MASTER THESIS

Once more... a Story about Oil and Stock Markets

HELLENIC REPUBLIC
UNIVERSITY OF MACEDONIA

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August 2018

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER IN ECONOMICS

Interdepartmental Programme of Postgraduate Studies
in Economics

with specialization in
Applied Economics and Finance

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Acknowledgements

I would first like to express my deepest gratitude to my supervisor Prof. Theodore Panagiotidis for the continuous support and motivation from the first day of this master programme. His useful comments and suggestions helped the most to the improvement of this dissertation. I would also like to express my appreciation to all my professors for their guidance through the years.

Moreover, I would like to thank my colleagues and friends for their support and the great time we spent together these years. Special thanks should go to Thanasis for the interesting and instructive talks we had, as well as for his general assistance during this programme.

Last but not least, I am particularly grateful to my family and Niki for their patience and continuous encouragement. Without them, this accomplishment would not have been possible. Thank you.

Abstract

In this study we take a fresh look on the relationship between oil and stock markets. Using a rolling SVAR model, we examine this relationship in a time-varying framework, which, to the best of our knowledge, has not been attempted before in the literature. Following a historical decomposition and an impulse response analysis, we examine this relationship on 15 net oil-importing and oil-exporting countries as well as on 49 US industries, using the largest dataset available, ranging from 1973:1 to 2016:12. The results indicate that the oil prices respond to a multitude of different structural shocks that vary over time. Another interesting finding is that there is significant time variation on the responses of the stock market returns to the different oil price shocks, while we also find that the responses of each country's share prices highly depend both on the underlying cause of the oil price change and on the net position of the country in the oil market. Finally, examining the role of economic policy uncertainty on this relationship, we find evidence that it plays an important role in the transmission of the oil price shocks to the stock market.

Keywords: Stock Returns, Oil Market Shocks, Economic Policy Uncertainty, Rolling SVAR, Oil-importing and Oil-exporting Countries, US Industries

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1. Introduction

Oil is maybe the only commodity involved in almost every aspect of modern lifestyle. It is one of the most important production factors, while it also plays a major role in transportation as well as in the heating process. Hence, crude oil and its derivatives, such as heating oil and gasoline, are the most tradable commodities in modern history. In addition, oil prices have traditionally been more volatile than other commodity prices since the 2nd World War. Thus, someone can understand why oil is so important for the global economy.

Oil price increases are responsible for economic recessions as they affect productivity, inflation, investments and other economic variables and thus, they reduce economic growth. More specifically, increases in oil prices lead to higher production and transportation costs. The consequence of such increases in costs is higher inflation. These developments negatively affect investments and productivity, which in turn lead to lower economic growth and recessions. Moreover, sharp oil price changes, whatever the sign, lead to increases in risk and uncertainty, which again negatively affect investments and economic growth in general.

On the other hand, it is equally important to identify the determinants of the stock market prices, not only because they are considered as leading indicators for the domestic and global economies, but also because they reflect the expected profits of the companies. Especially in the more recent years, the financialization of the commodity markets and the increased participation of speculative traders have led to a bigger impact of financial markets on economic conditions, increasing the importance of identifying the drivers of financial variables.

In that line, we have good theoretical reasons to expect that the price of oil is a major determinant of stock market returns. The rationale is that the stock prices are the present value of firms' future cash flows, which depend directly and indirectly on changes in macroeconomic factors. The direct impact is through shrinking the expected profits of the firms, while the indirect one is through their impact on interest rates, used to discount the future cash flows. As far as oil price shocks can affect these macroeconomic factors, they can also impact the stock market returns.

Is there any difference though between oil-importing and oil-exporting countries? Theoretically, oil price increases are expected to have a positive impact on oil-exporting countries, as the country's income will increase. The increased income is expected to create greater investments, which further lead to higher economic growth. In such case, and if the stock markets are efficient, they will react positively. On the other hand, oil price increases are expected to have the opposite results on oil-importing countries, as they lead to higher production costs. The consequences of these increases in costs are higher consumer prices and thus lower consumption. This further leads to lower production and higher unemployment. Stock markets tend to react negatively in such event. Consequently, changes in oil prices may lead to a transfer of wealth from oil-importing to oil-exporting countries.

Having said that, market participants and policy makers need a framework that identifies how oil price movements affect stock market returns. In this study, we take a fresh look on this relationship by employing time-varying techniques in order to identify the effects of oil price shocks on the stock market returns through the years. The analysis is conducted for 15 countries with different characteristics, as we argue that it is important to identify factors that are common across countries rather than country-specific.

The remainder of this paper is organized as follows. Section 2 reviews the empirical literature and lays the ground on the methodology employed in this study; Section 3 discusses the contributions of this paper and the different scenarios we examine; Section 4 describes the dataset; Section 5 presents the methodology; Section 6 provides the empirical results and Section 7 concludes.

2. Literature Review

Given the essential role of crude oil in the world economy, the relationship between oil prices and macroeconomic variables has been extensively studied. In a seminal work, Hamilton (1983) showed that, until that period, 7 out of 8 US postwar recessions had been preceded by sharp oil price increases. In another paper, Hamilton (2011) noted that this ratio has become 10 out of 11. In the more recent years, the literature on the oil-macro relationship has been widening with the focus shifting, besides GDP, also to other macroeconomic variables such as interest rates, inflation, unemployment, etc. Some influential papers are Bernanke et al. (1997), Hooker (2002), Barsky and Kilian (2004), Blanchard and Gali (2007), Segal (2011), Rahman and Serletis (2011), Baumeister and Peersman (2013), Lippi and Nobili (2012), Jo (2014), Cunado et al. (2015), Mohaddes and Pesaran (2017), among others. The majority of these studies voice the opinion that oil price increases exert a significant and negative impact on economic variables in most countries. However, some studies found that these effects have become smaller in the more recent years (see, e.g., Blanchard and Gali (2007), Cologni and Manera (2009), among others).

Despite the fact that the oil-macro literature dates back to the early 80s, the relationship between oil and stock markets has been extensively studied only in the last two decades, and especially in the more recent years, after the surge in oil prices in the summer of 2008. The first attempts to examine this relationship are by Jones and Kaul (1996) and Huang et al. (1996). These studies reveal a negative impact of oil price increases on stock market returns.

However, both these early studies and the subsequent ones provided inconclusive results on this relationship, probably due to their assumption of oil price exogeneity or due to differences in countries and datasets used. More specifically, despite that many authors found a negative relationship (Ciner (2001), Papapetrou (2001), Basher and Sadorsky (2006), Park and Ratti (2008)), there are others who document no or very weak relationship between oil and stock markets (Maghyereh (2006), Zarour (2006), Cong et al. (2008)).

Kilian (2009) criticized all these early conventional studies because economists considered the oil price changes as exogenous. However, Kilian (2009) and Kilian and Park (2009), building on a SVAR model, showed that changes in macroeconomic variables cause oil price changes, leading to the decomposition of such oil price changes into the structural shocks hidden behind them. Thus, different sources of oil price shocks may induce non-uniform effects on certain economic variables. Therefore, it is very important to distinguish if the oil price change comes from the demand or from the supply-side, as it may imply different effects on the stock returns. Hence, the conventional wisdom that increases in oil prices always lead to depreciation in the stock market shares is not necessarily the case anymore. This helps to explain the resilience of the stock markets to the surge in oil prices in the period 2002-2008.

Following the seminal work of Kilian (2009) and Kilian and Park (2009), many studies conducted by employing SVAR models in order to identify the origins of the oil price changes (see, e.g., Apergis and Miller (2009), Basher et al. (2012), Wang et al. (2013), Gupta and Modise (2013), Fang and You (2014), Broadstock and Filis (2014), Gunter (2014), Kang et al. (2016)). In general, these studies found that the demand-side shocks exert a bigger impact on stock market returns than the supply-side ones.

However, these studies come also with a deficit. The results may change considerably when the sample changes. Thus, studies with datasets over different time periods do not provide always the same results. This is something reasonable as the relationship between oil and stock markets is changing over time, because the sources of oil price shocks (i.e. demand- or supply-side) are also changing through the years. This observation makes necessary to examine this relationship in a time-varying framework.

In that line, there is a growing literature employing time-varying correlation models, such as BEKK and DCC, to examine this relationship in a dynamic environment. For instance, some interesting studies include Choi and Hammoudeh (2010), Filis et al. (2011), Broadstock et al. (2012), Antonakakis et al. (2013), Chang et al. (2013), Guesmi and Fattoum (2014), showing that the correlations between oil and stock markets are changing over time.

However, one major disadvantage of these studies is that correlation does not mean causality. Thus, even though these studies have successfully identified the time varying correlations, they do not tell us anything about the causal relationships between the two markets. For this reason, we argue that in order to have a complete picture of the dynamic relationship between oil and stock market prices, it is better to employ time-varying techniques that take into account the direction of causality. To the best of our knowledge, there is only one attempt in that line. Foroni et al. (2017) employed a Bayesian TVP-SVAR model for the US. They conducted an impulse response analysis, finding that there is substantial degree of time variation on the responses. More specifically, they found that while oil supply shocks historically do not have a large impact on stock returns, the demand-side ones exert a significant impact on the stock markets over the larger part of the sample, and especially during the Global Financial Crisis (hereafter GFC) period.

Another strand of the literature, instead of examining the relationship between oil prices and aggregate stock market indices in different countries, focuses on the effects of oil price changes on the stock returns of different industries. Some notable studies include those by Hammoudeh and Li (2005), Cong et al. (2008), Nadha and Faff (2008), Kilian and Park (2009), Scholtens and Yurtsever (2012), Arouri and Nguyen (2010), Broadstock and Filis (2014), Caporale et al. (2015), Li et al. (2017), among others. The general conclusion of these studies is that only the oil-related or oil-substitute sectors, such as the Oil & Gas and the Mining ones, are positively affected by higher oil prices. On the other hand, the majority of the other sectors, such as Food, Retail, Computer, Autos, etc., are negatively affected from positive changes in oil prices. Again, the results may change considerably when the span of the dataset changes.

Finally, there is a resurgence of interest on the determinants of economic policy uncertainty in the last years, due to some well-known events that took place recently, such as the GFC of 2007-2009, the oil price collapse in the early 2014, the Brexit vote in the UK's referendum, etc. (see e.g., Bloom (2009), Bachman et al. (2013), Antonakakis et al. (2013)). Thus, examining the effects of oil price shocks on economic policy uncertainty is rather important (see, inter alia, Antonakakis et al. (2014), Kang et al. (2017), Degiannakis et al. (2018)). Moreover, there are some authors that take into account economic policy uncertainty, when analyzing the effects of oil price changes on the asset prices (see e.g. Kang and Ratti (2013), Kang et al. (2016), Kang et al. (2017)). Overall, their findings suggest that only oil price shocks stemming from the demand-side have long-term consequences for economic policy uncertainty. Moreover, a negative relationship between increases in economic policy uncertainty and stock market returns has been identified.

3. Scenarios and Contributions

The whole analysis is conducted through examining three different scenarios. The first one relies on the seminal works of Kilian (2009) and Kilian and Park (2009). As mentioned in the previous section, Kilian (2009) changed the way that economists treat oil prices, as he made the oil price variable endogenous to the system. He employed a SVAR model for the oil market, containing the following three variables: global oil production, real economic activity and real oil price. His results indicate that oil prices are mostly affected by the demand- rather than the supply-side shocks. Subsequently, Kilian and Park (2009) augment this trivariate SVAR model with the US aggregate stock market returns variable, in order to assess the effects of oil price changes on the US stock market. Following an impulse response analysis, they found that the responses of the stock returns highly depend on the underlying cause of the oil price change. In the first scenario, we replicate, confirm and extend in time these two pioneering studies.

The second scenario concerns the same analysis, but this time in a time-varying framework to better capture the dynamic nature of this relationship. That is, we estimate the SVAR model using rolling samples and we subsequently plot the impulse responses of the stock market returns to the different oil price shocks in time. To the best of our knowledge, this is only the second attempt to conduct such analysis. Foroni et al. (2017) first tried to capture the time-varying nature of this relationship, but they only focus on the US. In this paper, we conduct this analysis for 15 countries with different characteristics as well as for 49 US industries. We find significant time variation in the responses both in country and in industry level, justifying the use of time-varying techniques.

In the last scenario, we augment the 4-variable rolling SVAR model with an economic policy uncertainty variable in order to examine the role of policy uncertainty on the relationship between oil and stock markets. Again, significant time-variation has been found. Finally, following Kang et al. (2016), we show that it is very important to disaggregate the global oil production variable to US and non-US oil production, when someone examines this relationship on the US, due to the "tight oil revolution" that took place in 2009.

Overall, the contribution of this paper to the existing literature is threefold. First, we confirm and extend in time the seminal work of Kilian (2009) and Kilian and Park (2009), as we use a dataset that contains 8 more years of observations, when major oil price changes occurred. Second, we try to assess if the results obtained from the first scenario change over time. This question has been fairly answered through a rolling

SVAR methodology. Last but not least, we encompass the economic policy uncertainty in the rolling SVAR and assess its role in a time-varying framework, while we finally show that the "tight oil revolution" might have changed the relationship between oil and stock markets in the US.

4. Data

This section describes the dataset employed in this study. We utilize monthly data over the period 1973:1-2016:12 for 15 countries and 49 US industries. The time dimension of this study is mainly constrained by the availability of the oil market data, which start on January 1973. Subsection 4.1 presents the data that are common for all countries and industries, while subsection 4.2 presents the country- and industry-specific data.

4.1 Global variables

As a proxy for the global oil supply, we use global oil production data, obtained from the US Energy Information Administrate (EIA), measured in millions of barrels pumped per day (averaged by month).

As a proxy for the real economic activity, we rely on an index constructed by Kilian (2009)[1]. This is a novel measure, based on data of single voyage dry cargo ocean shipping freight rates. The rationale is that increases in dry cargo ocean shipping rates, given a largely inelastic supply of suitable ships, will be indicative of higher demand for shipping services arising from increases in global real economic activity. According to Kilian (2009), this index have many advantages over industrial production or GDP measures, but the chief one is that unlike OECD indices of industrial production used in previous studies, it automatically incorporates the effects of increased real activity in large NIEs, such as China and India, for which monthly industrial production data are not available.[2] Hence, while industrial production indices fail to capture recent large increases in global demand for industrial commodities from emerging countries, Kilian's measure does. This index is deflated by the US CPI and is linearly detrended in order to remove the effects of technological advances in ship-building and other long-term trends in the demand for sea-transport. The final series measures the cyclical variations in ocean freight rates, thus can be considered as a business cycle index.

Finally, as a proxy for the world oil price, we use the US refiners' acquisition cost of imported crude oil, provided by the US Department of Energy.[3] To strengthen the robustness of our results, we also use the West Texas Intermediate (WTI) crude oil

[1] The data for this index are available on Kilian's personal website: http://www-personal.umich.edu/~lkilian/.

[2] For a more detailed description about the construction and the advantages of this index, see Kilian (2009).

[3] Notice that the data begin in 1974:1, but extended backward as in Barsky and Kilian (2001).

price, collected from FRED database, since it has been widely used as a benchmark for oil pricing. Both oil price variables are measured in dollars per barrel, deflated by the US CPI to get inflation-adjusted oil prices.

4.2 Country and industry-specific data

The country-specific data consist of the stock market prices and CPI indices, the availability of which determine the countries that could take part in this study. The countries that made it to enter the sample constitute 3 groups with different characteristics:

i. A group of 10 net oil-importing countries: Belgium, France, Germany, Italy, Netherlands, South Africa, Spain, Sweden, Switzerland and USA.
ii. A group of 3 net oil-exporting countries: Canada, Mexico and Norway.
iii. A group of 2 countries whose net position in the oil market has changed over time: Denmark and UK.[4]

The stock price data were collected from the MSCI database for all the countries, with the exceptions of Mexico and South Africa, which were collected from the OECD database. We chose to use the MSCI indices rather than other local stock price indices for several reasons. The first is due to data availability. Local stock price indices are available from 1973:1 only for few countries, while the MSCI indices are available from that early for the majority of the developed countries. Secondly, MSCI indices are value-weighted and reflect a substantial percentage of total market capitalization. Thirdly, these indices are constructed on a consistent basis, making cross-country comparisons more meaningful. Finally, they are widely employed in the literature (see, e.g., Maghyereh (2006), Fayyad & Daly (2011), Arouri et al. (2011), Asteriou and Bashmakova (2013)), making comparisons among studies easier. To obtain real stock prices, we divided the stock market prices of all countries with each country's CPI.[5]

As for the industry-specific data, these are the stock prices of the 49 US industries, deflated by the US CPI. The industries are: Agriculture, Food Products, Candy & Soda, Beer & Liquor, Tobacco Products, Recreation, Entertainment, Printing &

[4] Notice that the majority of the previous studies fail to examine countries with mixed net position in the oil market, as they could not classify them neither as oil-importing nor as oil-exporting countries. The problem arises because these studies conducted the whole analysis in a static framework. Contrastingly, our study can incorporate such countries, as it is conducted in a time-varying framework, allowing in this way changes in the net position of the country.

[5] CPI data were collected from IMF for all countries except for Germany and UK, which were collected from the FRED database.

Publishing, Consumer Goods, Apparel, Healthcare, Medical Equipment, Pharmaceutical Products, Chemicals, Rubber & Plastic Products, Textiles, Construction Materials, Construction, Steel Works etc., Fabricated Products, Machinery, Electrical Equipment, Automobiles & Trucks, Aircraft, Shipbuilding & Railroad Equipment, Defense, Precious Metals, Non-Metallic and Industrial Metal Mining, Coal, Petroleum & Natural Gas, Utilities, Communication, Personal Services, Business Services, Computers, Computer Software, Electronic Equipment, Measuring & Control Equipment, Business Supplies, Shipping Containers, Transportation, Wholesale, Retail, Restaurants & Hotels, Banking, Insurance, Real Estate, Trading, remaining firms.[6]

For the sake of the last scenario, we utilize an economic policy uncertainty index. Unfortunately, this analysis has been conducted only for the US, since the economic policy uncertainty data for the rest of the countries become available only in the more recent years, restricting in this way the span of our dataset. The economic policy uncertainty index for the US is constructed by Baker et al. (2016). It is a weighted average index of 4 uncertainty components:

i. News-based policy uncertainty, which reflects media coverage of economic policy uncertainty.
ii. CPI forecast interquartile range, which is measured by the forecasters' disagreement over future outcomes about inflation rates.
iii. Tax legislation expiration, which is a "transitory measure", constructed by the number of temporary federal tax code provisions set to expire in the contemporaneous calendar year and future 10 years.
iv. Federal expenditures forecast interquartile range, which is measured by the forecasters' disagreement over future outcomes about federal government purchases.

Finally, in order to assess the effects of "tight oil revolution" in the US stock market, we use US and non-US oil production data, obtained from the US Energy Information Administrate (EIA), measured in millions of barrels pumped per day (averaged by month).

[6] For a detailed definition of the industries in terms of their Standard Industry Classification Code (SIC), see http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

5. Methodology

This section describes the methodology employed in this paper. Subsection 5.1 refers to the methodology followed in the first scenario, which builds on a SVAR model as in Kilian (2009) and Kilian and Park (2009). Subsection 5.2 presents the rolling SVAR that corresponds to the second scenario. Finally, subsection 5.3 outlines the augmented with economic policy uncertainty SVAR model, corresponding to the third scenario.

5.1 SVAR model

In this subsection, we outline the baseline model of this study. Subsection 5.1.1 presents a SVAR model for the global oil market, used to replicate and extend in time the work in Kilian (2009), whereas subsection 5.1.2 describes a slightly different model in order to examine the effects of oil price shocks on the stock prices, as in Kilian and Park (2009). We estimate both models and we then proceed with a historical decomposition as well as an impulse response analysis.

5.1.1 A model for the global oil market

To construct a model for the global oil market, we follow Kilian (2009) and estimate the following SVAR (24):

$$A_0 y_t = a_0 + \sum_{i=1}^{24} A_i y_{t-i} + \boldsymbol{\varepsilon}_t \quad (1)$$

where $y_t = (\Delta prod,\ rea,\ oilp)$ is a 3x1 vector of endogenous variables. $\Delta prod$ is the percentage change of global oil production, rea is the logarithm of the real economic activity, while $oilp$ is the real crude oil price in logarithmic form. The exogenous error terms in vector ε_t are assumed to be serially and mutually independent, and are interpreted as structural innovations. $A_i, i = 0,\ldots,24$ refer to the 3x3 autoregressive coefficient matrices, while A_0 denotes the 3x3 contemporaneous coefficient matrix and α_0 is the 3x1 vector of constant terms.

We include 24 lags in our model, since Kilian (2009) showed the importance of including enough lags to precisely estimate the effects of aggregate demand shocks. Moreover, Ciner (2013) found that using a low lag order can bias the results in favor of more explanatory power to oil supply and oil-specific demand shocks.

The variance-covariance matrix of the structural shocks is typically normalized as follows:

$$E(\varepsilon_t \varepsilon_t^{'}) = D = \begin{pmatrix} \sigma_1^2 & 0 & 0 \\ 0 & \sigma_2^2 & 0 \\ 0 & 0 & \sigma_3^2 \end{pmatrix} \quad (2)$$

We retrieve the reduced form of our structural VAR model by multiplying both sides of Eq. (1) with A_0^{-1}:

$$y_t = B_0 + \sum_{i=1}^{24} B_i y_{t-i} + e_t \quad (3)$$

where $B_0 = A_0^{-1}\alpha_0, B_i = A_0^{-1}A_i$ and $e_t = A_0^{-1}\varepsilon_t$. e_t are the reduced-form VAR innovations. We derive the structural innovations from the reduced form disturbances by imposing exclusion restrictions on A_0^{-1}. Since we are not interesting in examining any particular model, our restrictions are exclusively based on economic theory. Following Kilian (2009), we decompose the structural innovations according to the following identification scheme:

$$e_t = \begin{pmatrix} e_t^{\Delta prod} \\ e_t^{rea} \\ e_t^{oilp} \end{pmatrix} = \begin{pmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{pmatrix} \begin{pmatrix} \varepsilon_{1t}^{Oil\ supply\ shock} \\ \varepsilon_{2t}^{Aggregate\ demand\ shock} \\ \varepsilon_{3t}^{Oil\text{-}specific\ demand\ shock} \end{pmatrix} \quad (4)$$

That is, we attribute fluctuations in the real oil price to 3 structural shocks: ε_{1t}, denotes exogenous shocks that capture changes to the global oil supply, ε_{2t} denotes shocks to the global demand for all industrial commodities (including crude oil) that are driven by fluctuations in the global business cycle and ε_{3t} captures oil-market specific shocks, which are combinations of different shocks, as they encompass any factor other than global oil supply or demand that can alter the price of oil. Kilian (2009) and Kilian and Park (2009) interpreted these shocks as precautionary demand ones, arising from the uncertainty about shortfalls of expected oil supply relative to expected demand. Such shortfalls could arise due to unexpected growth of demand or unexpected declines in crude oil supply or both. However, Hamilton (2011) questions such interpretation. In a more recent paper, Kilian and Murphy (2014) came up with another rendering. Controlling for oil inventory changes, they consider these shocks as speculative demand ones, which can capture changes in oil prices driven by speculative motives and forward-looking behavior. Since there is no unique interpretation of these shocks, in the rest of this paper we stick to the more general denomination, referring to them as "Oil-specific demand shocks".

As can be seen in Eq. (4), our model imposes a block-recursive structure. Although such structure is particularly convenient, we must ensure that the implied restrictions are also justified by economic theory. Following the existing literature, we rely on the following assumptions of short-run restrictions:

i. We assume that innovations on real economic activity or oil-specific demand do not affect global oil production within the same month. This implies a vertical oil supply curve in the short-run, which is a reasonable assumption since there are significant adjustment costs in the petroleum production as well as strong uncertainty about whether changes in oil demand are permanent or transitory.
ii. Furthermore, despite the assumption that aggregate demand shocks do not affect global oil supply in the short-run, we assume that the reverse does occur. That is, global oil supply shocks affect real economic activity within a month.[7] Moreover, we further assume that oil-specific demand shocks do not affect real economic activity, given the low short-run price elasticity of crude oil demand that leads to a sluggish behavior of real activity after each one of the major oil price increases in our sample.
iii. Finally, it is reasonable to assume that the real oil price responds to both oil supply and aggregate demand shocks in the short-term.

By imposing these restrictions, our SVAR model is exactly identified.

Notice that the second and third variables (i.e. *rea* and *oilp*) are in log levels, while the first variable (i.e. $\Delta prod$) is in log first differences. On the one hand, the real economic activity index is stationary by construction, since fluctuations in real economic activity are measured in per cent deviations from the trend. On the other hand, we are not sure about the level of integration of the real oil price, as the unit root tests provide mixed results. Sims et al. (1990) argue that the impulse response functions are precisely estimated using the levels of the variables in the VAR model, when we are not clear a priori whether a variable should be first-differenced or not. The potential cost of level specification would only be reflected in wider error bands, as there would be a loss in

[7] Because providers of shipping services hold large buffer stocks of bunker fuels, one would expect that oil price changes stemming from changes in global oil supply will not affect real economic activity within the same month. Imposing the overidentifying restriction $\alpha_{21}=0$ on the VAR's global oil market block hardly affects the results.

asymptotic efficiency. On the other hand, falsely imposing a unit root on a stationary time series renders the estimates inconsistent.[8]

5.1.2 A stock market model

To examine the effects of the different oil price shocks on the stock market returns, we augment the model in Eq. (1) with a stock returns variable. Now the vector of the endogenous time series becomes: $y_t = (\Delta prod, rea, oilp, ret)$, where *ret* represents the real stock returns, constructed by subtracting the CPI inflation rate from the log stock returns. Eq (4) also changes to:

$$e_t = \begin{pmatrix} e_t^{\Delta prod} \\ e_t^{rea} \\ e_t^{oilp} \\ e_t^{ret} \end{pmatrix} = \begin{pmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{pmatrix} \begin{pmatrix} \varepsilon_{1t}^{Oil\ supply\ shock} \\ \varepsilon_{2t}^{Aggregate\ demand\ shock} \\ \varepsilon_{3t}^{Oil\text{-}specific\ demand\ shock} \\ \varepsilon_{4t}^{Other\ shocks\ to\ stock\ returns} \end{pmatrix} \quad (5)$$

The first three lines represent the oil market block, described in the previous subsection, while the last line corresponds to the stock market. “Other shocks to stock returns” contain any remaining disturbances of real stock returns that are not attributable to the oil market. Notice that this last type of shock does not have a direct structural interpretation. Ordering real stock returns in the last place of this recursive SVAR model implies that the global oil market block is contemporaneously predetermined with respect to domestic stock markets. This is a common assumption in the literature, as it is nearly impossible that the stock market of a country could affect the three global oil market variables within a month. The results from Lee and Ni (2002) and Kilian and Vega (2011) provide further support to this assertion.

5.2 The rolling SVAR methodology

To examine the relationship between oil and stock markets in a dynamic framework, we estimate the SVAR model with the use of the rolling estimation methodology. To

[8] The econometric approach in Apergis and Miller (2008), Wang et al. (2013), Fang and You (2014) and Li (2017) can be challenged as they used all variables in first differences.

the best of our knowledge, this methodology has not been employed so far in the literature to examine this relationship.

More specifically, we estimate the model described in Eq. (1) using 180-month rolling samples. The rolling sample analysis uses the first sample over January 1973 to December 1987, the second over February 1973 to January 1988 and so on. This means that each subsequent sample adds a new monthly observation and drops the first month of the data in the preceding sample. We chose fixed versus expanding window in order to have comparable standard errors.

From each estimated sample we retrieve the impulse responses of stock returns to the different shocks up to 15 forecasting horizons. We then plot these responses in time both in a country as well as in an industry level. Since the sample starts on January 1973 and we use a fixed window of 180 months, the first impulse responses are available on January 1988, the second on February of the same year and so on.

5.3 A model for economic policy uncertainty

To assess the role of policy uncertainty on the relationship between oil and stock markets, we further augment the model in eq. (1) with an economic policy uncertainty variable. The vector of the endogenous time series contains now five variables, namely $y_t = (\Delta prod, rea, oilp, epu, ret)$, where *epu* stands for economic policy uncertainty. Eq. (5) now turns to:

$$e_t = \begin{pmatrix} e_t^{\Delta prod} \\ e_t^{rea} \\ e_t^{oilp} \\ e_t^{epu} \\ e_t^{ret} \end{pmatrix} = \begin{pmatrix} a_{11} & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{pmatrix} \begin{pmatrix} \varepsilon_{1t}^{\text{Oil supply shock}} \\ \varepsilon_{2t}^{\text{Aggregate demand shock}} \\ \varepsilon_{3t}^{\text{Oil-specific demand shock}} \\ \varepsilon_{4t}^{\text{Economic policy uncertainty shock}} \\ \varepsilon_{5t}^{\text{Other shocks to stock returns}} \end{pmatrix} \quad (6)$$

The policy uncertainty variable is ordered between the global oil market and the stock market blocks. The rationale of placing *epu* after the oil market variables is again that the oil prices are considered predetermined with respect to US macroeconomic aggregates within a given month. Thus, while US economic policy uncertainty is allowed to respond to oil supply and demand shocks, the reverse is assumed to happen only with a delay of at least one month. Moreover, real stock returns ordered after oil price shocks and economic policy uncertainty, which implies that the direct effects of oil price changes on the stock returns would be amplified by the endogenous responses of policy uncertainty. In that line, Kang and Ratti (2013) found that economic policy uncertainty plays an important role in the transmission of the three structural oil price shocks to the stock market.

Finally, we also test another specification only for the US, in order to examine the effects of "tight oil revolution" on the US economic policy uncertainty and on the US stock market. To do so, we replace the global oil production variable with US and non-US production variables. Of course Eq. (6) changes again, with the non-US oil production ordered in the first place and US oil production ordered in the second. This is motivated by Kang et al. (2016), who argue that the non-US oil production does not respond to US oil supply shocks within a given month, but only with a delay of at least one month.

6. Empirical Results

This section is divided into five subsections. Subsection 6.1 provides some descriptive statistics for the variables used in this paper as well as few information about the oil situation in the countries of our sample; Subsection 6.2 presents the results from the first scenario; Subsection 6.3 provides the results from the time-varying analysis, followed in the second scenario; Subsection 6.4 discusses the role of economic policy uncertainty on the relationship between oil and stock markets, examined in the third scenario; finally, Subsection 6.5 outlines some robustness tests.

6.1 Preliminary Analysis

6.1.1 A first look on the countries

As we have discussed in Section 4, there are 15 countries in our sample: 10 net oil-importers; 3 net oil-exporters; and 2 countries whose net position in the oil market has changed over time. Figure 6.1 plots the net position, oil consumption and production of these countries in time.[9] More specifically, the red area shows the net position of each country, defined as total oil imports minus total oil exports. Hence, positive values of this variable indicate that the country is a net oil-importer, whereas the negative values indicate that the country is a net oil-exporter. Furthermore, the blue and black lines correspond to the annual oil consumption and production of each country respectively, both measured in million tones of oil equivalent (Mtoe).

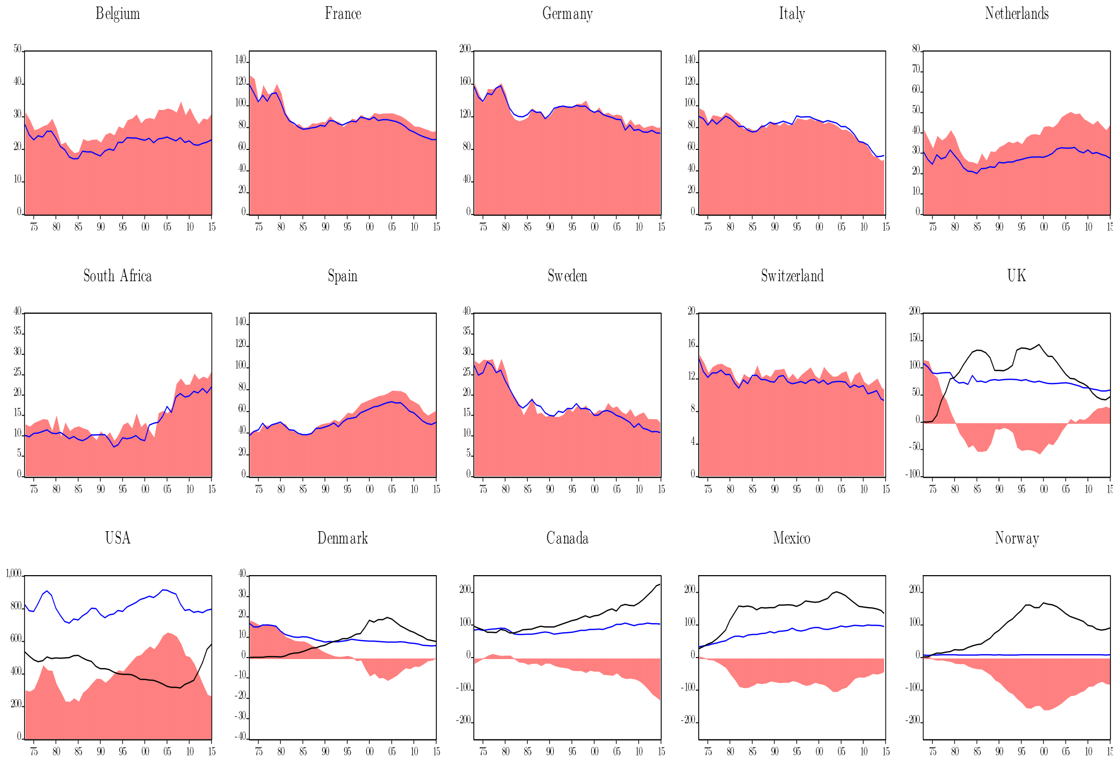
Taking a first look on the graphs, we can easily identify in which group each country belongs. Canada, Mexico and Norway are the 3 net oil-exporting countries; UK and Denmark are the 2 countries whose net position varies through the years; the rest of the countries belong to the group of net oil-importers.

Taking a closer look, we observe that the net position of the oil-importing countries highly depends on their oil consumption, as their oil production is almost zero. Notice also that the only emerging economy in our sample (i.e. South Africa) has faced an unprecedented expansion in oil consumption in the more recent years, which is indicative of the high growth rates in this country lately, while on the other hand, the oil consumption on the developed countries has stagnated or decreased through the years. Furthermore, USA is traditionally the largest net oil-importer (with a peak in

[9] Notice that we do not present the evolution of oil production for many countries, as it is zero or very close to zero.

the pre-financial crisis period), despite the fact that it is also a major oil producer. After 2009 though, the "tight oil revolution" has resulted to a sharp increase in the oil production. If this trend continues, USA may turn into a net oil-exporter for the first time in history.

Figure 6.1: Net Position, Oil Consumption & Production



Notes: Red areas indicate the net position of each country; blue and black lines correspond to the oil consumption and production of each country respectively. All variables are measured in million tones of oil equivalent (Mtoe).

Focusing on the three oil-exporting countries, we observe that Canada has gradually evolved to a big oil-exporter. On the other hand, Mexico is traditionally a big player in the oil market, since it is a net oil-exporter for a long time, while Norway has become a big oil-exporter after the mid-80s. An interesting fact, which may affect the results of the empirical analysis, is that Canada and Mexico consume much more oil than Norway. This may partially offset the potential gains of oil price increases more rapidly in these countries than in Norway.

Finally, the evolution of the net oil position in Denmark and UK is rather interesting. Denmark was net oil-importer until about mid-90s, when it became net oil-exporter following a significant increase in oil production after 1998. In the last years of our sample, oil production is only marginally above oil consumption, leading to a neutral net position. These developments in the oil market have consequences about Danish stock market, as we will see in Subsection 6.3. UK had followed a different route. It was net importer until 1980, it became net exporter during the period 1980-2005, and then it became again net importer until today.

The preliminary country analysis ends with Table 6.1, which shows the global ranking of these countries as regards their net position, oil consumption and production in 2015. Before we proceed with the empirical results, we recommend the reader to take a brief look on this table, as it helps to make comparisons between the countries in our sample.

Table 6.1: Net Oil Position, Consumption and Production Rankings (2015)

Countries	Net Imports Ranking	Oil Consumption Ranking	Oil Production Ranking
USA	2nd	1st	1st
Germany	6th	10th	49th
France	7th	14th	65th
Spain	9th	18th	80th
Italy	10th	16th	41st
Netherlands	12th	27th	56th
Belgium	16th	30th	-
UK	18th	15th	21st
South Africa	19th	31st	76th
Sweden	27th	47th	-
Switzerland	31st	52nd	-
Denmark	101st	68th	38th
	Net Exports Ranking	**Oil Consumption Ranking**	**Oil Production Ranking**
Canada	6th	9th	4th
Norway	11th	53rd	14th
Mexico	18th	11th	12th

6.1.2 Descriptive statistics

Figure 6.2 depicts the peaks and troughs of global oil production, real economic activity, global oil price, economic policy uncertainty and the stock market prices of the 15 countries in our sample.

The global oil production faced a major decline during the period 1980-1982, while on the same time, the price of oil had already risen. This is indicative of a precautionary demand shock, instead of a shock in the global oil supply, as the increase in the price of oil precedes the oil production cuts. The oil supply followed afterwards a steady incline until around 2005. Then it stagnated, as Saudi Arabia had reduced oil production and no new projects had been developed. This stagnation lasted until 2009, when the "tight oil revolution" took place in the US, giving a boost both in the US and the global oil production.

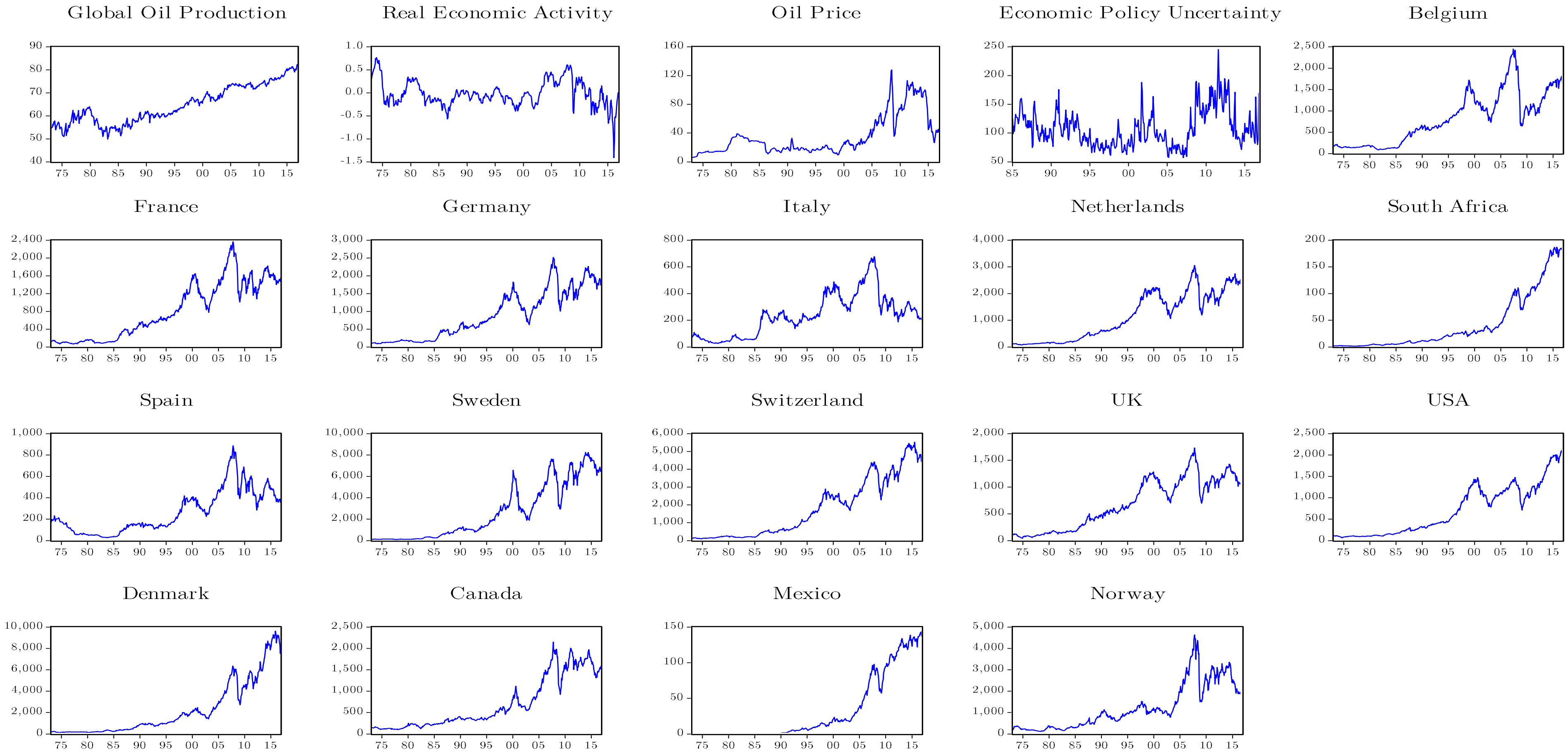
From the second graph, we can detect the worldwide recessions in the mid-70s as well as in the early 80s. We can also identify the global boom in the commodity markets since the early 2000s, driven by strong economic growth around the world, but particularly in Asia. Notice however that, in the same time, oil prices had also faced an unprecedented increase. This is a counter-intuitive fact, since sharp oil price increases are traditionally combined with economic recessions. After the synchronized increases of these variables, there is, of course, the GFC. In that time, both variables collapsed. Another common collapse took place around 2015.

From the US economic policy uncertainty graph, it can be seen that the dates of some well-known events are followed by rises in policy uncertainty. See for example the 9/11 terrorist attack (2001), the 2nd Gulf war (2003), the GFC (2009), the Arab spring (2011) and the sharp oil price decrease (2014-15).

Finally, from the rest of the graphs, it can be seen that the majority of the stock markets have followed the same pattern: a steady and gradual increase until about 2009, followed by the crash due to the GFC and a partial recovery in the following years. Exceptions to this pattern are South Africa, Denmark and Mexico, which have slightly affected by the GFC. Especially the South African stock market continued to follow sharp increases for the next years after the GFC, driven by the high growth rates in this country.

Table 8.1 summarizes the basic descriptive statistics for the global variables (i.e. the percentage change in the global oil production, the real economic activity and the real oil price) as well as for the country-specific variables (i.e. the real stock returns of each country and the epu for the US). On the other hand, Table 8.2 summarizes the basic

Figure 6.2: Graphical Overview of global and country-specific variables



descriptive statistics for the 49 US industries. Both tables can be found in the Appendix.

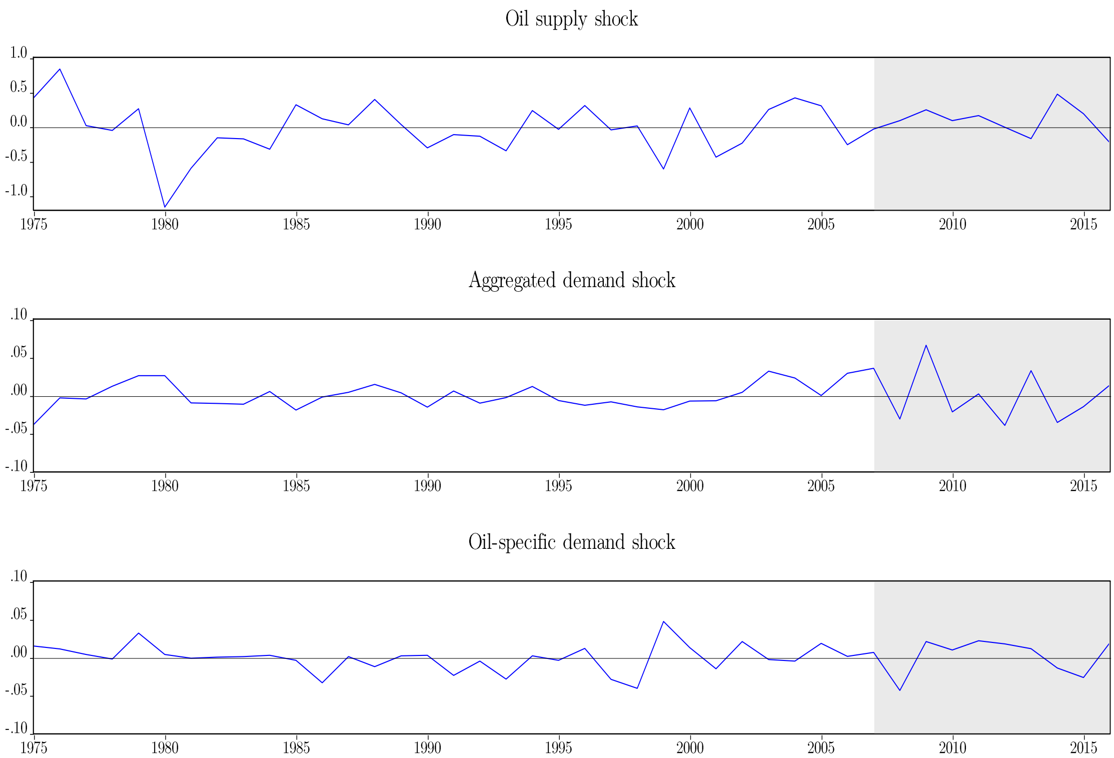
6.2 Scenario1: Replication and extension in time

We begin this section by replicating and extending in time initially the work of Kilian (2009), and then the work of Kilian and Park (2009).

6.2.1 A model for the Oil Market

In his seminal work, Kilian (2009) builds a model for the global oil market to analyze the factors that affect oil prices, finding that the sign and the magnitude of an oil price change highly depends on the underlying cause of this change.

Figure 6.3: Historical evolution of the structural shocks



Notes: The structural residuals are expressed as annual averages to improve the readability of the graphs. The shaded areas indicate the observations included in the analysis by the extended dataset.

We begin our analysis by estimating Eq. (1), which represents a model for the oil market. Figure 6.3 shows the evolution of the structural shocks implied by our model[10]. The shaded areas indicate the observations included in the analysis by the extended dataset. We can see that the price of oil responds to a number of different shocks that change over time. A fact that is worth-mentioning is the oil price shock of 1979-80. As we have seen in the preliminary analysis, there is no evidence of a decline in oil supply in 1978 or 1979 that can be considered responsible for the observed oil price increase in 1979-80. The oil supply disruption took place only in 1980, indicating that the cause of that sharp oil price increase were not the cuts in the global oil production. Indeed, the years 1978, 1979 and 1980 were characterized by consecutive positive shocks to aggregate demand, as can be seen on the second graph. Moreover, there is also a large increase in oil-specific demand in 1979, driven by concerns about future availability of oil supplies, due to the imminent events in the Middle East. The conclusion from this analysis is that, contrary to the common belief, the sharp oil price increase of 1979-80 is driven by the demand rather than the supply-side. Another fact that stands out is that from the early 2000s until the end of the sample, the aggregate demand shocks are dominant. This observation is even stronger in the extended sample.

We continue with Figure 6.4, which presents the responses of our 3 variables to one-standard deviation structural innovations. Panel A corresponds to the sample used by Kilian (2009), ranging from 1973:1 to 2007:12, and is just a replication of his results in order to make comparisons with the results from the extended dataset, presented on Panel B. Notice that all shocks have been normalized such that an innovation will tend to raise the oil price, in order to obtain comparable results from all types of shocks. This implies a negative shock to oil supply and positive shocks to aggregate and oil-specific demand.[11] The first, second and third columns in each Panel represent shocks to oil supply, aggregate demand and oil-specific demand respectively. On the other hand, the first, second and third rows represent the responses of oil production, real economic activity and oil price to the different structural innovations respectively.

Beginning with the results of the first Panel, an unexpected oil supply disruption causes an immediate and sharp decline in global oil production in the first month, followed by a partial reversal within a year. This pattern is consistent with the view that oil supply disruptions in one region trigger production increases in another region, partially offsetting the initial decrease. The response of oil production to aggregate demand shocks is temporal, not statistically significant and with a delay of about 6 months. Finally, oil-specific demand shocks have minor impact on the oil production.

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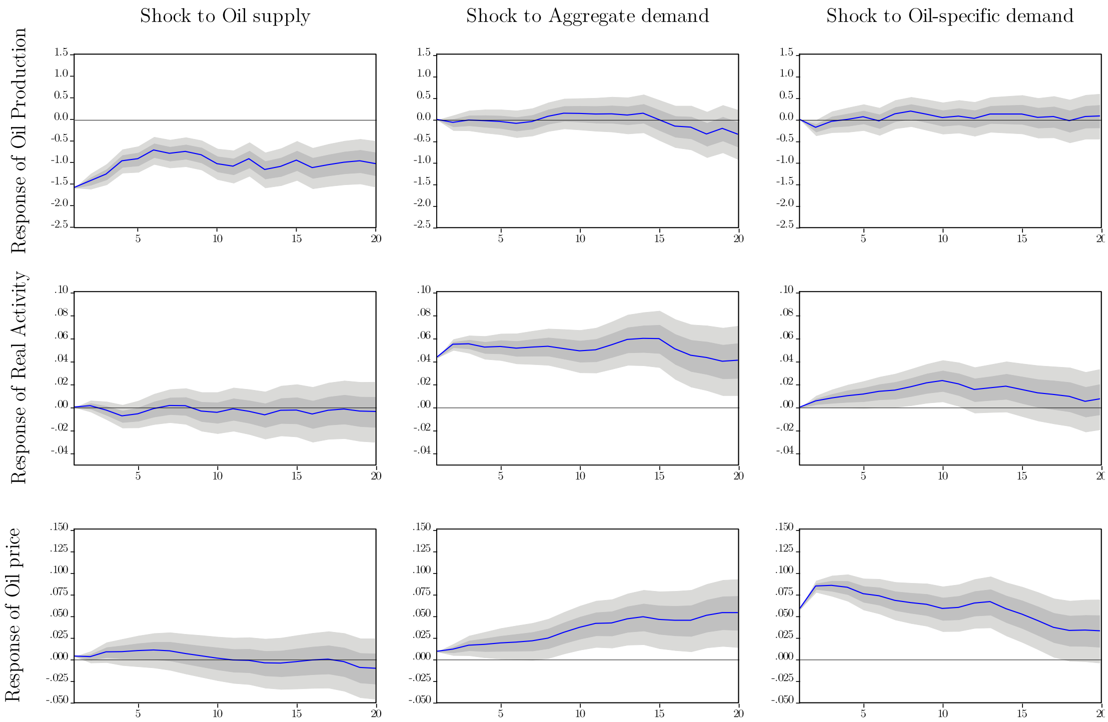
[10] They are expressed as annual averages to improve the readability of the graphs.

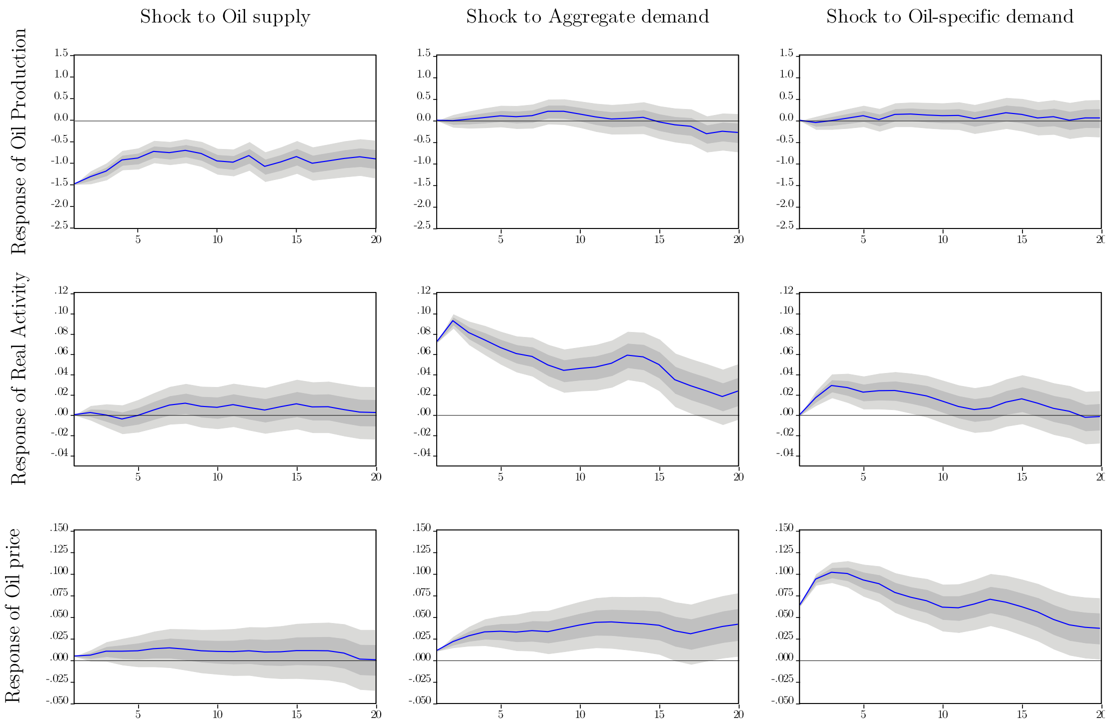
[11] This will be the case for the rest of the analysis.

Figure 6.4: Responses to one standard deviation structural shocks

Panel A:



Panel B:



Notes: Point estimates with one- and two-standard error bands. Panel A corresponds to Kilian's sample, while Panel B corresponds to the extended sample.

Turning to the second row of the first Panel, an unexpected oil supply decline causes a small but persistent enough reduction in real economic activity that is marginally significant only in the short-run. Moreover, an unexpected aggregate demand expansion has a very persistent and highly significant effect on the real economic activity, while oil-specific demand shocks temporarily increase real economic activity.

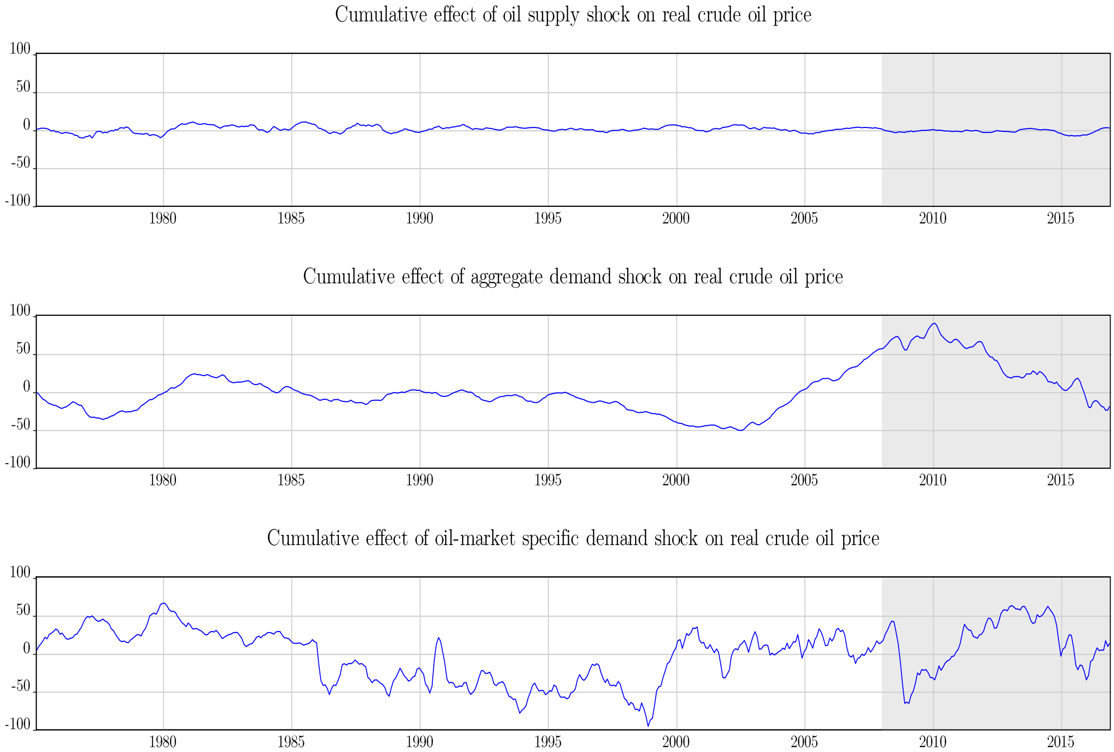
Finally, we move on to the final row of Panel A, which represents the responses of oil price to the different structural shocks. These responses are very important for our analysis, as they may indirectly affect the impacts of oil price changes on the stock prices. We begin with the effects of an unanticipated oil supply disruption. This disruption leads only to a small and transitory response of the oil price, which lasts for about 9 months. This result indicates the small impact of the oil supply on the oil price, probably contrary to the common view. On the other hand, aggregate demand expansions cause a delayed but persistent, large and highly significant increase in the price of oil. Finally, oil-specific shocks have also a large and statistically significant impact on the oil prices, but with the difference that this impact is immediate. There is also evidence of overshooting.

To assess if the results change when we include new observations, we move on to Panel B. The responses of the global oil production to all types of shocks present only minor changes. On the other hand, the responses of the real economic activity have changed enough. An unanticipated oil supply disruption now causes a decrease in real activity only for the first months. This is in contrast with the results in Kilian's sample, supporting the view that the lower volatility of oil supply in recent years leads to a smaller impact of oil supply shocks on the economy. Additionally, an aggregate demand expansion continues to have a large and highly significant effect on the real activity, but it is not that persistent anymore. This may be due to the effects of GFC. Finally, shocks to oil-specific demand have now an immediate impact on real activity, while the impact was somewhat delayed before.

Again, we are particularly interested for the third row. The only worth-mentioned change is that an oil supply decline raises the price of oil persistently in the extended sample, whereas the effect was only temporal in Kilian's sample. However, the responses in both samples are not significant.

The discussion about the oil market ends with Figure 6.5, which plots the respective cumulative contributions of each oil market shock to the real price of oil, based on a historical decomposition of the structural shocks.

Figure 6.5: Historical decomposition of real oil price



Note: The shaded areas indicate the observations included in the analysis by the extended dataset.

The first graph shows that oil supply shocks historically do not exert significant impacts on the real price of oil. In contrast, the two demand-side shocks have both made big contributions to the oil price variation over the years. On the one hand, aggregate demand shocks cause long swings in the real price of oil, while on the other hand, the oil-specific shocks are responsible for sharp changes in the oil prices.

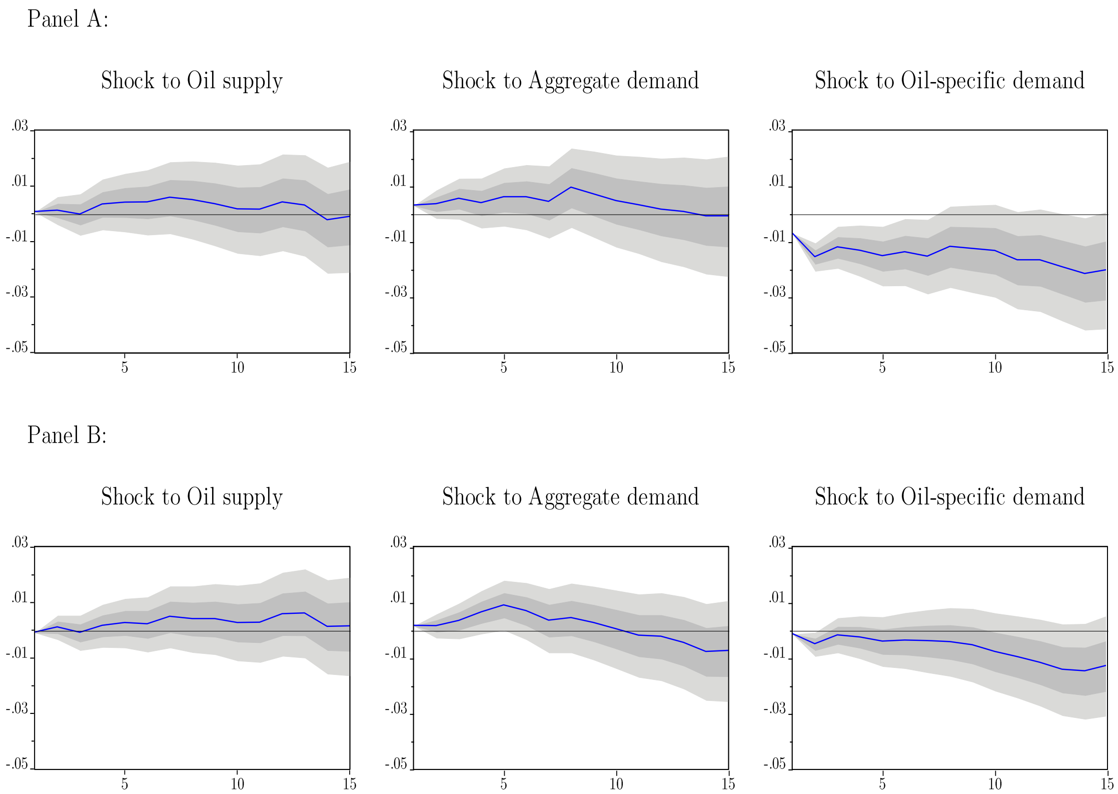
We will not discuss any details related to specific episodes, as a detailed analysis can be found in Kilian (2009). We make only a brief comment about the continuing oil price increases in period 2002-2008. As can be seen, they occurred mainly due to the surge in real economic activity. More specifically, the high economic growth around the world in that period led to increased demand for oil, which had as a consequence a rapid increase in the price of oil. Despite the higher oil prices, the economic growth was strong enough to persist for many years.

The conclusion of this subsection is that not all oil price shocks are alike. Hence, it is very important to identify the cause of the oil price change. This observation justifies the use of models that treat the oil prices as endogenous to the system, further casting doubt to the early conventional studies that treated the oil price changes as exogenous.

6.2.2 A model for the US stock market

Having analyzed the global oil market, it's time to continue with the effects of the oil market shocks on the stock market returns. We replicate this time the work of Kilian & Park (2009) and then, we extend again the dataset to make comparisons. Panels A and B of Figure 6.6 represent the responses of US stock market returns to the different oil prices shocks. Panel A corresponds to Kilian's sample, while Panel B to the extended dataset.

Figure 6.6: Accumulative responses of US real stock market returns



Notes: Point estimates with one- and two-standard error bands. Panel A corresponds to Kilian's sample, while Panel B corresponds to the extended sample.

We can see that the responses of the stock market returns to an oil supply disruption have remained the same. An unexpected decline of oil supply tends to increase the real stock returns, but this increase is not statistically significant in any forecasting period. This positive effect of an oil supply disruption on the aggregate stock market index is hard to reconcile given that an oil supply decline raises the price of oil and as a consequence is expected to hurt the oil consuming companies. In such case, we would expect the stock prices to decline. We will try to resolve this problematic result in the last section by replacing the global oil production variable with the US and non-US oil production variables.

Contrastingly, an aggregate demand expansion leads to an increase in stock market returns that is partially statistically significant in the first sample, but more significant during the first months of the second sample. Another difference between the two samples is that in the first one, the effect of the aggregate demand expansion is more persistent. This time, the positive response of the stock market returns to an aggregate demand expansion is something that we expected. The increase in the aggregate demand stimulates the economy and as a result the stock prices tend to rise. In the same time, there is also a rise in the demand of oil and as a consequence the price of oil also tends to increase, a development that pushes the stock prices down. The final result depends on which effect is larger.

Finally, the response of the stock market returns to an increase in the oil-specific demand is negative in both samples, but by far larger and more significant in the first sample. This is an expected outcome, as an increase in the demand of oil tends to raise the oil prices, which negatively affects the oil-consuming companies as the production costs increase.

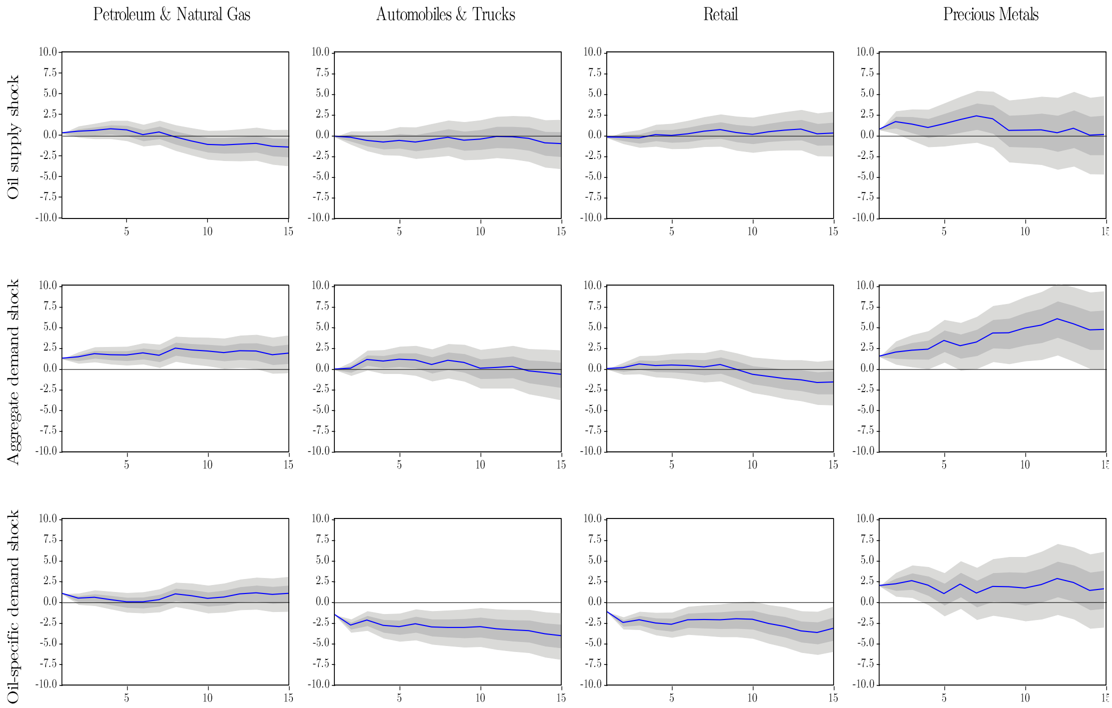
Overall, this analysis makes clear that the responses of the stock market returns to oil price changes highly depend on the underlying cause of these oil price changes.

Next, we conduct the same analysis, this time across industries. Panels A and B of Figure 6.7 provide a replication and an extension in time of the work in Kilian and Park (2009), respectively. In this section we conduct this analysis for the 4 industries examined in Kilian & Park (2009), while in the next section we examine the time-varying relationship for all the 49 US industries. Kilian and Park (2009) chose these 4 industries because they are most likely to respond to oil price changes.

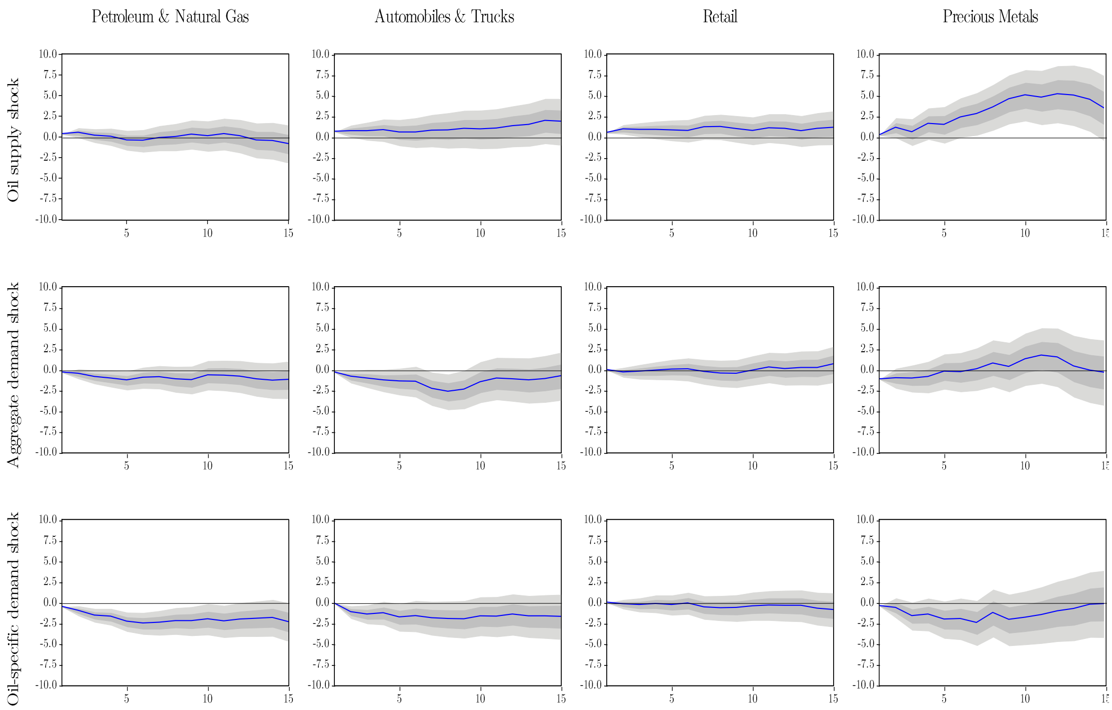
More specifically, in the first two columns we have the Oil & Gas and the Autos & Trucks industries, which are naturally related to the oil market. Notice however that it is not clear a priori whether the Oil & Gas industry would gain or lose from changes in the oil price. The answer depends on the extent to which oil companies own crude oil. We continue with the third column, where we consider the retail industry, because of the common view that higher oil prices hurt this sector through shrinking the

Figure 6.7: Accumulative responses of US real stock returns by industry

Panel A:



Panel B:



Notes: Point estimates with one- and two-standard error bands. Panel A corresponds to Kilian's sample, while Panel B corresponds to the extended sample.

disposable income. The rationale is that higher oil prices lead to lower consumer spending, as consumers have less money to spend on other items, hurting in this way the retail sales. Finally, in the last column we have the precious metal sector. This choice is meaningful given the widespread perception that investors, in times of turmoil, resort to precious metals, such as gold and silver, causing their share prices to increase.

In the first row of Panel A we can see the response of each industry to an oil supply disruption. The shares of automobile industry respond negatively to such shock, but this response is not significant, while the response of the retail industry is very close to zero. The share of the oil and gas industry tends to appreciate only in the first months. The only industry that clearly gains from an oil supply disruption, especially in the first months, is the precious metals one. That indicates the role of metals as safe haven.

The second row shows the response of each industry to an aggregate demand expansion. The two industries that clearly gain from such situation are the Oil & Gas and the Mining ones. Th**is** is reasonable since the aggregate demand shock, as we have discussed before, has two effects on stock markets, one positive and one negative. For these industries both effects are positive, since both higher economic growth and higher oil prices tend to increase the shares of these industries, and thus the aggregate response is positive and highly significant. In contrast, in the other two industries, the positive effect dominates the negative only in the first months.

Finally, in the last row we observe the responses to an oil-specific shock. For the same reasons as before, the response of Autos and Retail industries are negative and highly significant, while the responses of the other two industries are positive. Moreover, the response of the metal sector is statistically significant in the first months, indicating again the role of the metals as safe haven.

Panel B presents the same results for the extended sample. Almost everything has changed. The responses of each industry to aggregate demand as well as to oil-specific demand shocks are now negative, even for the Oil and Metal industries. This result is probably due to the negative effects of the GFC, included only in the new sample. On the other hand all industries respond now positively to oil supply disruptions. These substantial changes in our results justify the use of time-varying methodologies in order to have a clearer picture of the relationship between oil and stock markets.

6.3 Scenario 2: Time-varying analysis

The analysis of this scenario is divided into three parts. In Subsection 6.3.1 we follow an impulse response analysis to examine the effects of the oil price shocks on the stock returns of the 15 countries in our sample; in Subsection 6.3.2 we follow again an impulse response analysis, this time for the 49 US industries; finally, in Subsection 6.3.3 we use the time-varying forecast error variance decompositions in order to construct a spillover index for each country.

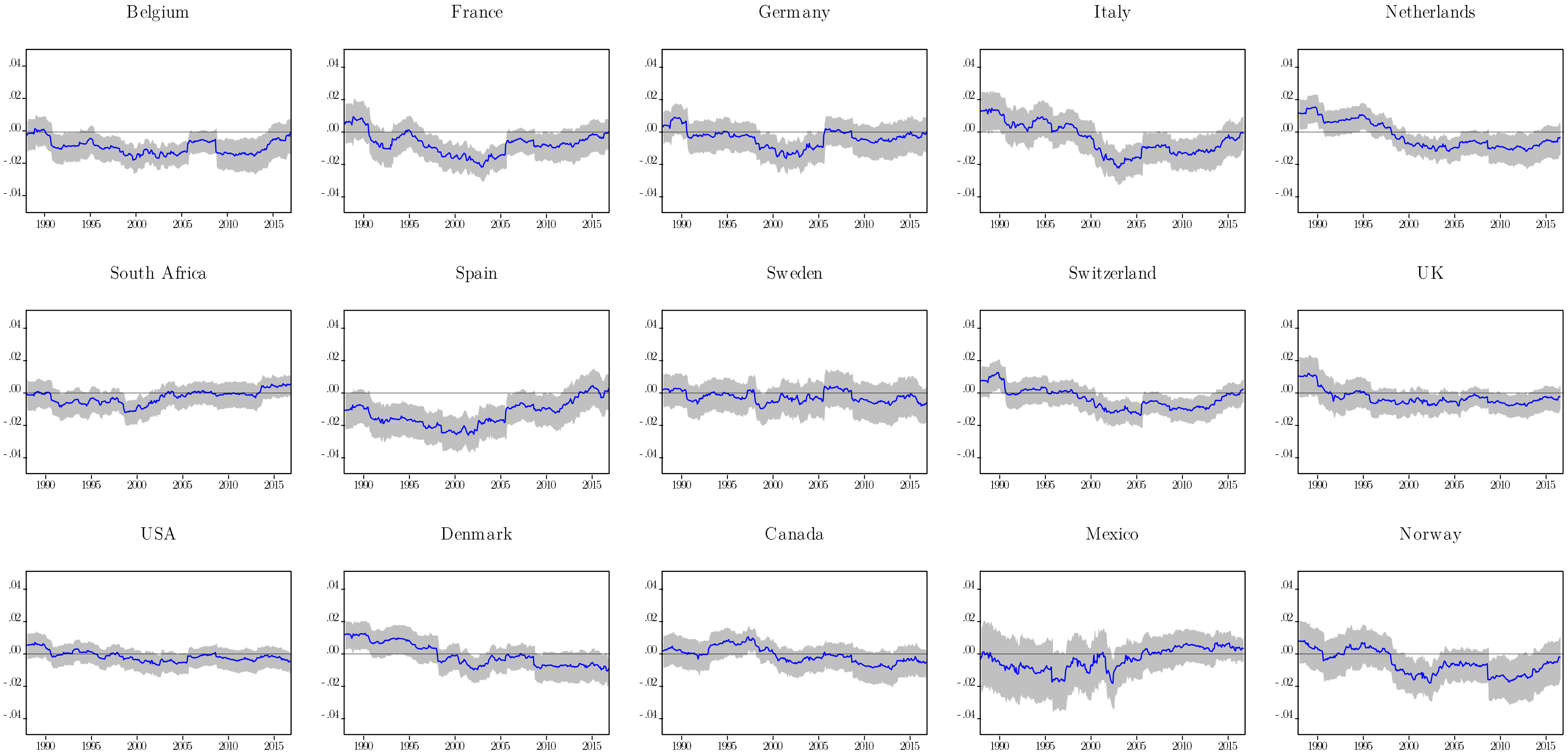
6.3.1 Impulse response analysis for countries

We follow a horizon-specific analysis, examining the second, sixth and twelfth forecasting horizons, representing the responses in the short-, medium- and long-run respectively. We also present the time-varying impulse responses up to 15 horizons, using 3D graphs. These two different ways of presenting the impulse responses partially contain overlapping information. However, each way has a unique advantage. On the one hand, horizon-specific analysis helps to address more detailed issues, while on the other hand, 3D analysis provides a more general picture on the evolution of the responses in time. Thus, we decided to present both ways to have a thorough understanding of the results. Figures 6.8-6.16 correspond to the horizon-specific analysis, whereas the 3D graphs are presented in Figures 8.1-8.15 in the Appendix.

Figures 6.8, 6.9 and 6.10 present the responses of each county's stock market to oil supply shocks in the second, sixth and twelfth forecasting horizons respectively. We observe that in the short-run, the responses are negative through the years in almost all counties, with the exceptions of Italy, Netherlands, Denmark and Canada, which respond positively in the first years and negatively afterwards. These negative effects are statistically significant only for the half of the countries, mainly during the period 2000-2005, while the country that is mostly affected in the short term is Spain.

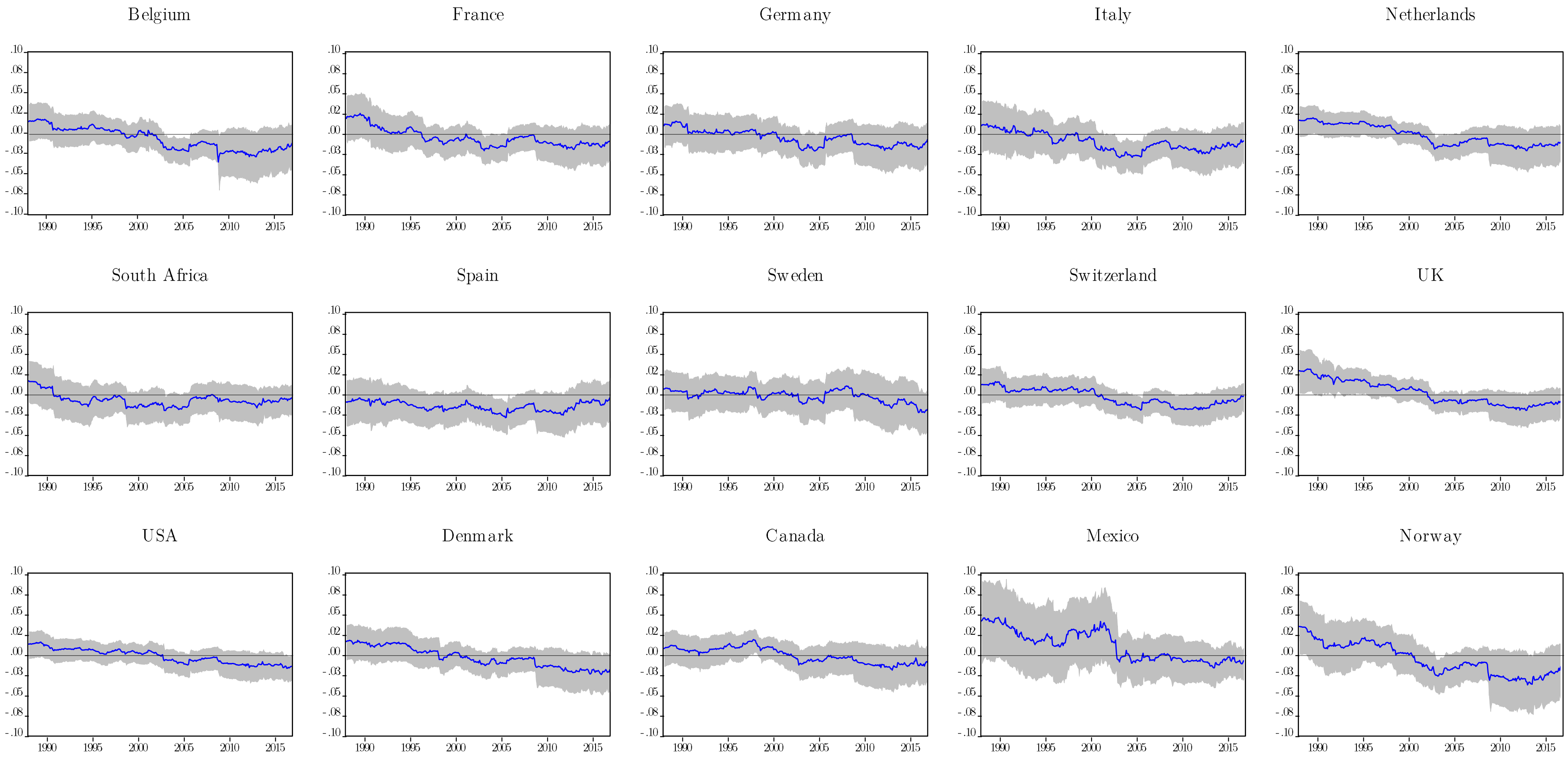
As we move on to longer forecasting horizons (Figures 6.9 and 6.10), the following pattern is created for almost all countries: a positive but statistically insignificant response in the first half of the sample, which becomes negative, but again insignificant in the second half. This indicates that oil supply disruptions historically do not have a big impact on stock markets. A plausible explanation is that financial and commodity markets are familiar with OPEC practices and thus, they are not "surprised" even when unanticipated oil supply changes take place. Note that there are no differences on the responses between oil-importing and oil-exporting countries.

Figure 6.8: Time-varying responses of real stock returns to oil supply shocks (Horizon 2)



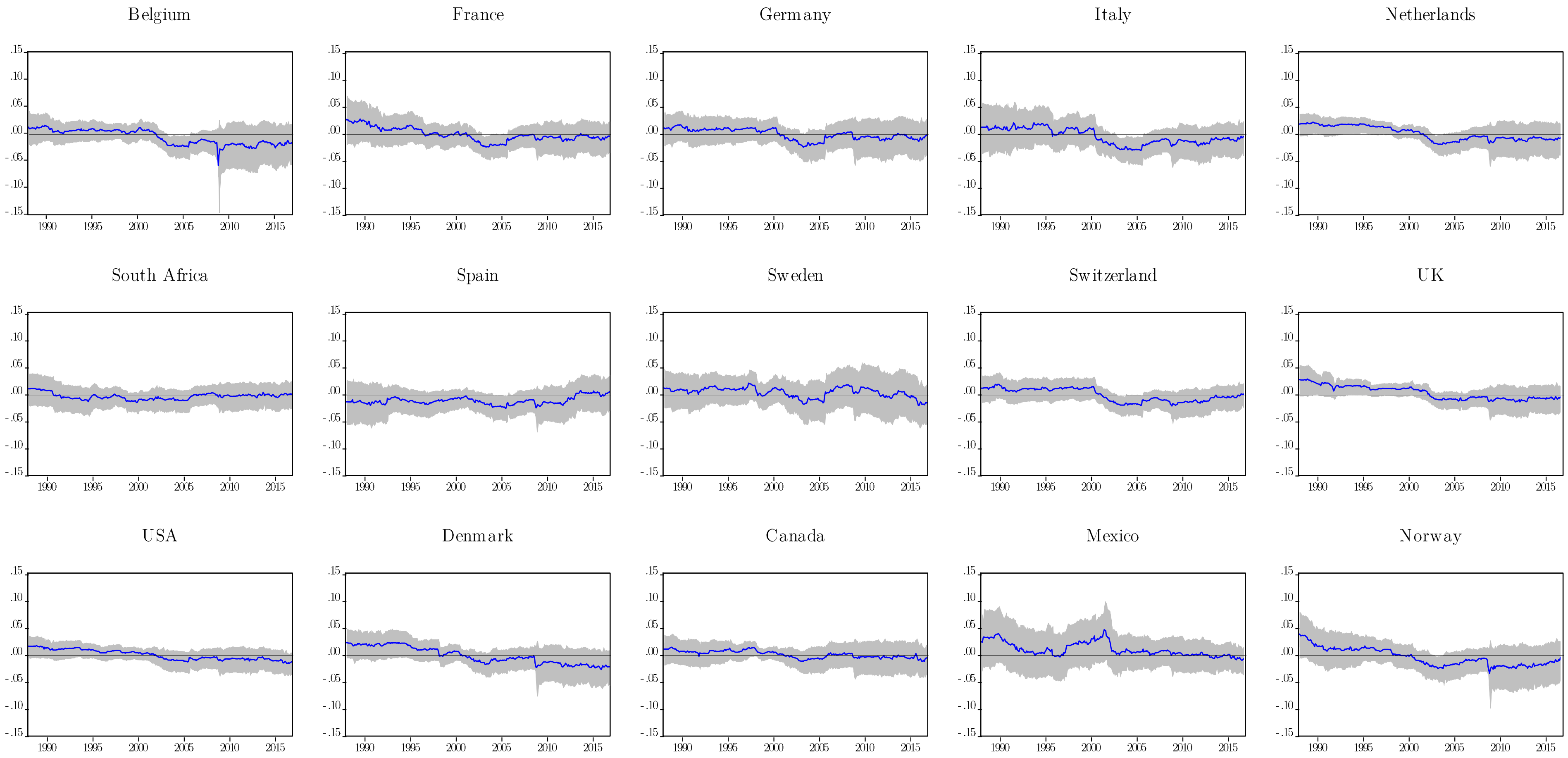
Note: Estimates based on the rolling SVAR with 2 standard-error bands.

Figure 6.9: Time-varying responses of real stock returns to oil supply shocks (Horizon 6)



Note: Estimates based on the rolling SVAR with 2 standard-error bands.

Figure 6.10: Time-varying responses of real stock returns to oil supply shocks (Horizon 12)



Note: Estimates based on the rolling SVAR with 2 standard-error bands.

Figures 6.11-6.13 show the responses of the same stock markets to a positive aggregate demand shock this time. There are now some differences between oil-importers and exporters. More specifically, the impacts of these shocks on oil-exporting countries are much stronger and much more persistent than on the oil-importing ones. This is a reasonable result as the growth in global economic activity induces increases in both oil and stock prices. For the oil-importing countries, an increase in oil prices will result in higher industry costs, which will negatively affect stock markets. As time elapses, these negative effects may gradually offset the positive effects of economic growth. On the other hand, both higher growth rates and higher oil demand tend to increase the stock prices in net oil-exporters, thus leading to a stronger aggregate effect.

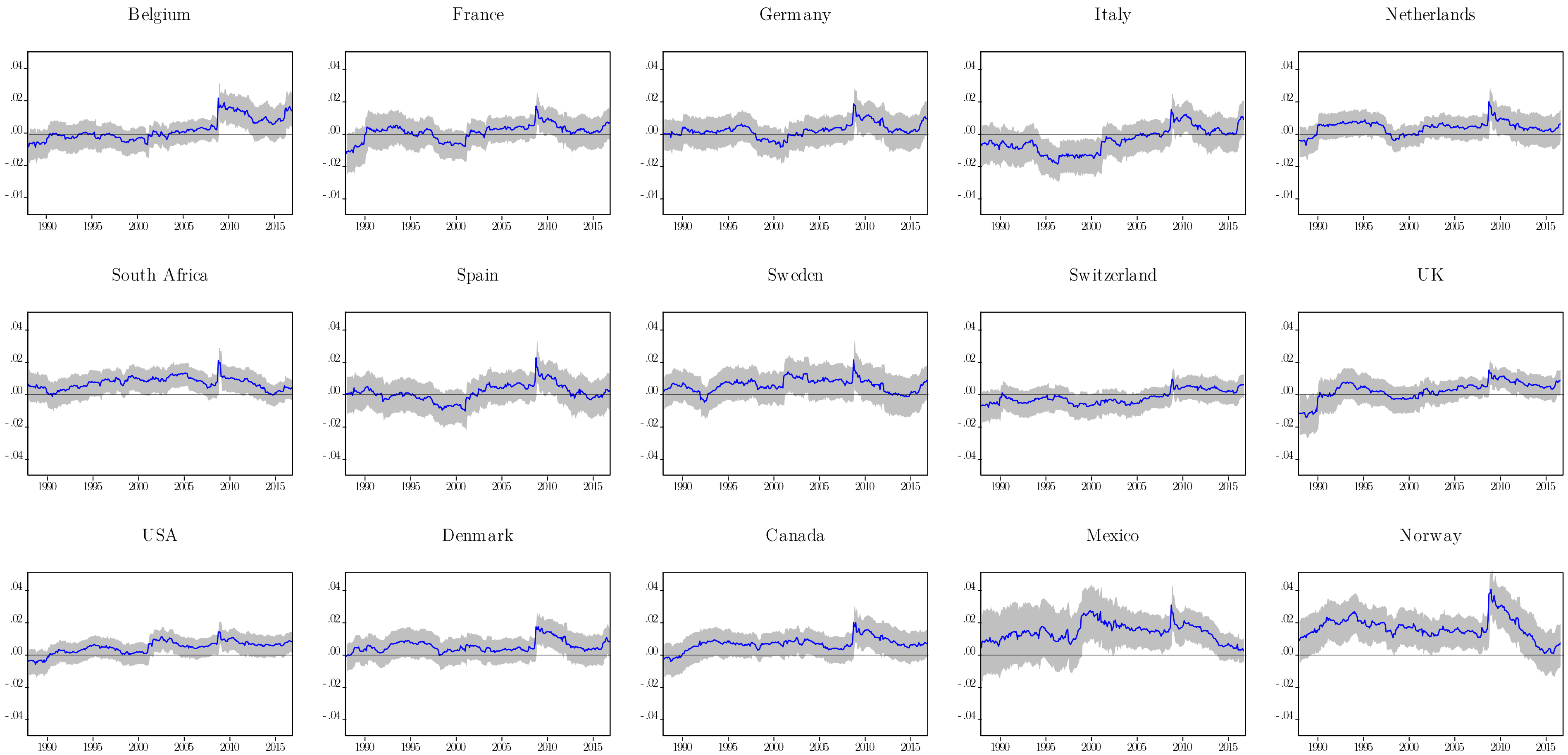
Notice however that there is a negative response in the first half of the sample for a few countries (e.g. Belgium, France, Germany and Italy), indicating that the negative effect was dominant in that period. Note also, that the responses around the GFC period are positive and statistically significant for all countries, indicating that the oil price shocks in periods of world turmoil or during fluctuations of the global business cycle seem to play a significant role on the relationship between oil and stock market prices, regardless the status of the market.

Another interesting observation is that the positive impacts of the aggregate demand expansion are shown as less persistent in Canada and Mexico than in Norway. This happens probably due to the higher crude oil consumption in the first two countries (as we have seen in the Preliminary analysis) that leads to a stronger negative impact, offsetting the positive effects of economic growth more rapidly.

Finally, Figures 6.14-6.16 plot the responses of the stock market returns to a positive shock in oil-specific demand. Again, there are notable differences in the responses between the importers and the exporters, especially in the short-run. The responses are negative for all the oil-importing countries (except South Africa in the short-run), since an increase in oil-specific demand leads to an increase in oil prices and as a result pushes down the stock prices in these countries. On the other hand, the responses are positive for the three oil-exporters, but statistically significant only in the short-term, indicating that the gains for these countries are short-lived. Again, Norway gains more than Canada and Mexico due to the lower oil consumption in this country.

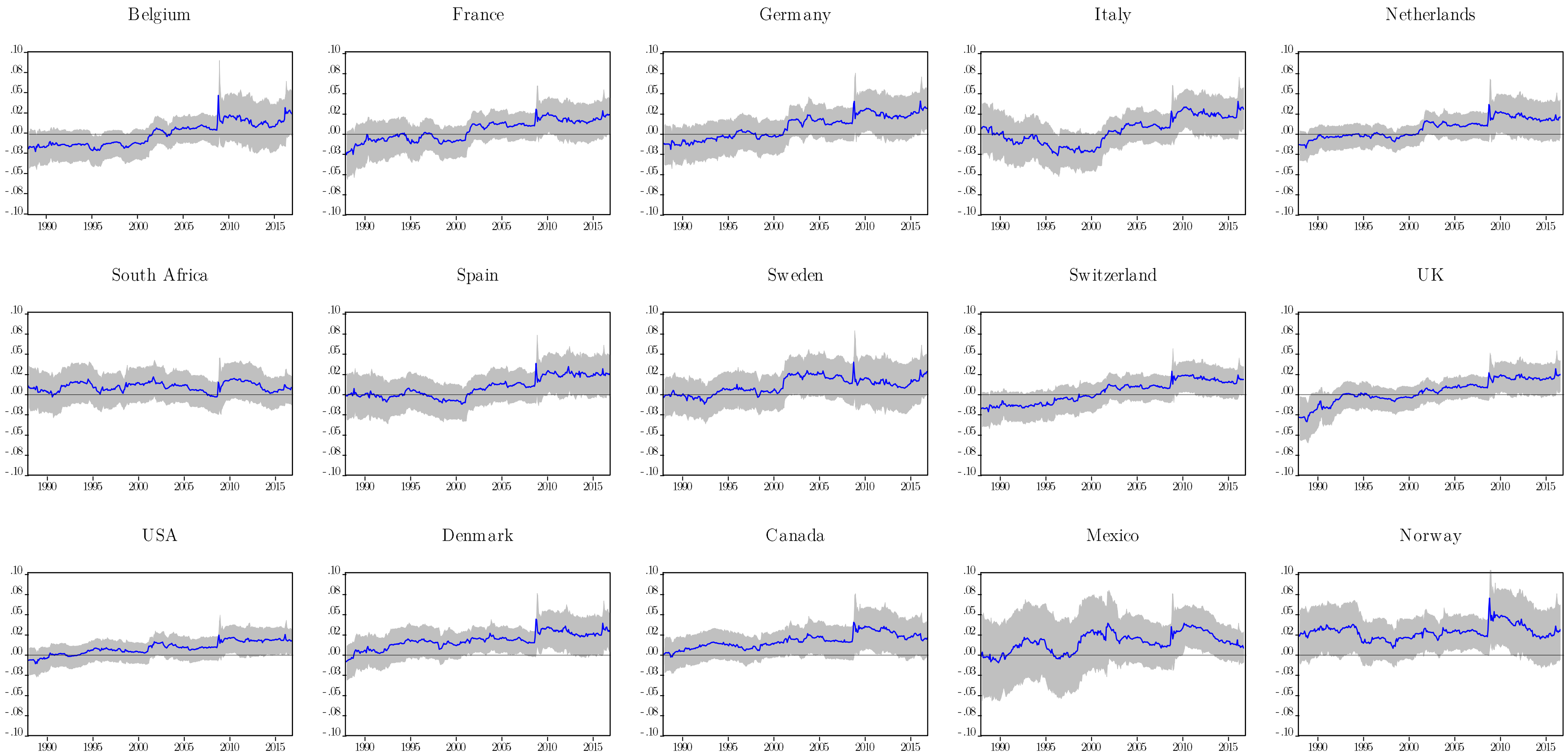
A fact that stands out, especially in the short-horizons, is that the responses have a positive trend in all countries at the end of the sample. This finding may seem counter-intuitive, given that a negative relationship is established in the previous periods. A plausible explanation can be found in the interpretation of these shocks as speculative ones. A number of authors claim that the increased speculation in the oil market, due

Figure 6.11: Time-varying responses of real stock returns to aggregate demand shocks (Horizon 2)



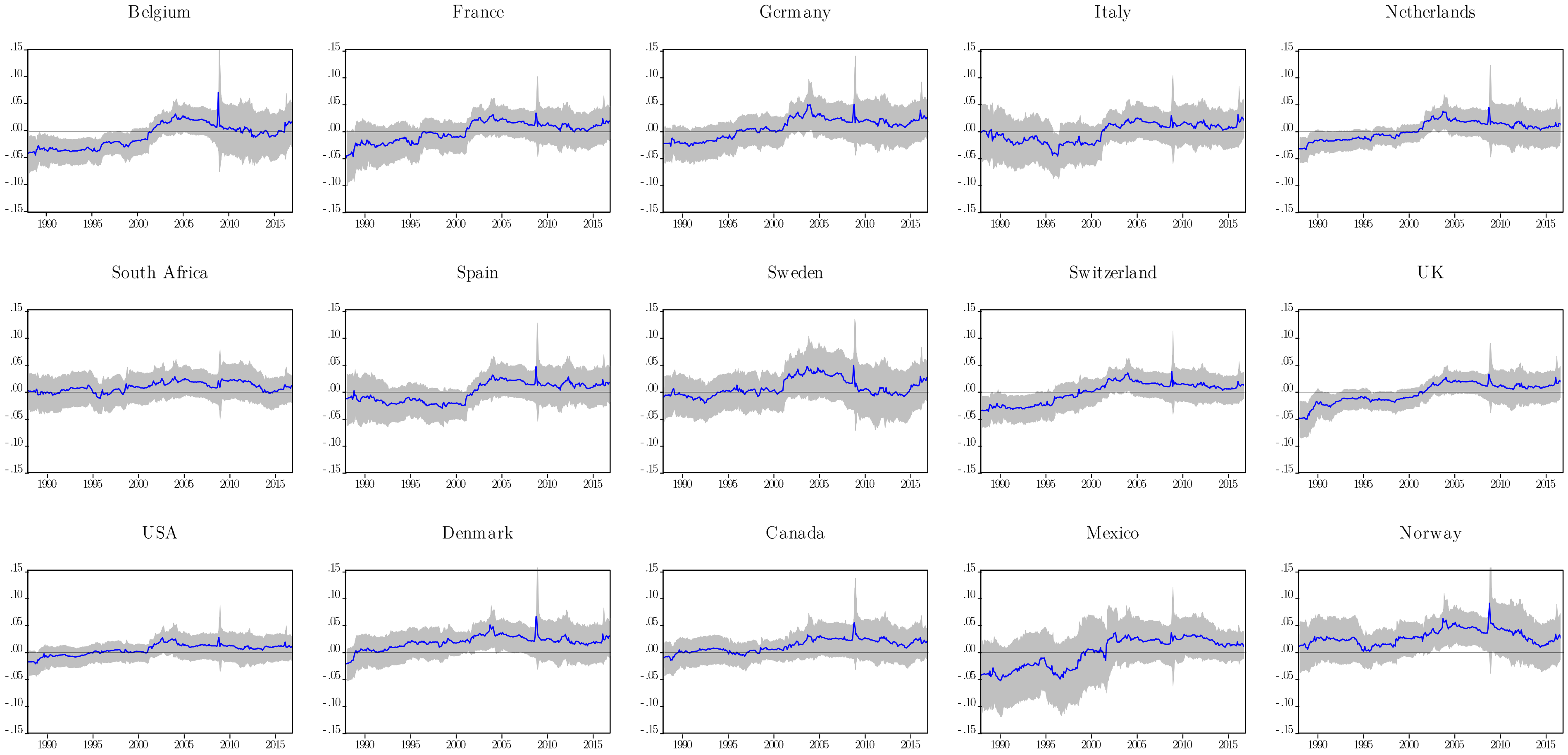
Note: Estimates based on the rolling SVAR with 2 standard-error bands.

Figure 6.12: Time-varying responses of real stock returns to aggregate demand shocks (Horizon 6)



Note: Estimates based on the rolling SVAR with 2 standard-error bands.

Figure 6.13: Time-varying responses of real stock returns to aggregate demand shocks (Horizon 12)

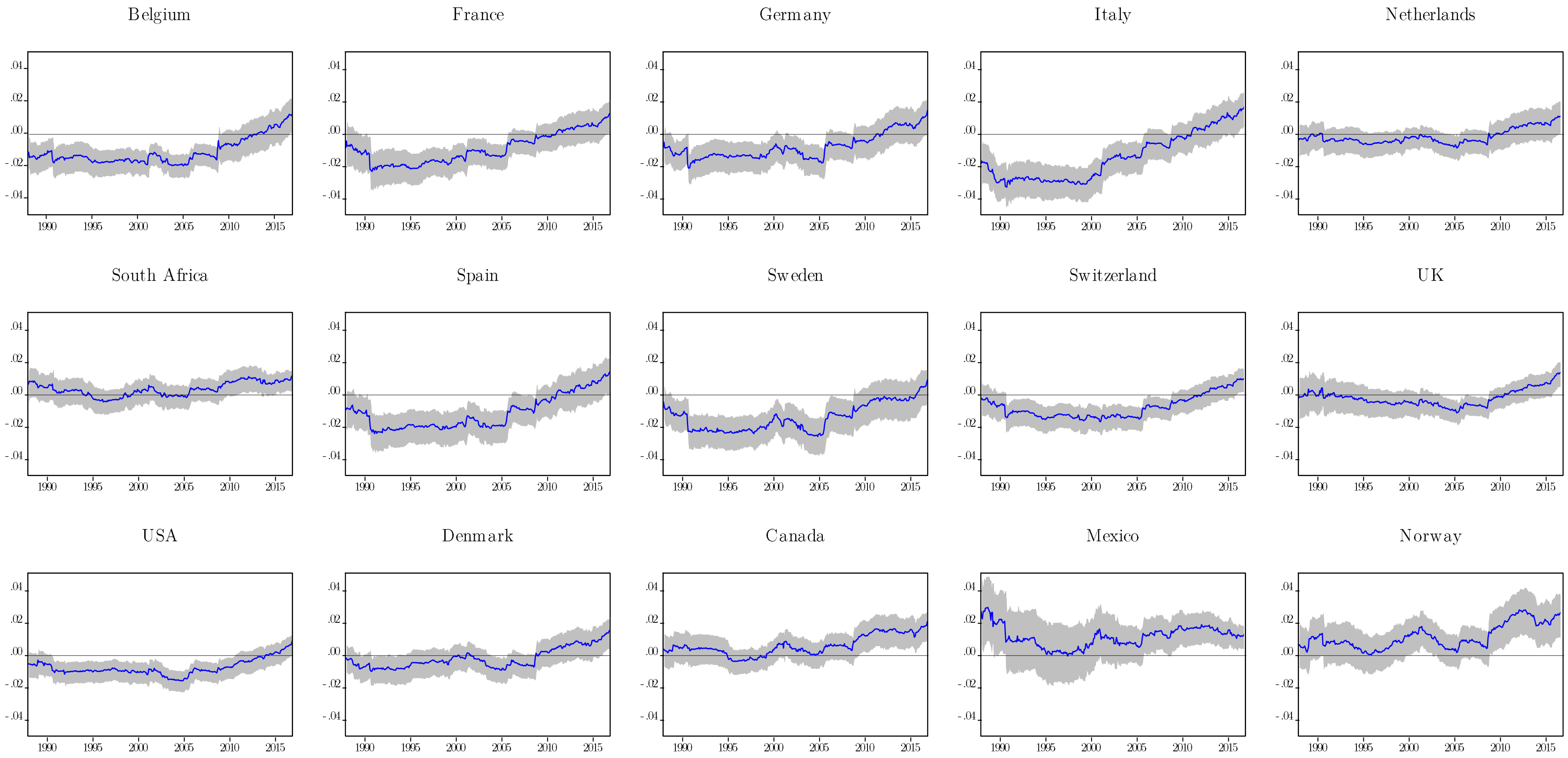


Note: Estimates based on the rolling SVAR with 2 standard-error bands.

to the increased participation of hedge funds, has created an increased correlation between oil prices and stock returns. Thus, such financialisation of the oil market could justify the positive response of the stock market returns to oil-market specific shocks in the more recent years.

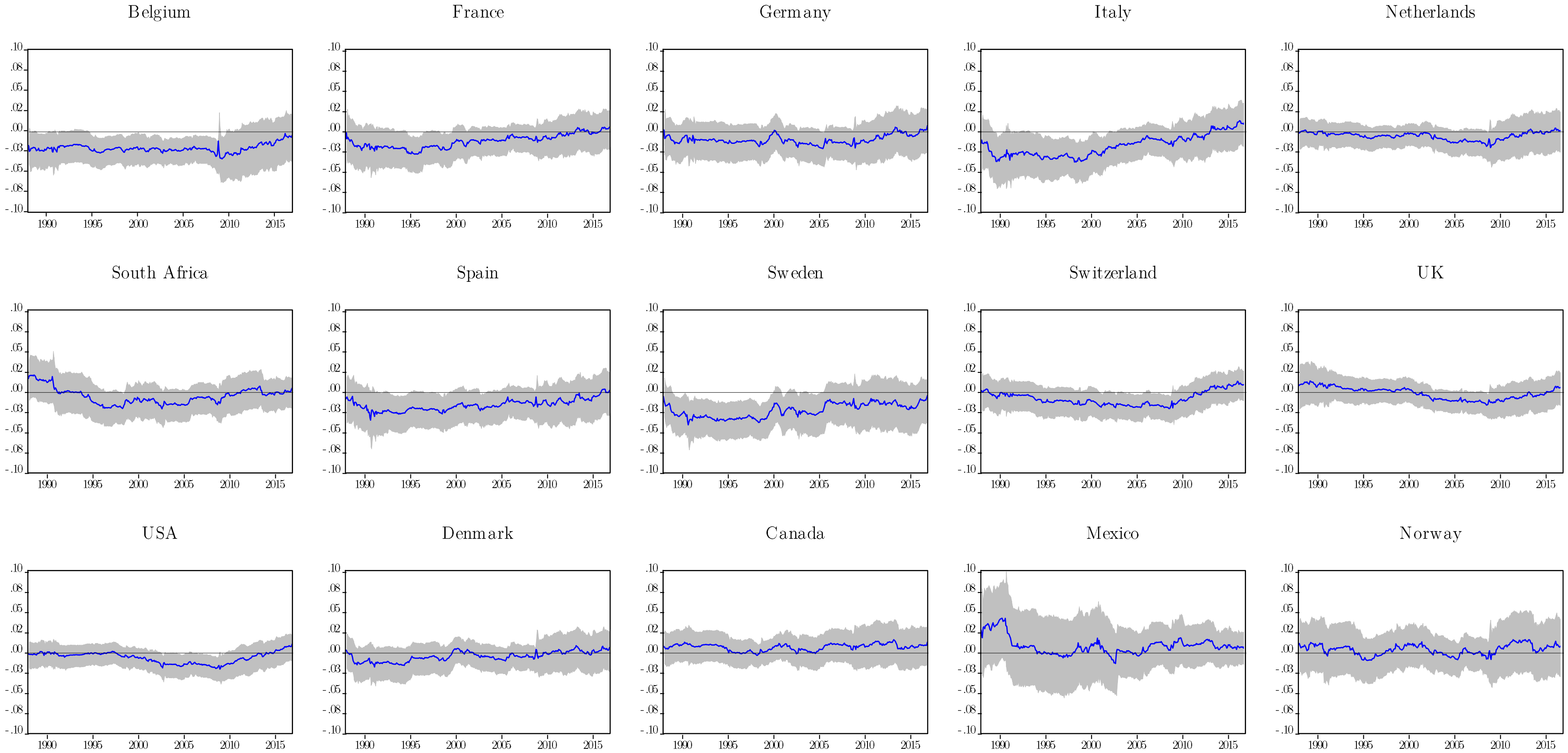
Before we conclude this subsection, we highly recommend the reader to take a brief look on the 3D graphs in the Appendix. We will not discuss here these Figures one by one since we believe that such a procedure would be exhaustive. However, the overall conclusion from both the horizon-specific as well as the 3D analysis is that there is significant time-variation on the responses of the stock markets to the different oil price shocks. As we have seen, different shocks may affect different countries in various ways over time, since the relationship between oil and stock markets is dynamic. Moreover, it is very important to identify the origins of the oil price change as well as the net position of the country that we are interesting.

Figure 6.14: Time-varying responses of real stock returns to oil-specific demand shocks (Horizon 2)



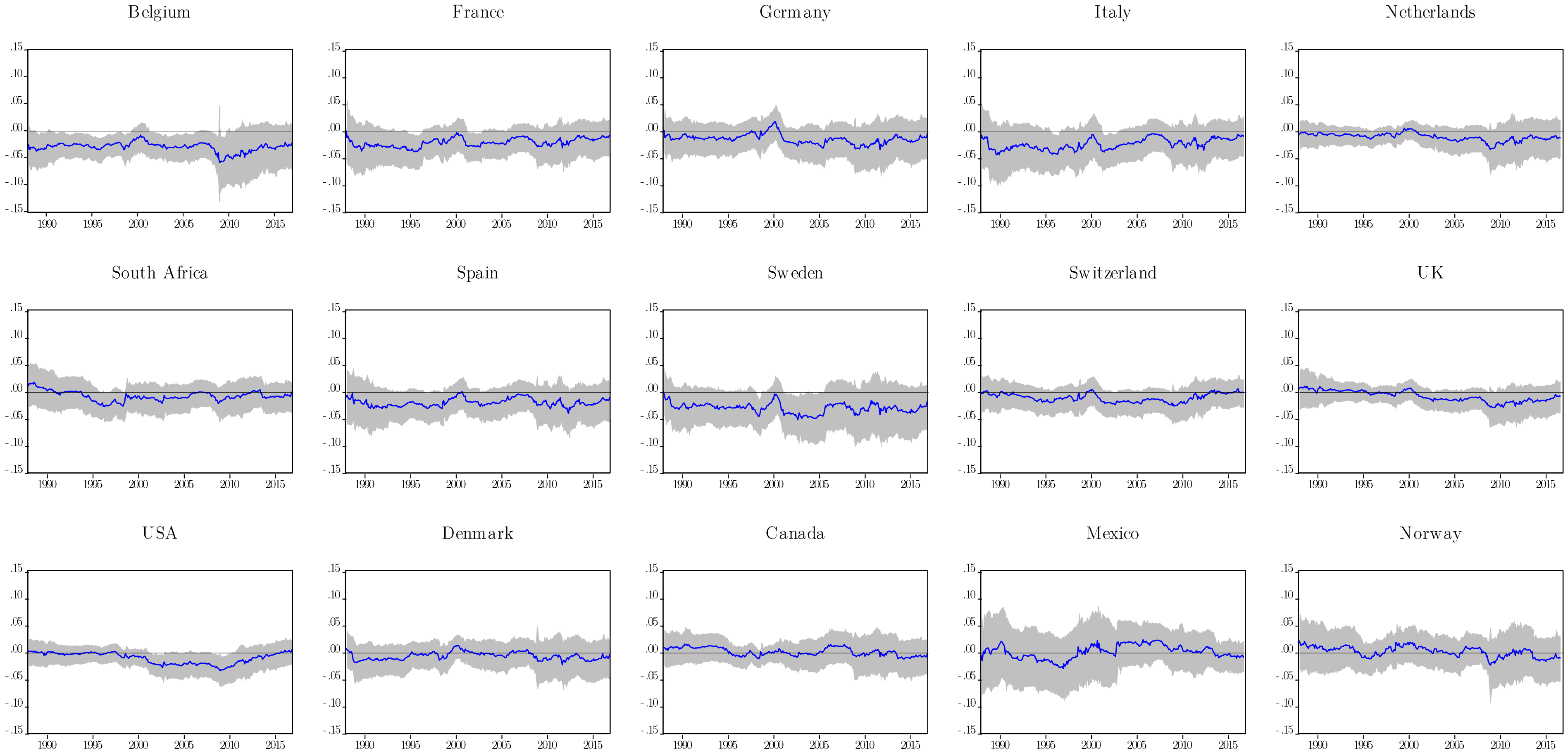
Note: Estimates based on the rolling SVAR with 2 standard-error bands.

Figure 6.15: Time-varying responses of real stock returns to oil-specific demand shocks (Horizon 6)



Note: Estimates based on the rolling SVAR with 2 standard-error bands.

Figure 6.16: Time-varying responses of real stock returns to oil-specific demand shocks (Horizon 12)



Note: Estimates based on the rolling SVAR with 2 standard-error bands.

6.3.2 Impulse response analysis for the US sectors

In this section, we conduct the same analysis, but this time we examine the responses of the 49 US industries to the different oil price shocks. We present here the results only for the 15 out of 49 industries to improve the readability of the graphs. The rest of the results can be found on Figures 8.16-8.24 in the Appendix. We follow only a horizon-specific analysis this time.

Figures 6.17-6.19 present the responses of the 15 selected US industries to oil supply disruptions in the second, sixth and twelfth forecasting horizons respectively. The responses of the majority of the industries are very close to zero in the short-run. Exceptions are the Mining and the Healthcare industries, which experience positive effects from an oil supply disruption that are statistically significant in some periods. As we move on to the larger forecasting horizons, all industries follow the same pattern as the aggregate stock market index that we have discussed in the previous section. The fact that in the more recent years the responses are negative and partially significant must be related to the "tight oil revolution", which we discuss in more detail in the next subsection.

The only exception to this pattern is the Mining industry that clearly gains from an oil supply disruption over the years, but especially after 2009, even in the longer horizons. Another interesting result is that the responses of the Petroleum & Gas industry, despite they change sign over time, they remain insignificant.

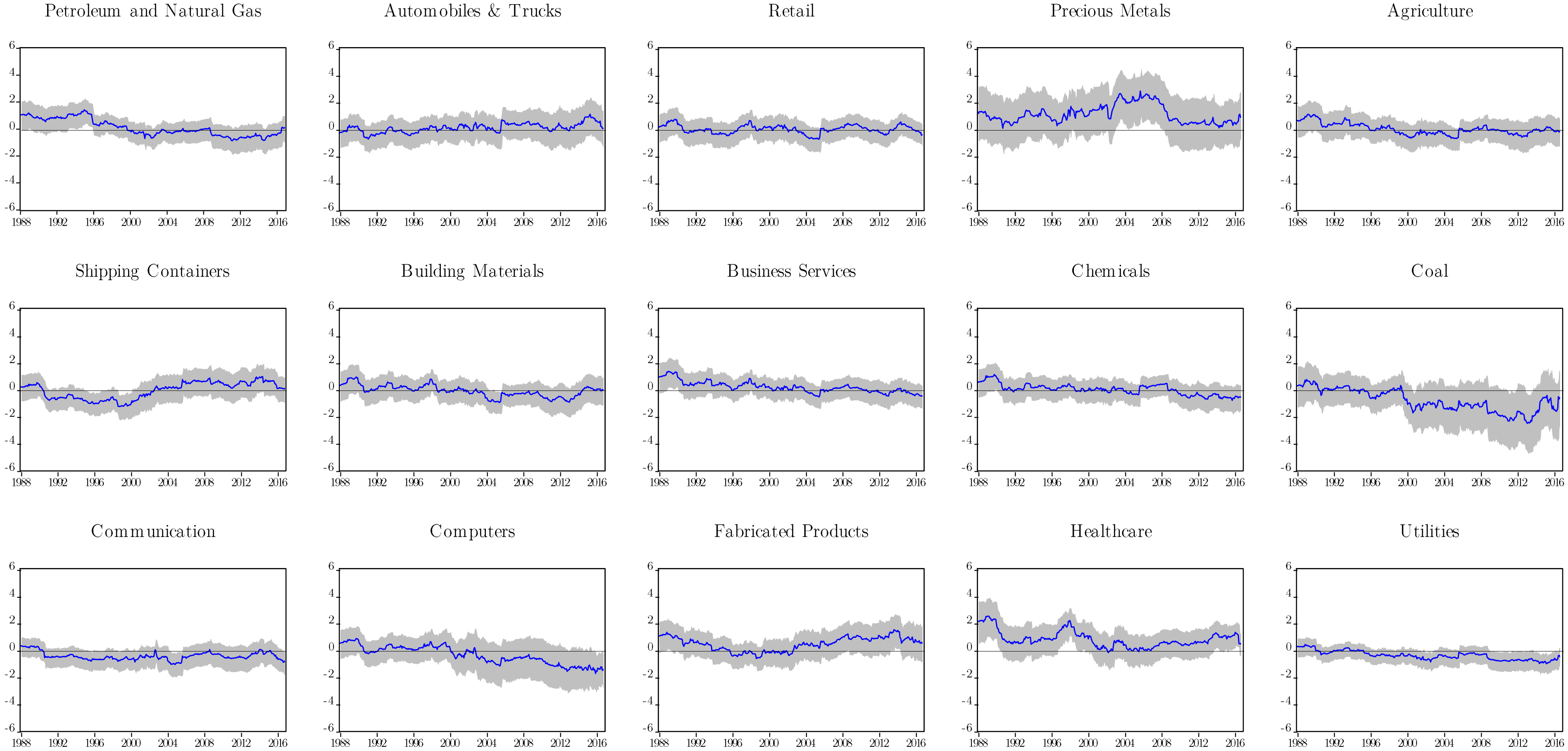
Figures 6.20-6.22 plot the time-varying responses of the same US industries to an aggregate demand expansion. After the first years that some industries respond negatively, the responses of all industries become positive in the rest of the sample. Statistically significance, in the short-run, exists only for the Petroleum, Mining and Communication industries. Overall, the industry that gains more is the Petroleum one, which is reasonable since higher growth rates together with higher oil prices both tend to increase the shares of this industry.

Finally, Figures 6.23-6.25 depict the responses of these industries to an increase in oil-specific demand. The responses of the majority of the industries are negative and highly significant in the short-run, while they remain negative but they gradually lose significance as we move to longer horizons. This is a reasonable result, as an oil-specific shock lead to an increase in oil prices, harming in this way these industries, the majority of which are oil-consuming.

However, there are three industries that are affected differently from an increase in oil-specific demand. The Petroleum industry responds positively through all the years, but statistical significance can be found only in some specific periods in the short-run. This result is reasonable, as increases in oil prices benefit this industry, since oil is their main product. On the other hand, the Mining and Coal industries respond positively in the short run, while they approach zero or become negative as the forecasting horizons increase. This indicates, on the one hand, the role of the Mining industry as safe haven in periods of world turmoil, while on the other hand, indicates the role of Coal as substitute to oil.

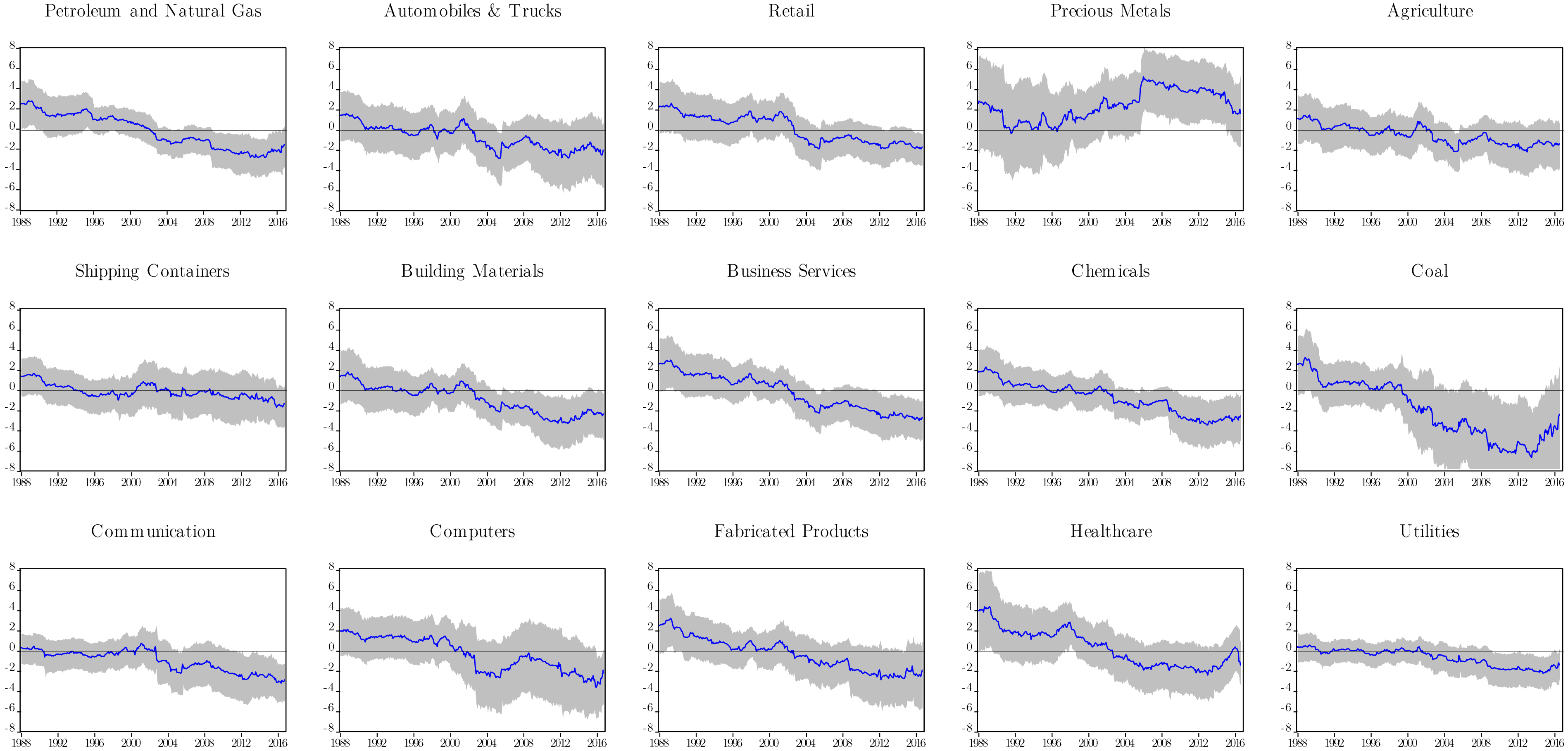
Overall, the results of this section illustrate the importance of distinguishing the origins of the oil price shocks, as each type of shocks affect differently the various US industries. Another significant conclusion of this analysis, which is in line with the conclusions made for the US aggregate stock market index, is that there is significant time-variation on the responses, justifying the use of time-varying techniques.

Figure 6.17: Time-varying responses of US industrial real stock returns to oil supply shocks (Horizon 2)



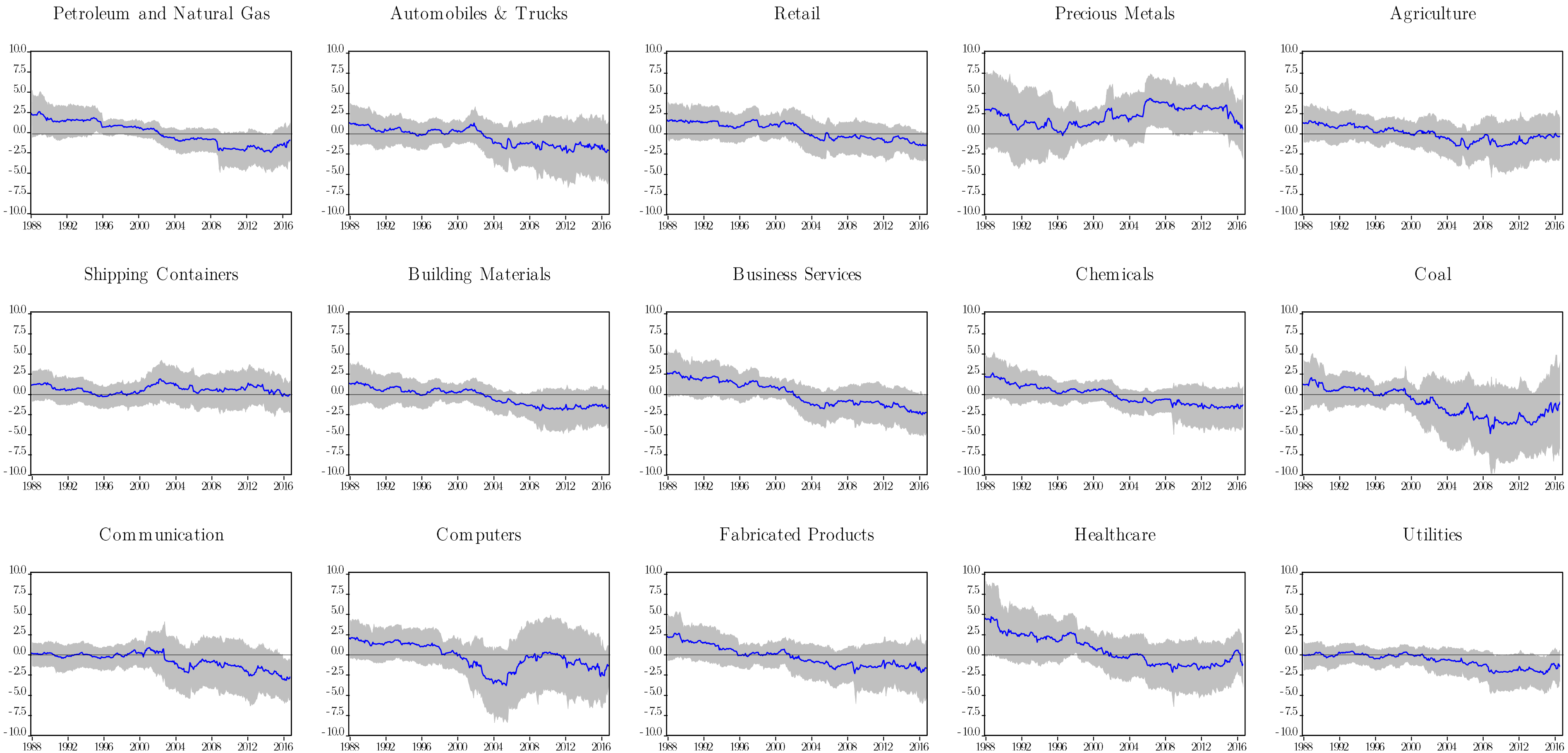
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for 15 out of 49 selected industries.

Figure 6.18: Time-varying responses of US industrial real stock returns to oil supply shocks (Horizon 6)



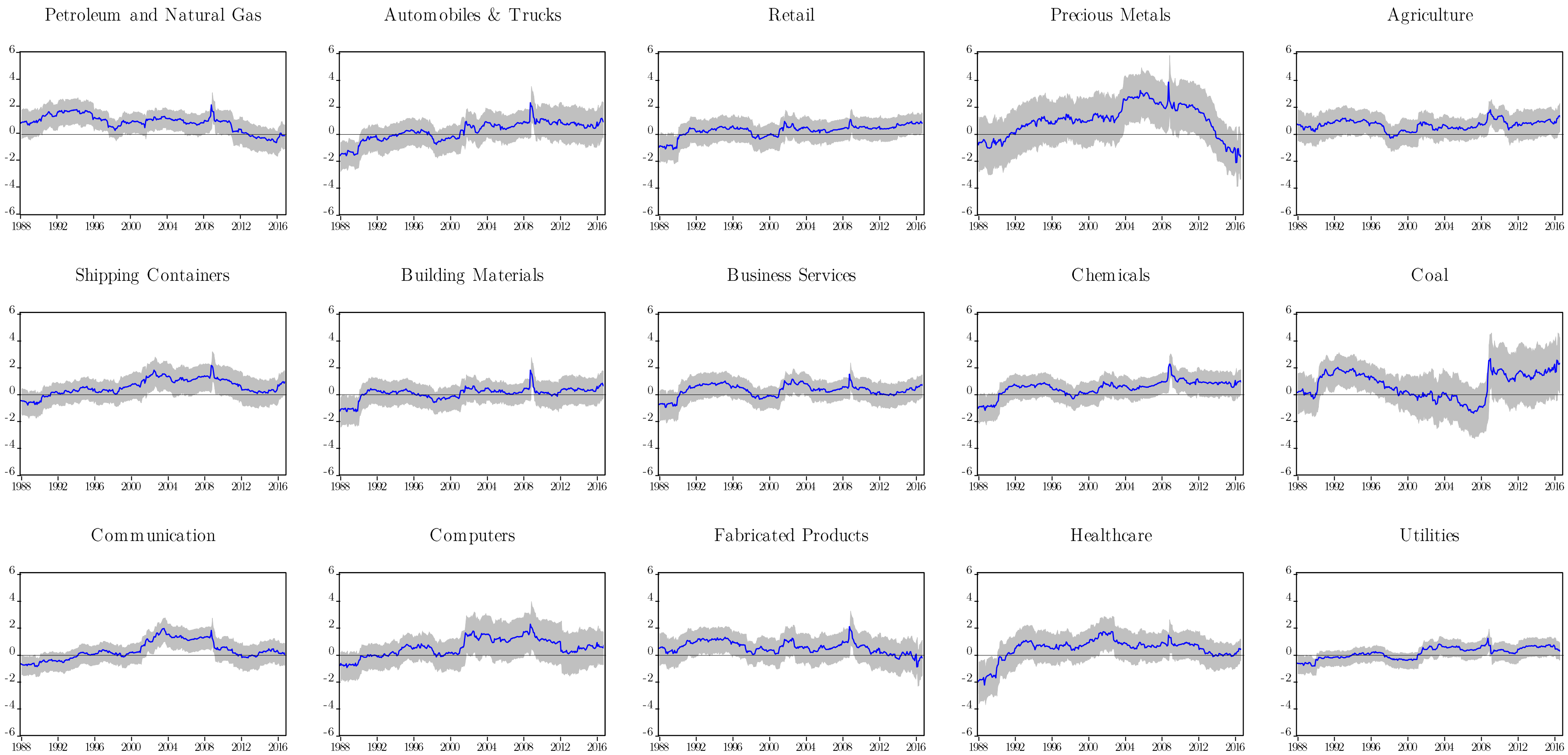
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for 15 out of 49 selected industries.

Figure 6.19: Time-varying responses of US industrial real stock returns to oil supply shocks (Horizon 12)



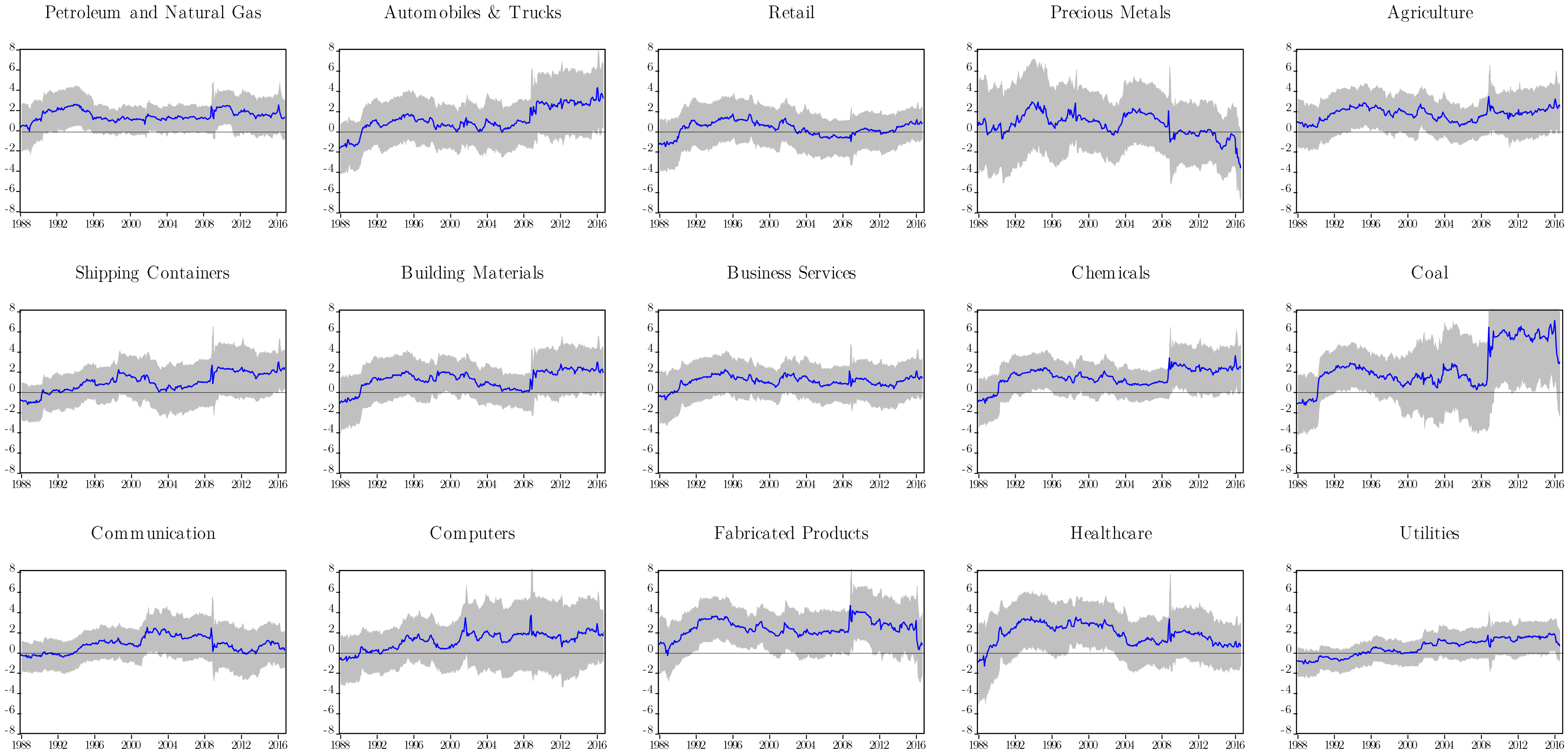
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for 15 out of 49 selected industries.

Figure 6.20: Time-varying responses of US industrial real stock returns to aggregate demand shocks (Horizon 2)



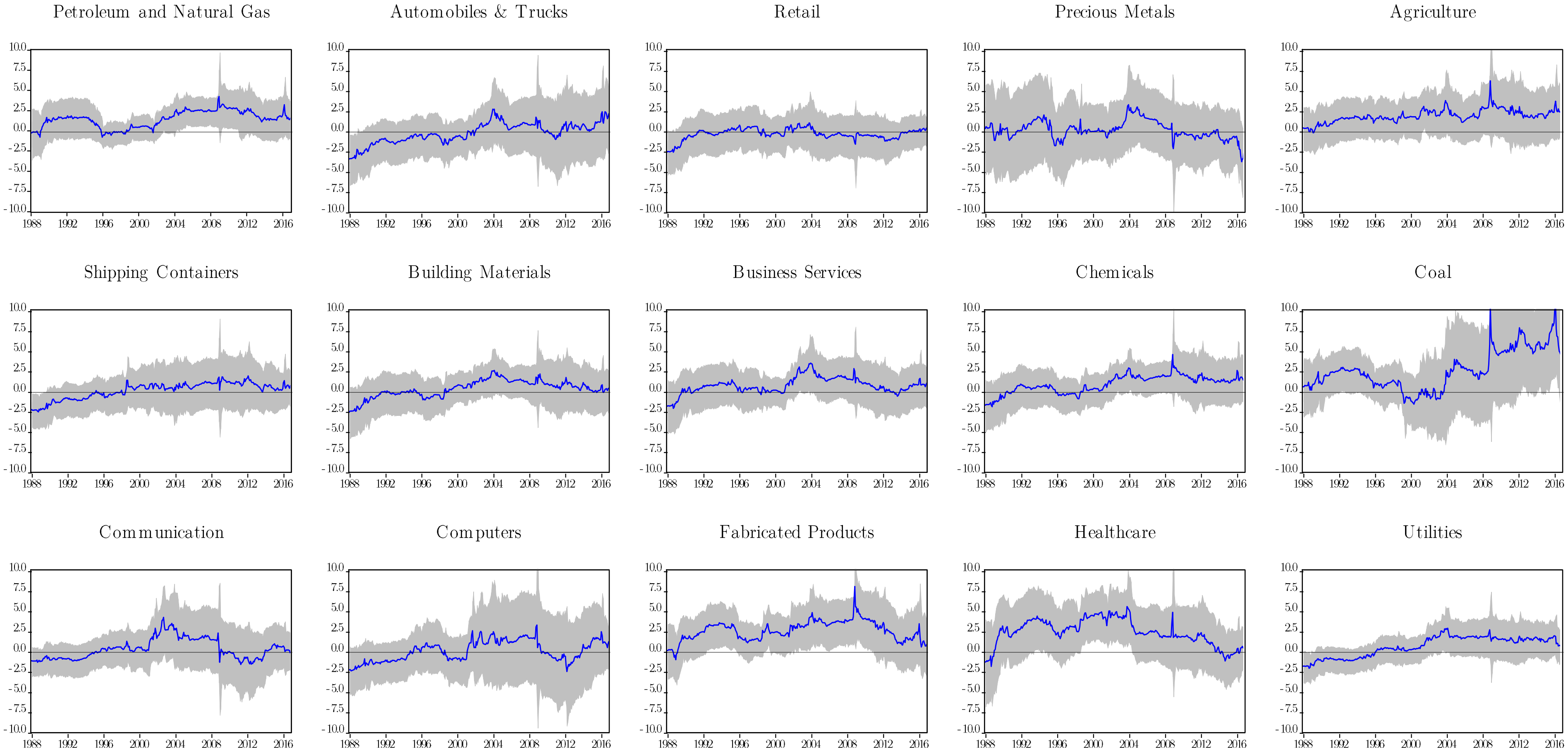
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for 15 out of 49 selected industries.

Figure 6.21: Time-varying responses of US industrial real stock returns to aggregate demand shocks (Horizon 6)



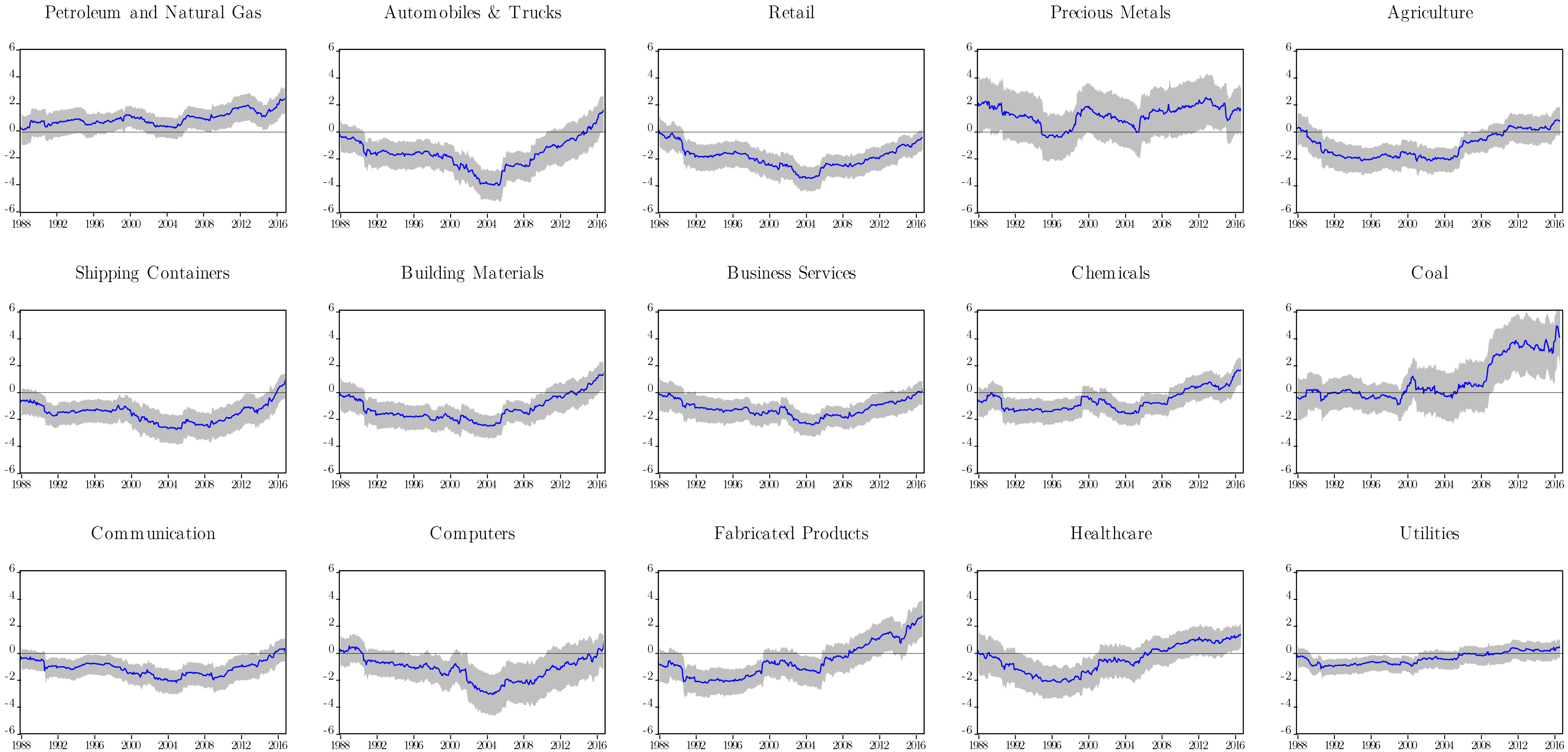
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for 15 out of 49 selected industries.

Figure 6.22: Time-varying responses of US industrial real stock returns to aggregate demand shocks (Horizon 12)



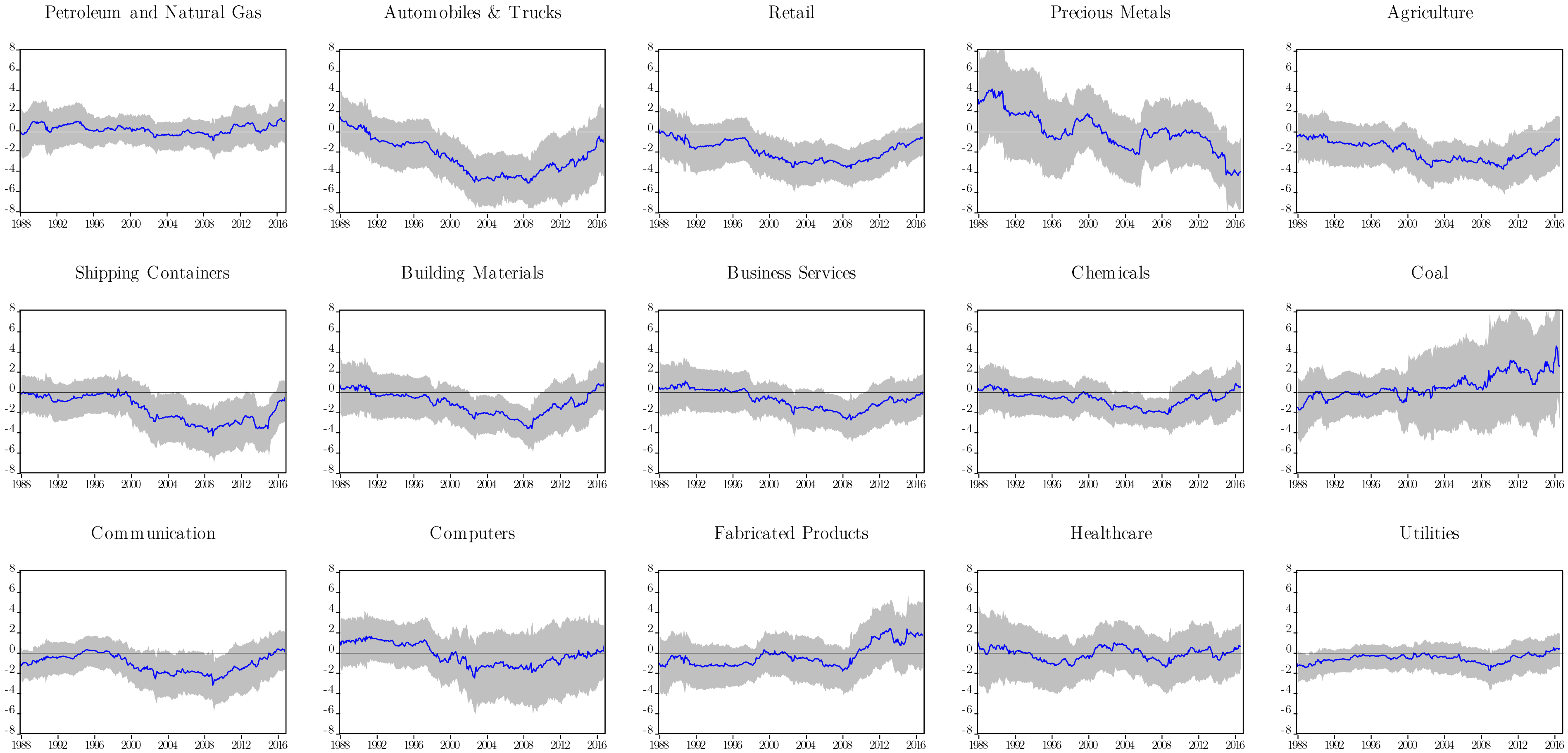
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for 15 out of 49 selected industries.

Figure 6.23: Time-varying responses of US industrial real stock returns to oil-specific demand shocks (Horizon 2)



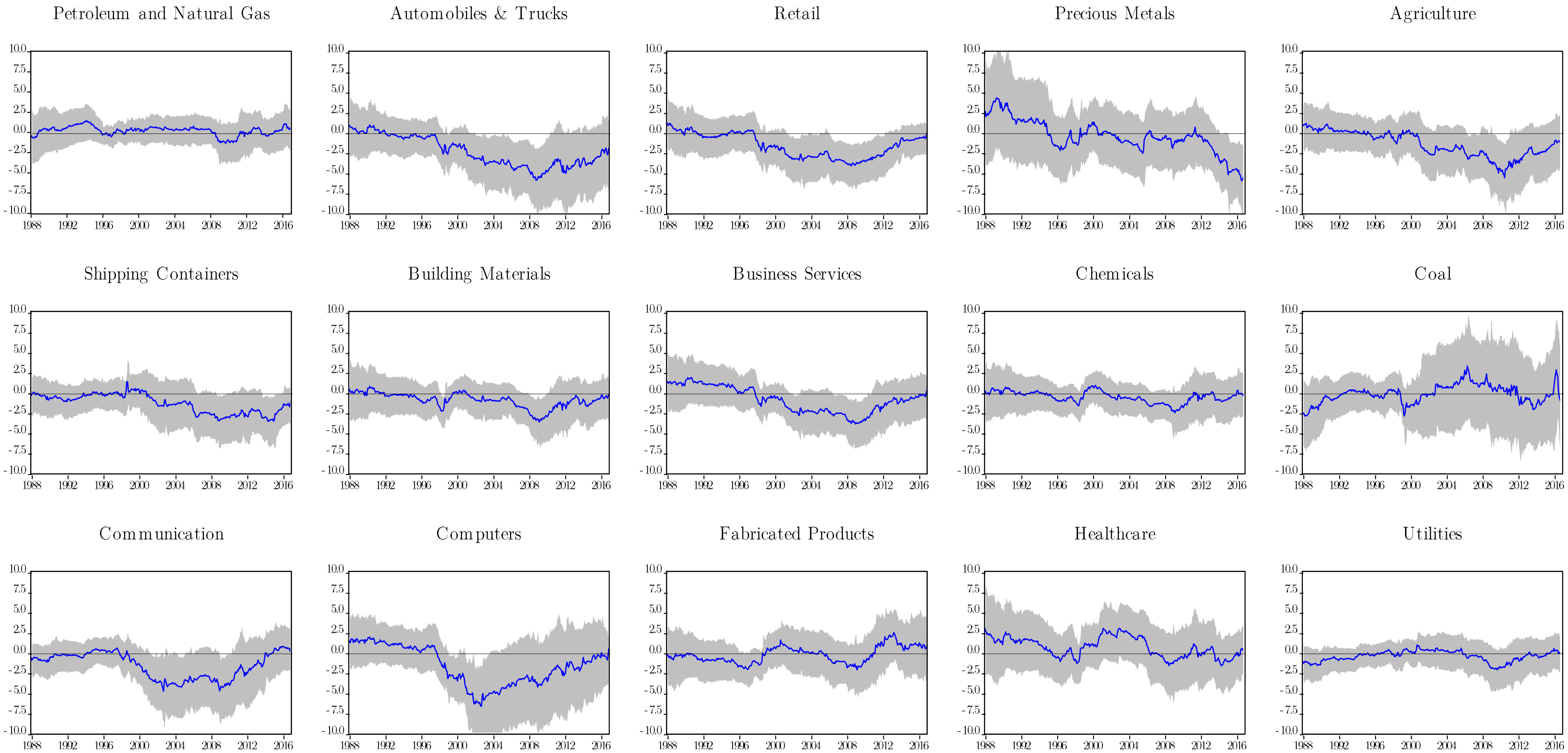
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for 15 out of 49 selected industries.

Figure 6.24: Time-varying responses of US industrial real stock returns to oil-specific demand shocks (Horizon 6)



Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for 15 out of 49 selected industries.

Figure 6.25: Time-varying responses of US industrial real stock returns to oil-specific demand shocks (Horizon 12)



Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for 15 out of 49 selected industries.

6.3.3 A spillover index

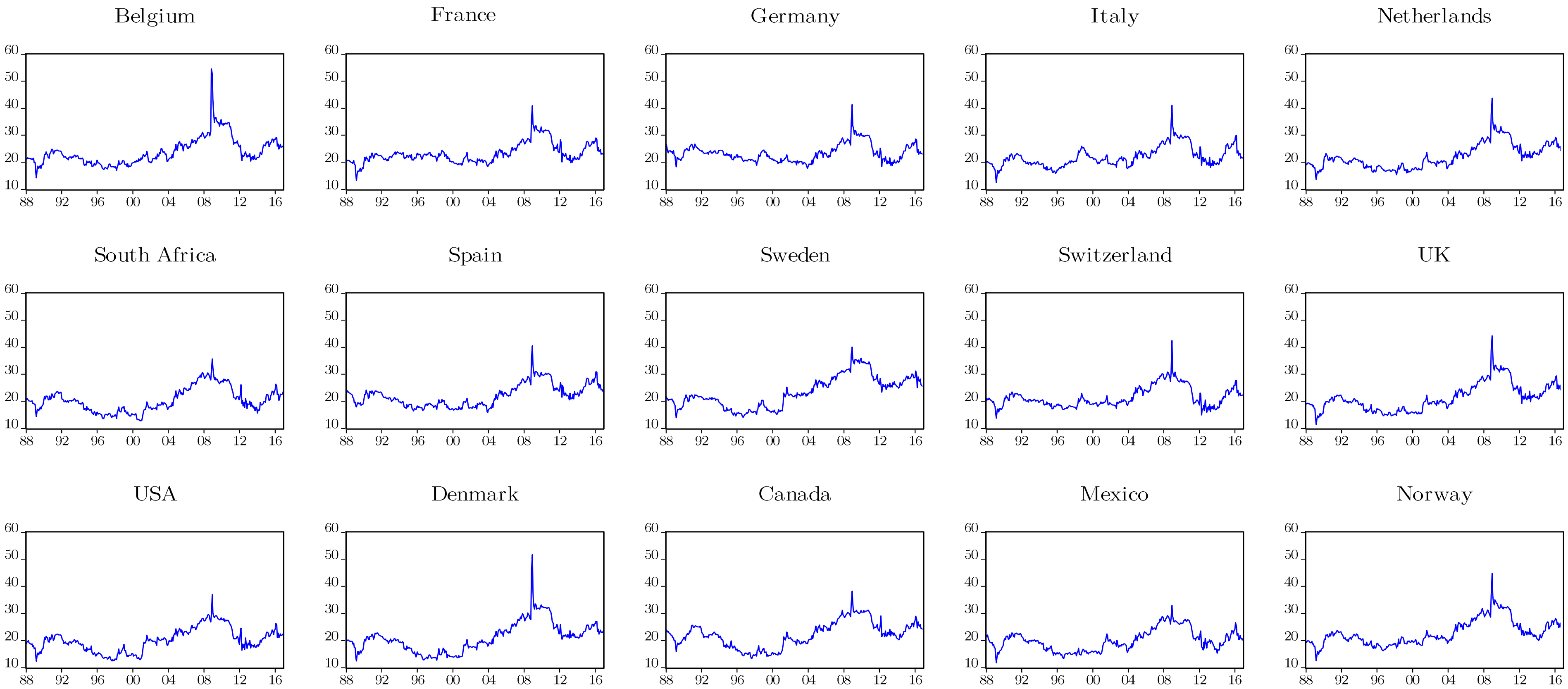
In this section, we use the estimates from the rolling SVAR model to calculate the time-varying forecast error variance decompositions, in order to construct a time-varying spillover index for each one of the 15 countries in our sample. This spillover index was introduced by Diebold and Yilmaz (2009, 2014) and shows the spillover between the oil and the stock markets for each country. It is a ratio having as numerator the sum of the contributions of each variable to the variation of the others, and as denominator, the sum of the contributions of each variable to the variations of the others plus to its own variation. After retrieving the variance decompositions from each estimated rolling sample, we construct the index for every country.

Figure 6.26 plots the spillover index for each country over time. We observe that the time path is more or less the same for all the countries. This is a reasonable result as the oil market is a global market. Taking a deeper look on the graphs, we can see that the dates of some well-known events are followed by rises in spillover indices. More specifically, there are some notable upticks during the 2nd Gulf War (2003), the terrorist attack in the US on the 9th of September in 2001, the Arab Spring (2011) and the 2014-2015 oil price down.

Of course the major event in our sample is the GFC (2008-09), when the spillover indices in all countries reached record values. Notice, however, that the spillover between the 2 markets (i.e. the oil and the stock) in each country has gradually increased before the GFC and took its highest value right before the GFC outbreak. This is reasonable as the oil and stock market prices had increased co-movement in that period, as has been found by many authors.

Overall, these results indicate that this time-varying spillover index can well identify some major events in the recent history that led to a significant spillover from the oil market to the stock markets around the globe.

Figure 6.26: Spillover indices



Notes: The spillover indices are defined in the text as the sum of the forecast error variance decomposition contributions from one variable structural shock to the other variables when the forecast horizon is 60 months, estimated using 180-month rolling windows.

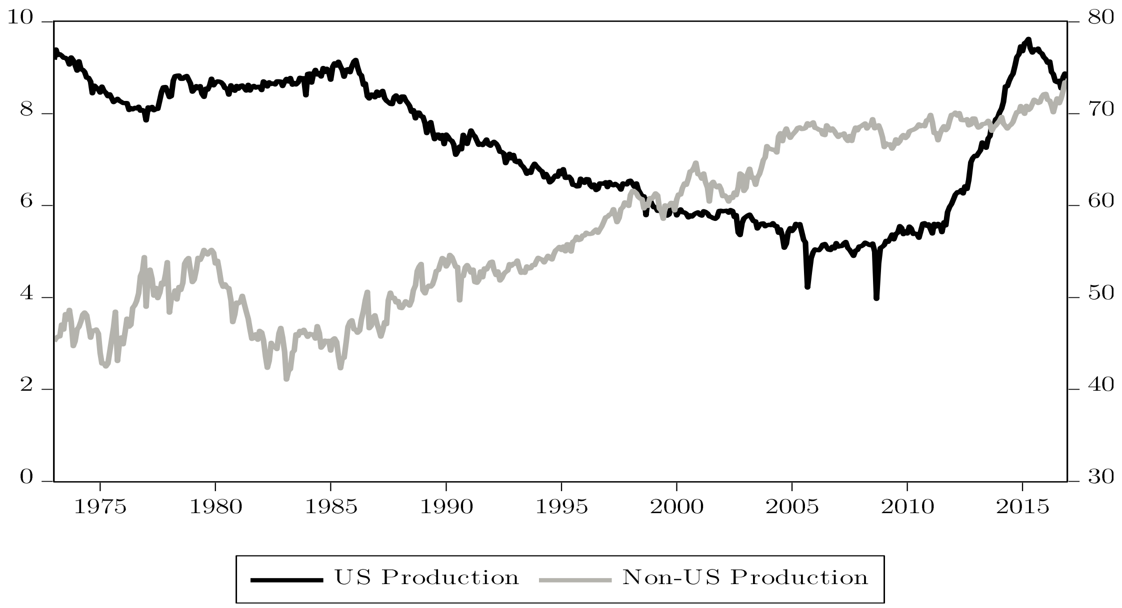
6.4 Scenario 3: The role of Economic Policy Uncertainty

We continue with the last scenario examined in this study. More specifically, in this section, we examine the role of economic policy uncertainty on the relationship between oil and stock markets. Moreover, we also examine if there is any difference in the responses of the US composite stock market index when we replace the global oil production variable with the US and non-US oil production ones. The rationale of doing this is discussed in Subsection 6.4.1, while the impulse response analysis is presented in Subsection 6.4.2.

6.4.1 The Tight Oil Revolution

Figure 6.27 plots the evolution of the US and non-US oil production in time. After about two decades of steady decline in the U.S. oil production, innovations and new technologies in the extraction of crude oil have resulted to an unprecedented expansion after 2009. This development, besides increasing the US domestic income, has also consequences about the political and economic security and hence for the U.S. asset market.

Figure 6.27: Monthly US and Non-US oil production



Note: US production is measured on the left hand side, while Non-US oil production is measured on the right hand-side.

Kang et al. (2016) showed that the disaggregation of global oil production into US and non-US oil production changes the conclusions reached by following an impulse response analysis. They found that an US oil supply disruption has a negative impact on US real stock returns, which is in contrast to the established finding that shocks to global oil production have no effects on US real stock prices.

Thus, we incorporate the US production in our model. This can only be done by replacing the global oil production variable with non-US and US oil production variables and re-estimate the rolling SVAR model. We further augment our model with an US economic policy uncertainty index, as discussed in Section 5.3. The next subsection provides the results from this analysis.

6.4.2 An impulse response analysis

Figures 6.28 and 6.29 present the impulse responses of US policy uncertainty and stock returns respectively. The first, second and third rows in both Figures correspond to the second, sixth and twelfth forecasting horizons respectively.

We begin with Figure 6.28. The first column presents the responses of the US policy uncertainty to a non-US oil supply disruption. We observe that reductions in oil supply coming from the rest of the world hardly affect the policy uncertainty in the US. There is a marked increase in uncertainty in period 2000-2004, but only in the short-run. In contrast, disruptions in US oil production significantly increase the policy uncertainty in the US, especially after 2009, when the "tight oil revolution" took place. Notice also that the responses remain significant even in the longer horizons.

On the other hand, increases in aggregate demand significantly lower the policy uncertainty, as they are indicative of a flourishing economy. The responses remain negative over almost the entire sample, but they are statistically significant mainly in the short-run. Finally, increases in oil-specific demand, cause an increase in policy uncertainty, which is partially significant only in the long-run.

The final Figure of this study is Figure 6.29, which shows the responses of US stock market to oil market and policy uncertainty shocks. We do not present again the responses to demand-side shocks, since they remain the same as in Section 6.3.1.

Figure 6.28: Time-varying responses of US policy uncertainty

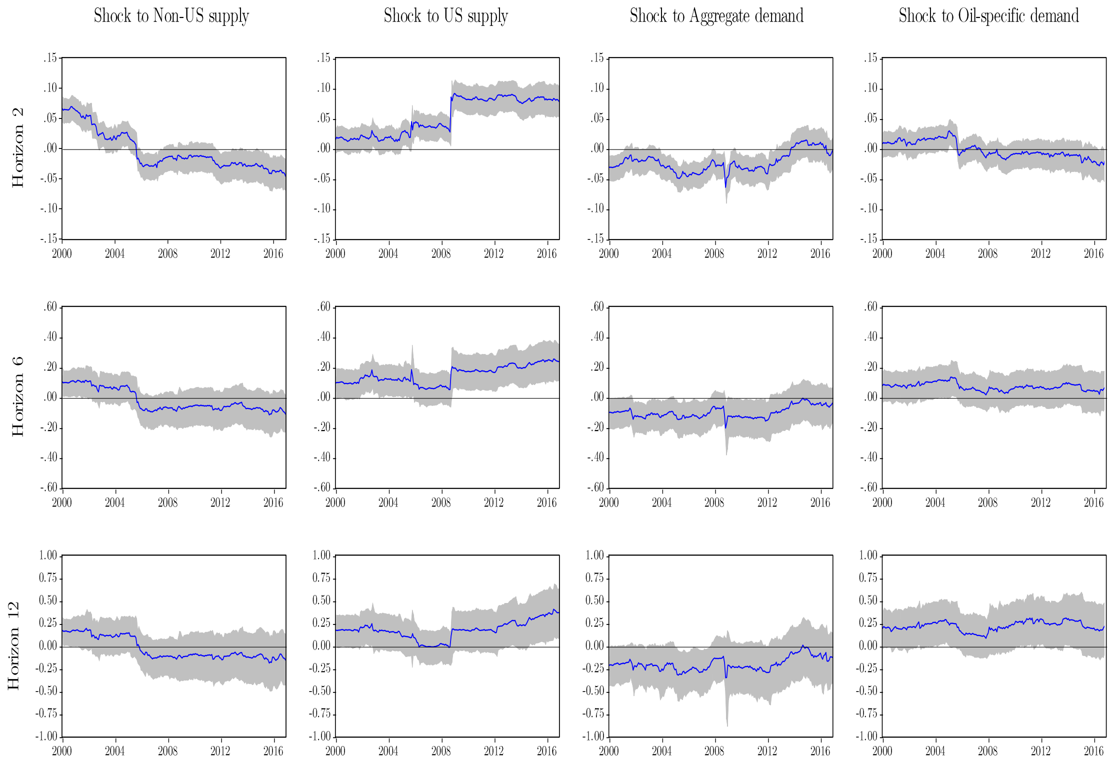
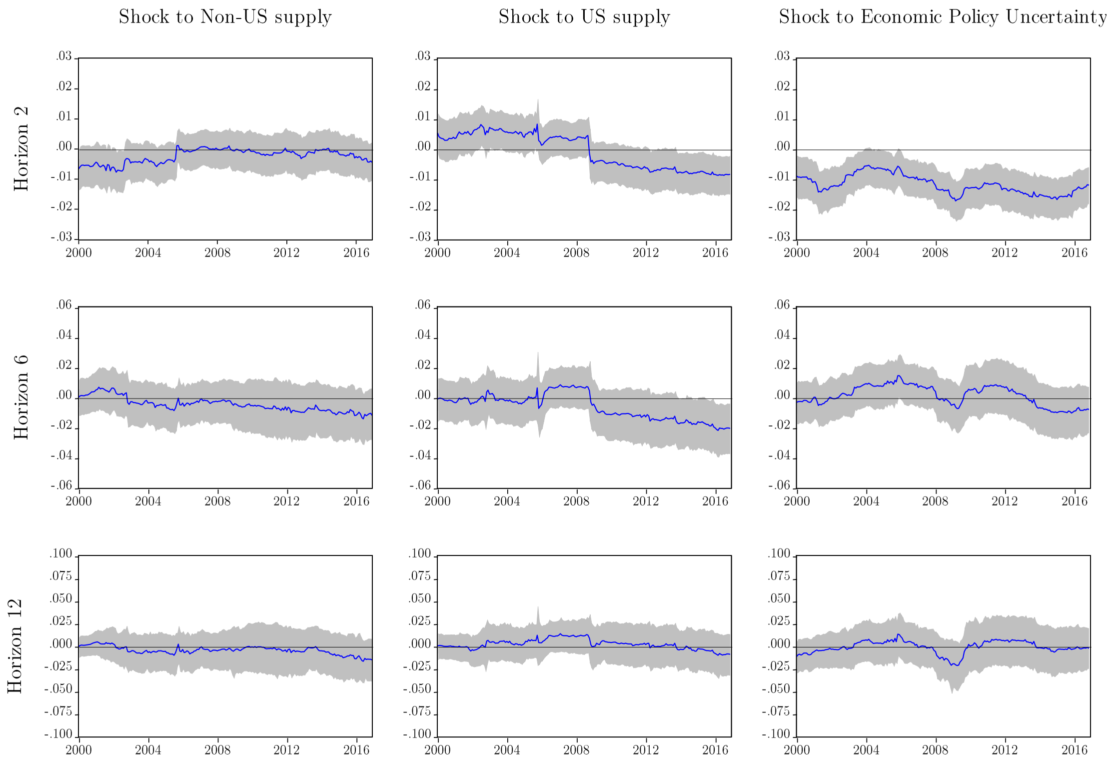


Figure 6.29: Time-varying responses of US real stock returns



Notes: Estimates based on the augmented rolling SVAR with 2 standard-error bands.

We begin with the first column that shows the responses of the US stock market returns to a non-US oil supply disruption. The responses are negative in all horizons, but very close to zero and thus not statistically significant. This is in line with the analysis in Section 6.3.1, which indicates again that oil supply shocks coming from the rest of the world do not affect the US stock market prices. On the other hand, the second column refers to the responses to an US oil supply disruption. Despite the fact that the responses are positive on the first half of the sample, they become negative and marginally significant after the "tight oil revolution". This pattern remains even in the longer horizons, indicating that the "tight oil revolution" might have changed this relationship to some degree. Finally, increased policy uncertainty significantly lowers the stock prices, but this occurs only in the short run. As the horizon increases the responses lose significance, indicating that the effects of economic policy on the stock returns are short-lived.

6.5 Robustness

To check the robustness of our results we made several modifications. First of all, we replaced the US refiner's acquisition cost of imported crude oil, used to measure the global real oil price, with the WTI price. The results show strong stability, indicating that the choice of crude oil price do not affect the nature of the empirical results.

Moreover, since the choice of 24 lags for our SVAR model may be a little bit contradictory, we re-estimated the model using 6 or 12 lags. The results remain qualitatively the same. Finally, we changed the fixed window in the rolling analysis from 180-month (i.e. 15 years) to 204-month (i.e. 17 years), but again the results do not change considerably.[12]

[12] We do not present the results from these tests here due to space limitations, but they are all available upon request.

7. Conclusion

In this study, we take a fresh look on the relationship between oil and stock markets. Building on the seminal work of Kilian and Park (2009), we go a step further by employing time-varying techniques in order to unveil the dynamic nature of this relationship. The whole analysis is conducted through examining three different but interrelated scenarios.

Since this study is mainly based on the seminal papers of Kilian (2009) and Kilian and Park (2009), it is natural to begin by replicating and extending their work in time. Thus, building on a SVAR model for the global oil market as well as for the US stock market, we confirm their results. The conclusions of this exercise are that the oil prices respond to a multitude of shocks and additionally, the responses of the stock market returns to the different oil price shocks highly depend on the underlying cause of the oil price change.

Second, we employ the rolling SVAR methodology in order to examine this relationship in a time-varying framework. We conduct the analysis for 15 countries and 49 US industries. We find that there is significant time variation on the responses, justifying the use of time-varying techniques. Moreover, we confirm the findings of previous studies that the effects of the oil price shocks on the stock market returns depend on the net position of the country in the oil market (as regards the analysis in country level) or the oil dependency of the industry (as regards the industry-level analysis).

Finally, we try to assess the role of economic policy uncertainty on this relationship. We find that economic policy uncertainty responds differently to the various oil market shocks, whereas increases in policy uncertainty significantly lower the stock prices in the short-run. Moreover, we show that it is important to disentangle the global oil production variable to US and non-US, when someone conducts this analysis for the US, due to the "tight oil revolution" that has probably changed the relationship between US oil production and stock market returns.

Overall, our results propose that policymakers and investors should consider the source of the oil price shocks and the net position of each country in the oil market before implementing policies or make investment decisions. They should also have in mind that this relationship is not constant, but it is changing over time.

8. Appendix

Table 8.1: Descriptive Statistics of the global and country-specific variables

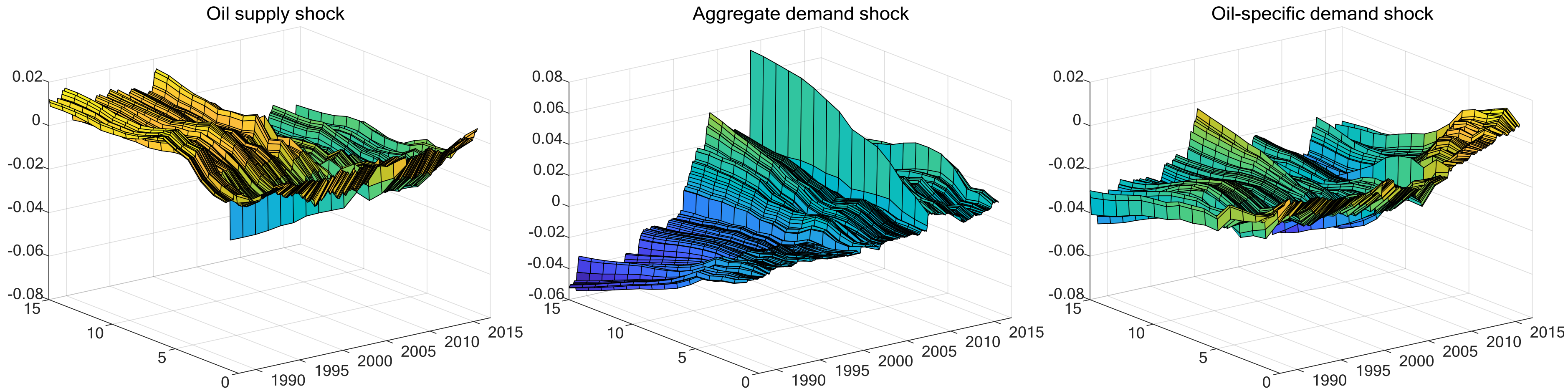
	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis
Global Oil Production	0.077	0.178	6.506	-9.904	1.555	-1.628	12.909
Real Economic Activity	-0.019	-0.059	0.766	-1.409	0.280	0.119	4.363
Real Oil Price	3.015	3.084	4.066	1.743	0.499	-0.018	2.033
Policy Uncertainty	4.639	4.610	5.502	4.047	0.282	0.321	2.544
Belgium	0.001	0.005	0.206	-0.419	0.057	-1.295	11.054
France	0.002	0.007	0.245	-0.264	0.062	-0.538	4.784
Germany	0.003	0.007	0.189	-0.248	0.060	-0.655	4.930
Italy	-0.003	0.000	0.257	-0.262	0.069	-0.079	4.151
Netherlands	0.003	0.010	0.177	-0.267	0.053	-0.982	6.321
South Africa	0.001	0.007	0.130	-0.292	0.048	-1.032	6.623
Spain	-0.004	0.000	0.198	-0.350	0.067	-0.545	5.509
Sweden	0.004	0.005	0.199	-0.290	0.065	-0.576	5.063
Switzerland	0.005	0.008	0.190	-0.181	0.050	-0.517	4.812
UK	0.000	0.002	0.319	-0.242	0.057	-0.059	6.348
USA	0.002	0.004	0.164	-0.234	0.041	-0.715	6.010
Denmark	0.003	0.004	0.178	-0.269	0.053	-0.410	5.189
Canada	0.001	0.003	0.175	-0.291	0.054	-0.860	6.713
Mexico	0.007	0.009	0.271	-0.622	0.088	-1.445	12.238
Norway	0.001	0.006	0.198	-0.408	0.076	-0.931	6.869

Table 8.2: Descriptive Statistics of the industry-specific variables

	Mean	Median	Max	Min	Std. Dev.	Skewness	Kyrtosis
Agriculture	0.68	0.71	28.78	-29.36	6.44	0.01	4.96
Food Products	0.79	0.71	19.19	-18.18	4.57	0.13	5.14
Candy & Soda	0.69	0.67	37.87	-26.96	6.80	0.19	6.63
Beer & Liquor	0.76	0.70	25.69	-19.96	5.37	-0.05	5.38
Tobacco Products	1.07	1.41	32.77	-25.23	6.29	-0.07	5.77
Recreation	0.43	0.71	26.48	-34.71	7.08	-0.18	4.59
Entertainment	0.88	0.95	38.56	-32.16	7.76	-0.19	6.09
Printing & Publishing	0.58	0.23	30.53	-23.31	5.88	0.14	5.09
Consumer Goods	0.44	0.64	18.14	-21.94	4.80	-0.26	5.02
Apparel	0.74	0.71	31.97	-31.20	6.72	-0.03	5.53
Healthcare	0.79	1.04	36.07	-31.73	7.58	0.11	4.84
Medical Equipment	0.59	0.88	20.63	-20.86	5.34	-0.27	4.14
Pharmaceutical Products	0.67	0.71	31.40	-19.41	5.20	0.19	5.59
Chemicals	0.65	0.76	20.95	-28.30	5.83	-0.10	5.01
Rubber & Plastic Products	0.72	1.10	31.74	-30.87	6.09	-0.24	6.06
Textiles	0.70	0.80	58.83	-32.81	7.49	0.57	12.37
Construction Materials	0.71	0.96	35.30	-28.79	6.39	-0.02	6.84
Construction	0.59	0.48	23.61	-31.40	7.29	-0.10	3.98
Steel Works etc.	0.44	0.36	29.63	-31.22	7.77	-0.19	4.96
Fabricated Products	0.35	0.07	30.17	-26.97	7.24	-0.06	4.34
Machinery	0.60	0.87	22.87	-31.49	6.47	-0.38	5.20
Electrical Equipment	0.77	0.28	23.01	-32.50	6.48	-0.19	4.55
Automobiles & Trucks	0.48	0.42	49.36	-34.53	7.18	0.25	8.47
Aircraft	0.89	1.00	24.23	-30.53	6.61	-0.45	5.16
Shipbuilding Equipment	0.76	0.74	29.00	-32.57	7.56	-0.01	4.46
Defense	0.96	1.31	32.44	-30.38	6.43	-0.27	5.74
Precious Metals	0.60	0.06	78.58	-31.69	11.24	0.80	7.39
Metal Mining	0.68	0.39	26.76	-33.62	7.78	-0.30	4.67
Coal	0.67	0.26	45.66	-38.13	11.01	0.20	4.69
Oil & Gas	0.67	0.70	23.76	-18.85	5.63	0.04	4.10
Utilities	0.56	0.68	18.44	-13.42	4.10	-0.18	4.20
Communications	0.61	0.82	20.96	-15.81	4.83	-0.25	4.14
Personal Services	0.44	0.46	23.87	-28.55	6.47	-0.22	4.57
Business Services	0.61	0.80	24.94	-27.97	5.73	-0.37	5.22
Computers	0.51	0.26	25.66	-33.90	7.41	-0.14	4.65
Computer Software	0.99	1.23	40.69	-30.05	9.52	0.38	4.94
Electronic Equipment	0.73	1.02	26.57	-32.63	7.67	-0.35	4.72
Measuring equipment	0.67	0.59	21.46	-30.45	7.18	-0.10	4.13
Business supplies	0.67	0.70	23.67	-26.65	5.63	0.07	5.47
Shipping Containers	0.65	0.62	20.47	-28.54	5.90	-0.39	4.84
Transportation	0.64	0.86	19.21	-28.02	5.72	-0.28	4.50

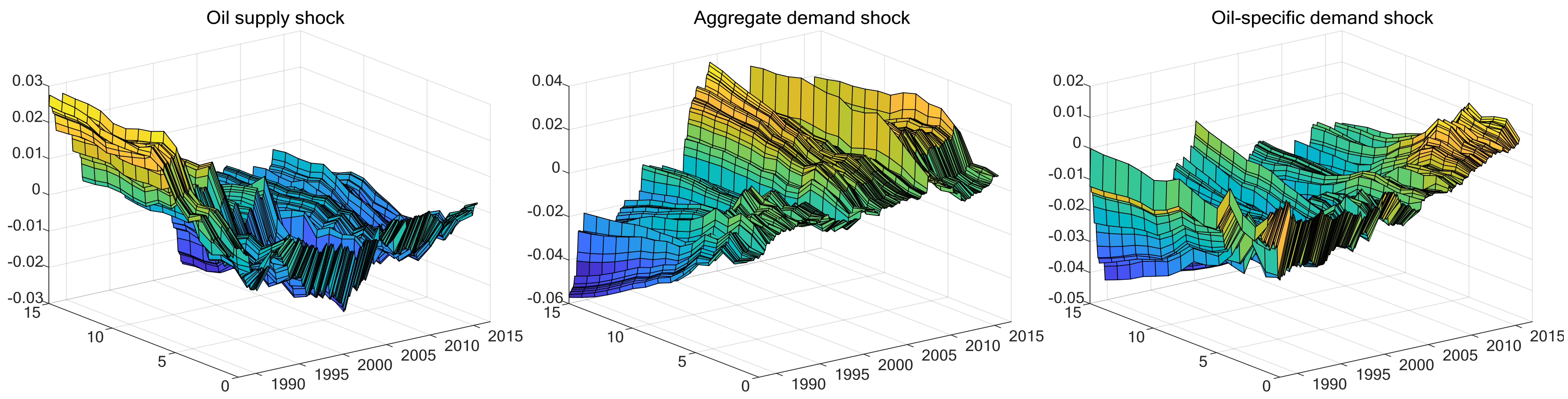
Wholesale	0.63	0.76	17.72	-28.95	5.38	-0.31	5.61
Retail	0.66	0.30	26.67	-29.44	5.64	-0.16	5.07
Restaurants & Hotels	0.66	0.98	27.56	-31.63	6.07	-0.51	5.98
Banking	0.61	0.81	24.66	-27.79	6.20	-0.32	5.07
Insurance	0.71	1.00	26.44	-24.58	5.54	-0.25	5.20
Real Estate	0.22	0.40	69.02	-37.54	7.89	1.07	16.83
Trading	0.76	1.15	19.77	-26.11	6.35	-0.39	4.20
Other	0.29	0.51	20.82	-26.79	6.56	-0.45	4.68

Figure 8.1: Time-varying responses of Belgian stock market returns



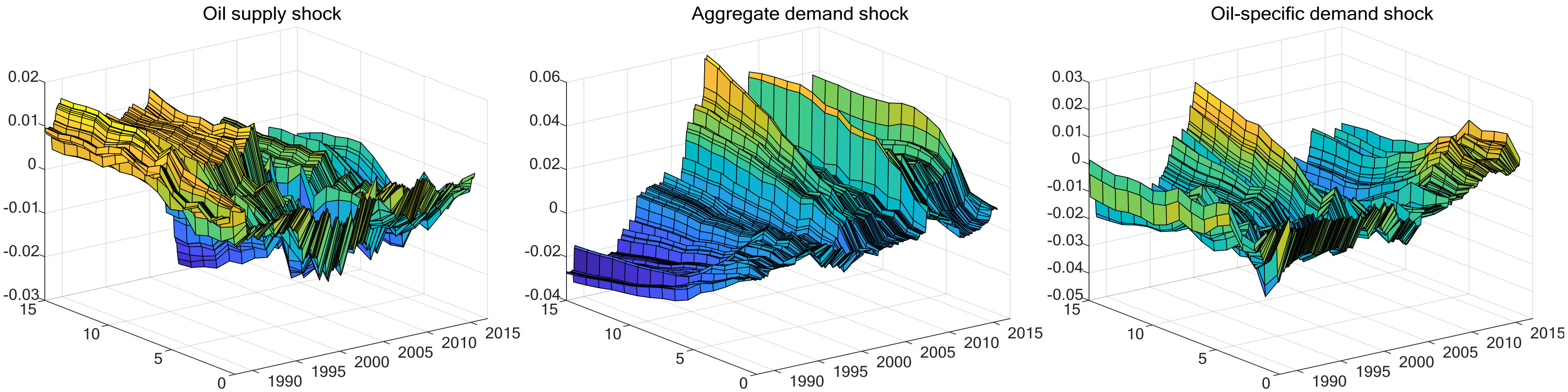
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.2: Time-varying responses of French stock market returns



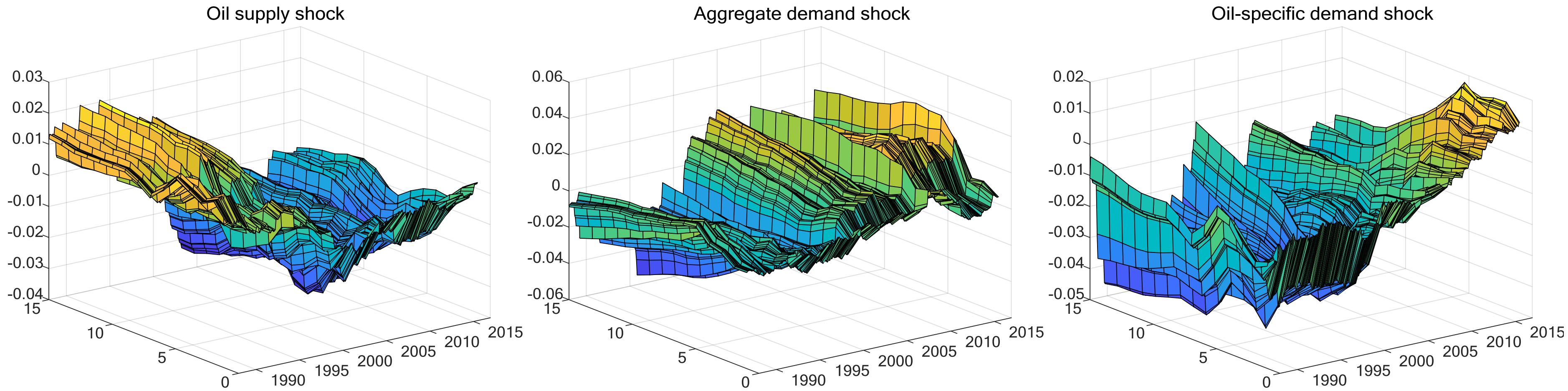
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.3: Time-varying responses of German stock market returns



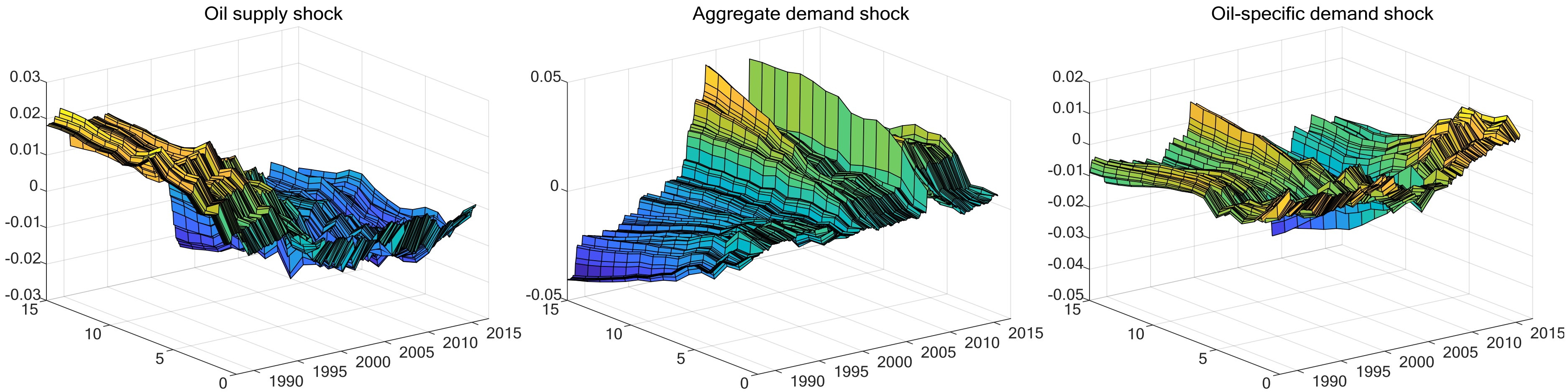
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.4: Time-varying responses of Italian stock market returns



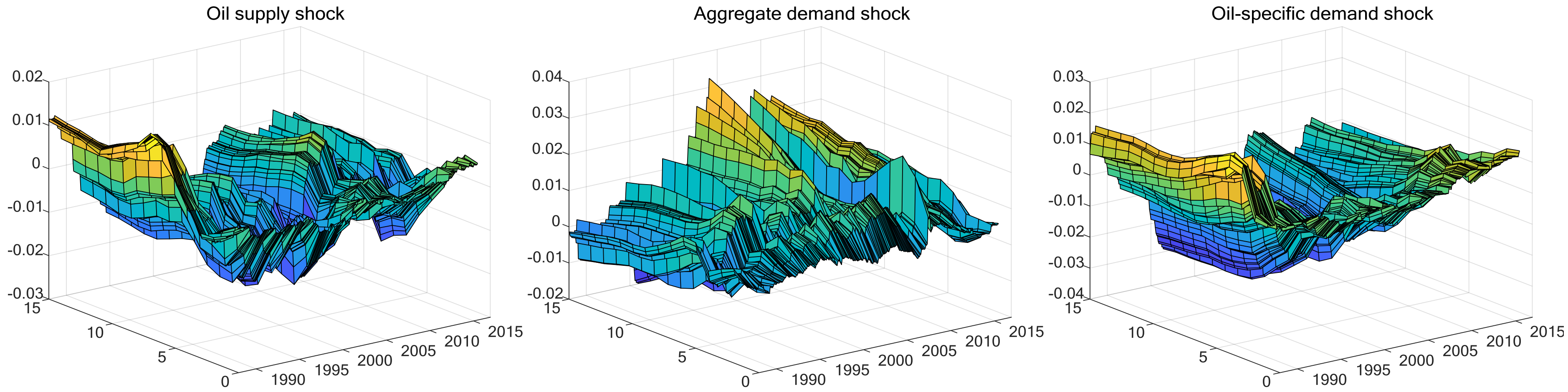
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.5: Time-varying responses of Dutch stock market returns



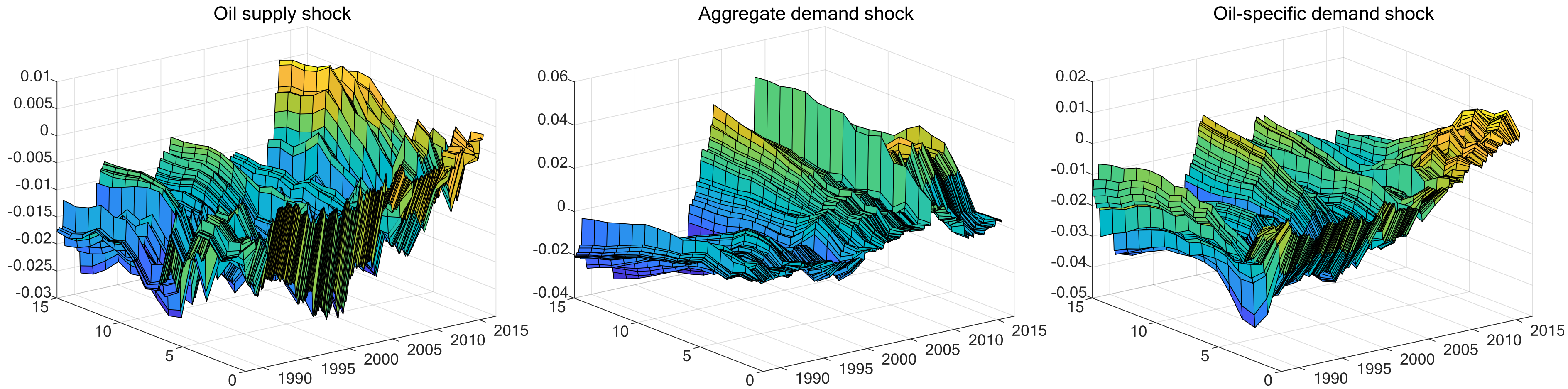
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.6: Time-varying responses of South African stock market returns



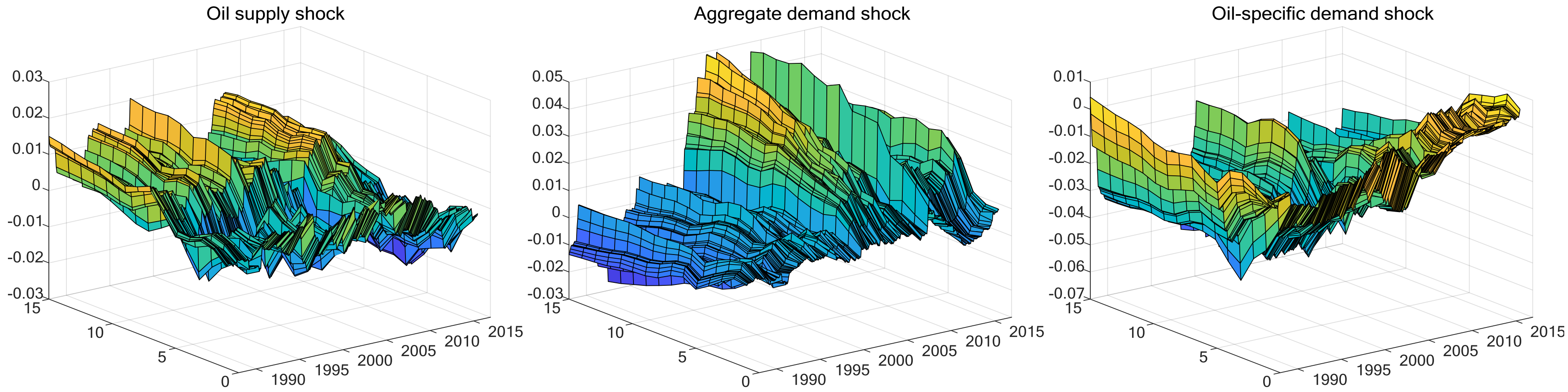
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.7: Time-varying responses of Spanish stock market returns



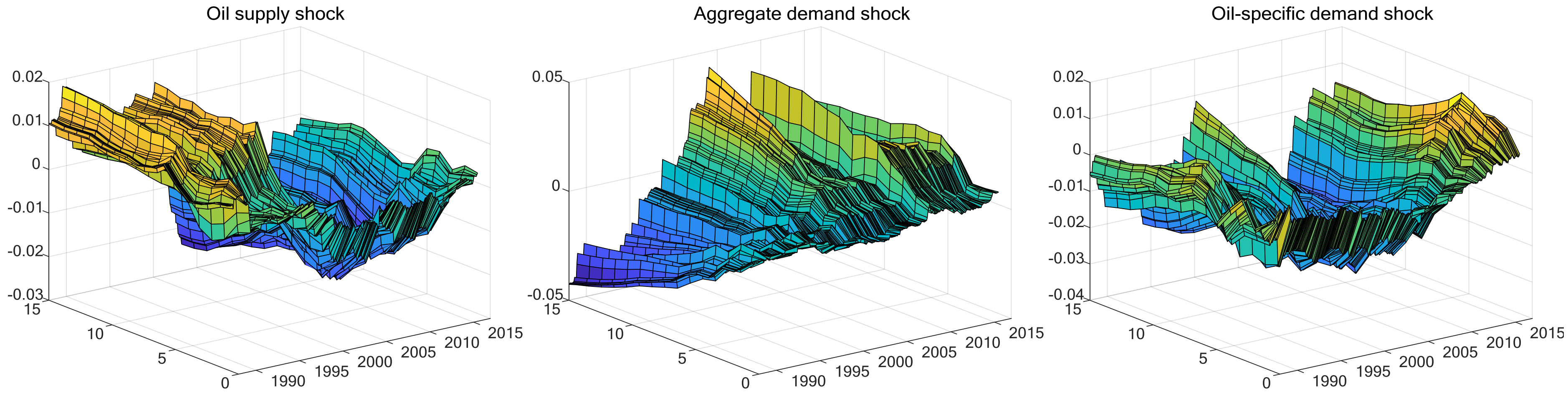
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.8: Time-varying responses of Swedish stock market returns



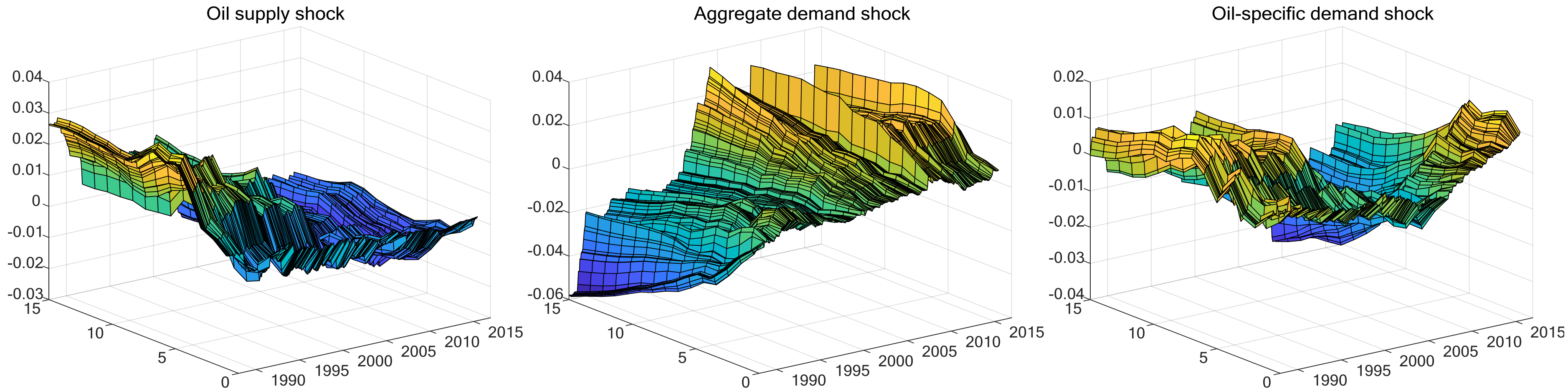
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.9: Time-varying responses of Swiss stock market returns



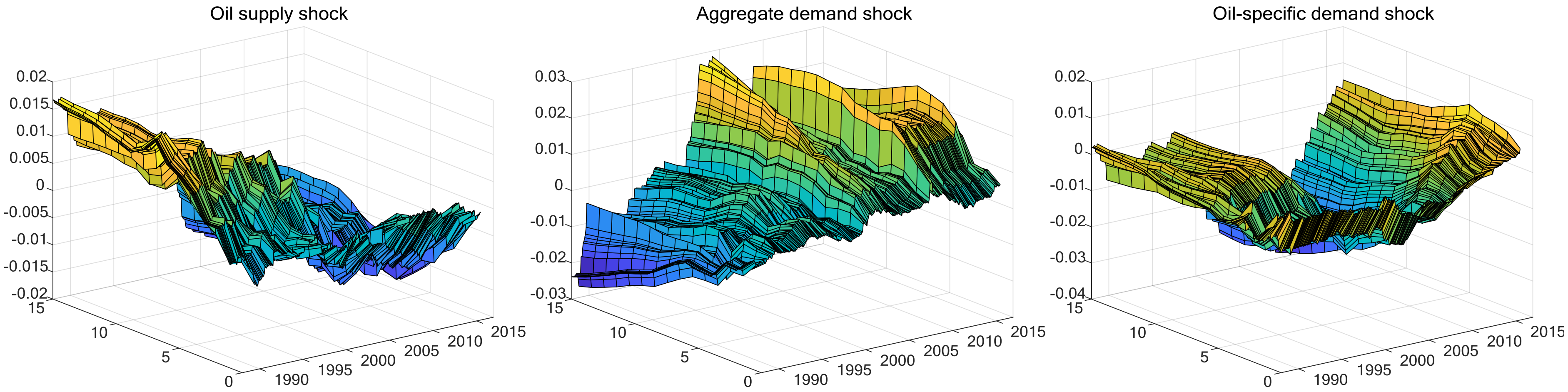
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.10: Time-varying responses of English stock market returns



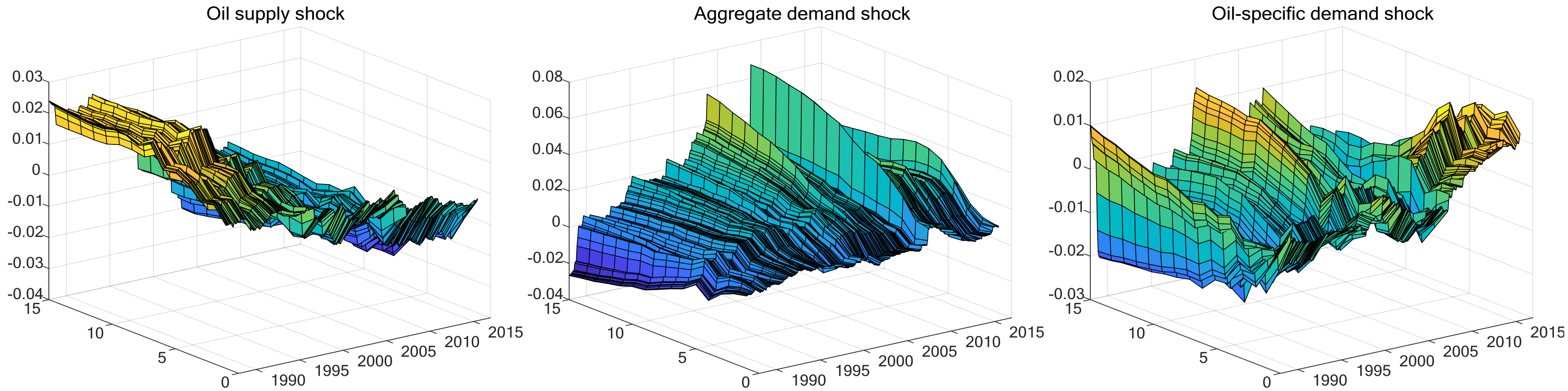
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.11: Time-varying responses of American stock market returns



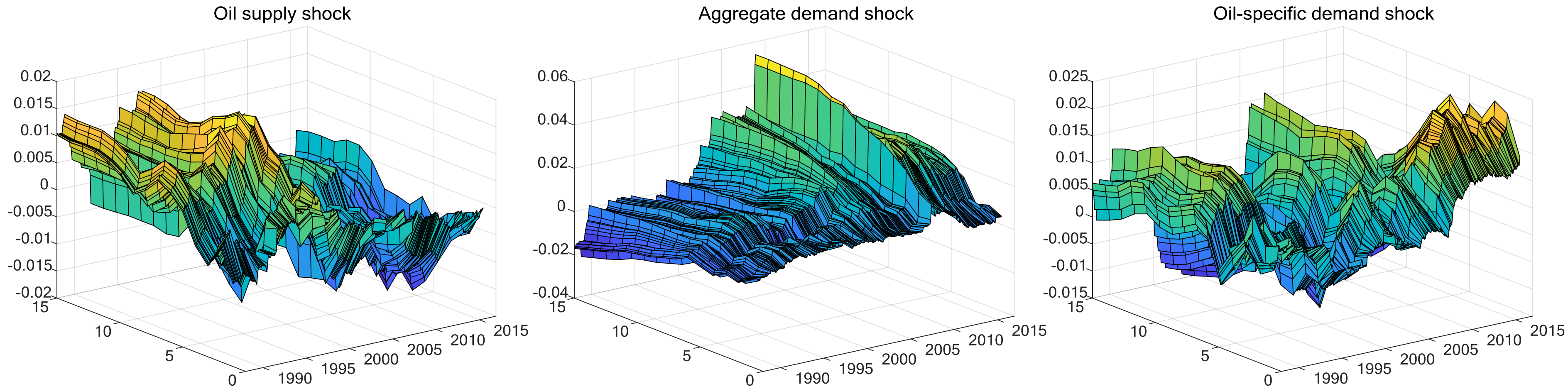
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.12: Time-varying responses of Danish stock market returns



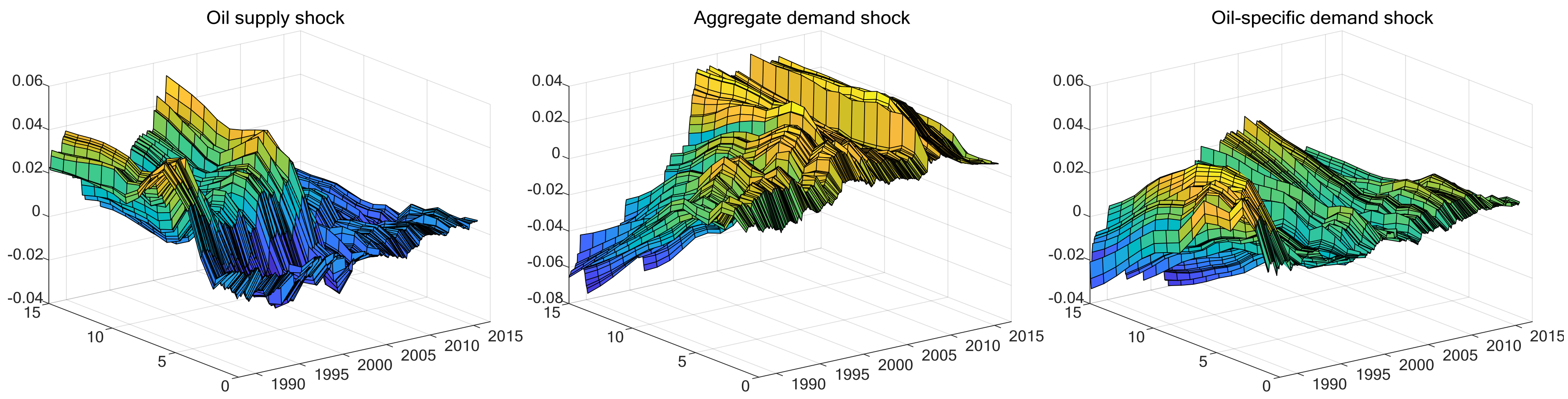
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.13: Time-varying responses of Canadian stock market returns



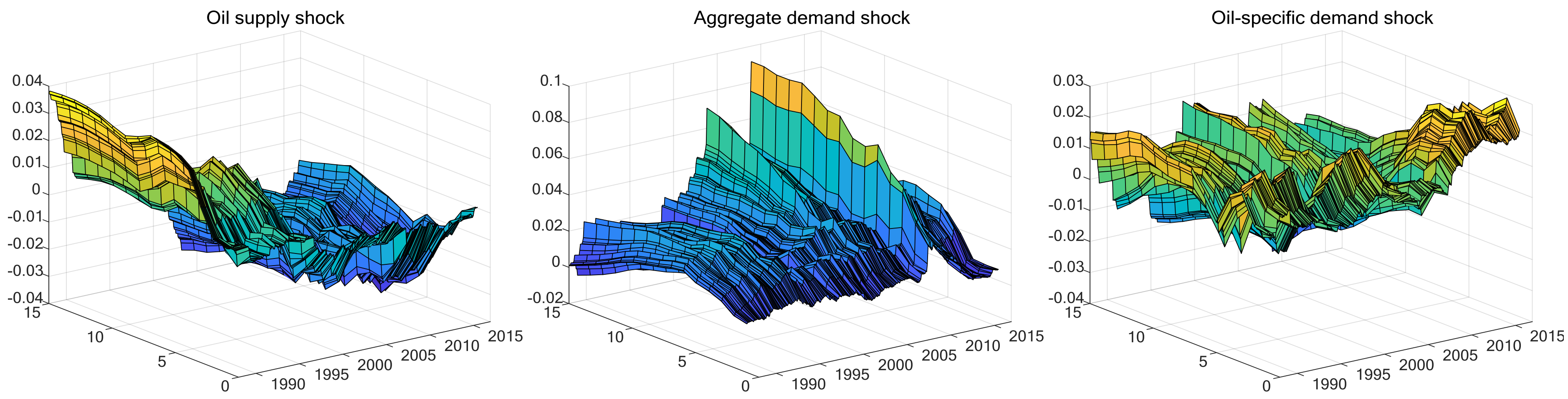
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.14: Time-varying responses of Mexican stock market returns



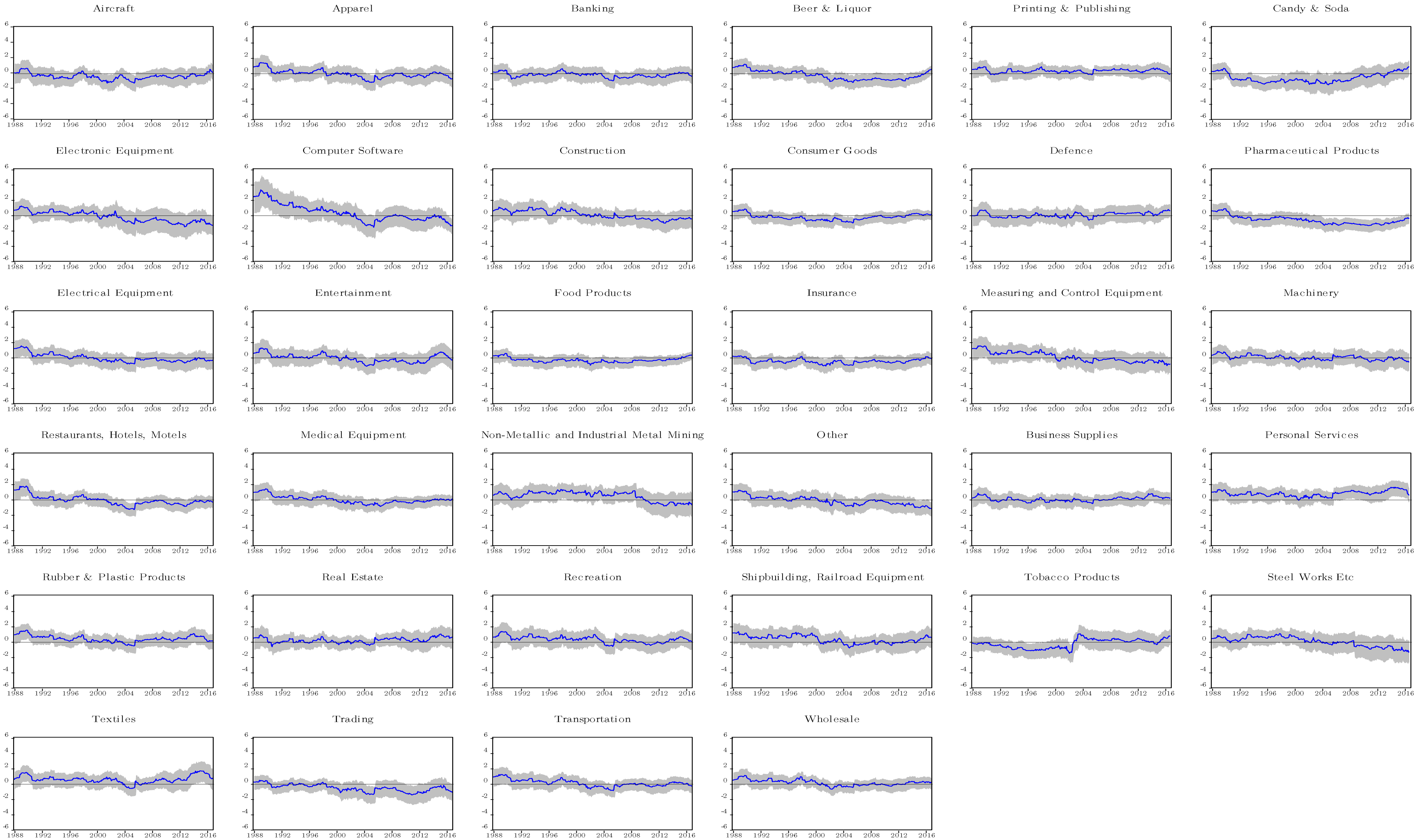
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.15: Time-varying responses of Norwegian stock market returns



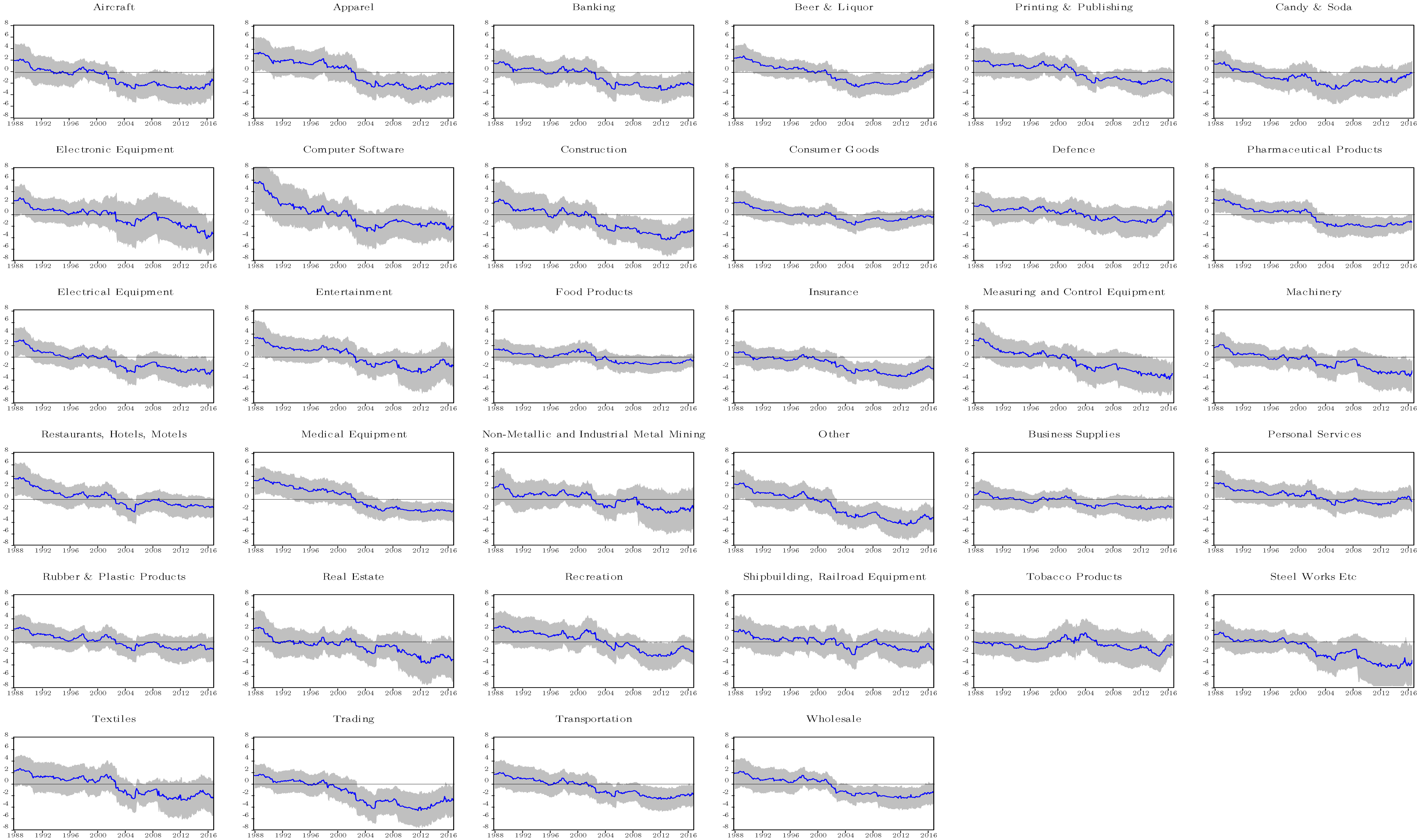
Notes: This Figure shows the time-varying impulse responses of the stock market returns to the different structural oil price shocks up to 15 forecasting horizons. X-axis corresponds to the period of time; Y-axis corresponds to the forecasting horizons; and Z-axis corresponds to the scale of the responses.

Figure 8.16: Time-varying responses of US industrial real stock returns to oil supply shocks (Horizon 2)



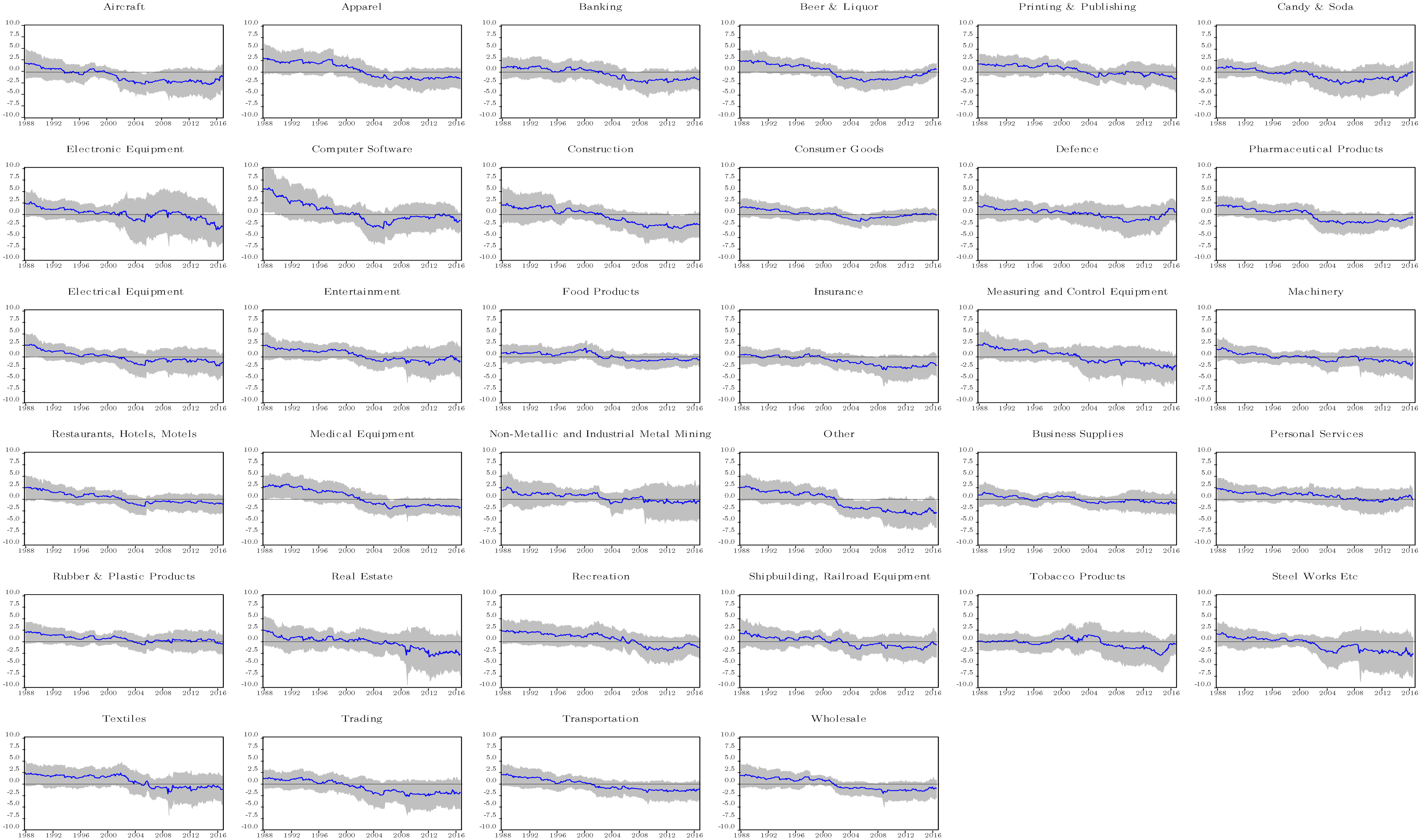
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for the rest US industries.

Figure 8.17: Time-varying responses of US industrial real stock returns to oil supply shocks (Horizon 6)



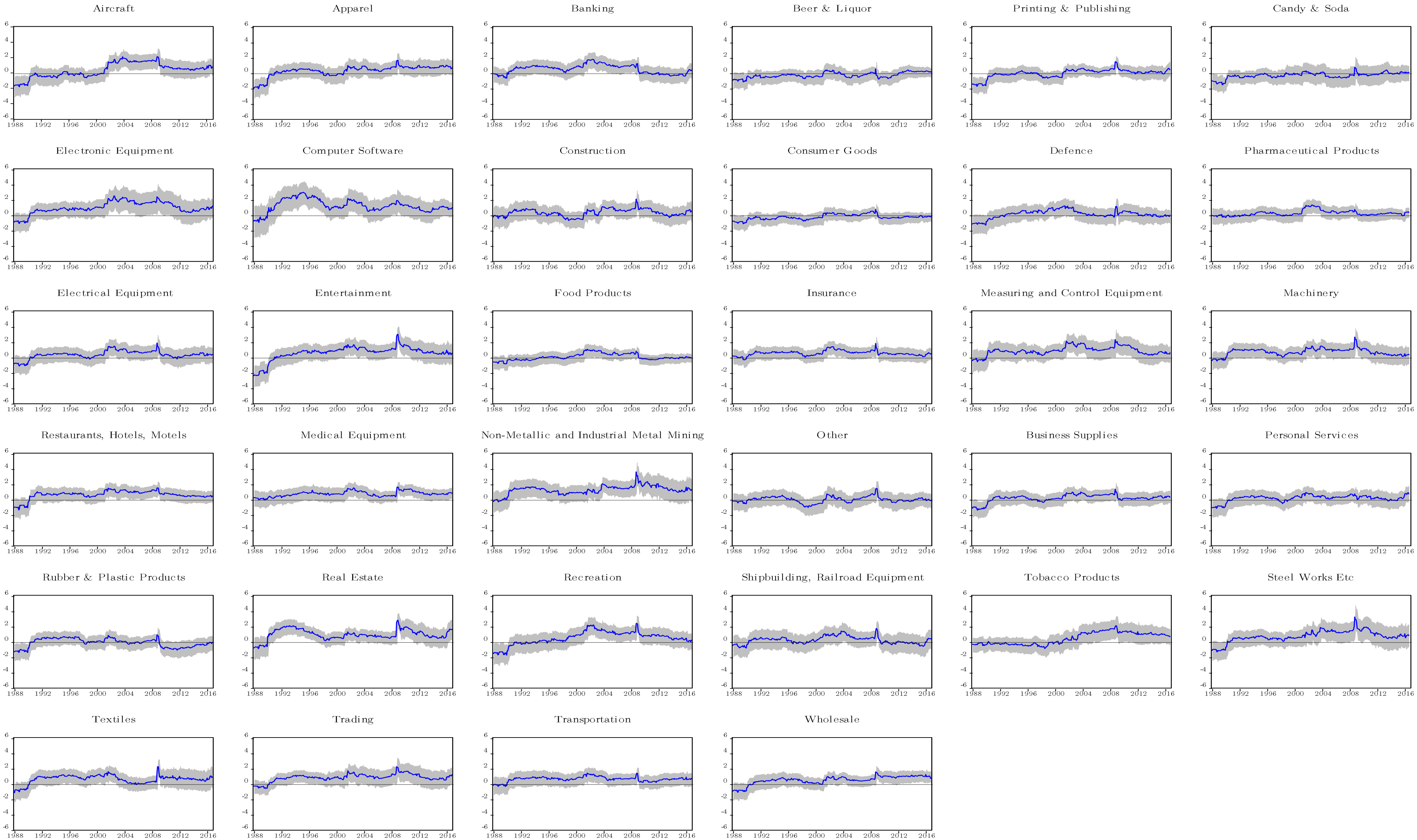
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for the rest US industries.

Figure 8.18: Time-varying responses of US industrial real stock returns to oil supply shocks (Horizon 12)



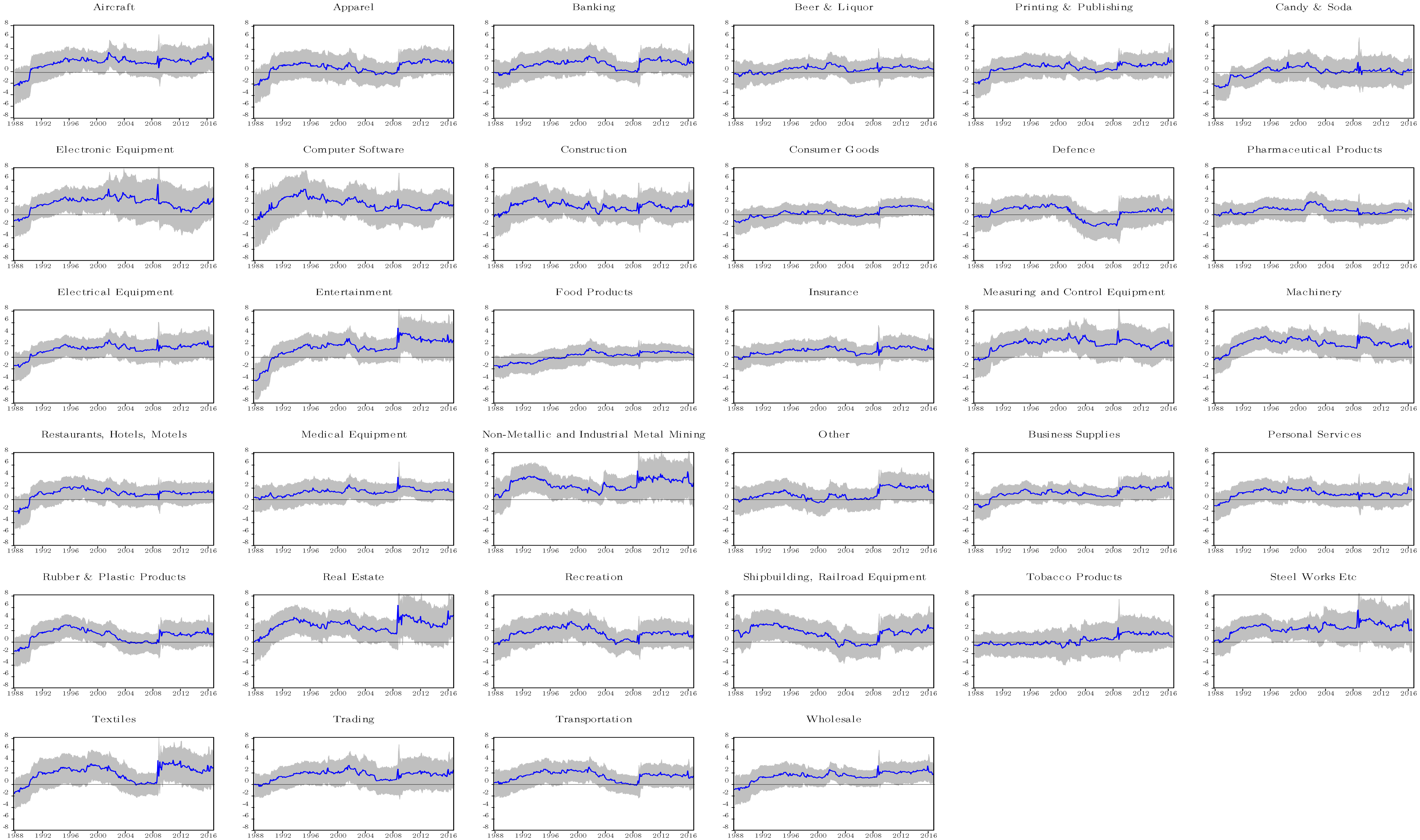
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for the rest US industries.

Figure 8.19: Time-varying responses of US industrial real stock returns to aggregate demand shocks (Horizon 2)



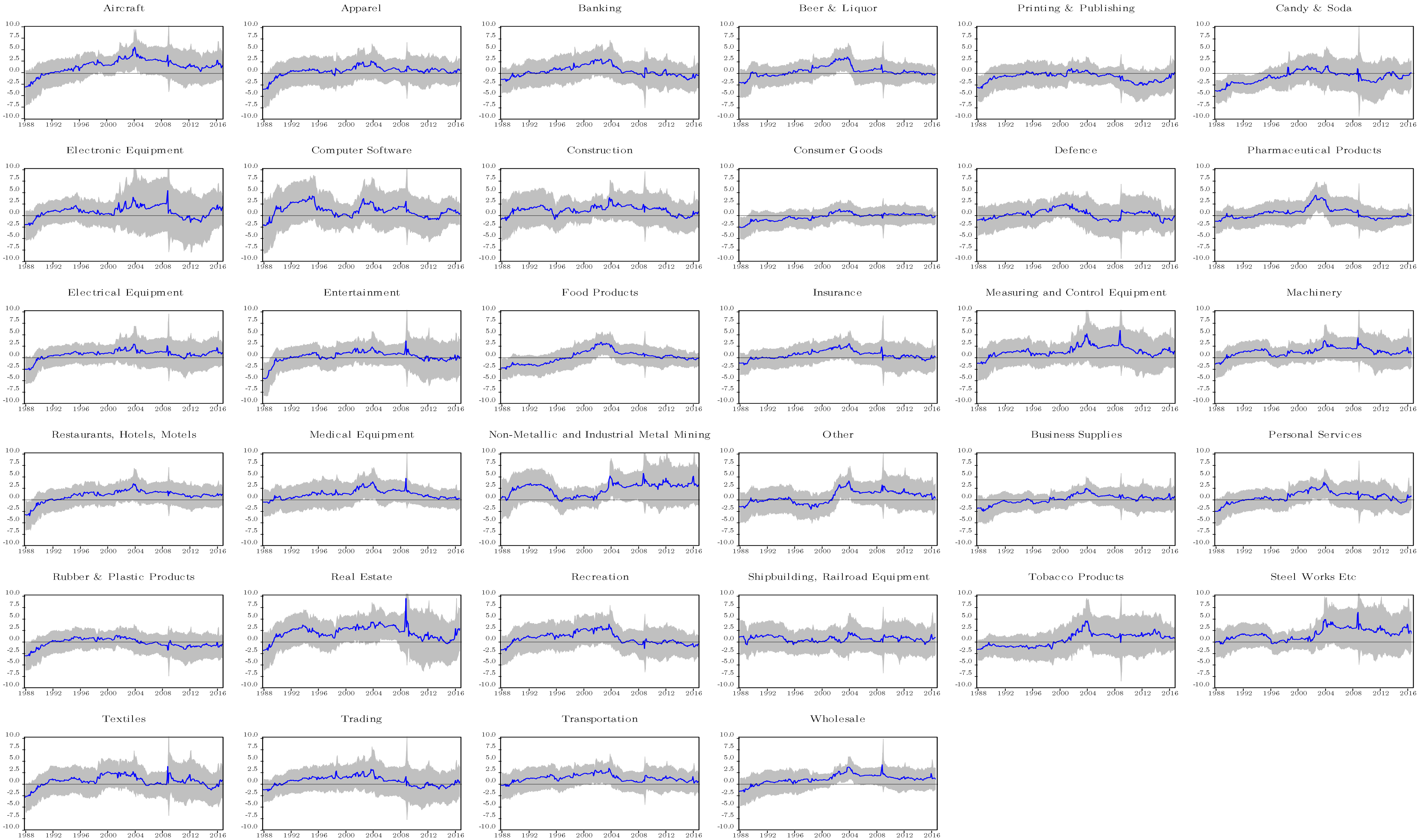
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for the rest US industries.

Figure 8.20: Time-varying responses of US industrial real stock returns to aggregate demand shocks (Horizon 6)



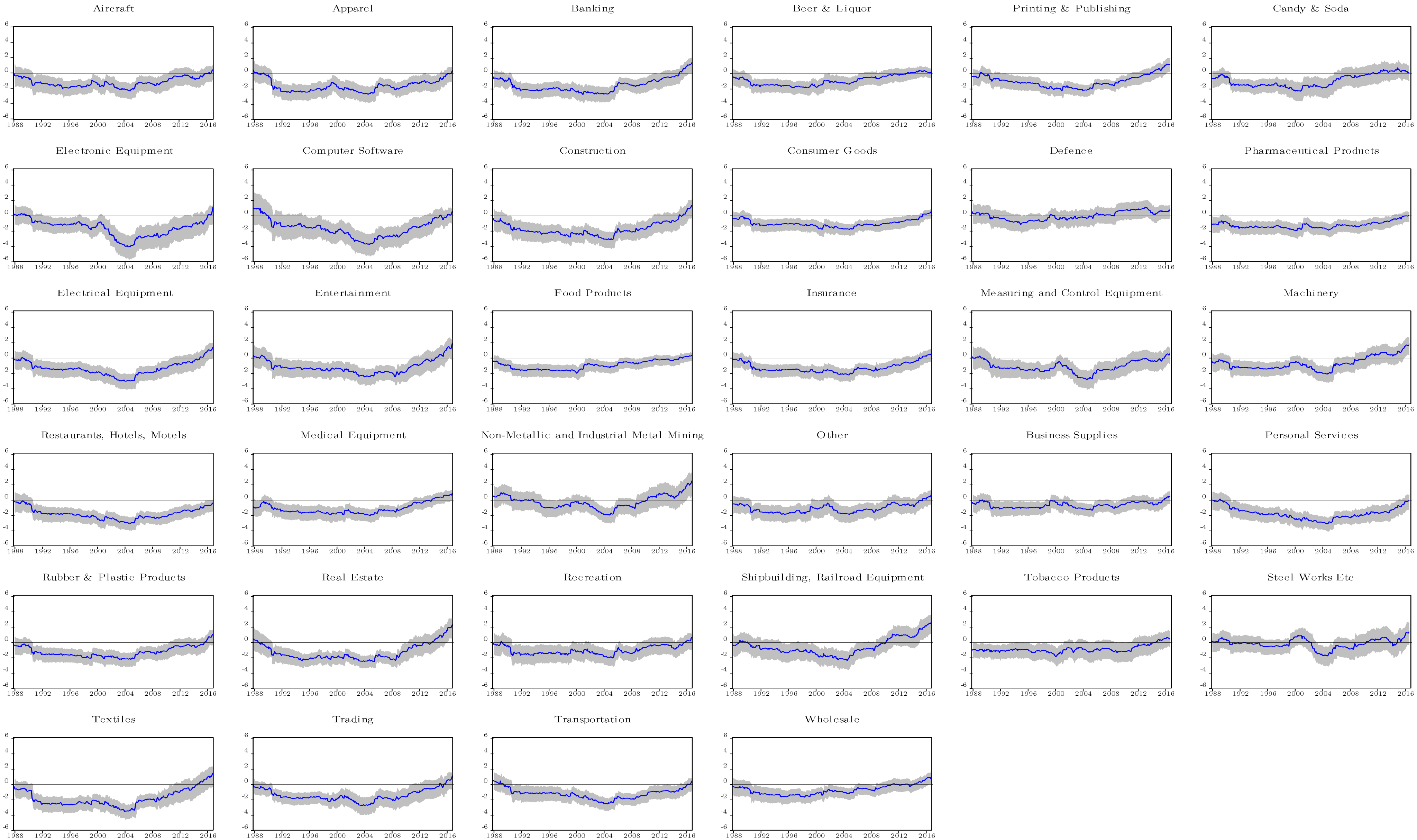
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for the rest US industries.

Figure 8.21: Time-varying responses of US industrial real stock returns to aggregate demand shocks (Horizon 12)



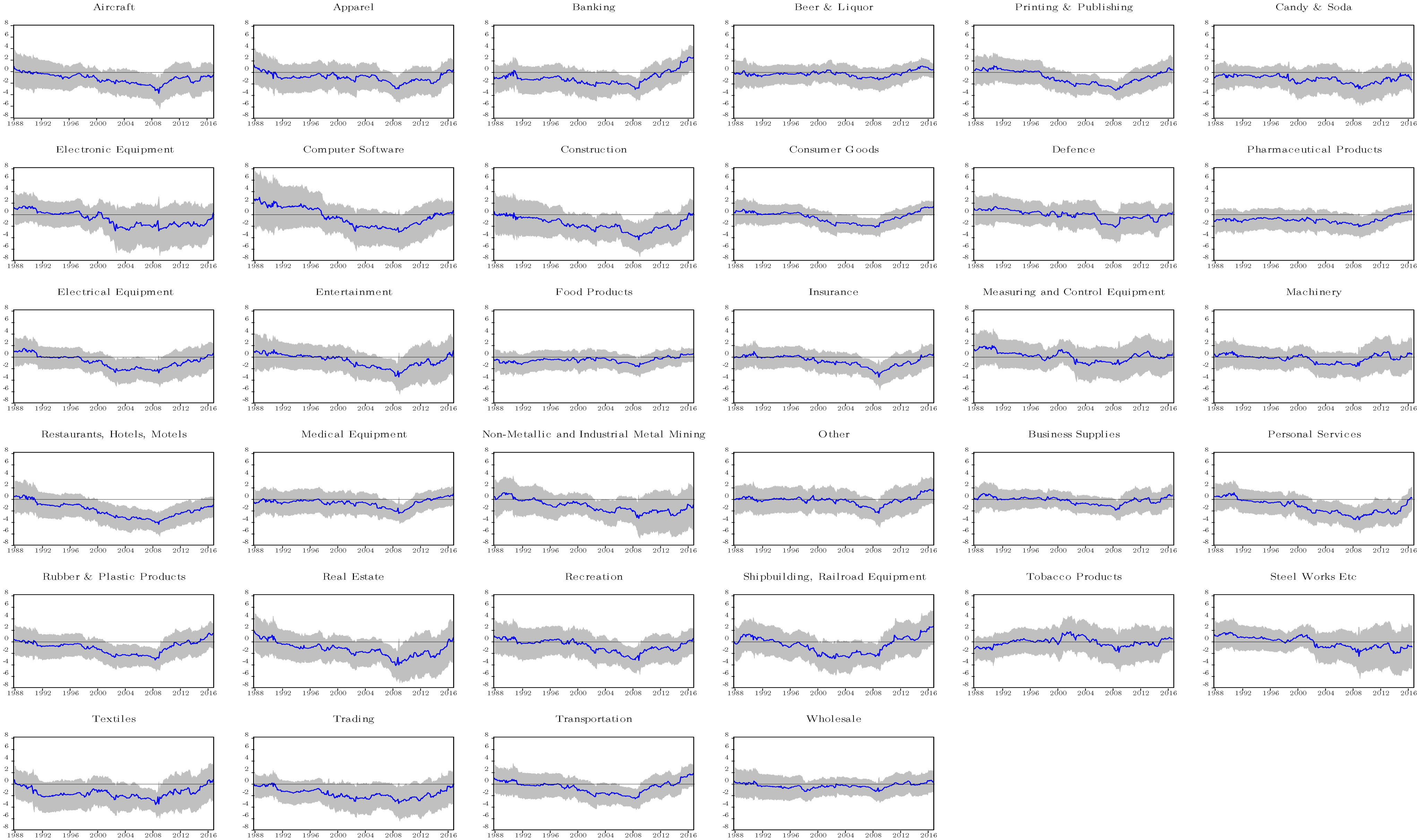
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for the rest US industries.

Figure 8.22: Time-varying responses of US industrial real stock returns to oil-specific demand shocks (Horizon 2)



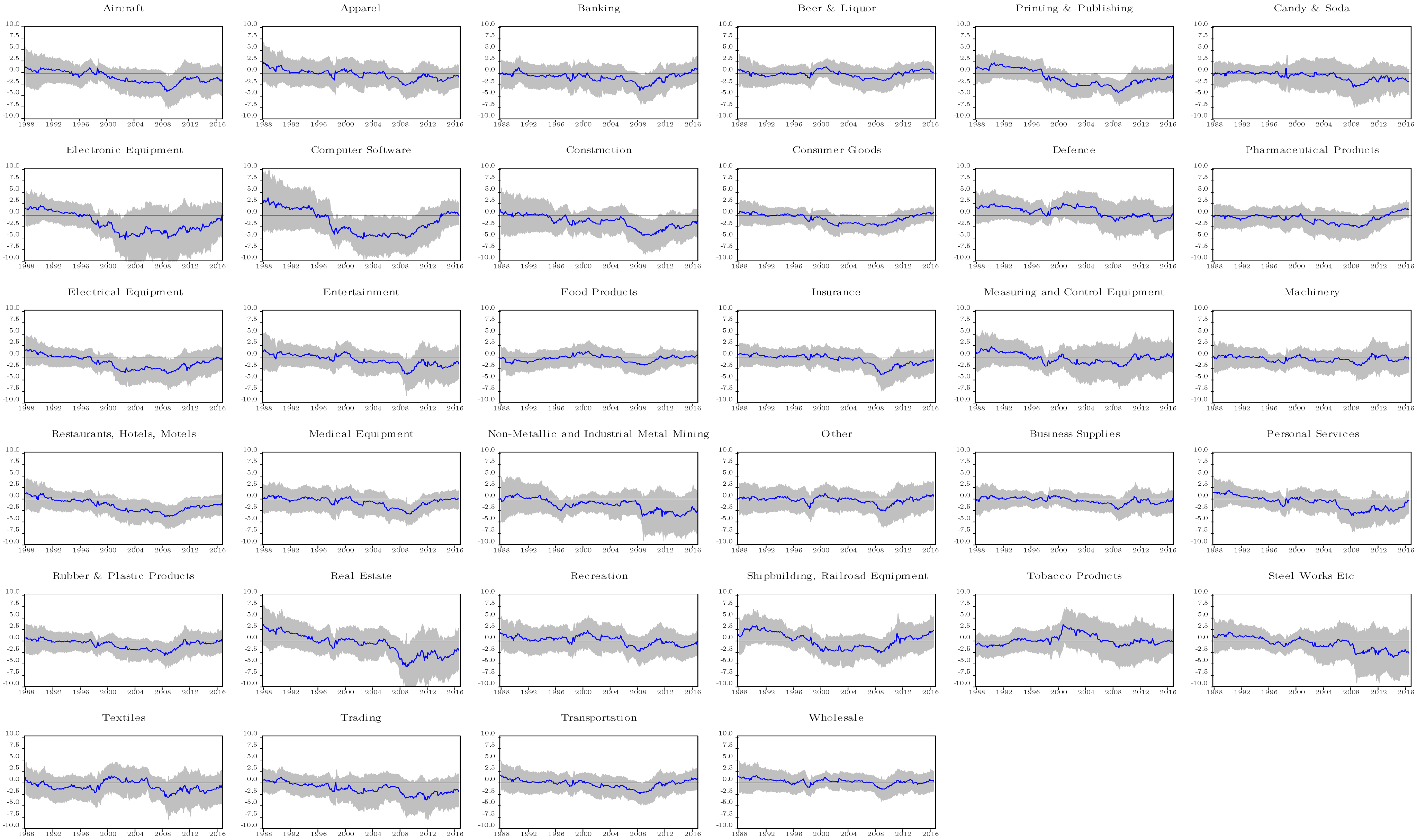
Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for the rest US industries.

Figure 8.23: Time-varying responses of US industrial real stock returns to oil-specific demand shocks (Horizon 6)



Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for the rest US industries.

Figure 8.24: Time-varying responses of US industrial real stock returns to oil-specific demand shocks (Horizon 12)



Notes: Estimates based on the rolling SVAR with 2 standard-error bands. Results for the rest US industries.

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