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An Empirical Analysis of How Oil Price Changes Influence the Norwegian Economy.

A Structural Vector Autoregressive Approach.

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Abstract.

This thesis examines the relationships between disentangled oil price shocks and macroeconomic variables by utilizing structural vector autoregressions (SVAR). The first SVAR extends Killian`s (2009) analysis and supports his findings that shocks from oil-specific demand and aggregate economic activity leads to changes in real oil prices, while supply shocks have smaller effects. The second SVAR applies this methodology to Norway, a small, open and net oil-exporting country. Surprisingly, aggregate economic activity shocks have weak effects on the Norwegian economy which is in contrast to other net oil-exporters. Supply and oil-specific demand shocks significantly affects the unemployment and inflation rate respectively, while there is a time-varying effect on the interest rate dependent on whether there is a supply or an oil-specific demand shock.

Foreword

From the moment I started my master degree at NHH it was my intention that my thesis should be based upon empirical work. Through various econometric classes an interest for vector autoregressions developed and I started to search for relevant topics. Stumbling over the oil shock research area when planning an empirical assignment in Professor Anti Nilsen`s "Econometric Analysis and Applications" class and Norway being a large net oil-exporter the choice of topic was easy. After advice from my supervisor Gernot Doppelhofer I decided to raise the bar a bit and utilized structural vector autoregressions (SVAR) instead of ordinary vector autoregressions (VAR).

During the preliminary work I decided to drop some of the more advance econometric techniques as various bootstrap procedures which are normally included in this area of research. This decision was made since no classes at master level at NHH teaches these topics and I decided that investing time to both learning and utilizing bootstrap procedures in addition to structural vector autoregressions in Stata was too much. I also learned the hard way that time series is not Stata`s forté as there are several questions I have been unable to find an answer for (especially the inclusion of dummies in the SVAR`s would have been beneficial).

I would first like to offer my gratitude to my supervisor Gernot Doppelhofer. When I told Doppelhofer my plans for the thesis it was he who introduced me to Kilian`s work and convinced me to use a similar econometric approach. Although that meant a more demanding and challenging process the satisfaction upon completing this thesis is not easily exaggerated. Doppelhofer has also continuously been giving thorough and constructive feedback which is much appreciated. I would also like to give my thanks to Professor Øyvind Anti-Nilsen as it was through his classes of econometric techniques which spurred my interest for vector autoregressive methods.

I must also offer my thanks to my one and only Janne, who is probably even happier than me that this project is finally complete. Lastly, my thanks go to our son Andreas which during his second year slept through most nights, keeping the *"restrictions"* on my sleep to a minimum.

Contents

Tables

Figures

1.0 Introduction

This thesis presents two SVAR analyses where the oil price and its effect on macroeconomic variables are studied. The first SVAR reexamines the findings of Kilian (2009), where disentanglement of the oil price was suggested in order to be able to credible predict effects from oil price changes to economic variables. Disentanglement is crucial due two reasons. Firstly, one cannot exclude the possibility of reverse causality regarding the oil price and macroeconomic variables. This means that the assumption of varying the oil price variable while holding other variables constant does not hold up as macroeconomic development itself can influence the oil price. Secondly, in previous research the oil shocks observed were assumed to be exogenous since they coincided with political turmoil and cartel behavior which caused lower supply of oil from the Middle-East region. As the recent oil price hikes is commonly believed to stem from increasing demand, especially the BRIC countries, this assumption is no longer valid. Consider the following example of a net oil-importer, if the oil price increases due to a supply shock this consequently rise energy and transport costs and all else equal, affects the economy negatively. If the oil price on the other hand increases because of higher demand, energy and transport costs surely increases in this example as well, but the negative effects may be neutralized because economic activity is growing such that firms still maintains their production and sale despite higher input costs. In other words, one must assess whether it is supply or demand factors which explain the price change as different shocks have different effects on the real price of oil and different effects on macroeconomic variables. The first SVAR in this thesis, called the aggregate oil market, extends Kilian`s (2009) analysis to include data until March 2010, such that the recent rise and fall of the real oil price is included. The first part of the thesis finds that:

1. Supply disruptions have small effects on the real oil price development.
2. Shocks in aggregate economic activity increases the real price of oil.
3. Oil-specific demand is predicted to increase both the supply and the real price of oil.
4. By quantifying the structural shocks from the SVAR model, the notion that it was increase in oil-specific demand, or precautionary demand, which led to the rise in real oil prices in the late 1970s is supported. This counters the common belief that is was just supply disruptions which caused the price hike in that time period.

The confirmation of Kilian`s (2009) findings makes Kilian`s analysis robust for the sample period extension and constitutes the main finding of the first part of this thesis. This allows the transition to the next step of the thesis where this methodology is applied on a net oil-exporter.

The second SVAR applies the procedure of Kilian (2009) to Norway which is a small, open and net oil-exporting economy. When analyzing the Norwegian economy the likelihood of reverse causality stated above is not a plausible concern due to Norway`s limited economic size. It is highly doubtful that Norwegian macro development have any effect on the world real oil price. It would however be interesting to examine if the underlying reason for the price change may be of importance though. Intuitively, one would expect the Norwegian economy to react with higher economic activity with oil price increases regardless of the underlying factor of the price change, as it plausible to expect investment and government revenue to coincide with the price changes anyway. The net effect of the price increase is however dependent upon two factors. Firstly, it is the degree of wealth transferred to the oil-exporters. As the price of oil increases a shift of wealth from oil-importers to oil-exporters occurs. This effect can however be short lasting as the economy of the oil-importers may deteriorate due to higher energy and transport costs which will hence reduce aggregate demand. As a consequence, higher oil prices may therefore lead to a negative trade effect which would decrease the net effect of oil-exporters. This illustrates the importance of disentangling the underlying reason of the price change as a supply or demand shock may lead to different outcomes for the oil-importers economies and thus different net effects for the oil-exporters as well. The economy of a net oil-exporter may therefore be highly contingent on why the oil price changes as well as the price level and therefore justify an econometric analysis of this phenomenon.

The SVAR model applied in this part is based on New-Keynesian principles to see how the disentangled real price of oil influences Norwegian macro development. This part of the thesis is inspired by Bjørnland`s empirical methodology and her work constitutes a foundation which my analysis is based upon.

The second part of this thesis finds:

1. Significant findings despite macroeconomic control functions implemented to deter such effects. The introduction of the Norwegian Petroleum Fund and measures to limit the degree of investments from the petroleum sector are thereby not entirely successful. However, as the overall responses of the model is of moderate degree this thesis gives support to Thøgersen`s (2004) conclusion that the mechanism of oil revenue management is relative successful.
2. Significant findings despite indications that Norway has entered a mature phase as an oil-producer. This means that the impulses from the oil sector are not weaker even though the oil production has stagnated.
3. Shocks originating from aggregate economic activity have surprisingly weak effects on the domestic economy, which is in contrast to the findings of other net oil-exporters. This is quite puzzling as it would be plausible to expect that oil price increases due to higher demand would lead to stronger results since the negative trade impact from the oil importing countries discussed above would at least be partly negated by increased economic activity.
4. Supply shocks are the only shocks which affect the unemployment rate, although only moderately. The unemployment rate in Norway has however fluctuated around relatively low values, especially in recent time.
5. Oil-specific demand is the only variable to give significant predictions about the inflation rate.
6. A time-varying response in the interest rate is found regarding supply and oil-specific demand shocks. An increase in oil-specific demand leads to a significant increase in the interest rate three months after the shock, while a significant response following a supply shock is not predicted to happen before nine months after.
7. The exchange rate is predicted to appreciate with aggregate economic activity or oil-specific demand shocks. The appreciation is expected when examining a net oil-exporter, but the effect is however weak. The thesis confirms Bjørnland`s explanation of why the predictions of the Norwegian exchange rate have such low significance. Since the interest rate in Norway has a lagged response to oil price increases relative to the foreign interest, the interest differential offsets the appreciation pressure on the Norwegian exchange rate.

The thesis is organized as follows. Section 2 gives a descriptive overview of the development of the oil industry in Norway, economic performance and the relevant political strategies from the 1970s to present time. Section 3 presents a literature review of the oil price shock area starting with the oil crisis of the 1970s, followed by the notion of asymmetric price effects and structural change in the 1980s and finishing off with the disentanglement of oil prices. Section 4 presents the methodology utilized in the thesis. Section 5 contains the first SVAR, an empirical analysis of the aggregate oil market, where the oil supply and demand are disentangled from the oil price. Section 6 contains the main empirical analysis where three different oil price shocks are induced to see how Norwegian macroeconomic variables respond in a New-Keynesian setting. Section 7 concludes.

2.0 The Oil Age in Norway

Norway is one of the largest exporters of petroleum products today and is generally perceived as an oil and commodity driven economy. The oil age in Norway started in the 1970s when Phillips Petroleum started drilling in the marine reservoir known as Ekofisk, which actually was still in operation when this analysis was performed in 2010/2011. Since oil is a scarce product which enables higher capital gains, the discovery of oil opened up new possibilities for Norway and it did not take long before impacts on the Norwegian society could be observed. This section starts with a descriptive section which gives a short overview of the development in relevant economic indicators from the initial phase of the oil age to present day. The political strategy is also given attention and has been divided into two entities where the first part is regarding industrial policy, which focuses on actions related to building up an industry which could serve domestic oil production. The second part of the political strategy presented can be described as policies introduced to provide a stable macroeconomic environment. Lastly, I discuss if Norway has entered a mature phase as an oil producer as this potentially influences the results from the econometric analysis.

2.1 Overview

The development in the government budget describes the transition to a net oil-exporting country well. As illustrated in figure 2.1 the Norwegian government budget has gone through dramatic changes post-WWII. The budget balance was relative stable and negative until the middle of 1970s. From 1975 there is a dramatic increase in the deficit and does not return to previous levels until the middle of 1980s. The dip in the mid-1980s is a reaction to the recession caused by the bank crisis which had a significant effect on the whole of Norwegian economy. From the 1990`s there is a clear upward trend in the budget balance which has continued to increase until present time. One shall not draw too strong conclusion from a single descriptive graph, but the pattern in the budget balance coincide with the huge initial investment related to petroleum extraction and the following extra profits related to this industry.

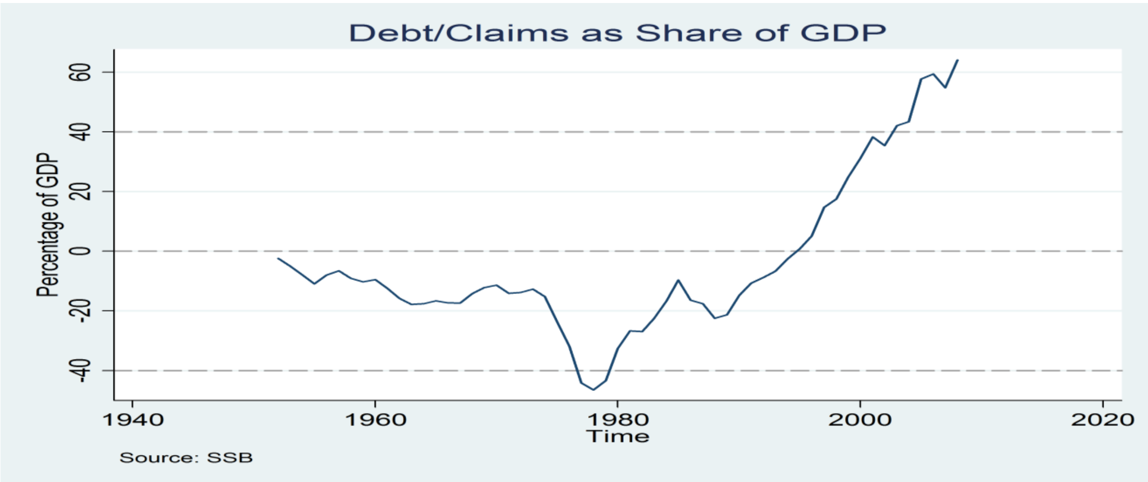


Figure 2.1: Norwegian Debt and Claims as a Share of Norwegian GDP.

There are however other important events which could explain the increased deficits. In the 1970s the Norwegian labor market can be classified as a corporative, where the unions of employees and employers, LO and NHO included the government in wage negotiations. The rationale for the government to participate in these negotiations was to have an opportunity to keep the price level stabilized, by using subsidies and price controls. The general perception was that government intervention thereby would have a positive impact on the economy and securing a stable economic environment. During the 1970s when the public became aware of the profit opportunities the oil extraction would bring, this translated into demands for higher wages. As the government was not willing to use political capital to reject the demands this resulted in increased budget deficits. Other groups in the Norwegian society also lobbied to get increase funding, especially Norges Bondelag, the main farmer organization in Norway. The lobbying successfully accomplished increased capital allocation to farmers with the *"Opptrappingsvedtaket for landbruket"* in 1975 (Hanisch, 1995). This certainly contributed to the negative development in the 1970s illustrated in the graph due to increased wage demand and prices which contributed to loss of market share for Norwegian export firms and higher unemployment.

In a small economy as Norway it is reasonable to illustrate the total GDP and the mainland GDP as separate entries since the revenues related to petroleum activities on the continental shelf are such an important source of income. This is illustrated well in the figure 2.2 which graphs the development of the total GDP and mainland GDP for Norway from 1978-2010. It is from the beginning of the 1980`s that the petroleum revenues begin to make an impact in the GDP figures, which not surprisingly coincidently was also when the Norwegian deficit began to decrease (see figure 2.1) The share of petroleum revenues continues to increase through the whole sample until 2005, where a slight decrease is observed. It should also be mentioned that both of the GDP measures show a small contraction at the end of the sample due to the financial crisis of 2008.

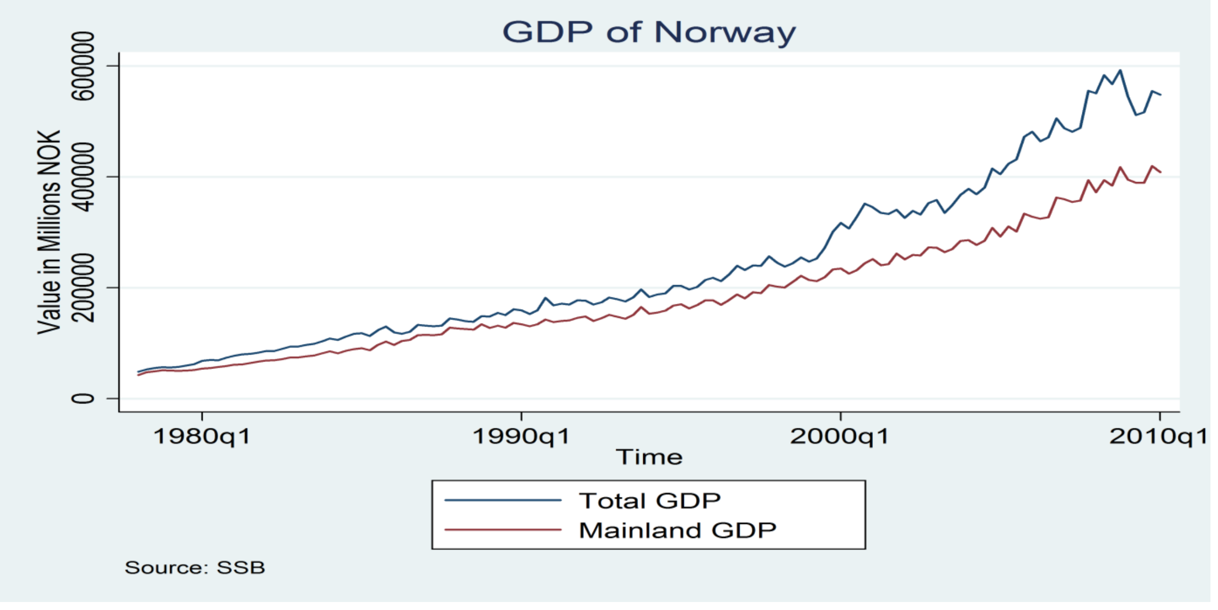


Figure 2.2: Norwegian Total and Mainland GDP.

Figure 2.3 shows the value of total Norwegian export and the value of petroleum product exports and oil related exports[1] in millions NOK from 1978-2008. As can be seen the total value of export are closely related to the value of petroleum exports. This is an additional support for the reasoning previously done regarding the government budget balance, where there are strong indications that the oil revenues are main determinants of the government balance. At the end of the sample we see a decline in the response of the financial crisis in both export measurements. It also seems to be a reduction of the value from oil and gas from 2003 to present time indicating Norway has entered a phase as a mature oil exporter. As we can see the export of other oil related products is quite stabile throughout the whole time period so these exports will not compensate for the reduction of revenue directly stemming from oil and gas exports.

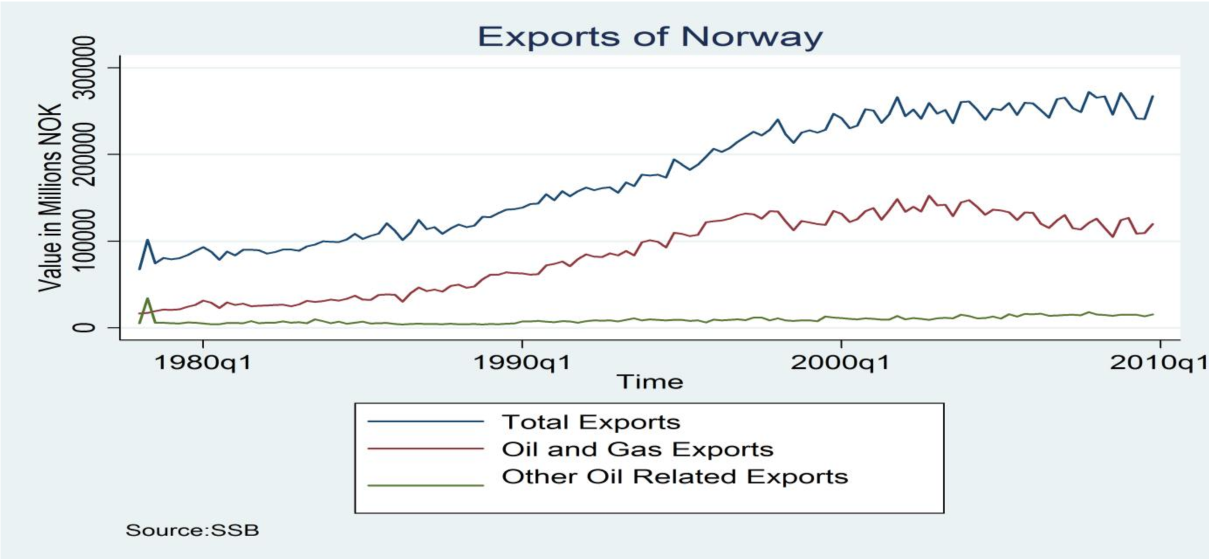


Figure 2.3: Norwegian Total and Oil and Gas Related Exports.

2.2 Political Strategy

2.2.1 Industrial Policy

Before Phillips Petroleum proved oil reserves in the Ekofisk sector only a marginal share of the Norwegian industry was related to oil extraction and services. Consequently, foreign labor and knowledge was necessary in order to build up required infrastructure for oil extraction. A political strategy was then formed to ensure the demands from the petroleum sector could be

[1] Oil related exports include sales of new and old platforms, refined oil products, oil services, drilling, pipe transport and other diverse oil products.

met by domestic capacity. In January of 1976 the Norwegian parliament approved a buy-up of companies to create a large nationalized oil-company with total costs estimated to reach 900 million NOK (Drzwi, 2005). The ambitions of the development and control of the petroleum sector can be clearly seen in government reports from that era[1]. The goals were firstly, government involvement in all phases of the extraction and refining of oil. Secondly, foreign suppliers should be gradually replaced with Norwegian firms. Thirdly, full control over reservoirs, including production quotas and timing of construction and various development.

To secure that Norwegian workers and firms could participate in the oil industry Stortinget also legislated that the state-owned oil company Statoil, should have a minimum share of 50 percent on each extraction field in the Norwegian continental shelf. This legislation had to be abandoned during the ratification of EU`s oil-directive in 1994 (Drzwi, 2005). However, by then the protective barrier had enabled Norwegian companies to build up a considerably amount of experience and knowledge and several firms were even able to compete at an international level.[2] Halvorsen et al. (2004) supports this as they report that among the FDI originating from Norway, it is investments related to the oil industry which make up the largest share, mostly coming from Statoil and Hydro.[3]

In order to see how successful the Norwegian industrial strategy has been one could look at figure 2.4 which graphs the share of oil related products relative to total imports. If the industrial strategy is successful one would expect a decline in the amount of imports needed since the demand is covered by domestic firms. The development in figure 2.4 must be characterized as volatile with huge spikes in the early 1980s, 1990s and 2000s. It is also a downward trend from the late 1970s to present time which indicates that imported inputs to the Norwegian oil industry is declining and thereby a higher coverage by domestic firms. Other important factors which could explain the development in the figure is firstly the Norwegian exchange rate. In times of appreciation (depreciation) imports would become relatively cheaper (more expensive) and domestic firms would be less (more) competitive.

[1] St.meld. nr. 53, 1979-80.

[2] International contracts won by Norwegian firms related to the oil industry: Helikopter Service: 250 mill NOK in Canada, Ugland Gruppen: 750 mill. NOK Canada, Scandinavian Service Partner & Industrial Catering: 220 mill. NOK in Uganda, Kongsberg Offshore: 100 mill. NOK in Brazil.

[3] Statoil and Hydro merged 2007.

Domestic production capacity could also be of relevance, as capacity gap gets smaller the marginal costs would increase and make domestic firms less competitive. This second effect could be very relevant when large projects are undertaken which would raise the need to put some orders in firms abroad. The side effect from building up an industrial sector aimed to serve the oil industry is that the domestic economy will increasingly be affected by impulses and cycles from this business.

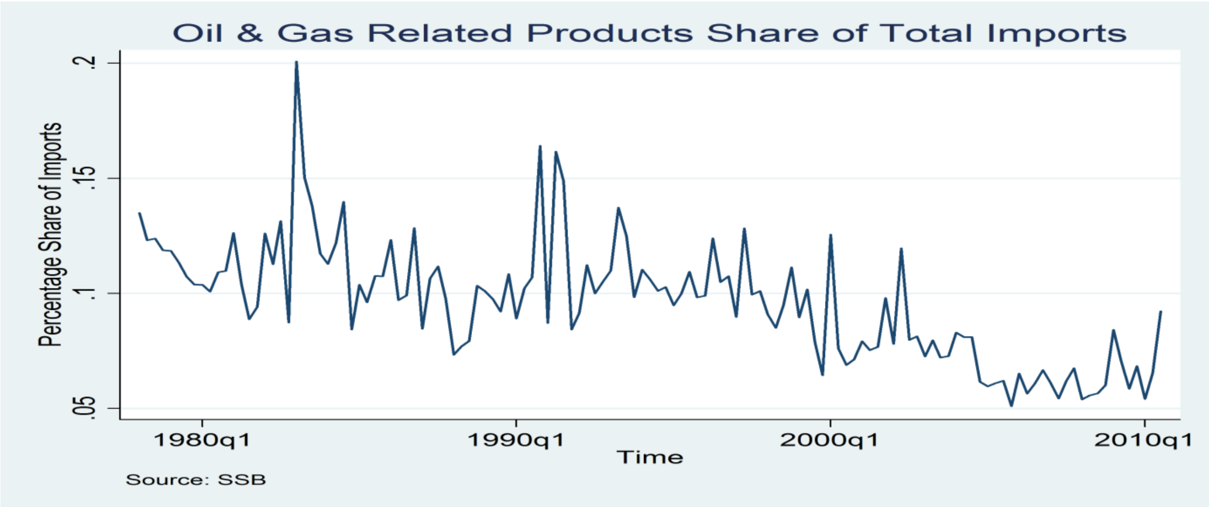


Figure 2.4: Norwegian Oil and Gas Related Imports to Total Imports.

The Norwegian state also encouraged firms to achieve higher extraction rates from oil reservoirs which could also be linked to the goal of increased Norwegian competence within the oil industry. The increased rate of extraction is important as it is not unusual that the marginal cost of oil extraction surpasses the marginal revenue when only roughly 50 percent of the petroleum has been extracted from a given reservoir. In a government report increased funding for PETROMAKS is proclaimed, a program aimed at increasing effectiveness in petroleum extraction[1]. In addition it is also opened up for tax refund for searching and test drilling costs. Firstly, a direct effect of increased extraction rates would lead to increased revenue due to increased tax base. Secondly, as Norwegian firms would be able to extract more oil from a given field than their competitors they would increase competitiveness as they can bid higher for any given marine reservoir in the world. It should also be mentioned that incentives offered by the Norwegian government was given to all companies and therefore not excluding foreign companies. But since Statoil at least had 50 percent of each

[1] St.meld nr. 38 2003-2004

developed reservoir, Norwegian companies surely gained the lion`s share of the benefits from this policy.

2.2.2 Macroeconomic Measures

2.2.2.1 Investment Reallocations

In order to reduce the vulnerability of the domestic economy from impulses originating in the oil industry, a focus on reallocations of investments originating from the petroleum sector can be observed in public records. In a government proposition[1], we see that the government wants to reduce investment on the continental shelf to enable a higher activity in the mainland economy. Given limited amount of resources in an economy increased activity in one sector will divert resources from other sectors. As the Norwegian economy has been characterized by a relatively low unemployment rate, labor resources are indeed of a limited amount. By reducing or stabilizing the need for labor in the petroleum sector the government could use those resources to mainland investments instead. Analysis by Eika (1996b) and Johansen & Eika (2000) finds, despite the attempts from the government, that the petroleum industry has had a pro-cyclical effect. Even though the impulses were not strong enough to change the overall pattern of Norwegian business cycles, the ambitions to control the effects from the impulses of the oil industry on the domestic economy could not be described as successful. An explanation for this could be the composition of the demand of the oil industry. The total demand from this sector can be divided in three. First, investment related to searching, building and development of fields. Secondly, direct demand for workers on and offshore. Thirdly, demand of goods and services related to ongoing operations. Eika, Prestmo & Tveter (2010) finds that investments from the oil industry, the first demand effect, has become less significant for the Norwegian economy since the Norwegian oil production has in their opinion entered a mature phase. Accordingly, this makes it much more difficult for institutions to control the effects from the oil industry by focusing on investments since wages and inputs makes up a larger share of the total costs. Eika et al. (2010) further estimates that

[1] St.prp. nr.1 Tillegg nr.3, 1.1
"http://www.regjeringen.no/nb/dep/fin/dok/regpubl/stprp/19971998/stprp-nr-1-tillegg-nr-3-1997-98-/1.html?id=136851"

in 2009 roughly 206.000 persons or 8 percent of the labor force is directly or indirectly connected to the oil industry. When such a large fraction is connected to the oil industry, controlling the effects from this industry will be notoriously difficult.

2.2.2.2 The Norwegian Petroleum Fund

"I spent 90% of my money on women and drink. The rest I wasted", George Best.

The first time the question of how the oil revenues should be utilized was first taken up in October 1984 and March 1985 when a commission was established to answer this question (Drwzi, 2005). Most likely this was a response to the government white paper NOU:1983:27 ("Tempoutvalget"), but it was not until NOU:1988:21 ("Steigumutvalget") wheels were set in motion to introduce a separate fund to manage the increasing oil revenues. In 1996 the first deposit in the Norwegian Petroleum Fund (NPF) "Statens Petroleumsfond" was made, while Norges Bank hired the management in charge of the fund in January 1998. NPF annually receives capital equal to the cash flow earned from the oil revenue in addition to the returns from previous investments. The capital is invested in real estates, equities or fixed-income securities in foreign markets. In present time the NPF holds over 3000 trillion NOK or a value equivalent to a holding of 1 percent of all the world's stock markets.

There are two important mechanisms which the petroleum fund utilizes. First, since NPF investments are strictly done in foreign markets oil revenues are not directly transferred into the Norwegian economy. Instead, the revenues are kept in US dollar currency until capital has been invested in various foreign countries. The positive effect of this is that any supply or demand pressures on the Norwegian currency directly originating from the oil revenues are circumvented.

The second mechanism is regarding the extraction of wealth from the NPF. The Norwegian government extracts adequate capital to cover the budget deficit each year, but this amount shall not exceed four percent of the total value of the fund. This rule based policy called the “handlingsregel” came into effect in 2001 and is respected by most of the political parties represented in the Storting. Although the rule based policy has not been strictly followed, Thøgersen (2004) concludes that it has been highly successful, relative to other countries attempts to reduce the inflow of capital related to oil revenues. It should also be mentioned that the extraction policy has exceptions, as when there are downturns in the business cycle or when the fund`s returns is higher than expected.

2.2.2.3 The Dutch Disease

The two above mentioned mechanisms of the NPF contribute to macroeconomic stability in Norway and could quite possible offer the explanation for why the Dutch Disease phenomenon is not to a large degree observed in Norway. The Dutch Disease originated in the Netherlands in the 1970s and explains the significant changes in its industrial structure. As the extraction of petroleum products channeled large revenues into the economy, more resources were allocated to the petroleum and service sectors while the industrial sector declined. When most of the petroleum had been extracted a painful transformation of its economic structure was necessary to adapt to the new reality when super profits from the petroleum sector had declined. Even though Norway has not seen the kind of de-industrializing as the Dutch economy experienced the Dutch Disease may be observed in other areas. As can be seen in figure 2.5 the government sector has been steadily increasing by increasing employment, while the industrial sector has stagnated. Change in labor costs have in more recent time also increased more than the costs in our main trading partners. It should however be mentioned that costs increases in Norway has also been lower than in the OECD in most part of the 1990s, see figure 2.6. Bjørnland (2010) presents other noteworthy points which should be given attention; one fourth of all Norwegian receives some kind of benefit from the state and every fourth worker works in the public sector. In addition to this a large degree of people are outside the workforce (which are then not considered when calculating unemployment rate, thereby partly explaining low unemployment rates in Norway).

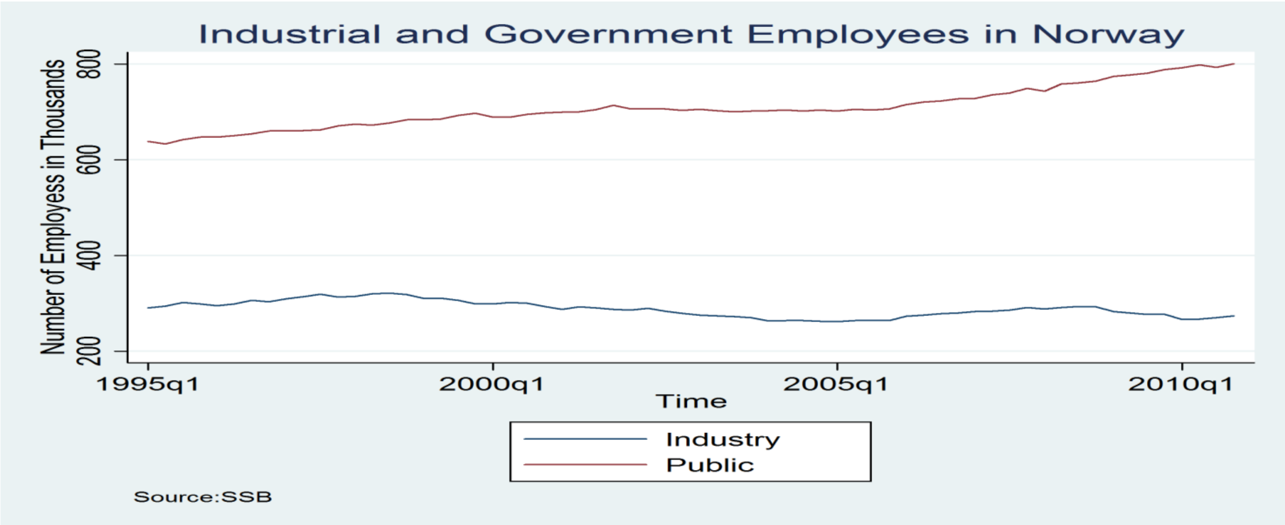


Figure 2.5: Employment in the Industrial and Public Sector of Norway 1995-2010.

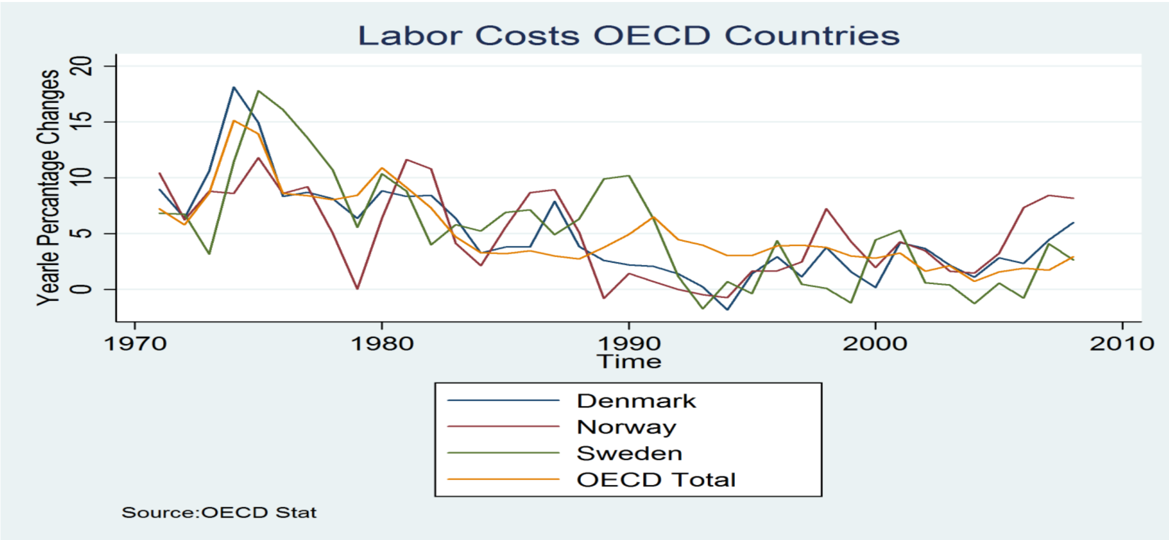


Figure 2.6: Labor Costs in Various OECD Countries 1971-2008.

Eventually, the only way to evaluate how infected the Norwegian economy is from the Dutch Disease is when oil reservoirs starts to run empty. Several studies have tried to predict how the transition from not being an oil exporter will affect the Norwegian economy. Cappelen, Eika & Prestmo (2010) predicts that the transition will go "fairly well" if the Norwegian economy still retains its flexibility as previously experienced. Bjørnland on the other hand is more skeptical to this scenario and believes the Norwegian economy to be more dependent on oil than Cappelen et al. (2010) assumes. Bjørnland especially points to her finding her finding (2009) where a close relationship between the stock market and oil prices was found and argues that much of the Norwegian industry enjoys a positive indirect financial effect from the oil sector which diminishes as oil extraction is reduced. Bjørnland & Moen (2011) also points to the fact that when Norwegian oil reserves runs dry, many Norwegian firms serving the oil sector will lose the geographical advantage of being close to extraction sites and thereby lose competitive power.

2.3 Has Norway Entered a Mature Oil Producer Phase?

As oil is a non-renewable resource oil producers will eventually experience declined oil production as reservoirs empties, entering a mature oil producer phase. The nature of the oil industry is also characterized by heavy initial investments as fields are developed, while investments related to expansions are relatively less capital intensive. This means that as a country enters a mature oil producer phase the impact from the oil industry on the economy lessens both directly from the reduced production, but also indirectly since the highest degree of investment is done in the initial producer phase. Eika, Prestmo & Tveter (2010) reports that purchases of goods and services related to operations are at present times almost at the same level as investments, indicating a mature phase has indeed started.

Looking at figure 2.7, the Norwegian oil production has passed its peak production in 1996 and 2001. Gas production has on the other hand increased steadily since 1995 and shown no signs of slowing down. This further opens up the possibility that Norway has entered a mature oil producer phase, but as a gas producer such a description would be incorrect. However, since gas extraction utilizes much of the same infrastructure as oil extraction, this would consequently mean that investments not necessarily rise due to increased gas extraction. The figure 2.8 does however clearly show that investments have increased in the later time periods. The lower oil production can also be explained by a reduced emphasize on replacing existing reservoirs with new findings. Insight from Cole & Elliott (2003) predicts that environmentalism principles increase as the GDP per capita increases. That is, as a nation grows richer and standard of living gets higher ecology and green politics becomes prioritized. This is exemplified in Norway with the political discussion of 2010 regarding oil development in the Lofoten region in North-Norway. As Lofoten is a remarkable location hosting both world unique fishery resources and a nature hoisted by tourist agencies for its distinctiveness, development plans in this region has been heavily criticized. Despite reassurance from oil companies that any effect from eventual spill-out will have marginal consequences, any plans of oil development in this area has been postponed by the current government. Consequently, using insight from Cole & Elliott (2003) findings means that even if Norway`s undeveloped reservoirs could keep oil production volumes stable or even increased, society`s increased utility from “untouched” nature hinders such a scenario. Another indication that Norway has entered a mature phase is Statoil`s announcement in 2011 of a new type of oil rig, specially designed for cost effective extraction of oil in mature reservoirs, called cat D[1]. Statoil has also opened up for taking ownership shares to encourage buyers to invest in this oil rig, which is unusual in this industry, indicating the importance of this kind of development for Statoil. As there are several indications that Norway has entered a mature phase as an oil producer this will be considered during the econometric analysis.

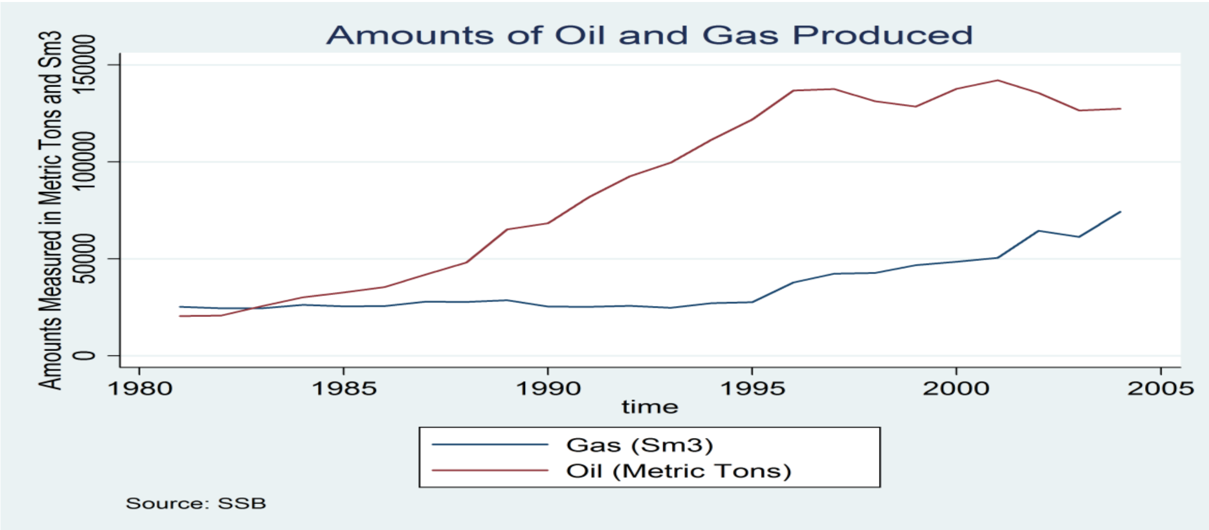


Figure 2.7: Amounts of Oil and Gas Produced in Norway.

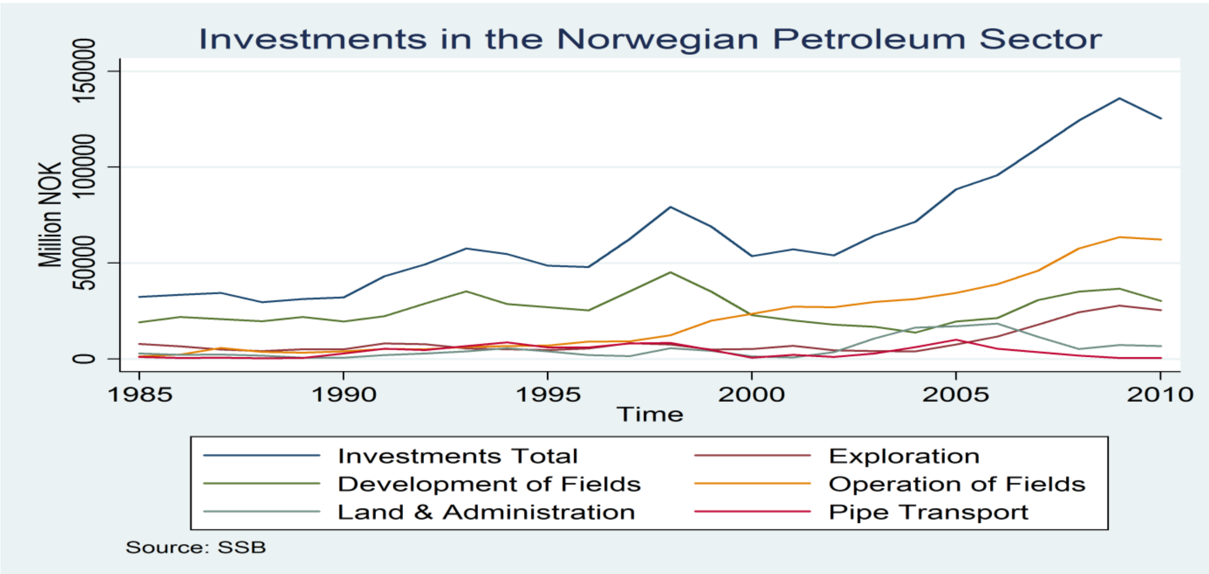


Figure 2.8: Value of Investments Related to the Norwegian Oil and Gas Sector.

[1] http://www.statoil.com/catd

3.0 Oil Shock Literature Review

This section presents first the stages the oil shock research area has gone through from the 1970s to present day. The oil shock research can be roughly divided into three development stages where the first stage in the late 1970s and beginnings of the 1980s first utilized vector autoregressive (VAR) techniques to analyze the relationship between oil prices and economic variables. The second stage in the 1980s was born out of the weaker and low significance of the oil price and economic development relationship. This made the researchers focus on price definitions in order to achieve significance in their analysis. The third stage focus on the underlying factors which explains why oil prices changes and it is the insight gained from this area which makes up the basis for the econometric analysis in this thesis. Research findings with emphasis on studies regarding net oil-exporters will also be presented to illustrate that responses to oil price changes differs from one oil-exporter to another. This demonstrates that generalizations between different oil-exporters without a deeper country specific assessment could be faulty. The econometric analysis of this thesis is thereby justified as Norway share few characteristics with other noteworthy net oil-exporters and generalizations to the Norwegian economy is unlikely not be robust. There is also a section presenting critical remarks about the various oil price definitions and the censoring of data which is applied and is a further support of the econometric foundation this thesis is based on. Lastly, a detailed presentation of the last stage of the oil shock research is given since this stage is the most important regarding this thesis and also illustrates why some of the earlier research provided unstable results.

3.1 The Start of Oil Shock Research

The first wave of research regarding oil price shocks stems from the experiences of the oil crisis in the 1970s. One of the first articles within this field is Rasche & Tatom (1977), where the oil price and potential GNP level were analyzed. Their findings gave clear indications that the higher oil prices had a negative effect on the US GNP. Another important article was Hamilton (1983) who also suggests a negative relationship between the oil price and US macro variables, and in addition that oil price changes Granger caused changes in US unemployment and GNP. Hamilton also pointed to the suggestive fact that nine out of ten US recessions post WW-II was preceded by a spike in oil prices. Most of the research performed in this period was heavily concentrated at the US response, but Burbidge & Harrison (1984) confirms that major OECD countries show similar response as the US. Although most body of research done in this early period confirmed the significant negative effect of oil price shocks there were some studies who reported conflicting results with the mainstream, as Darby (1982).

3.2 Asymmetric and Non-Linear Price Definitions

During the 1980s the linear relationship predicted by the early research began to fade. That is, when the oil price decreased in the second half of the 1980s, the effect on economies was smaller than what the models predicted. This gave rise to a new paradigm within the oil shock research area and the idea of asymmetric price effects was born. The first article which presented an analysis based on asymmetric effects from the oil price was Mork (1989), utilizing price definitions seen in equation 3.1 and 3.2. (The price definitions are presented fairly detailed since section 3.5 presents arguments of their weaknesses.) Mork found support for the notion that oil price increases had a negative significant effect on the GDP of US and other OECD countries, while oil price decreases had no significant effect at all. The rationale behind the asymmetric response was that oil crises caused concerns about the energy price and availability, which caused a delay or cancelling in decisions of irreversible investments. Accordingly, a decrease in oil price will not lead to a positive effect which mirrors the negative consequences of an oil price.

$$\Delta op_t^+ = \max(0, \Delta op_t) \tag{3.1}$$

$$\Delta op_t^- = \min(0, \Delta op_t) \tag{3.2}$$

Hamilton produced the most widely used oil price definition in 1996, called the net oil price measure. This is in essence a further development on the predicted non-linear relationship between the oil price and the macro economy. Hamilton (1996) argues that Mork`s definition does not adequately handle the data since most of the oil price increases since 1986 have followed immediately after larger decreases. Thus, Hamilton claims an oil price definition where the price of oil is given time to adjust to new levels is necessary, see equations 3.3 and

3.4. The mechanics is as follows; an observed oil price takes the value of zero if the price is not higher than any of the previous 12 months and takes the observed value otherwise. The basic idea is that the oil price is given time to adjust to a new equilibrium level. In other words, Hamilton argues that most oil price movements are correction to earlier time periods. Hamilton further builds on this definition in his 2003 article where he increases the time period to 36 months.

$$netop_t^{12M} = max[0, op_t - max(op_{t-1}, op_{t-2}, op_{t-3}, \dots, op_{t-12})] \qquad (3.3)$$

$$netop_t^{36M} = max[0, op_t - max(op_{t-1}, op_{t-2}, op_{t-3}, \dots, op_{t-36})] \qquad (3.4)$$

An alternative non-linear oil price definition which is popular in the literature is Lee, Ni & Raati (1995) definition. By using a univariate GARCH error process Lee et al. compute the unexpected component and conditional variance of the oil price. The basic premise for this process is to illustrate that oil price shocks have a larger effect on macro variables in stable environments than in environments characterized as volatile. Lee et al. then augment the VAR models of Mork and Hamilton and support their findings regarding asymmetric relationship between the oil price and macroeconomic variables.

The last definition presented is an oil price band definition. That is, a band is defined which transform the variable to zero if the observed price is within a set of given values and takes the observed value if the price is outside the chosen band. This definition is not widespread in the literature, but Akram (2004) used it to observe if the oil price would affect the Norwegian exchange rate.

$$opband_t = \begin{cases} 0 \; if \; (\log)x \rangle op_t \langle (\log) \, y \\ \Delta op_t \; otherwise \end{cases} \qquad (3.5)$$

3.3 Structural Change

There has also been a growing literature that a structural change happened in most modern economies during the 1980s. A structural change in this setting means transformations in economic fundamentals. Economic fundamentals which are often brought into the discussions in this topic are real wage rigidity, monetary policy, the declining share of oil in economies and lastly the lack of other big exogenous adverse events.

This area of research have been rising lately since the oil price shocks in mid and late 1970s caused the dreaded stagflation while recent oil price spikes have contrariwise coincided with GDP growth and stable inflation. Blanchard & Gali (2007) finds strong indications that a structural change indeed has taken place. By dividing the sample in pre and post 1984, they find that output and inflation measures are less influenced by oil prices in the latest sample. Blanchard & Gali base their findings firstly on reduced share of oil in consumption, as this makes each country less vulnerable to changes in oil prices. Secondly, changes in monetary policy which has emphasized a stable inflation rate. Thirdly, more competitive labor markets have reduced the wage rigidities. When the wages are increasingly flexible this leads to less negative consequences for the output and inflation rate. Fourth, recent time period of high oil prices has not coincided with other adverse shocks. Hooker (2002) supports the structural change hypothesis, but cannot attribute this to changes in energy intensity or monetary policy.

Jiménez-Rodríguez & Sánchez (2009) also confirms that the effects of oil price shocks were greatest in the 1970s, but they also maintain that the oil price is still very relevant regarding macroeconomic development in advanced major economies in both the 1980s and 2000s. Lastly, Baumeister & Peersman (2008, 2009) and Peersman & Von Robays (2009b) objects the comparison made over time periods done by Blanchard & Gali, due to structural changes within the global oil market. By structural changes within the oil market Baumeister & Peersman (2008) means that the oil supply and demand curves have become much steeper and less elastic over time. That is, recent shocks in demand or supply are characterized by a much smaller impact on world oil production and a greater effect on oil prices compared to the 1970s and early 1980s. Since Blanchard & Gali (2007) assumes constant elasticity of demand, Baumeister & Peersman (2008) argue their comparison over time periods is faulty.

3.4 Net Oil-Exporting Countries

Historically the research within the oil shock area mainly concentrated on the US economy, in fact most articles mentioned so far in this thesis either examine the US or one of the G7 economies. This implies that most of the research focused on how oil prices influence a net oil-importing country. Only in more recent times have researches started to focus on how oil price shocks influences economies which are net oil-exporters. This section provides an overview of relevant findings regarding net oil-exporters.

Studies regarding the GDP and government expenditures offer indications that the effect from oil price changes differs from oil-exporting countries. Lorde, Jackman & Thomas (2009) and Farzanagan & Markwardt (2009) conclude respectively that Trinidad & Tobago and Iran have higher GDP and government expenditures during positive oil price shocks. As those countries do not have similar mechanism as the Norwegian Petroleum Fund which lessen the degree of impact from oil price shocks on the domestic economy (see section 2.3), generalization from these studies to the Norwegian economy would be naïve.

Mehrara & Oskoui (2007) examine Iran, Saudi Arabia, Kuwait and Indonesia and finds that oil price shocks are the main source of output fluctuations of output in Saudi Arabia and Iran, but not in Kuwait and Indonesia. Regarding Kuwait, the non-influence from oil prices is attributed to savings and stabilization funds and could be interesting compared to Norway. In Indonesia structural reforms and diversification away from resource based production are the main explanations. It should also be mentioned Indonesia`s oil export has fallen dramatically over the years (Indonesia actually left OPEC in 2008) which offer an alternative explanation. Regarding the top oil-exporters in the world (see table 3.1), Dibooglu & Aleisa (2004), finds that the Saudi-Arabian CPI, exchange rate and output are driven by the real oil price, while Rautava (2004) finds that the Russian exchange rate appreciates during oil price increases. This is in line with what Haldane (1997) claims, as net oil-exporting countries experience higher demand pressure, this increases inflation and thereby the exchange rate.

Country	Net Oil Exports[1]	GDP per capita[2]	Finanical Devolopment[3]	Economic Freedom[4]
Saudi-Arabia	8.406	39	**26**	65
Russia	6.874	54	40	143
United Arab Emirates	2.521	**8**	**21**	46
Iran	2.433	90	NA	168
Kuwait	2.390	**23**	**28**	42
Norway	2.246	**2**	**15**	37
Angola	1.948	87	NA	154
Venezuela	1.893	60	56	174
Algeria	1.888	92	NA	105
Nigeria	1.769	133	57	106
Iraq	1.597	119	NA	NA
Libya	1.185	48	NA	173
Kazakhstan	1.185	64	49	82
Canada	1.089	**11**	**6**	**7**
Qatar	1.085	**3**	NA	39

Table 3.1: Descriptive Summary of the Most Prominent Oil Exporters in the World.

There is however a caveat which invalidates any generalization from these findings to the Norwegian economy, since countries with similar amount of oil-exports has different economic characteristics. The table 3.1 ranks the top 15 net oil exporters in the world with Saudi-Arabia and Russia as the dominant net exporters, while Norway is ranked sixth. Also found in the table are different development indices with the respective world rank given to the countries. As shown there are large differences within the group of countries, where especially Canada, Qatar, United Arab Emirates, Kuwait and Norway separates from the rest of the group. The argument raised here is that empirical results from oil-exporting countries not necessarily can be generalized to other net oil exporters since higher economies in developed countries might react differently than less developed countries.

[1] US Energy Information Administration (EIA):
http://www.eia.doe.gov/country/index.cfm

[2] International Monetary Fund:
http://www.imf.org/external/pubs/ft/weo/2010/02/weodata/index.aspx

[3] World Economic Forum:
http://www.weforum.org/reports/financial-development-report-2010?fo=1

[4] The Heritage Foundation and Wall Street Journal:
http://www.heritage.org/index/ranking.aspx

As an example of how oil price effect may vary across oil exporters with different levels of development may be due to a credit risk effect and capital costs. The CME Group releases risk assessments of sovereign debt on a quarterly basis. Their latest CMA report (2010:5) concludes that Norway is the least risky country included in their sample while Venezuela is at the bottom of the same list. Hypothetically, if the oil price unexpectedly increases the perceived risks of both countries decreases due to higher expected future revenues. Since Norway already has a very low risk it would however be reasonable to expect that Venezuela will have a relative larger reduction of risk. Consequently, this further leads to relatively lower capital costs in the risky country which enables agents to channel capital to investment projects which was not profitable before the oil price increase. In other words, investments might increase relatively more in Venezuela than in Norway since Norway already have low capital costs thus stimulating the Venezuelan economy higher than the Norwegian.

Jiménez-Rodríguez & Sánchez (2005) examines how selected OECD countries, which are roughly equal developed economies, including both net importers and exporters of oil, respond to oil price changes. First, their findings regarding net oil-importers show decreasing output and increased inflation in line with previous research. Secondly, Norway and UK which are both net oil-exporters show contrasting result. Interestingly they find that Norway has a positive response, while the UK reacts similar to oil-importing countries. Jiménez-Rodríguez & Sánchez (2005) argue that the exchange rate behavior explains this phenomenon as the pound appreciates relatively more than the Norwegian exchange rate, which is an indication of the Dutch Disease. That is, the positive effect from increased revenue is negated by the rise of the exchange rate which lessens the competitive power of the UK export oriented industry. Thirdly, the Canadian economy which became a net oil-exporter during the sample period is the only country which reacts negatively to oil price decreases, while the UK again reacts as an oil-importing country and Norway has no significant response. Using an alternative measure for oil shocks Kilian (2008a) supports the findings that UK reacts similar to an oil-importing country.

Bjørnland (1998b, 2000) offers further insight into how similar net oil-exporters react differently and illustrates the importance of economic structures in the respective countries studied. More specifically, Bjørnland (1998b) argues that during the oil price increase in the

1980s, the macroeconomic policy in UK differed from the Norwegian policy in two areas. Firstly, UK had external debt which needed to be paid off and secondly combatting the high inflation rate was highly prioritized. This lead to fiscal and monetary tightening which ultimately resulted in higher unemployment. Thus, whereas Norway followed an expansionary fiscal policy to maintain the industry structure, the UK allocated the extra windfall revenue to debt reduction and increasing the social security costs (as unemployment increased due to monetary policy). Another reason for the different response could simply be a quantity effect, as Canada and UK have relatively less exports of oil and thereby gains less, as indicated figure 3.1. Even though the UK export volume was greater in the 1980s figure 3.2 illustrates the importance of the oil volume relative to the size of the oil-exporter economy. Figure 3.2 supports the view that the oil industry makes up a larger share of the Norwegian economy than both the UK and Canadian economy. The difference between the UK and Norwegian response could also be due to the fact that both countries are net oil-exporters, but whereas Norway is also a net energy-exporter, UK on the other hand is a net energy-importer (Peersman & Von Robays, 2009b). In fact, UK is the largest receiver of Norwegian oil as un-stabilized crude oil is pipelined from Ekofisk to Teeside.

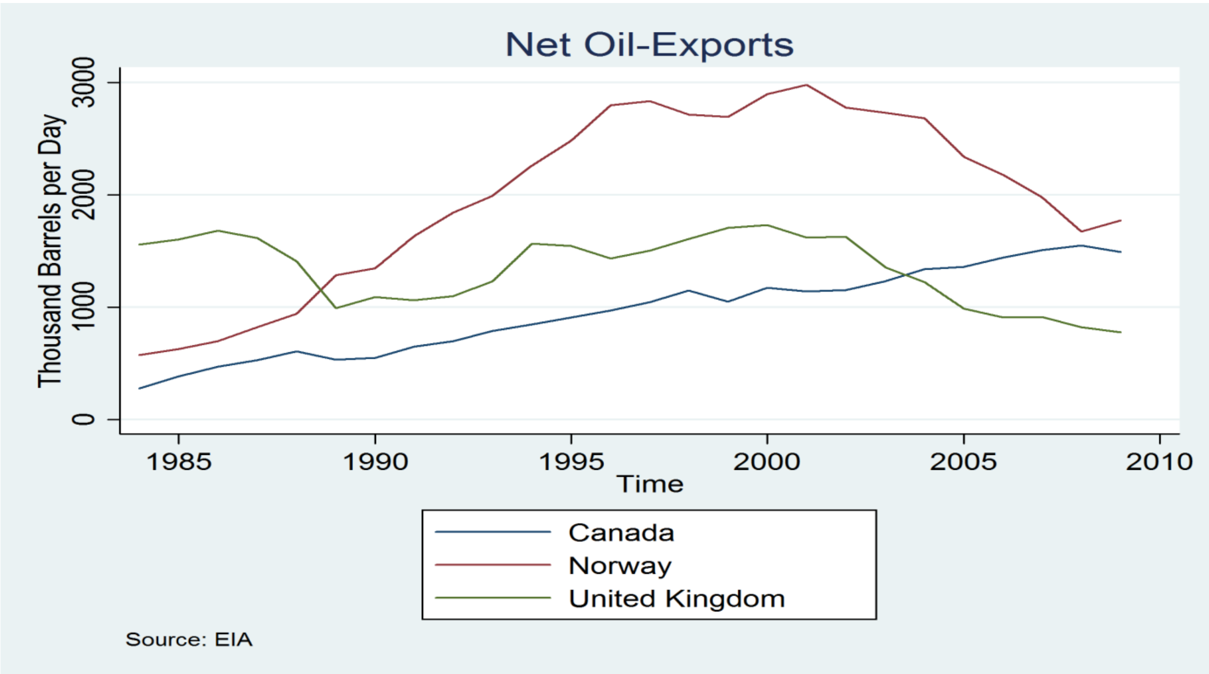


Figure 3.1: Crude Oil Exports in Canada, Norway and United Kingdom.

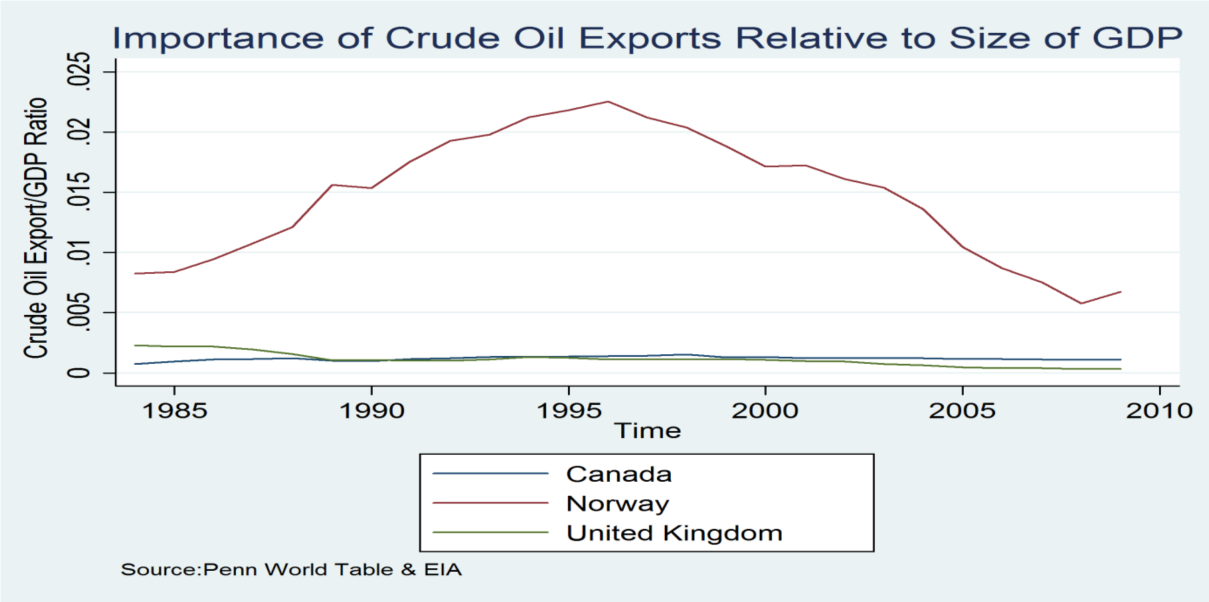


Figure 3.2: Crude Oil Exports Relative to Economic Size.

Akram (2004) examined the response of the Norwegian exchange rate and finds that when the oil price wanders outside a specific price range a negative relationship with the nominal exchange rate develops. Bjørnland (1998a) finds that the Norwegian real exchange rate depreciates during an oil shock and this result is robust if the oil price is measured in US or NOK and nominal or real terms. Her explanation for this finding is that the Norwegian consumer prices behave more sluggishly than the trading partners of Norway. Bjørnland (2009) on the other hand finds that during an oil price increase an appreciation of the nominal NOK is predicted, but this is not significant. The insignificance in the NOK exchange rate is explained by the findings of different monetary response of Norway and countries abroad. Bjørnland`s (2009) estimations show that countries abroad react more quickly with monetary tightening during an oil increase while the Norwegian response is more sluggish. This leads to an interest differential which, ceteris paribus, puts depreciation pressure on the Norwegian exchange rate. Solheim (2008) on the other hand finds that the Norwegian nominal exchange rate appreciates during higher oil prices.

3.5 Criticism Against Previous Research

As stated above Mork`s (1989) definition allows for an asymmetric effect from the oil price (see equation 3.1 and 3.2). That is, an oil price increase (decrease) may be significant while an oil price decrease (increase) may not be a significant factor explaining the development of macroeconomic variables. Kilian & Vigfusson (2009) is however critical to this censuring method, where the researcher can simply set values to zero dependent on their sign. This censuring process might lead to inconsistent results and overstate the true relationship between the oil price and other macroeconomic variables. Kilian & Vigfusson (2009) finds weak support for the slope coefficients to show any indications of asymmetry. Also, tests of the symmetry regarding the impulse reaction functions do not offer strong evidence against the null of symmetric relationship between the oil price and macroeconomic variables (Kilian & Vigfusson, 2009).

Although the net oil price definition has gained support in the empirical analysis in this area, (see equation 3.3 and 3.4) Hooker (1996) responded quickly with critical remarks to Hamilton`s oil price definition. Hooker questioned how Hamilton disregards decreases in the oil price and says this could influence the structure in the model. Hooker later follows up his criticism in his 1999 article and support this by not finding a relationship between Hamilton`s net oil price definition and US unemployment or inflation rates.

As with Mork`s oil price definition Kilian & Vigfusson (2009) also criticize the net oil price definitions and notes that few articles support the asymmetric assumptions this method requires since they find no evidence against the null regarding symmetry. It should be mentioned that Balke (2002) does indeed find results that support the asymmetry view, but since Kilian & Vigfusson uses a longer time series, the real instead of the nominal price of oil and induces one standard deviation in their impulse responses instead of Balke`s two standard deviations, Kilian & Vigfusson`s results is more robust and precise.

Kilian & Vigfusson (2009) further support the notion of symmetry by the use of slope-based tests. They find no support for the $netop_t^{12M}$ oil definition, but do however find some weak support for the $netop_t^{36M}$ oil price regarding asymmetric effects. However, even if there is an asymmetry in the slope coefficients, this does not necessarily mean that the impulse reaction functions are affected. In other words, it is entirely possible that using impulse response functions under symmetric assumptions gives consistent and robust results even when the data generating process is asymmetric. This point of view is supported by the tests which is performed by Kilian & Vigfusson (2009), which find no support for asymmetric effects on the price of oil to macroeconomic variables using both $netop_t^{12M}$ and the $netop_t^{36M}$ definitions.

As with the previous asymmetric oil price definitions, the variability measure of Lee, Ni & Raati is also vulnerable to the same criticism forwarded by Kilian & Vigfusson (2009:50), due to the censoring methods applied in the definition. While an apparent weakness of the band definition (see equation 3.5) is that the values which the band consists of are seemingly arbitrarily chosen and the researcher therefore has freedom to choose values to his own liking.

3.6 Disentangling Supply and Demand Forces in the Oil Price

"Not all oil price shocks are alike", Kilian, L. (2009)

Barsky & Kilian (2004) strongly advocate that in order to analyze the effects of oil price on macroeconomic variables it is crucial to search for the reasons for why the oil price changes. This is important firstly, as Barsky & Kilian (2004) points to the plausible fact of potential feedback effects between the oil price and macroeconomic variables. That is, the oil price could influence macro variables and macro variables could influence the oil price. This means that the exogenous oil price increases assumed in much of the literature is not valid. It should be mentioned that this insight is mostly relevant for studies on big economies such as the US since smaller economies would hardly have a plausible impact on oil prices.

Secondly, the demand and supply conditions in the oil market are very closely related to the oil price development. This is an important issue, since it is reasonable to expect macro variables to react differently on whether oil price changes due to a supply or demand shock. The intuition is as follows, if the oil price increases due to a demand shock this would imply higher input prices for the economy and all else equal this would have a negative effect. But since the price increases due to higher economic activity, it is possible that the ripple effect from higher economic activity entirely or at least partly outweighs the negative oil price effect. However if the oil prices increase due to a reduction in supply this would intuitively lead to negative consequences for the economy, since all else equal this would lead to higher prices and no positive demand effect except for oil-exporters. Lippi & Nobili (2009) supports Kilian`s notion of disentangling the oil price is vital in order to be able to predict the US business cycles under oil price shocks. Blanchard & Gali (2007) also mentioned the underlying reasons for price changes as a possible reason for the structural change previously discussed. They do however not include this quantitatively in their analysis as their identification does not incorporate supply or demand effects on the price of oil.

Another possible caveat in previous research can be the implicit assumption that macro variables could not predict oil price changes (Hamilton, 1983) and that exogenous events (wars, political turmoil) explained most of the observed oil price spikes. Barsky & Kilian (2002, 2004) and Kilian (2008b) argue that the oil supply shocks are less important for explaining oil price movement than previously thought. Although important in the 1970s the supply effect has diminished and is only of importance on a limited amount of time periods. This has implications for previous research since exogenous oil supply shocks have been extensively used as a basis for identification of the VAR specifications. Instead it is the aggregate and precautionary demand which can explain most of the variations in the oil price after the 1970s oil price shocks. This is further supported by Baumaister & Peersman (2008).

3.7 Findings of Disentangled Oil Price Shocks Research

Kilian (2009) finds results that are in line with the intuition above. Oil price shocks which stem from oil supply disruptions have a negative effect on US GDP, while shocks from increased aggregate demand have no initial effect on US GDP, but becomes negative and significant after three years. Oil market-specific demand decreases US GDP, but is not significant until three years of the induced shock. Kilian`s results therefore provides an explanation of why earlier regressions on oil prices have proven unstable since those studies did not incorporate the underlying reasons for the price changes.

Peersman & Van Robays (2009a) supports the findings of Kilian that the disentanglement of the oil price is necessary in their analysis of the Euro members.[1] Although there are similarities between the Euro and US response to oil price shocks, some deviations are significant. The first difference is the speed of transmission from an oil supply shock to both inflation and output, where the Euro response is more sluggish (Peersman & Van Robays, 2009a). During an oil-specific demand shock there is loosening monetary response in the US, while the Euro area shows no reaction. Peersman & Van Robays (2009a) argue that labor market dynamics and monetary policy transmission mechanisms are the source of the differing responses. As trade unions are stronger in the Euro area than in the US, a higher elasticity of labor supply is assumed to prevent loss of purchasing power for the Euro worker. They also find that the income and precautionary savings effects are probably not relevant in the Euro area. Lastly, there are also asymmetric responses between the individual Euro members which is attributed to differences in wage rigidity and thereby inflation between the Euro members, while sharing the same monetary policy.

Using a slightly different SVAR approach, where sign restrictions are utilized and allowing simultaneous effects from the US economy to the oil price, Lippi & Nobili (2009) supports the notion oil price disentanglement. More specifically their findings was that oil supply shock causes negative changes in the US economy as Kilian`s (2009) paper predicted. While Kilian (2009) predicted a delayed negative effect on the US GDP during a demand shock, Lippi & Nobili (2009) actually predicts a positive response of the GPD in these conditions.

[1] Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain.

They base this finding on a low elasticity of substitution between US and “*rest of the industrial world*” goods. That is, higher demand abroad also increases the consumption of US goods.

Not many studies have included both net oil-exporters and at the same time disentangle the causes of oil price changes, but Berument, Ceylan & Dogan (2010) is the exception. They study the effect of oil price shocks in selected MENA countries[1], including both net oil importers and exporters and supports Kilian`s (2009) findings. For importers they find that output decreases when it is a supply shock which is causing the oil price increase, while output increases if there is an oil price increase due to aggregate demand. The net oil-exporting countries experience a growing output regardless of the underlying shock causing price changes. A comparative analysis of Berument et al. (2010) results with this thesis will be interesting due to the differences in economic development between Norway and the various MENA oil-exporters.

Sørensen (2010) utilizes a SVAR methodology when analyzing the oil and the Norwegian economy while also considering the underlying reason for the oil price changes. Sørensen (2010) does however only partly include an oil supply variable in his analysis. He is also only focusing on financial performance and thereby Oslo Stock Exchange is the only Norwegian macroeconomic variable included. Sørensen (2010) finds that the financial markets of Norway and Canada react positively to both oil-specific and global demand shocks.

[1] Exporters: Algeria, Iran, Iraq, Kuwait, Libya, Oman, Qatar, Syria, United Arab Emirates. Importers: Bahrain, Djibouti, Egypt, Israel, Jordan, Morocco and Tunisia.

4.0 Methodology

4.1 VAR and SVAR

The VAR methodology was introduced by Sims in 1980 and represented an alternative to the Cowles Commission econometric techniques widely used during that time. A VAR model is essentially an ordinary regression model which provides a multivariate framework where changes in a particular variable are related to changes in its own lags and to changes in other variables and their lags. The VAR treats all variables as jointly endogenous and does not impose any restrictions on structural relationships. Since the VAR expresses the dependent variables in terms of predetermined lagged variables it is called a reduced form model. Analytically the VAR can be represented as:

$$y_t = A_1 y_t + \ \dots + A_i y_{t-i} + B z_t + \varepsilon_t \tag{4.1}$$

Where y_t is a vector of endogenous variables, z_t is a vector of exogenous variables, A_i and B are coefficient matrices while i is the lag length and ε_t represents an innovation process which is an unobservable zero-mean white noise process with a time invariant positive definite variance-covariance matrix.

The order of which variables enter the VAR is called the Cholesky ordering. The Cholesky ordering is important since the innovations calculated are dependent on the Cholesky decomposition. The ordering should therefore reflect the degree of how exogenous the variables are relative to other variables in the model. In other words, a variable which is not influenced by the development of other variables should be ranked first, while a variable which is considered to be highly dependent on other included variables should be designated a lower position. Note that in a VAR it is only in the Cholesky ordering a priori knowledge is used. It is also a general accepted that additional lags improve the stability of VAR results to changes in the Cholesky ordering.

The difference from a VAR model is that a SVAR model imposes restrictions on the included variables. As such the SVAR is an alternative to the Cholesky recursive orthogonalization described above. That is, parameters in the impact multiplier matrix are not free parameters, but are set to a given value. The rationale for doing this lies in the relationship between the variables and is often justified with characteristics of the variables short run demand and supply curves. By construction we can get the reduced form innovations, e_t, from equation 4.2 due to its relation to the innovation process, ε_t.

$$A_0 y_t = \alpha + A_1 y_{t-1} + \ ... + A_i y_{t-i} + \varepsilon_t \tag{4.2}$$

The relationship between the reduced form errors, e_t, and the vector of serially and mutually uncorrelated structural innovations can be described as:

$$e_t = A_0^{-1} \varepsilon_t \tag{4.3}$$

In a three variable setting the reduced form errors can then be defined as the following:

$$e_t \equiv \begin{pmatrix} e_t^{\mathrm{M}} \\ e_t^{\mathrm{N}} \\ e_t^{\mathrm{O}} \end{pmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} \varepsilon_t^{\mathrm{M-shock}} \\ \varepsilon_t^{\mathrm{N-shock}} \\ \varepsilon_t^{\mathrm{O-shock}} \end{pmatrix} \tag{4.4}$$

The left hand side in equation 4.4 represents the reduced form innovation, while the first matrix on the right hand side is the impact multiplier matrix, $[A_0^{-1}]$, and the last term represents the structural shocks. The critical phase of the SVAR lies in the identification of the elements in the impact multiplier matrix, namely the $\alpha_{i,j}$, where $i = 1,2,3, j = 1,2,3$. The restrictions allow us to orthogonalize the error term in a non-recursive way for the analysis of the impulse response functions.

The SVAR methodology opens up for short and long run restrictions, but since my thesis only utilize short run restrictions I will concentrate on this option. The short run restrictions are formulated such that one of the variables cannot instantaneously respond to the changes or shocks produced in other variables. Often the short run restrictions are based on the characteristics of the short run supply or demand curves of the respective variables and this make the frequencies of the data of the upmost importance. That is, it could be reasonable that an agent not instantaneously reacts to new information if the data is weekly, monthly or even quarterly, but when dealing with annual data it is doubtful that short run restrictions are justifiable. It should however be stressed that there is no fixed time period that can be marked to distinguish the short run from the long since this varies from one specific relationship to another. Sections 5.3 and 6.3 discuss the restrictions applied in the analysis.

4.3 Innovation Accounting

The central idea of using VAR is to trace the dynamic response of variables to innovations in other variables. In this thesis I use two methods to explain the innovations, impulse response functions and forward error variance decomposition.

When using impulse response functions we induce a shock in variable to examine how another variable respond. The induced shock is a one period shock which immediately reverts to zero. In the IRF graphs the confidence interval has been included to highlight if a relationship is significant or not. The confidence interval could either be calculated based on standard errors obtained from bootstrapping or asymptotic methods. In this thesis I have based the confidence intervals from asymptotic methods. Note that it is only the confidence interval which is potentially affected by switching between these methods and consequently the coefficient values should be identical.

To complete the innovation accounting the forward error variance decomposition is also reported (FEVD). The forward error variance decomposition is the percentage of the variance of the error made in forecasting a variable due to a specific shock at a specific time horizon. That is, it tells how much of a change in a variable is due to its own and other variables shocks. Generally it is the own shock in a variable which explains most of the variance, but as the effect from the lagged variables starts to come into force, the percentage of the effect of other shocks increases over time (Enders, 2010).

4.3 Other Statistical Properties

To produce credible and robust SVAR results there are statistical properties which must be satisfied. Firstly, the time series in the models must be stationary (as long as cointegration is not used), that is, integrated of order zero, I(0). Most macroeconomic time series are however usually non-stationary and integrated of order one, I(1) and must therefore be first differenced. It should be mentioned that by first differencing variables we lose information and therefore cointegration could be a better alternative. The unit root tests do however indicate that some variables in the thesis are stationary while others are non-stationary, effectively ruling out the option to use cointegration. The unit root tests utilized are listed in section C.1 in the appendix.

The number of lag lengths could also affect the SVAR results and information criterions are often used to determine how many lags the SVAR model utilizes. There is however qualitatively differences between these criterions such that some criterions are better suited to certain datasets. The SBIC will for instance punish the model harder for each lagged added than AIC and is also found to be a better information criterion for large data samples, Enders (2010). Ivanov & Kilian (2005) finds that each of the information criterions has its strengths dependent on the series frequencies. Akaike Information Criterion performs best with monthly frequencies, while the Hannah-Quinn Information Criterion is the most accurate with quarterly frequencies and observations over 120 and lastly the Schwarz Information Criterion is the best option with quarterly observations and less than 120 observations. The presentation for the various information criterions is placed in section in C.2 in the appendix**.** The discussion of the VAR lag lengths applied in the analysis is located in sections 5.3.2 and 6.4.2.

To avoid spurious regressions it is also necessary to examine the model for autocorrelation. To ensure that autocorrelation is not a likely problem I use two tests for this purpose, Lagrange-Multiplier and Portmanteau test. Details are presented in the appendix in section C.3.

The stability of the SVAR model must also be examined. If the model is not stable, some relationships are characterized as explosive. This means that predictions of the impulse response functions increase over time instead of fading out. Stability of the model is tested by checking the eigenvalues of the SVAR model, details listed in the appendix C.4. Lastly, the normality of the residuals is also inspected. Details presented in C.5 in the appendix.

5.0 SVAR I, Aggregate Oil Market

The central idea is to disentangle the oil price from demand and supply forces, which is following the discussion in section 3.6, of substantial importance. The first SVAR therefore examines the relationship between the oil production, economic activity and the oil price. This part is inspired by the Kilian`s (2009) analysis. I will however test this relationship with a different methodology by using a slightly different VAR approach. More specifically, instead of calculating the standard errors by non-parametric bootstrap procedure, I use the asymptotic standard errors. The choice of asymptotic procedure is taken since non-parametric bootstrap procedure is an advanced econometric technique and I find it out of scope for a master thesis. I will also use a different sample than Kilian to examine if his conclusions are robust to recent experiences. The data sample used in Kilian (2009) ends in December 2007 which means the recent spike and downfall in the oil price and world economy is not included. Finally, I use a different oil price since I am taking the perspective of a net-oil exporter instead of a net-oil importer. The first SVAR analysis also takes the role of a crucial base analysis in which the second SVAR analysis is dependent of. That is, the first analysis must hold up in order to perform the second analysis.

The supply forces are included by using the world total oil production, while an index based on shipping rates represents the demand forces. The first SVAR therefore examines if shocks in these two underlying variables have significant effect on the oil price. The last variable included is the oil price and shocks from this variable are described as oil-specific demand shocks. As both supply and demand shocks are explained by the first two variables the remaining innovations in the oil price is characterized as precautionary demand for oil. Kilian (2009:1059) firstly argues that oil-specific demand is a good representation for precautionary demand since there are no other plausible explanations for exogenous oil market-specific demand shocks. Secondly, the large effect from the oil-market specific shocks he finds is difficult to reconcile with shocks from other sources than expectation shifts. Thirdly, the timing and the direction of the effects from these shocks is consistent with the timing of other exogenous shocks, as the Persian Gulf War that would all else equal rise uncertainty of oil supply. Fourthly, the overshooting of the oil price to oil-market specific shocks is similar to what theoretical models of precautionary demand predict. Fifthly, Kilian (2009) finds that movements in the real price of oil induced by this shock are highly correlated with independent measures of the precautionary demand component of the real price of oil based on futures prices.

5.1 Data

5.1.1 World Crude Oil Production

The world production or supply of oil is obtained from the U.S. Energy Information Administration, "*November 2010 Monthly Energy Review*". The estimated world production of oil used in this thesis is graphed in figure 5.1. The graph display the monthly averaged crude oil production in thousands barrels per day. The supply of oil has been volatile the late 1970s and early 1980s most likely reflecting the OPEC ambitions to increase the price of oil. After 1985 the production has increased steadily with some breaks in the late 1990s and early 2000s. From the mid-2000s the oil production has been relatively steady.

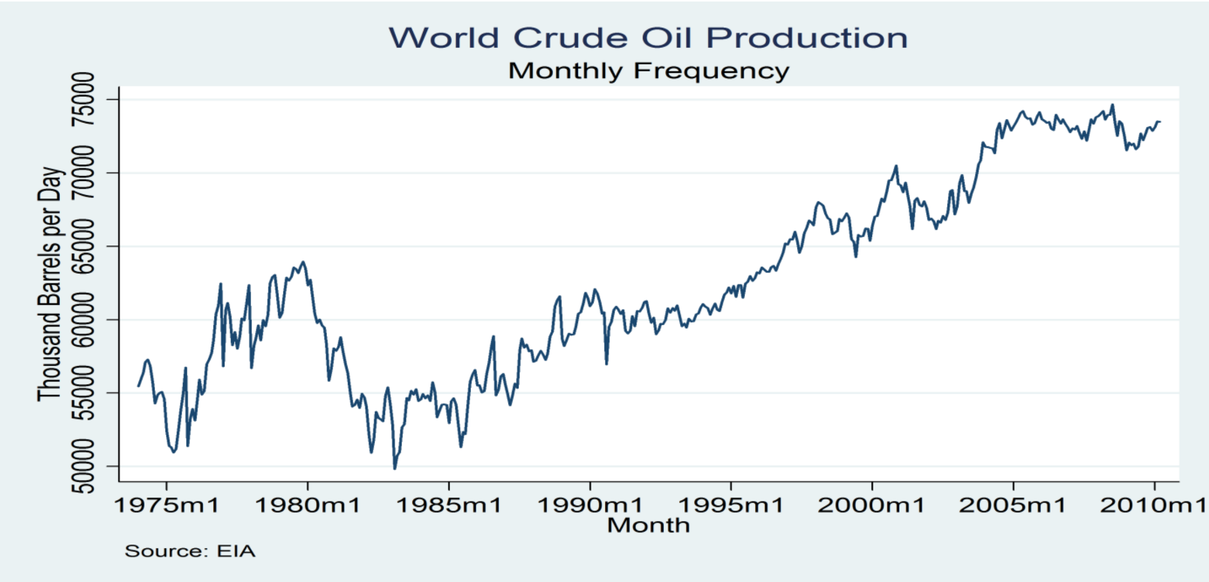


Figure 5.1: World Crude Oil Production.

5.1.2 Aggregate Economic Activity

To measure the aggregate economic activity in the world I have used an index created by Kilian (2009), graphed in figure 5.2. The basic idea is that the index should reflect the demand for commodities in the global market and thereby be a good measure for the world economic activity. This index then represents the world demand for oil as oil is an important input in most economic activity. In order to quantify such an index Killian has used dry cargo single voyage ocean freight rates. This is justified first by Klovland`s (2002 & 2009) historical research, using data as far back as 1850, which concludes that economic activity is the main variable explaining demand for transport services. In addition Klovland (2009) also finds that wars and harvest failure had significant effects. First, wars tend to increase shipping rates due to higher risks at sea combined with reduction in supply of shipping services as ships are captured or sunk at sea. It is also likely that ports get blockaded or simply deemed too risky to use for trading and is substituted with other ports farther away and thereby inducing higher fare costs and ultimately higher freight prices.[1] As Klovland (2009) also discuss government requisition or demand for shipping also reduces the available amount of shipping supply, inducing upward pressure on the freight prices. Harvest influence freight prices as the need to import food can greatly vary from one season to the next. As there have been few wars after WW-II which had the potential to affect world economic activity I consider Kilian`s index a good measure for economic activity, since such a war must either influence the US or the majority of European countries.[2]

In addition to the insight gained from Klovland, Stopford (1997) also reports as the total shipping freight volumes operates at near full capacity, the supply curve of shipping becomes virtually vertical. In other words, as economic activity increases relative to shipping volumes, freight rates tend to increase. An index based on the prices of shipping thereby indicates high or low aggregate world economic activity. Kilian used shipping rates from Drewry`s Shipping Monthly to construct the index, the US CPI for deflation and lastly detrended the series to counter technological advances in the shipping industry.

[1] Klovland (2009) also mentioned that it is the perceived risks of war instead of the war itself which could have caused the freight prices to rise.
[2] Vietnam War could plausibly have the potential, but ended 1975 April, before the analysis sample period.

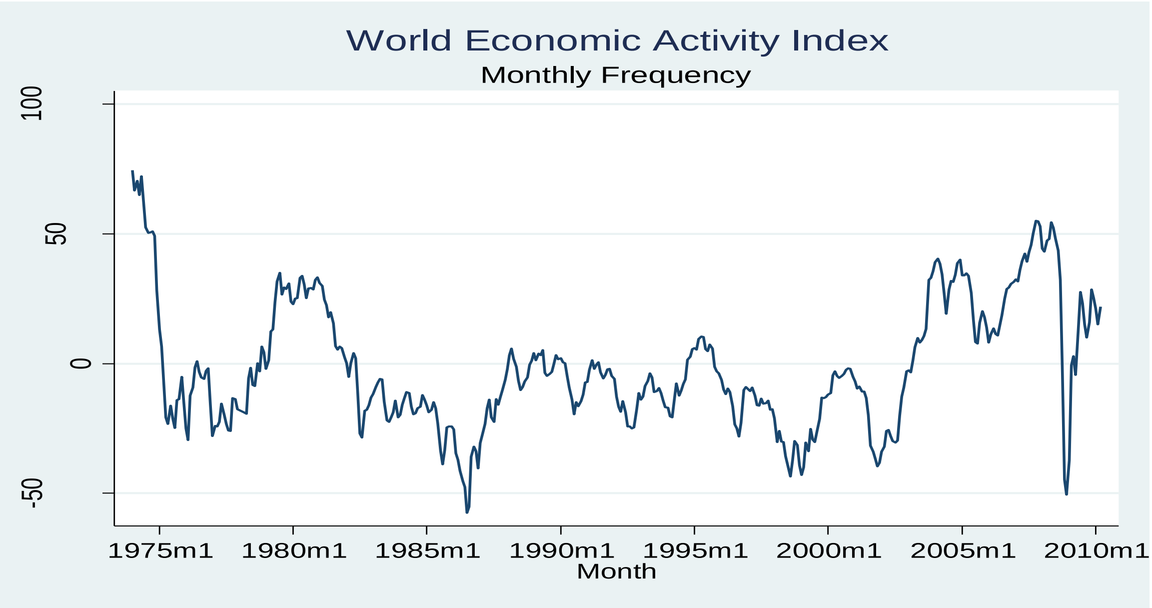


Figure 5.2: Index of World Aggregate Economic Activity.

5.1.2.1 Shipping Industry

There are however some drawbacks with this index. First, as Kilian (2009) himself points out ship building, excess capacity and scrapping cycle may influence the link between freight rates and economic activity. As demand for shipping increases freight companies first use existing excess capacities and increase speed of ships in order to cover increased demand. Excess capacities, reduced layovers and higher transport speed will increase the time in which the increased economic activity affects freight prices. Thereby it should be expected that freight prices will lag relative to aggregate economic activity.

Secondly, shipbuilding also influences the relationship due to the strong pro-cyclical behavior of the shipping industry. In other words, as demand for shipping services grows the demand for new ships also tends to increase. This trend is confirmed by the ISL report (2009) which analyze the recent time period. In the 2000s there was a huge increase in new ship orders relative to the existing size of the merchant fleet for tankers, container, general cargo and dry bulk ships measured both in dead-weight tonnage (dwt) and compensated gross tonnage (cgt). Only dry bulk is interesting in this setting since the index in constructed using dry bulk freight rates. Since shipbuilding is a time consuming process, this mechanic only influences the freight rates in the long term. The problem arises when there is a surge in supply of new vessels which enter the market after the business cycle has already peaked. In other words, the freight prices are already adjusting to a new equilibrium due to lower demand when there is a further downward pressure on the freight prices due to a higher supply of shipping services. This puts extra downward pressure on the index and thus a downward bias when estimating the aggregate economic activity. This effect is however partly adjusted due to a higher rate of demolition when freight prices are significantly reduced. This could be seen from the UNCTAD Maritime Review report (2009) where the recent global recession in 2008 led shipping companies to increase their scrapping rate. But as the report also mentions the scrapping was severely reduced during the economic upturn. This means that the increased scrapping could come from ships which got an increased lifetime due to exceptionally good profit opportunities. It should also be mentioned that if the business cycle has a dramatic negative development shipping companies will cancel orders and as such the impact discussed here will to certain degree be weakened.

A further supplement to Kilian`s (2009) discussion of the drawbacks are two new observations made in recent time. First, there is a political ambition in China to become the leading ship builder in the world which has led to government support for shipyards experiencing cancelled orders (ISL 2009). This means that shipyards in China gets support to finish construction of ships and thus lead to further overcapacity in the supply of shipping services. This could potentially affect the link discussed above as the impact from cancelled orders will be weakened. It is however most likely that this would mainly be a problem in the future use of this index since the supply of these ships is limited in present time.

Secondly, several observations have been made that a substantial amount of ships have been rebuilt in order to transport certain types of cargo which have had a relatively higher price increase (Lee, 2008:6). That is, ships are being converted into ships where the profits are the highest. Especially conversions into iron ore handling has been observed and as iron ore are one of the bulk dry cargoes which the shipping index consists of this increased the strength of the lag between economic activity and shipping prices. It is however only in more recent times that this effect has been observed and potential disturbances should be limited.

The index of aggregate economic activity is also robust using other shipping indices than Drewry`s Shipping Monthly. Basing his analysis on insights from Kilian (2009) Sørensen (2010) utilize the Baltic Dry Index to construct another index to represent aggregate economic activity. Sørensen (2010) reports a correlations of 0.94 and 0.97 between his and Kilian`s (2009) indices which ensures both quantitatively and qualitatively similarity. Sørensen (2010) also finds that the freight index is robust when using other measures to capture real aggregate economic activity, among others Chicago Fed National Activity, Total Capacity Utilization and a term structure consisting of the difference between a 10-year government bond and the 90-day T-bill.

5.1.2.2 Piracy

"*Come, let us make a hell of our own, and try how long we can bear it.*"

Edward "Blackbeard" Tatch.

Another factor which Kilian (2009) does not consider when discussing his index is hijacking at sea, or piracy. Although the world has changed dramatically since the infamous Blackbeard raided the Caribbean waters in the 18th century, piracy has always to a certain degree been present. Pre-2004 the Straits of Malacca, the body of water separating Malaysia and Indonesia leading to Singapore`s important trade ports, had a piracy problem, but declined substantially after the 2004 tsunami (Shipping Digest, 2009). Piracy attacks have recently also been on the rise in this sector though. In addition, the Nigerian coast has also been a site of piracy attacks from time to time. The main culprit which makes piracy a relevant factor in this analysis stems however from the Gulf of Aden, off the Somali coast. Somalia is a failing state with no central government from 1991 and has no effective naval or police force to stop local warlords profiting from piracy and thus provide a good haven for pirates.

The problem of piracy related to our index is that piracy increases the costs of shipping firms. The obvious direct costs are upon companies which suffer from attacks at sea and are forced to pay ransom for crew, cargo and ship in addition to any damages inflicted upon ships. These costs would most likely have low impact when using aggregate numbers as Kilian`s index. The indirect costs could however be quite significant. First, higher insurance premiums must be paid as the perceived risk of an attack increase. Although there has only been recorded about 100 attacks of a total 16.000 potential ships (Shipping Digest, 2009:7&11) the insurance premium costs have increased up to 40 times the normal costs. This means that insurance premiums has increased from about 500$ to 20.000$ for sailing through the Bay of Aden (Lloyd`s List). Thus, trade lines in risky waters increases freight prices. Secondly, shipping companies might change the route to decrease the probability of piracy. Since these new routes most likely cover longer distances, this would increase costs in two ways, higher fuel costs and higher opportunity costs due to longer time at voyage. An example of this is that ships are routed around the Cape of Good Hope to avoid the infamous waters of the Gulf of Aden. Sailing around Cape of Good Hope can use up to an extra 10-14 days than through the Gulf of Aden. Bendall (2008) simulates the costs due to piracy and reports that these costs are not to be understated. Several marine detachments have also been sent from various EU and NATO countries in Operation Allied Provider to provide security along the coast of Somalia. In addition several private security firms have also expressed interests to provide services to the shipping industry, most notably Blackwater Worldwide (Harrelson, 2010). This indicate that piracy pose a significant problem for the shipping industry. As long as piracy is a real threat these factors contributes to an upward shift in the freight index, thereby the estimated business cycle will be biased upwards.

As the UNCTAD (2009) report points to, the decision to sail around the Cape of Good Hope, to avoid piracy, is dependent on the bunker fuel costs as the fuel costs are not a trivial part of the total expenditures. World Shipping Council estimates in their fuel cost statement[1], that fuel costs represent 50-60% of total ship operating costs. As such the increased probability of piracy may make shipping companies more focused on fuel costs since travel distance increases and fuel costs increase their share of total expenditures. Several shipping companies have also enacted slow steaming to save on fuel costs. By ordering ships to sail slower ships energy usage per nautical mile is more efficient which conserves fuel and bring operating costs down. Although prolonging travels and thereby increasing wage expenditure this policy significantly reduce overall costs.[2] A side effect from this practice is that the oversupply of shipping services previously discussed is reduced, since available shipping volume is reduced due to slower voyages. Shipping companies are then effectively putting a downward pressure on the supply curve by slow steaming.

[1] http://www.worldshipping.org/public-statements/other-public-statements
[2] http://articles.latimes.com/2010/jul/31/business/la-fi-slow-sailing-20100731

5.1.2.3 Advantages

Although there are shortcomings using freight prices as proxy for economic activity the advantages most likely overcomes these. As Kilian (2009) points out the main advantages is that the use of exchange rates and country weighting are avoided. In addition lack of data from certain countries is not an issue. Low quality and even lack of access for historical statistics would certainly pose a problem for developing countries and would easily make a model vulnerable for data critique. This is especially important since it is the general perception that the recent development in BRIC countries is thought to be a main determinant of the increases in the growth of the global economy during the latest decade.

5.1.3 Oil Price

The real price of oil is displayed in figure 5.3. The series is taken from the US Energy Information Administration (EIA) in their Monthly Energy Review report. The series have then been deflated with the US CPI downloaded from OECD.Stat in order to obtain the real price. In Kilian (2009) the aim was to examine how the oil price influences a net oil importer and Kilian used a price series based on the cost of imported oil. This means that various transport costs are added to the oil price to reflect the true costs for the consumers. Since I am examining the effect on an exporter of oil this approach would not be optimal. To get a measure of the income related to oil revenues I use the first purchasing price also known as actual domestic wellhead price. The average domestic first purchase price represents the average price at which all US domestic crude oil is purchased.[1] This is also an imperfect solution since the US and Norwegian prices could possibly differ, but the availability of oil price data dating back to 1974 is very limited.[2]

The oil price is remarkable steady until late 1970s when OPEC countries successfully managed to increase the price by cutting oil supply, as illustrated in figure 5.1. In the mid-1980s the price decreases to previous levels which are generally attributed to the collapse of OPEC. As other members of OPEC over time continuously supplied more oil than the agreed quotas, Saudi-Arabia finally increased its production which put a downward pressure on the

[1] Prior to February 1976 estimations by EIA have been used to represent prices.
[2] In the SVAR II analysis the Brent Crude price is used since the analysis starts from 1987 Jan.

oil price. The price level was relatively steady until the 2000s were the price skyrocketed until the financial crisis eventually decimated the oil price. The price has however been steadily increasing to present times and the latest observation has reach the previous levels of 2007.

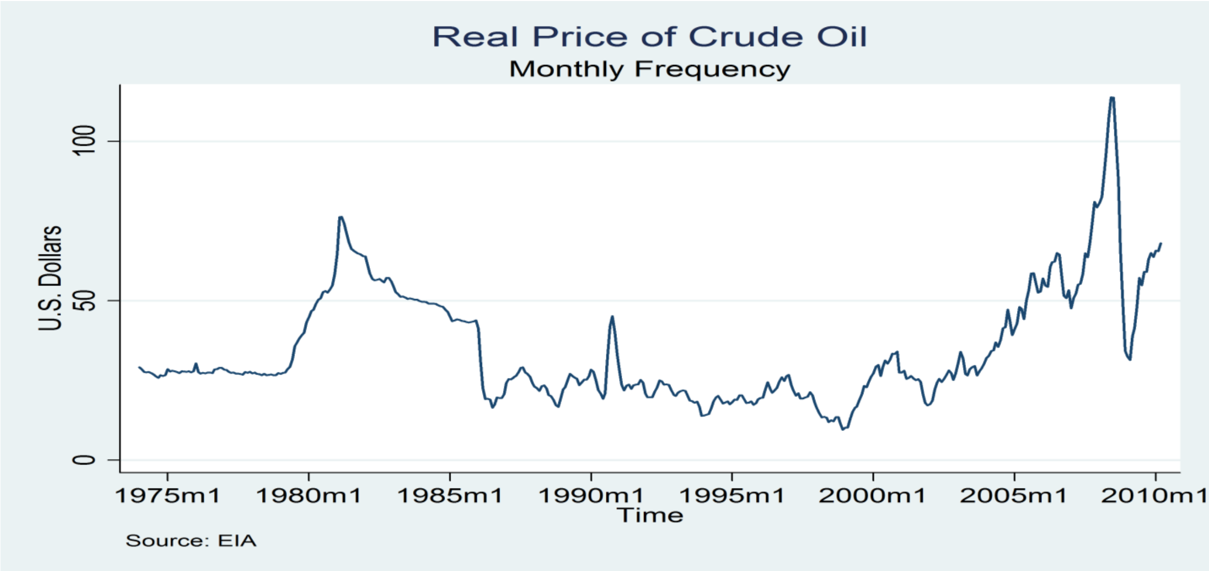


Figure 5.3: Real Price of Crude Oil.

5.2 The SVAR Model

The model estimated can be described as such:

$$y_t = (prod_t, econ_t, price_t)$$

Where $prod$ is the first differenced of the world oil production, $econ$ is the shipping index representing world aggregate demand and $price$ is the first differenced of the real oil price. All variables are expressed in logs. This leads to the following structural VAR:

$$A_0 y_t = \alpha + \sum_{k=1}^{5} A_k y_{t-k} + \varepsilon_t \qquad (5.12)$$

The unrestricted SVAR is presented in equation 5.13.

$$\begin{pmatrix} e_t^{prod} \\ e_t^{\text{econ}} \\ e_t^{\text{price}} \end{pmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} \varepsilon_t^{\text{prod-shock}} \\ \varepsilon_t^{\text{econ-shock}} \\ \varepsilon_t^{\text{price-shock}} \end{pmatrix} \tag{5.13}$$

The restrictions imposed on the impact matrix can be seen below where the parameters a_{12}, a_{13} and a_{23} from equation 5.13 takes the value of zero.

$$\begin{pmatrix} e_t^{prod} \\ e_t^{\text{econ}} \\ e_t^{\text{price}} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} \varepsilon_t^{\text{prod-shock}} \\ \varepsilon_t^{\text{econ-shock}} \\ \varepsilon_t^{\text{price-shock}} \end{pmatrix} \tag{5.14}$$

Following the discussion in section 4.1, the identification scheme is highly relevant for the analysis and the plausibility of the applied restrictions must be presented and discussed. A restriction in this SVAR setting means a variable cannot respond immediately to changes in other variables. An immediate response is defined as a reaction within the same time period the observation is done. That is, a restricted variable is assumed to not react to innovations in another variable in the same month. The first two restricted parameters are a_{12} and a_{13} which refers to the restrictions that economic activity and the oil price not immediately influences the production of oil. This restriction is based on the assumption that oil producers slowly change their production due to demand and price changes. This is based firstly on the costs of changing oil production and the uncertainty which exists in the crude oil market. Support for this view is that the state owned Saudi-Arabian oil company, Saudi Aramco, produces forecasts of oil demand only once a year thus indicating slowly changes of production. A further support is the extraction restrictions the Norwegian government put on North Sea oil producers during the 1980s and 1990s (Drzwi, 2005). The restrictions were reviewed every six months and are a further indication that oil production decisions are not updated on a high-frequency basis. Thirdly, Kirchene (2006) reports that oil supply is rigid and inelastic in the short run, while Ringlund, Rosendahl & Skjerpen (2008) and Farzin (2001) reports that oil price changes influence production mainly through their impact on investments in exploration activity and field development, implying a long term effect. This argument would apply for most oil producers, but could be weakened by the fact that some significant oil producers have large excess capacity. The excess capacity of Saudi-Arabia has given them the term swing producer. The term implies that the Saudi-Arabian production adapts to the market situation. The estimation of the excess capacity of Saudi-Arabia is rather uncertain. The Oil Market Report published by OPEC in March 2011 states that the organization`s total excess capacity is roughly 6 million barrels a day, roughly half of which stem from Saudi-Arabia. Estimations gathered by The Economist (March, 2011) however suggest OPEC`s level of excess capacity at roughly 4 million barrels a day.[1] This excess capacity of Saudi-Arabia could allow production increases in the short term if demand pressure is strong enough. The political turmoil in North-Africa and Middle-East at the start of 2011 exemplify this. The turmoil led to higher oil prices due to increased uncertainty about future production and minor supply disruptions. Eventually Saudi-Arabia declared increased production to meet higher demand pressure and to reduce uncertainty of future oil supply. Even though there excess extraction capacity exists the supply curve of oil can be very steep due to other constraints as pipelines, regional storage capacity and available tankers. It should also be mentioned that different oil types could have significantly different characteristics such that not all refineries are compatible to all oil types. The situation in North-Africa and Middle-East explains this as well. As most of the European refineries which depended on Libyan oil import are relatively old, they have constraints on which oil types to process. The Saudi-Arabian oil is not compatible to these refineries which mean a supply increase from the Saudi-Arabians not simply replaces the previous Libyan import (The Economist, March 2011)[2]. Consequently, if increased extraction from Saudi-Arabian reservoirs should reach the market the refineries compatible to Saudi-Arabian oil must have excess capacity or replace current input (which other refineries then can use as input) with Saudi-Arabian oil. Consequently, although it is very possible that Saudi-Arabian oil production accommodates to higher demand there are short-run constraints which obstruct rapid production changes or that the increased production reach the global market within the month. These constraints are however regarding the physical supply of oil, but in some cases where the perceived risks are high, Saudi-Arabia could influence the price by signaling increased oil production which would lower risks and price within the month. As such, the identification scheme is not a perfect representation of the aggregate oil market, but I deem the identification in equation 5.13 to be valid.

[1] http://www.economist.com/node/18285768?story_id=18285768&CFID=165794558&CFTOKEN=32601482
[2] http://www.economist.com/node/18285768?story_id=18285768&CFID=165794558&CFTOKEN=32601482

The last restriction a_{23} means that the oil price have no immediate effect on world economic activity. As seen in the discussion related to the economic index, fuel costs represents a major share of total ship operating cost. It is then no doubt that shipping companies are focused on the price of fuel and the model allows the oil prices to affect the shipping rates. The question is whether innovations in oil price have an immediate effect on shipping prices. Kilian (2009) points to the fact that the contemporaneous correlation between shipping rates and bunker fuels are very low. This might be due to the insight offered by Bunkerworld (Wilson-Roberts, 2010:4) which point to bunker prices in a given location are determined by regional fuel oil markets in addition to the behavior of buyers and sellers. That is, by using aggregated crude and bunker oil prices on the global level, high correlation is observed, but by splitting up in regional level, low or even negative correlation can be observed. Consequently bunker oil prices may differ significantly between Caribbean, Rotterdam or Singapore ports. Thus, the identity assumption may hold since shipping agents focus on the regional price which is the price of relevance for the respective ships operating costs.

5.3 VAR Set-up

5.3.1 Unit Root Tests Results

All of the unit root tests strongly indicates that both the oil production and oil price is non-stationary and integrated of order one, I(1), see table A.5.1. Regarding the economic activity index the results are conflicting. The generalized least square version of Dickey-Fuller (DF-GLS) indicates that the variable is integrated of order higher than one regardless of the lag information criterion used. KPSS also indicates that the variable is non-stationary, but is consistently concluding that the economic activity and the rest of the variables are integrated of order one, I(1). Lastly, both the augmented Dickey-Fuller (ADF) and the Phillips and Perron (P&P) tests regard the economic index as a stationary variable.

One of the weaknesses of the ADF test is that structural breaks, or jumps in the data series can lure the tests into classifying a non-stationary variable as stationary. Looking at the figure 5.2 there are two possible breaks, at the very beginning and end of the sample period. The time series do however also move around the mean value of the sample, which is one of the main characteristics of a stationary variable. By excluding the first and last time periods I re-run the unit roots tests and the unit root characteristics of the economic activity variable becomes stationary, see table A.5.2. The change of unit root characteristics could be due to low test power of the DF-GLS because of the large breaks in variance early in the sample period (Cook, 2004). It is also a possibility that the economic activity variable is in fact a fractionally integrated variable. This means that the variable is neither stationary, I(0), or integrated of order one, I(1), but instead located at a continuum between them (closer to I(1) than I(0)). Since the unit roots testing results are unclear regarding the economic activity variable this could pose problems for the analysis performed. I emphasize the results from the full sample testing and assume that the variable is stationary in the base SVAR analysis, but robustness tests will also be reported to see if any results are dependent on this assumption.[1] The results from the unit root testing leads me to take the first difference of both the oil production and oil price to make them stationary, while the economic activity is treated as a stationary variable.[2]

5.3.2 SVAR Lag Length , Autocorrelation and Stability

Kilian (2009) uses 24 lag lengths in his model which correspond to two years of lag length when utilizing monthly frequencies. As such I use this as a base and impose a maximum lag length of 36 time periods, equal to three years of data. Table A.5.3 gives the results from the optimal lag length selection. Most of the information criterions, except the likelihood ratio, give similar test output. The Schwarz criterion recommends two lags, while the Hannan-Quinn, Akaike and FPE all recommend three lags. Since most of the criterions points to three lags and according to Ivanov & Kilian (2005) since we have monthly observations extra emphasize should be put on Akaike, I use three lags.

It is however proven to be autocorrelation in the residuals using the recommended lag length, as shown in tables A.5.4 and A.5.5. It is not until the lag length is increased to five lags that we are able to assume that the residuals free from the risk of autocorrelation using both

[1] Another procedure would be to add a dummy in the SVAR and see if it is significant. While STATA is able to do this in a regular VAR, it did not work in a SVAR, excluding this option.
[2] Unit root tests conclusion: *prod* I(1), *econ* I(0), *price* I(1).

Lagrange-Multiplier and Portmanteau tests, see tables A.5.6 and A.5.7. To have a model free of autocorrelation I therefore increase the amount of lags to five.

As described in the methodology section it is crucial that the VAR model is stable. As shown in figure B.1 in the appendix, all values are strictly less than unity and as such we do not have explosive variables and stability is safely assumed.

5.3.3 Normality

With the exception of economic activity and oil price all other variables in the skewness test reject the null hypothesis with high statistical significance, see table A.5.9. As explained in the methodology section 4.6 this might have implications for the model estimated. The model have monthly observations from 1974 to 2010 which means over 400 observations have been used. Since the amount of observations is large the rejection of normality in the residuals does not need to have a significant effect for the model estimated in the first SVAR.

5.4 Impulse Response Functions

Figure 5.4 shows the Impulse Response Functions from the first SVAR model. The blue line in the graphs represents the predicted response of a variable from a positive shock in itself or other variables. The grey area represents the 95 percent significance level.

Not unexpectedly, an oil supply shock has a significant effect on the oil supply. Interestingly, there is also a significant decrease in oil production after a two month time period after the shock has been induced. This could be interpreted as oil producers tend to hold cut production to keep oil prices up. This is classical cartel behavior and OPEC is a potential explanation of this observation. The research of OPEC market power is however conflicting where Wirl (2004) reports that the market power of OPEC has diminished since the oil crisis of the 1970s and OPEC conference meetings does not have a significant impact on oil prices. Kaufmann (2004) on the other hand reports that OPEC impact on oil prices has in fact not diminished.

Regarding the two other variables, oil production has low significance in this SVAR model which is similar to what Kilian (2009) found. A positive shock in the oil production is predicted to immediately lower the price of oil before the effect fades out and economic activity have a two month delayed positive response. Both effects are however non-significant.

A positive shock in the economic activity index is firstly predicted to lead to an increase in oil supply, but this effect never becomes significant. The oil price increases however immediately due to a positive shock in aggregate economic activity. Unlike Kilian (2009) where the oil price have a non-significant immediate response followed by a continued price increases and eventual significance, the SVAR model below predicts an immediate and significant response which fades out after four months. The response of the economic activity on increased aggregate demand is highly statistical significant and a month after the shock a slowly decline is predicted, which makes the effect long lasting.

The last shock, a shock in oil-specific demand first leads to an insignificant decrease in oil production, but after two months the oil production is predicted to increase to meet the higher demand. This increase is significant, hence some proof that oil producers reacts to price changes is obtained. This is in contrast to Kilian`s findings where no effect from oil-specific demand to oil supply was found. It should however be mentioned that it is only marginally significant. Oil-specific demand shocks are also found to coincide with an increase in economic activity, although the activity reaches significant response with a two months delay. We see that oil-specific demand is predicted to have the largest impact on oil prices. The immediate response is highly statistical significant and steadily decreases over time and becomes insignificant three months after the shock.

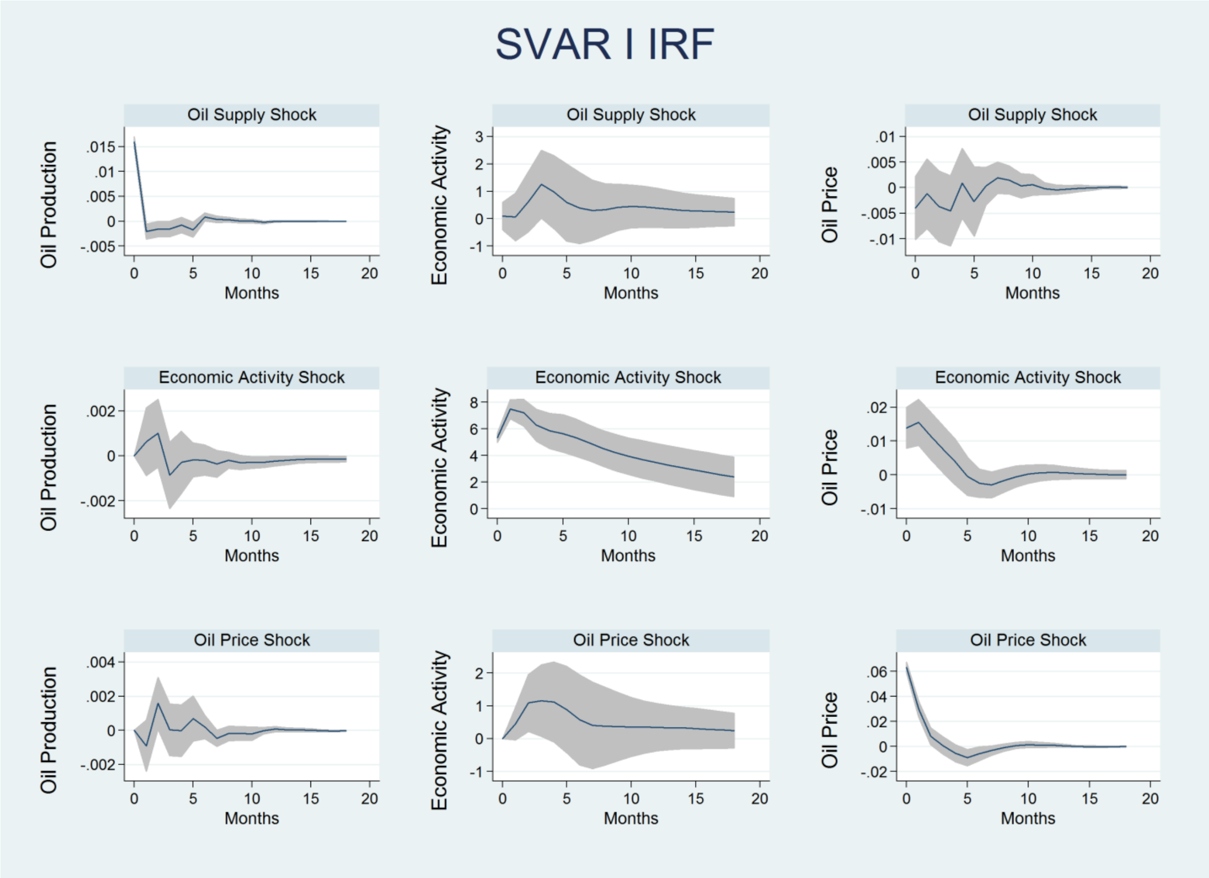


Figure 5.4: Impulse Response Functions SVAR I.

5.5 Forward Error Variance Decomposition

Table A.5.9 gives an overview of the forward error variance decomposition from the SVAR model above. By decomposing the error variance it is possible to identify the importance of variables in explaining the development in its own relative to others. As is clearly seen all variables variance is to a large extent dependent on innovation in its own values, especially world oil production (*prod*) and economic activity (*econ*) which explains above 90% throughout the time horizon. The real price of oil (*price*) is also highly dependent on its own values, but economic activity explains more of the price variance in the longer run. The real price do however explains just beneath 90 percent of its variance.

5.6 Quantifying the Structural Shocks

This section examines the structural shocks used in SVAR I and compare them with historical events. Figure 5.5 gives a graphical overview of the three quantified structural shocks used in the SVAR I model. The structural shocks are obtained from predicting the residuals from the equations in the model. The values have then been annually averaged in order to make visual inspection easier.

5.6.1 Production Shocks

The production of oil is concentrated to few areas in the world and especially the Middle-East represents a large fraction of world oil production and reservoirs. It is therefore likely that political turmoil in these countries can potentially disrupt the flow of oil to the world market. From the graph it seems as it was not until the Iran-Iraq war that notable disruptions in the oil supply materialized and thus supporting the belief that the Iranian revolution only had marginal effects on the oil prices through production shocks. Although the Iranian oil production clearly fell and should isolated increase the price of oil, the Iranian oil production decrease was met with higher production elsewhere.

In 1986 Saudi-Arabia increased its production due to constant freeriding and overproduction by other OPEC cartel members. This resulted in immediate reduction of the oil price. From figure 5.5 there are no indications of a positive oil supply shock until 1988. From figure 5.6 where the world total, non-OPEC, OPEC and Saudi-Arabian oil production is graphed it is clear that the Saudi-Arabian production increased, but looking at world oil production it seems the impact did not matter much. This could partly be explained by insights from Baumeister & Peersman (2008) which argues that even small changes in supply after the early 1980s can have significant price changes due to less elastic demand. Another explanation for why an oil price decline coincided with small supply increases in this period could be due to reduced uncertainty discussed in section 5.6.3.

It might sound intuitive that when countries engage in wars this might lead to lower production volumes due to destruction, blockades and other disruptions, but Kilian (2008a) finds indications that in some cases the oil output actually increased. This could possibly be related to the substantial increases in expenditure related to warfare. Warfare is notoriously resource demanding which leads countries involved in a long conflict to maximize their revenues by producing oil at full capacity. This is a possible explanation as to why no production shocks can be observed in military conflicts involving oil-producing nations as Iraq and Kuwait in the beginning of the 1990s.

In more recent times we see that both unrest in Venezuela and Nigeria in 2003 and the American invasion of Iraq the same year has not lead to notable disruptions in the oil production. In fact the positive residuals indicate positive innovations in the oil production during these episodes. In more recent time we see low amount of residuals either positive or negative which is in accordance to Hamilton (2009a) hypothesis of the oil price development in 2007-08. Hamilton argues that most of the previous oil price increases were due to physical supply disruptions, but the price spike experienced in 2007-08 was instead caused by increased demand and stagnating world oil supply together with a low price elasticity of demand for oil.

5.6.2 Economic Shocks

The second graph in figure 5.5 shows the economic shocks predicted from the model. I have included four episodes which are widely accepted as global recessions in the relevant time period. Since it varies from country to country when a global recession hits a certain economy I have marked the dates for US recessions since US is the leading world economy.

The early 1980s US recession came as a response to the stagflation experiences in the 1970s and the following monetary policy by FED Chairman Volcker. Both the 1980s and 1990s recession are shown as negative shocks by the structural shocks, but they are both weak relative to the recent shocks. When looking at the early 2000s recession there is actually a positive shock when using the US recession date, indicating the index is not flawless. The financial crisis which unraveled during 2007 made its impact on economies across the world. In the US the recession started in December of 2007, but I have marked the recession date as 2008 due to the annual frequencies and 2008 therefore represents the recession better. As seen from figure 5.5 the index is clearly picking up this recession.

5.6.3 Oil-Specific Shocks

The oil-specific shocks make up the bottom graph in figure 5.5. As is shown, the Iranian Revolution triggered a demand for oil-specific products which supports Barsky & Kilian (2002, 2004) and Kilian (2009) that the oil price hike in late 1970s was a result of increased precautionary demand rather than decreased supply of oil. Thereby explaining why there is no oil supply shock during the Iran revolution discussed above in section 5.6.1 and also countering Hamilton`s (2009a) perspective that it was supply disruptions which were the main factor explaining all oil price development. This adds weight to the argument that the assumption of exogenous changes in the price of oil in this time period is not well founded. It is also striking that the oil-specific demand decreased sharply the same year as Saudi-Arabia declared its annoyance towards other OPEC members of their free ride behavior and increased the oil production significantly. This might have led the market to believe that oil now was in excess supply and therefore the perceived risks regarding access to energy lowered substantially and this effect actually had a bigger effect than the increased oil supply in itself, explaining the low oil production shocks observed in this time period.

According to the perceived risk logic the precautionary demand for energy products should rise when two important oil producers are involved in conflict as in 1990 when Iraq invaded Kuwait. The predicted shock relating to this episode is however quite low. In the following year there is a negative shock in the oil-specific demand although this was the year that US-led coalition attacked Iraqi forces. The US-led coalition attacked Iraqi forces January 1991 which could further increase the risks, but it seems risks actually decreased as a whole this year. This may firstly be due that markets expected intervention in Kuwait from allied forces. Secondly, President Bush stated in his National Security Directive 45 (Bush, 1990) at 20. August, three weeks after the Iraqi invasion, several request aimed at securing US energy needs. Chief among them were request for oil-producing countries to increase production, but also orders to start drawing on strategic oil-storages and encouragement for oil-substitution where economically feasible. This might have calmed the markets and lowered the perceived risk. Thirdly, the coalition forces were technologically and tactically superior to the Iraqi forces and hostilities ceased February 28, after only roughly two months of fighting. Since the intervention ended so quickly the observed energy security risk would diminish when measured annually. Lastly, there are no proofs of any effect of increased risks related to the 9/11 terrorist attack in New York or the 2003 US invasion and occupation of Iraq when using annually aggregated data series. This is not surprising given that 9/11 caused less economic impact than first feared and could also be a result of the annually aggregation as more than eight months of the year had passed before the attack. Regarding the US invasion of Iraq in 2003 most observers anticipated the attack and thereby the perceived risk did not rise significantly. We also see a negative oil specific shock coinciding with the financial crisis in the late 2000s which is also intuitive as the perceived risk of oil delivery during these times were quite low.

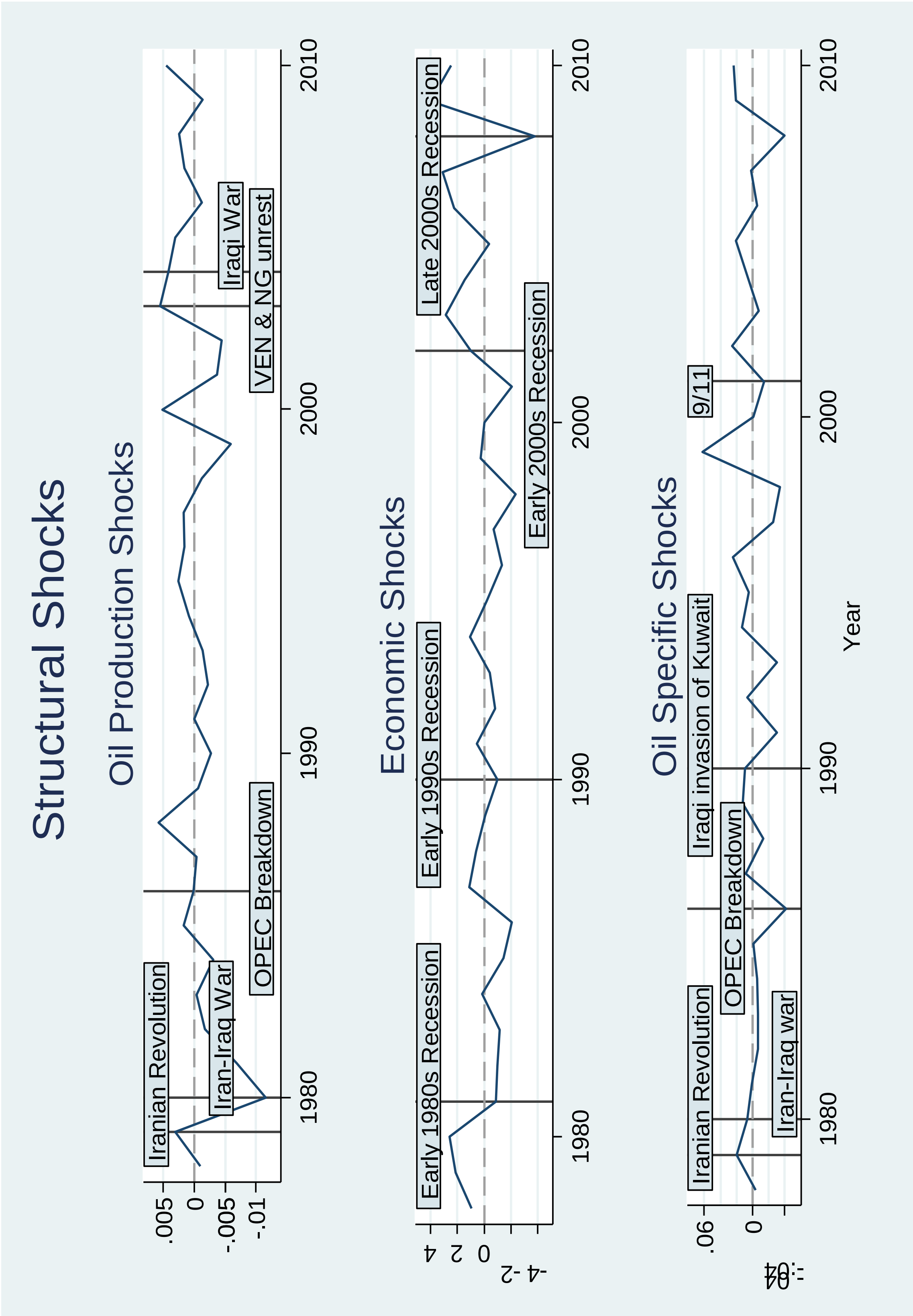


Figure 5.5: Structural Shocks of SVAR I.

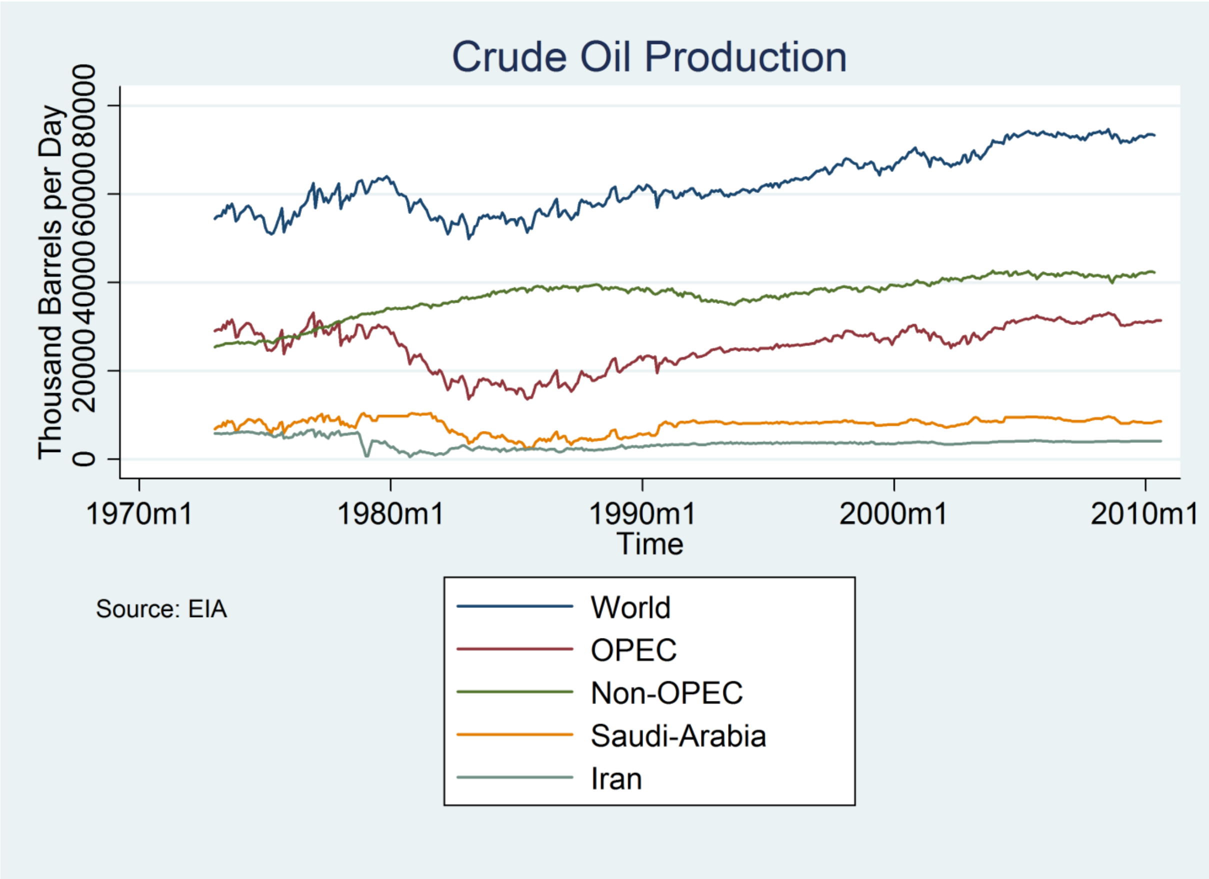


Figure 5.6: World, OPEC, Non-OPEC and Saudi-Arabian Oil Production.

5.6 Robustness Tests

The first robustness test is due to the conflicting unit root tests results regarding the economic activity variable. In this robustness test the variable is classified as integrated of order one, I(1). This change in specification changes the outcome of the analysis as seen in figure 5.7. Firstly, the oil supply shock now has a significant effect on the economic activity. The pattern is very similar, as there is still no immediate, but delayed response, but the confidence interval is narrower. The pattern of economic activity response from shocks to itself seems to change as there is a decline from the immediate reaction, but qualitatively the predictions remain similar. Lastly, oil-specific demand no longer has any significant effect on either the oil production or the economic activity.

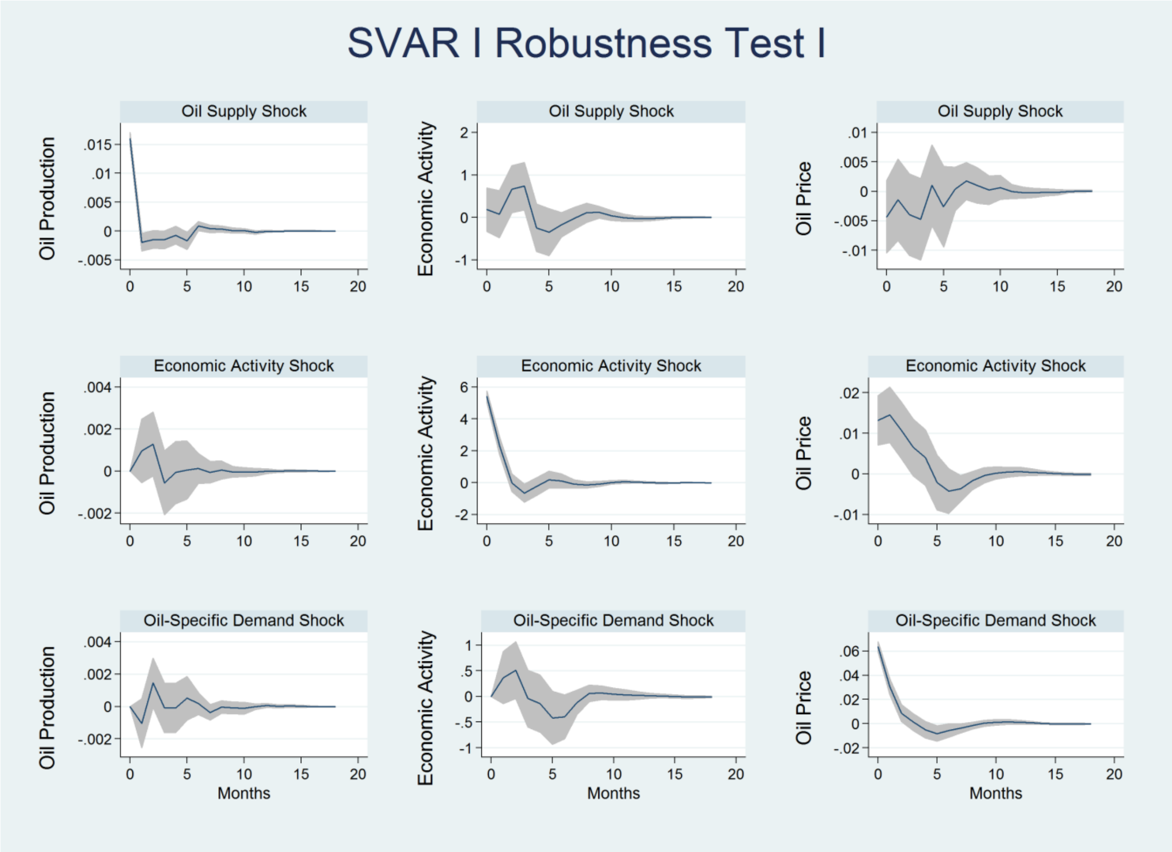


Figure 5.7: Robustness Test I for Impulse Response Functions SVAR I.

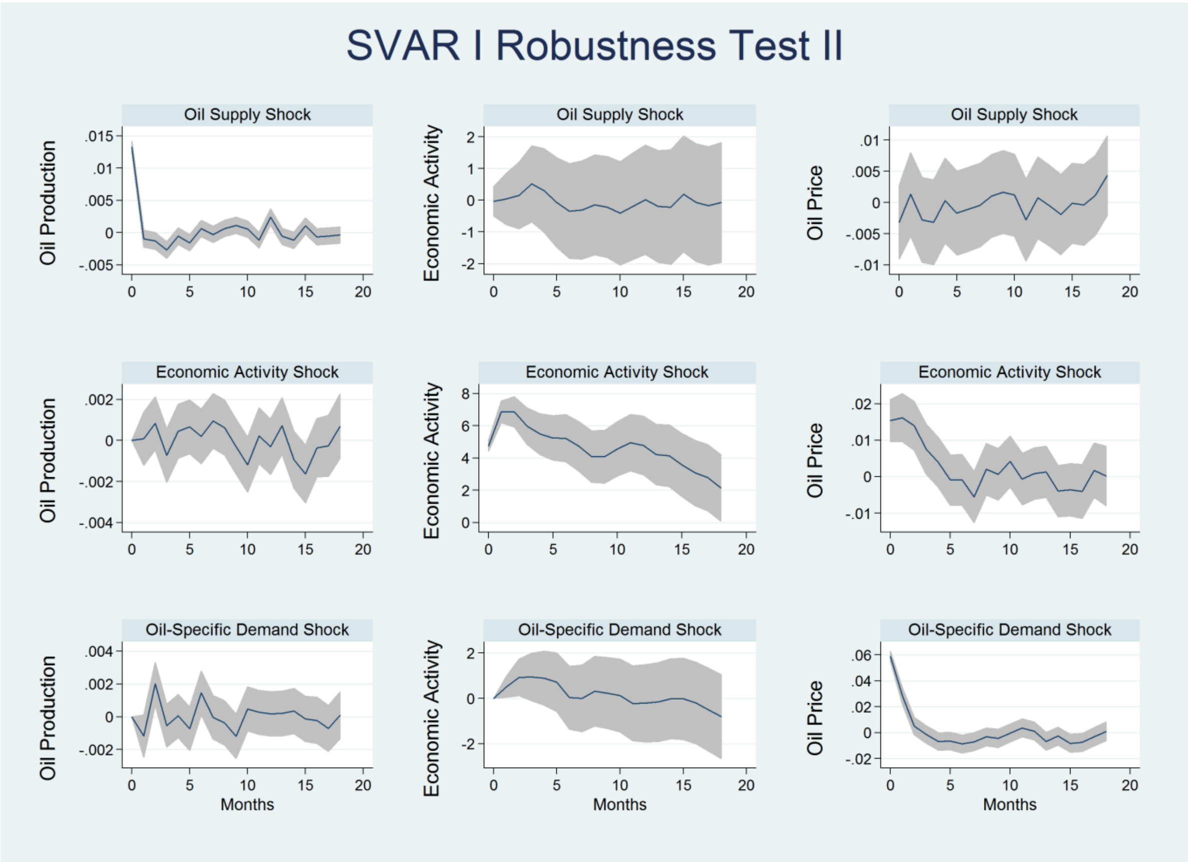


Figure 5.8: Robustness Test II for Impulse Response Functions SVAR I.

Figure 5.8 show the impulse response functions from the second robustness test when the lag-length which has been altered. The likelihood-ratio information criterion indicated a substantial lag-length, while Kilian (2009) utilizes 24 lags in his analysis. I therefore increase the lag-length to 24 to see if the results are dependent on this specification. As with the previous robustness test, oil supply shocks have no longer any significant effect on the economic activity or the oil price. Economic activity shocks have similar predictive power on the oil price as the base analysis, while oil-specific demand shock have an immediate positive response regarding economic activity and erratic and some responses of low significant power in the supply of oil.

6.0 SVAR II, Small, Open and Net Oil-Exporting Economy

6.1 New-Keynesian Model of the Norwegian Macro Economy

This stage is inspired by Bjørnland`s (2009) work where she studies the impact of oil price on Norwegian macroeconomic variables in a New-Keynesian setting. This means I build a similar SVAR model to hers, where I include the demand and supply variables for oil in order to disentangle their effect on oil prices. In addition I drop the stock market variable to avoid including too many variables in the model. The financial effects in Norway from oil shocks have also been extensively examined by Sørensen (2010) where he uses recent sample periods and also disentangle the oil price. New findings about the links between oil price and financial development in Norway would therefore be marginal at best.

An important mechanic in this analysis is the behavior of the central bank to development in macroeconomic variables. As Bjørnland (2009) I base my construction of the New-Keynesian model upon the theoretical works of Clarida, Gertler & Gali (1999, 2001) and Svensson (2000). The theoretical model from Clarida et al. (1999:1668) is presented in equation 6.1, which present a monetary policy from a central bank perspective:

$$\max -\frac{1}{2} E_t \left[\sum_{i=1}^{\infty} \beta^i \left[\alpha x_{t+i}^2 + \pi_{t+1}^2 \right] \right] \tag{6.1}$$

The term π_t and x_t respectively refers to the inflation rate and the output gap in period *t*, while α is the relative weight the output gap has on the central bank decisions. The output gap is defined as (CCG, 1999:1665):

$$x_t \equiv y_t - z_t \tag{6.2}$$

Where y_t is the stochastic components of output, while z_t is the natural level of output. The natural level of output is defined as the level of output obtained if the wages and prices were perfectly flexible. To maximize the welfare for the public the central bank should minimize the output gap and the inflation rate.[1] Clarida et al. reach the following solution for the central bank behavior:

$$x_t = \frac{\lambda}{\alpha} \pi_t \tag{6.3}$$

[1] Norges Bank inflation target is a 2,5% growth in consumer prices .

Equation 6.3 implies central banks pursue a “lean against the wind policy”. This means that when inflation is above the set target the interest rate should be raised to contract demand. Aggregate demand contracts due to an intertemporal shift in consumption as present consumption becomes relatively more expensive. Whenever the inflation is below target interest rates should be lowered to increase demand which put an upward pressure on prices. In practice the determination of the interest rate level is of course much more cumbersome, but simplicity is in order as to not have an overwhelming analysis. The motivation to keep the inflation rate stable is because this provides a steady environment for firms and individuals to intertemporally allocate their resources. In other words, in order for the agents in the economy to optimally smooth their consumption and investments over time they need a reliable framework which enable them to approximately predict the future.

By reducing the output gap a central bank is able to keep the economy running at a higher rate increasing output and total welfare. Increases in total welfare do not necessary mean that all of the public gets increased welfare since some groups may get more at the expense of others even if the overall level rises. As distribution of wealth is hardly a task for a central bank and I will not dwell further on this issue. An important implication of the CGT model is that the unemployment rate tends to decrease when the output gap is reduced since non-utilized resources are put to use in the economy. (Note that this assumption holds independently of the productivity growth due to productivity growth itself increases the output gap.) This relationship is also known as Okun`s law and is an important assumption since there are no monthly data on output levels which force me to find alternative data to represent the output. The unemployment rate is assumed to satisfy this role.

Clarida et al. later updated their theoretical work by covering open economies in addition to closed economies (2001). Although the fundamental solution remains the same as in equation 6.1, the important extension is that the model also comprises the exchange rate as well. The exchange rate represents a transmission channel of monetary policy in and between economies and is a critical variable when dealing with small open countries like Norway.

Important characteristics of the exchange rate can be found in Svensson (2000:158). Firstly, the real exchange rate affects the relative price between domestic and foreign goods which influences domestic and foreign demand for domestic goods. Secondly, the exchange rate also affects domestic currency prices of imported final and intermediate goods which possibly influence domestic inflation. Thirdly, the exchange rate also fulfills the role of a forward-looking variable and expectations-determined variable. Lastly, the exchange rate also transmits foreign disturbances and thus shocks in foreign demand for domestic goods. Svensson (2000:157) also points to several important features regarding monetary policy and foreign variables. Since most inflation-targeting economies are quite open economies with free capital mobility, shocks originating far away could quite possibly have significant impacts on other economies. The financial crisis of 2008 illustrated this thoroughly as financial turmoil in the US quickly spread to global markets. Inclusion of foreign variables such as inflation, output and interest rates should therefore be built-in to avoid any bias from missing variables. The notions of Svensson above is supported in empirical works by Cushman & Tao (1997) which document that lack of foreign variables may be the cause to exchange rate and price puzzles. Especially when dealing with small open economies puzzles may arise due to lack of foreign variables which have significant effect on domestic economic development.

To account for the insights of Svensson above, I have constructed an exchange rate to allow for the transmission effects. Since I have constructed a trade weighted *real* effective exchange rate the inflation rate is implicitly covered by this variable and is not separately included. Regarding the foreign output I refrain from using such a variable since I consider the economic activity index to fulfill the task of representing foreign economic conditions.

6.2 Data Description

6.2.1 Oil Price

Figure 6.1 price show the development in the real price of Brent Crude Oil over the whole base sample period. I have used Brent Crude Oil since this is the type of oil most similar to the oil in the Norwegian Sea reservoirs. The different prices of oil are however quite similar (see table A.6.1) such that other types of oil should yield similar results. The real price of oil is calculated by deflating the Brent Crude Oil with the US CPI[1]. Both the oil price series and the US CPI are obtained from OECD.STAT database. I have kept the oil price in dollars to avoid using the US/NOK exchange rate as this would imply dividing a variable by another endogenous variable in the system.

We can see that the price of Brent crude oil had a spike in 1991 and a downturn at the end of the 1990s. In 2006 the price broke through the 50$ ceiling and reached a value of over 100$ before tumbling below 50$ as a consequence of the financial crisis. The price has however steadily increased with the recovering world economy and the last observation in March 2010 equals the price levels seen during 2007. The oil production and economic activity variables used in this stage is identical to the series used in the previous SVAR analysis of the aggregate oil market, see figure 5.1 and 5.2.

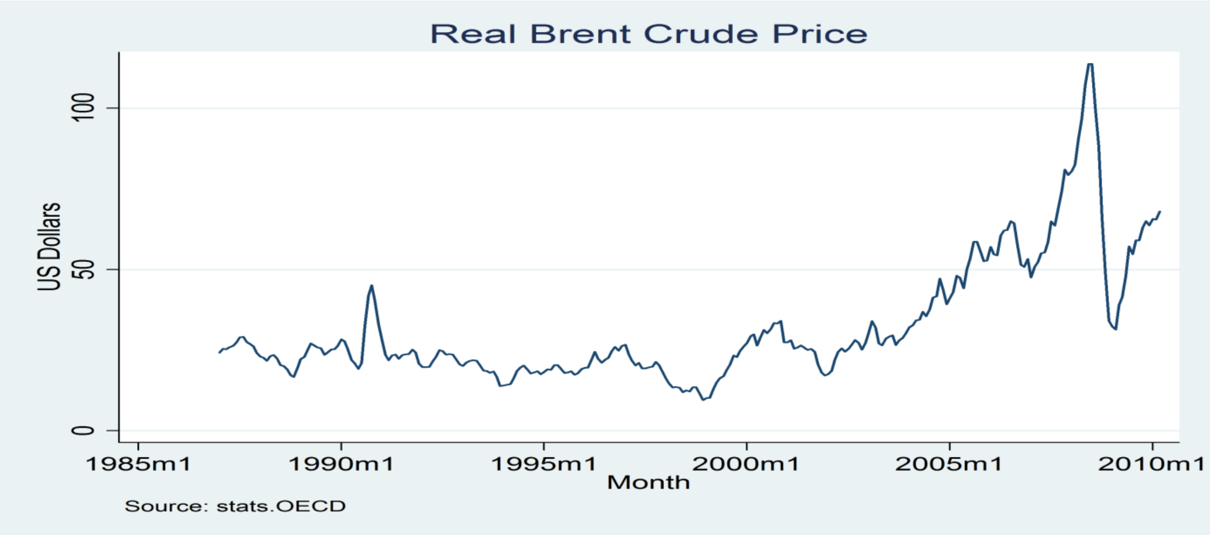


Figure 6.1: Real Price of Crude Brent Oil.

[1] 2005 US Dollars (US. CPI Index=100 between June-July 2005).

6.2.2 Foreign Interest Rate

Highly inspired by Bjørnland (2009) I construct a variable which should represent an interest rate consisting of the main trading partners of Norway. As Bjørnland, I have chosen the interest rates of Sweden, Euro, US and UK to fulfill this role.[1] The respective interest rate weighting is determined using the trade weights published by Norges Bank. The trade weighted interest rate is graphed in figure 6.2 below along with the 3M-NIBOR.

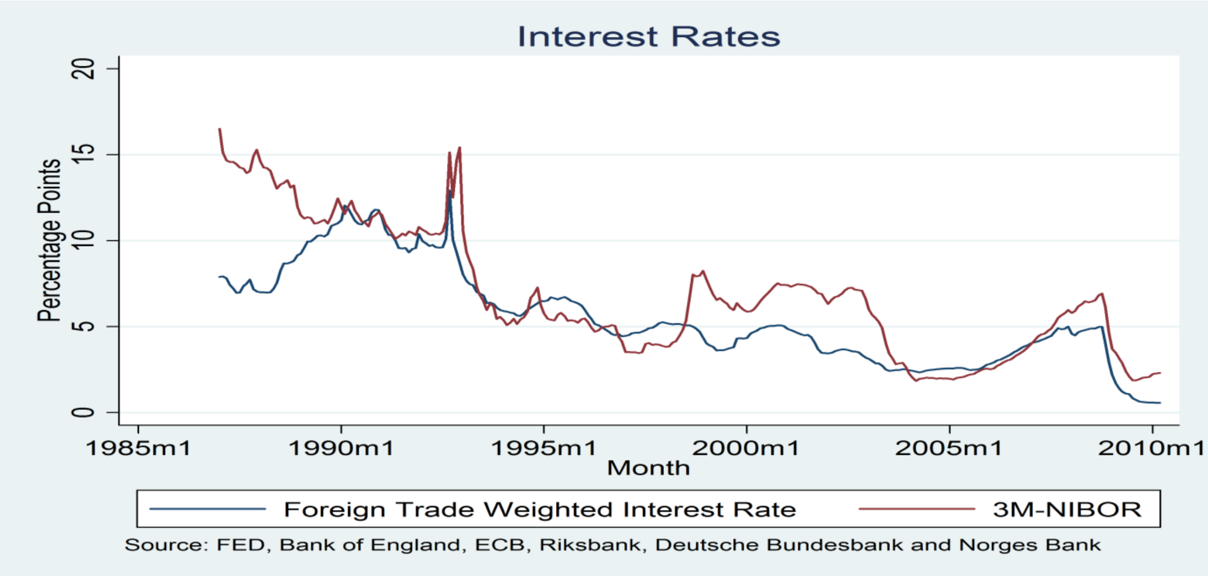


Figure 6.2: Foreign Interest Rate and 3-Month NIBOR.

6.2.3 Unemployment

As explained above I use the unemployment to represent a gauge for the output in the Norwegian economy. The unemployment rate is taken from the Norwegian Bureau of Statistics (SSB) and the series from 1987-2010 is graphed in figure 6.3. As is obvious, the unemployment rate has varied a lot and is closely related to the economic performance in Norway. The graph clearly shows that unemployment rose in the early 1990s recessions and sunk considerably from 1993 and outwards. During the 2000s there is a steady rise in the unemployment until 2005-06 where there is a significant reduction. From 2009 unemployment increased due to the financial crisis. Although the unemployment rate has varied a lot the level of the unemployment has throughout the sample period been relatively low compared to other OECD countries (Halvorsen, 2002).

[1] Pre-Euribor I use the German 3M-Frankfurt rate.

Figure 6.3: Norwegian Unemployment Rate.

6.2.4 Inflation

Inflation could be measured by using the gross domestic product (GDP) deflator or the consumer price index (CPI). The main difference between these two measures is that the basket of the GDP deflator is weighted by the market value of all consumption of goods and services. This allows for a changing basket of commodities which picks up shifting trends in the market. The CPI on the other hand has a fixed basket of the goods it measures. The weakness of this method is that outdated goods which are less popular by the consumers are still included in the calculation. As the name says, it is the prices the consumers face which are of importance, thereby intermediate or investment goods are not included. It also means that imported goods are included in the CPI which by definition is not included in the GDP-deflator. I have chosen to use the consumer price index reported by the Norwegian Bureau of Statistics (SSB) graphed in figure 6.4. Since SSB does not publicly offer a seasonal adjusted CPI monthly series which corrects for taxes and energy prices I use a CPI index which includes these prices. This could potentially bias the CPI, but since characteristics of the Norwegian power marked limit these. As most of Norwegian electricity productions stem from hydro power the oil price has limited effect on power prices.[1] This does not necessarily mean that the direct effect of the oil price is eliminated, as transport expenses is dependent on the oil price.

[1] As the Norwegian power grid market has in recent periods become more integrated with neighboring countries the oil price may have increased its effect.

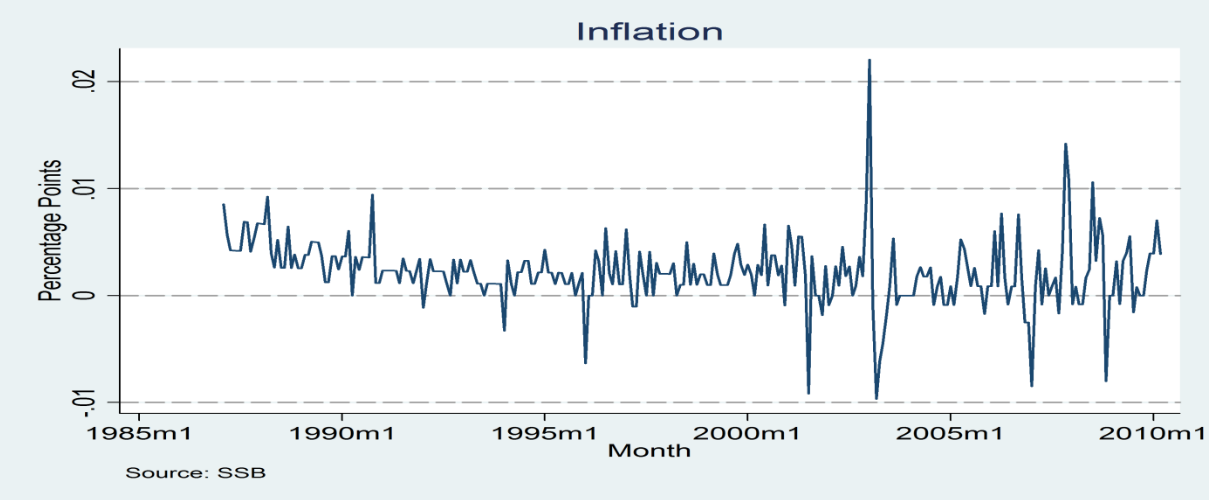


Figure 6.4: Norwegian CPI.

6.2.5 3-Months NIBOR

The 3-Months NIBOR (Norwegian Interbank Offered Rate) is taken from the Norwegian central bank (Norges Bank). The liquidity policy performed by Norges Bank ensures that the short term interest rates fluctuate near the interest rate level determined by the central bank. The liquidity policy of the Norwegian central bank consists of directly interventions in the financial marked by offering F-loans and F-deposits (“F-lån” and “F-innskudd”) to the banking system. The goal is to ensure that the banking system total deposits at the central bank is between 5-12 billion NOK each day as this reduce the liquidity risks perceived by the market, hence the risk premium added by the markets are insignificant. As such the 3M-NIBOR is a good representation of the monetary policy of Norges Bank. The problem of using the interest rate in this setting is that inflation target policy was not formally introduced until 2001. Olsen et al. (2003) reports that Norway has closely followed a Taylor rule since 1993, with the exception of 1996-98. This special time period occurred due to speculative pressure on the NOK and interventions in the financial markets was deemed necessary to avoid a too large depreciation of exchange rate (Gjedrem, 1999:7). Robustness tests will be executed to see if the results vary when changing time periods.

As is readily seen the two interest variables share much of the same pattern. There are some significant differences in the beginning of the sample where the Norwegian rate is higher than the foreign rate. The high interest rate can be explained by the economic downturn Norway experienced due to the bank crisis. One of the solutions to the problems was to increase rates to get inflation under control. Other countries also had failing banks in this period, but the timing in the Norwegian economy differed. As Eika (1996a) finds, the petroleum industry has shifted the exposure to international influences such that Norway does not share the typical economic cycles as other nations. This is also supported by Sørensen (2010) which finds different economic response between Norway and Sweden, which are two very similar countries except Norway`s oil industry and petroleum wealth. In the period from the late 1990s to the mid-2000s the Norwegian interest rate is again higher than the foreign rate. The first period of this rate difference can be attributed to the Norges Bank`s currency protection as the interest rate was raised to prevent further depreciation. The Norwegian economy was also characterized by high capacity utilization of and low unemployment in the rest of this period (see figure 6.3) which ensured interest rates were kept high to ensure low inflation.

6.2.6 Real Effective Exchange Rate

Following Svensson (2000:157) I include the exchange rate to see if there are any significant transmission effects. The exchange is represented by using a trade weighted exchange rate index published by Norges Bank, the KKI/TWI[1]. The KKI index is calculated using the exchange rate of the top 25 trade partners of Norway and is the nominal effective exchange rate. I have transformed the index to real terms by using the inflation rate in each of Norwegian`s trading partners[2] and the respective trade weights[3] of each country, comparing them to the Norwegian inflation. One weakness is that the inflation rates of some countries were not publicly available; consequently they have not been included. This could lead to a "depreciation" bias in the calculated real exchange rate. This should be quite small since the total share of these countries makes up 1.1 percent in 1987, 1.7 percent in 1997 and not until 2008 and onwards do they make up a total of 5.5 percent of total trade with Norway. The index is graphed in figure 6.5, where a lower (higher) value of 100 in the index indicates appreciation (depreciation) of the NOK currency relative to Norway`s trading partners exchange rates.

[1] Alternatively one could use I(44) which consists of the top 44 trading partners and covers 96,6% of total Norwegian import, but Norges Bank only publish I(44) back to 1990.
[2] All countries inflation rates, except Norway, is taken from OECD.Stat.org.
[3] Published by Norges Bank.

As the exchange rate and the interest are often closely related the need for robustness tests is necessary regarding the exchange rate as well. In more detail the NOK did not follow a floating currency regime pre-1993, but was fixed by using a trade weighted basket. From 1986 to December 1992 Norway had a fixed exchange rate which served as a nominal anchor for economic policy and eventually brought inflation under control (Gjedrem, 1999). Klovland (1999:47) also points to the fact that when the fixed rate regime was implemented, there was a change from discretionary towards commitment in the monetary policy and the interest rates were aggressively used to maintain the exchange rate. In 1992 December 10th the fixed rate regime was abandoned and exchange rate stability was prioritized. The new policy guidelines regarding this managed float were however not formalized before the Royal Decree of May 1994 where stability towards European exchange rates was the priority. The new policy meant Norges Bank had no obligation to intervene in the foreign exchange market. However, in substantial changes where the exchange rate clearly deviated from economic fundamentals, Norges Bank could utilize its instruments in an effort to return the exchange rate to its initial range. This is important for the analysis since Norges Bank from the managed float period in practice conducted monetary policy to bring inflation to the level of other European trading partners. That is, when Norges Bank was given the mandate to target inflation in 2001, this did not significantly change the monetary policy (Olivei, 2002). As the relationship between these two variables did not go through any fundamental changes from 1992 and to present time this means that an empirical analysis are still valid. A robustness test should however be performed due to the notes by Gjedrem (1999) and Klovland (1999) which advocates a fundamental regime change happened in 1992, and this could potentially influence the analysis.

From the figure 6.5 we see that the real and nominal exchange rates differ until the currency defense in 1996. From there on the two rates follow each other closely[1]. For the most of the 1990s the NOK was depreciated relative to the Norway`s trading partners with the exception of the period of currency defense. As most other commodity based countries the NOK depreciated as the financial crisis in Asia dragged on and brought commodity prices to a downfall. In the 2000s a more volatile pattern emerges where a substantial appreciation took place from 2002. It is also clearly indicated that the financial crisis brought about depreciation

[1] Correlation between nominal and real effective exchange rate for whole sample: 0.7953.

in the NOK reflecting a run from NOK to more liquid currencies as yen or dollars since the NOK could as Flatnes (2009) conclude, hardly be considered a "safe haven". In addition, commodity prices declined rapidly during the crisis which also fueled the depreciation. In recent time the depreciation has been reversed and the index indicate an appreciated NOK at the end of the sample period.

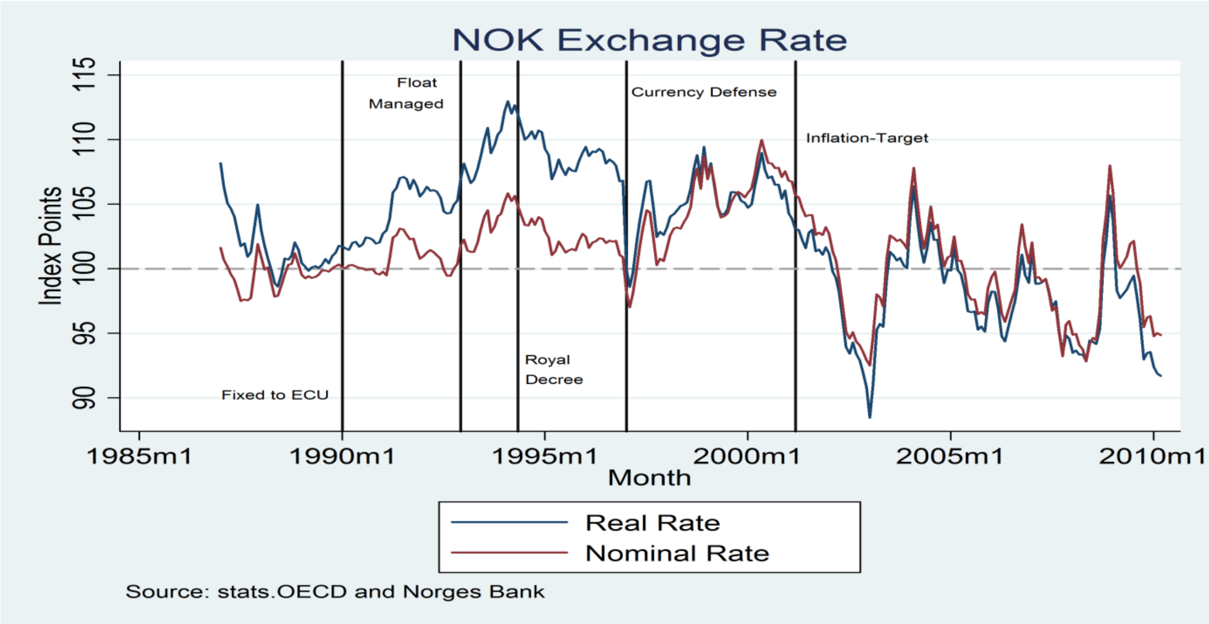


Figure 6.5: Real and Nominal Trade Weighted Exchange Rate.

6.3 New-Keynesian SVAR Specification

The New-Keynesian SVAR model can be described as:

$$\begin{pmatrix} prod_t \\ econ_t \\ price_t \\ fir_t \\ unem_t \\ inf_t \\ 3M-N_t \\ exc_t \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & 0 & 0 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} & 0 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & a_{77} & 0 \\ a_{81} & a_{82} & a_{83} & a_{84} & a_{85} & a_{86} & a_{87} & a_{88} \end{bmatrix} \begin{pmatrix} \varepsilon_t^{prod-shock} \\ \varepsilon_t^{econ-shock} \\ \varepsilon_t^{price-shock} \\ \varepsilon_t^{fir-shock} \\ \varepsilon_t^{unem-shock} \\ \varepsilon_t^{inf-shock} \\ \varepsilon_t^{3M-N-shock} \\ \varepsilon_t^{exc-shock} \end{pmatrix} \tag{6.4}$$

The SVAR model follows a recursive ordering as used in the first SVAR and thereby constraining the A_0 matrix to be triangular and just identified. The first three variables in the Cholesky ordering follow the same rationale as the first SVAR analysis (see section 5.3). That is, *prod* refers to the world production of oil, *econ* refers to the freight index as a measure of economic activity, while *price* refers to the real price of Brent crude oil. These three variables are placed on the top due to the fact that these are macro variables which are decided on global markets and development in a small country like Norway will at best have negligible effect on these.[1] I find this assumption very plausible as Kilian & Vega (2008) does not find any systematic significant response of the oil price on US macroeconomic news within one month time horizon. If US macro-news cannot influence the oil price within the month then Norwegian macro-news surely cannot.

The fourth variable is the foreign interest rate, *fir*. This variable is rated above the Norwegian macro variables since Norway is a small open economy and developments in the Norwegian economy have marginal impact on the monetary policy of our main trading partners. Norway also has the smallest economy measured by nominal GDP, although fairly close to the Swedish GDP. The exemption of this assumption could therefore be Sweden which in addition to the similar size of output, is Norway`s closest and main trading partner. Since the

[1] I must stress the meaning of these assumptions. Norway can plausibly affect the oil price by significantly cutting oil production or raise expectations of such an action, but in this setting we are discussing if pure macroeconomic development in Norway could have any effect whatsoever on the first three variables.

foreign interest rate is constructed with countries as US and big Euro-zone countries this effect would however be small. One critique regarding this set-up may be that the foreign interest rate should be ranked higher in the system, more specifically above the economic activity as interest rates are important for economic performance. The foreign interest variable is however constructed to reflect Norwegian trade relations and would therefore not necessarily reflect an interest rate relevant for global markets. This point is supported by the fact that the US share of Norwegian import, the main economic actor in the world, is consistently below 10 percent. In the robustness section I will however run an analysis where the foreign interest variable is ranked higher in the Cholesky ordering.

Unemployment, *unem,* is the fifth variable and I use this as a measure of the output in Norway. This is due to the mechanic in the New-Keynesian monetary policy discussed in section 6.1. The unemployment rate is ranked before the inflation as I assume that a high pressure in the economy reduces unemployment and initiate a pressure on wages as the demand of labor is relatively higher than the supply. This puts an upward pressure on wages and consequently gives rise to higher inflation. In other words, I assume that the unemployment is more important in explaining the inflation rate than the inflation rate is important in explaining the unemployment rate.

The sixth and seventh variables are respectively the inflation rate, *inf*, and the 3-Months NIBOR, *3M-N.* The inflation is ranked higher than the 3M-NIBOR as a consequence of the CGG equation 6.3 where the central bank sets the interest rate after observing the inflation rate. Since the Norwegian central bank has an inflation-targeting monetary policy this is a reasonable assumption. This follows the central idea in New-Keynesian economics where there is assumed to be a slow pass through (sticky prices) to macroeconomic variables due to nominal rigidities.

The last variable in this SVAR model is the real exchange rate, *exc.* By designating the exchange rate at the bottom of ordering, the exchange rate can react immediately to changes in all variables, and will not immediately impact any other variables. It is possible that this restriction is too stringent as Norges Bank is not oblivious to the exchange rate when deciding upon the monetary policy. That is, the zero value restriction on the parameter a_{78}, which means that the central bank will not consider the exchange rate observation in the same month when determining the interest rate, may not be reflecting the true relationship. This criticism has its merit since the trade weighted currency, I(44), is a mandatory post in the publications of the central bank`s decisions on the interest rate.[1] Flatner, Tornes & Østnor (2010) confirms that the exchange rate is part of the interest rate level decision and gives a good summary of how the exchange rate is included in the analysis of interest rate decisions. In the regulations from the Norwegian Finance Department the exchange rate stability is also explicitly mentioned as a core task.[2] Bjørnland (2008) also show that effects from monetary policy shock will be biased if this restriction is used when utilizing quarterly data. As Bjørnland (2009) points to, Norges Bank normally meets every sixth week to decide upon the interest rate and since we have monthly observations the bias from this restriction should not be critical for the estimated model. It should however be mentioned that McCallum (1994) argues a quick policy response to exchange rate changes as a possible explanation for his findings regarding uncovered interest parity. In addition Faust & Rogers (2003) find the relationship between monetary policy and exchange rates are highly sensitive to the imposed restrictions which lead to failing robustness tests indicating a weak model. Since there are indications that supports the notion of a different Cholesky ranking of the exchange and interest rate, robustness tests will be performed to see if the assumption made in the model set-up significantly affect the stability of the VAR structure.[3]

6.4 VAR Set-Up

6.4.1 Unit Root Tests

The test results from the various unit root test methods are listed in the appendix table A.6.2. Starting with the oil production, the figure 5.1 indicates that the series follow a trend from 1987. In addition the trend coefficient in the augmented Dickey-Fuller test is highly

[1] Norges Bank list of interest rates declarations:
http://www.norges-bank.no/templates/pagelisting____76082.aspx

[2] Regulation from the Norwegian Finance Department, (Forskrift nr 278 2001-03-29):
http://www.lovdata.no/cgi-wift/ldles?doc=/sf/sf/sf-20010329-0278.html

[3] The zero value restriction on "a_{78} " can be removed, allowing the exchange rate to immediately effect the monetary policy, but this would require to introduce long-run restrictions in order to get a just identified model.

significant. As such the series is classified as stationary by all tests utilized, I(0). The variables economic activity, oil price, foreign interest rate and unemployment all have, independently from including a trend term or not, a robust classification as non-stationary variables and are both integrated of order one, I(1).

With the inflation rate the test results start to turn ambiguous. First of all, the DF-GLS tests reject that the inflation rate is either integrated of order zero or one. Since the DF-GLS method is not rejecting the null hypothesis of unit root even when the series have been differenced up to four times, I will not emphasize the results from this tests as it is highly unlikely that macroeconomic variables have such characteristics. The Phillips & Perron test and augmented Dickey-Fuller indicate that the inflation rate is stationary, while the KPSS test suggests that it is non-stationary and integrated of order one, I(1). By looking at the figure 6.4 there are incidents of huge variations in the series and as argued before this can falsely lead the augmented Dickey-Fuller to conclude with stationarity. The follow up unit root tests show that the series are still stationary when testing the sample before the huge increase and decrease in the inflation rate, see table A.6.3 Independently of following a trend or not it seems that the inflation rate is stationary, I(0). However, I perform robustness tests on this assumption (see section 6.7) and see if the results qualitatively change since the KPSS still maintains the conclusion of integrated of order one when excluding the large deviations.

Lastly, the NIBOR and the exchange rate are not easily classified using the DF-GLS test. As with the inflation rate, differencing the series further are not leading to significant unit root results either, which again leads to in less emphasize on DF-GLS . The rest of the unit root tests conclude that the NIBOR and the exchange rate is non-stationary and integrated of order one, I(1). As some of the variables are stationary this effectively exclude the option of using cointegration as a method in the analysis. The variables which are classified as integrated of order one is therefore differenced such that all variables can be treated as stationary.[1] All unit

[1]Unit root classifications: *prod* I(0), *econ* I(1), *price* I(1), *fir* I(1), *unem* I(1), *inf*, I(0), *3M-N* I(1), *exc* I(1).

root tests, with the exception of DF-GLS, indicate that all variables classified as I(1) becomes stationary when first differenced.

6.4.2 SVAR Lag Length, Autocorrelation, Stability and Normality.

Table A.6.4 shows the optimal amounts of lags. For this test I have arbitrarily allowed maximum 24 lags, which is equivalently to two year of data being used in the lags. Since we are now using a data sample which cover a considerable less amount of data than the previous SVAR, I find it intuitive that the allowed amount of lags need to be reduced as well. This follows the same logic as argued in section 4.3 and C.2 and due to loss of data as the lag-structure increases.

The recommended amount of lags varies from test to test. Both the HQIC and SBIC have recommendations of one lag, while the FPE has four lags. Both of these lag structures have serious amount of autocorrelation and are dropped from the analysis, see appendix tables A.6.5-A.6.8 (even though the Portmanteau test cannot reject the hypothesis of no autocorrelation at four lags, table A.6.8, the Lagrange Multiplier test indicate autocorrelations at both the second and third lag order for the same lag structure). Both of the AIC and the LR recommends 24 lags and following Ivanov & Kilian (2005) AIC should be emphasized in this setting due to monthly frequency in the data sample. However, due to the high degree of data processing needed to compute a SVAR with 8 variables and 24 lags I limit the amount of lags to reduce the computational requirements.[1] In addition, such a large amount of lags could very possibly hinder the effectiveness of later robustness tests. Since several of the robustness tests is regarding the sample period, a high lag order reduces the amount of observations to a critical level and the validity of the robustness tests could be questioned. Lastly, the lag order chosen is similar to the levels used by other researchers analyzing the Norwegian macroeconomic response to oil shocks such as Bjørnland (2009) and Solheim (2008) which uses 6 and 2 lags respectively. Consequently I increase the amount of lags from the FPE recommendation and eventually find the lag order of six lags sufficient for both the Lagrange

[1] The computational requirements increase exponentially as more variables and lags are included in the VAR system. Computing the IRF in SVAR I took mere seconds, while IRF in SVAR II with 4 lags took 5 hours, SVAR II with 12 lags took roughly 24 hours.

Multiplier test and Portmanteau to reject the possibility of autocorrelation, see tables A.6.9 and A.6.10. The model also passes the eigenvalue stability test, see figure B.2 in the appendix. Thus, using six lags satisfies the criterions of stability and white noise.

The tests of normality of the residuals indicate that the disturbances of the time series, with the exception of the real oil price, are not normally distributed. The SVAR II analysis contains 279 observations which may be enough to counter the normality tests results as done in the first SVAR analysis. This assumptions is however weaker since the amount of observations are reduced and is a potential risk for the analysis. The use of non-parametric procedures would solve this issue, but as previously stated I have decided not to utilize this method.

6.5 Impulse Response Functions

The following impulse response functions are created by inducing a shock in the respective shock variable. For presentational purpose it would be optimal to normalize the innovations such that the all shocks induced would represent an oil price increase. Since Stata by default induces a positive shock, and I have been unable to change this specification, the oil production shocks will instead represent an oil price decline since a positive supply shock will all else equal decrease price. Economic activity and oil-specific demand will on the other hand represent demand shocks which will all else equal increase the price. In section 6.6.5 where the results are discussed I presents the predictions as coinciding with an oil price increase for making comparison and discussion of the results easier. This means that the results from oil supply shocks must be interpreted as opposite than what is presented in the figures, since the figures present oil supply shocks as coinciding with lower oil prices. Although the focus is on how shocks in the three variables is predicted to affect the Norwegian macroeconomic variables the shocks from the foreign interest rate and Norwegian domestic variables are also presented. This is done to see if the model predicts any non-plausible estimations which would indicate weaknesses in the model.

6.5.1 Oil Production Shocks

As shown in figure 6.6 we see that the predictions about oil production, economic activity and oil price changes from the results obtained in the aggregate oil market analysis (see section 5.4). First, we see that a positive oil supply shock predicts substantial increases in world oil production, but we also see a sharp decline in the first periods of the time horizon. This pattern could arise due to the fact that oil producers try to hold back production in order to increase or at least stop falling oil prices. Secondly, the oil production shock is predicted to increase world economic activity. Although the immediate positive response is not significant, there is a delayed significant effect two months after the shock. As oil prices decline, which lead to a reduction in energy input costs for firms and consumers this might help triggering an economic expansion. As such we see evidence in contrary to the supporters of asymmetric price effects, a decrease in oil price helps fuel economic activity growth. The effect is however short lasting as the response is predicted to align around zero four months after the shock. Thirdly, the supply shock predicts an immediate decline of the oil price, but this is not significant. As with the economic activity there is a delayed significant effect in period four where the oil price actually is predicted to increase. This may be seen in relation to the observed pattern of oil production declines previously discussed which might indicate a coordinated behavior of oil-exporting cartel. That is, they try to increase the price of oil by supply contraction to replace the loss of revenue.

Regarding the Norwegian variables there are is a lagged increase in unemployment. As an increased supply of oil makes oil investments less profitable, the Norwegian demand for labor may be negatively affected. The highest impact is in the first month after shock and a predicted increase of 0.02 percentage points in the unemployment rate is predicted. The model also predicts a negative change in inflation and the interest rate under a supply shock, but this remains insignificant through the time horizon, except for the interest rate which becomes significant after nine months. Since any significant effect on the interest rate is not observed before nine months, one should be careful to emphasize this finding. Lastly, the immediate prediction of depreciation of the exchange rate is not significant, but a short time period of appreciation is significantly reported three months later after the shock. This may be an observation of the so-called overshooting effect first reported by Dornbusch (1976).

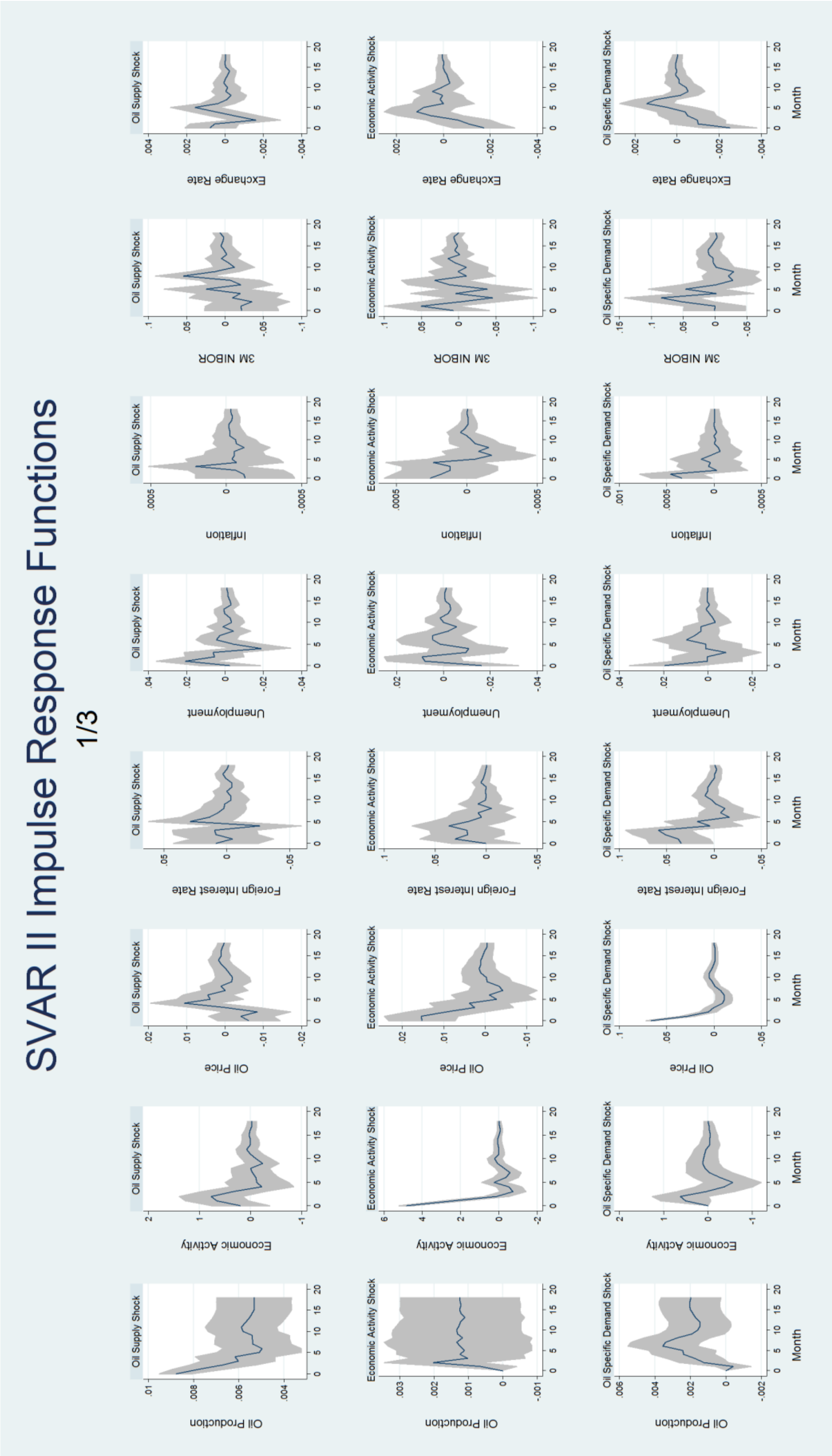


Figure 6.6: Impulse Response Functions SVAR II, 1/3.

6.5.2 Economic Activity Shocks

A shock in the aggregate demand have no immediate effect on world oil production as also found in Kilian (2009), but where Kilian finds a significant response after half a year after the shock the results of this SVAR predicts a short significant response in the second month after the shock. The pattern of shocks in aggregate demand on economic activity also differs from Kilian (2009) as Kilian shows statistically significant responses through all of the 18 time periods in his analysis, while this SVAR analysis predicts an identical immediate effect which instead is followed by a sharp decline and centers on the zero value by the second month. As in the analysis of the aggregate oil market, economic activity immediately increases the price of oil which is significant until two months after the shock and the oil price fluctuates around zero through the time horizon. Surprisingly, increased economic activity have no significant effect on either the foreign or domestic interest rate and no effect on unemployment or inflation. It is however estimated that the exchange rate have a significant immediate appreciation followed by depreciation before the effect fades out. It could be that the index is not a good proxy for economic activity in Norway and thereby supports the view that Norway`s business cycles are not identical to other economies. Eyeballing figure 5.2**,** the economic activity index indicate a recession in the mid-1980s, while Norway`s recession in the 1980s did not materialize before the end of the decade (bank crisis) when the economic activity index already had climbed up to positive numbers. A lagged effect from the international demand pressure is thus suggested from the figure, which could be the reason for the lack of significance in the response of Norwegian macroeconomic variables from economic activity shocks in the analysis.

6.5.3 Oil-Specific Demand Shocks

During an oil-specific demand shock the effect on oil production pattern is quite similar to what was observed in the first SVAR analysis of the aggregate oil market and Kilian (2009) reports; an initial insignificant decline of oil production which eventually turns into a significantly increased production. We can also see that the oil-specific demand shock leads to nearly double effect on the predicted coefficient values of world oil production than an economic activity shock. The response of oil production reach the maximum response 7 months after the shock which means oil-specific demand shocks are long lasting. With the exception of the dip in prediction oil production 10-12 months after the shock, the predictions are significant throughout the time periods presented.

In contrary to what was found in analysis of the oil market, the economic activity is not predicted to coincide with higher oil-specific demand in this SVAR. Interestingly, economic activity also responded insignificantly in the first robustness test in the first SVAR analysis (see figure 5.7) where the economic activity variable was first differenced as done in the second SVAR baseline analysis. The pattern and coefficient values are although very similar to the first SVAR baseline analysis, but a broader confidence interval from the oil-specific demand shock makes the prediction non-significant. It is therefore quite possible that the VAR model is vulnerable to the specification of this variable.

It is also estimated that the foreign interest rate significantly increases with such a shock which could mean that higher economic pressure that oil-specific demand coincides with, are instead picked up by the foreign interest rate. At the most, the foreign interest rate is predicted to increase with 5.9 basis points three months after the shock and from there on the effect fades out. When there is an oil-specific demand shock the price of oil immediately increases and drops steadily for each following time period becoming insignificant three months after the shock.

As a major oil exporter it would be at least be reasonable to see a predicted decrease in the unemployment rate but surprisingly the predicted response is an increase in unemployment, but the estimated effect steadily floats around zero and never becomes significant. The predicted response of the inflation rate is an immediate significant positive reaction which becomes insignificant after just one month has passed by. The effect of the oil-specific shock is then predicted to fade away.

Regarding the NIBOR there is a lagged significant effect. Interestingly this effect comes in the time period after the inflation rate has significantly increased and may accordingly be interpreted as a response from the central bank to counter the increased inflation. Three months after the shock the NIBOR rate is predicted to increase by 8.5 basis points, before it becomes non-significant.

Lastly the exchange rate has the same predicted pattern of response as with the activity shock where an immediate significant appreciation is predicted. As with the economic activity shock the strength of the predictions are just moderate and turns insignificant already one month after the shock. In contrary to what was found regarding economic activity shocks the exchange rate is also predicted to have a minor depreciation six months.

6.5.4 Remaining Shocks

Shocks originated from the foreign interest rate have no large effect on the Norwegian economy, see figures 6.7 and 6.8. The only variable which has a significant response is the domestic interest rate. This is not surprising given the information from figure 6.2 where the two time series have a similar pattern and a correlation of 0.8184.

A shock in the Norwegian unemployment rate, called a domestic demand shock, also have low significant effect on the other variables in the VAR system.[1] The 3-Months NIBOR have an immediate negative response which fits the expected response. As the unemployment rises, the central bank lowers interest rates to increase aggregate domestic demand in an effort to close the output gap. This is in line with the theoretical view of CCG presented in section 6.1.

The predicted effect from shock in the domestic inflation rate, called a cost push shock, is in some ways quite puzzling. First we see significant responses from both the economic activity and the oil price variables from the cost push shock which are highly implausible. Secondly, the jump in inflation tends to coincide with an increase in unemployment which becomes significant four months after the shock. Normally, as higher inflation is an indicator of higher pressure in the economy one would expect a rise in inflation to coincide with a decline in unemployment rather than increased unemployment. Thirdly, there is no significant effect

[1] Since Stata by default induces a positive shock the unemployment shock represents a negative demand shock.

from the 3-Months NIBOR. The confidence interval of the 3-Months NIBOR response spans similar range as those shocks from other variables, but the predicted coefficient values are quite low regarding cost push shocks and fluctuate near the zero border. As inflation is one of the major variables which are considered in the interest setting decision it is quite surprisingly that no significant effects is observed. In addition the predicted coefficients are in the majority of time periods of the opposite sign than what could be expected from the theoretical presentation of section 6.1. The last significant effect of the inflation increase is that the exchange rate experiences an immediate appreciation. Lastly, a domestic monetary shock is predicted to coincide with a decrease in foreign interest rates.

Using alternative econometric specifications as Lippi & Nobili (2009) and Baumeister & Peersman (2008, 2009) may solve the problem of non-plausible responses. They introduce sign restrictions on the responses generated by the structural vector autoregressive model to get closer to the true dynamics in the market. These sign restrictions then replace the exclusion restrictions which would make the structural VAR model partially identified instead of an exactly identified model as this thesis presents. Kilian & Murphy (2010) also supports the notion of sign restrictions but emphasize that sign restrictions alone could be insufficient and especially the use of median responses to characterize the responses to structural shocks are questioned. In addition Stata has limited amount of options regarding SVAR techniques which would require me to estimate the model in another statistical program. I have therefore refrained from introducing sign restriction in this thesis.

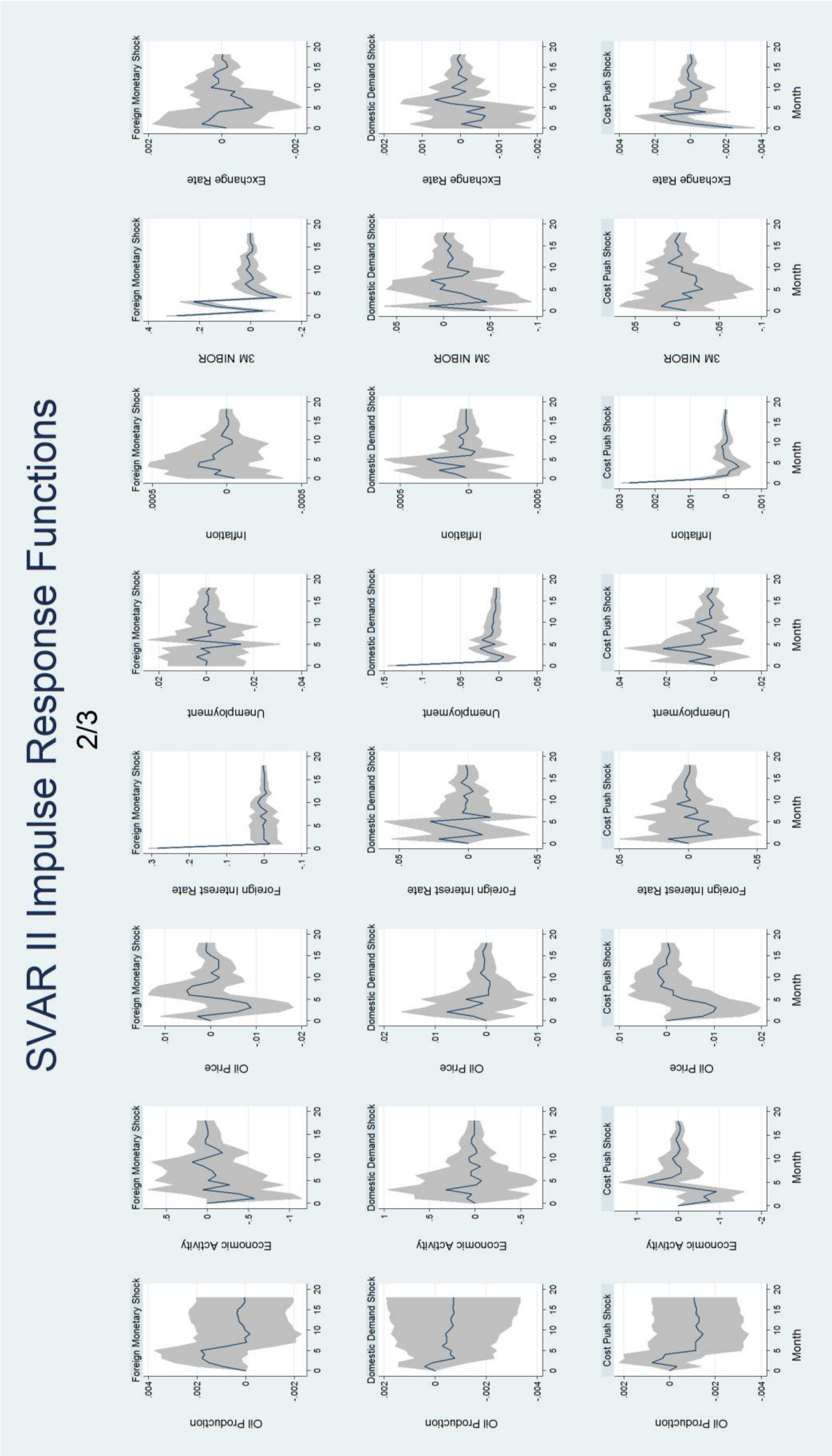


Figure 6.7: Impulse Response Functions SVAR II, 2/3.

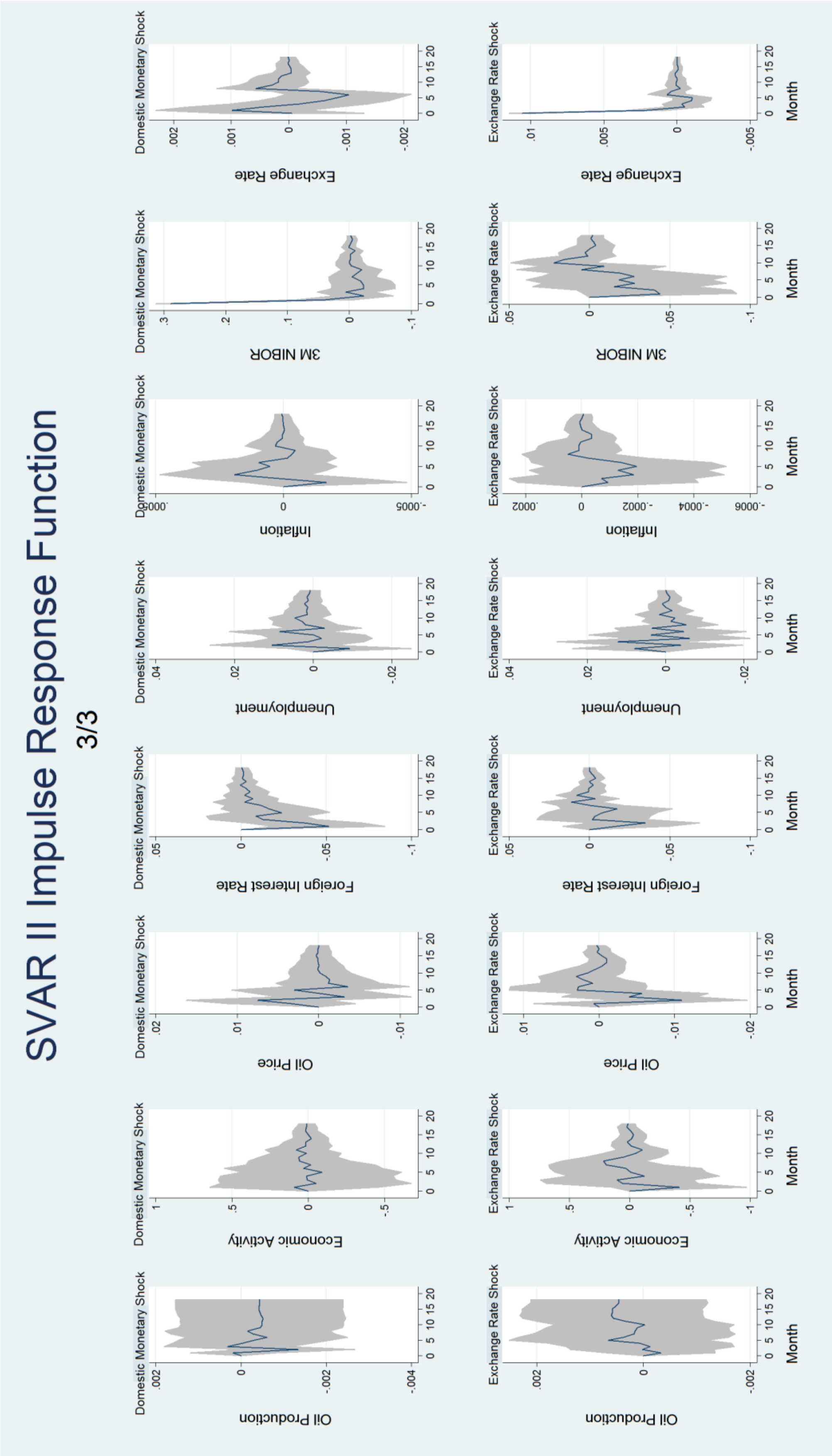


Figure 6.8: Impulse Response Functions SVAR II, 3/3.

6.5.5 Discussion of the Innovation Results

Since this thesis is inspired by Bjørnland (2009) and utilizes a similar New-Keynesian setting it is only natural to compare the results with her findings. As Bjørnland (2009) reports most of the impulse response functions in SVAR II represent plausible reactions for an oil-exporting country. Shocks coinciding with higher oil prices generally tend to increase economic pressure in Norway. As Bjørnland finds most of the significant responses are although moderate which most likely can be contributed to the mechanism of how oil revenue is handled (see section 2.2.2). Thøgersen (2004) reports that the Norwegian Petroleum Fund has been highly successful relative to methods of other oil-exporters, but as the results presented below it has not been completely successful of deterring influences from oil prices to the economy of Norway. The question then arise, will the underlying reason play an important role in explaining the development of Norwegian macroeconomic variables?

Let us start with the predicted response of the foreign interest rate. Bjørnland (2009) finds a positive response in the foreign interest rate following a positive oil price shock, where the interest rate is predicted to increase by a maximum of 10 basis points after 7-15 months after the shock. The results from SVAR II indicate that the response in this variable when disentangling the supply and demand from the oil price suggest that the response reach coefficient values which are roughly half of what Bjørnland finds.

Regarding the unemployment rate it is only the oil supply shock which has a significant effect in and the response of the unemployment has a similar immediate effect as Bjørnland (2009), but where Bjørnland finds an increasing rate of unemployment over time horizons, this SVAR predicts a short time effect and returns to zero changes in the unemployment rate six months after the shock. Are the low responses from the unemployment rate a sign that the labor market is decoupled from the oil price? One possible reason for the moderate response is that Norway has a relatively large amount of people working in the public sector, which is somewhat independent of the business cycles (see figure 2.5 for the development in industry and public employment). Increased employment in the public sector was also one of the main interventions of the government in the Norwegian economy during the financial crisis of 2007-08, when both lower world aggregate economic activity and oil prices were observed. In addition to a large share of the workforce in the public, a relatively large share of the population receives various forms of government benefits, which again contributes that the aggregate domestic demand is less influenced by business cycles. The labor unions in Norway are also quite influential such that higher demand pressure in the economy could lead to higher wages instead of higher employment. That is, higher bargaining power of the labor unions increases wages and thereby increases input costs in firms. Thus, increased costs due to higher oil prices and wages gives firms incentives hold off increased employment. At the same time the Norwegian unemployment rate has been quite low through the sample period, especially the later periods (see figure 6.3). The rate has been below 3.5 percent for almost 40 percent of the total observations and 2.9 percent for the 2005-2010 period (Bjørnland`s sample period ends in 2005). Consequently, the unemployment rate has been near the structural rate of unemployment which means that the costs related to reduce the unemployment further likely surpasses the benefits of such a reduction.

The predicted responses of the inflation rate are positive from all shocks coinciding with oil price increases.[1] It is however only the oil-specific demand which leads to significant responses. Like the rates of foreign interest and unemployment the predicted coefficients are of lower values than the predictions by Bjørnland (2009). Figure 6.6 presents the predicted increased monthly inflation with half of the power predicted by Bjørnland (2009). This is not surprising as two additional variables have been added and placed at the top in the Cholesky ordering, but it illustrates the fact that not oil price increases are alike and disentanglement of the oil price is necessary to understand the dynamics. Specifically, the results indicate that no extraordinary maneuvers are needed from the central bank to keep the inflation rate stabile if the oil price changes are due to supply or demand shocks. On the other hand, if the oil price increase stems from oil-specific demand this all else equal leads to higher inflation. In addition, since the predicted coefficient values are half of what Bjørnland (2009) predicts, a less powerful intervention by the central bank is sufficient to keep the inflation rate near the inflation target as long as the underlying reason for the price change can be correctly assessed.

[1] Remember the interpretation of the oil supply shock. As Stata by default induce a positive innovation this reflects an oil price decline. A negative innovation (simply the opposite of the results in oil supply shocks in IRF figures) on the other hand reflects an oil price increase.

Turning to the 3-Months NIBOR the responses of this variable is also predicted to increase following all shocks coinciding with oil price increases. Although all shocks share a similar pattern to Bjørnland`s (2009) findings where higher oil prices increase the interest rates, the predictions from the model have lower response values, as also found in the inflation and foreign interest rate predictions. In addition we find that disentanglement of the oil price is of interest when focusing at the time horizons. In figure 6.6 we can see that the supply and oil-specific demand gives significant results at different time periods after the induced shock. The predicted response of the oil-specific demand leads to 8.9 basis points increase in the 3-Months NIBOR 3 months after the shock, while predicted response from the supply shock is an increase of 5.0 basis points 9 months after the shock. This opens up the possibility for time varying investments decisions by market agents as long as they can adequately observe the underlying reason for the oil price change.

Lastly, the exchange rate is predicted to appreciate whenever a shock coinciding with increased oil prices occur, which is also consistent with Jiménez-Rodríguez & Sánchez (2005). A significant appreciation over a short time period after a positive oil price change is to be expected as long as economic activity or oil-specific demand is the underlying reason for the price increase. Unlike Bjørnland (2009) the predictions of the exchange rate are of statistical significance but the coefficient values are however quite small, hence the economic significance of this finding is limited. It does however illustrate that disentanglement of oil prices can shed some light over previously undiscovered dynamics, but the coefficient values are low and Haldane`s (1997) proposition of the Norwegian currency as a petroleum currency is thus only partially supported. As presented in section 3.3, Bjørnland argues that the weak response observed in the exchange rate is due to the delayed response in the 3-Months NIBOR relative to the foreign interest rate, such that the interest differential partially offsets the appreciation pressure on the Norwegian currency. The IRF`s from the SVAR II analysis shows that the foreign interest rate tends to increase following shocks coinciding with oil price increases, although the supply shock yields low response which never wanders far from the zero bound. The aggregate demand shock predicts an immediate response in both the foreign and domestic interest rate, but neither response is significant. The oil-specific demand shock is the only variable which significantly affects both of the variables, where an immediate response in the foreign interest rate and a delayed response in the 3-Months NIBOR are predicted. Bjørnland`s (2009) reasoning of the low response from the exchange rate is therefore supported when disentangling the oil price for supply and demand forces. This result implies that Norwegian firms which depend on exports and international trade only for a limited time lose their competitive power due to appreciation of the NOK in oil price increases. Following the discussion in Jiménez-Rodríguez & Sanchéz (2005) the low amount of significance in the exchange rate predictions could indicate that Norway is less infected by the Dutch Disease. The importance of this finding should not be overstated though as absence of evidence is not evidence of absence. As discussed in section 2.2.2.3 it is quite possible the Norwegian economy is infected by the Dutch Disease in other ways than what can be picked up by the exchange rate. Section 2.2.2.2 presented the mechanism that ensures dollar revenue from oil sales is not transferred into Norwegian economy and thereby avoiding an appreciation pressure on the NOK. The low significance must therefore be attributed to the mechanism of the petroleum fund in addition to the explanation of Bjørnland (2009). The answer for why the exchange rate responds significantly must therefore be found elsewhere and one possible source could be the Oslo Stock Exchange (OBX). Since oil related companies make up a significant share of the OBX unexpected oil price increases will raise expected future profit of these companies. It is therefore possible that foreign investors change their stock holdings towards stocks at the OBX and thereby increasing the demand for NOK. It should be mentioned that several of the largest companies listed in OBX are also listed in other stock markets such that the OBX is not supplying the total demand of stocks and thereby the appreciation pressure from this source is weakened. As Bjørnland (2009) and Sørensen (2010) finds there is a significant response from the stock exchange following an oil shock such that this relationship is plausible. Bjørnland (2009) does however not find a significant relationship between the exchange rate and oil price developments in her analysis. The lack of a variable representing the OBX in this thesis could be one explanation for this phenomenon, as the inclusion of the OBX variable could potentially influence the dynamics in the model such that the exchange rate have a weaker predicted response (see section 6.1 for why OBX is not included). Another explanation could be that oil companies makes up a larger share of the OBX in more recent times and thereby making the foreign investor effect stronger. Lastly, the significance of the exchange rate can stem from the fact that I have calculated the real exchange rate while Bjørnland uses the nominal rate. As figure 6.5 shows the overall difference between the two exchange rates is quite small, but the deviation occurring in the 1990s could explain some of the finding.

Berument, Ceylan & Dogan (2010) finds that their MENA oil-exporting countries are reacting positive regardless of the underlying reason for the oil price increases. As found in the base analysis this is also true for Norway during supply and oil-specific shocks, but not when inducing economic activity shocks. This is surprising given that not only is there a large industry related to oil in Norway, but also large exports of other commodities (fish & aluminum) which are very dependent on world aggregate demand. It was however discussed in section 3.3 that generalizations from net oil-exporters to another could be problematic due to differences in economic structure and development. This argument holds up well against most of the net oil-exporting MENA countries, except Kuwait which is roughly ranked along Norway in table 3.1. A potential reason for the low predictions from economic activity shocks could arise from the appreciation of the exchange rate. As the exchange rate appreciates domestic firms lose competitive power relative to foreign firms. This increases imports and at least some of the higher economic activity will be channeled through increased imports and thereby reducing the domestic economic pressure. The predicted response of the exchange do however only marginally support this explanation as the appreciation is both low in value and in addition short lasting.

In addition, the oil supply variable in Sørensen`s (2010) study is excluded due to its low explanatory power in the development in Oslo Stock Exchange. This is in contrast to what is reported in this thesis as it is the supply variable along with the oil-specific demand which lead to significant predictions. A simple interpretation of this phenomenon could be that Norwegian macroeconomic variables, besides the stock exchange, are more sensitive to developments in supply and oil-specific demands for oil, while changes in oil supply only marginally influence the financial markets. This would however ignore the important relationship between the macroeconomic variables and financial markets. This relationship is emphasized by Bjørnland`s (2009) secondary finding where monetary policy shocks are of importance in the variability at Oslo Stock Exchange in the short term. Sørensen`s (2010) findings do also give additional support for the appreciation reasoning made earlier related to increased demand for stocks at OBX. Since he drops the supply variable due to low explanatory power and supply are not predicted to affect the exchange rate in this thesis, while Sørensen keeps the economic activity and the oil-specific demand variables and it is these variables which are predicted to appreciate the exchange rate in the SVAR II analysis.

6.6 Forward Error Variance Decomposition

As in the first SVAR analysis the forward error variance decomposition is also reported in this analysis to get an overview of the importance of which variables explain the variance of itself and other variables. As the first FEVD analysis the world oil production (*prod*), aggregate economic activity (*econ*) and the real price of oil (*price*) still explains the most of their own variance throughout the time horizon included in the model, see table A.6.12. In addition the foreign interest rate have similar pattern and it is also these four variables which represents the highest share of explained variance in each other.

The unemployment (*unem*) and inflation rate (*inf*) also dominates the developments in their own variance where none of the variables never explain less than 80 percent of their own variance. Regarding the unemployment rate it is the world oil production and inflation rate which roughly explains 6 percent of the variance throughout the horizon, while it is the oil price and aggregate economic activity which explains about 6 percent of the inflation rate.

The three months NIBOR (*3-M*) is however an exception to the tendency from above and we see that the foreign interest level explains roughly half of the domestic interest variance and it also increases further out in the horizon. The oil price is the third explanatory variable, but is quite low compared to the foreign interest rate and never explains above 5 percent of the variance.

The exchange rate (*exc)* follows the tendency of explaining its own variance and never goes beneath 70 percent. The inflation rate and oil price is chief among the other variables and explains about 10-15 percent of the variance.

6.7 Robustness Tests

To examine how robust the predictions presented above are I perform tests where the model specification are altered to see if the outcome of the analysis changes. In this section I only report the impulse response functions from the three main shocks (*prod*, *econ* and *price*) to save place and focus the discussion.

The first two robustness tests are done regarding the sample periods. As it is quite possible that several of the variables went through structural changes tests must be performed to examine if the dynamics in the model changed substantially. The first robustness test takes the sample period 1993-2010 due to the change in monetary policy of the Norwegian central bank in 1993. The sample period cover the speculation attacks on the NOK in 1996-1997 and therefore potentially contains deviating monetary policy. The results in figure 6.9 show that the "top triangle" are quite alike the results from the base analysis. Supply disruptions still have significant effects on production, economic activity and the oil price. The effects on the Norwegian domestic variables changes though. Supply disruptions lose the significant effect on unemployment and the domestic interest rate, while inflation is now showing significance. Shocks originating from increased economic activity also show similar results as the base analysis, but the effect on oil prices and oil production from economic activity shocks has higher coefficient values. This is not surprising since Barsky & Kilian (2002) and Hamilton (2009a & 2009b) considers demand pressure to have increased importance in the oil price development in recent time periods. The effects on the domestic variables from economic activity shocks all show similar pattern as the base analysis, but the domestic interest rate is now significant while the effect on the exchange rate diminishes to such an extent that no significant effect is predicted. Oil-specific demand shocks are almost identical to what was seen in the base analysis with the exception of the domestic interest rate which slightly changes pattern and the foreign interest rates which have lower predicted coefficient values.

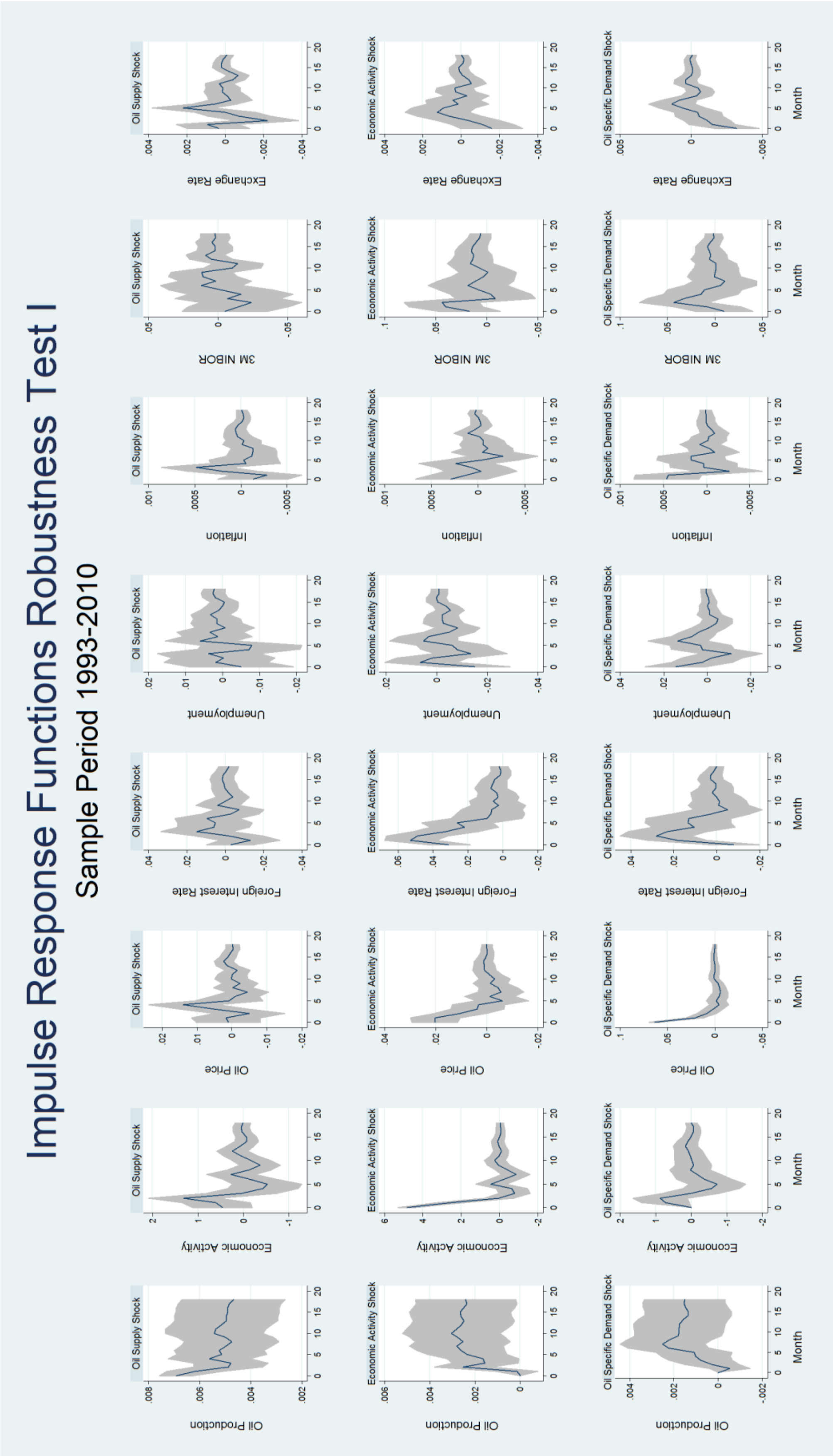


Figure 6.9: Robustness Test I of Impulse Response Functions SVAR II.

The second sample period is from 1999-2010 which is a period of consistent monetary policy and also avoid the exchange rate situation in 1996-98. On the other hand this analysis contains the lowest amount of observations which could have consequences for the validity of the results. The sample is however larger than Bjørnland (2009) study which ended in 2005. The predictions are graphed in figure 6.10 and the effect from the oil disruptions are similar to what was observed in the first robustness test, unemployment and the domestic interest rate no longer significantly respond while inflation gains significance. With the exception of the exchange rate shocks in the economic activity and oil-specific demand are also similar to the first robustness shock. As both the robustness tests regarding time sample periods estimates that unemployment is not significantly affected by oil price can be due to the fact that unemployment rate in the later time periods has been quite low and. From 1997 the unemployment rate has never been above 4.5% and the average for the 1999-2010 time period is 3,5%, which therefore makes the unemployment rate less elastic to changes in demand pressure. In other words, even if the economy becomes more active as a result of increased oil prices, the marginal costs of reducing the unemployment are higher than the gains from increased economic activity. It is however quite possible that there internal changes in the work force as oil related jobs become more profitable, which replace or crowd out less valuable jobs, but the unemployment rate itself does not change much.

The third robustness is the first of two tests regarding the Cholesky ordering of variables, see figure 6.11. As presented in section 4.2 it is always a possibility that the VAR results are vulnerable to changes in the Cholesky ordering. As discussed in section 6.3 it is a possibility that the 3-Months NIBOR and the exchange rate could be best described by changing their Cholesky rank order. Figure 6.11 illustrates the impulse response functions when the exchange rate is ranked above the 3-Months NIBOR. The vulnerability related to these two variables rankings are quite low regarding supply or demand shocks as the results are almost identical with the base analysis. The only change in the predictions of oil-specific demand shocks is that economic activity now significantly coincides with these shocks.

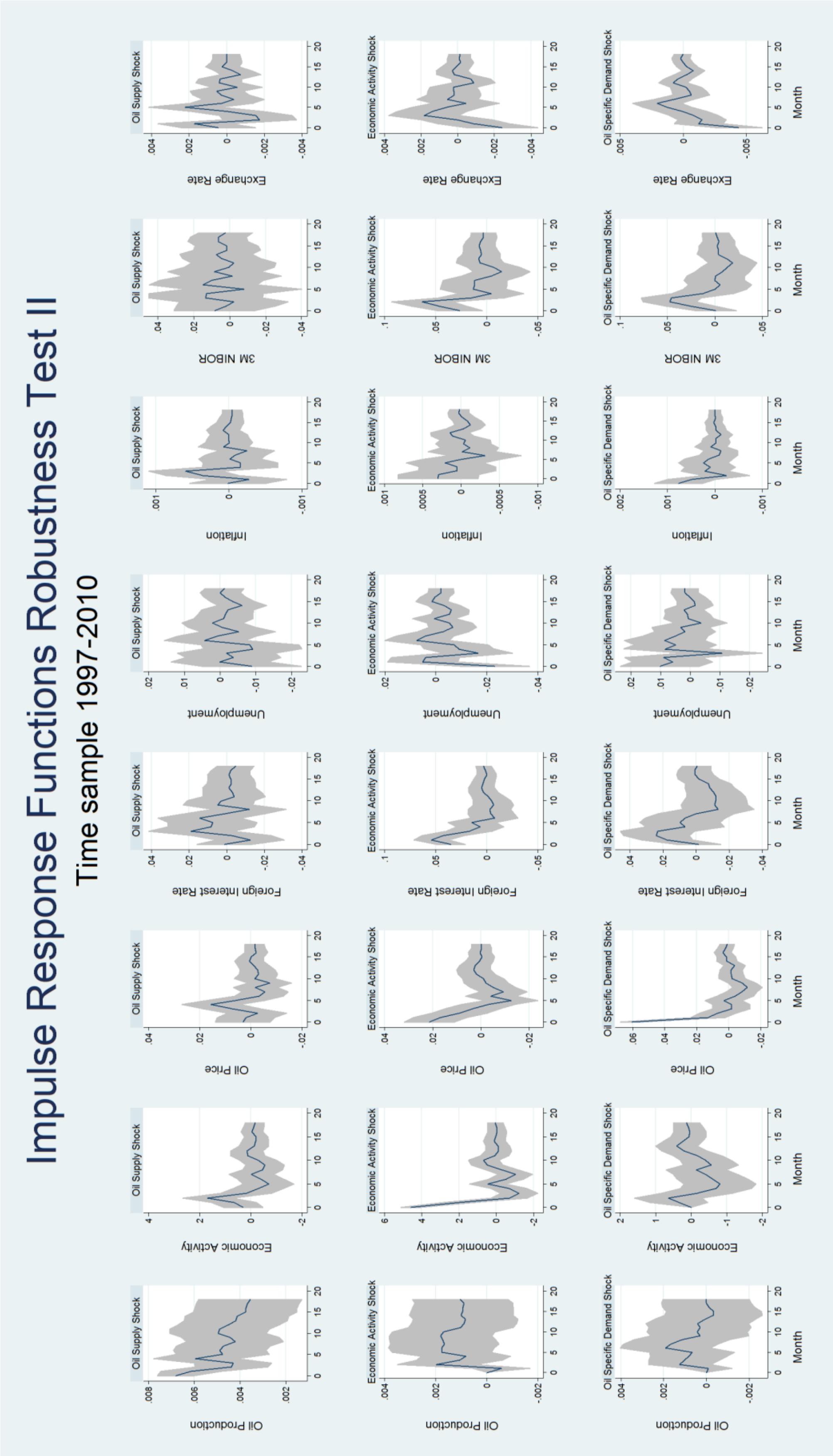


Figure 6.10: Robustness Test II of Impulse Response Functions SVAR II.

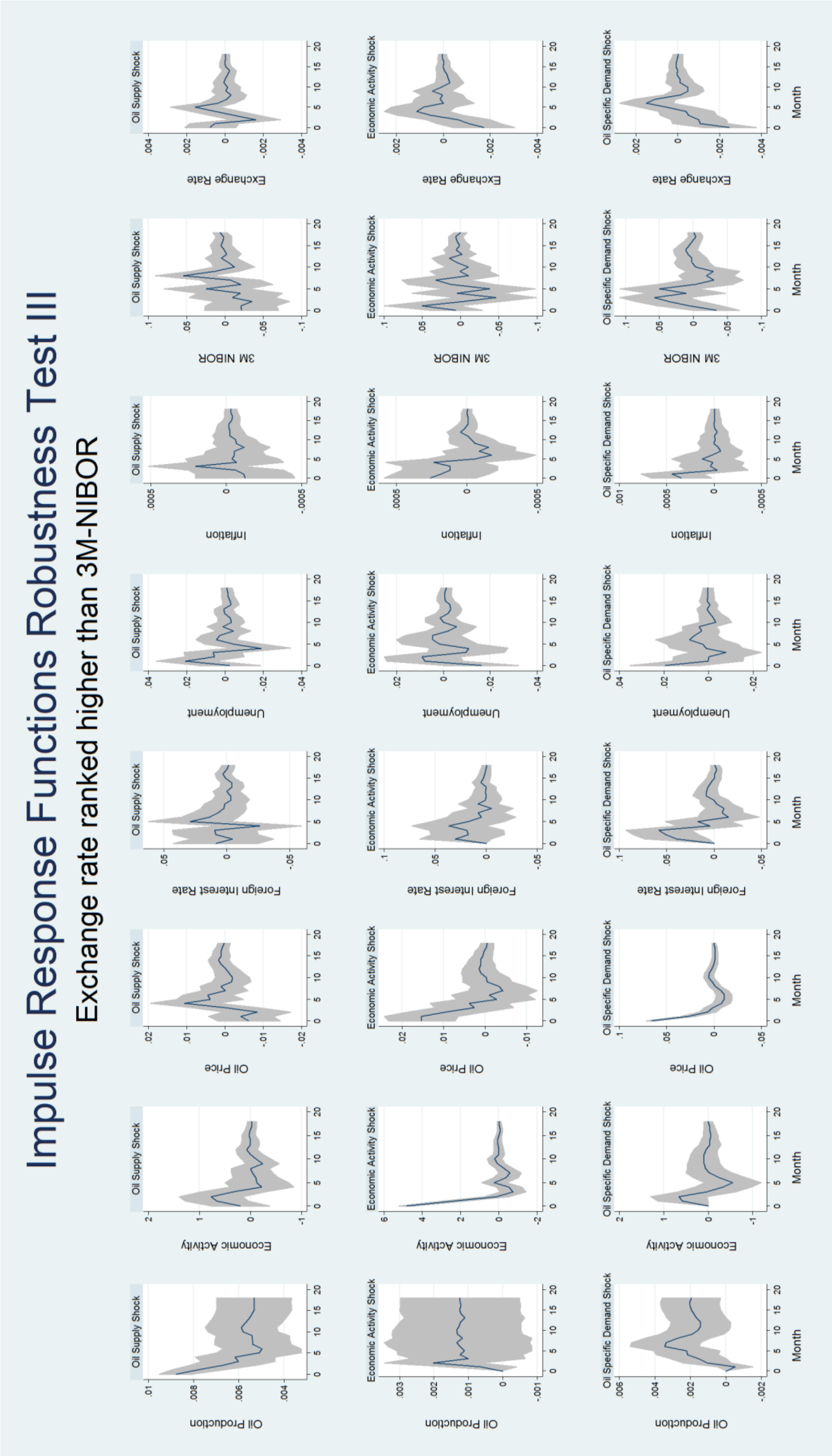


Figure 6.11: Robustness Test III of Impulse Response Functions SVAR II.

The fourth robustness test is the second test regarding the ordering of variables, see figure 6.12. As it is possible that several of the variables react to changes in monetary policy I rank the foreign interest rate at the top. As explained in section 6.3 the foreign interest rate variable is constructed to reflect Norway`s trade relations and as such is not representative of a global interest rate. I will however perform this test since the variable contains interest rates from leading economic countries as the U.S, Great Britain and Germany. The results from the oil supply and economic activity shocks are virtually identical. The oil-specific demand shocks now leads to an immediate positive response in the economic activity. This effect stays statistically significant till the third month after the shock. There is also no immediate predicted response regarding the foreign interest variable as in the base analysis, but three months after the shock the two predictions converge and have similar pattern from this time period. It should also be mentioned that the 3M-NIBOR gets smaller predicted coefficient values than the base analysis.

The fifth robustness test is in the period of 1987-1997. This test is done to get indications of whether the effects from the oil industry have diminished over time. Following the discussion in section 2.3 there are indications that Norway has entered a mature phase as an oil producer. The ripple effects felt throughout the Norwegian economy could therefore be smaller and affect the econometric analysis. If this reasoning is true we should see a higher degree of effect from the oil variables on the Norwegian macroeconomic variables. The end date for the sample period is taken on the basis of Eika, Prestmo & Tveter (2010) and from the figure 2.5 where the investments related to development of new fields starts to decrease. The impulse response functions in figure 6.13 predict that only the inflation rate is significantly affected by an oil supply shock. A demand shock on the other hand affects the interest rate and the exchange rate, while losing the significant effect on oil prices. This might be, as mentioned earlier, be due to the effect that the sample period does not contain the episodes where demand pressures have been strongest, as pointed out by both Hamilton (2009a & 2009b) and Barsky & Kilian (2002). Shocks from oil-specific demand will now not initiate an immediate significant response in the foreign interest rate, but after three months the predicted increase becomes statistically significant and from thereon shares the same pattern as in the base analysis. The predictions about the immediate response of the 3M-NIBOR are also changed as there is no significant reaction before the first month after the oil-specific demand shock.

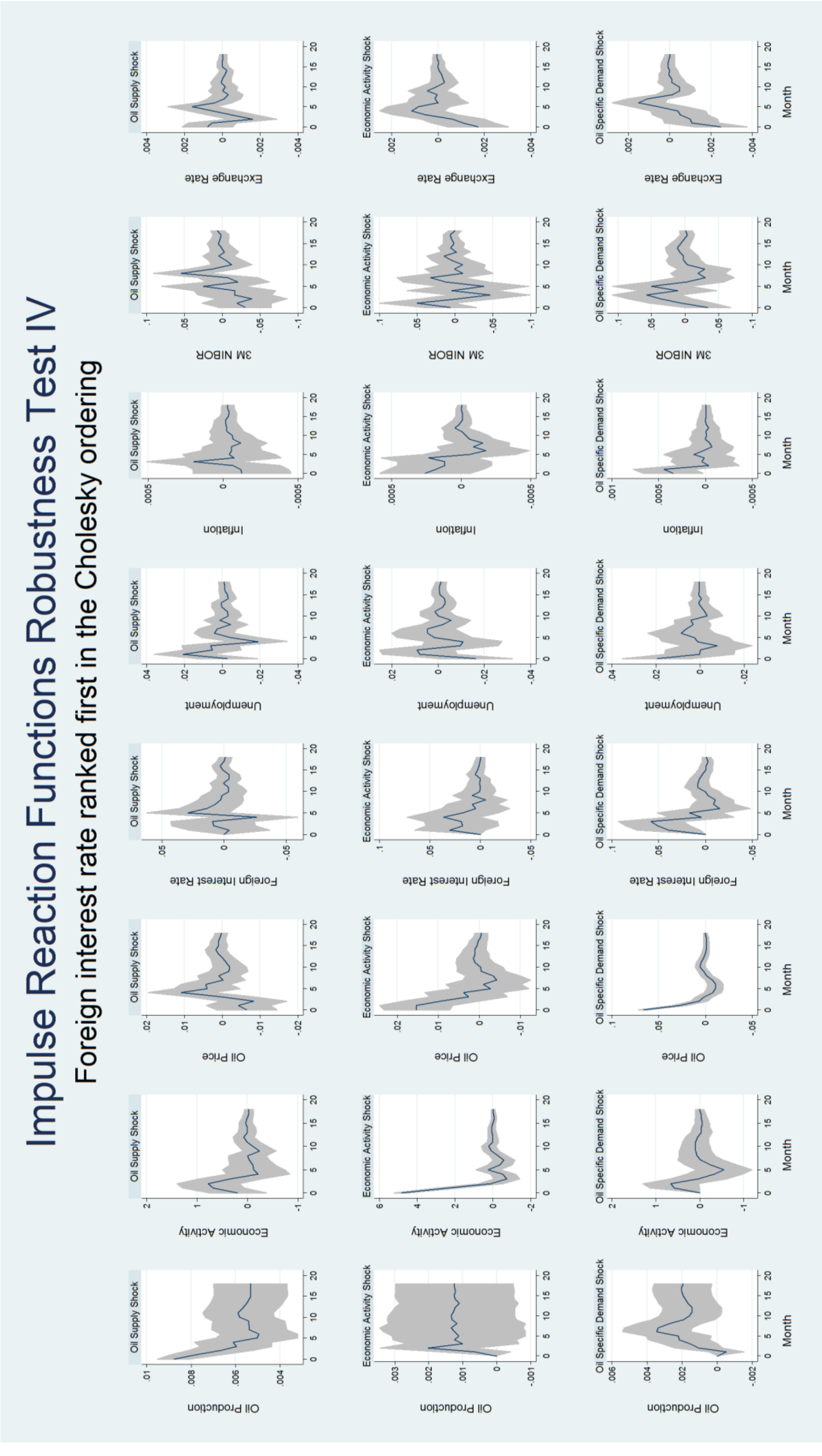


Figure 6.12: Robustness Test IV of Impulse Response Functions SVAR II.

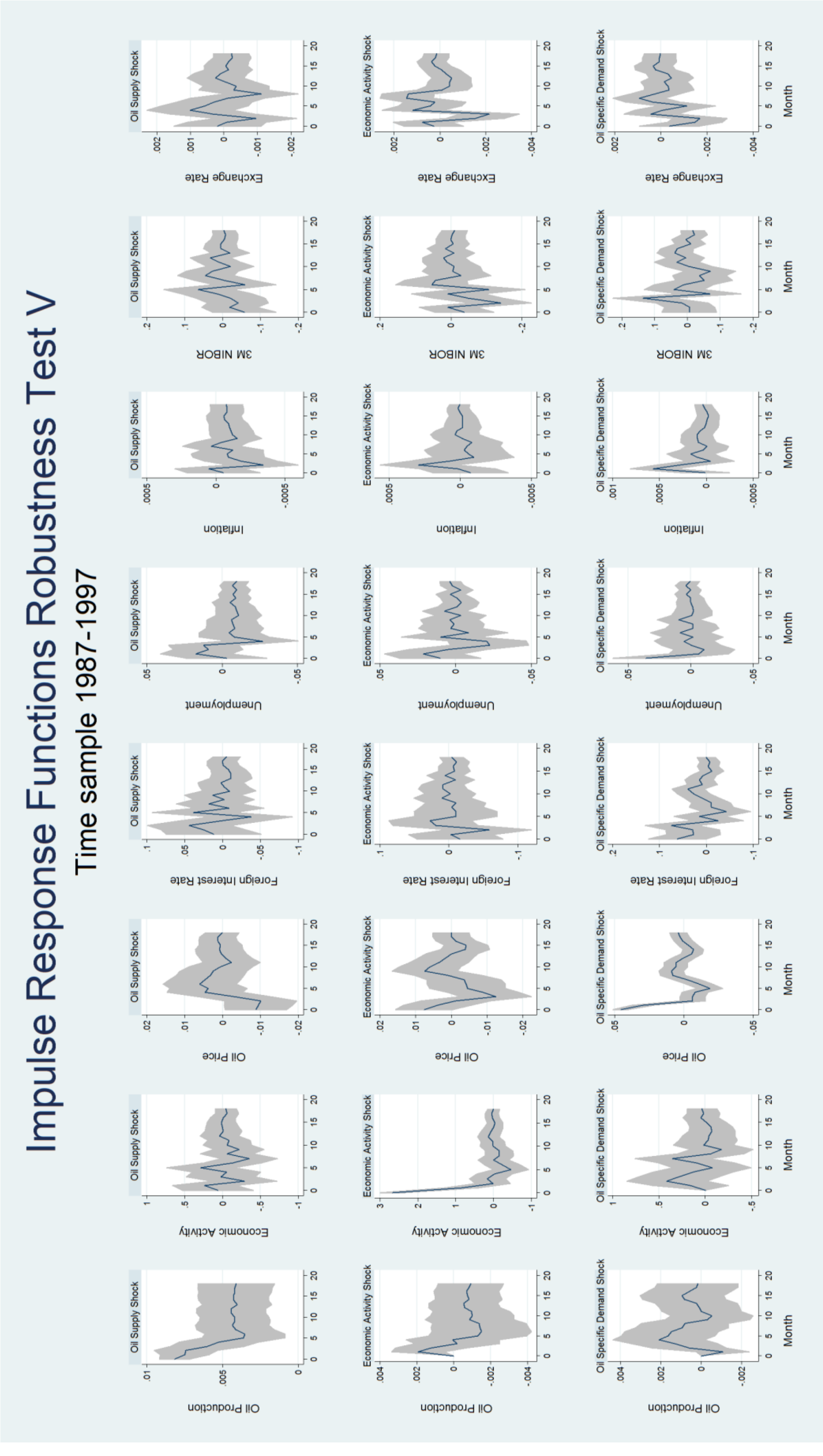


Figure 6.13: Robustness Test V of Impulse Response Functions SVAR II.

Although the predicted pattern changes from the base analysis, especially during oil-specific demand shocks, the notion of less impact from oil prices due to a status as a mature oil producer is rejected since the Norwegian variables are not more sensitive to shocks in the oil variables. This is also supported by Solheim (2008) which uses a data sample larger[1] than Bjørnland (2009). The result is perhaps not very surprising given that total investments related to petroleum have increased steadily over the total sample period, even if investment related to new fields decreased in the mid-1990s (see figure 2.5). As new field investment started falling it was field operations which increased the most. When new field investment gets replaced with operating investments could mean that a higher degree of the capital is channeled into the Norwegian economy. This is plausible since it is more likely operations are run by people inhabited in Norway, since domestic firms have a geographical advantage, and thereby capital flow into the domestic economy. New field investments on the other hand are characterized by international competition and the likelihood of international firms undertaking the work increases. A switch from investments which is characterized by competition to investments which increase the likelihood that operations are run by domestic firms then makes the relationship between the Norwegian economy and the oil market stronger. Remember also that in the time period in focus here the protective barriers on oil fields was razed when Norway ratified the EU`s oil-directive in 1994, increasing the chances for international firms winning new fields investments contracts and this channel capital elsewhere than Norway.

The sixth robustness is done when the inflation variable first differenced. As discussed in section 6.4 the majority of unit root tests indicated that the inflation was integrated of order zero, I(0), and thereby stationary. The KPSS unit root test strongly indicated that the variable was integrated of order one, I(1). The predictions of this specification can be seen in figure 6.14. The predictions are remarkably similar to what was found in the base analysis under both supply and demand shocks. The only change, which is a marginal one, is observed in the response of inflation due to an oil-specific demand shock. The initial response is an increase in inflation, but in the second time period a negative inflation is predicted, whereas the baseline analysis centered on zero. The negative response in the second time period is

[1] Solheim (2008) sample period is from 1987-2007.

however not statistically significance which makes it safe to say that model predictions are independent from the inflation variable`s order of integration.

The seventh and eight robustness tests are regarding lag lengths. The seventh robustness test increases the amount of lags to include 18 months, see figure 6.15. Tripling the amount of lags does not change the overall predictions much. Regarding the domestic variables oil supply shocks now causes increase in inflation seven months after the shock while NIBOR significantly responds eight months after the shock to counter the increase in inflation. Economic activity now significantly decreases unemployment both immediately and three months after the shock. By quadrupling the amount of lags the results changes substantially, see figure 6.16. The first general result is that most of the shocks are predicted to respond weaker than in the base analysis, while retaining their significance. Secondly the patterns of several variables also changes indicating that the predictions are vulnerable when lags are increased.

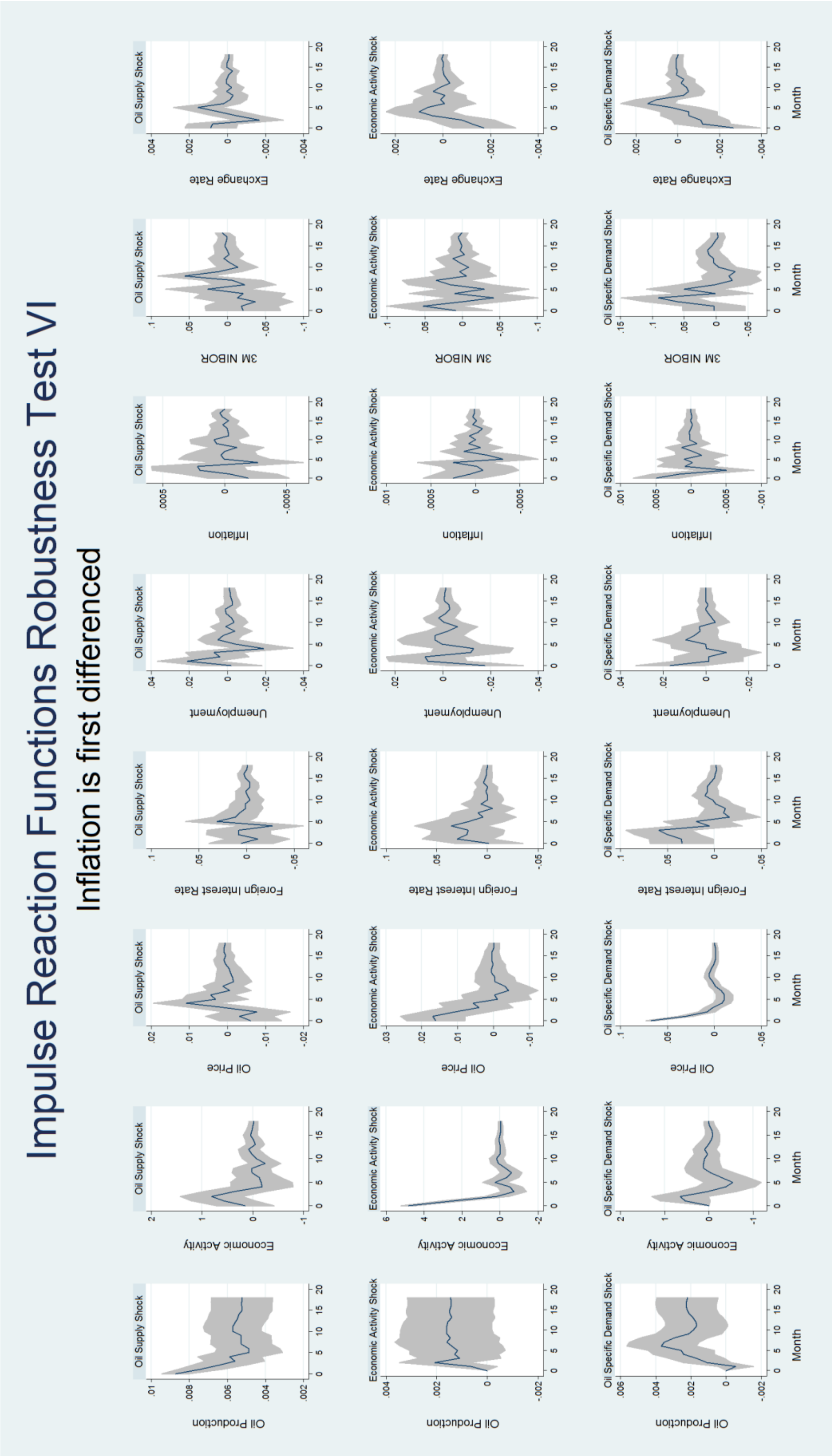


Figure 6.14: Robustness Test VI of Impulse Response Functions SVAR II.

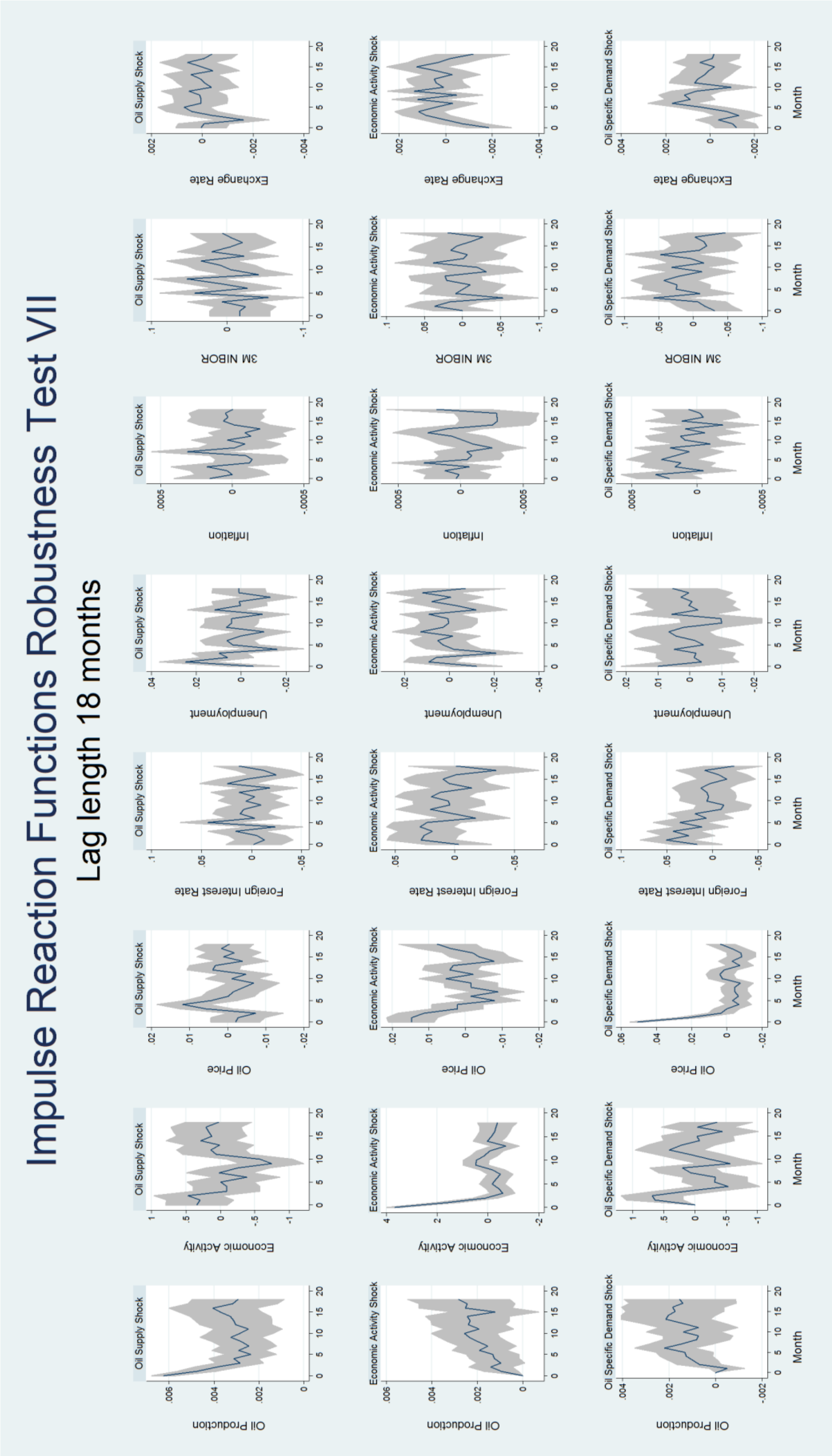


Figure 6.15: Robustness Test VII of Impulse Response Functions SVAR II.

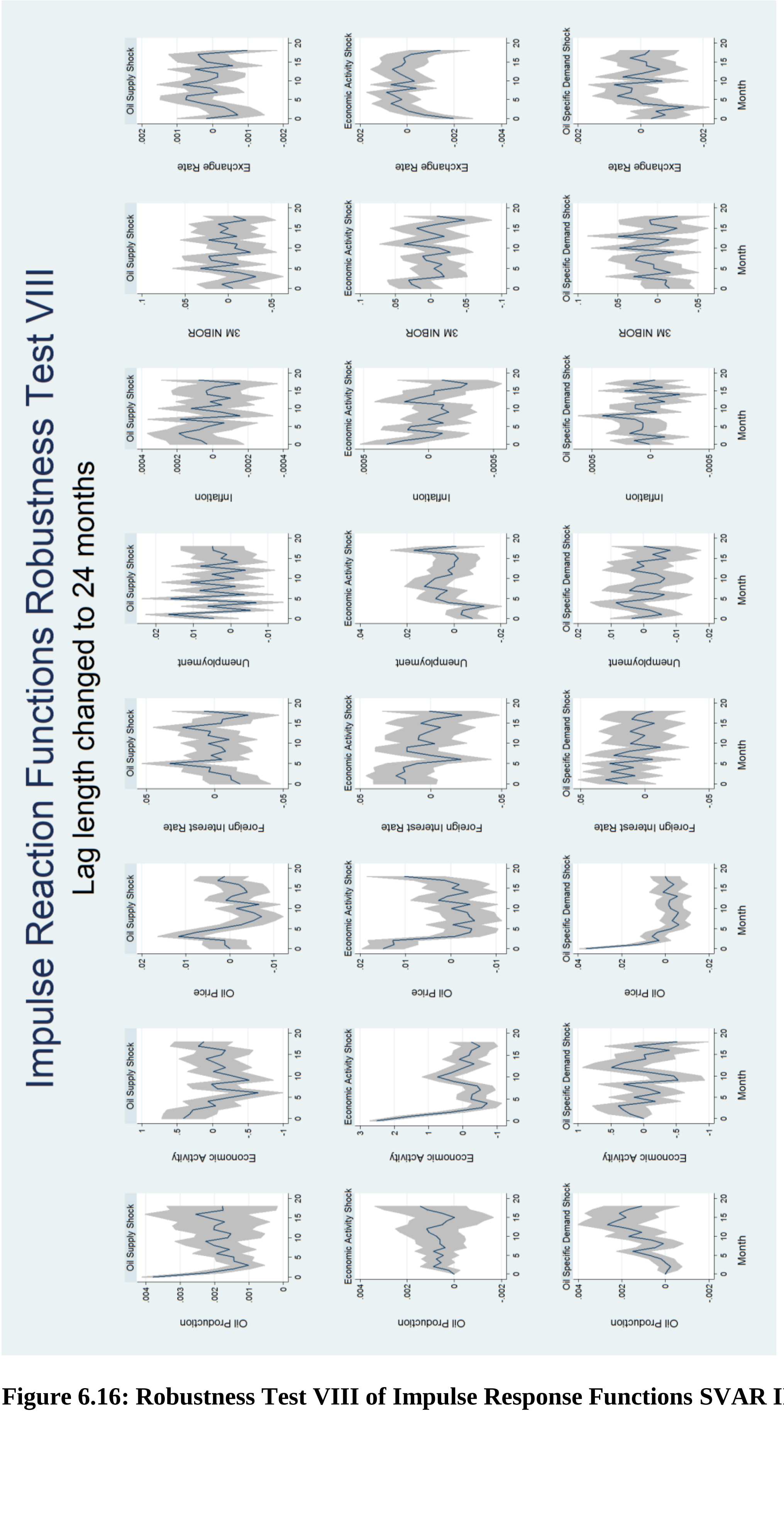


Figure 6.16: Robustness Test VIII of Impulse Response Functions SVAR II.

7.0 Conclusions

The first analysis in this thesis extends the sample period and uses a slightly different methodological approach than Kilian`s (2009) analysis. Kilian`s findings regarding the predicted impulse responses and the quantified structural shocks are confirmed by this thesis. This adds additional support for the notion of oil price disentanglement is necessary to credible predict the effect oil price changes have on macroeconomic variables. This enabled me to move forward to the second part of the thesis and construct a structural autoregressive (SVAR) model of the Norwegian economy.

By extending Bjørnland`s (2009) New-Keynesian model with supply and demand variables for oil, I find that Norway significantly, although moderately, responds to the developments in the oil market. The moderate degree of responses is probably the result of the mechanism of how the oil revenue is managed and lends support to Thøgersen`s (2004) opinion that the Norwegian Petroleum Fund has been relative successful. The main discoveries of the thesis stem either from supply or oil-specific demand shocks, where supply shocks affects unemployment while oil-specific demand affects the inflation. Shocks from economic activity have unexpectedly low significance with Norwegian macroeconomic variables. The low effect from economic activity shocks is puzzling and is in contrast to studies on other net oil-exporters and illustrates that generalizations from one oil-exporter to another can be problematic. In addition, the disentanglement of the oil price also led to a discovery of a time varying response of the 3M-NIBOR dependent of the origin of the shock. An increase in oil-specific demand leads to a significant increase in the interest rate three months after the shock, while a significant response following a supply shock is not predicted to happen before nine months have passed. It should also be mentioned that the model produced some implausible predictions which could be improved on by using more advanced econometric techniques and opens up a possible area of future research. Moreover the outcomes in this paper partly supports Bjørnland`s (2009) conclusions. Especially the explanation of why the predictions of the Norwegian exchange rate have such low significance is supported. Since the interest rate in Norway has a lagged response to oil price increases, while the foreign interest rate reacts immediately, the interest rate differential limits the appreciation pressure on the Norwegian exchange rate. The analysis does also not indicate that the effects from the oil price have become weaker over time, despite indications that Norway has entered a mature phase as an oil producer. A number of robustness tests is also presented and discussed and although some results are vulnerable to specifications, the overall outcome is that the conclusion of Norwegian macroeconomic variables moderate dependency on the oil market`s development is solid.

Appendix A

Table A.5.1: Unit Root Tests SVAR I.

***,** and* respectively indicate 1%, 5% and 10% significance. Lags used in parentheses.

DF-GLS (mAIC)								
	Constant				Trend			
	Level		First Differenced		Level		First Differenced	
prod	0.054	(15)	-2.009**	(14)	-2.418	(15)	-3.469**	(14)
econ	-1.181	(2)	-1.212	(11)	-1.862	(2)	-2.095	(17)
price	-1.239	(15)	-4.668***	(10)	-1.433	(14)	-11.347***	(1)

DF-GLS (SIC)								
	Constant				Trend			
	Level		First Differenced		Level		First Differenced	
prod	-0.300	(1)	-2.410**	(11)	-2.857*	(1)	-15.614***	(1)
econ	-1.181	(2)	-1.391	(10)	-1.862	(2)	-11.116***	(1)
price	-2.547**	(1)	-10.671***	(1)	-2.675*	(1)	-11.347***	(1)

ADF (mAIC)								
	Constant				Trend			
	Level		First Differenced		Level		First Differenced	
prod	-1.400	(15)	-5.321***	(14)	-2.423	(15)	-5.296***	(14)
econ	-4.004***	(2)	-5.771***	(11)	-4.244***	(2)	-6.246***	(17)
price	-1.290	(15)	-6.121***	(10)	-1.559	(14)	-11.683***	(1)

ADF (SIC)								
	Constant				Trend			
	Level		First Differenced		Level		First Differenced	
prod	-1.248	(1)	-5.940***	(11)	-3.173*	(1)	-16.531***	(1)
econ	-4.004***	(2)	-6.079***	(10)	-4.244***	(2)	-14.405***	(1)
price	-2.633*	(1)	-11.684***	(1)	-2.677	(1)	-11.683***	(1)

KPSS, BK								
	Constant				Trend			
	Level		First Differenced		Level		First Differenced	
prod	2.65***	(13)	.0601	(13)	.387***	(13)	.0396	(13)
econ	.37*	(13)	.151	(6)	.309***	(13)	.0392	(7)
price	.441*	(13)	.0945	(9)	.455***	(13)	.0511	(9)

KPSS, QS								
	Constant				Trend			
	Level		First Differenced		Level		First Differenced	
prod	6.82***	(4)	.044	(4)	.936***	(4)	.0289	(4)
econ	.805***	(4)	.142	(4)	.666***	(4)	.0359	(4)
price	1.07***	(4)	.0749	(4)	1.11***	(4)	.0403	(4)

P&P, 5				
	Constant		Trend	
	Level	First Differenced	Level	First Differenced
prod	-1.066	-23.446***	-2.973	-23.427***
econ	-3.904***	-13.776***	-4.076***	-13.787***
price	-2.040	-11.988***	-2.092	-11.982***

Table A.5.2: Follow Up Unit Root Test on the Economic Activity Variable.

ADF, SIC								
	Constant				Trend			
	Level		First Differenced		Level		First Differenced	
econ	-2.434	(2)	-6.856***	(5)	-2.471	(2)	-13.790 ***	(1)

Table A.5.3: VAR Length Selection Output SVAR I.

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-241.588				.000686	1.22908	1.24099	1.25913
1	369.613	1222.4	9	0.000	.000033	-1.79705	-1.74944	-1.67685
2	405.962	72.698	9	0.000	.000029	-1.93448	-1.85117	-1.72414*
3	424.941	37.958	9	0.000	.000028*	-1.98463*	-1.86561*	-1.68414
4	431.826	13.771	9	0.131	.000028	-1.974	-1.81927	-1.58337
5	439.914	16.176	9	0.063	.000028	-1.96942	-1.77899	-1.48864
6	443.569	7.3097	9	0.605	.000029	-1.94256	-1.71642	-1.37163
7	450.363	13.587	9	0.138	.000029	-1.93147	-1.66963	-1.2704
8	456.582	12.438	9	0.190	.00003	-1.9175	-1.61995	-1.16628
9	462.446	11.727	9	0.229	.00003	-1.90174	-1.56848	-1.06038
10	467.289	9.6875	9	0.376	.000031	-1.88085	-1.51189	-.949344
11	472.171	9.7628	9	0.370	.000031	-1.86016	-1.45549	-.838502
12	487.265	30.187	9	0.000	.00003	-1.89078	-1.4504	-.778977
13	491.655	8.7814	9	0.458	.000031	-1.86761	-1.39153	-.665669
14	494.563	5.8146	9	0.758	.000032	-1.837	-1.32521	-.544906
15	503.559	17.993	9	0.035	.000032	-1.83698	-1.28949	-.454743
16	511.344	15.57	9	0.076	.000032	-1.83088	-1.24768	-.358492
17	512.647	2.6063	9	0.978	.000034	-1.7922	-1.17329	-.229669
18	515.479	5.6641	9	0.773	.000035	-1.7612	-1.10659	-.108528
19	519.061	7.1627	9	0.620	.000036	-1.73397	-1.04366	.008847
20	524.982	11.843	9	0.222	.000036	-1.7185	-.992483	.114462
21	540.556	31.147	9	0.000	.000035	-1.75154	-.989809	.171576
22	547.091	13.071	9	0.159	.000036	-1.73915	-.941719	.274106
23	553.469	12.755	9	0.174	.000036	-1.72597	-.892834	.377431
24	558.294	9.6501	9	0.380	.000037	-1.70499	-.836148	.488557
25	568.279	19.971	9	0.018	.000037	-1.70995	-.805395	.573749
26	578.263	19.967	9	0.018	.000037	-1.71489	-.774631	.658953
27	583.097	9.6689	9	0.378	.000038	-1.69396	-.717993	.770032
28	589.504	12.812	9	0.171	.000038	-1.68092	-.669253	.873212
29	604.331	29.656	9	0.001	.000037	-1.71021	-.662832	.934072
30	612.275	15.887	9	0.069	.000037	-1.7049	-.621816	1.02953
31	620.835	17.12*	9	0.047	.000038	-1.70269	-.583899	1.12188
32	625.353	9.0358	9	0.434	.000039	-1.68016	-.52567	1.23455
33	628.096	5.4875	9	0.790	.00004	-1.64873	-.458526	1.35614
34	632.802	9.4105	9	0.400	.000041	-1.62714	-.401238	1.46787
35	640.331	15.059	9	0.089	.000041	-1.61975	-.358143	1.5654
36	646.051	11.439	9	0.247	.000042	-1.60327	-.305952	1.67203

Table A.5.4: Lagrange-Multiplier Test for Autocorrelation SVAR I.

Lagrange-Multiplier Test			
VAR Lag Length: 3			
Lag	Chi-Squared	Degrees of Freedom	Prob > Chi-Squared
1	14.3942	9	0.10898
2	19.9017	9	0.01853
3	7.4037	9	0.59516
4	11.4477	9	0.24627
5	12.8113	9	0.17133
6	11.7374	9	0.22852
7	14.9808	9	0.09147
8	7.1862	9	0.61774
9	12.7721	9	0.17319
10	6.8593	9	0.65177
11	11.2806	9	0.25697
12	17.2157	9	0.04544

Table A.5.5: Multivariate Ljung-Box Portmanteau Test for Autocorrelation SVAR I.

Multivariate Ljung-Box Portmanteau	
VAR Lag Length: 3	
Test Statistic (3 Variables, 12 Lags)	108.6019
Prob > Chi-Squared (81)	0.0221

Table A.5.6: Lagrange-Multiplier Test for Autocorrelation SVAR I.

Lagrange-Multiplier Test			
VAR Lag Length: 5			
Lag	Chi-Squared	Degrees of Freedom	Prob > Chi-Squared
1	7.2269	9	0.61351
2	7.9972	9	0.53443
3	5.4676	9	0.79179
4	4.0722	9	0.90660
5	14.4077	9	0.10854
6	8.2378	9	0.51037
7	13.2492	9	0.15165
8	6.1328	9	0.72656
9	12.8756	9	0.16832
10	5.7801	9	0.76171
11	11.5805	9	0.23801
12	15.1061	9	0.08806

Table A.5.7: Multivariate Ljung-Box Portmanteau Test for Autocorrelation SVAR I.

Multivariate Ljung-Box Portmanteau	
VAR Lag Length: 5	
Test Statistic (3 Variables, 12 Lags)	81.9232
Prob > Chi-Squared (63)	0.0548

Table A.5.8: Normality Tests of SVAR I.

Jarque-Bera			
Equation	Chi-Squared	Degrees of Freedom	Prob > Chi-Squared
prod	927.824	2	0.00000
econ	451.460	2	0.00000
price	128.868	2	0.00000
All	1508.152	6	0.00000

Skewness				
Equation	Skewness	Chi-Squared	Degrees of Freedom	Prob > Chi-Squared
prod	-1.2695	115.230	1	0.00000
econ	-.04457	0.142	1	0.70629
price	.16446	1.934	1	0.16434
All		117.306	3	0.00000

Kurtosis				
Equation	Kurtosis	Chi-Squared	Degrees of Freedom	Prob > Chi-Squared
prod	9.7424	812.593	1	0.00000
econ	8.0248	451.318	1	0.00000
price	5.6648	126.934	1	0.00000
All		1390.846	3	0.00000

Table A.5.9: The Forward Error Variance Decomposition of SVAR I.

Forward Error Variance Decomposition				
Horizon			Shocks	
		ε^{pro}	ε^{eco}	ε^{rop}
prod	*1*	1	0	0
	4	.979542	.008035	.012424
	8	.976183	.008945	.014872
	12	.974735	.010043	.015222
	18	.974018	.010744	.015238
econ	*1*	.000321	.999679	0
	4	.011112	.973739	.015149
	8	.011690	.971048	.017262
	12	.011328	.973202	.015470
	18	.011192	.974003	.014805
price	*1*	.003777	.045933	.950290
	4	.009096	.110891	.880013
	8	.010883	.112273	.876845
	12	.011333	.112631	.876037
	18	.011378	.112782	.875840

Table A.6.1: Oil Price Correlations. Sample Period 1988-2010.

	Brent	*WTI*	*WTS*	*F-D*	*Urals*	*Minas*	*Tapis*	*I-Light*	*I-Heavy*
Brent	1,0000								
West Texas Intermediate	0,9987	1,0000							
West Texas Sour	0,9981	0,9988	1,0000						
Fatah-Dubai	0,9976	0,9959	0,9974	1,0000					
Urals	0,9988	0,9971	0,9982	0,9987	1,0000				
Minas	0,9980	0,9967	0,9974	0,9979	0,9981	1,0000			
Tapis	0,9989	0,9979	0,9967	0,9967	0,9973	0,9978	1,0000		
Iranian Light	0,9989	0,9975	0,9983	0,9988	0,9995	0,9982	0,9977	1,0000	
Iranian Heavy	0,9983	0,9965	0,9978	0,9986	0,9996	0,9978	0,9965	0,9996	1

Source: OECD.Stat.org.

Table A.6.2: Unit Root Tests SVAR II.

***,** and* respectively indicate 1%, 5% and 10% significance. Lags used in parentheses.

DF-GLS, (SIC)	Constant				Trend			
	Level		First Differenced		Level		First Differenced	
prod	0.763	(1)	-0.797	(11)	-3.055**	(1)	-5.270***	(3)
econ	-1.072	(7)	-9.578***	(1)	-3.219**	(2)	-10.654***	(1)
price	-1.926*	(1)	-8.050***	(1)	-2.804*	(1)	-8.794***	(1)
fir	0.300	(1)	-9.671***	(1)	-1.659	(1)	-10.037***	(1)
unem	-0.566	(1)	-6.072***	(3)	-0.692	(1)	-6.101***	(3)
inf	-1.051	(6)	-1.051	(6)	-2.303	(6)	-2.303	(6)
3M-N	-0.059	(3)	-1.778*	(2)	-2.106	(3)	-3.671***	(2)
exc	-1.475	(1)	-1.835*	(6)	-1.475	(1)	-1.835*	(6)

DF-GLS, (mAIC)	Constant				Trend			
	Level		First Differenced		Level		First Differenced	
prod	0.763	(1)	-0.587	(15)	-2.052	(7)	-1.916	(15)
econ	-1.072	(7)	-2.461**	(13)	-2.662*	(7)	-3.454**	(13)
price	-1.164	(4)	-3.099***	(10)	-2.032	(4)	-3.993***	(10)
fir	0.109	(2)	-3.730***	(8)	-1.659	(1)	-4.090***	(8)
unem	-1.038	(6)	-2.932***	(11)	-1.278	(6)	-2.935**	(11)
inf	-0.507	(12)	-0.266	(15)	-1.170	(15)	-1.808	(15)
3M-N	0.135	(4)	-0.591	(12)	-1.562	(6)	-1.829	(12)
exc	-0.367	(14)	-1.311	(10)	-0.367	(14)	-0.367	(10)

P&P, 5 Lags	Constant		Trend	
	Level	First Differenced	Level	First Differenced
prod	-1.478	-18.480***	-3.930**	-18.498***
econ	-2.797*	-10.114***	-3.178*	-10.090***
price	-1.577	-9.737***	-2.654	-9.735***
fir	-0.589	-15.416***	-2.271	-15.415***
unem	-1.523	-15.632***	-2.483	-15.720***
inf	-12.162***	-31.629***	-12.382***	-31.594 ***
3M-N	-2.371	-15.902***	-2.883	-15.898***
exc	-2.028	-12.812***	-2.028	-12.812***

ADF, SIC	Constant				Trend			
	Level		First Differenced		Level		First Differenced	
prod	-1.672	(1)	-5.261***	(11)	-3.933**	(1)	-9.013***	(3)
econ	-2.078	(7)	-11.594***	(1)	-3.190*	(2)	-11.572***	(1)
price	-2.124	(1)	-9.387***	(1)	-3.377*	(1)	-9.396***	(1)
fir	-0.480	(1)	-10.253***	(10)	-2.117	(1)	-10.269***	(1)
unem	-1.455	(1)	-6.142***	(3)	-2.549	(1)	-6.337***	(3)
inf	-5.009***	(6)	-12.128***	(6)	-5.270***	(6)	-12.134***	(6)
3M-N	-2.106	(3)	-7.267***	(2)	-3.034	(3)	-7.265***	(2)
exc	-2.403	(1)	-5.745***	(6)	-3.189*	(1)	-5.798***	(6)

KPSS, BK	Constant				Trend			
	Level		First Differenced		Level		First Differenced	
prod	2.36***	(11)	.088	(11)	.104	(11)	.0427	(11)
econ	.913***	(11)	.0284	(5)	.272***	(11)	.0295	(5)
price	1.39***	(11)	.0878	(8)	.452***	(11)	.0239	(7)
fir	1.91***	(11)	.085	(11)	.173**	(11)	.0655	(11)
unem	.785***	(11)	.273	(12)	.192**	(11)	.164**	(12)
inf	.779***	(8)	.0484	(8)	.257***	(5)	.0199	(8)
3M-N	1.71***	(11)	.125	(14)	.266***	(11)	.0477	(14)
exc	1.15***	(11)	.0561	(8)	.335***	(11)	.0337	(8)

***,** and* respectively indicate 1%, 5% and 10% significance.

Table A.6.3: Follow Up Unit Root Tests in *inf* SVAR II.

	Inflation pre 2001							
	Constant				Trend			
	Level		First Differenced		Level		First Differenced	
ADF	-3.271***	(2)	-4.552***	(10)	-5.149***	(2)	-4.712***	(10)
P&P	-9.547***	(4)	-29.089***	(4)	-10.901***	(4)	-29.036***	(4)
KPSS	.92***	(10)	.054	(3)	.3***	(10)	.0147	(3)

Table A.6.4: VAR Length Selection Output SVAR II.

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1535.65				8.2e-16	-12.0288	-11.9839	-11.9174
1	2163.95	1256.6	64	0.000	9.7e-18	-16.4721	-16.0687*	-15.4694*
2	2230.28	132.65	64	0.000	9.5e-18	-16.4904	-15.7284	-14.5964
3	2318.46	176.37	64	0.000	7.9e-18	-16.6808	-15.5603	-13.8955
4	2412.6	188.27	64	0.000	6.3e-18*	-16.9181	-15.439	-13.2415
5	2446.22	67.244	64	0.367	8.1e-18	-16.6789	-14.8413	-12.111
6	2488.98	85.517	64	0.038	9.7e-18	-16.5116	-14.3155	-11.0524
7	2534.12	90.273	64	0.017	1.2e-17	-16.3631	-13.8084	-10.0126
8	2572.67	77.111	64	0.126	1.4e-17	-16.1628	-13.2495	-8.92097
9	2629.5	113.66	64	0.000	1.6e-17	-16.1063	-12.8345	-7.97322
10	2675.96	92.924	64	0.011	1.9e-17	-15.9682	-12.3378	-6.94383
11	2723.7	95.47	64	0.007	2.3e-17	-15.8401	-11.8512	-5.92446
12	2769.29	91.178	64	0.014	2.9e-17	-15.6952	-11.3477	-4.88819
13	2818.67	98.775	64	0.003	3.6e-17	-15.5801	-10.874	-3.88184
14	2870.7	104.05	64	0.001	4.4e-17	-15.4858	-10.4212	-2.89626
15	2930.52	119.63	64	0.000	5.3e-17	-15.4529	-10.0297	-1.97202
16	3000.37	139.7	64	0.000	5.9e-17	-15.4989	-9.7172	-1.12679
17	3049.7	98.661	64	0.004	8.0e-17	-15.3834	-9.24314	-.11998
18	3105.96	112.53	64	0.000	1.1e-16	-15.3225	-8.82368	.832213
19	3173.32	134.72	64	0.000	1.4e-16	-15.349	-8.49158	1.69705
20	3281.17	215.7	64	0.000	1.3e-16	-15.6943	-8.47831	2.24307
21	3363.45	164.55	64	0.000	1.6e-16	-15.8382	-8.26364	2.99047
22	3471.1	215.3	64	0.000	1.8e-16	-16.1819	-8.24878	3.53807
23	3642.33	342.46	64	0.000	1.3e-16	-17.0262	-8.73455	3.58504
24	3773.93	263.2*	64	0.000	1.4e-16	-17.5585*	-8.90827	3.94406

Table A.6.5: Lagrange-Multiplier Test for Autocorrelation SVAR II.

Lagrange-Multiplier Test		
VAR Lag Length: 1	Degrees of Freedom: 64	
Lag	Chi-Squared	Prob > Chi-Squared
1	122.5669	0.00001
2	111.0559	0.00024
3	144.7321	0.00000
4	137.1431	0.00000
5	69.4107	0.30015
6	46.6107	0.94982
7	67.0040	0.37440
8	59.6680	0.63028
9	77.5822	0.11845
10	49.9005	0.90174
11	61.6438	0.56030
12	66.6387	0.38634

Table A.6.6: Multivariate Ljung-Box Portmanteau Test for Autocorrelation SVAR II.

Multivariate Ljung-Box Portmanteau	
VAR Lag Length: 1	
Test Statistic (8 Variables, 24 Lags)	1581.5528
Prob > Chi-Squared (1472)	0.0237

Table A.6.7: Lagrange-Multiplier Test for Autocorrelation SVAR II.

Lagrange-Multiplier Test		
VAR Lag Length: 4		Degrees of Freedom: 64
Lag	Chi-Squared	Prob > Chi-Squared
1	59.6609	0.63053
2	96.9591	0.00492
3	90.7255	0.01566
4	65.2728	0.43226
5	54.6402	0.79153
6	72.1126	0.22747
7	69.4730	0.29834
8	54.6368	0.79163
9	79.8239	0.08764
10	58.8200	0.65963
11	56.6929	0.72995
12	70.3650	0.27311

Table A.6.8: Multivariate Ljung-Box Portmanteau Test for Autocorrelation SVAR II.

Multivariate Ljung-Box Portmanteau	
VAR Lag Length: 4	
Test Statistic (8 Variables, 24 Lags)	1301.2542
Prob > Chi-Squared (1280)	0.3333

Table A.6.9: Multivariate Ljung-Box Portmanteau Test for Autocorrelation SVAR II.

Lagrange-Multiplier Test		
VAR Lag Length: 6	Degrees of Freedom: 64	
Lag	Chi-Squared	Prob > Chi-Squared
1	67.9623	0.34387
2	61.6777	0.55908
3	70.3571	0.27332
4	75.6912	0.15045
5	69.6886	0.29213
6	70.6101	0.26639
7	69.2199	0.30573
8	59.6278	0.63168
9	77.1486	0.12528
10	65.9400	0.40959
11	56.6425	0.73155
12	77.2870	0.12307

Table A.6.10: Multivariate Ljung-Box Portmanteau Test for Autocorrelation SVAR II.

Multivariate Ljung-Box Portmanteau	
VAR Lag Length: 6	
Test Statistic (8 Variables, 24 Lags)	1185.0550
Prob > Chi-Squared (1152)	0.2432

Table A.6.11: Normality Tests of SVAR II.

SVAR II

Jarque-Bera			
Equation	Chi-Squared	Degrees of Freedom	Prob > Chi-Squared
prod	97.568	2	0.00000
econ	205.717	2	0.00000
price	1.241	2	0.53757
fir	1.8e+04	2	0.00000
unem	809.245	2	0.00000
inf	369.778	2	0.00000
3-M	107.442	2	0.00000
exc	201.752	2	0.00000
All	2.0e+04	16	0.00000

Skewness				
Equation	Skewness	Chi-Squared	Degrees of Freedom	Prob > Chi-Squared
prod	-.36453	6.024	1	0.01411
econ	-.11621	0.612	1	0.43397
price	.03754	0.064	1	0.80044
fir	1.2702	73.142	1	0.00000
unem	.93618	39.732	1	0.00000
inf	.84158	32.107	1	0.00000
3-M	.15419	1.078	1	0.29920
exc	-.58752	15.648	1	0.00008
All		168.407	8	0.00000

Kurtosis				
Equation	Kurtosis	Chi-Squared	Degrees of Freedom	Prob > Chi-Squared
prod	5.8421	91.544	1	0.00000
econ	7.2541	205.105	1	0.00000
price	3.3223	1.177	1	0.27787
fir	42.88	1.8e+04	1	0.00000
unem	11.24	769.513	1	0.00000
inf	8.4584	337.670	1	0.00000
3-M	6.0635	106.364	1	0.00000
exc	7.0523	186.104	1	0.00000
All		2.0e+04	8	0.00000

Table A.6.12: The Forward Error Variance Decomposition of SVAR II.

Forward Error Variance Decomposition									
Horizon									
		ε^{pro}	ε^{eco}	ε^{rop}	ε^{for}	ε^{une}	ε^{inf}	ε^{3-M}	ε^{exc}
prod	1	1	0	0	0	0	0	0	0
	4	.914737	.022945	.020355	.026904	.003245	.003298	.008001	.000515
	8	.817102	.028224	.098960	.032182	.004392	.011377	.005976	.001788
	12	.813180	.031820	.099324	.023358	.005244	.019940	.005588	.001548
	18	.809636	.033967	.097800	.017303	.007421	.024879	.005590	.003403
econ	1	.001684	.998316	0	0	0	0	0	0
	4	.035242	.869513	.019175	.014257	.003318	.052735	.000331	.005428
	8	.035210	.839785	.032678	.015826	.003377	.065995	.000565	.006564
	12	.036589	.833753	.033227	.017545	.003674	.066039	.000933	.008241
	18	.036743	.832763	.033444	.017865	.003772	.066147	.000970	.008296
price	1	.008094	.049403	.942503	0	0	0	0	0
	4	.018862	.085336	.794656	.018167	.011285	.039619	.011663	.020413
	8	.036612	.081228	.752782	.032608	.012270	.046514	.013423	.024562
	12	.037161	.081404	.747686	.034748	.012372	.046834	.013549	.026246
	18	.037819	.081663	.745123	.035998	.012446	.047023	.013496	.026432
for	1	.000907	4.2e-06	.014503	.984586	0	0	0	0
	4	.002649	.016192	.088878	.823142	.005698	.005790	.042756	.014894
	8	.019226	.031523	.088876	.768038	.016807	.008517	.049666	.017347
	12	.019254	.032000	.090042	.763612	.016790	.009358	.049885	.019060
	18	.019567	.032253	.090810	.761574	.017110	.009539	.049937	.019209
unem	1	.000320	.013824	.020659	2.7e-06	.965194	0	0	0
	4	.024990	.024333	.022095	.001032	.897563	.009095	.009708	.011185
	8	.039050	.028250	.025085	.013083	.838000	.031033	.012100	.013398
	12	.039681	.029129	.025988	.015524	.828955	.032773	.013356	.014594
	18	.040199	.029769	.025856	.015523	.826794	.033298	.013874	.014686
inf	1	.002066	.008729	.015571	.000344	.000032	.973258	0	0
	4	.008602	.014735	.039023	.005600	.006513	.912483	.007549	.005496
	8	.009284	.024218	.039070	.010963	.021887	.871769	.009571	.013238
	12	.011614	.027044	.038855	.011293	.023047	.864762	.010000	.013385
	18	.012120	.027254	.038896	.011368	.023214	.863520	.009987	.013639
3-M	1	.002732	.000298	9.4e-06	.492504	.011611	.000593	.492253	0
	4	.008262	.017754	.037901	.575695	.020231	.003327	.322540	.014290
	8	.012590	.025390	.044549	.567680	.020486	.009700	.298848	.020756
	12	.023153	.025426	.047647	.552924	.024020	.011663	.292193	.022974
	18	.023281	.026348	.048309	.551440	.024812	.011771	.291077	.022961
exc	1	.004684	.023570	.049025	.000097	.002290	.043979	.000023	.876332
	4	.025552	.033338	.057683	.003219	.006888	.067876	.008187	.797258
	8	.040096	.041790	.072763	.011606	.011875	.074517	.022327	.725026
	12	.040321	.043066	.074770	.013092	.012191	.076028	.024868	.715665
	18	.040631	.043400	.074676	.013691	.012448	.076369	.024922	.713862

Appendix B

Figure B.1: Eigenvalue Test for Stability SVAR I.

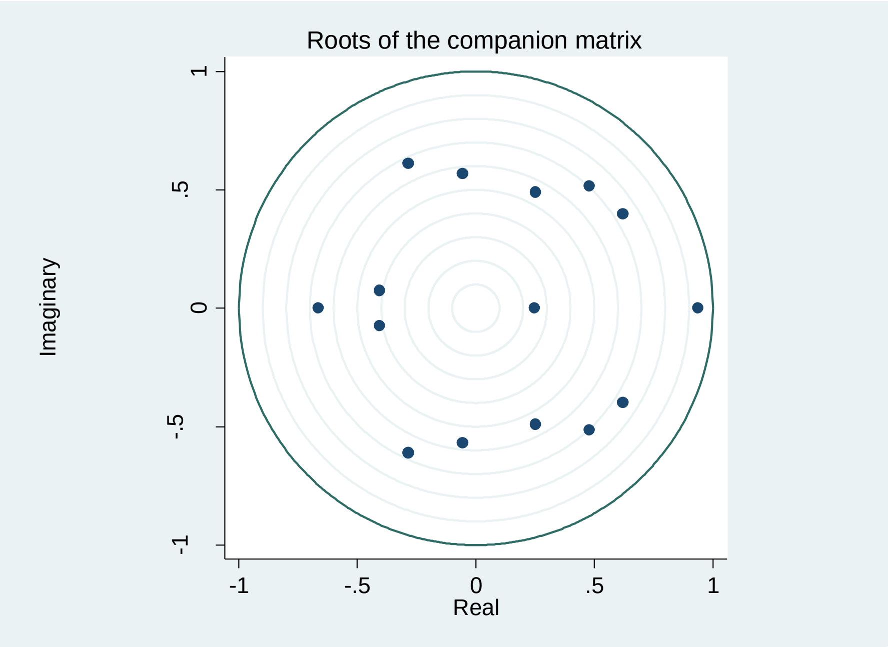
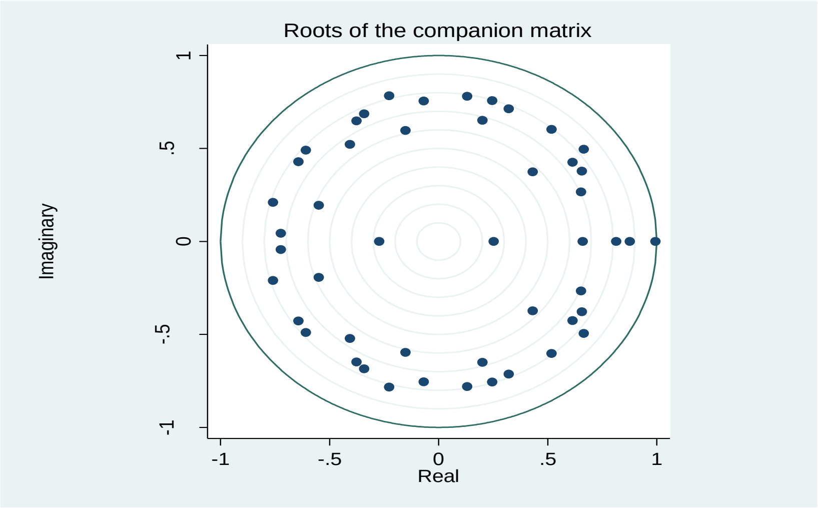


Figure B.2: Eigenvalue Test of Stability SVAR II.



Appendix C

C.1 Unit Root Tests

To avoid the possibility of spurious regressions when dealing with time series it is crucial to examine the data for unit roots. If any indications of unit roots is found the time series are classified as non-stationary. A time series, y_t, is said to be strictly stationary if the joint distribution of $(y_{t_1}, \dots, y_{t_k})$ is exactly as $(y_{t_{1+t}}, \dots, y_{t_{k+1}})$ for all t, where k is an arbitrary positive integer and $(t_1, \dots, t_k)$ is a collection of k positive integers. This means that strict stationarity requires that the joint distribution of $(y_{t_1}, \dots, y_{t_k})$ is invariant under time shifts. In empirical work it is however the norm to accept a weaker form of stationarity summed up below:

$$E(y_t) = \mu \tag{C.1}$$

$$Var(y_t) = \sigma^2 \tag{C.2}$$

$$Cov(y_t, y_{t-s}) = \gamma_s \tag{C.3}$$

Where **equation C.1** and **C.2** respectively postulates that the expected value of a variable should have a constant mean and variance, while **equation C.3** assumes that the covariance of a variable is dependent on s and not t. Whenever time series does not fulfill these definitions there is a risk that regression analysis produces spurious regressions. In other words, models may predict relationships that empirically are not true.

C.1.1 Augmented Dickey-Fuller

Analytically the augmented Dickey-Fuller consists of testing the null hypothesis,$H_0: \beta = 0$, in **equation C.4**. The term δt refers to a time specific trend parameter, while α is a constant and represent a drift.

$$\Delta y_t = \alpha + \beta y_{t-1} + \delta t + \varphi_1 \Delta y_{t-1} + \varphi_2 \Delta y_{t-2} + \dots + \varphi_k \Delta y_{t-k} + \varepsilon_t \tag{C.4}$$

To decide the maximum amount of lags allowed in the unit roots testing I use the Schwert Information Criteria (Schwert, 1989):

$$int\left[12\left\{\frac{T+1}{100}\right\}^{0.25}\right] \tag{C.5}$$

To find the optimal amount of lags in the unit roots testing I have used several information criteria. The first one is an updated version of the Akaike Information Criteria (AIC) developed by Ng & Perron (2000) called the modified Akaike Information Criteria (MAIC):

$$MAIC(k) = ln(\widehat{rmse}^2) + \frac{2\{\tau(k)+k\}}{T-k_{max}} \tag{C.6}$$

Where:

$$\tau(k) = \frac{1}{\widehat{rmse}^2}\hat{\beta}_0^2 \sum_{t=k_{max}+1}^{T} \hat{y}_t^2 \tag{C.7}$$

The second information criterion is the Schwarz Information Criteria (SIC): The Schwarz Information Criteria can be calculated using the log likelihood or the sum of squared errors from a regression. In this thesis the sum-of-squared errors are used.

$$SIC = ln[(\widehat{rms})^2] + (k+1)\frac{ln(T-k_{max})}{(T-k_{max})} \tag{C.8}$$

Where:

$$\widehat{rmse} = \frac{1}{(T-k_{max})}\sum_{t=k_{max}+1}^{T} \hat{e}_t^2 \tag{C.9}$$

The augmented Dickey-Fuller has some weaknesses, especially regarding the variance of the sample examined. Hamori (1997) concluded that when samples have an upward shift in variance this might lead to spurious regressions while Kim et al. (2002) also found indications for spurious regressions when the variance contained downward shifts.

C.1.2 Phillips & Perron

The Phillips & Perron (1988) is another unit root test which has the same null hypothesis as the ADF and will also fit the **equation C.1** as the augmented Dickey-Fuller. The difference between the two tests lies in how the problem of auto correlation is countered. While the augmented Dickey-Fuller adds lags of the first-differenced variable, the Phillips & Perron use Newey-West (1987) standard errors. That is, the Phillips & Perron test statistics have been made robust due to Newey-West heteroskedasticity and autocorrelation-consistent covariance matrix estimator. This also implies that while the augmented Dickey-Fuller test loses observations due to the inclusions of lags the Phillips & Perron test keep all observations. As such the Phillips & Perron test serves as a complement to augmented Dickey-Fuller.

The amount of lags used to calculate the standard errors in the Phillips & Perron test is the following:

$$int\left[4\left\{\frac{T}{100}\right\}^{\frac{2}{9}}\right] \tag{C.10}$$

The Phillips & Perron test gives two test statistics outputs, the $Z(\tau)$ and $Z(\rho)$. The conclusions of unit roots from these two tests are seldom conflicting and as such I only report the $Z(\tau)$ output. I will however make the reader aware of any conflicting results from these two outputs.

C.1.3 KPSS

The KPSS is a unit roots tests which has the opposite null hypothesis than the two above mentioned tests. That is, the null hypothesis is that the series examined are stationary. Developed by Kwiatkowski, Phillips, Schmidt and Shin (KPSS) in 1992 the denominator of this test is an estimate of the long run variance of a time series. The autocorrelation function this is based on could either stem from the Bartlett or the quadratic spectral kernel. The kernels find the optimal amount of lags within the Schwert Information Criterion previously explained (see **equation C.2**). I report the KPSS results from both kernels.

C.1.4 Dickey-Fuller Generalized Least Square

The Generalized Least Square version of Dickey-Fuller follows the same test mechanics as the ordinary augmented Dickey-Fuller (see **equation C.1**). The difference is that the DF-GLS use Generalized Least Square-detrended data. As with augmented Dickey-Fuller we can use the Generalized Least Square with a trend or drift specification. Cook (2004:311) finds that the DF-GLS unit roots test is much more robust than the augmented Dickey-Fuller when the unit root process has decreases in innovation variance, a weakness found by Kim (2002).

C.2 VAR Lag Lengths

When constructing a VAR model the lag lengths selection is critical in order to get a model which reflects the true relationship between the variables, but at the same time it is important to avoid the inclusion of too many variables. Firstly, this is important due to a reduction in the degrees of freedom for each additional lag. Secondly, the inclusion of too many lags enables the VAR model to increasingly pick up variations in the time series, but it is a risk that this is random variations instead of a reflection of the true relationship. Increased forecasting error variance could also be a result of too many lags included in the model. A model with many variables often tends to produce faulty out of sample predictions (Enders, 2010).

To decide the amount of lags I use several information criterions and make a balanced decision on how many lags to use. The information criterions used are

Final Prediction Error (FPE), (Lütkepohl, 2005:147)

$$FPE = |\Sigma_u \quad | \left(\frac{T+K_p+1}{T-K_p-1}\right)^K \tag{C.15}$$

All the other information criteria make us of the log likelihood (LL) of the VAR system which can be presented as (Hamilton, 1994:295-296):

$$LL = -\left(\frac{T}{2}\right)\left\{ln\left(\left|\widehat{\Sigma} \quad \right|\right) + Kln(2\pi) + K\right\} \tag{C.16}$$

Likelihood-ratio test (LR):

$$LR(j) = 2\{LL(j) - LL(j-1)\} \tag{C.17}$$

Akaike`s Information Criterion (AIC), by Akaike (1973),

$$AIC = -2\left(\frac{LL}{T}\right) + \frac{2t_p}{T} \tag{C.18}$$

Schwarz`s Bayesian Information Criterion (SBIC) by Schwarz (1978)

$$SBIC = -2\left(\frac{LL}{T}\right) + \frac{ln(T)}{T}t_p \tag{C.19}$$

Hannan & Quinn Information Criterion (HQIC) by E.J. & Quinn (1979).

$$HQIC = -2\left(\frac{LL}{T}\right) + \frac{2ln\{lnT\}}{T}t_p \tag{C.20}$$

C.3 Autocorrelation and White Noise

The random vectors ε_t are a white noise process if:

$$E(\varepsilon_t) = 0 \tag{C.21}$$

$$E(\varepsilon_t \varepsilon'_t) = \sum_\varepsilon \tag{C.22}$$

$$E(\varepsilon_t \varepsilon'_s) = 0 \;\; if\ s \neq t \tag{C.23}$$

If there is autocorrelation in the error terms in the VAR model this will conflict with the underlying statistical assumptions necessary to produce consistent and asymptotically efficient estimates. Autocorrelations could also produce biased standard errors such that the confidence interval is too small and thereby provide spurious significant relationships.

For testing the whiteness of our residuals I primarily use the Lagrange Multiplier which is the default option in STATA. For robustness I also complement the Lagrange Multiplier with the Portmanteau test.

The Lagrange Multiplier test assumes a VAR model for the error, ε_t:

$$\varepsilon_t = D_1\varepsilon_{t-1} + \cdots + D_i\varepsilon_{t-i} + v_t \tag{C.24}$$

And test the following hypothesis:

$$H_0\colon D_1 = \cdots = D_i = 0\ vs. H_1\colon D_j \neq 0\ for\ at\ lest\ one\ j < i \tag{C.25}$$

The testing procedure could either follow the Breusch-Godfrey tests or be based on the Johansen method (1995). Since STATA by default utilize Johansen method I report the results from this technique.

The Portmanteau test jointly tests the significance of all error autocorrelations up to a set order, i. R_p is defined as the autocorrelation matrix for lag p among the errors. The Portmanteu test then evaluates:

$$H_0\colon R_i = (R_1, \ldots, R_h) = 0 \;\; vs.\;\; H_1\colon R_p \neq 0 \tag{C.26}$$

The test statistic is:

$$Q_i = T \sum_{p=1}^{i} tr\left(\hat{R}_p^T \hat{R}_\varepsilon^{-1} \hat{R}_p \hat{R}_\varepsilon^{-1}\right) \tag{C.27}$$

Where $\hat{R}_p$ is the estimated autocorrelation of lag p, while $\hat{R}_\varepsilon$ is the estimated correlation matrix of ε_t. Johansen (1995:179) is critical to the use of Portmanteau in cointegration settings due to the underlying assumptions regarding unit roots. I therefore restrain the use of Portmanteau to settings where the variables are stationary. By default the Portmanteau test uses the criteria in **equation C.28** to determine how many lags to use, where N is the number of observations.

$$min\left(\frac{N}{2} - 2{,}40\right) \tag{C.28}$$

This leads however to a lag order of 40 when performing the tests in SVAR II which could be too many. The more lags included the higher the chance of obtaining results that indicate no autocorrelations. I therefore restrict the amount of lags to equal two years of observations (24 lags) which should increase the likelihood of autocorrelation and hence results which indicate no autocorrelation should be more robust.

C.4 Stability

In order to make inference from VAR and SVAR models we must have variables which are covariance stationary. That is, the variables in y_t are covariance stationary if their first two moments exist and are independent of time, see **equation C.1-C.3**. In addition, interpretation of VAR models requires that the model is invertible and has an infinite-order vector moving average representation. When this stability criterion is met the impulse reaction functions and forecast error variance decompositions have known interpretations.

Analytically the stability test creates a companion matrix and calculates the roots directly by solving the characteristics polynomial. Eigenvalues are the output of the test which determines if the model is stable or explosive. If the eigenvalues are strictly lower than one (inside the unit circle) the eigenvalues are stationary and the model is stable. If one or more roots are take the value of unity (on the unit circle) the process is non-stationary and lastly, if one or more roots are strictly higher than one (outside the unit circle) the process is explosive. In practice a stable model means that a shock from a variable eventually fade away over time, while an explosive model contains shocks that increases over time and lead to unrealistically extreme short-rate projections, thus invalidating the model.

C.5 Normality of the Residuals

In order to make inference of the observations the distribution of the variables coefficients must be known and a normality distribution is a standard assumptions. Wooldridge (2003:753) states that if the random variables defined over populations are normally distributed this simplify the probability calculations. If the normality distribution assumption is not met the coefficients confidence interval might be affected. Since it is not possible to directly observe if this assumption is met the residuals, ε_t, are used as a proxy. According to Verbeek (2008:195) non-normality of the residuals does not necessary invalidate the consistency of the estimators or its asymptotic distribution, but heavily skewed distributions of the residuals may indicate that some variables needs to be transformed. It is however possible to get a good approximation for the distribution of the sample average, $\bar{y}$, even when dealing with non-normal distribution (Wooldridge 2003:787). Even though there are no standard distribution a large sample size negates the effect of non-normality due to the central limit theorem.

To test for normality three test statistics is reported, the skewness statistic, the kurtosis statistic and lastly the Jarque-Bera which is a combination of the first two. The results reported are all tests against the null hypothesis that the K disturbances follow a K-dimensional multivariate normal distribution. Regarding the VAR the test statistics are computed on the orthogonalized VAR residuals and the Cholesky decomposition of the estimated variance-covariance matrix of the disturbances is utilized to orthogonalize the residuals. While in the SVAR normality tests the estimated structural decomposition $\hat{A}^{-1}\hat{B}$ on

$\hat{C}$ is used to orthogonalize the residuals of the underlying VAR. Rejection of the null hypothesis indicates a model misspecification.

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