship in the data.

In another study by Gospodinov, Herrera and Pesavento (2013), the unrestricted VAR models that were not based on differenced or co-integrated variables were considered the most robust specification. This was the case when the magnitude of the unit roots and co-movement between variables were uncertain. They conclude that VAR models in levels and structural impulse responses through short-run restrictions was the best approach in applied work. It is essential, however, to make sure that the VARs are stable before they are applied in any empirical analysis. Elaboration on VAR stability is given in section ***4.3***.

4. Methodology

4.1 Vector Autoregressive (VAR) Model

Vector autoregressive (VAR) models are widely used in macroeconomics for a wide range of analyses. The VAR model extends the univariate AR models to a vector of many variables. The model has *n* variables and *n* equations, where each variable is a linear function of past values of itself and lagged values of the other variables. The theory in this section and in the next is based on Bjørnland and Thorsrud (2015), if otherwise is not explicitly sited.

We have a $(K \times 1)$ vector of random variables:

$$y_t = \left(y_{1,t},\ \dots\ , y_{K,t}\right)' \tag{1}$$

Then a VAR of order *p* can be specified in the reduced form:

$$y_t = \mu + A_1 y_{\mathbf{t-1}} + A_2 y_{\mathbf{t-2}} + \ldots + A_p y_{\mathbf{t-p}} + e_t \qquad (2)$$

where y_t is a (*5 × 1*) vector including the variables:

$$y_t = \left(gact_t,\ rpo_t,\ gdp_t,\ emp_t,\ rw_t,\ reer_t\right)' \qquad (3)$$

μ denotes a (*5 × 1*) vector of intercept terms and e_t is a (*5 × 1*) vector of error terms, which we assume are white noise with the properties:

$$e_t \sim i.i.d.\ N\ (0, \textstyle\sum_{\mathrm{e}})$$

where $\sum_{\mathrm{e}}$ is the covariance matrix.

4.2 Structural Vector Autoregressive (SVAR) Model

In early 1980's Sims (1980) introduced the methodology of structural vector autoregressive (SVAR) models. This methodology is widely used to study causal relations in macroeconomics. In order to estimate and analyze the effect of an oil price shock on the different sectors, a SVAR model based on the baseline model in the previous section will be used for each sector. We can reformulate any VAR(p) into a VAR(1) process by expressing the VAR in the companion form. From there, the VAR(1) can be reformulated into an infinite moving average (MA(∞)) representation using the method of recursive substitution or the lags operators. The reduced form MA(∞) representation of the VAR is expressed as the following:

$$y_t = v + \sum_{i=0}^{\infty} C_j e_{t-j} \qquad (4)$$

Before we can express the model in the MA(∞) representation we need to make sure that the VAR(p) is stable and, thusly, invertible. The VAR model is then covariance-stationary, and the effect of a shock in a variable in the system eventually dies out. The system is stable if the eigenvalues of the companion form matrix are all less than one in absolute value.

In macroeconomic relations, a shock in one variable is most likely accompanied by a shock in another variable. This can give misleading results when doing structural analysis. To be able to assess the casual effects of a shock, we need to make them uncorrelated, i.e. orthogonal. Hence, the analysis will be carried out with a MA representation, where the residuals are orthogonal. The most common approach to achieve uncorrelated residuals is to apply the Cholesky decomposition. It is a very popular identification scheme to obtain orthogonal shocks and is a short-run contemporaneous restriction. It can be applied to the MA representation in equation (4), with assumption that $\sum_e = PP'$, where P is the Cholesky decomposition of $\sum_e$. It is as lower triangular matrix with positive values on the diagonal. With a stable VAR model and the Cholesky decomposition sufficiently and correctly justified with economic theory, the system illustrates the contemporaneous linkage between the variables in the system (Bjørnland and Thorsrud 2015).

4.3 Model Specification

In this section an overview over the model specification, which includes lag selection, model stability and diagnostic tests of autocorrelation in the residuals, will be given. As emphasized in section ***3.4*** and ***4.2***, it is essential to check whether the VARs are stable before we continue with the analysis. The theory behind stability of VARs and the test results are provided in Appendix **C.2** and **C.3**. The baseline VAR for all the sectors fulfil the stability requirement.

The appropriate lag length for the model can be decided through several types of statistical lag information criterions or by economic reasoning. The Akaike (AIC), Schwarz (SC) and Hannan-Quinn (HQ) information criterions were used[6]. For all

[6] For further details on the lag information criterions see Appendix **D**.

sectors, apart from the Mainland Economy, AIC suggested to include seven lags. For the Mainland Economy it suggested to include one lags only. SC and HQ both suggested a lag length of one for all the sectors. However, a lag length of one might be too short for this paper and lead to misspecified models with biased OLS estimates. A lag length of seven might somewhat be too many as the system might bear the risk of getting poor and inefficient estimates because there are too many lags relative to the number of observations (Bjørnland and Thorsrud 2015, 200). It is therefore chosen to work with four lags, as using a year's span is considered common practice for quarterly data (Sims 2011).

Autocorrelation in the residuals may result in more persistent and smoother IRF's. This could stem from misspecification of the model or too short lag length. Formal tests on autocorrelation in the residuals are performed to ensure that the VARs do not suffer from this problem. The LM test, also referred to as the Breusch-Godfrey test for residual autocorrelation, was used as suggested by Lütkepohl (2011). The test results are provided in Appendix **E**.

4.4 Cholesky Decomposition

Recall that all variables are transformed in line with section ***3.3***. In the final SVAR, the constant term is excluded. The SVAR is expressed as the following:

$$\begin{bmatrix} gact_t \\ rpo_t \\ gdp_t \\ emp_t \\ rw_t \\ reer_t \end{bmatrix} = \begin{bmatrix} C_{11} & 0 & 0 & 0 & 0 & 0 \\ C_{21} & C_{22} & 0 & 0 & 0 & 0 \\ C_{31} & C_{32} & C_{33} & 0 & 0 & 0 \\ C_{41} & C_{42} & C_{43} & C_{44} & 0 & 0 \\ C_{51} & C_{52} & C_{53} & C_{54} & C_{55} & 0 \\ C_{61} & C_{62} & C_{63} & C_{64} & C_{65} & C_{66} \end{bmatrix} \times \begin{bmatrix} \varepsilon_t^{GlobActivity} \\ \varepsilon_t^{OilPrice} \\ \varepsilon_t^{GDP} \\ \varepsilon_t^{Emp} \\ \varepsilon_t^{RW} \\ \varepsilon_t^{REER} \end{bmatrix} + \sum_{i=1}^{4} C_i \varepsilon_{t-i} \tag{5}$$

The employment of economic arguments is a crucial feature in the identification scheme. The restrictions are partly inspired by Kilian (2009) and Broadstock and Filis (2014) and the motivation of the ordering is as follows:

The oil variables

1) Fluctuations in the real price of oil that are driven by shocks specific to the oil market will not affect real economic activity contemporaneously as global real activity reacts sluggishly to shocks.
2) Changes to the real price of oil that is not due to shocks to aggregated demand for industrial commodities is then because of shocks that are specific to the oil market. Real price of oil is allowed to react contemporaneously to global aggregated demand shocks. The domestic activity of a small and open economy like Norway do no effect global activity. This justifies placing the oil variables on top.

Domestic variables

3) The domestic variables; GDP, employment and real wage are placed in the bottom of the ordering as Norway is a small and open economy that takes the oil prices as given. The Norwegian macroeconomic variables do not affect the aggregated global demand nor the global oil price, at least not on impact.
4) The ordering of the domestic variables may be arbitrary as whatever ordering will mostly give the same impulse responses. The argument for GDP being placed over employment is that the production level reacts more sluggishly to employment and real wage changes due to irreversible investments and signed contracts for future deliveries. However, it is worth noting that other valid arguments for placing employment and wage over GDP do exist. One can argue that the labor unions in Norway are significantly powerful. This would make instant and large movements in employment and wage level (due to changes in production) a rare phenomenon. It is chosen to precede with the initial argument in this paper.
5) The real wage is placed such that it is allowed to respond to all variables on impact but the real exchange, as it is claimed to have high flexibility to shocks.
6) The real exchange rate responds consecutively to all new information. Therefore, it is allowed to react contemporaneously to shocks in all variables.

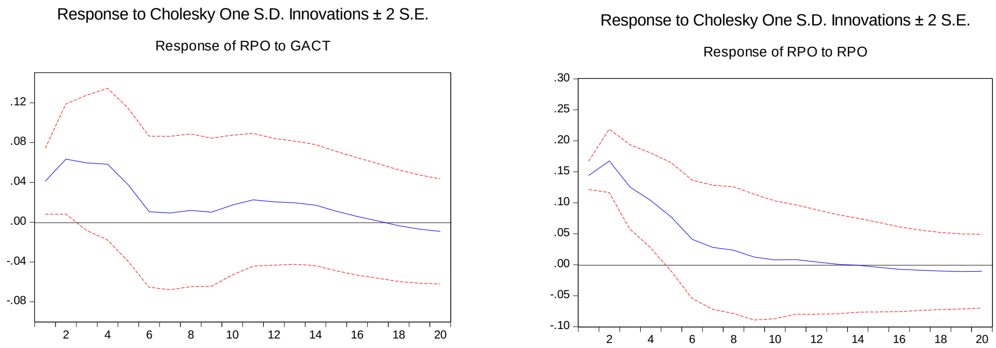
5. Empirical Results

In this section, the empirical results are presented and discussed. Recall, all shocks in the global oil market are identified as explained in section ***4.2***. The section is divided into six subsections, one subsection with results and implications for each of the sectors. All IRFs are provided in Appendix **F**[7].

5.1 Mainland Economy

The responses for all the variables in the model, for both shocks are provided in Appendix **F.1**. It may be useful to, first, elaborate on how the real oil price reacts to a global demand shock and an oil-specific shock and **Figure 2** displays the responses in the real oil price. A one standard deviation shock of the size 14.4 percent in *global demand* increases the real oil price significantly on impact with 4.1 percent. The real oil price continues to increase the next quarter to the maximum 6.3 percent before the shock eventually dies out. An *oil-specific shock* (not by physical disruption in oil supply) increases the real oil price significantly on impact by 14 percent. It continues to move upwards in the next quarter to peak point 17 percent before it starts to revert to its initial level. The oil-specific shock, thusly, creates the strongest increase in the price. The response pattern of the real oil price is similar to the one described above in the other sectors as well, especially the response on impact.

Figure 2: Impulse Responses for Mainland Economy



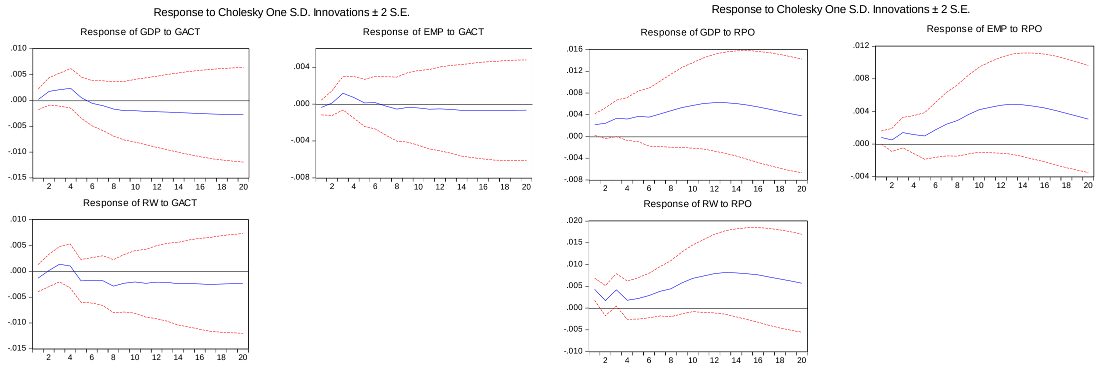
Note: The IRFs shows the responses of the real price after a shock in global demand (left) and an oil-specific shock (right).

[7] The impulse response functions are displayed with two thin lines representing two-standard error bands that are equivalent to 95 percent confidence intervals.

It is important to mention that an increase in the oil price results in a real appreciation of the exchange rate. This happens in all of the sectors and for both types of shocks. The shocks, thusly, penetrates the economy indirectly through the real exchange rate. An appreciation of the exchange rate reduces Norway's competitiveness and gives a contraction in the exporting industry, i.e. the tradeable sector. The reason why this variable was initially included in the model was to make sure this particular transmission channel, namely the "Resource Movement Effect", was captured. However, it is worthwhile noting that the oil-specific shock clearly gives the largest and the most statistically significant exchange rate appreciation for all the sectors. This could be an indication that the oil-specific shock is the most influencing shock for the exporting industry.

Figure 3 displays the responses of GDP, employment and real wage to one standard deviation of global demand shock and oil-specific shock. Both of the structural shocks tend to increase the real oil price, as explained above, but have very different implication on the domestic economy in terms of the persistence and the magnitude of the responses. Nonetheless, the effects from both shocks are small and the majority of IRFs are statistically insignificant. The reactions in all three macroeconomic variables from a shock in *global demand* are negligible. The *oil-specific shock* leashes a small reaction in the aggregated GDP of .22 percent on impact. The GDP continues to move upwards to peak point .62 percent after 3 years before the shock dies out. The maximum point is, however, statistically insignificant. The responses of employment and real wage are somehow similar to the response in GDP. The largest, contemporaneously increase is in the variable real wage, which increases with .44 percent.

Figure 3: Impulse Responses for the Mainland Economy



NOTE: The IRFs on the left-hand side display the responses of the Mainland GDP, employment and real wage, respectively, of a shock in global demand of the size of one standard deviation. The right-hand side display the equivalent for an oil-specific shock.

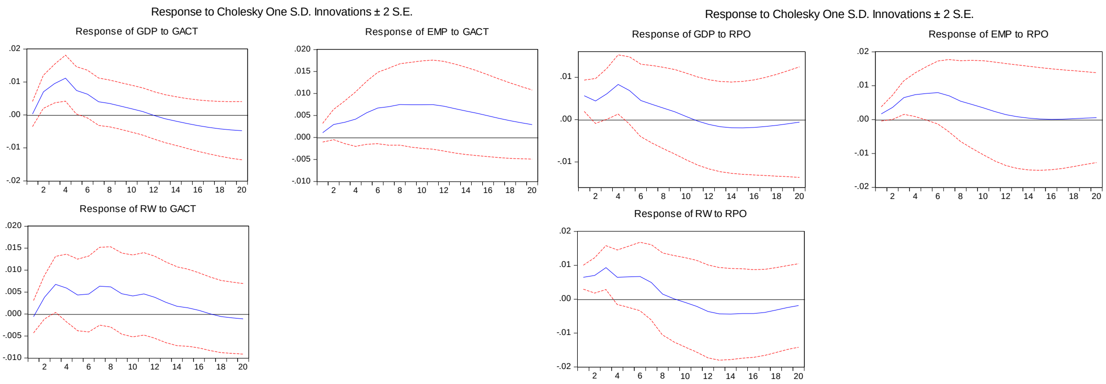
The findings of the IRFs may indicate towards an oil-independent Mainland Economy. Shocks in oil prices may evidently be more important to smaller parts of the economy, as the results for aggregated data suggests that the overall economy would be rather stable upon a shock in the oil prices. However, the oil-specific shock is apparent to create the largest responses in the Mainland Economy. The fact that all three variables are positively stimulated is consistent with economic theory. The variance decomposition for the Mainland Economy is provided in Appendix **G.1**. It demonstrates that shock in global demand has negligible effects on all the domestic macroeconomic variables in the long term. The oil-specific shock, however, accounts for a relatively large portion of the variance in GDP, employment and real wage over time. The shock explains approximately 24, 23 and 26 percent of variance, respectively, after a period of 3 years.

5.2 Industry

The responses for all the variables in the model are reported in Appendix **F.2**. **Figure 4** display the IRFs for the macroeconomic variables. As the responses of the real oil price and the real exchange rate is discussed thoroughly under the section ***5.1***, there will hereafter only be discussion on the domestic variables. For the aggregated Industry, a shock in *global demand* gradually but significantly raises the GDP over a year and it peaks at 1.1 percent before it gradually reverts to its initial level after 3 years. After that, the IRF shows that GDP even reaches negative levels. The effects on employment are statistically negligible even though the IRF has a hump-shaped form, indicating that employment would increase and then decrease gradually after the shock. The reaction in real wage is significant after 3 quarters where the real wage has reached its maximum increase of .67 percent.

The positive effect of the *oil-specific shock* is statistically more significant than the global demand shock. GDP increases contemporaneously with .56 percent and has a maximum increase at .83 percent after a year, before the effect dies out after approximately three years. The IRF for employment has a smooth hump-shape where it increases on impact by 0.20 percent and continues with an upward trajectory that is statistically significant. The shock has penetrated the employment level fully at .80 percent after about a year, before the effect dies out after approximately three and a half years. The real wage increases on impact by 0.60 percent and continues to increase to maximum 0.90 percent after 3 quarters. It reaches back to its initial level after approximately a year.

Figure 4: Impulse Responses for the Industry



NOTE: The IRFs on the left-hand side display the responses of the Industry GDP, employment and real wage, respectively, of a shock in global demand of the size of one standard deviation. The right-hand side display the equivalent for an oil-specific shock.

The findings are consistent with economic theory. All domestic variables move in the same direction after the shock. An increase in the real oil price is considered to be good news for the overall Industry and it will increase production, employment and, thus, the real wage. It is worth noting that the responses are not drastic even though they are statistically significant. Similar to the results of the aggregated

Mainland Economy, economic activity in the aggregated Industry is rather stable after the two structural shocks. Also similar to the Mainland Economy, the oil-specific shock is the most important structural shock for the Industry.

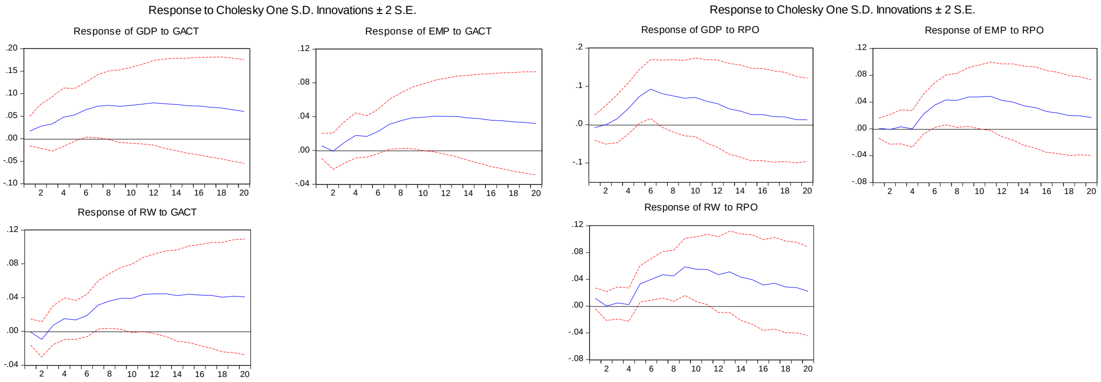
The variance decomposition for the Industry is reported in Appendix **G.2**. It demonstrates that the shock that explains most of the variation in the variables over time differs across GDP, employment and the real wage. The global demand shock explain a relatively large portion of the variation in GDP and employment with approximately 27 and 18 percent, respectively, after a period of 3 years. The oil-specific shock is the most important shock for the real wage over time, explaining around 18.5 percent of the variation after 3 years.

5.3 Services Related to Extraction of Oil and Gas

This sector has the closest link to the petroleum industry, both in terms of production and employment, according to the input-output reports from Statistical Norway. Appendix **F.3** shows all the IRFs for this sector**. Figure 5** display the responses in GDP, employment and the real wage. The responses, in terms of magnitude and persistence, differs substantially with the origin of the shocks. An unexpected shock in *global demand* gives the sector a small but statistically significant boost, where GDP increases gradually and reaches the maximum point after a year at 1.10 percent. The effect eventually dies out after 3 years and even reaches negative levels. The effects in employment and real wage are positive but small and statistically negligible.

The effects from an unexpected *oil-specific* shock are positive and the shock appears to have a larger influence on the employment and the real wage, then on the GDP. GDP increases on impact by .56 percent and slowly reaches the peak point after a year at 0.83 percent. The response in employment is smooth and hump-shaped, where the response is statistically significant after 3 to 4 quarters. Employment increases by .80 percent at the maximum. The real wage also increases on impact by .60 percent and continues to increase to .90 percent before the shock eventually dies out. Recall that the real exchange has a larger and statistically significant positive reaction after an oil-specific shock.

Figure 5: Impulse Responses for the sector Services Related to Extraction of Oil and Gas



NOTE: The IRFs on the left-hand side display the responses of the sector-specific GDP, employment and real wage, respectively, of a shock in global demand of the size of one standard deviation. The right-hand side display the equivalent for an oil-specific shock.

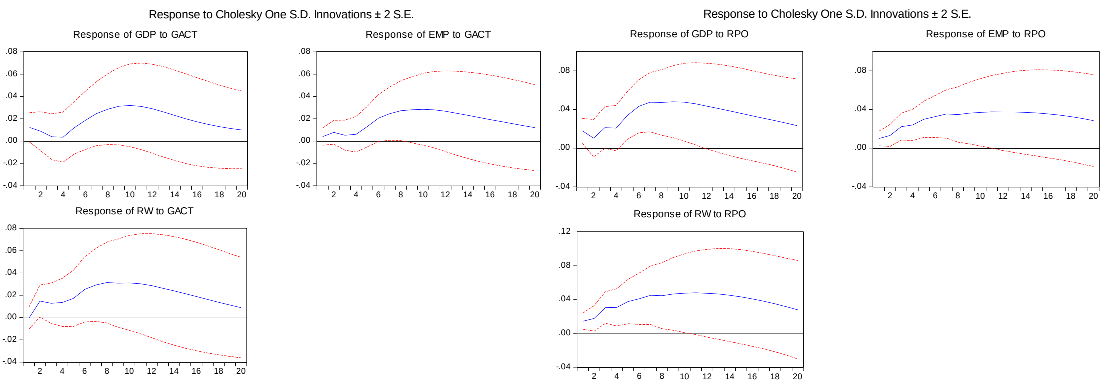
These finding suggests that an oil-specific shock has a larger influence on this sector and is more important than the global demand shock. The responses in the domestic variables, however, are not drastically large. Considering the close linkage with the petroleum industry, thus potentially strong transmission mechanism, one would expect larger responses in the variables. These small reactions may be due to the size of the shock that is used in the analysis, that is, a one standard deviation increase. Large positive and negative shocks that doubles the oil price or decreases it to the half of its initial level is more likely to give a stronger reaction in investments in the petroleum industry. The extended effects on closely linked sectors would therefore be larger.

The variance decomposition is reported in Appendix **G.3**. The results for GDP are interesting as the most important shock to explain the variation changes over time for this variable. The oil-specific shock explains approximately 23 percent of the variation in GDP after 3 years (12 quarters). However, after 4 years (16 quarters) the global demand shock explains a larger portion of the variation by approximately 27 percent. For employment and the real wage, the oil-specific shock is clearly the most important shock to explain the variation over time. It explains around 34 percent of all the variation in employment and approximately 42 percent of all the variation in the real wages after 3 years.

5.4 Maintenance and Installation of Machines and Equipment

The IRFs are provided in Appendix **F.4**. **Figure 6** display the IRFs for the macroeconomic variables. An unanticipated shock in *global demand* gives an increase in all three variables. The impulse responses are smooth and reaches their maximum point after 10 quarters for all three variables, before the effect of the shock dies out. Nonetheless, none of reactions are statistically significant. An unanticipated *oil-specific shock* raises the GDP contemporaneously by 1.80 percent and it continuous to increase to 4.80 percent after approximately a year before it slowly revert back to its initial level. The response of employment is also upward sloping and reaches the maximum increase of 3.70 percent after two and a half years before the shock slowly dies out. The reaction in real wage is quite similar to the one in employment. It has an upward trajectory and reaches maximum point at 4.70 percent after two and a half years before the shock dies out. All of the impulse responses are statistically significant between quarter 1 to 11 and are noticeably persistent.

Figure 6: Impulse Responses for the sector Maintenance, Installation of Machines and Equipment



NOTE: The IRFs on the left-hand side display the responses of the sector-specific GDP, employment and real wage, respectively, of a shock in global demand of the size of one standard deviation. The right-hand side display the equivalent for an oil-specific shock.

These findings suggests that this sector would experience noticeable changes in economic activity, particularly from an oil-specific shock. One would expect such reactions considering the sectoral background information provided in Appendix **A.1**, and that it is a subsector of the total Industry. The petroleum industry is based on the usage of machinery and on the installation of new equipment. A real oil price increase would boost this industry, increasing its demand for its services. It is interesting that this sector is more responsive to the shocks in the short-term than the sector for *Services Related to Extraction of Oil and Gas*, which would be expected to be more affected.

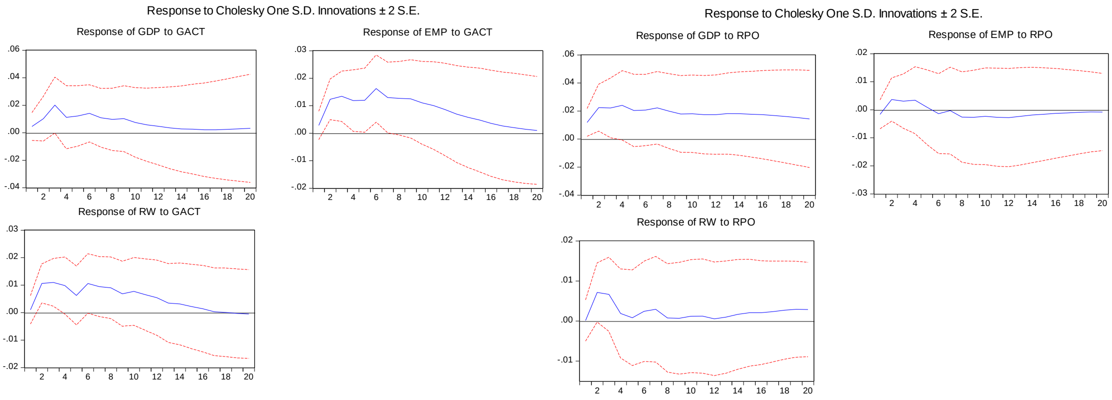
The variance decomposition is provided in Appendix **G.4**. The results share parallels with the impulse responses. The oil-specific shock is by far the most important shock to explain the variation in all three domestic variables. To illustrate, it explains approximately 50 percent of the variation in GDP, around 43 percent of the variation in employment and 41 percent of the variation in real wage after 3 years. This is a remarkably high percentage, making this sector very sensitive to oil-specific shocks over time.

5.5 Rubber- and Plastic Industry, Mineral Product Industry

The IRFs are given in Appendix **F.5**, and **Figure 7** display the responses in the sector-specific domestic variables. This sector is also a subsector of the aggregated Industry. An unexpected shock in *global demand* gives statistically negligible reaction in GDP. The responses in employment and real wage are positive and significant for some periods. Employment increases by 1.60 percent at the maximum after 6 quarters before the shock gradually dies out. The real wage increases gradually and reaches maximum point at 1.10 percent increase after 3 quarters. It is worth noting that the impulse responses are not smoothly hump-shaped for this sector.

An *oil-specific shock* releases a significant response in GDP after 3 periods with an increase of 2.20 percent. The response in employment and real wage is statistically insignificant. The impulse responses after an oil-specific shock are, even though statistically insignificant, noticeable persistent. This sector is resource based in production, using oil as one of the main inputs. The findings suggests that to some degree, both of the structural shocks create fluctuations in the economic activity. There is, however, no major changes as one would expect by economic theory. This may be due the fact that a lot of the production of plastic and rubber in Norway is outsourced to other countries where production is cheaper. The small reaction in the economic activity may also be due to the fact that the dataset is aggregated and does not only include the rubber and plastic industry but also the mineral product industry.

Figure 7: Impulse Responses for the sector Rubber- and Plastic Industry, Mineral Product Industry



NOTE: The IRFs on the left-hand side display the responses of the sector-specific GDP, employment and real wage, respectively, of a shock in global demand of the size of one standard deviation. The right-hand side display the equivalent for an oil-specific shock.

The variance decomposition is given in Appendix **G.5**. The global demand shock is the most important shock to explain the variation in employment and real wage over time. It explains approximately 33 percent of the variation in employment and around 23 percent of the variation in real wage after 3 years. The oil-specific shock it the most important shock for the GDP. It explains approximately 30 percent of the variation in GDP after 3 years.

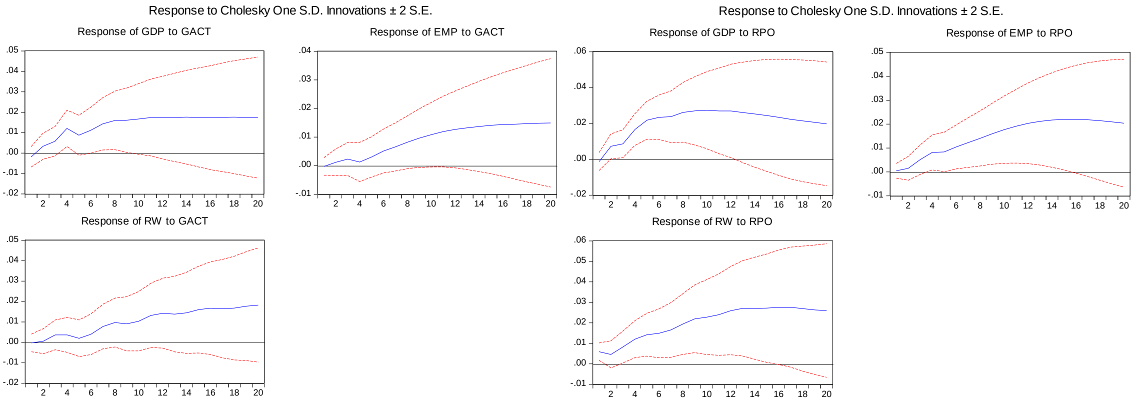
5.6 Professional, Scientific and Technical Services

The IRFs are displayed in Appendix **F.6** and **Figure 8** displays the responses in the sector-specific domestic variables. An unanticipated shock in *global demand* does not give any remarkable changes in the economic activity. The only significant change is in GDP that increases with 1.60 percent after 2 years.

The *oil-specific shock*, on the other hand, has the largest influence on the sector-specific variables of this sector. Following the shock, GDP reaches peak point at

2.70 percent after about 2 years where it continues to stay for some periods before the effect of the shock gradually dies out. Employment increases significantly between quarter 5 and 16 and it increases by maximum 2.20 percent. Real wage has similar IRFs as employment and increases at maximum by 2.70 percent.

Figure 8: Impulse Responses for the sector Professional, Scientific and Technical Services



NOTE: The IRFs on the left-hand side display the responses of the sector-specific GDP, employment and real wage, respectively, of a shock in global demand of the size of one standard deviation. The right-hand side display the equivalent for an oil-specific shock.

All of the variables are positively affected and the changes are statistically significant. Nevertheless, all the variables increase gradually and does not have an immediate reaction. This is reasonable considering the sector background and sector characteristics. This sector contains a variety of businesses that are not directly related to the petroleum industry, but provide services to the industry itself and to the sectors that support the petroleum industry. A shock in real oil price is not expected to affect this sector immediately as it would take time for the shock to transmit through the petroleum industry, the industry related to extraction of oil and gas and through other support businesses, first. However, when the effect reaches this part of the economy, the change is noticeable. This is especially the case with an oil specific-shock, which appears to be the most influential shock for this sector.

The variance decomposition is reported in Appendix **G.6**. The most important structural shock to explain the variation in all three domestic variables is the oil-specific shock. To illustrate, after 3 years the oil-specific shock explains approximately 64 percent of all the variation in GDP, 52 percent of all the variation in employment and 59 percent of all the variation on real wage, which are remarkably high percentages.

6. Robustness Check – Asymmetry and Non-linearity

There are limitations to the VAR methodology that should be addressed. The standard VAR model may ignore possible non-linear relationships between variables in the system if it is not modified (Stock and Watson, 2011). A large body of literature has been dedicated to assess whether there is an asymmetric relationship between the oil price and the macroeconomy. A study by Mork (1989) finds that oil price *increases* have larger impact on the U.S. macroeconomy than oil price *decreases*, which suggests a non-linear relationship. Several other studies like Hamilton (1996, 2003), Hooker (1996), and Davis and Haltiwanger (2001), that are all based on different econometric specification and identification assumption, conclude an asymmetric relationship between the oil price and the macroeconomy in the U.S. More specifically, that the oil price *increases* have larger effects on both aggregated and regional activity than oil price *decreases*.

Even though this issue has been subject to a lot of empirical research, many of the studies are on oil importing countries. The existing literature on oil-exporting countries is limited. Bjørnland (2009) is a study on Norway that considers this issue, and I will take inspiration from her study later on in this chapter. Nonetheless, this is a unique opportunity to perform asymmetric and non-linearity tests on Norwegian macroeconomic variables. The test is done on sector-specific GDP, employment and the real wage. Due to the linear assumptions made by a VAR, this also functions as an important validity check of the model.

6.1 Alternative Oil Price Measures

This section introduces four alternative oil price measures that are transformation of the real oil price changes. These are the so-called censoring variables. The transformations separates the upward and downward movements of the oil price variable in different manners. Morks study (1989) was the first to motivate investigating oil price decreases and oil price increases separately, where he found important evidence for asymmetric effects of oil price changes on the U.S. economy. He proposed the original oil price proxies for oil price increases and decreases. This was followed by Hamilton (1996) who suggested another oil price proxy, the net oil price measure that is considered to be one of the most successful oil price transformations.

The net oil price measure is motivated by the argument that majority of all oil price increases since 1986 were followed by even larger decreases. Hamilton (1996) suggests that all oil price increases was merely corrections for previous declines rather than increases from a stable environment. He suggests a construction of the net oil price increase that consider this, where one compares the current oil price with the level it has been over the previous year and not only with the previous quarter alone, as Morks (1989) original oil price proxy do.

It is important to note that Hamilton (1996) uses the nominal price of oil in his oil price measures. He argues that consumers responds more to nominal changes due to the visibility of the nominal price. However, this argument has gained little empirical support. The forthcoming analyses uses the real price of oil to specify the net oil price increase. This is to ensure consistency and because the real oil price is the relevant measure to be used in theoretical models of the transmission mechanism of oil price shocks (Kilian and Vigfusson 2011b).

The oil price measures used in this paper are inspired by Hamilton (1996) and Mork (1989) and are defined as follows:

1) Hamilton (1996): The net oil price increase (*$nrpoi_t$*) and the net oil price decrease (*$nrpod_t$,*):

$$nrpoi_t = \max\left[0, rpo_t - \max\left[rpo_{t-1}, ..., rpo_{t-4}\right]\right] \tag{6}$$

$$nrpod_t = \min\left[0, rpo_t - \min\left[rpo_{t-1}, ..., rpo_{t-4}\right]\right] \quad (7)$$

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

In Hamilton's original paper (1996) on the U.S. oil-macro relationship, the net oil price decreases are omitted from the model based on the argument that consumers do not respond to net decreases in the oil price (Kilian and Vigfusson 2011a). Nonetheless, this argument may be plausible for an oil importing country, but flawed or even inconsistent if the analysis is on an oil exporting country. Oil price declines may leash a greater response in oil exporting countries than an oil price increase. This is credible considering the recent oil price fall discussed in the introduction.

The net oil price decrease measure is created based on the same logic as for the net oil price increase. The $nrpoi_t$ is constructed by comparing the real price of oil each quarter with the largest observed value in the previous four quarters. If the value of the current quarter exceeds the largest value of the price in the four preceding quarters the percentage change is plotted. If the current price is lower than the maximum value in the four preceding quarters, the series is zero for date t (Hamilton 1996). The same logic applies to the net oil price decreases.

2) Mork (1989): Separation of oil price increases Δrpo_t^+ and decreases Δrpo_t^-:

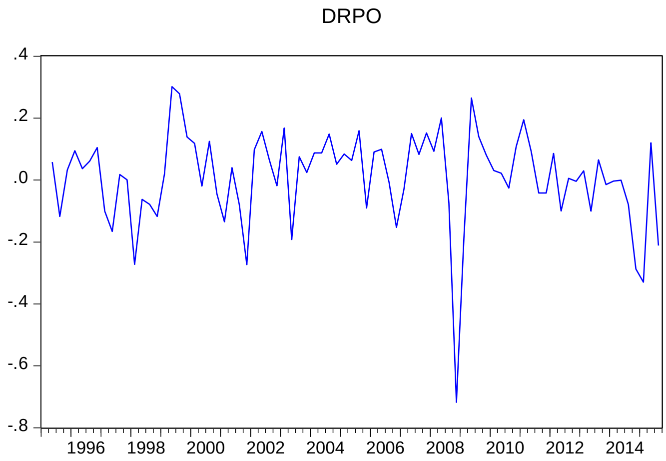
$$\Delta rpo_t^+ = \max\left[0, \Delta rpo_t\right] \quad (8)$$

$$\Delta rpo_t^- = \min\left[0, \Delta rpo_t\right] \quad (9)$$

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

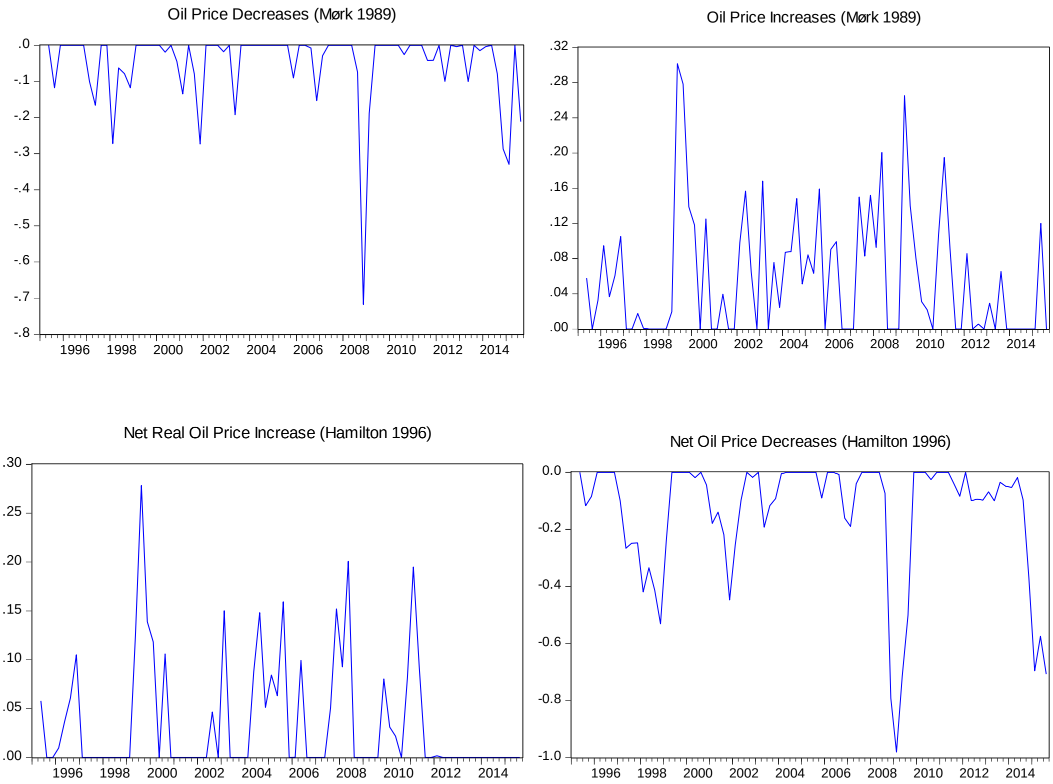
The construction of this oil price proxy is rather simple, where equation (8) functions as a filter for oil price increases and equation (9) as a filter for oil price declines.

Figure 9: Real oil price changes 1995-2015



NOTE: The fluctuations in the real oil price, Δrpo_t.

Figure 10: Alternative oil price measure



NOTE: The top left and the top right figure display the Δrpo_t^- and the Δrpo_t^+, respectively, based on Mork (1989). The bottom left and the bottom right figure display the $nrpoi_t$ and the $nrpod_t$, respectively, inspired by Hamilton (1996). All the various oil price measures are expressed in logs and the data frequency is quarterly from the period 1995-2015.

Table 1 shows the correlation of changes in the real oil price with the alternative oil price measures. Morks (1986) original oil price measures are highly correlated with the differenced real oil price, while the net oil price changes display a weaker linear relationship.

Table 1: Correlation of quarterly oil price change, *Δrpo$_t$* with alternative oil price proxies

	Varies Oil Price Measures			
Time period	Δrpo_t^-	Δrpo_t^+	*nrpoi*	*nrpod*
1995Q1-2015Q3	0,898	0,756	0,554	0,569

NOTE: The differenced real oil price is expressed in logs.

6.2 Asymmetry Test and the Test Results

Two types of tests to assess non-linear relationships are suggested in the literature, namely the slope based test and the impulse-response based test (Kilian and Vigfusson 2011b). The traditional approach to test for symmetry in the transmission mechanism of oil price shocks is the slope-based tests (Mork 1989). The test is useful to assess the symmetry of the slope parameters of single-equation regression models. However, it is not appropriate to find the degree of symmetry, where impulse-response based test perform better (Kilian and Vigfusson 2011b). Since the objective here is to decide whether there is a linear relationship between the oil price and the macroeconomic variables, slope-based tests are utilized. Inspired by Bjørnland's study on stock prices (2009) and Kilian and Vigfusson (2011a), I have the following test equations[8]:

Mork's (1989) oil price measure:

$$\Delta Y_t = \mu + \sum_{t=1}^{4} \beta_i \Delta Y_{t-i} + \sum_{t=0}^{4} \gamma_i nrpoi_t + \varepsilon_t \tag{10}$$

[8] Ordinary least squares (OLS) applied to find equation coefficients.

$$\Delta Y_t = \mu + \sum_{t=1}^{4} \beta_i \Delta Y_{t-i} + \sum_{t=0}^{4} \gamma_i nrpod_t + \varepsilon_t \tag{11}$$

Hamilton's (1996) oil price measures:

$$\Delta Y_t = \mu + \sum_{t=1}^{4} \beta_i \Delta Y_{t-i} + \sum_{t=0}^{4} \gamma_i \Delta rpo_t^{+} + \varepsilon_t \tag{12}$$

$$\Delta Y_t = \mu + \sum_{t=1}^{4} \beta_i \Delta Y_{t-i} + \sum_{t=0}^{4} \gamma_i \Delta rpo_t^{-} + \varepsilon_t \tag{13}$$

where $Y_t \in \{GDP, emp, rw\}$

Changes in the respective macroeconomic variables are explained by the contemporaneous[9] and lagged oil price changes and lagged changes in the variables themselves. The null hypothesis of linearity and symmetry is $H_0 : \gamma_i = 0$ for $i = 0,1,...,4$. Four lags (four quarters) are included rather than six lags (six months) as in Bjørnland (2009) because macroeconomic variables reacts more sluggishly than stock prices. Table 2, 3 and 4 displays the test results for GDP, employment and real wage, respectively.

[9] Including the contemporaneous effects of oil price changes is based on the assumption that the oil price is exogenous for Norway. This is a plausible small, open economy assumption (Bjørnland 2009).

Table 2: Test results for the variable *GDP* from the varies sectors

Sector		Variable			
		nrpoi$_t$	***nrpod***$_t$	Δrpo_t^+	Δrpo_t^-
Mainland Economy	γ_0	0,010	0,016	-0,025	0,006
	(p-value)	**[0,616]**	**[0,058]**	**[0,111]**	**[0,549]**
	F-stat. (4 lags)	1,255	2,052	1,427	2,000
	p-value	[0,277]	[0,046]	[0,194]	[0,053]
Industry	γ_0	0,074	0,053	-0,074	-0,016
	(p-value)	**[0,061]**	**[0,000]***	**[0,021]**	**[0,372]**
	F-stat. (4 lags)	1,422	4,534	1,575	4,591
	p-value	[0,196]	[0,000]	[0,141]	[0,000]
Services Ex. Oil&Gas	γ_0	-0,336	0,038	-0,051	-0,033
	(p-value)	**[0,310]**	**[0,784]**	**[0,848]**	**[0,850]**
	F-stat. (4 lags)	4,528	5,065	4,532	4,497
	p-value	[0,000]	[0,000]	[0,000]	[0,000]
Maint. Mach. and Equip.	γ_0	-0,079	0,099	0,006	0,120
	(p-value)	**[0,541]**	**[0,077]**	**[0,952]**	**[0,081]**
	F-stat. (4 lags)	0,777	0,863	0,758	0,705
	p-value	[0,638]	[0,562]	[0,655]	[0,702]
Rubber, Plastic &Mineral	γ_0	0,144	0,107	-0,006	0,061
	(p-value)	**[0,126]**	**[0,008]***	**[0,941]**	**[0,217]**
	F-stat. (4 lags)	1,485	2,626	1,253	2,439
	p-value	[0,171]	[0,011]	[0,279]	[0,018]
Profes., Scient and Tech.	γ_0	-0,001	-0,028	-0,012	-0,029
	(p-value)	**[0,9876**	**[0,239]**	**[0,807]**	**[0,304]**
	F-stat. (4 lags)	1,846	3,322	1,548	3,178
	p-value	[0,075]	[0,002]	[0,149]	[0,002]

*NOTE: The contemporaneous lags of the different oil price measures, their p-values, the F-statistic of the regression process and F-statistics p-value. *Significant at 1 % significance level.*

The test output in table 2 shows that the immediate link between changes in the oil price and changes in sector-specific GDP, (γ_0) is statistically insignificant at one percent significance level for almost all the sectors. This suggests linearity and symmetry in the relationship between the oil price and GDP. However, the results shows that the contemporaneous coefficients for $nrpod_t$ are statistically significant for the *Industry* and the subsector *Rubber, Plastic and Mineral Product Industry* at one percent significance level, suggesting a weak asymmetric effect in GDP from large oil price decreases. Furthermore, the F-statistics suggests that including additional lags of the oil proxies may be helpful predicting GDP (reject the null hypothesis) in some of the sectors. Specifically for the *Industry* and *Services Related to Ext. of Oil and Gas.*

Table 3: Test results for the variable *employment* from the varies sectors

Sector		Variable			
		$nrpoi_t$	**$nrpod_t$**	**Δrpo_t^+**	**Δrpo_t^-**
Mainland Economy	γ_0	0,009	0,007	0,001	0,010
	(p-value)	**[0,312]**	**[0,064]**	**[0,860]**	**[0,036]**
	F-stat. (4 lags)	3,842	5,150	3,833	4,585
	p-value	[0,000]	[0,000]	[0,000]	[0,000]
Industry	γ_0	0,008	0,010	-0,043	0,002
	(p-value)	**[0,674]**	**[0,222]**	**[0,009]***	**[0,842]**
	F-stat. (4 lags)	3,654	4,613	3,989	3,687
	p-value	[0,001]	[0,000]	[0,000]	[0,001]
Services Ex. Oil&Gas	γ_0	-0,181	0,000	-0,174	-0,005
	(p-value)	**[0,266]**	**[0,997]**	**[0,178]**	**[0,950]**
	F-stat. (4 lags)	1,661	1,727	2,219	1,452
	p-value	[0,116]	[0,100]	[0,031]	[0,184]
Maint. Mach. and Equip.	γ_0	-0,033	0,059	0,050	0,068
	(p-value)	**[0,665]**	**[0,074]**	**[0,428]**	**[0,098]**
	F-stat. (4 lags)	1,417	1,569	0,841	1,345
	p-value	[0,198]	[0,142]	[0,581]	[0,231]
Rubber, Plastic &Mineral	γ_0	0,038	0,018	-0,119	-0,003
	(p-value)	**[0,516]**	**[0,420]**	**[0,013]**	**[0,907]**
	F-stat. (4 lags)	0,842	2,564	1,261	1,991
	p-value	[0,580]	[0,013]	[0,274]	[0,053]
Profes., Scient and Tech.	γ_0	0,003	0,008	-0,008	-0,008
	(p-value)	**[0,923]**	**[0,515]**	**[0,718]**	**[0,614]**
	F-stat. (4 lags)	1,149	1,575	1,304	1,700
	p-value	[0,342]	[0,140]	[0,251]	[0,106]

*NOTE: The contemporaneous lags of the different oil price measures, their p-values, the F-statistic of the regression process and F-statistics p-value. *Significant at 1 % significance level.*

The test results for the variable *employment* are similar to the results of *GDP*. The immediate link between changes in the oil price and changes in sector-specific employment, (γ_0) is statistically insignificant at one percent significance level for almost all the sectors. This suggests linearity and symmetry in the relationship between the oil price and the employment as well. However, the significant effect of the oil price proxy Δrpo_t^+ on changes in the employment in the *Industry* suggests a potential asymmetric relationship between the real price of oil and the employment for the *Industry*. Nonetheless, the overall results indicate towards a symmetric relationship. The F-statistics suggests that including additional lags of the oil proxies may be helpful predicting employment in some sectors, especially in the aggregated sectors *Mainland Economy* and the *Industry*.

Table 4: Test results for the variable *real wage* from the varies sectors

Sector		Variable			
		$nrpoi_t$	$nrpod_t$	Δrpo_t^+	Δrpo_t^-
Mainland Economy	γ_0	0,045	0,028	0,016	0,021
	(p-value)	**[0,168]**	**[0,038]**	**[0,541]**	**[0,208]**
	F-stat. (4 lags)	2,162	2,801	2,226	2,727
	p-value	[0,036]	[0,007]	[0,031]	[0,009]
Industry	γ_0	0,044	0,029	-0,041	0,032
	(p-value)	**[0,281]**	**[0,074]**	**[0,209]**	**[0,131]**
	F-stat. (4 lags)	3,039	4,741	2,728	3,556
	p-value	[0,004]	[0,000]	[0,009]	[0,001]
Services Ex. Oil&Gas	γ_0	0,033	-0,007	-0,079	-0,024
	(p-value)	**[0,854]**	**[0,929]**	**[0,576]**	**[0,804]**
	F-stat. (4 lags)	6,708	7,084	7,314	6,425
	p-value	[0,000]	[0,000]	[0,000]	[0,000]
Maint. Mach. and Equip.	γ_0	0,014	0,078	0,087	0,081
	(p-value)	**[0,887]**	**[0,057]**	**[0,277]**	**[0,112]**
	F-stat. (4 lags)	1,522	2,358	1,499	1,967
	p-value	[0,158]	[0,022]	[0,166]	[0,057]
Rubber, Plastic &Mineral	γ_0	0,036	0,027	-0,128	-0,014
	(p-value)	**[0,564]**	**[0,248]**	**[0,009]***	**[0,638]**
	F-stat. (4 lags)	2,951	6,116	3,842	4,393
	p-value	[0,005]	[0,000]	[0,000]	[0,000]
Profes., Scient and Tech.	γ_0	0,012	0,041	0,002	0,028
	(p-value)	**[0,778]**	**[0,013]**	**[0,951]**	**[0,171]**
	F-stat. (4 lags)	4,775	6,066	4,902	5,445
	p-value	[0,000]	[0,000]	[0,000]	[0,000]

*NOTE: The contemporaneous lags of the different oil price measures, their p-values, the F-statistic of the regression process and F-statistics p-value. *Significant at 1 % significance level.*

The test results for the variable *real wage* are similar to the results of *GDP* and *employment*. The contemporaneous lag of the oil price measures are statistically insignificant for most of the sectors at one percent significance level. This suggests linearity and symmetry in the relationship between the oil price and the real wage. However, the only sector that indicates the presence of asymmetric relationship between the oil price and the real wage is the *Rubber Plastic and Mineral Product Industry*. The contemporaneous coefficient of the oil price measure Δrpo_t^+ is significant at one percent significance level for this sector. Nonetheless, the overall results indicate towards symmetry for the real wage as well for the other variables. Judging from the F-statistic, many of the oil price proxies (if not all of them) indicate that additional lags of the oil price are significant in predicting the real wage in the majority of the sectors.

The conclusion from the asymmetry tests is that there is indication for a linear and symmetric immediate response of an oil price shift on the three macroeconomic variables for all the sectors included in this paper.

7. Extensions

7.1 Alternative Model Specification – Monetary Policy

To control for monetary policy adjustments in the domestic economy, the Norwegian Interbank Offered Rate (NIBOR) (r_t) is included in the baseline SVAR model, see section ***4.4***. NIBOR is the three-month domestic interbank rate. It has a close linkage with the key policy rate set by Norges Bank and is used as a proxy for the monetary policy adjustments. The recent decline in oil prices, which this paper was inspired by, has resulted in historical low monetary policy rates. The extension is therefore highly relevant. The extended SVAR if specified has follows:

$$\begin{bmatrix} gact_t \\ rpo_t \\ gdp_t \\ emp_t \\ rw_t \\ r_t \\ reer_t \end{bmatrix} = \begin{bmatrix} C_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ C_{21} & C_{22} & 0 & 0 & 0 & 0 & 0 \\ C_{31} & C_{32} & C_{33} & 0 & 0 & 0 & 0 \\ C_{41} & C_{42} & C_{43} & C_{44} & 0 & 0 & 0 \\ C_{51} & C_{52} & C_{53} & C_{54} & C_{55} & 0 & 0 \\ C_{61} & C_{62} & C_{63} & C_{64} & C_{65} & C_{66} & 0 \\ C_{71} & C_{72} & C_{73} & C_{74} & C_{75} & C_{76} & C_{77} \end{bmatrix} \times \begin{bmatrix} \varepsilon_t^{GlobActivity} \\ \varepsilon_t^{OilPrice} \\ \varepsilon_t^{GDP} \\ \varepsilon_t^{Emp} \\ \varepsilon_t^{RW} \\ \varepsilon_t^{MP} \\ \varepsilon_t^{REER} \end{bmatrix} + \sum_{i=1}^{4} C_i \varepsilon_{t-i} \quad (14)$$

The ordering of the Cholesky decomposition is identical to the baseline SVAR, except the inclusion of the r_t above the exchange rate. As macroeconomic variables reacts sluggishly to most shocks, including monetary policy shocks, it is consistent to set the domestic variables above the interest rate. The ordering does not allow the interest rate to react contemporaneously to real exchange rate fluctuations, which can be debatable. Nonetheless, the interest rate is not an overly volatile measure as the board of Norges Bank have a meeting every six week to decide on the policy rate (Bjørnland 2009).

Appendix **H** displays the IRFs of a shock in global demand and for an oil-specific shock. The results appears to be in accordance with the baseline model, but the interest rate clearly gives a more muted effect of both types of shocks in all the sectors. This muted effect is consistent with economic theory. The responses in GDP, employment and real wage are of smaller magnitude and weaker persistence. In some of the sectors, the effect on the domestic variables has even become statistically insignificant, for example in the sector *Rubber, Plastic and Mineral Product Industry*. As Norway is a net oil-exporter, higher oil prices is considered good news and generates higher domestic economic activity. This will eventually increase the inflation level in the economy and therefore give a relative increase in the key policy rate to meet the inflation target. Some of the effect of oil price shock is therefore absorbed by monetary policy adjustments. From the IRFs we observe evidence for the economic reasoning. The two oil price shocks gives a slight contemporaneous increase in the interest rate for all sectors, before the rate reverts to its initial level within maximum two years. The variance decompositions for all the sectors are reported in Appendix **J**. The results are in accordance with the baseline model.

Responses of a monetary policy shock is also reported in Appendix **H**. It is worth noting that all the variables responds as predicted by economic theory. A one standard deviation increase in the interest rate makes GDP, employment and real wages decline in all of the sectors. The contraction is of different persistence and magnitude, but the variables have similar response patterns. They fall until they reach a bottom point and then begins an upward trajectory to initial levels. A slight real appreciation of the exchange rate is also observed in all of the sectors.

7.2 Considerations

Some considerations should to be addressed regarding the validity of the model. To start with the methodology, there may be potential misspecifications of the model that could result in biased estimates. The chosen lag length may not be the ideal with the number of variables included in the model. VAR models can easily become heavily parameterized, where there is not enough observations to estimate the amount of parameters, i.e. degrees of freedom problem (Bjørnland and Thorsrud 2015, 200). Additionally, there might be omitted variable bias that may have resulted in inaccurate IFRs. However, including more variables and adding more lags gives a trade-off.

The focus of this paper is on a demand-driven oil price, and the supply side (physical disruption) has been rather disregarded. Even though the literature suggests that innovations on the demand side are the most important, the supply shocks may be of importance for the price formation as well.

8. Conclusions

The objective of this paper has been to assess the effects of two distinct oil price shocks on different business sectors in Norway. Utilizing a structural autoregressive model, an impulse response analysis was performed for six different sectors. According to input-output analyses reported by Statistic Norway, many of these sectors have a particular link to the petroleum industry in terms of their production and employment. By performing an impulse response analysis of oil price shocks on these sectors, it is possible to identify a potential extended effect mechanism, such as the “Spending Effect”.

On the aggregated level, the *Mainland Economy* and the *Industry* was investigated. On the sectoral level there was investigation on *Services Related to Oil and Gas, Maintenance and Installation of Machines and Equipment*, *Rubber- and Plastic industry, Mineral product industry* and *Professional, Scientific and Technical services*. Economic activity was measured in sector-specific GDP, employment and real wage. The main finding is that the oil-specific shock has the greatest influence on the Norwegian macroeconomic variables. More specifically, the oil-specific shock generates responses in GDP, employment and the real wage that are of higher magnitude, larger persistence and of larger statistical significance, than the responses from an innovation in the global demand. This result is similar for all the sectors. However, some of the sectors are more exposed to the oil price shocks than others, making the extended effects of a shock a sector-specific issue. The *Mainland Economy* and the *Industry* responded modestly to the shocks, suggesting a rather stable aggregated Norwegian economy.

Sectors *Services Related to Oil and Gas, Maintenance and Installation of Machines and Equipment* and *Professional, Scientific and Technical services* were the ones with largest fluctuations in the economic activity. All of them were positively simulated, as all three macroeconomic variables increased. The close link with the petroleum industry could be an explanation for this. An increase in the real price of oil makes the investments in the petroleum industry increase and the industry demands more goods and services from the oil service-supplying sectors such as the sector for *Services Related to Oil and Gas*. The effect spreads to other parts of the economy when there is also a higher demand for services that are not directly related to extraction of the natural resources, like the services provided by *Maintenance and Installation of Machines and Equipment* and *Professional, Scientific and Technical services*. Based on these findings one can conclude that the Norwegian economy is considerably affected by a shock in the real oil price, but the effects are unevenly distributed on specific business sectors. Naturally, the sectors that are more closely linked to the petroleum industry will get a stronger impulse of the shock.

The latter part of this paper investigates whether there is asymmetry in the relationship between the real oil price and the macroeconomic variables. Most of the studies that has performed such asymmetry tests has mainly focused on oil-importing countries. Therefore, the tests did not only function as a validity test of the models, but it also gave insight on how this relationship is for Norway, a net oil-exporting country. The findings suggests that there is symmetry and linearity in the relationship between the oil price and the macroeconomic variables for all of the sectors. By these findings, one can visualize the effects of a *negative* real oil price shock on the macroeconomic variables. If the relationship is linear, a negative oil price shock should work the same way as in the main analyses, but in the opposite direction. As this paper is inspired by the recent fall in the oil price, its helps visualize the results for a negative shock. Lastly, the extension of the baseline model illustrated the role of monetary policy interventions to mute the effects of a real oil price shock.

As such, the present paper contributes to the debate on the Norwegian oil dependency and to policymaking related to oil price shocks, especially in the light of the recent oil price fall. Oil price shocks of different origins have substantial effects on the Norwegian economy. More specifically, changes in the demand from the petroleum industry create impulses through the rest of the economy and makes sectors linked to this industry vulnerable to shocks. This paper reveals that the demand for goods and services from the petroleum industry works as an important transmission channel for oil price shocks in Norway. An interesting topic for future research is to investigate how macroeconomic variables respond to distinct oil price shocks with higher magnitude than the magnitude used in this paper, and see whether the consequences gets more significant. Another interesting study would be to consider an asymmetric relationship between the real price of oil and Norwegian macroeconomic variables and investigate the responses of distinctive negative oil price shocks.

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Appendix A: Descriptive Statistics and Sector Characteristics

A.1 Sector Characteristics

1) ***Services related to extraction of oil and gas*** includes extraction services like production- and exploration services, piping, and transportation services. Additionally, this sector also include external engineer firms that delivers services to the petroleum industry. According to Statistic Norway's report, this sector stands for approximately 23 percent of all direct deliveries of investment products and services to the petroleum industry (Hungnes, Kolsrud, Nitter-Hauge, Prestmo, and Strøm 2016, 15).

2) ***Maintenance and installation of machines and equipment*** includes two industries, which are maintenance of fabricated metal products, machines and equipment and installation of industry machines- and equipment. Firms in this sector provide special, routinely maintenance- and installation services of machines and equipment used in the industry-sector (Mælum 3013)

3) ***Rubber- and plastic industry, mineral product industry*** includes firms that produces rubber- and plastic products. This sector is not of particular importance in SN's 2016 report on extended effects of petroleum industry (Hungnes, Kolsrud, Nitter-Hauge, Prestmo, and Strøm 2016), but it is included in this paper as this sector is heavily raw-material based and has oil as one of the main input factors in production. It is of interest to see whether an increase in oil prices may reduce production and employment in this sector, as theory predicts. As sector 2 and 3 are classified as subsectors under the Norwegian industry as a whole, it will also be interesting to investigate whether these moves with the aggregated industry or not.

4) ***Professional, scientific and technical services*** includes industries that provide services from the Mainland economy that are not related to extraction of oil and gas. In Statistic Norway's report this is a large subsector under the category *other business related services* that accounts for over 30 percent of direct deliveries to the petroleum industry. It also have *Professional, scientific and technical services*

includes firms that provide juridical- and accounting services, business consulting, administrative services, architect and technical consulting services and R&D (Solhom 2012). With this large set of businesses, it is possible to measure the extended effects of an oil shock on the other parts of the economy than the petroleum industry.

A.2 Descriptive statistics and graphs

Descriptive statistics are reported to provide overall information on the sample period 1995-2015. The variables are transformed in line with section ***3.3***, and are presented in first difference in order to have a useful interpretation. The correlation with the changes in real price of oil is also reported. The abbreviation of the sectoral names are **ME**: Mainland Economy, **I**: Industry, **O&G:** Services related to extraction of oil and gas, **M&R**: Maintenance and installation of machines and equipment, **R&P**: Rubber- and plastic industry, mineral product and **P,T&S**: Professional, scientific and technical services.

Table 5: Descriptive statistics of Δ*gdp* from all sectors (1995-2015)

	ME	*I*	*O&G*	*M&R*	*R&P*	*P,T&S*
Mean	0,0066	0,0032	0,0129	0,0053	0,0036	0,0079
Median	0,0063	0,0049	0,0072	0,0057	0,0050	0,0062
Maximum	0,0326	0,0598	1,0003	0,2821	0,1261	0,0750
Minimum	-0,0224	-0,0595	-1,0066	-0,2807	-0,1298	-0,0893
Std. Dev.	0,0097	0,0200	0,1816	0,0603	0,0456	0,0285
Skewness	0,2228	-0,1769	-0,1247	-0,2403	-0,4118	-0,5075
Kurtosis	3,8122	4,3684	23,6431	12,6084	4,0071	4,2706
Jarque-Bera	2,9326	6,8251	1456,1870	316,2194	5,7822	9,0362
Probability	0,2308	0,0330	0,0000	0,0000	0,0555	0,0109
Correlation Δ*rpo*	0,2201	0,3390	-0,0922	0,1379	0,3227	0,0115
Probability	0,047	0,0018	0,4098	0,2168	0,0031	0,9181
Observations	82	82	82	82	82	82

The average quarterly growth of GDP among the sectors is between 0.32 percent at the lowest in **I** to the highest at 1.29 percent in the sector for **O&G**. This is a remarkable difference in quarterly growth rate. This may come from the fact that the data for **I** is aggregated and therefore fluctuates less than the sectoral-data. The difference between the mean and the median are relatively small in all the sectors, except for in **I, O&G and R&P,** indicating that the changes in GDP may have been asymmetric for these sectors. Observing the largest drop (minimum point) and the largest increase (maximum point), it is worthwhile noticing the 100 percent increase in **O&G** and the 100 percent decrease, which indicates that this sector is highly volatile. Lastly, the **O&G** also have the largest standard deviation among all sectors at around 18 percent and **ME** has the lowest with 0,97 percent. The correlation analysis indicates that the relationship with the real price of oil appears to be statistically insignificant for most of the sectors, except **I, R&P** and **ME** (on 5 percent significance level).

Table 6: Descriptive statistics of Δ*emp* from all sectors (1995-2015)

	ME	*I*	*O&G*	*M&R*	*R&P*	*P,T&S*
Mean	0,0034	-0,0012	0,0237	0,0077	0,0003	0,0079
Median	0,0032	-0,0003	0,0118	0,0095	0,0000	0,0060
Maximum	0,0176	0,0399	0,3795	0,2394	0,0942	0,0432
Minimum	-0,0099	-0,0315	-0,1506	-0,1370	-0,1305	-0,0236
Std. Dev.	0,0048	0,0108	0,0789	0,0367	0,0279	0,0141
Skewness	0,0586	0,0604	1,9098	2,1693	-0,7115	0,1907
Kurtosis	3,9708	5,1083	9,5478	23,4031	9,1471	3,0000
Jarque-Bera	3,2671	15,2360	196,3320	1486,6250	136,0233	0,4969
Probability	0,1952	0,0005	0,0000	0,0000	0,0000	0,7800
Correlation Δ*rpo*	0,0282	-0,0294	-0,0242	0,1508	0,1052	-0,0606
Probability	0,8017	0,7935	0,8293	0,1762	0,3471	0,5888
Observations	82	82	82	82	82	82

The average quarterly growth rate in employment among the sectors is between a negative growth rate of -0.12 percent in **I** to 2.37 percent in **O&G** at the highest. These are the same sectors that had the largest difference in the growth rate for GDP as well. Observing the small difference between the mean and the median in most of the sector, there is an indication that the fluctuations in employment have been more or less symmetric in this sample period. However, it is worth highlighting the large difference for the **O&G**, demonstrating a volatile sector. The **O&G** also have the largest increase of 37.95 percent and the largest drop of -15.06 percent among all sectors. Lastly, the **O&G** has the largest standard deviation at approximately 8 percent and **ME** has the lowest with 0.48 percent.

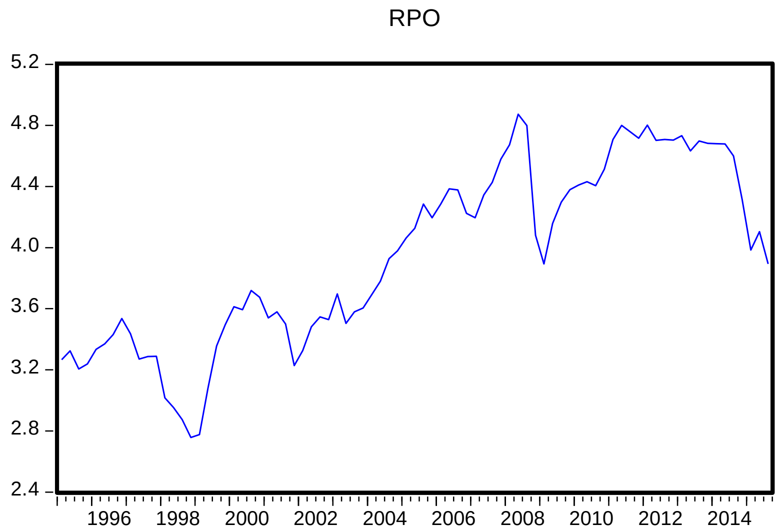
The correlation of the employment with the real price of oil appears to be statistically insignificant for all the sectors.

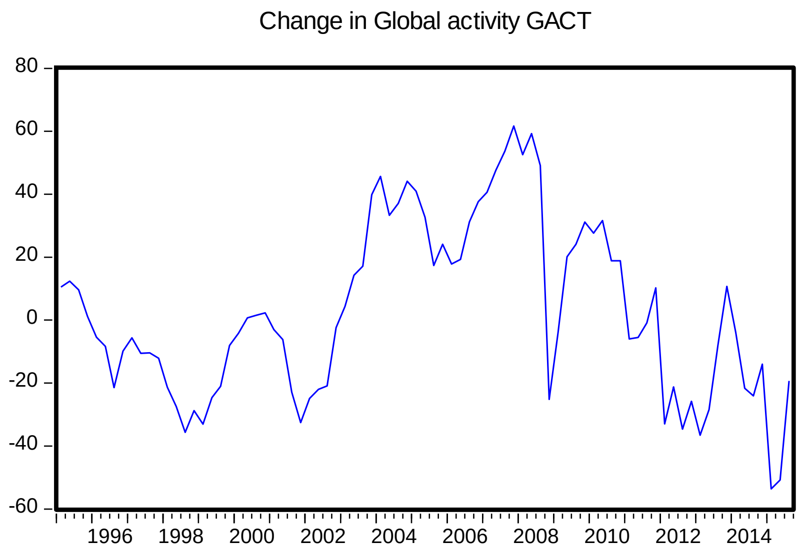
Table 7: Descriptive statistics of Δ*rw* from all sectors (1995-2015)

	ME	*I*	*O&G*	*M&R*	*R&P*	*P,T&S*
Mean	0,0073	0,0018	0,0287	0,0103	0,0024	0,0121
Median	0,0032	-0,0004	0,0180	0,0094	-0,0012	0,0112
Maximum	0,0478	0,0538	0,3985	0,2773	0,1069	0,0995
Minimum	-0,0279	-0,0550	-0,1806	-0,1604	-0,1240	-0,0238
Std. Dev.	0,0159	0,0211	0,1082	0,0478	0,0339	0,0229
Skewness	0,2803	-0,0591	0,8702	1,3469	0,2579	0,7646
Kurtosis	2,6402	2,8119	4,0971	15,5393	5,6968	4,1609
Jarque-Bera	1,5162	0,1686	14,4620	562,0131	25,7584	12,5935
Probability	0,4686	0,9191	0,0007	0,0000	0,0000	0,0018
Correlation Δ*rpo*	0,0989	0,0978	0,0302	0,1931	0,1598	0,0619
Probability	0,3767	0,3822	0,7876	0,0822	0,1516	0,5806
Observations	82	82	82	82	82	82

The average quarterly growth in real wage among all the sectors spans from 0.18 percent at the lowest in **I** to 2.9 percent in **O&G** at the highest. Analysing the difference between mean and median for this variable it indicates that fluctuations have been relatively asymmetric, as the differences are quite large. The largest increase (maximum point) among all the sectors is in **O&G** at approximately 40 percent and the largest drop (minimum point) is also in **O&G** at around -18 percent, again, indicating that this sector is the most volatile among all the sectors. Lastly, the highest standard deviation is in **O&G** at around 11 percent and the lowest is in **ME** at approximately 1.6 percent. The repeatedly low standard deviation in **ME** for all the variables may be due to the fact that it is aggregated data and therefore fluctuates less than smaller, sectoral data. The correlation with the real price of oil is statistically insignificant.

Figure 11: Development of the real price of oil and Killian's index 1995-2015





Appendix B: Stationary and Non-stationary Processes

Stationarity is a fundamental and important concept in time series analysis. Non-stationary variables is problematic in terms of generating spurious regression and make the use of standard large-sample theory not allowed for (Favero 2001, 46). Spurious regression implies that standard test statistics suggest a statistically relationship between variables that in reality do not exists at all (Granger and Newbold 1974). The economic interpretation of this econometrical problem is that in the presence of unit root (non-stationary) process a shock will persist forever (Favero 2001, 47), and the series will not have the important mean-reverting property.

Assume the following AR(1) process:

$$Y_t = \gamma + \phi_1 Y_{t-1} + e_t \tag{15}$$

where $e_t \sim i.i.d.\, N \;\; (0, \sigma^2)$

The essential question is whether $\phi_1 = 1$ or $\phi_1 \prec 1$. If it is equal to one, then equation (15) represents a random walk process with drift. If it is less than one then the AR(1) process is stationary (Bjørnland and Thorsrud 2015, 118). If we remove the constant, the equation can be rewritten as:

$$\Delta Y_t = \mu Y_{t-1} + e_t \tag{16}$$

where $\mu = \phi - 1$

B.1 Augmented Dickey-Fuller test

Many types of tests has been proposed to detect the presence of a unit root process and the Augmented Dickey-Fuller (ADF) has been remarkably successful among those (Favero 2001, 47).

A unit root test on equation (16) is to test the null hypothesis:

$$H_o : \mu = 0$$

Which implies non-stationarity, i.e. that the process contains a unit root. This is against the alternative hypothesis:

$$H_o : \mu \prec 0$$

Which implies stationarity (Bjørnland and Thorsrud 2015, 118).

B.2 Augmented Dickey-Fuller test: Results

Table 8: ADF unit root test

Log levels, 4 lags, constant and trend

	GDP		Employment		Real wage	
Sector	t-stat	Prob.	t-stat	Prob.	t-stat	Prob.
ME	-2,2516	0.4547	-3,3042	0.0732	-2,5546	0.3020
I	-2,1606	0.5043	-3,3096	0.0723	-3,4496	0.0523
O&G	-1,5892	0.7885	-2,8206	0.1945	-3,1283	0.1071
M&R	-2,0176	0.5825	-2,0178	0.5824	-2,3450	0.4050
R&P	-2,4042	0.3746	-2,4029	0.3753	-2,4064	0.3735
P,T&S	-2,1986	0.4835	-2,6023	0.2806	-3,3220	0.0703

Table 9: ADF unit root test

1st difference, 4 lags and a constant

	GDP		Employment		Real wage	
Sector	t-stat	Prob.	t-stat	Prob.	t-stat	Prob.
ME	-2,9370	0,0458	-2,6945	0,0796	-2,8032	0,0625
I	-3,5023	0,0105	-2,4888	0,1221	-2,1413	0,2295
O&G	-4,4464	0,0005	-3,3084	0,0178	-3,2660	0,0200
M&R	-3,4162	0,0133	-2,8287	0,0590	-2,8848	0,0518
R&P	-3,8315	0,0040	-3,0971	0,0309	-3,1929	0,0242
P,T&S	-3,4008	0,0139	-2,3342	0,1641	-2,1069	0,2426

Table 10: ADF unit root test

	Log level and constant		Log level, constant and trend		1st difference and constant	
	t-stat	Prob.	t-stat	Prob.	t-stat	Prob.
Kilian's index	-2,2199	0,2010	-2,1468	0,5118	-4,7886	0,0002
ROP	-1,4990	0,5290	-1,8089	0,6911	-4,4878	0,0005
REER	-1,2837	0,6335	-0,6393	0,9736	-4,6717	0,0002

Appendix C: Stable VAR

C.1 Stability of the VAR

The notation and theory follows Bjørnland and Thorsrud (2015). Consider the following VAR(1) process:

$$y_t = v + A_1 y_{t-1} + e_t \tag{17}$$

where $A_1 = \begin{bmatrix} 0.5 & 0 \\ 1 & 0.2 \end{bmatrix}$

For a process of higher order, VAR (p), the system is stable if the eigenvalues of the coefficient matrix is less than one in absolute value. A VAR of any order can be reformulated to VAR (1) form using the companion form. For illustration the eigenvalues of the VAR (1) process above is the following:

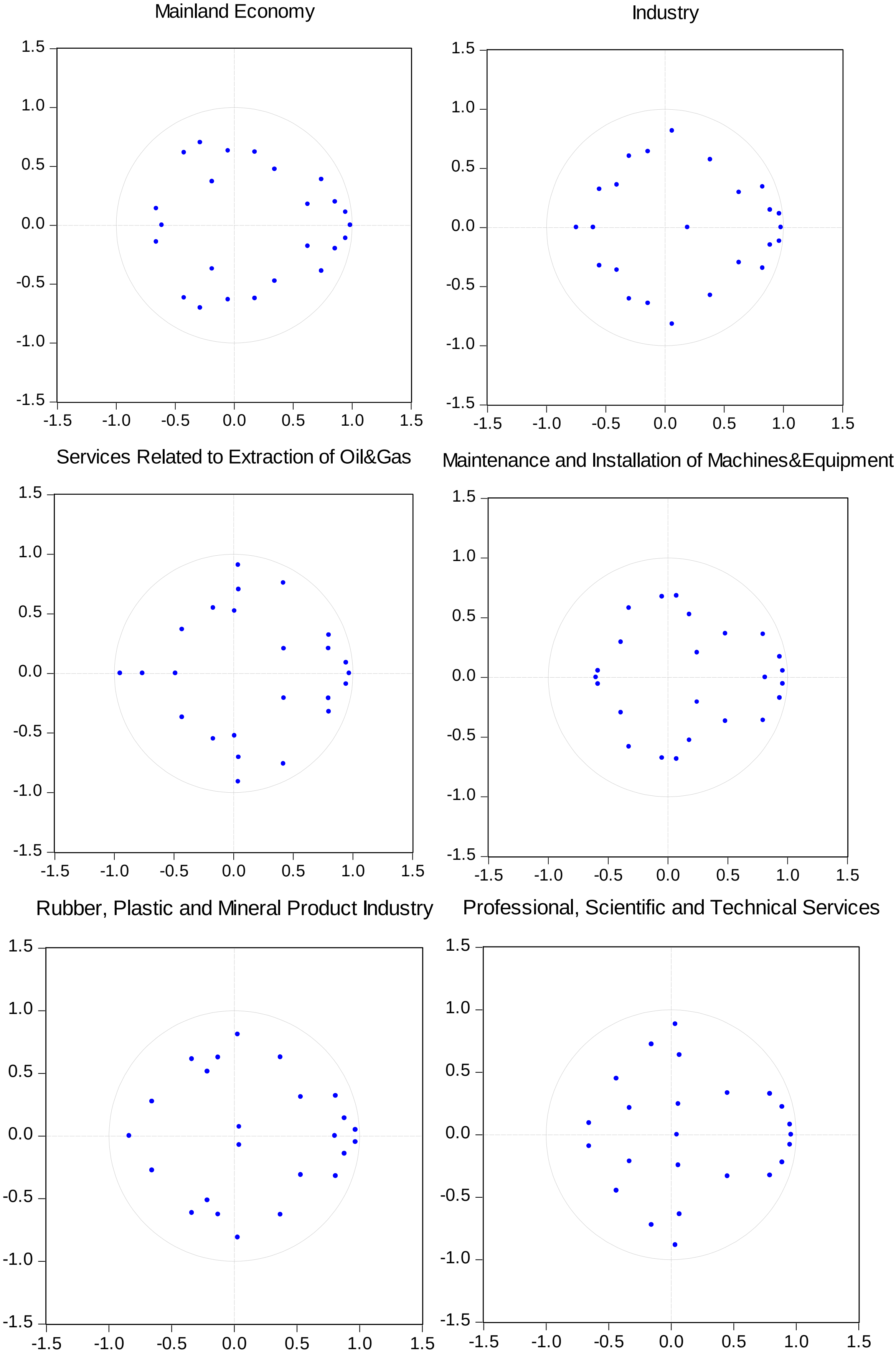
$$\det\left[\begin{bmatrix} 0.8 & 0 \\ 1 & 0.4 \end{bmatrix} - \lambda \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}\right] = \det\left[\begin{bmatrix} 0.8-\lambda & 0 \\ 1 & 0.4-\lambda \end{bmatrix}\right]$$

$$= (0.8-\lambda)(0.4-\lambda) = 0 \tag{18}$$

The eigenvalues in this case are therefore $\lambda_1 = 0.8$ and $\lambda_2 = 0.4$, and both have a value less than one, which makes the VAR(1) a stable process. There is also common to use the term *roots* rather than the *eigenvalues* to check VAR stability. The interpretation is in this case is reversed as a stable stochastic VAR has roots that are larger than one. In applied work, it is common to use the unit circle from any statistical software to check for VAR stability.

C.2 Stability: Results

Figure 12: Stability test results



Appendix D: Lag Length selection

Two widely used information criterions for lag selection are the Schwarz (SC) (also referred to as the Bayes) information criterion and the Akaike (AIC) information (Bjørnland and Thorsrud, 2015). The notation is:

$$SC(p) = \ln\left(\frac{SSR(p)}{T}\right) + (p+1)\frac{\ln(T)}{T} \tag{19}$$

(19)

$$AIC(p) = \ln\left(\frac{SSR(p)}{T}\right) + (p+1)\frac{2}{T} \tag{20}$$

The difference between these is the last term, making the SC give harder penalty on the size of the model. The SC, therefore, typically suggest fewer lags than the AIC (Bjørnland and Thorsrud 2015, 69)

Appendix E: Residual Autocorrelation test

Table 11: Autocorrelation LM test

	Mainland Economy		**Industry**		**Services Ext. Oil&Gas**	
Lags	LM-Stat	Prob	LM-Stat	Prob	LM-Stat	Prob
1	46,0840	0,1211	64,8922	0,0022	54,0697	0,0270
2	43,6787	0,1775	59,1675	0,0088	37,1616	0,4153
3	34,9508	0,5183	49,5855	0,0653	27,8671	0,8319
4	44,2055	0,1637	54,7171	0,0236	32,1197	0,6537
5	19,5156	0,9886	32,7839	0,6224	46,1407	0,1199
6	32,7926	0,6219	27,3226	0,8505	41,8835	0,2307
7	33,6548	0,5806	41,6322	0,2389	43,7019	0,1769
8	41,3036	0,2500	42,1427	0,2224	56,3858	0,0165

Table 12: Autocorrelation LM test

	Maint. & Inst.		**Prof., Scien. & Tech.**		**Rub., Plast. & Mineral**	
Lags	LM-Stat	Prob	LM-Stat	Prob	LM-Stat	Prob
1	56,0352	0,0178	56,5815	0,0158	54,6174	0,0241
2	46,7617	0,1080	65,8289	0,0017	33,5356	0,5864
3	67,5806	0,0011	64,8320	0,0022	36,5829	0,4416
4	54,7425	0,0234	32,9539	0,6142	55,0720	0,0219
5	39,5220	0,3155	51,0022	0,0500	35,5194	0,4913
6	36,9329	0,4256	23,4044	0,9477	30,0804	0,7454
7	44,0257	0,1683	31,6596	0,6751	33,5903	0,5837
8	49,2906	0,0690	49,1741	0,0705	49,3229	0,0686

The majority of the models show no signs of significant autocorrelation. The results for the sector *Professional, Scientific and Technical Services* indicate, however, that there may be a risk of autocorrelation in lag 2 and 3. There is also a small indication of it in lag 2 for the sector *Maintenance and Installation of Machines and Equipment.* The aggregated Industry shows signs of autocorrelation in lag 1, 2 and 4.

Appendix F: Impulse Responses

F.1 Mainland Economy

Figure 13: Global Activity Shock

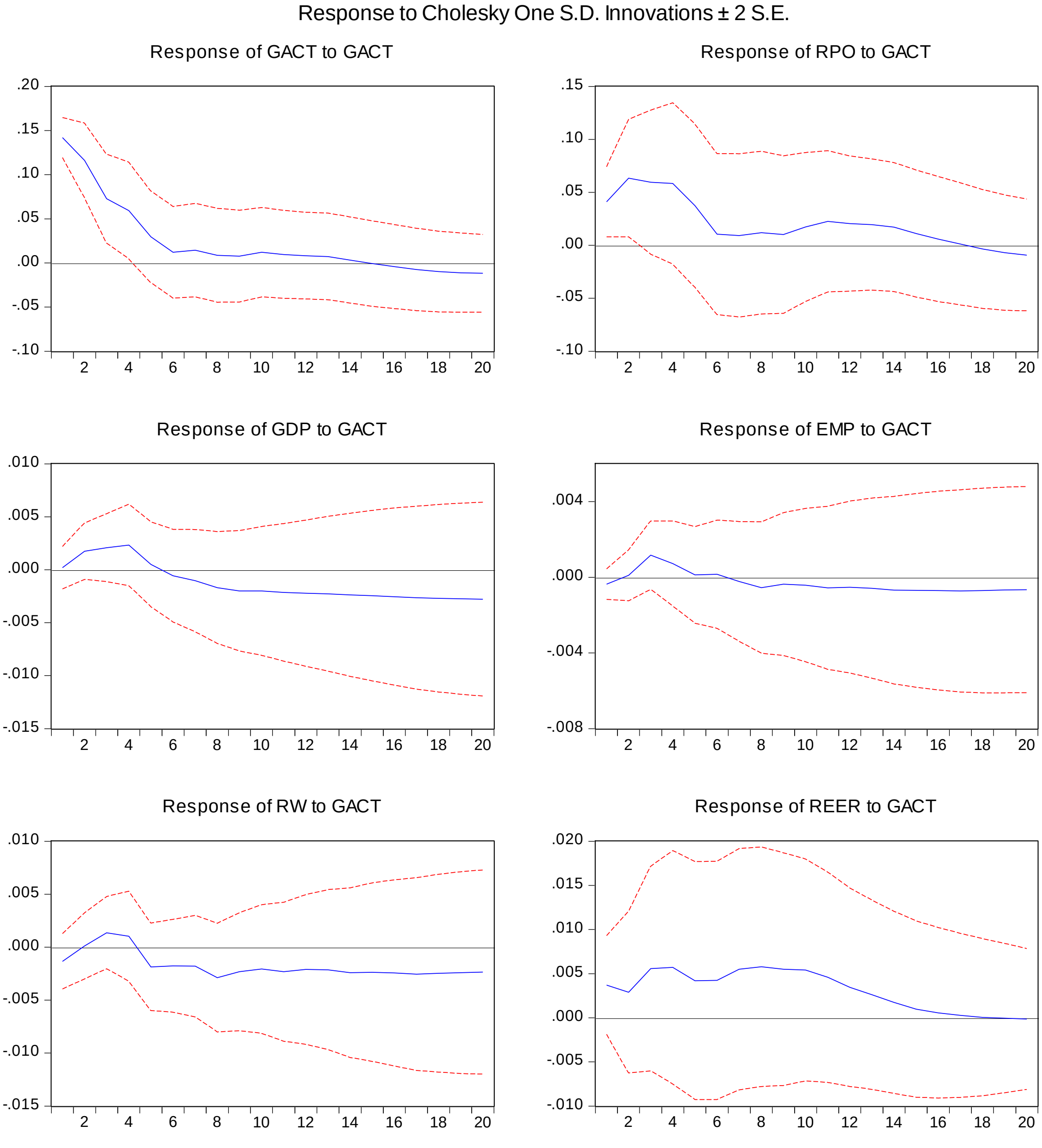
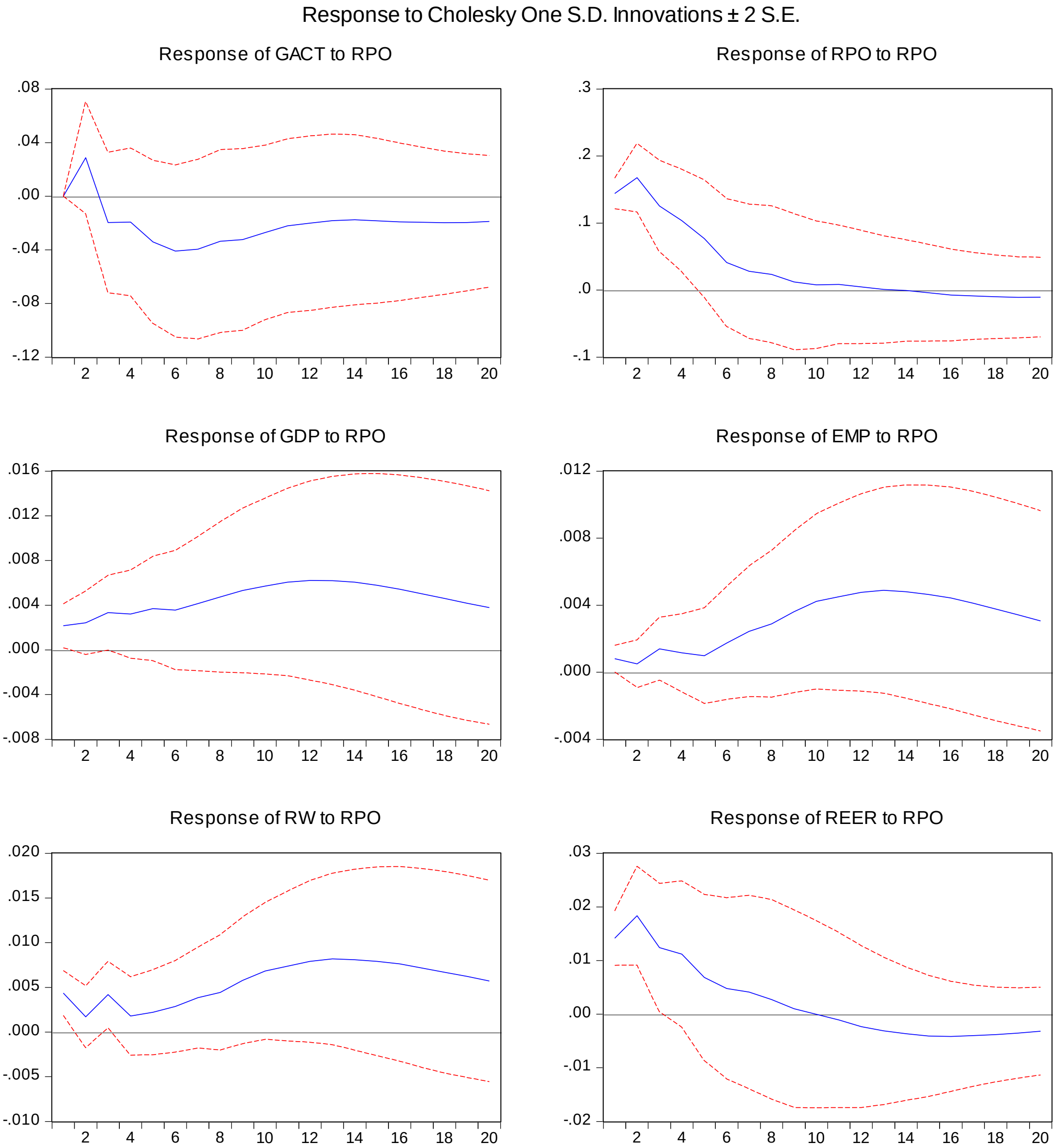


Figure 13: Oil-specific shock



F.2 Industry

Figure 14: Global Activity Shock

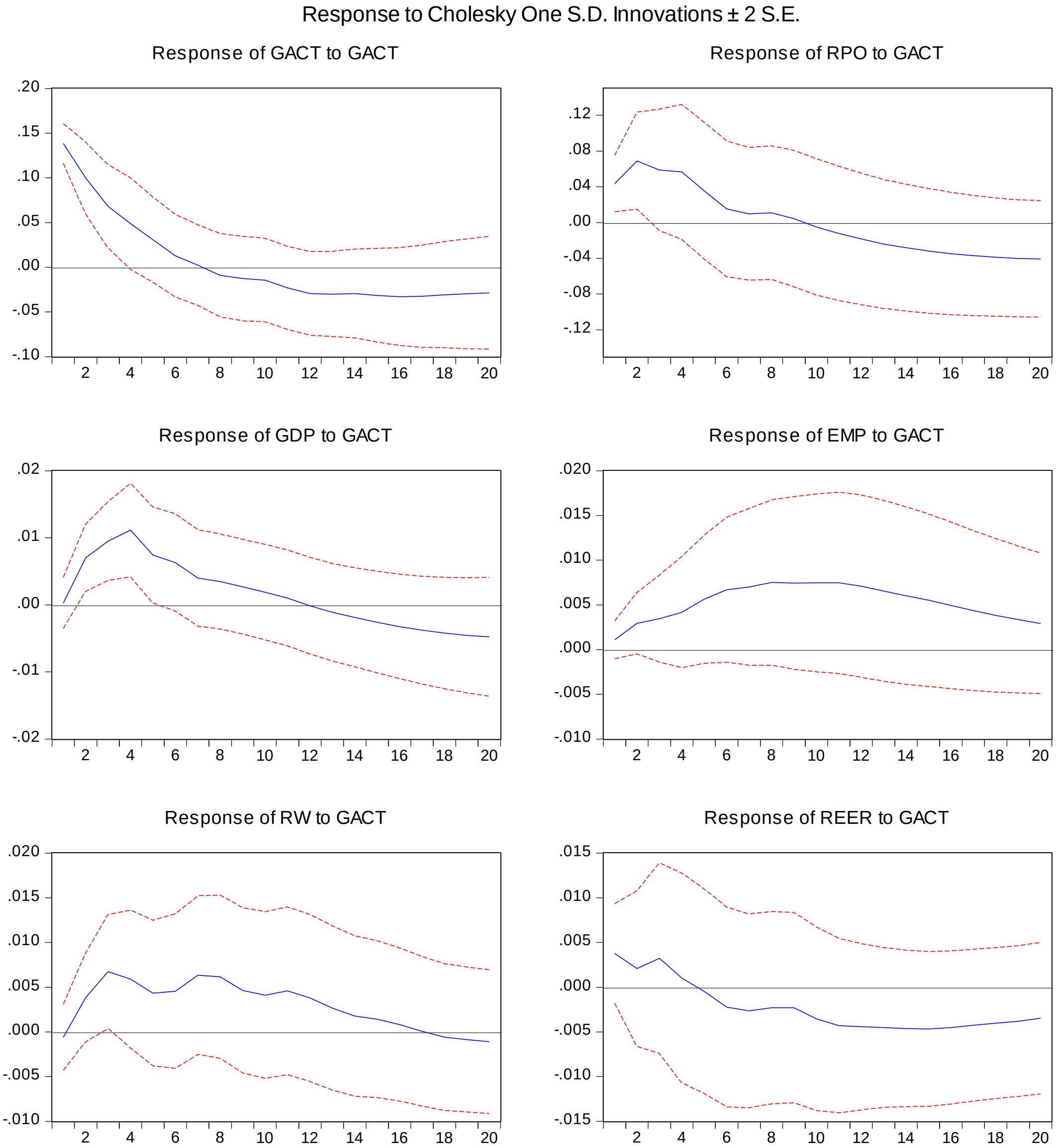
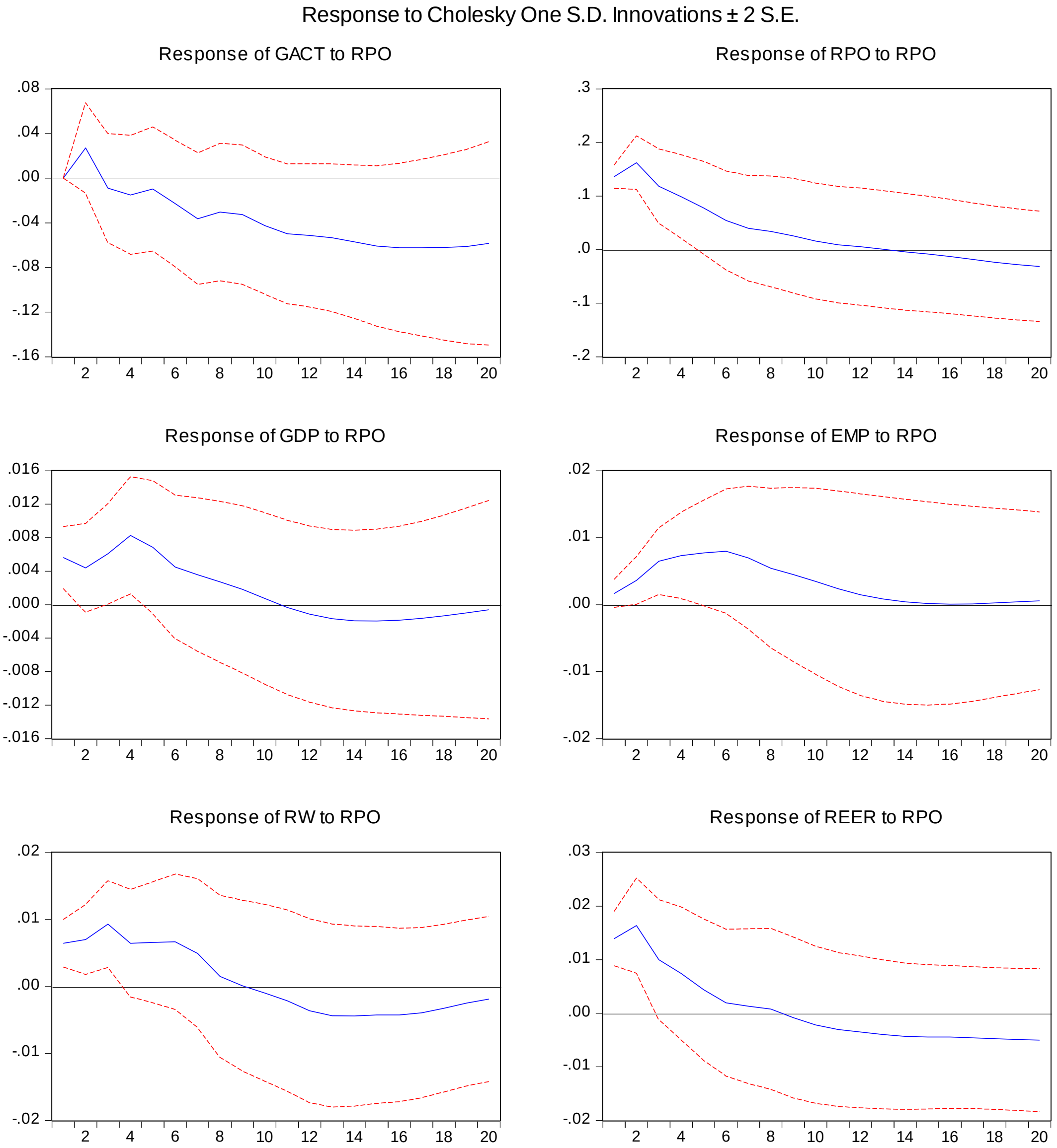


Figure 15: Oil-specific shock



F.3 Services Related to Extraction of Oil and Gas

Figure 16: Global Activity Shock

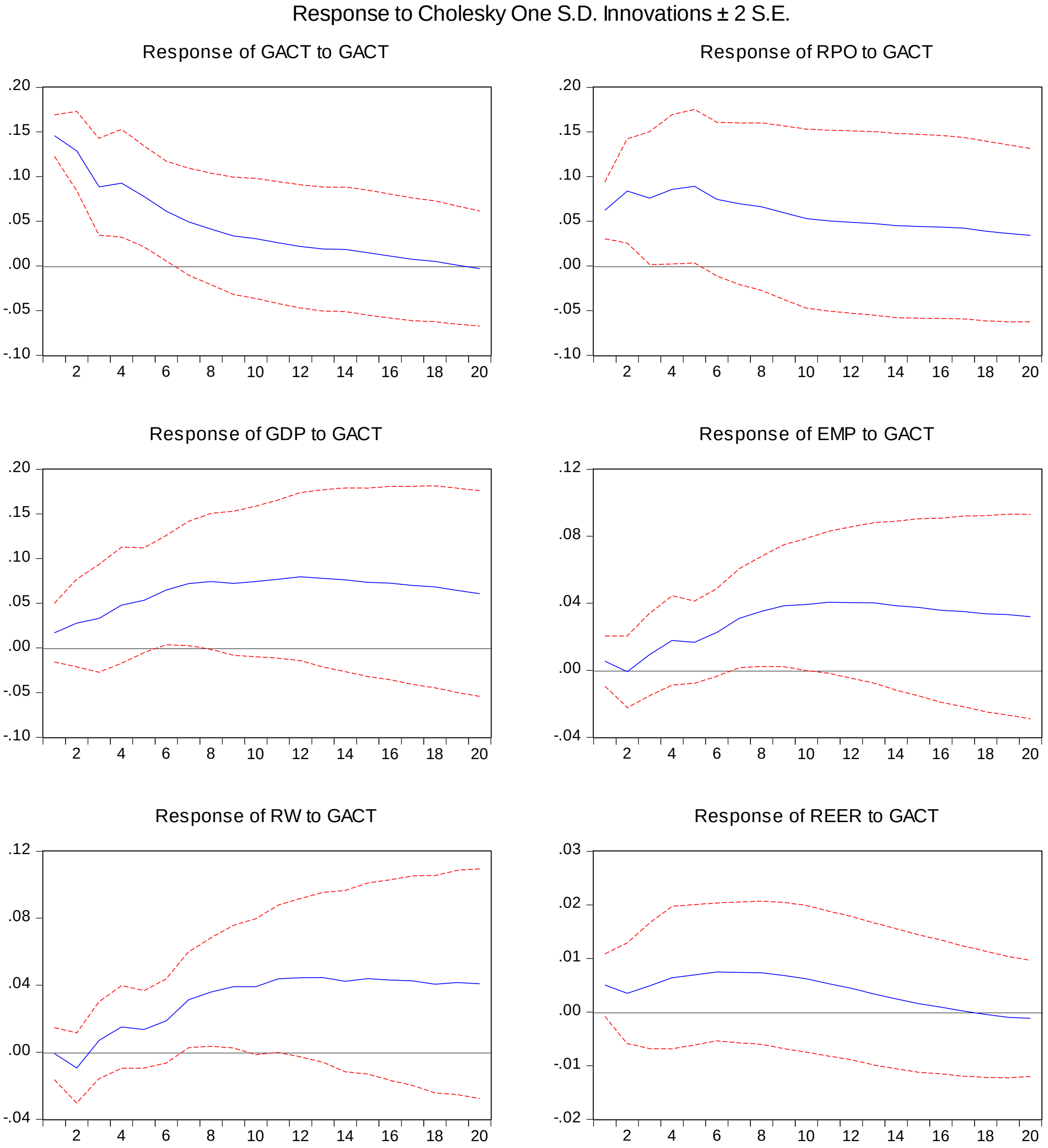
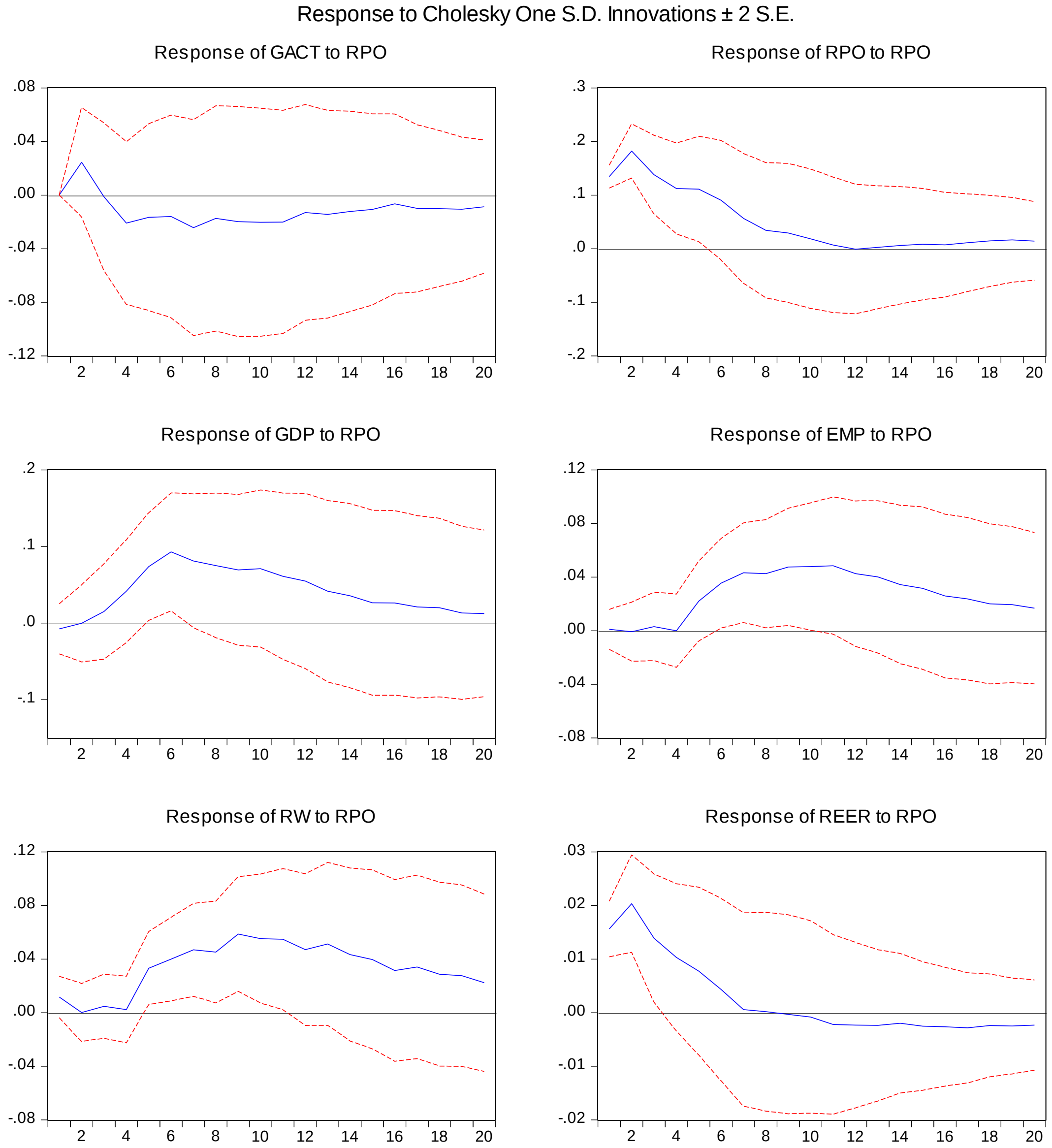


Figure 17: Oil-specific shock



F.4 Maintenance and Installation of Machines and Equipment

Figure 18: Global Activity Shock

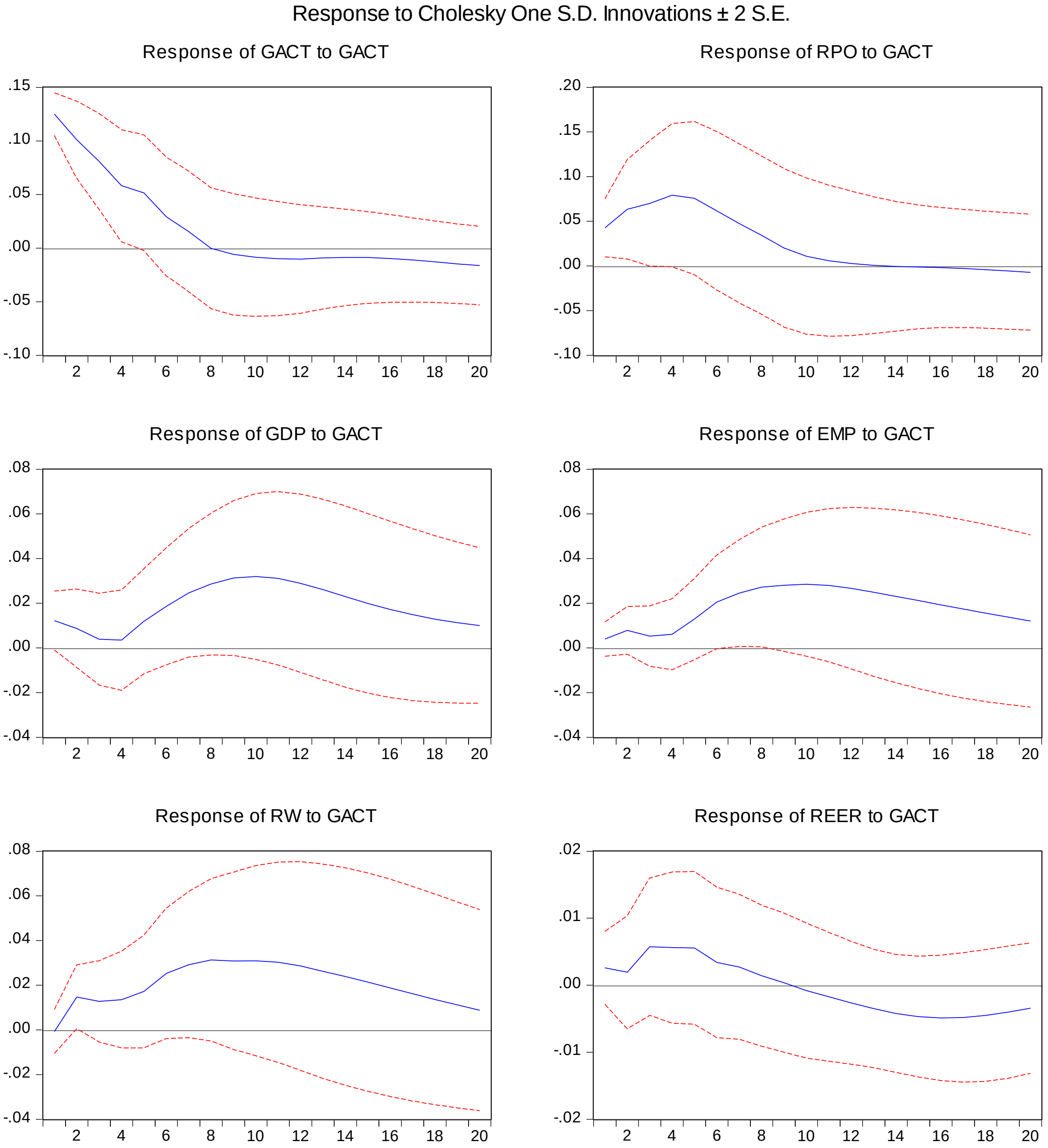
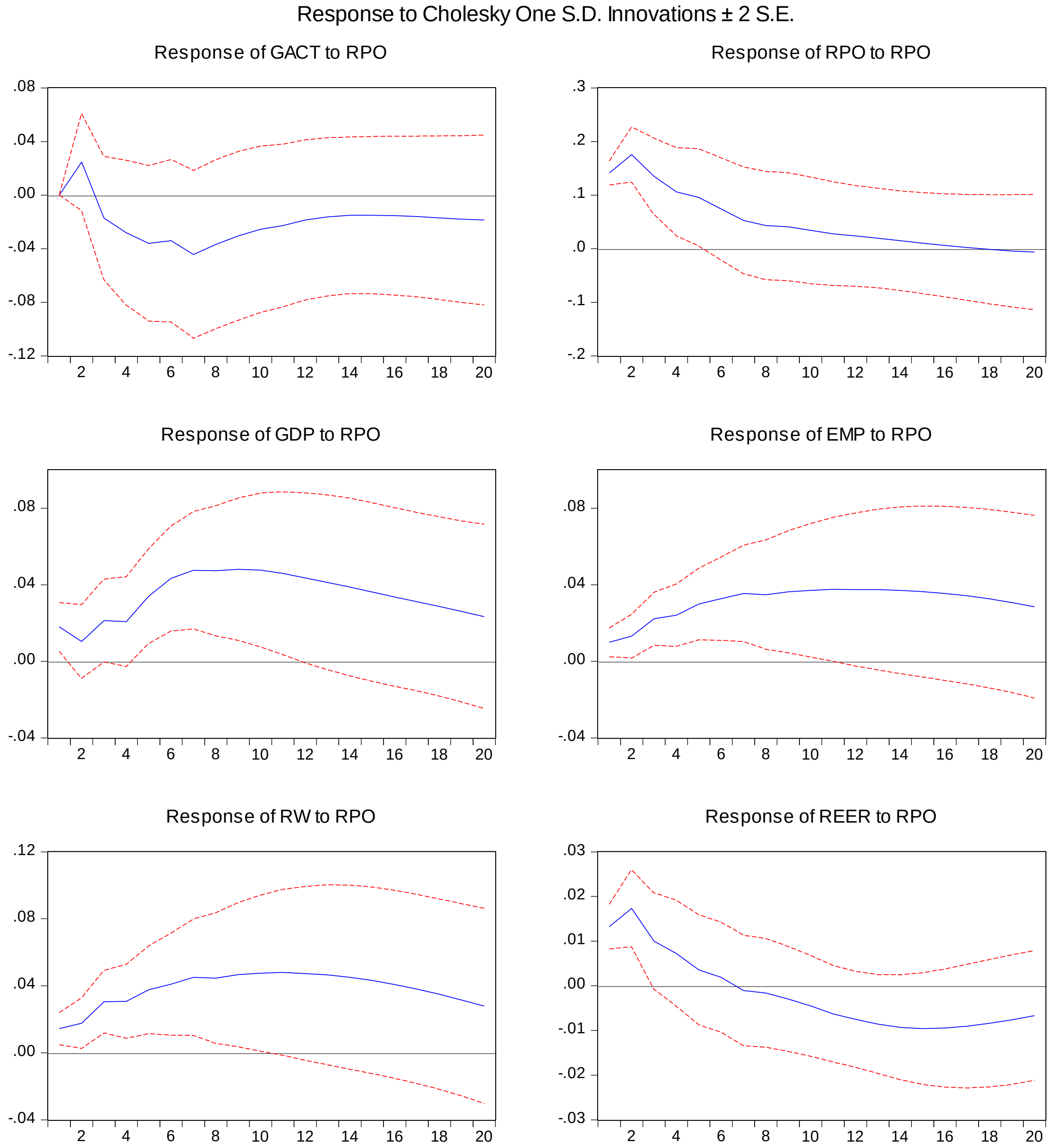


Figure 19: Oil-specific shock



F.5 Rubber, Plastic and Mineral Product Industry

Figure 20: Global Activity Shock

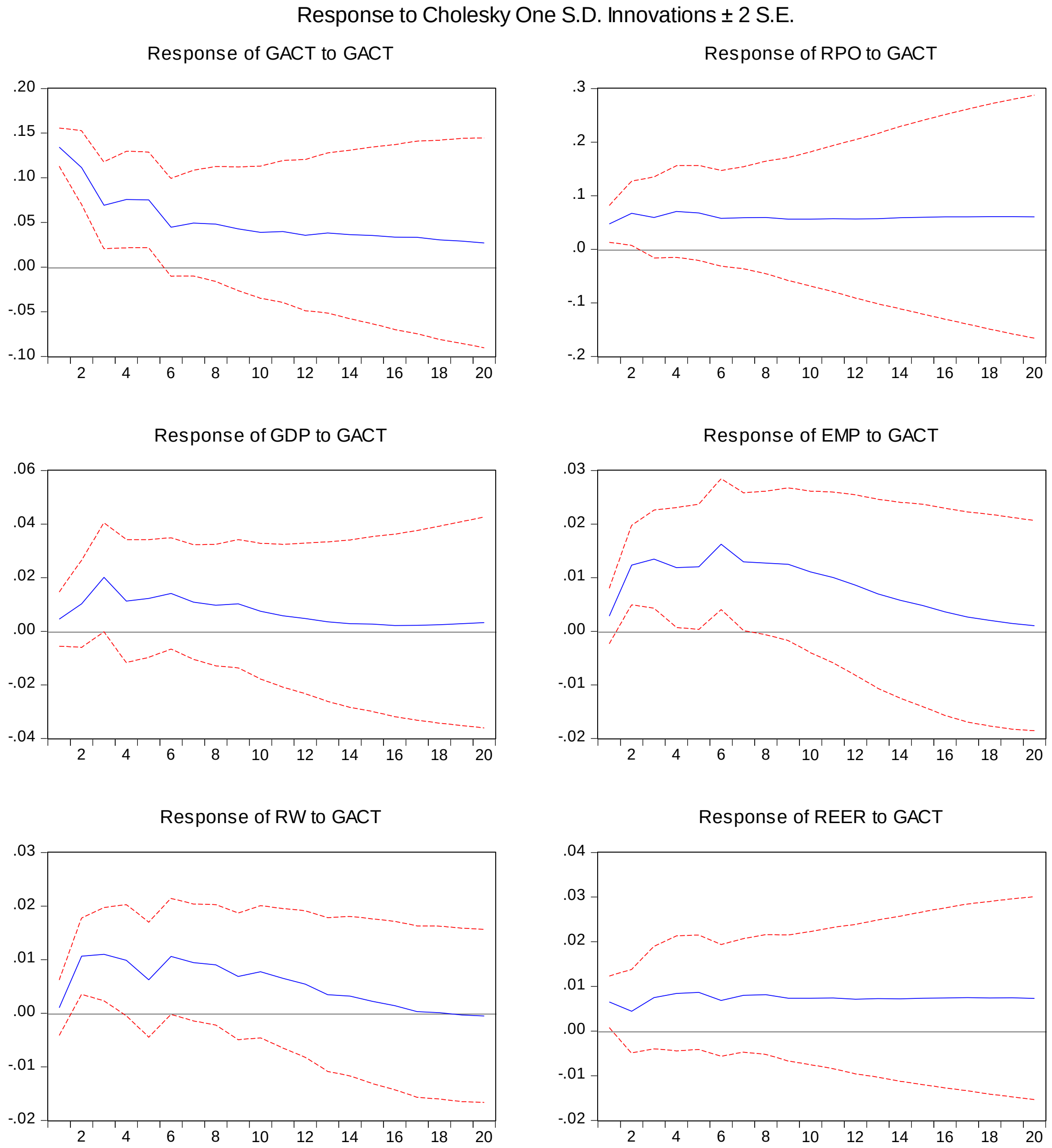
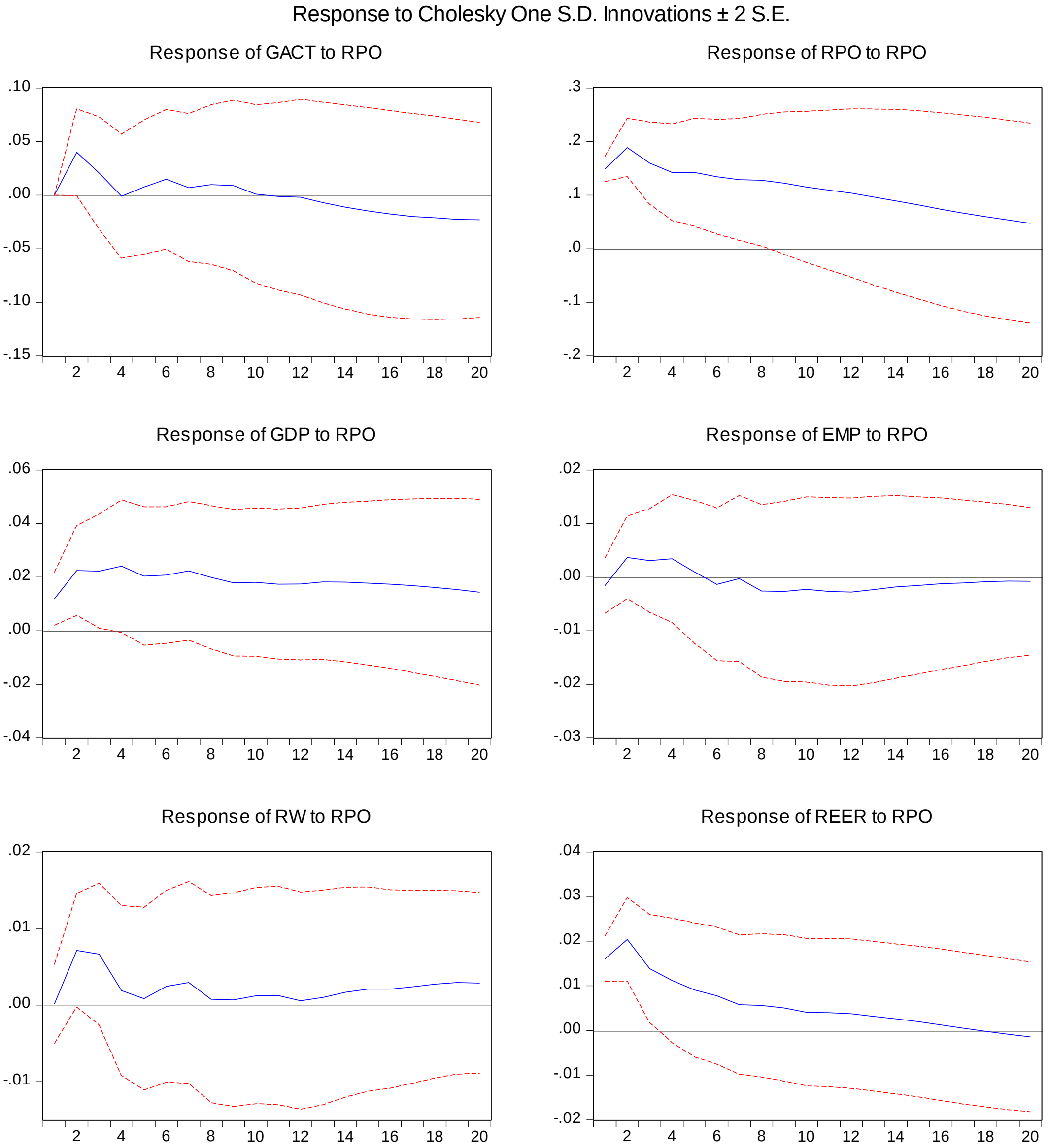


Figure 21: Oil-specific shock



F.6 Professional, Scientific and Technical Services

Figure 22: Global Activity Shock

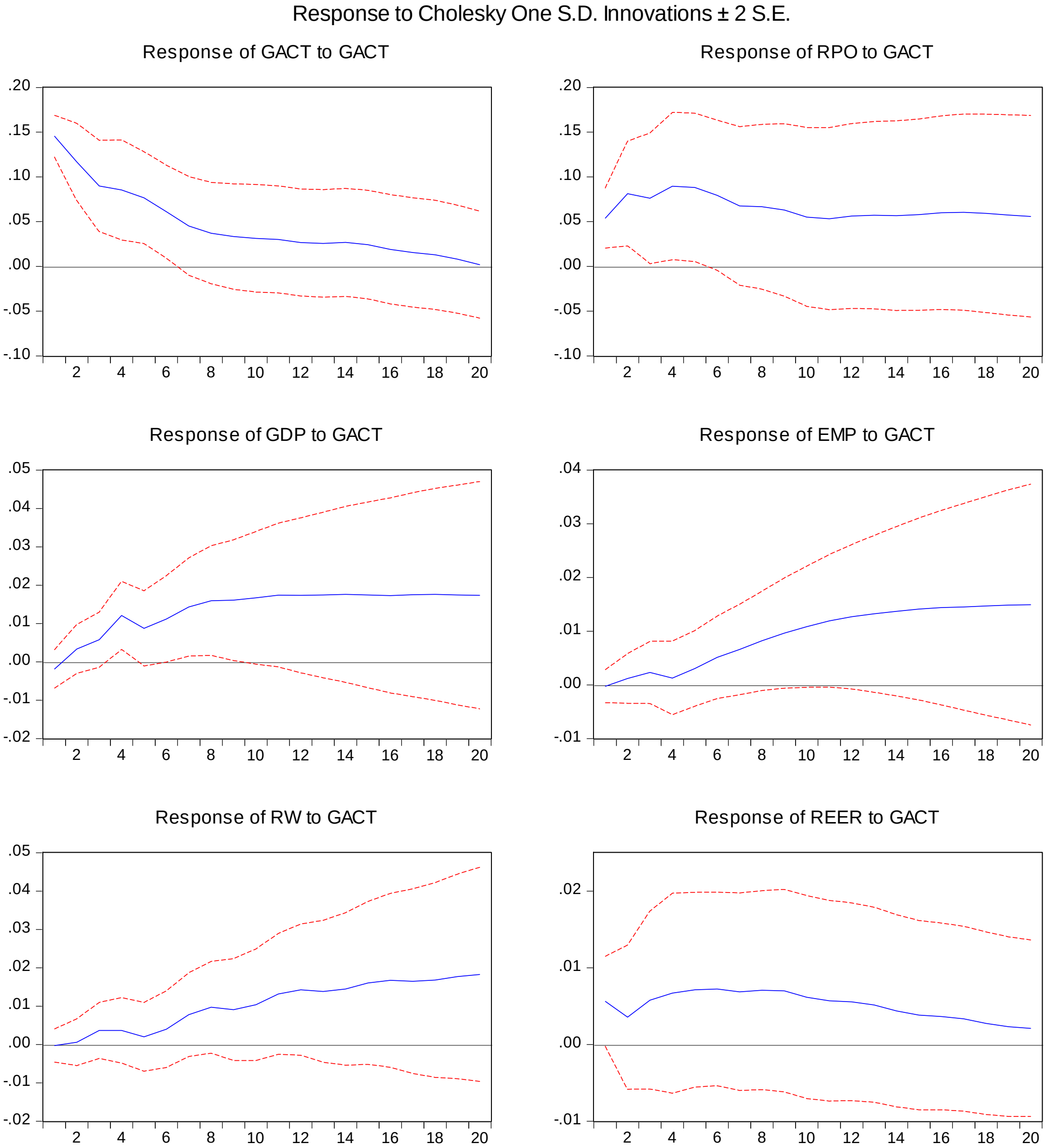
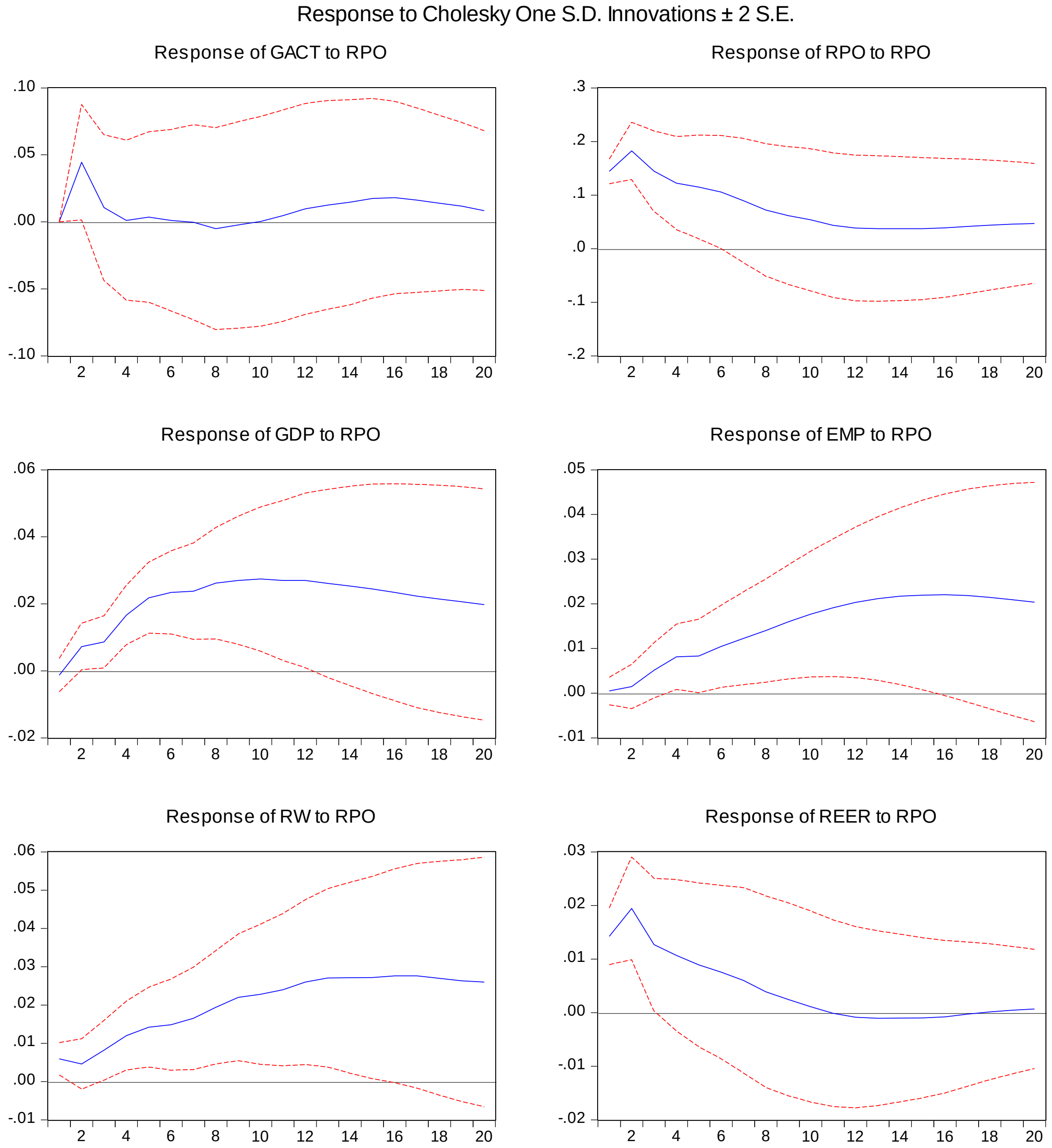


Figure 23: Oil-specific shock



Appendix G: Variance Decomposition

G.1 Mainland Economy

Table 13: Mainland Economy

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,15	7,51	92,49	0,00	0,00	0,00	0,00
	2	0,23	10,40	88,93	0,11	0,02	0,35	0,17
	3	0,27	12,44	86,73	0,09	0,10	0,36	0,27
RPO	4	0,30	13,88	82,53	0,23	2,05	0,92	0,39
	8	0,34	12,17	71,18	1,11	7,87	2,22	5,45
	12	0,37	11,72	62,99	1,64	10,85	2,39	10,41
	16	0,38	11,50	58,74	2,32	13,17	3,25	11,02

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,01	0,05	5,84	94,11	0,00	0,00	0,00
	2	0,01	2,72	9,28	82,02	3,75	2,00	0,22
	3	0,01	4,35	12,68	74,31	6,11	2,29	0,27
GDP	4	0,02	5,40	13,41	72,85	5,25	1,87	1,21
	8	0,02	3,22	18,14	71,73	3,23	2,35	1,34
	12	0,03	3,61	24,27	62,05	7,84	1,38	0,84
	16	0,04	4,06	25,99	53,64	14,45	1,22	0,64

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,00	1,05	5,10	0,02	93,83	0,00	0,00
	2	0,01	0,46	2,88	3,54	90,95	1,34	0,84
	3	0,01	2,79	5,25	9,51	77,97	2,29	2,19
EMP	4	0,01	2,49	5,10	14,90	70,39	5,09	2,03
	8	0,01	1,10	10,16	25,49	44,67	11,71	6,88
	12	0,02	0,82	23,77	28,75	25,47	11,96	9,23
	16	0,02	0,88	31,80	29,11	20,38	10,14	7,70

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,01	1,32	14,04	22,21	1,58	60,85	0,00
	2	0,01	1,24	15,05	21,25	5,33	57,12	0,01
	3	0,01	1,89	20,40	24,18	10,12	43,32	0,08
RW	4	0,02	1,62	14,73	41,28	12,29	29,38	0,70
	8	0,02	3,91	15,51	51,12	10,43	17,18	1,84
	12	0,03	3,95	26,83	48,46	6,10	10,85	3,80
	16	0,04	3,95	33,22	44,02	7,54	7,68	3,59

G.2 Industry

Table 14: Industry

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	10,21	9,73	90,27	0,00	0,00	0,00	0,00
	2	16,41	13,73	84,40	1,55	0,29	0,02	0,01
	3	19,50	17,14	76,81	5,00	0,80	0,01	0,24
RPO	4	21,47	20,49	70,64	6,36	0,90	0,05	1,56
	8	24,80	19,35	63,54	6,96	4,92	0,55	4,67
	12	27,24	16,48	55,88	8,52	7,70	1,98	9,43
	16	28,61	15,35	51,20	10,08	9,01	3,79	10,57

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,02	0,07	8,65	91,28	0,00	0,00	0,00
	2	0,02	10,37	12,76	72,76	0,10	0,68	3,33
	3	0,02	21,55	17,83	57,68	0,15	0,47	2,32
GDP	4	0,03	30,49	21,04	43,00	1,55	0,42	3,50
	8	0,03	32,44	21,44	39,76	1,94	0,32	4,09
	12	0,04	27,37	17,71	37,80	12,06	0,29	4,77
	16	0,04	21,41	13,81	30,40	29,53	0,50	4,33

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,01	0,84	4,81	1,52	92,84	0,00	0,00
	2	0,01	3,40	11,76	1,08	83,19	0,44	0,13
	3	0,02	4,07	19,00	0,75	74,84	0,96	0,37
EMP	4	0,03	4,96	20,45	0,49	72,08	1,79	0,24
	8	0,04	13,02	17,38	0,33	65,25	3,22	0,79
	12	0,05	18,19	13,50	1,28	59,83	4,82	2,39
	16	0,05	19,85	13,11	2,51	56,35	5,73	2,45

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,02	0,01	15,12	0,86	36,10	47,92	0,00
	2	0,02	4,79	20,41	0,60	38,07	35,78	0,33
	3	0,03	8,28	25,54	0,88	44,14	20,88	0,28
RW	4	0,03	8,29	24,86	0,68	48,59	15,23	2,36
	8	0,04	10,77	19,13	4,05	53,07	10,25	2,72
	12	0,05	11,55	16,87	10,52	47,13	9,14	4,80
	16	0,05	10,15	18,43	16,00	42,05	8,34	5,03

G.3 Services Related to Extraction of Oil and Gas

Table 15: Services Related to Extraction of Oil and Gas

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,15	17,61	82,39	0,00	0,00	0,00	0,00
	2	0,25	17,33	81,55	0,74	0,05	0,04	0,29
	3	0,30	18,74	79,15	0,74	0,22	0,29	0,85
RPO	4	0,33	21,57	74,51	1,68	0,21	0,45	1,58
	8	0,43	25,78	59,43	2,15	0,58	2,83	9,23
	12	0,47	26,64	50,02	1,88	2,38	3,54	15,54
	16	0,49	27,97	46,12	2,22	3,52	3,52	16,65

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,15	1,34	0,28	98,38	0,00	0,00	0,00
	2	0,20	2,61	0,15	95,71	1,04	0,24	0,25
	3	0,24	3,70	0,50	90,19	4,47	0,21	0,94
GDP	4	0,25	6,92	3,14	82,58	4,50	0,29	2,57
	8	0,36	17,21	21,93	51,29	2,43	0,46	6,69
	12	0,44	23,25	23,05	35,78	2,84	1,01	14,07
	16	0,50	27,22	19,77	28,49	3,50	1,34	19,68

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,07	0,66	0,02	0,07	99,25	0,00	0,00
	2	0,09	0,40	0,02	0,99	88,57	1,09	8,92
	3	0,10	1,26	0,12	0,82	81,66	1,03	15,11
EMP	4	0,10	4,01	0,10	0,78	74,45	1,18	19,49
	8	0,15	14,79	23,44	0,86	45,98	1,06	13,89
	12	0,20	23,50	34,15	0,57	27,68	1,98	12,11
	16	0,24	26,98	32,32	0,42	21,91	3,08	15,28

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,07	0,01	2,87	0,27	70,83	26,02	0,00
	2	0,08	1,30	1,96	0,77	71,18	19,06	5,74
	3	0,09	1,73	1,94	0,66	70,34	16,21	9,12
RW	4	0,10	4,00	1,78	0,73	66,04	14,44	13,01
	8	0,15	14,13	31,58	0,70	36,19	9,08	8,31
	12	0,21	22,40	41,53	0,99	19,79	6,88	8,42
	16	0,26	26,15	38,19	0,77	15,30	6,81	12,78

G.4 Maintenance and Installation of Machines and Equipment

Table 16: Maintenance and Installation of Machines and Equipment

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,15	8,38	91,62	0,00	0,00	0,00	0,00
	2	0,24	9,90	86,00	0,01	0,65	2,97	0,48
	3	0,29	12,65	81,17	0,13	0,86	4,67	0,52
RPO	4	0,33	15,92	74,96	0,87	0,78	6,89	0,58
	8	0,40	18,54	61,41	1,28	1,38	12,87	4,52
	12	0,44	15,90	53,86	1,13	2,60	16,28	10,23
	16	0,46	14,48	49,39	1,30	3,19	19,12	12,52

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,06	4,28	9,21	86,51	0,00	0,00	0,00
	2	0,07	4,19	7,96	86,41	0,63	0,48	0,34
	3	0,08	3,43	12,54	79,03	1,05	2,96	1,00
GDP	4	0,09	3,10	16,03	75,83	1,20	2,67	1,17
	8	0,14	10,64	43,35	43,06	0,60	1,30	1,04
	12	0,19	17,18	50,10	29,43	0,48	1,85	0,97
	16	0,21	17,91	52,41	24,61	0,48	3,11	1,47

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,03	1,32	8,25	29,57	60,86	0,00	0,00
	2	0,05	3,73	13,13	29,47	52,72	0,92	0,03
	3	0,06	3,34	24,44	26,55	44,76	0,68	0,23
EMP	4	0,06	3,37	31,94	24,91	38,08	0,80	0,91
	8	0,12	15,51	43,06	23,03	13,21	4,72	0,48
	12	0,16	19,67	42,85	20,11	6,82	9,35	1,20
	16	0,20	18,52	43,10	17,16	4,73	12,81	3,69

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,04	0,03	10,82	41,16	22,06	25,93	0,00
	2	0,06	5,77	13,78	37,18	19,45	23,62	0,20
	3	0,08	6,68	25,50	33,14	17,73	16,21	0,73
RW	4	0,09	7,22	30,68	31,39	14,60	14,72	1,40
	8	0,16	13,67	39,00	25,96	4,89	14,34	2,14
	12	0,21	15,69	41,57	20,66	2,68	16,08	3,31
	16	0,25	14,78	42,84	16,71	1,99	18,19	5,49

G.5 Rubber, Plastic and Mineral Product Industry

Table 17: Rubber, Plastic and Mineral Product Industry

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,16	9,18	90,82	0,00	0,00	0,00	0,00
	2	0,26	10,25	87,98	0,27	1,15	0,03	0,32
	3	0,31	10,57	85,72	0,30	3,10	0,05	0,26
RPO	4	0,35	12,23	83,32	0,63	3,28	0,22	0,32
	8	0,49	12,45	72,36	3,67	4,93	2,09	4,49
	12	0,61	11,43	60,14	6,11	4,73	3,66	13,93
	16	0,70	11,44	51,31	8,49	4,03	4,19	20,55

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,04	1,02	6,97	92,01	0,00	0,00	0,00
	2	0,07	2,68	13,80	82,69	0,53	0,08	0,23
	3	0,08	7,43	15,94	75,92	0,34	0,17	0,19
GDP	4	0,09	7,50	19,62	71,38	0,39	0,47	0,63
	8	0,11	9,78	27,74	52,85	2,28	2,37	4,98
	12	0,13	9,08	29,79	42,56	6,22	5,02	7,32
	16	0,14	7,19	29,35	36,09	8,20	6,63	12,55

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,02	1,50	0,48	2,23	95,79	0,00	0,00
	2	0,03	16,02	1,60	10,91	70,75	0,25	0,47
	3	0,04	22,71	1,70	18,35	54,70	2,09	0,45
EMP	4	0,05	22,09	1,71	28,31	44,34	1,61	1,94
	8	0,06	29,35	1,13	33,15	33,75	1,48	1,15
	12	0,07	33,22	1,47	33,63	28,81	1,32	1,53
	16	0,07	33,83	1,64	32,44	27,62	2,41	2,05

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,02	0,20	0,00	1,10	42,96	55,74	0,00
	2	0,03	12,66	5,65	15,11	31,23	32,63	2,72
	3	0,04	17,47	7,06	26,47	23,08	22,11	3,81
RW	4	0,04	18,00	5,34	39,30	17,67	16,15	3,54
	8	0,06	20,53	3,59	45,93	15,75	10,68	3,52
	12	0,06	22,64	3,21	46,66	14,08	10,25	3,16
	16	0,06	22,00	3,33	44,10	14,87	11,74	3,95

G.6 Professional, Scientific and Technical Services

Table 18: Professional, Scientific and Technical Services

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,15	12,25	87,75	0,00	0,00	0,00	0,00
	2	0,25	14,76	83,72	1,06	0,24	0,00	0,22
	3	0,30	16,49	80,58	1,81	0,70	0,24	0,19
RPO	4	0,34	19,85	76,29	2,19	0,62	0,75	0,30
	8	0,44	23,88	65,42	2,19	2,03	1,25	5,23
	12	0,50	24,10	55,64	1,77	3,69	1,39	13,41
	16	0,53	26,19	51,37	1,62	3,83	1,26	15,72

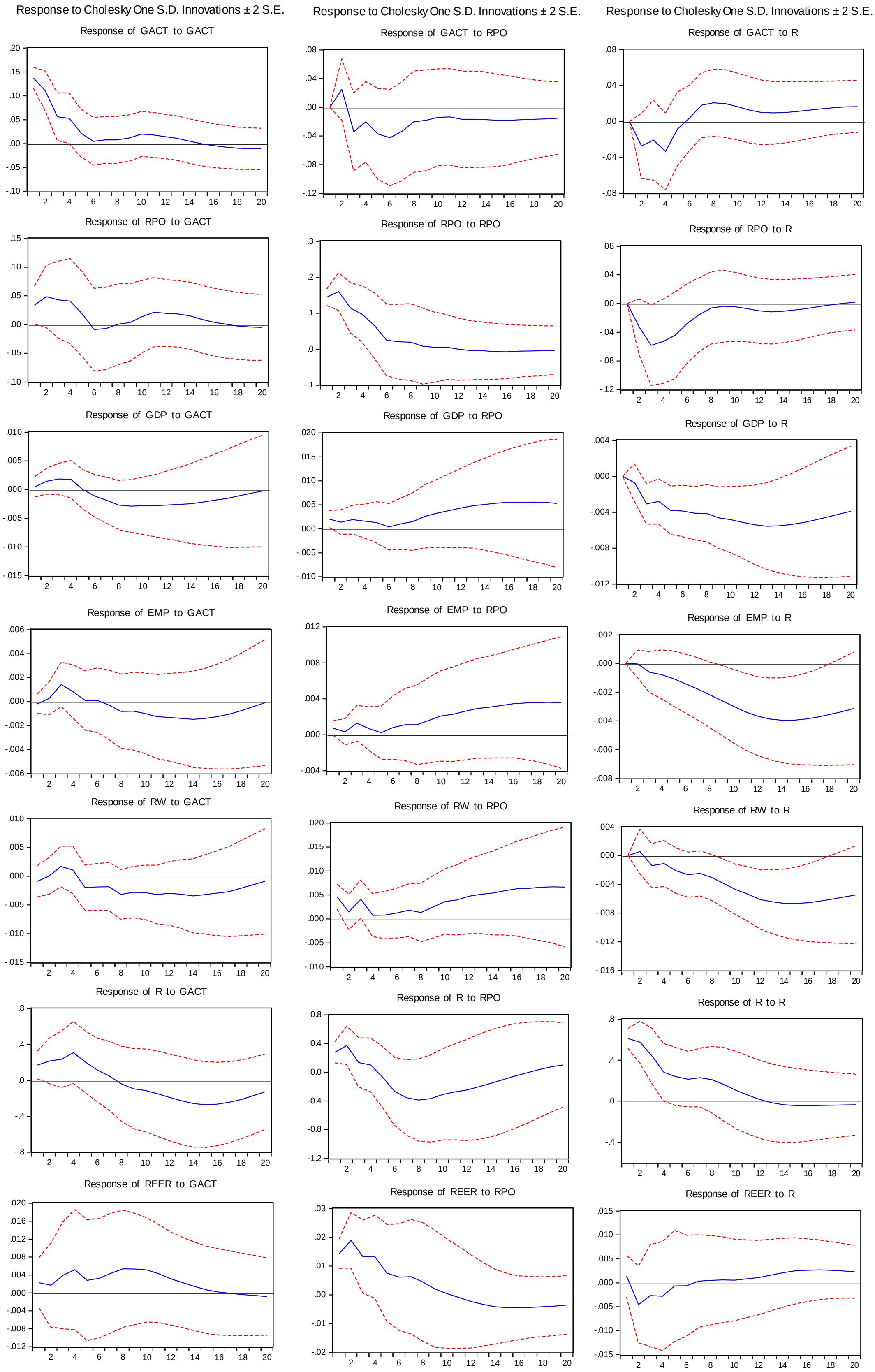
Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,02	0,73	0,34	98,93	0,00	0,00	0,00
	2	0,03	2,21	8,03	78,91	6,40	3,64	0,81
	3	0,03	5,47	14,68	62,54	13,03	3,05	1,23
GDP	4	0,04	13,90	29,06	40,55	11,38	4,32	0,78
	8	0,07	19,20	60,25	13,95	4,35	1,87	0,38
	12	0,09	22,77	64,12	7,16	2,66	0,95	2,34
	16	0,12	24,20	60,94	4,85	2,55	0,69	6,78

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,01	0,04	0,12	6,78	93,05	0,00	0,00
	2	0,02	0,39	0,65	7,90	88,55	2,48	0,03
	3	0,02	1,16	4,95	8,55	81,27	2,78	1,29
EMP	4	0,03	1,04	11,91	9,12	73,76	3,03	1,14
	8	0,04	8,38	33,69	9,41	42,93	3,71	1,89
	12	0,06	17,50	51,65	5,28	21,99	2,45	1,13
	16	0,08	21,53	57,88	3,04	13,13	1,44	2,98

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	REER
	1	0,02	0,02	9,54	1,04	42,95	46,44	0,00
	2	0,03	0,06	8,81	2,40	53,51	34,97	0,26
	3	0,03	1,50	13,47	3,95	55,14	24,50	1,43
RW	4	0,04	2,19	21,63	4,58	50,15	19,71	1,75
	8	0,06	6,50	43,33	4,64	28,38	14,10	3,05
	12	0,08	12,53	58,62	2,69	15,87	8,47	1,82
	16	0,10	16,53	63,64	1,60	10,47	5,19	2,56

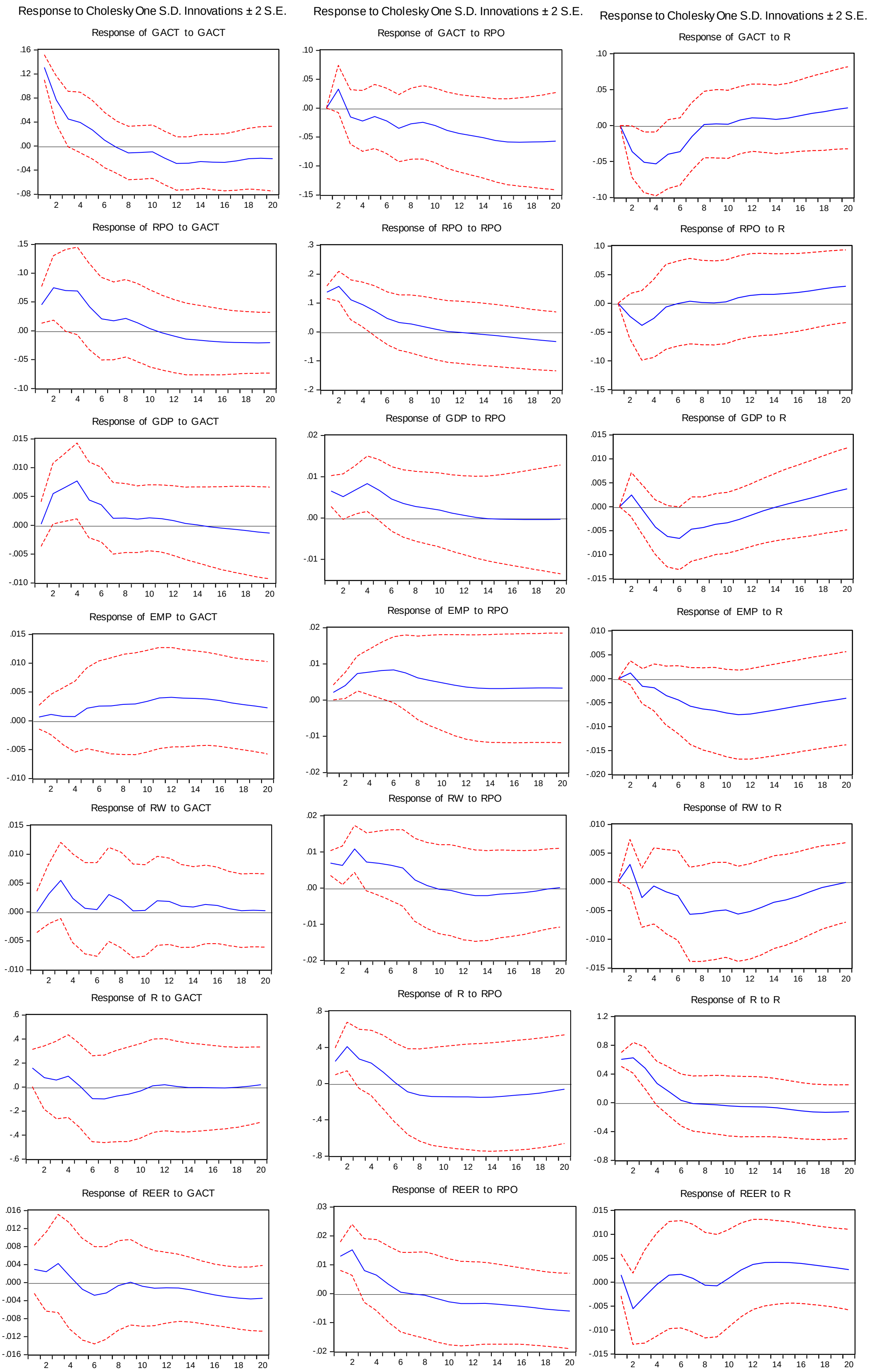
Appendix H: Impulse Responses – Monetary Policy

Figure 24: Mainland Economy



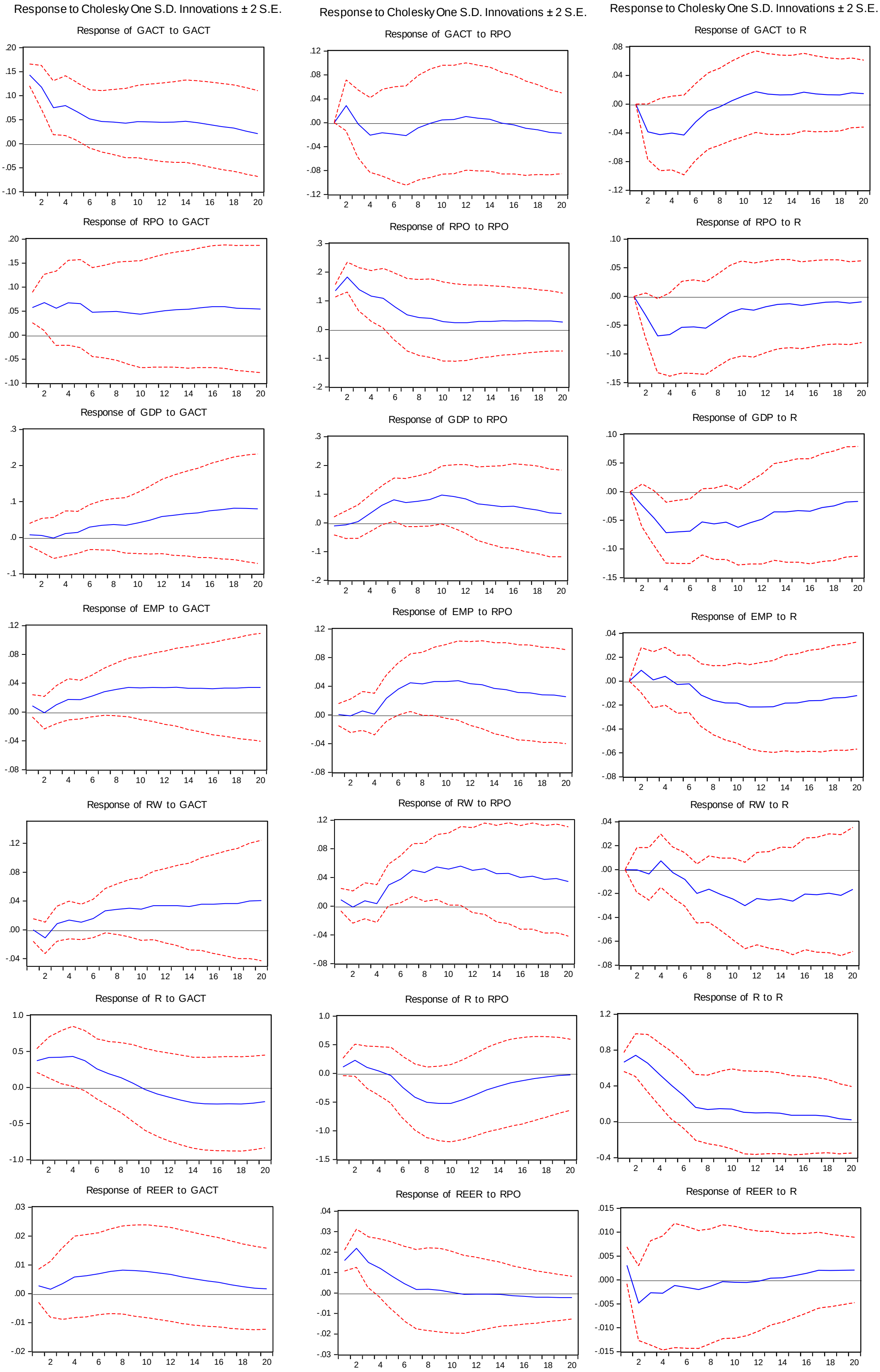
NOTE: The left column display a shock in global activity, the middle column display an oil-specific shock and the right column display a monetary policy shock.

Figure 25: Industry



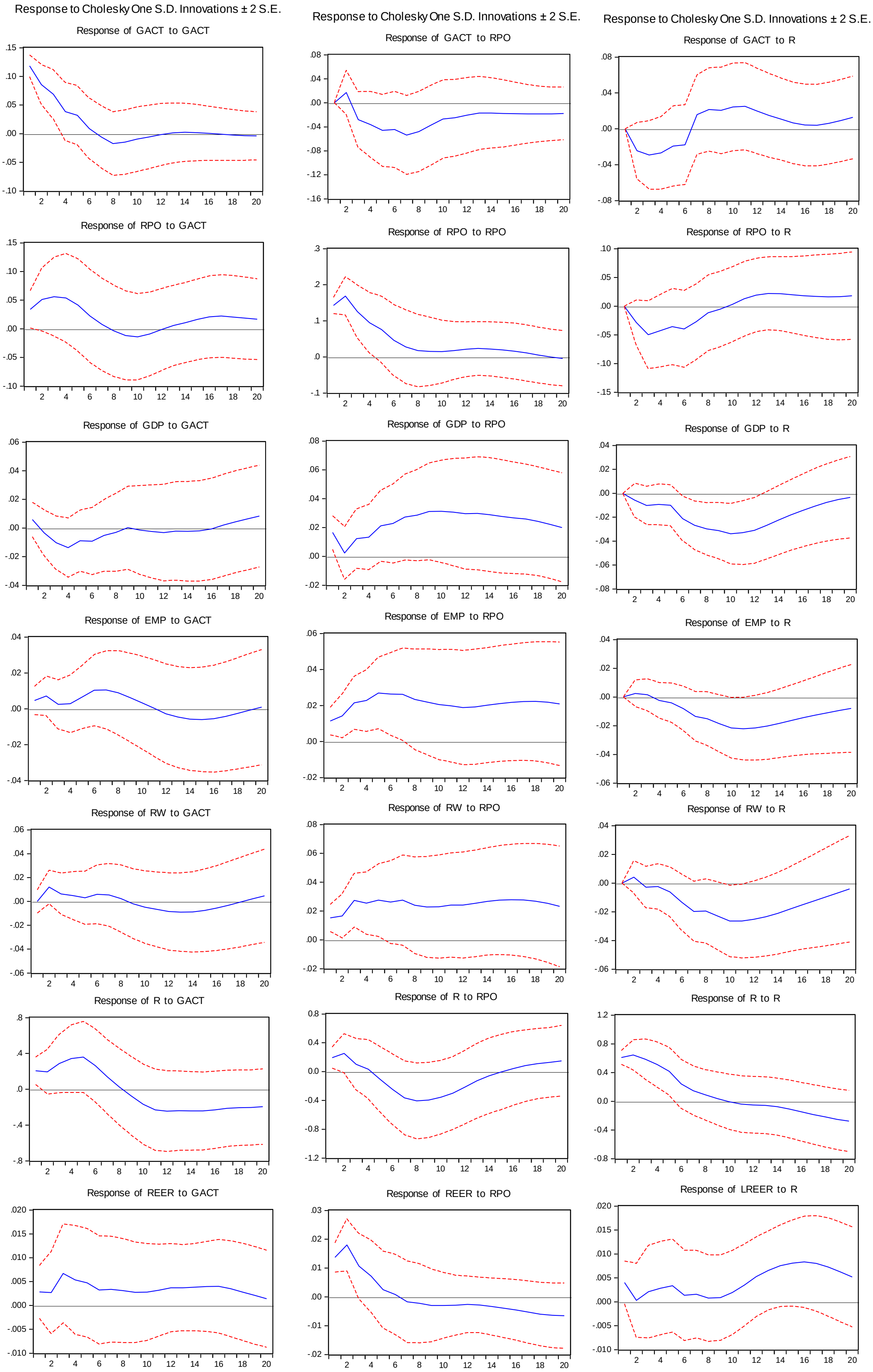
NOTE: The left column display a shock in global activity, the middle column display an oil-specific shock and the right column display a monetary policy shock.

Figure 26: Services Related to Extraction of Oil and Gas



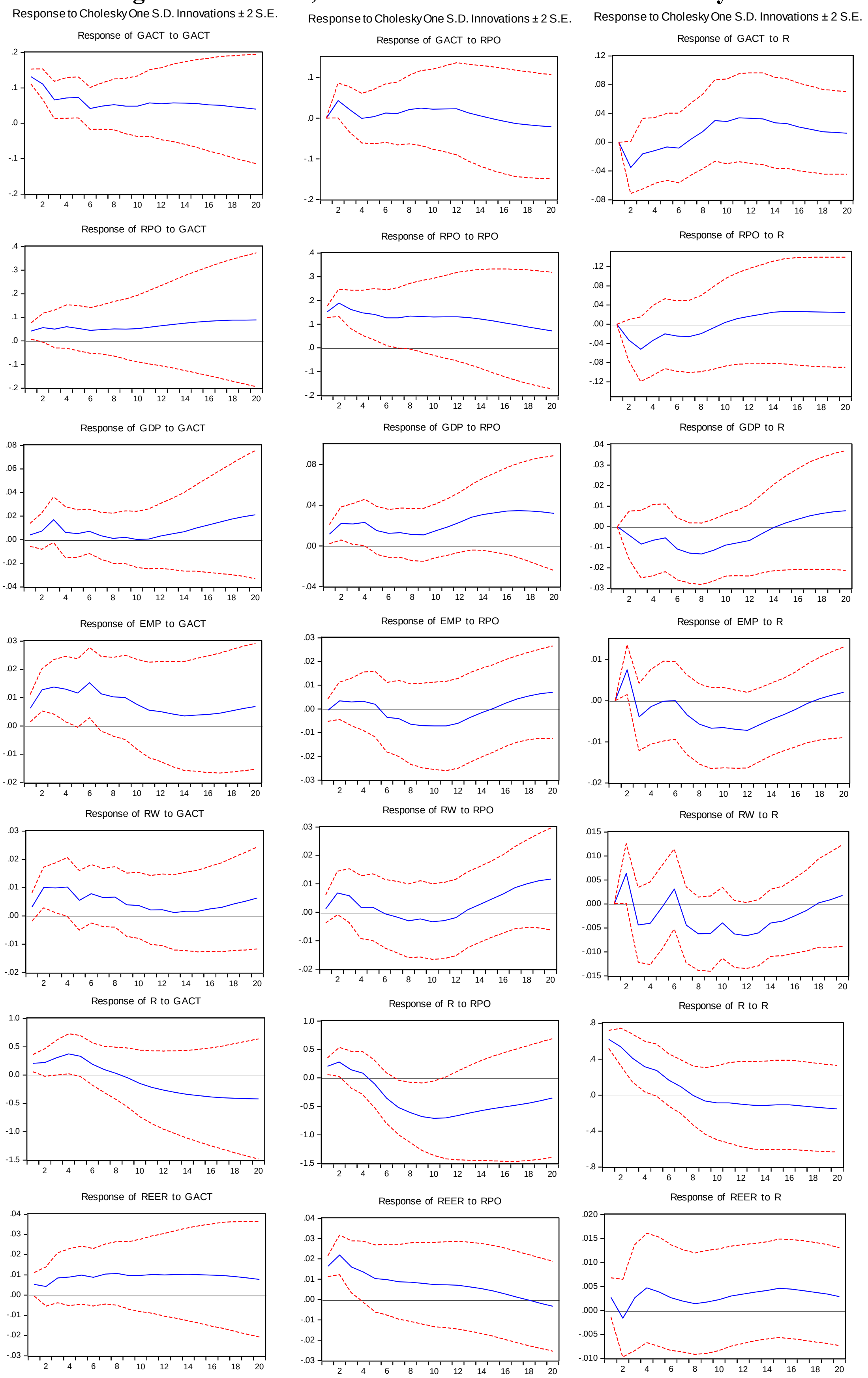
NOTE: The left column display a shock in global activity, the middle column display an oil-specific shock and the right column display a monetary policy shock.

Figure 27: Maintenance and Installation of Machines and Equipment



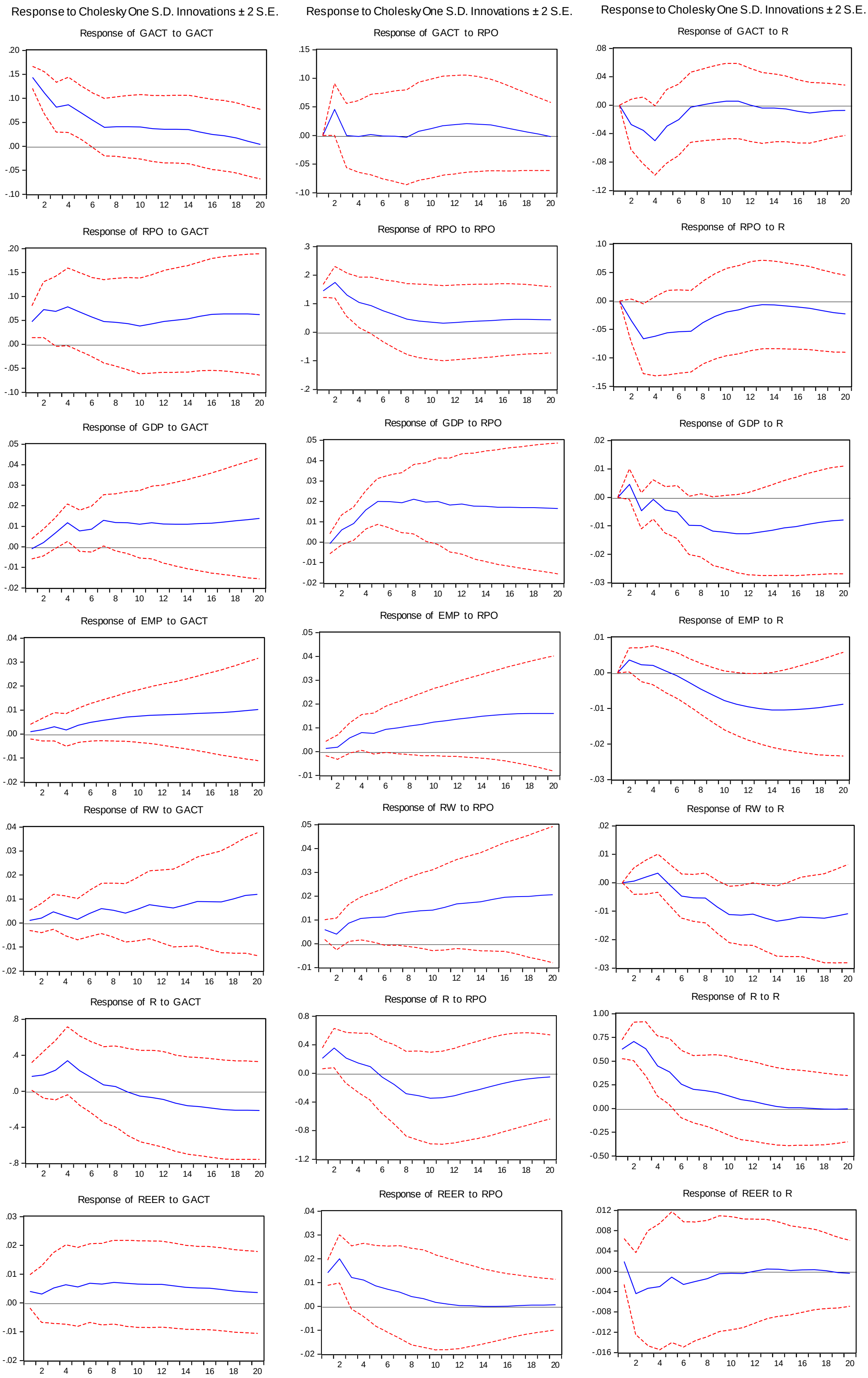
NOTE: The left column display a shock in global activity, the middle column display an oil-specific shock and the right column display a monetary policy shock.

Figure 28: Rubber, Plastic and Mineral Product Industry



NOTE: The left column display a shock in global activity, the middle column display an oil-specific shock and the right column display a monetary policy shock.

Figure 29: Professional, Scientific and Technical Services



NOTE: The left column display a shock in global activity, the middle column display an oil-specific shock and the right column display a monetary policy shock.

Appendix J: Variance Decomposition – Monetary Policy

J.1 Mainland Economy

Table 19: Mainland Economy

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
RPO	1	0,15	5,23	94,77	0,00	0,00	0,00	0,00	0,00
	2	0,23	6,86	90,20	0,05	0,02	0,53	2,09	0,25
	3	0,27	7,62	84,17	0,81	0,15	0,50	6,32	0,44
	4	0,30	7,94	77,57	2,31	2,26	1,20	8,19	0,52
	8	0,34	6,62	65,66	3,62	8,09	2,47	9,07	4,46
	12	0,36	6,49	56,46	3,56	10,48	2,97	7,93	12,11
	16	0,38	6,37	51,53	3,86	13,36	4,20	7,49	13,18

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
GDP	1	0,01	0,38	6,36	93,26	0,00	0,00	0,00	0,00
	2	0,01	2,92	7,31	80,39	7,87	0,18	0,64	0,68
	3	0,01	4,63	7,67	67,58	11,47	0,17	8,03	0,46
	4	0,01	5,07	6,80	66,39	10,00	0,59	10,11	1,05
	8	0,02	5,37	4,32	61,15	6,04	0,99	20,53	1,60
	12	0,03	6,64	8,42	41,63	13,46	3,96	22,82	3,08
	16	0,04	5,03	11,94	26,36	19,87	5,81	20,36	10,63

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
EMP	1	0,00	0,28	4,17	0,02	95,54	0,00	0,00	0,00
	2	0,01	0,34	1,94	3,59	90,77	1,46	0,00	1,89
	3	0,01	3,76	3,97	7,82	78,27	2,16	0,64	3,38
	4	0,01	3,44	3,32	10,86	74,31	3,69	1,17	3,21
	8	0,01	1,85	3,03	17,23	55,63	6,03	6,18	10,04
	12	0,02	2,72	7,87	20,00	35,60	4,74	16,62	12,47
	16	0,02	3,44	13,74	17,67	28,66	3,26	23,93	9,30

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
RW	1	0,01	0,57	14,85	27,69	1,33	55,56	0,00	0,00
	2	0,01	0,53	15,24	26,24	5,41	52,26	0,21	0,11
	3	0,01	1,86	20,11	25,99	10,46	40,34	1,12	0,12
	4	0,02	1,76	14,78	38,15	13,79	29,29	1,26	0,99
	8	0,02	5,41	10,05	43,18	14,80	17,10	6,43	3,04
	12	0,03	7,59	13,02	38,32	9,94	10,58	16,87	3,69
	16	0,04	7,56	17,42	28,44	12,82	7,24	23,00	3,52

J.2 Industry

Table 20: Industry

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,14	9,76	90,24	0,00	0,00	0,00	0,00	0,00
	2	0,23	14,14	81,50	1,61	0,67	1,14	0,94	0,00
	3	0,28	16,08	72,26	5,18	2,90	1,05	2,53	0,01
RPO	4	0,31	17,82	67,15	7,53	3,34	1,23	2,73	0,20
	8	0,36	15,33	56,29	8,37	12,35	2,65	2,05	2,97
	12	0,41	12,42	45,20	9,24	14,82	5,92	1,81	10,58
	16	0,43	11,81	40,98	10,22	15,03	8,30	2,26	11,41

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,02	0,01	14,40	85,58	0,00	0,00	0,00	0,00
	2	0,02	7,34	16,84	72,64	0,01	0,15	1,48	1,53
	3	0,02	13,38	20,96	62,01	0,23	0,34	1,24	1,83
GDP	4	0,03	17,96	24,94	47,30	2,14	0,77	3,38	3,51
	8	0,03	15,86	25,57	36,79	2,33	1,02	13,99	4,43
	12	0,04	12,24	19,97	29,82	13,10	1,08	12,95	10,85
	16	0,04	8,77	14,29	21,44	29,93	1,83	9,39	14,35

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,01	0,48	5,33	1,90	92,30	0,00	0,00	0,00
	2	0,01	0,81	10,39	1,37	86,60	0,05	0,70	0,08
	3	0,02	0,56	18,85	0,71	78,20	0,40	0,99	0,29
EMP	4	0,03	0,44	21,47	0,81	75,25	0,61	1,19	0,23
	8	0,04	1,74	22,17	0,89	65,49	1,69	6,87	1,13
	12	0,05	3,59	19,80	0,67	57,21	3,33	14,13	1,26
	16	0,05	5,19	18,37	1,53	49,81	3,35	18,07	3,68

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,02	0,00	18,75	1,95	34,88	44,42	0,00	0,00
	2	0,02	2,46	21,58	1,29	40,35	30,14	2,28	1,91
	3	0,03	5,57	28,42	1,26	44,29	17,03	2,35	1,09
RW	4	0,03	4,79	26,96	0,96	50,03	12,87	1,83	2,55
	8	0,04	3,47	22,05	1,95	55,16	8,99	5,17	3,20
	12	0,05	3,26	18,61	7,21	49,46	8,57	9,60	3,29
	16	0,05	3,16	17,46	9,47	46,60	8,08	10,83	4,40

J.3 Services Related to Extraction of Oil and Gas

Table 21: Services Related to Extraction of Oil and Gas

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,15	15,22	84,78	0,00	0,00	0,00	0,00	0,00
	2	0,25	12,81	84,40	0,66	0,09	0,11	1,82	0,10
	3	0,30	12,20	79,10	0,52	0,25	0,90	6,48	0,55
RPO	4	0,34	13,42	73,58	1,06	0,21	1,53	8,89	1,32
	8	0,42	14,87	59,43	1,21	0,75	4,97	11,48	7,29
	12	0,47	15,82	49,13	1,23	3,56	5,48	10,13	14,64
	16	0,51	18,36	43,57	1,50	5,19	5,31	9,00	17,08

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,14	0,32	0,58	99,10	0,00	0,00	0,00	0,00
	2	0,18	0,30	0,48	95,25	1,15	0,73	1,71	0,38
	3	0,22	0,22	0,38	85,73	5,64	0,95	5,70	1,36
GDP	4	0,24	0,43	2,25	73,81	5,24	0,82	14,18	3,27
	8	0,33	3,54	20,72	44,81	3,01	0,84	22,12	4,96
	12	0,44	6,32	27,37	25,15	5,41	1,42	18,24	16,08
	16	0,53	10,77	23,78	17,64	7,02	2,06	14,11	24,62

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,07	1,56	0,00	0,00	98,44	0,00	0,00	0,00
	2	0,09	0,93	0,02	0,39	90,28	1,60	1,03	5,76
	3	0,10	1,75	0,32	0,31	83,24	1,66	0,82	11,90
EMP	4	0,11	4,17	0,29	0,31	76,37	1,81	0,85	16,20
	8	0,16	12,37	23,43	0,51	47,65	1,90	2,05	12,09
	12	0,21	17,85	33,57	0,36	29,34	3,76	4,94	10,18
	16	0,25	19,95	32,70	0,30	23,00	5,24	5,81	12,99

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,07	0,00	1,67	0,09	73,63	24,61	0,00	0,00
	2	0,08	1,75	1,15	0,39	75,59	18,65	0,00	2,47
	3	0,09	2,28	1,59	0,33	73,59	15,65	0,16	6,40
RW	4	0,10	3,94	1,53	0,41	69,60	13,88	0,69	9,95
	8	0,15	9,74	31,06	0,56	39,26	9,28	3,51	6,58
	12	0,21	13,79	41,02	0,52	22,15	8,49	7,46	6,56
	16	0,26	15,74	38,83	0,38	17,12	8,68	8,26	11,00

J.4 Maintenance and Installation of Machines and Equipment

Table 22: Maintenance and Installation of Machines and Equipment

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,15	5,33	94,67	0,00	0,00	0,00	0,00	0,00
	2	0,24	6,71	87,15	0,09	1,12	2,94	1,45	0,54
	3	0,28	8,58	80,28	0,63	1,60	4,17	4,11	0,63
RPO	4	0,31	9,96	74,74	1,35	1,31	6,63	5,23	0,78
	8	0,36	9,27	63,38	1,79	2,78	12,46	6,81	3,50
	12	0,39	8,21	55,04	1,99	3,28	13,30	6,21	11,97
	16	0,42	7,52	48,12	2,88	3,72	13,72	6,26	17,78

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,05	1,24	9,49	89,28	0,00	0,00	0,00	0,00
	2	0,07	1,07	6,38	85,45	5,05	0,26	0,78	1,01
	3	0,08	2,56	7,18	72,14	8,46	5,85	2,31	1,51
GDP	4	0,08	4,79	8,53	66,22	10,14	5,19	3,18	1,94
	8	0,12	3,61	21,09	47,25	4,98	4,45	16,03	2,59
	12	0,16	2,21	27,52	36,05	3,01	2,78	26,17	2,26
	16	0,18	1,77	31,48	30,59	2,87	2,18	25,96	5,15

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,04	1,67	10,40	35,89	52,04	0,00	0,00	0,00
	2	0,05	3,34	15,55	32,33	47,69	0,75	0,29	0,05
	3	0,06	2,41	24,86	28,27	43,40	0,63	0,27	0,16
EMP	4	0,07	2,01	31,02	26,23	38,93	0,58	0,34	0,89
	8	0,10	4,19	39,15	26,51	20,92	3,75	4,99	0,50
	12	0,13	2,96	34,57	26,88	14,19	6,70	13,91	0,79
	16	0,15	2,75	33,31	23,34	11,02	7,40	15,88	6,29

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,04	0,00	12,29	39,88	21,72	26,11	0,00	0,00
	2	0,06	4,15	14,48	33,76	23,04	24,08	0,49	0,01
	3	0,07	3,65	24,74	28,97	25,05	16,71	0,49	0,39
RW	4	0,08	3,14	28,63	26,69	24,44	15,33	0,46	1,31
	8	0,12	1,96	31,90	27,75	13,47	16,31	6,91	1,70
	12	0,15	1,89	30,09	24,90	9,01	15,27	15,59	3,26
	16	0,18	2,16	30,97	19,42	6,87	13,23	16,23	11,12

J.5 Rubber, Plastic and Mineral Product Industry

Table 23: Rubber, Plastic and Mineral Product Industry

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,16	7,00	93,00	0,00	0,00	0,00	0,00	0,00
	2	0,26	7,41	89,50	0,33	0,72	0,00	1,67	0,36
	3	0,32	7,45	85,40	0,42	2,54	0,02	3,82	0,36
RPO	4	0,36	8,62	83,09	0,70	3,02	0,24	3,85	0,49
	8	0,49	8,58	72,79	3,42	5,29	2,35	2,89	4,69
	12	0,64	8,31	60,77	6,24	5,08	4,49	1,85	13,27
	16	0,76	10,00	52,14	8,59	4,04	5,40	1,73	18,11

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,04	0,85	7,03	92,11	0,00	0,00	0,00	0,00
	2	0,06	1,73	15,59	81,22	0,33	0,31	0,44	0,36
	3	0,08	6,16	18,92	72,52	0,26	0,22	1,56	0,36
GDP	4	0,08	5,81	23,94	66,11	0,44	0,36	1,96	1,38
	8	0,10	5,23	24,93	49,56	2,40	1,10	6,75	10,04
	12	0,12	3,59	25,46	38,49	7,52	2,07	6,81	16,05
	16	0,16	3,24	30,01	30,00	7,35	3,47	3,87	22,07

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,02	8,16	0,07	2,36	89,41	0,00	0,00	0,00
	2	0,03	20,29	1,16	7,87	64,71	0,16	5,70	0,11
	3	0,04	26,09	1,33	13,64	50,82	3,14	4,81	0,17
EMP	4	0,05	26,41	1,42	21,59	42,87	2,51	3,50	1,70
	8	0,06	31,72	2,85	21,30	36,69	3,21	3,24	1,00
	12	0,07	31,32	6,68	18,95	31,82	3,33	6,94	0,97
	16	0,07	29,65	6,50	18,30	29,31	3,26	7,74	5,23

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,02	2,01	0,28	0,71	36,71	60,29	0,00	0,00
	2	0,03	12,77	5,46	11,16	28,48	34,46	4,65	3,02
	3	0,04	16,61	6,41	20,28	23,00	24,65	4,73	4,32
RW	4	0,04	18,62	4,97	31,13	18,20	18,49	4,50	4,09
	8	0,05	19,93	4,01	31,00	19,25	14,36	5,84	5,61
	12	0,05	19,13	4,60	28,05	17,86	12,92	10,14	7,30
	16	0,06	15,80	5,76	26,39	16,79	10,95	10,24	14,06

J.6 Professional, Scientific and Technical Services

Table 24: Professional, Scientific and Technical Services

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,15	9,68	90,32	0,00	0,00	0,00	0,00	0,00
	2	0,25	12,31	84,35	0,69	0,08	0,01	1,99	0,57
	3	0,30	13,87	77,32	0,99	0,25	0,05	6,36	1,16
RPO	4	0,33	16,41	70,87	1,06	0,63	0,26	8,44	2,32
	8	0,41	17,78	57,79	0,94	1,74	0,54	11,50	9,72
	12	0,48	16,59	45,51	0,71	2,53	1,10	9,26	24,30
	16	0,53	18,18	39,73	0,63	2,94	1,05	7,71	29,76

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,02	0,20	0,12	99,68	0,00	0,00	0,00	0,00
	2	0,03	0,82	5,57	78,64	9,22	2,52	3,18	0,05
	3	0,03	5,60	13,13	59,24	14,44	2,12	4,72	0,74
GDP	4	0,04	13,47	26,28	40,02	12,69	3,96	3,10	0,49
	8	0,06	16,02	50,29	16,55	6,67	2,57	7,22	0,68
	12	0,08	16,53	49,50	9,58	4,12	1,59	12,95	5,73
	16	0,10	15,42	43,47	6,23	2,97	1,12	13,10	17,68

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,01	0,52	0,89	4,56	94,03	0,00	0,00	0,00
	2	0,02	1,15	1,36	5,45	86,56	1,56	3,57	0,35
	3	0,02	2,33	6,55	5,36	78,26	1,53	3,25	2,70
EMP	4	0,03	2,08	13,01	5,64	72,17	1,63	2,96	2,51
	8	0,04	7,43	27,32	7,70	49,51	2,87	3,04	2,14
	12	0,05	11,86	36,51	6,69	29,39	3,20	10,59	1,76
	16	0,07	12,75	39,54	4,32	17,60	2,09	14,74	8,96

Variable	Period (Q)	S.E.	GACT	RPO	GDP	EMP	RW	R	REER
	1	0,02	0,32	9,75	1,00	43,49	45,44	0,00	0,00
	2	0,02	0,91	8,58	2,79	53,19	33,86	0,06	0,62
	3	0,03	3,16	14,67	3,24	52,89	23,61	0,51	1,92
RW	4	0,03	3,16	20,99	3,08	50,23	18,76	1,38	2,40
	8	0,05	4,77	32,99	4,50	36,03	14,95	3,84	2,92
	12	0,07	6,42	40,24	4,37	22,50	11,32	12,76	2,38
	16	0,08	7,42	42,85	2,90	13,81	7,14	16,78	9,10