ESSAYS ON THE CAUSES AND DYNAMIC EFFECTS OF OIL PRICE SHOCKS

by

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ABSTRACT

Since the 1973 oil crisis, the causes and macroeconomic effects of oil price shocks remain relevant issues for academics and policymakers. Where do oil price shocks come from? How are they transmitted? What are their macroeconomic impacts? Which policies appear promising in helping an economy adjust to such shocks? Indeed, understanding the causes of oil price shocks and quantifying the magnitude of their impacts on the macroeconomy is crucial for designing appropriate policy responses. The three essays in this dissertation extend recent advances in the oil shocks literature to investigate the underlying causes of oil price shocks and examine the macroeconomic effects of the shocks on oil-importing countries.

The first essay (contained in Chapter 3) uses a structural Vector Autoregressive (VAR) model of the global crude oil market to identify the underlying causes of oil price shocks and quantify the contributions of the different sources of the shocks. Empirical results reveal that oil price shocks are caused by distinct supply and demand shocks: an oil supply shock caused by disruptions in global oil production; an aggregate demand shock driven by changes in global economic activity; and an oil-specific demand shock driven by shifts in precautionary demand for oil due to uncertainties about future oil supply shortfalls. An unexpected oil supply disruption causes a modest transitory increase in the real price of oil; an unanticipated increase in aggregate demand causes a strong increase in the real price of oil; and an unanticipated increase in precautionary demand for oil triggers an immediate and large increase in the real price of oil.

In the second essay (Chapter 4), I propose a two-step modeling framework that combines the structural VAR model and panel autoregressive distributed lag (ARDL) model to examine the elasticities of oil import demand to oil price shocks for a sample of 30 oil-importing countries: Organization for Economic Cooperation and Development (OECD) and non-OECD. The elasticity estimates show that import demand for oil is less sensitive to oil price shocks driven by supply disturbances but highly sensitive to oil price shocks driven by aggregate demand and precautionary demand shocks. Dividing the sample into OECD and non-OECD countries, both groups are found to be identical in their responses to oil supply shocks but they differ in their responses to aggregate demand and precautionary demand shocks.

The final essay (Chapter 5) estimates the effects of oil price shocks on the macroeconomic performance of 14 OECD oil-importing countries. Utilizing a block recursive VAR, the results show that increases in the price of oil driven by oil supply shocks and precautionary demand shocks are inflationary and unfavorable for economic growth while increases in the price of oil driven by aggregate demand shocks are inflationary but increase the rhythm of economic activity. Also, Chapter 5 evaluates whether structural differences matter for the impact of oil shocks across countries, focusing on the role of oil intensity defined as the share of oil consumption in total energy consumption.

The overarching conclusion of the dissertation is that oil price shocks do not originate solely from the exogenous supply shocks but also originate from the endogenous demand shocks. Consequently, the macroeconomic effects of the shocks as well as the appropriate policy responses crucially depend on the source of the shock.

For my parents, Adama and Mohammed.

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CHAPTER 1

INTRODUCTION

1.1 Motivation

The world economy is inherently unstable. It enjoys periods of relative calmness and occasionally experiences major shocks. These shocks include the panics of the 1870s, the financial crashes of the 1920s, the oil shocks of the 1970s, developing countries' debt crisis in the 1980s, the Asian currency crisis in the 1990s, and the financial crisis in the 2000s. Interestingly, among all these major shocks to the world economy, oil shocks exhibit the most remarkable degree of recurrence, occurring roughly once every decade since the 1970s.

Figure 1.1 provides graphical representation of oil shocks based on data from the United States Energy Information Administration (EIA). In addition to the remarkable degree of recurrence of the shocks, two interesting observations stand out. First, the two extreme oil shocks (1973 and 2009) coincided with significant events in the global business cycle: the 1973 oil shock precipitated a major recession in industrialized countries such as the United States, West Germany, France, and Japan whereas the most recent oil shock in 2009 followed the severe contraction in the global economy. Another interesting observation is that, whereas pre-2000 oil shocks tend to be associated with supply conditions, post-2000 shocks are mostly associated with demand conditions. Overall,

Figure 1.1 suggest that oil shocks are inextricably related with the global business cycle in general, and business cycles of oil-importing countries in particular.

The need to understand the oil shocks-business cycles relationship and the importance that this understanding can have on macroeconomic stability raises interesting questions about (1) the sources of oil shocks, (2) their modes of transmission, (3) the magnitudes of their impact, and (4) the appropriate policy responses. Motivated by these questions, the goal of this dissertation is to explore the underlying causes of oil price shocks and examine their dynamic effects on the macroeconomy of oil-importing countries.

A major gap in the oil shocks literature is that almost all studies tend to focus on industrialized oil-importing countries such as United States, Japan, countries in Europe, and most recently China, but not so much on oil-importing countries in the developing regions of the world. Another major gap in the literature is that although oil shocks are widely accepted as terms of trade shocks transmitted to oil-importing countries through their demand for imported oil, the literature completely ignores the impact of oil price shocks on oil import demand. A final gap in the literature is that it is dated. In fact, the most recent study that applies structural VAR model to disentangle oil price shocks – Kilian and Murphy (2014) – uses data from 1973-2009.

To address these three gaps, I extend the sample to include other major oil-importing countries in the developing regions of the world, that is, Asia, Africa, and Latin America in addition to United States, Japan, and countries in Europe. Also, I adopt a more systematic approach to model the causes and macroeconomic effects of oil price shocks on oil-importing countries. More specifically, since the transmission of oil shocks begins with oil import demand before affecting other macroeconomic variables such as inflation and real output, I begin the analysis by identifying the oil price shocks and estimating their impact on oil import demand before proceeding to gauge the effects of the shocks on inflation and real output growth. Finally, I use more recent data spanning from 1980-2013.

1.2 Contributions

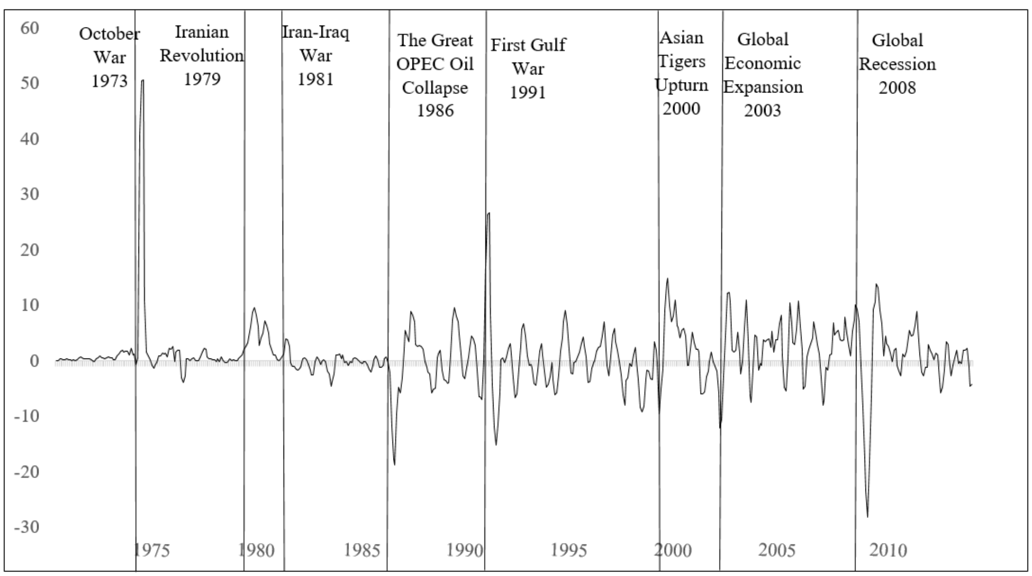
My contributions to the literature are three-fold. First, my decomposition of the structural disturbances to the real price of oil provide new evidence that the increase in the real price of oil between 2009 and 2010 is driven in most part by aggregate demand shocks despite the sluggish global economic activity post-2008 recession. However, the increase in the real price of oil from 2011 to 2013, is driven mainly by precautionary demand motives due to uncertainties about future oil supply shortfalls. Supply disturbances played a marginal role during these two periods.

Second, I provide new evidence that changes in oil import demand across oil-importing countries (OECD and non-OECD) are not only responsive to supply-driven oil price shocks as commonly believed, but also responsive to aggregate demand and precautionary demand-driven oil price shocks. More specifically, supply-driven oil price shocks cause mild transitory decrease in oil import demand whereas demand-driven oil price shocks (aggregate demand and precautionary demand shocks) trigger a strong increase in oil import demand.

Finally, I provide new evidence that oil-intensity – defined as the percent of oil consumption in total energy consumption – can explain the differences in the effects of oil supply shocks across oil-importing OECD countries but it cannot explain the differences in the effects of aggregate demand and precautionary demand shocks.

1.3 Organization

The dissertation is divided into four chapters. Chapter 2 reviews the literature on oil shocks and the macroeconomy. In Chapter 3, I disentangle oil price shocks using a structural VAR model of the global crude oil market. In Chapter 4, I propose a two-step modeling framework that combines the structural VAR model and the panel ARDL model to estimate the elasticities of oil import demand to the decomposed oil price shocks for a sample of 30 oil-importing countries (18 OECD and 12 non-OECD). Chapter 5 uses a block recursive structural VAR model to examine the effects of oil price shocks on the macroeconomy of 14 OECD countries.



Source: The oil price series is monthly refiner's acquisition cost of imported oil for January 1974 to December 2013 from U.S. Energy Information Administration (EIA). I use the U.S. producer price index and the composite index for refiner's acquisition cost of imported and domestic crude oil to extend the data back to January 1970.

Figure 1.1 Percent change in nominal oil price (1970-2013)

CHAPTER 2

SURVEY OF THE LITERATURE ON OIL SHOCKS AND THE MACROECONOMY

2.1 Introduction

The relationship between oil shocks and the macroeconomy is well-documented in literature. This chapter reviews the leading explanations on the several channels through which oil shocks can affect the macroeconomy.

2.2 Supply Shocks

In the history of economic growth and development of industrialized countries, energy was always considered nearly ubiquitous (Tsai, 1980). Not only was it essential but also abundant and inexpensive. The relative abundance of low-priced energy promoted the development of energy-intensive industries in many countries. For instance, countries like the Great Britain, France, and Germany, which were once largely self-sufficient in energy needs because of their domestic coal production became increasingly dependent on cheaper imported oil. Other industrial nations like Italy and Japan, which were already dependent on energy imports greatly increased the extent of their dependence as their economies advanced and their energy demand increased. Even the United States which had been largely self-sufficient became one of the world's largest importer in the 1970s (Cohen &

Hickman, 1983; Tsai, 1980).

Then came the oil crisis in 1973 that began with the October War and followed by the oil embargo by the Organization of Petroleum Exporting Countries (OPEC). These events dramatically signaled the end of the era of abundant oil. The unanticipated fourfold increase in oil prices significantly impacted the rhythm of economic activity in oil-importing industrialized countries. The annual growth rate of industrialized countries fell drastically from 5.8% to 0.1%.[1] With oil supply shortages resulting in soaring prices and inhibiting economic growth in oil-importing nations, the problem of economic growth became the problem of oil supply.

As a consequence, the first-generation economic models designed in the late 1970s and throughout the 1980s to explain the business cycles across industrialized oil-importing countries naturally placed great emphasis on exogenous oil supply disturbances driven by events in the Middle East and the actions of OPEC. Most of the early models have been theoretical and generally predict that oil price shocks lead to increases in inflation and decreases in the rhythm of economic activity (see, for example, Branson & Rotemberg, 1979; Bruno & Sachs, 1982; Flood & Marion, 1982; Harkness, 1982; Malinvaud, 1977; Sachs, 1982). These predictions were largely supported by subsequent empirical models in Hamilton (1983), Burbige and Harrison (1984), Santini (1985), among others. For instance, Hamilton (1983) finds that all but one of the United States' recessions since World War II have been caused by a dramatic increase in the price of oil. Burbige and Harrison (1984) find similar results for the United States, Japan, Germany, United Kingdom, and Canada.

In the 1990s, the interest in oil price shocks and the macroeconomy waned. Few

[1] Source: OECD Economic Outlook, December 1988, p. 180.

notable studies during this decade include Bernanke, Gertler, and Watson (1997), Kim and Loungani (1992), Mork, Olsen, and Mysen (1994), and Rotemberg and Woodford (1996). These studies reechoed the unfavorable macroeconomic impacts of supply-driven oil price shocks although Bernanke et al. (1997) stressed more on the possible indirect effects of oil price increases on output and inflation arising from the Federal Reserve's response to the inflation rather than the direct effects of oil supply shocks as emphasized by the first-generation models.

2.3 Demand Shocks

The fluctuations in the real price of oil since 2000 led to a resurgence of research on oil markets ushering in a new era of modeling the relationship between oil shocks and the business cycles of oil-importing nations. Following a closer examination of the seemingly identical political events in the Middle East and other major oil producing regions, many economists began to cast doubt on the oil supply shock view and shifted their attention to the demand side. Examining the causal mechanism that generated the stagflation of the 1970s across major oil-importing countries, Barsky and Kilian (2002) argued that while exogenously driven oil price shocks are important for understanding the business cycles across oil-importing countries, the relationship between real price of oil and business cycles is far more complex than suggested by models of exogenous oil price shocks. The study emphasized that unexpected oil price increases may sometimes be associated with strong recessionary effects, yet may coexist with strong domestic economic growth at other times. In addition, changes in the real price of oil can affect the macroeconomic performance of oil-importing economies and changes in macroeconomic conditions in oil-importing economies can also affect the real price of oil. They concluded that the complex interlinkages between business cycles and the global oil market conditions suggest that the real price of oil, like the real price of other industrial commodities, is endogenous with respect to global macroeconomic conditions. Thus, identifying cause and effect in the relationship between the price of oil and macroeconomic performance of oil-importing economies requires a structural model of the world economy including the global oil market.

In a 2009 paper, Kilian used a structural VAR model of the global oil market to identify the underlying demand and supply shocks in the global crude oil market and decomposed the real price of oil into three components: shocks caused by disruptions in global oil supply (*oil supply shocks*); shocks to global real economic activity (*aggregate demand shocks*); and shocks driven by shifts in demand for oil due to precautionary motives (*precautionary demand shocks*). His decomposition provided compelling evidence that demand-driven oil price shocks tend to be stronger and persistent whereas supply-driven oil price shocks tend to be milder and transitory.

Building on Kilian's approach, researchers began to explore the underlying causes of oil price shocks and their relationship to global business cycles in general, and oil-importing countries' business cycles in particular. Notable among them are Baumeister and Peersman (2013), Chen and Hsu (2012), and Peersman and Van Robays (2009), all of which concluded that major oil price fluctuations since 1973 appear to be associated in large part with fluctuations in the global business cycles.

2.4 The Role of Financial Speculation in Oil Futures Markets

Another popular view besides the demand and supply views of oil price shocks is the role of speculation driven by increasing financialization in the oil futures markets.[2] The role speculation as a major determinant of the spot price of oil gained popularity following the unprecedented surge in the spot price of oil from 2003-2008 and have drawn significant interest from academics and policymakers. The literature identifies different strands of explanations, which range from empirical methodologies that examine whether higher oil futures prices systematically precede increases in the spot price of oil (Alquist, Kilian, & Vigfusson, 2013; Baumeister & Kilian, 2012), to empirical methodologies that focus on the breakdown of the historically negative relationship between oil prices and oil inventories (Alquist & Kilian, 2010; Dvir & Rogoff, 2010; Hamilton, 2009; Pirrong, 2008), and yet others that relies on structural VAR models to identify the role of speculation taking account of the mutual endogeneity of all oil market variables, including the spot price and futures price of oil (Kilian & Murphy, 2014). Overall, the findings in the literature suggest that while speculative pressures played a significant role in earlier oil price shock episodes including 1979, 1986, and 1990, there is no evidence of such speculative demand pressures in oil futures market after 2003. However, the legacy of financial speculation as the cause of increased systemic risks in the global economy during the 2008 recession continues to generate strong interest about the role of speculation in the oil futures markets.

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[2] Oil futures contracts are financial instruments that allow traders to lock in today a price at which to buy or sell a fixed quantity of the commodity on a predetermined date in the future. Futures contracts can be retraded between issuance and maturity on futures exchanges such as the CME Group and the Intercontinental Exchange. Exchanges offer institutional features that allow traders to transact anonymously, reduce individual default risk, and ensure homogeneity of the traded commodity, making the futures market a low-cost and liquid mechanism for hedging against and for speculating on oil price risks (Fattouh, Kilian, & Mahadeva, 2013).

2.5 Conclusion

The oil shocks literature has made great strides over the last four decades. It began with models that invoke supply-driven oil price shocks to explain business cycles in oil-importing economies and evolved to models that invoke demand-driven oil price shocks to explain the business cycles. As the demand-side story gained more relevance in the literature, another popular view attributed oil price increases to speculative activities in the oil futures markets. This view stresses that speculation has become the primary driving force in determining the spot price of oil. Recent studies, however, conclude that the existing evidence is not supportive of an important role of speculation in driving the spot price of oil since 2003.

As it stands now, the prevailing conventional view is that oil price fluctuations are driven by supply and demand conditions in the global crude oil market. Consequently, understanding the causes of oil price shocks and quantifying the magnitude of their impacts on the macroeconomy as well as the appropriate policy responses requires a structural VAR model of the global crude oil market that identifies the supply and demand shocks. The dissertation builds on this new paradigm. However, the dissertation fills three important gaps in the literature. In particular, it uses more recent data and extends the sample to include other major oil-importing countries in the developing regions of the world in addition to United States, Japan, and countries in Europe. Also, the dissertation adopts a more systematic approach to model the causes and macroeconomic effects of oil price shocks on oil-importing countries. More specifically, since the transmission of oil shocks begins with oil import demand before affecting other macroeconomic variables such as inflation and real output, the dissertation begins by identifying the oil price shocks and estimating their impact on oil import demand before proceeding to gauge the effects of the shocks on inflation and real output growth.

CHAPTER 3

WHERE DO OIL PRICE SHOCKS COME FROM? A STRUCTURAL VAR APPROACH TO IDENTIFYING THE UNDERLYING CAUSES OF OIL PRICE SHOCKS

3.1 Introduction

This chapter focuses on identifying the underlying causes of oil price shocks. It also quantifies the historical contributions of the different sources of the shocks. Section 3.2 lays out the empirical methodology. Section 3.3 describes the data. Results are presented and discussed in Section 3.4. Robustness checks are discussed in Section 3.5. The chapter ends with few concluding remarks in Section 3.6.

3.2 Methodology

Following Kilian (2009), I define a structural VAR model of the global crude oil market as follows:

$$\mathbf{A}_0\mathbf{z}_t = \boldsymbol{\alpha} + \sum_{i=1}^{24} \mathbf{A}_i\mathbf{z}_{t-1} + \boldsymbol{\varepsilon}_t \tag{3.1}$$

where $\mathbf{z}_t$ denotes a vector time series consisting of monthly global crude oil production ($PROD_t$); an index of monthly global real economic activity (REA_t); and the monthly real oil price (ROP_t). The model allows for two years of lags. The sample period is January 1980 to December 2013. The error term, ε_t, denotes the vector of serially and mutually uncorrelated structural innovations. $\mathbf{A}_0^{-1}$ has a recursive structure such that the reduced-form errors $\mathbf{e}_t$ can be decomposed according to $\mathbf{e}_t = \mathbf{A}_0^{-1}\,\varepsilon_t$:

$$\mathbf{e}_t \equiv \begin{pmatrix} e_t^{prod} \\ e_t^{rea} \\ e_t^{rop} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} \varepsilon_{t\,oil\ supply\ shock} \\ \varepsilon_{t\,aggregate\ demand\ shock} \\ \varepsilon_{t\,oil-specfic\ demand\ shock} \end{pmatrix}$$

This model postulates that the real price of oil is determined by the intersection of a vertical supply curve of oil and a downward sloping demand curve for oil. Oil supply shocks triggered by – say, a disruption in global oil supply – move the vertical supply curve along the demand curve causing the real price of oil to change. Oil demand shocks (driven by aggregate demand shocks or oil market specific demand shocks) move the demand curve along the vertical supply curve, again causing the real price of oil to change.[3]

As in Kilian (2009), I impose the following restrictions in the $\mathbf{A}_0^{-1}$ matrix. First, I define *oil supply shocks* as unpredictable innovations to global oil production and assume that oil supply does not respond to innovations to the demand for oil within the same month. This exclusion is conceivable as in practice oil-producing countries tend to be slow in their response to demand shocks due to increased adjustment costs of oil production and the uncertainty about the state of the crude oil market. Second, I define *aggregate demand shocks* as innovations to global real economic activity that cannot be explained based on oil supply shocks. Here, I impose the exclusion restriction that increases in the real price of oil driven by shocks that are specific to the oil market will not lower global real economic activity immediately, but with a delay of at least one month as it takes time

[3] In structural vector autoregression terminology, an oil price shock is generally defined as a sudden unexpected change in the price of oil either positively or negatively.

for global real economic activity to adjust. This restriction captures the sluggish response of global real economic activity after major oil price increases. Finally, by construction, I attribute all other shocks to the real price of oil that cannot be explained based on oil supply shocks or aggregate demand shocks to changes in the demand for oil driven by events specific to the oil market and referred to them as *oil-specific demand shocks*. According to Kilian (2009), this latter structural shock will reflect, in particular, fluctuations in precautionary demand for oil due to uncertainty about future oil supply shortfalls. The problem, however, is that, the oil-market specific shocks could also be driven by several other factors including weather shocks and speculative shocks in the oil futures markets. Thus, conceptually, labelling oil-market specific demand shocks as precautionary demand shocks raises questions.

To ascertain the main driver of shifts in oil-market specific demand shocks, I examine the following three questions: *(1) Is there any evidence that the observed oil-specific demand shocks are associated with unexpectedly cold winters or other weather shocks?* I proxy unexpected cold winters or other weather shocks with U.S. temperature anomaly data from the National Oceanic and Atmospheric Administration (NOAA) and examine its relationship with the monthly oil market specific demand shocks. I find no evidence that the observed oil-specific demand shocks are associated with unexpectedly cold winters or other weather shocks. More specifically, I find very low correlation between the weather deviations and oil specific demand shocks (0.0086) at monthly frequency which indicates that neither direction of causality matters.

(2) Is there any evidence that the observed oil-specific demand shocks are associated with speculative shocks in the oil futures market? I estimate the correlation

between oil-market specific shocks and percent changes in the volume of oil traded on the futures market, and again, find no significant correlation between the two (correlation is about 0.0525) again indicating that neither direction of causality matters. In fact, empirical evidence in the literature suggest that while speculative pressures played a role in earlier oil price shock episodes including 1979, 1986, and 1990, there is no evidence of such speculative demand pressures in the oil futures market after 2003 (Alquist & Kilian, 2010; Dvir & Rogoff, 2010; Hamilton, 2009; Kilian & Murphy, 2014; Knittel & Pindyck 2013; Pirrong, 2008).

(3) If the observed oil-specific demand shocks are not associated with either weather shocks or speculative shocks, could precautionary demand shocks driven by concern about future oil supply shortfalls explain the observed oil-specific demand shocks? Following a closer examination of past regional conflicts, I find that oil market specific shocks coincide with periods prior to major conflicts including the India-China skirmish of 1987; the Lord's Resistance Army insurgency in Central Africa Republic, Congo, and Uganda that began in 1987 late 1990s; the Liberian Civil War in 1989, the First Gulf War and the Russian Constitutional Crisis in the early 1990s; the East Timor Crisis between Australia and East Timor in the late 1990s; the Second Gulf War in 2003; and most recently, the Arab Spring (2011) and the Syrian Civil War (2012 –). While this evidence about the coincidence of shifts in oil-specific demand shocks and periods prior to major conflicts is circumstantial, there are no other plausible candidates for exogenous oil-market specific demand shocks after ruling out weather shocks and speculative shocks. Thus, I attribute the oil-market specific demand shocks to precautionary demand motives.

The exclusion restrictions on $\mathbf{A}_0^{-1}$ suggests a Cholesky decomposition with a specific ordering of the variables in the structural VAR as PROD → REA → ROP, to determine the structural shocks and their respective impact on the system. The structural shocks implied by the VAR model are in monthly frequency.

3.3 Data

The oil market variables are monthly data from January 1980 to December 2013 and include world oil production, global real economic activity, and the real price of oil. Oil production and oil price data are obtained from the United States Energy Information Administration (EIA). The oil price used is the nominal refiner acquisition cost of imported crude oil deflated by the United States Gross Domestic Product (GDP) deflator, which is considered to be the best proxy for global price of oil in the literature. The global economic activity indicator is proposed in Kilian (2009) and available on his research webpage. All the oil market variables are expressed in detrended logs. The plots of the data series are shown in Figures 3.1 to 3.3. For all the variables, I can reject the null hypothesis of the existence of unit root at the 10% level using Augmented Dicky-Fuller test (Table 3.1). Also, I can reject the null of no cointegration at the 1% level based on the Johansen cointegration test (Table 3.2).

3.4 Empirical Results

Figure 3.4 depicts the time path of the decomposed oil price shocks implied by the VAR model. As indicated by the plots, at any giving point in time, fluctuations in the real price of oil is driven by a multitude of shocks: shocks from the global crude oil production (oil supply shocks), shocks to global real economic activity (aggregate demand shocks), and shocks driven by shifts in the precautionary demand for oil (precautionary demand shocks). The magnitude and time path of the decomposed shocks are consistent with Kilian (2009). Since I extended the data beyond 2007 which was the endpoint in Kilian (2009), I captured more recent shocks that occurred from 2008 to 2013.

To test the assumption that the monthly shocks are serially and mutually uncorrelated, I applied the VAR test for serial correlation. Results in Table 3.3 confirm that the shocks are serially and mutually uncorrelated. Also, it is likely that the monthly shocks could exhibit seasonal patterns. For instance, global demand for commodities tend to increase during the last three months of the year even during periods of slowdown in global economic activity. If so, then it is necessary to seasonally adjust the shocks before estimating their impact on the system. Table 3.4 summarizes the test results for seasonal variations in structural shocks. As the results indicate, except for two months for aggregate demand shock, there is no evidence of significant seasonal variations in the monthly structural shocks.

Figure 3.5 shows the impulse response pattern of real oil price to the supply and demand shocks in the global oil market based on the structural VAR model in Eq. (3.1). I normalized all shocks such that an innovation will tend to raise the price of oil. The plots show that fluctuations is the real price of oil originates from three distinct sources, that is, oil supply shock, aggregate demand shock, and precautionary demand shock. Consistent with Kilian (2009) and Peersman and Van Robays (2009), the study finds that an unexpected oil supply disruption causes a modest transitory increase in the real price of oil; an unanticipated increase in aggregate demand causes a strong increase in the real price of oil; and an unanticipated increase in precautionary demand for oil triggers an immediate and large increase in the real price of oil.

Figure 3.6 shows the cumulative contribution of each shock to the real price of oil based on the historical decomposition of the data. As evident from the plots, oil supply shocks have historically made relatively small contributions to fluctuations in the real price of oil. Indeed, the largest contributions come from aggregate demand shocks and precautionary demand shocks. While aggregate demand shock is responsible for longer swings in the real price of oil, precautionary demand shock is responsible for relatively sharp swings in the real price of oil. These results are in line with the findings in the oil shocks literature (Barsky & Kilian, 2004; Fattouh et al., 2013; Kilian & Murphy, 2014; Kilian, 2009; Knittel & Pindyck, 2013; Peersman, 2009).

Adding to the oil shocks literature, the decomposition of the structural disturbance to the real price of oil provide new evidence that the increase in the real price of oil between 2009 and 2010 is driven in most part by aggregate demand shock despite the sluggish global economic activity post-2008 recession. However, the increase in the real price of oil from 2011 to 2013, is driven mainly by precautionary demand motives due to uncertainties about future oil supply shortfalls. Supply disturbances played a marginal role during these two periods.

3.5 Robustness Checks

The section examines whether the ordering of the variables used to identify the baseline VAR can affect the structural shocks results. In other words, are the results from the VAR model in Eq. (3.1) robust? While the use of the Cholesky decomposition to identify the structural shocks and their impact on the system is justified by the theory postulated in the SVAR model, the data cannot show that since different ordering of the variables in the SVAR is likely to generate completely different results. As robustness checks, I considered alternative identifying restrictions. In particular, I estimated an alternative reduced-form errors $\mathbf{e}_t$ with reversed exclusion restrictions on $\mathbf{A}_0^{-1}$ as follows:

$$\mathbf{e}_t \equiv \begin{pmatrix} e_t^{prod} \\ e_t^{rea} \\ e_t^{rop} \end{pmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ 0 & a_{22} & a_{23} \\ 0 & 0 & a_{33} \end{bmatrix} \begin{pmatrix} \varepsilon_{t\, oil\ supply\ shock} \\ \varepsilon_{t\, aggregate\ demand\ shock} \\ \varepsilon_{t\, oil-specfic\ demand\ shock} \end{pmatrix}$$

The reversed exclusion restrictions imply that oil supply shocks do not contemporaneous affect global real economic activity. Also, aggregate demand shocks do not contemporaneous affect the real price of oil. These restrictions suggest the following ordering of the variables in the SVAR: REA → PROD → ROP.

Also, I estimated another alternative reduced-form errors et with no exclusion restrictions on $\mathbf{A}_0^{-1}$ as follows:

$$\mathbf{e}_t \equiv \begin{pmatrix} e_t^{prod} \\ e_t^{rea} \\ e_t^{rop} \end{pmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} \varepsilon_{t\, oil\ supply\ shock} \\ \varepsilon_{t\, aggregate\ demand\ shock} \\ \varepsilon_{t\, oil-specfic\ demand\ shock} \end{pmatrix}$$

The no-exclusion restrictions imply that all the structural shocks have contemporaneous impact on all variables in the system. In other words, there is no particular ordering of the variables.

The results from both alternative specifications (as shown in Appendix A) are consistent with results from the Cholesky decomposition suggesting that the baseline structural VAR results are robust and not sensitive to the ordering of the variables in the model.

3.6 Conclusion

In this chapter, I disentangled the underlying causes of oil price shocks using the structural VAR model of the global crude oil market. Empirical results from the model reveal that fluctuations in the real price of oil originate from three distinct sources, that is, an oil supply shock caused by disruptions in global oil production, an aggregate demand shock driven by global economic activity, and an oil-specific demand shock driven by precautionary motives. An unexpected oil supply disruption causes a modest transitory increase in the real price of oil; an unanticipated increase in aggregate demand causes a strong increase in the real price of oil; and an unanticipated increase in precautionary demand for oil triggers an immediate and large increase in the real price of oil.

In addition, the historical decompositions of the real price of oil show that oil supply shocks have historically made relatively small contributions to fluctuations in the real price of oil. The largest contributions come from aggregate demand shocks and precautionary demand shocks. While aggregate demand shock is responsible for longer swings in the real price of oil, precautionary demand shock is responsible for relatively sharp swings in the real price of oil.

Finally, adding to the oil shocks literature, the decomposition of the structural disturbance to the real price of oil provide new evidence that the increase in the real price of oil between 2009 and 2010 is driven in most part by aggregate demand shock despite the sluggish global economic activity post-2008 recession. However, the increase in the real price of oil from 2011 to 2013, is driven mainly by precautionary demand motives due to uncertainties about future oil supply shortfalls. Supply disturbances played a marginal role during these two periods. Overall, the findings provide further evidence that not all price shocks are the same; they originate from different sources and thus have different macroeconomic consequences.

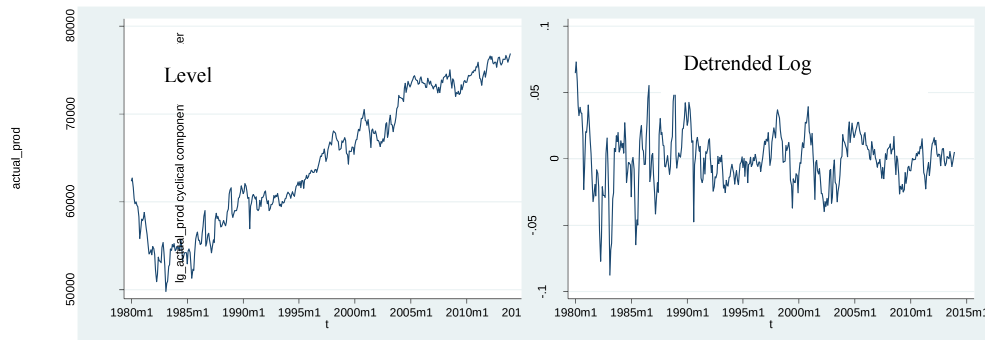

Figure 3.1 Data plot of global oil production and its transformation

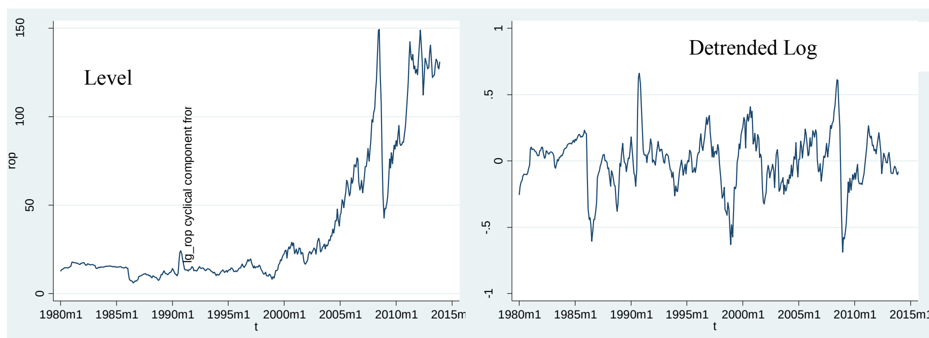

Figure 3.2 Data plot of real oil price and its transformation

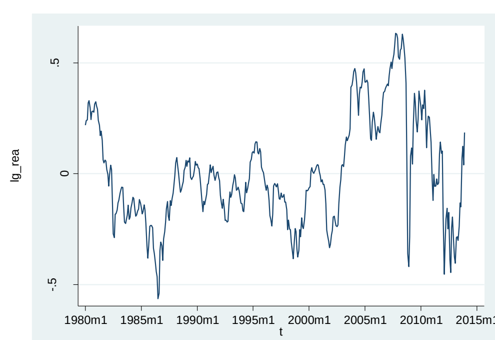

Figure 3.3 Data plot of index of real global economic activity

Table 3.1

Unit root test

Augmented Dickey-Fuller Test
Null: series not stationary

Variable	Test statistic
Global oil production	-6.936*** (0.000)
Real oil price	-4.322*** (0.000)
Index of real global economic activity	-2.842*** (0.000)

Notes: Data on all oil-related variables are obtained from the U.S. Energy Information Administration (EIA). The oil price variable used is the nominal refiner acquisition cost of imported crude oil, which is considered the best proxy for the global price of imported crude oil in the literature. The world economic activity indicator is proposed in Kilian (2009) and available on his research webpage. All the oil-related variables are expressed in detrended logs. Probabilities in parenthesis. For all the variables, we can reject the null hypothesis of the existence of unit root at the 10% level.

Table 3.2

Cointegration test

Johansen Cointegration Test
Null: no cointegration

Hypothesized # of cointegrating equations	Test statistic
None *	15.494*** (0.000)
At most 1 *	3.841*** (0.004)

Notes: Probabilities in parenthesis. Null of no cointegration rejected at the 1% level.

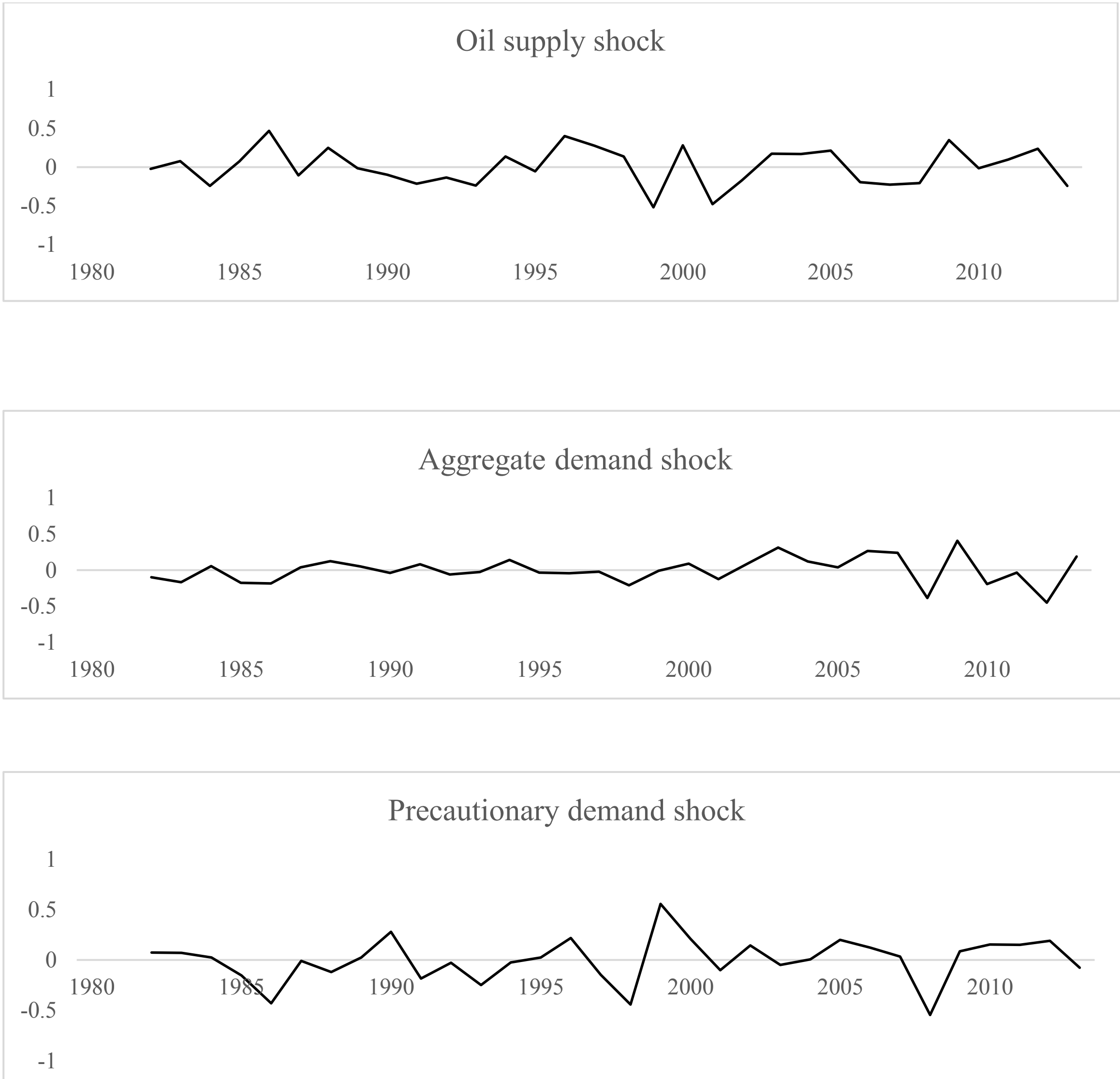

Figure 3.4 Historical evolution of the annualized structural shocks, 1980-2013

Table 3.3

VAR test for serial correlation in structural shocks

Null: no serial correlation at lag order h

Lag	LM Test statistic Probabilities in parenthesis.
1	5.913 (0.749)
2	11.065 (0.271)
3	11.368 (0.251)
4	13.393 (0.146)
5	5.656 (0.774)
6	16.546 (0.056)
7	2.403 (0.983)
8	9.671 (0.378)
9	17.287 (0.044)
10	14.103 (0.119)
11	11.128 (0.267)
12	11.324 (0.254)
13	6.701 (0.668)
14	9.580 (0.386)
15	11.323 (0.254)
16	17.285 (0.044)
17	18.230 (0.033)
18	15.425 (0.080)
19	5.036 (0.831)
20	10.371 (0.321)
21	8.404 (0.494)
22	3.889 (0.919)
23	4.749 (0.856)
24	6.265 (0.713)

Notes: Test statistic based on Lagrange multiplier (LM) test for autocorrelation in the residuals of VAR models.

Table 3.4

VAR test for seasonal variations in structural shocks

Null: no serial correlation at lag order h

Month	Oil supply shock	Aggregate demand shock	Precautionary demand shock
	Coefficient	Coefficient	Coefficient
1	-0.0022	-0.0074	0.0233
	(0.255)	(0.458)	(0.077)
2	0.0016	-0.0073	-0.0087
	(0.405)	(0.458)	(0.500)
3	-0.0021	0.0216	0.0016
	(0.264)	(0.028)	(0.899)
4	-0.0024	-0.0037	0.0130
	(0.210)	(0.702)	(0.317)
5	-0.0031	0.0101	0.0113
	(0.101)	(0.304)	(0.382)
6	-0.0018	-0.0279	-0.0186
	(0.351)	(0.005)	(0.150)
7	0.0035	-0.0002	0.0068
	(0.068)	(0.984)	(0.599)
8	-0.0019	-0.0040	0.0024
	(0.327)	(0.685)	(0.854)
9	0.0012	0.0107	-0.0021
	(0.525)	(0.274)	(0.870)
10	0.0053	0.0068	0.0044
	(0.006)	(0.488)	(0.733)
11	0.0017	0.0025	-0.0278
	(0.375)	(0.798)	(0.032)
12	0.0001	-0.0014	-0.0048
	(0.941)	(0.884)	(0.713)

Notes: Probabilities in parenthesis.

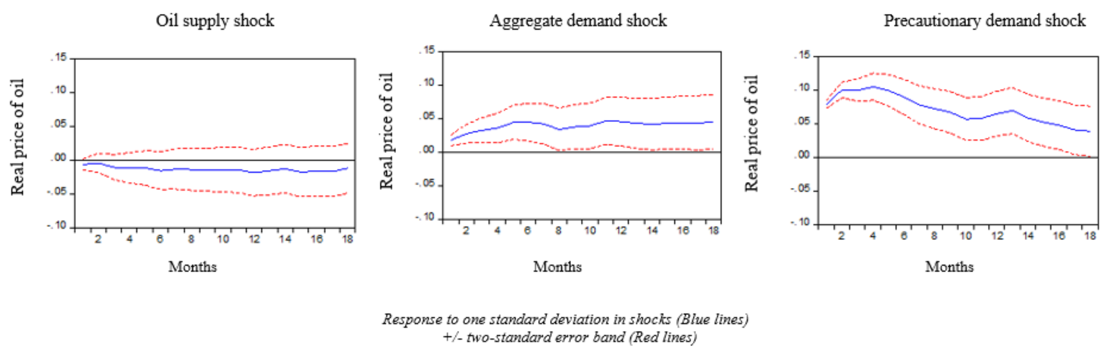

Figure 3.5 Response of real price of oil to supply and demand shocks

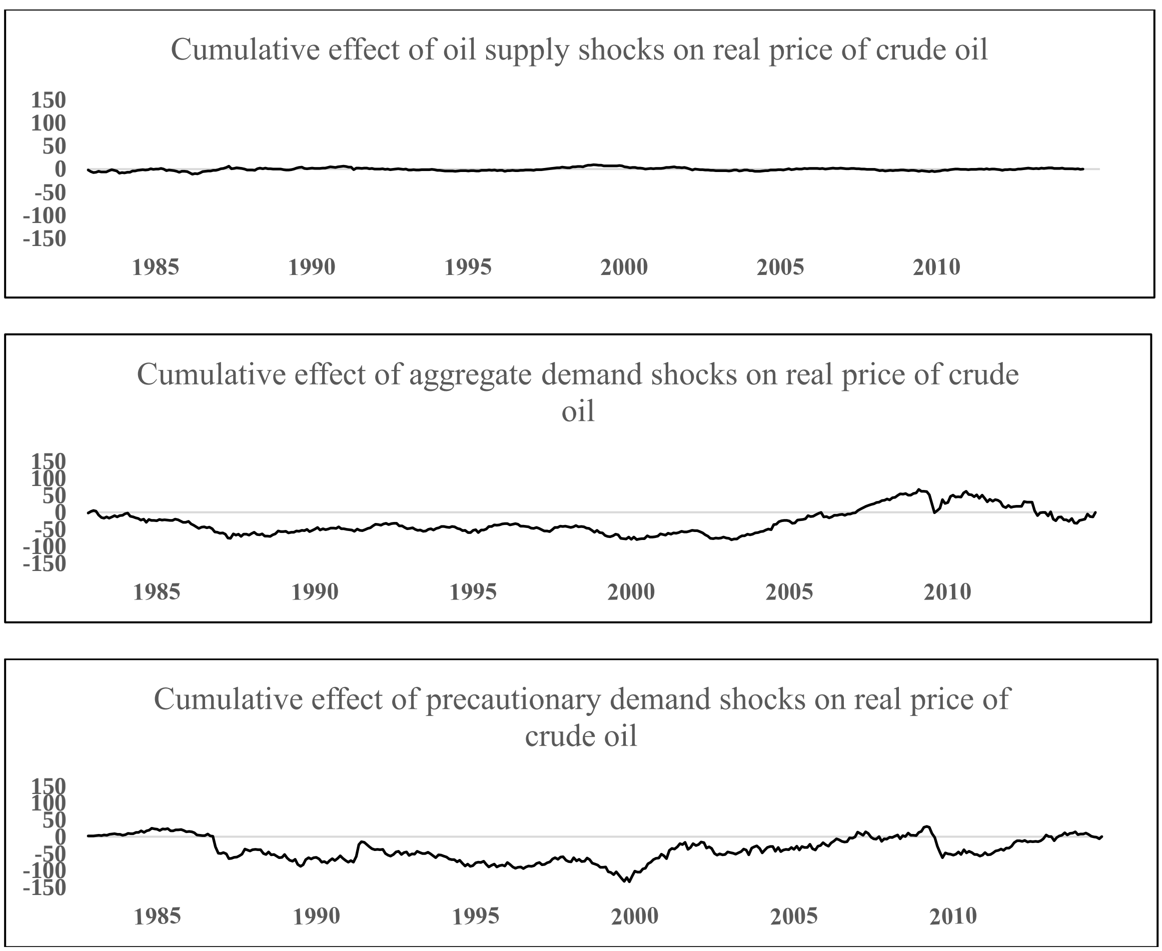

Figure 3.6 Cumulative effect of oil demand and oil supply shocks on the real price of oil (1980-2013)

CHAPTER 4

OIL PRICE SHOCKS AND OIL IMPORT DEMAND: A STRUCTURAL VAR-PANEL ARDL APPROACH

4.1 Introduction

Oil import demand has been of particular interest in the energy-growth literature as it constitutes the principal channel for the transmission of energy shocks to the macroeconomy of energy-importing countries. A considerable amount of research has examined the demand for oil in general and raw crude or petroleum products in particular. Atkins and Jazayeri (2004) provide an excellent survey on earlier studies. Recent studies conducted in a time-series context include Cooper (2003) on the United States and 22 other countries; Altinay (2007) on Turkey; Gosh (2009) on India; Ziramba (2010) on South Africa; Sun, Qi, and Jia (2010) on China; Asali (2011) on Group of Seven (G7) countries and Brazil, Russia, India, and China (commonly termed as BRIC); and Kim and Baek (2013) on South Korea. Other studies conducted in pooled cross-section or panel context include Dargay and Gately (2010) for six groups of countries; International Monetary Fund (IMF, 2011) for a panel of 45 OECD and non-OECD countries; and Javan and Zahran (2015) for a panel of 25 OECD and non-OECD countries that represent 75% of global oil demand. The elasticity estimates from these country-specific and panel studies vary substantially. Nonetheless, the overall empirical results point to one direction: oil import demand is generally price and income inelastic in the short-run.

A standard approach utilized by these studies is to model oil import demand as a function of the price of oil and income (GDP). One reason for this modeling approach is that fluctuations in the real price of oil is thought to originate from oil supply disturbances driven by events in the Middle East. Since these events are outside the confines of macroeconomic models, they are, together with oil price fluctuations, treated as exogenous. Another reason relates to the notion that oil import demand for any single country is not large enough to affect world oil prices; hence the price of oil is assumed to be exogenously determined.

Recent research on oil shocks have challenged these long-held beliefs about the causes of oil price shocks and provided strong theoretical and empirical evidence that oil supply disruptions are not the only driver of fluctuations in the real price of oil, but other factors such as dynamics in global macroeconomic activity as well as concerns about future oil supply shortfalls also influence the real price of oil (Alquist et al., 2013; Kilian & Murphy, 2012; Kilian, 2009; Kilian, 2014; Peersman, 2009).

Since Kilian (2009), it has become evident that oil price shocks are driven by distinct supply and demand shocks: an oil supply shock caused by disruptions in global oil production (oil supply shocks), an aggregate demand shock driven by global economic activity (aggregate demand shocks), and an oil market specific demand shock driven by precautionary demand motives (precautionary demand shocks). Consequently, current research efforts have been directed towards the re-examination of the effects of these distinct oil price shocks on macroeconomic variables such as output and inflation, but none on oil import demand.

My goal in this chapter is to fill in the gap by building on the recent advances in the oil shocks literature to develop a two-step empirical framework to examine the effects of the three distinct oil price shocks on oil import demand. The analysis relies on more recent data (1980-2013) for a sample of 30 oil-importing countries.

The central message of the chapter is that the standard approach to modeling oil import demand as a function of oil price and GDP is not well-defined because it implicitly assumes that one can vary the price of oil while holding all other variables fixed. This *ceteris paribus* assumption is not appropriate for two reasons.

First, the standard approach implies that oil import demand is endogenous while the price of oil and GDP are exogenous. But this is not the case since the price of oil and GDP are potentially endogenous and reverse causality may run from one to the other. Second, shocks to the global economic activity reflected in the demand for all industrial commodities may have direct effects on oil import demand as well as an indirect effect working through the price of oil. Thus, even if one controls for the reverse causality, these direct and indirect effects of global demand shocks on oil import demand invalidate the *ceteris paribus* assumption.

I jointly address these issues by developing a two-step structural VAR-panel ARDL approach. More specifically, I used the structural VAR model proposed by Kilian (2009) to identify the underlying demand and supply shocks in the global crude oil market and decompose the real price of oil into three components: oil supply shocks, aggregate demand shocks, and precautionary demand shocks. I then estimate the sensitivity of oil import demand to the oil price shocks for a panel of 30 oil-importing countries from 1980-2013 using the panel ARDL model.

Empirical results from the structural VAR model of the global crude oil market reveal that an unexpected oil supply disruption causes a modest transitory increase in the real price of oil; an unanticipated increase in aggregate demand causes a strong increase in the real price of oil; and an unanticipated increase in precautionary demand for oil triggers an immediate and large increase in the real price of oil. As robustness checks, I estimate alternative specifications of the VAR by changing the order of the variables and find that the results are not sensitive to the ordering of the variables in the model.

Empirical results from the panel ARDL model reveal that import demand for oil is less sensitive to oil price shocks driven by supply disturbances but highly sensitive to oil price shocks driven by aggregate demand and precautionary demand shocks. Dividing the sample into OECD and non-OECD, I find that while OECD and non-OECD oil-importing countries are identical in their response to oil supply shocks, they differ in their responses to aggregate demand and precautionary demand shocks. The elasticity estimates are robust to whether raw crude imports or petroleum products imports are used as measures of oil import demand.

My principal contribution to the literature is that I model oil import demand as a function of the decomposed oil price shocks and provide new evidence that contrary to the standard modeling approach in existing literature, changes in the demand for imported oil do not depend on a single oil price shock but depend on multiple oil price shocks resulting from oil supply shocks, aggregate demand shocks, and precautionary demand shocks.

The rest of the chapter is organized as follows. In Section 4.2, I lay out the two-step methodology utilized to disentangle the supply and demand shocks to the real price of oil and examine their respective impact on oil import demand. I describe the data in Section

4.3. In Section 4.4, I present and discuss the empirical results. I follow up with a discussion of the observed differential response of oil import demand across oil-importing countries in Section 4.5 leading to the conclusion in Section 4.6.

4.2 Methodology

To examine the effects of oil price shocks on oil import demand, I develop a two-step estimation procedure. First, I use the structural VAR model to disentangle the underlying demand and supply shocks to the real price of oil. Second, I used the panel ARDL model to estimate the degree of responsiveness – elasticities – of oil import demand to the shocks.

4.2.1 The Structural VAR Model

Following Kilian (2009), I define a structural VAR model of the global crude oil market as follows:

$$\mathbf{A}_0\mathbf{z}_t = \boldsymbol{\alpha} + \sum_{i=1}^{24} \mathbf{A}_i\mathbf{z}_{t-1} + \boldsymbol{\varepsilon}_t \qquad (4.1)$$

where $\mathbf{z}_t$ denotes a vector time series consisting of monthly global crude oil production ($PROD_t$), an index of monthly global real economic activity (REA_t), and the monthly real oil price (ROP_t). The model allows for two years of lags. The sample period is January 1980 to December 2013. The error term, ε_t, denotes the vector of serially and mutually uncorrelated structural innovations. $\mathbf{A}_0^{-1}$ has a recursive structure such that the reduced-form errors $\mathbf{e}_t$ can be decomposed according to $\mathbf{e}_t = \mathbf{A}_0^{-1} \varepsilon_t$:

$$\mathbf{e}_t \equiv \begin{pmatrix} e_t^{prod} \\ e_t^{rea} \\ e_t^{rop} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} \varepsilon_{t\,oil\ supply\ shock} \\ \varepsilon_{t\,aggregate\ demand\ shock} \\ \varepsilon_{t\,precautionary\ demand\ shock} \end{pmatrix}$$

This model postulates that the real price of oil is determined by the intersection of a vertical supply curve of oil and a downward sloping demand curve for oil. Oil supply shocks triggered by – say, a disruption in global oil supply – move the vertical supply curve along the demand curve causing the real price of oil to change. Oil demand shocks (driven by aggregate demand shocks or precautionary demand shocks) move the demand curve along the vertical supply curve, again causing the real price of oil to change.

As in Kilian (2009), I impose the following restrictions on $\mathbf{A}_0^{-1}$. First, I define *oil supply shocks* as unpredictable innovations to global oil production and assume that oil supply does not respond to innovations to the demand for oil within the same month. This exclusion is conceivable as in practice, oil-producing countries tend to be slow in their response to demand shocks due to increased adjustment costs of oil production and the uncertainty about the state of the crude oil market. Second, I define *aggregate demand shocks* as innovations to global real economic activity that cannot be explained based on oil supply shocks. I impose the exclusion restriction that increases in the real price of oil driven by shocks that are specific to the oil market will not lower global real economic activity immediately, but with a delay of at least one month, as it takes time for global real economic activity to adjust. This restriction captures the sluggish response of global real economic activity after major oil price increases. Finally, I attribute shifts in demand for oil that are not driven by changes in global real economic activity to oil-market specific events driven by fears concerning the availability of future oil supply shortfalls. I refer to this shock as *precautionary demand shock*.[4]

Since my main concern is to examine how each of the decomposed oil price shocks affect oil import (data on which are available only on annual basis for majority of the countries in the sample), I constructed annual shock series by averaging the monthly oil price shocks for each year as follows:

$$\hat{\zeta}_{s,t} = \frac{1}{12}\sum_{i=1}^{12}\hat{\varepsilon}_{s,i,t}, \quad s = 1, 2, 3 \tag{4.2}$$

where $\zeta_{s,t}$, s = 1,2,3 are the three decomposed oil price shocks and $\hat{\varepsilon}_{s,i,t}$ refers to the estimated residual for the s_{th} oil price shock in the i_{th} month of the t_{th} year of the sample.[5] Figure 3.4 depicts time path of the annualized oil price shocks implied by the model. As indicated by the plots, at any giving point in time, fluctuations in the real price of oil is driven by a multitude of shocks: shocks from the global crude oil production (oil supply shock), shocks to the global demand for all industrial commodities including oil (aggregate demand), and shocks driven by shifts in precautionary demand for oil (precautionary demand shocks).

One approach to estimating the elasticities of oil import demand to the decomposed shocks is to use a distributed lag regression model of the following form:

5

[4] The justification for labelling the latter shocks as precautionary demand shock is provided in Chapter 3.

[5] I used simple averaging of the monthly shocks to generate the annualized shocks. As robustness checks, I applied alternative frequency conversion methods for converting data from high frequency (monthly) to low frequency (yearly). The elasticity estimates from the alternative frequency conversions remain largely consistent with the elasticity estimates from the baseline model that uses simple averaging. The alternative frequency conversation methods include *sum observations* that set the low observation equal to the sum of the observations in the corresponding high observations, that is, take the sum of say Jan. 2009, Feb. 2009,..., Dec. 2009 and put them into Y2009; *first observation* that sets the low observation equal to the value in the first of the corresponding high observations, that is, take the value of Jan. 2009 and put it into Y2009; *last observation* that sets the low observation equal to the value in the last of the corresponding high observations, that is, take the value of Dec. 2009 and put it into Y2009; *max observation* that sets the low observation equal to the maximum of the corresponding high observations, that is, take the maximum of Jan. 2009, Feb. 2009,..., Dec. 2009 and put it into Y2009; and *min observation* that sets the low observation equal to the minimum of the corresponding high observations, that is, take the minimum of Jan. 2009, Feb. 2009,..., Dec 2009 and put it into Y2009.

$$M_t = \alpha_s + \psi_{s,i} \sum_{i=1} \zeta_{s,t-i} + e_{s,t}, \qquad s = 1, 2, 3 \tag{4.3}$$

where M_t, denotes oil import demand; $\psi_{s,i}$ are the impulse response coefficients which corresponds to horizon i; ζ_s are the three serially uncorrelated oil price shocks; and $e_{s,t}$ are potentially serially correlated errors.

Kilian et al. (2009) utilized this distributed lag regression model on an equation-by-equation basis to examine the effects of oil shocks on external balances for individual and groups of countries. Though dynamic, the distributed lag equation-by-equation approach is less parsimonious especially if the study is dealing with a large set of countries. In addition, the equation-by-equation approach does not fully incorporate the sample dynamics since each country or group is modelled separately.

Thus, the study employs the panel ARDL approach to cointegration which takes the sample dynamics into account by using the lags of the dependent variable and the lagged and contemporaneous values of the explanatory variable(s) to estimate a single equation that concurrently provides elasticity estimates at the panel level as well as the country-specific level. An added advantage of the panel ARDL model is that it can be applied irrespective of whether the underlying variables in the model are purely $I(0)$ or purely $I(1)$ or partially integrated (Altinay, 2007; Pesaran, Shin, & Smith, 1999; von Arnim & Prabheesh, 2013).

4.2.2 The Panel ARDL Model

The panel ARDL model was developed by Pesaran, Shin, and Smith (1999). To estimate the elasticities of oil import demand to the decomposed structural shocks, I constructed the following panel ARDL(p,q) model:

$$M_{i,t} = \sum_{j=1}^{p} \lambda_{i,j} M_{i,t-j} + \sum_{j=0}^{q} \psi_{i,j} \zeta_{s,t-j} + \mu_i + e_{i,t} \quad p = 1;\ q = 5 \qquad (4.4)$$

where $i = 1, 2,.., N$; $t = 1, 2,.., T$; $M_{i,t}$ denotes oil import demand; $\zeta_{s,t}$, $s = 1,2,3$ are the three decomposed oil price shocks; μ_i is the fixed effects; $e_{i,t}$ is the error term and are independently distributed across i and t with means 0 and variance $\sigma_i^2 > 0$; the coefficients of the lagged dependent variable, $\lambda_{i,j}$, are scalars; $\psi_{i,j}$ are k x 1 coefficient vectors of the oil price shocks.

Reparameterizing Eq. (4.4) yields the following error correction model to be estimated:

$$\Delta M_{i,t} = \varphi_i (M_{it-1} - \beta_i \zeta_{s,t-1}) + \sum_{j=1}^{p-1} \lambda_{i,j} \Delta M_{i,t-j} + \sum_{j=0}^{q-1} \psi_{i,j} \Delta \zeta_{s,t-j} + e_{i,t} \quad p = 1;\ q = 5 \qquad (4.5)$$

where φ_i is the error-correction speed of adjustment parameter; ($M_{i,t-1}$ - $\beta_i \zeta_{s,t-1}$) represents the long-run component of the model; and $\psi_{i,j}$ are k x 1 vector of short-run elasticities of oil import demand to the three decomposed oil price shocks. The parameter q is chosen to coincide with the maximum horizon of the short-run price elasticities to be estimated. As standard in the literature for short-run analysis, the maximum horizon is set to five years.

To capture the time path of the short-run response to the decomposed oil price shocks, I did not sum the short-run price elasticities across the five years worth of lags. Rather, I presented the elasticities for each period as estimated by the model. Also, I included a time trend in Eq. (4.5) to account for trends in oil import demand.

Of primary interest in Eq. (4.5) are the error-correction speed of adjustment parameter, φ_i, the long-run oil price elasticity coefficients, β_i, and the short-run oil price elasticity coefficients, $\psi_{i,j}$. Theoretically, φ_i is expected to be negative if the variables exhibit a return to long-run equilibrium. For an adverse oil supply shock, the long-run price elasticities of oil import demand, β_i, and short-run price elasticities of oil import demand, $\psi_{i,j}$, are expected to be negative and the absolute value < 1 (inelastic). For demand shocks (positive aggregate demand shock and adverse precautionary demand shock), the long-run price elasticities of oil import demand, β_i, and short-run price elasticities, $\psi_{i,j}$, are expected to be positive.

4.3 Data

The global oil market variables in the structural VAR model include world oil production, global real economic activity, and real oil price. All the variables are in monthly series and covers the sample period from January 1980 to December 2013. Oil production and price data are obtained from the United States EIA. The oil price is the nominal refiner acquisition cost of imported crude oil deflated by the United States GDP deflator, which is considered to be the best proxy for global price of oil in the literature. The global economic activity indicator is proposed in Kilian (2009) and is available on his research webpage. All the oil market variables are expressed in detrended logs. The plots of the data series are shown in Figures 3.1 to 3.3. For all the variables, I can reject the null hypothesis of the existence of unit root at the 10% level using the Augmented Dicky-Fuller test (Table 3.1). Also, I can reject the null of no cointegration at the 1% level based on the Johansen cointegration test (Table 3.2).

The primary data source for the oil demand variable is the International Energy Agency (IEA) Energy Balances database. Annual volume of raw crude (import and export) and petroleum products (import and export) in million tons of oil equivalent was taken from the IEA database for a sample of 30 oil-importing countries from 1980-2013. A country is classified as an oil importer if its average volume of raw crude exports is less than 15% of its average volume of raw crude imports during 1980-2013 period. Table 4.1 contains the list of countries included the sample.

To control for the size of the oil importing countries, I constructed the oil demand variable as follows. I converted the annual oil import data from million tons of oil equivalent (*mtoe*) to million barrels of oil per year (*mbpy*) based on Brent crude conversion factor of 1 metric ton (*mt)* of oil equivalent equals 7.57 barrels of oil. I then multiplied the resultant volume of oil import, in *mbpy*, by the nominal crude oil price and expressed it as a share of GDP. The baseline panel ARDL model uses this measure of oil import demand as the dependent variable. However, the results are robust whether raw crude import or petroleum products (expressed as shares of GDP) are used as the dependent variable.[6]

Since the oil demand variables are for a panel of countries, panel unit root tests were applied to examine stationarity. The choice of panel unit root test however depends on whether the sample data is cross-sectional dependent or independent. If the sample is cross-sectionally dependent, the appropriate panel unit root test is the Pesaran (2007) CIPS test but if the sample is cross-sectionally independent, the appropriate panel unit root is Levin, Lin, and Chu (2002) LLC test and Phillips and Perron (1988) PP test. Table 4.2 reports the results from the Pesaran (2004) cross-sectional dependence (CD) test on oil import demand. The results indicate that the null hypothesis of cross-sectional

[6] I excluded China from the baseline panel ARDL model because China was a net oil-exporter from 1980-1992 before it became a net oil-importer in 1993 and thereafter. In addition, its average oil export as a share of average oil import from 1980-2013 is 20% (which is above the 15% threshold and more than twice the highest in the sample). I however estimated a separate model for China and the elasticity estimates generally exhibits similar patterns like most oil-importing countries in the sample. Oil import is strongly responsive to demand-driven oil price shocks but mildly responds to supply-driven oil price shocks.

independence can be rejected at the 5% level. Thus, I applied the Peseran (2007) panel unit root CIPs test to examine the stationarity of the oil import demand variable. Results in Table 4.3 indicate that oil demand variables are stationary.

4.4 Empirical Results

4.4.1 Decomposed Oil Price Shocks

Figure 4.1 shows the impulse response pattern of real oil price to the supply and demand shocks in the global oil market based on the structural VAR model in Eq. (4.1). The plots show that fluctuations in the real price of oil originate from different sources: oil supply shock, aggregate demand shock, and precautionary demand shock. Consistent with Kilian (2009) and Peersman and Van Robays (2009), the study finds that an unexpected oil supply disruption causes a modest transitory increase in the real price of oil; an unanticipated increase in aggregate demand causes a strong increase in the real price of oil; and an unanticipated increase in precautionary demand for oil triggers an immediate and large increase in the real price of oil.

Figure 4.2 shows the historical decompositions of the real price of oil. As evident from the plots, oil supply shocks have historically made relatively small contributions to fluctuations in the real price of oil. Indeed, the largest contributions come from aggregate demand shocks and precautionary demand shocks. While aggregate demand shock is responsible for longer swings in the real price of oil, precautionary demand shock is responsible for relatively sharp swings in the real price of oil. These results are consistent with the findings in the oil shocks literature (Barsky & Kilian, 2004; Fattouh et al., 2013; Kilian & Murphy, 2014; Kilian, 2009; Knittel & Pindyck, 2013; Peersman, 2009).

4.4.2 Effects of Decomposed Oil Price Shocks on Oil Import Demand

Before estimating the panel ARDL model, a necessary step is to test for cointegration among the underlying variables to determine the existence or absence of a long-run relationship. This requirement ensures that the ARDL model reaches a long-run stable equilibrium. To test for cointegration, I applied three standard panel cointegration tests (Fisher-Johansen, 1988; Kao, Chiang, & Chen 1999; Pedroni, 1999). The results in Table 4.4 indicate that oil import demand and the oil shocks are cointegrated based on at least two of three panel cointegration tests. Having established the cointegration relationship among oil import demand and the oil shocks, I estimated the long-run and short-run elasticities of the ARDL model in Eq. (4.5).

Tables 4.5, 4.6, and 4.7 report the panel results for oil import demand response to each of the decomposed oil price shocks. The long-run price elasticities of oil import demand are reported in the first part of each table while the short-run dynamics are reported in the second part. The elasticity estimates represent the degree of responsiveness to a 10% structural innovation in each of the decomposed oil price shocks.

As expected, the error-correction speed of adjustment parameter, φi, is negative and significant in all estimated models, confirming that the underlying variables in the model exhibit a return to long-run equilibrium. Also, as expected, the panel long-run price elasticities of oil import demand, βi, are negative and inelastic in response to an adverse oil supply shock although not statistically significant (Table 4.5). For a positive aggregate demand shock and precautionary demand shock, the long-run price elasticities of import demand have the theoretically unexpected signs and are not statistically significant (Tables 4.6 and 4.7).

Figure 4.3 plots the panel short-run elasticities of raw crude, petroleum products, and oil (crude plus petroleum) import demand to the three decomposed oil shocks from Tables 4.5, 4.6, and 4.7. All the short-run elasticity estimates (with few exceptions in Models 1, 2, 5, 6, and 7) are statistically significant at the 5% level. For a 10% structural innovation in each of the three distinct oil price shocks and a maximum elasticities horizon of five years, the elasticity estimates at the panel level reveal the following results. In response to an adverse oil supply shock, the price elasticity of oil import demand is negative and price inelastic. This suggests that, an adverse oil supply shock results in a less than proportionate decrease in oil import on impact but the decrease is transitory as the elasticity turns positive after the second year. After a positive aggregate demand shock, the price elasticity of oil import demand is positive and price inelastic implying that, a positive aggregate demand shock results in a relatively strong persistent increase in oil import with about a year delay. The increase in imports peaks about the third year and begins to decline afterwards. Finally, precautionary demand for oil driven by concerns about the availability of future oil supply triggers a sharp increase in oil import demand in the first year, followed by a decline thereafter as concerns about future oil supply shortfalls ease. These results are identical for raw crude and petroleum products import demand.

The assumption that the oil price shocks $\zeta_{s,t}$, $s = 1, 2, 3$ are exogenous is tested using the Hausman-Durbin-Wu regressor endogeneity test. Exogeneity here means predeterminess of the oil price shocks, that is, the oil price shocks are determined outside the panel ARDL model. Table 4.8 reports the results which confirms the exogeneity of the shocks across all countries in the sample.

The country-level short-run elasticity estimates of the various measures of oil import demand to the decomposed oil price shocks are summarized in Appendix B. All the short-run elasticities are statistically significant at the 5% level. Given the large degree of heterogeneity across oil-importing countries, Figures 4.4 to 4.9 compare the results from 3 OECD and 3 non-OECD countries.[7] Figures 4.4, 4.5, and 4.6 plot the short-run elasticities for 3 OECD oil-importing countries (United States, Germany, and the Netherlands) and Figures 4.7, 4.8, and 4.9 plot the short-run elasticities for 3 non-OECD oil-importing countries (Bangladesh, Kenya, and El Salvador).[8]

Regarding OECD oil-importers, plots in Figure 4.4 (United States), Figure 4.5 (Germany), and Figure 4.6 (the Netherlands) show that an unanticipated oil supply disruption causes a small transitory decrease in oil import demand (negative and price inelastic) in the United States and Germany but does not have an immediate impact on oil import demand in the Netherlands as the price elasticity is zero in the first year and turns positive from about the second year. A positive aggregate demand shock results in a strong and persistent increase in oil import with about a year's delay (positive but price inelastic) across the OECD countries. Precautionary demand for oil triggers an immediate increase demand for imported oil in all the 3 countries. However, it appears that the Netherlands' immediate response to precautionary demand for imported oil is stronger relative to United States and Germany.

Turning now to non-OECD oil-importing economies, plots in Figure 4.7 (Bangladesh), Figure 4.8 (Kenya), and Figure 4.9 (El Salvador) indicate that Kenya is more sensitive to adverse oil supply shocks in their demand for imported oil (negative and

[7] The country classification is based on World Bank GNI per capita from 1980-2013. Alternative classifications based on World Bank PPP GNI per capita and PPP GDP per capita (data on which is available from 1990-2013) yielded similar country categorization.

[8] Plots for the remaining 24 oil-importing countries in the sample are available but not reported due to space constraints.

persistently price inelastic), while Bangladesh and El Salvador are less sensitive to adverse oil supply shocks in their demand for imported oil (literally zero price elasticity for most part of the five-year horizon). A positive aggregate demand shock results in a strong increase in oil import in El Salvador than in Kenya and Bangladesh. Among the 3 non-OECD oil-importing economies, demand for imported oil is more responsive to precautionary demand shocks in El Salvador and Kenya than in Bangladesh.

Comparing OECD and non-OECD oil-importing countries, their responses to oil supply shocks are found to be identical. For instance, demand for imported oil in Bangladesh, like in the United States and Germany, is not sensitive to adverse oil supply shocks in the first year immediately after the shock. Also, oil import demand in El Salvador exhibits similar pattern to the Netherlands. In both countries, oil import demand decreases marginally in the first year following an adverse oil supply shock but increases from about the second year. Since OECD oil-importing countries with advanced financial systems tend to be less financially constrained, and hence, less sensitive to supply-driven oil price shocks, the identical response by OECD and non-OECD countries could reflect the role of oil consumption subsidies in non-OECD countries (Bangladesh and El Salvador) to help absorb the adverse oil supply shocks.[9]

In contrast to the identical response to supply-driven oil price shocks, the response to demand-driven oil price shocks, especially in the case of aggregate demand shocks, differs between OECD and non-OECD. Among OECD countries, the largest response to aggregate demand comes from the Netherlands (with price elasticity of 0.22 in the first year following the shock) while among non-OECD countries, the largest response is from

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[9] According to IEA estimates for 2012, oil subsidies amounted to $100 million in El Salvador and $900 million in Bangladesh (IEA World Energy Outlook, 2015).

Kenya (with price elasticity of 0.15 three years following the shock). As summarized in Appendix B, the observed differences across the 3 OECD and 3 non-OECD oil-importing countries highlighted in this section are representative of the remaining 24 countries (OECD and non-OECD) in the sample.

4.5 Discussion

The observed differential response of oil import demand to the three distinct oil price shocks between OECD and non-OECD oil-importing countries could reflect cross-country heterogeneity driven by factors such as the size of manufacturing sector, refinery capacity, oil consumption subsidies, and financial constraint variables. For example, demand for imported oil in countries with relatively large manufacturing sector may be less responsive to supply-driven oil price shocks but highly responsive to aggregate demand-driven oil price shocks. Similarly, oil-importers with relatively large refinery capacity may be less responsive to supply-driven price shocks but respond strongly to aggregate demand-driven price shocks.

In addition, oil-importing countries with oil consumption subsidies may not significantly decrease their demand for imported oil following a supply-driven shock. In the case of demand-driven shocks, the effect of oil consumption subsidies on oil import demand could also depend on the size of manufacturing sector and the combination of these two factors can lead to completely different responses to oil price shocks even among oil-importing countries with significant oil consumption subsidies.

Finally, oil-importers with relatively large net foreign asset positions (less financially constrained) may be resilient to supply-driven price shocks and respond strongly to aggregate demand-driven price shocks.

The two-step structural VAR-panel ARDL approach proposed in this chapter cannot separate out the potential influence of these cross-country heterogeneity factors on oil import demand response to the decomposed oil price shocks. However, the evidence I have presented here based on the two-step approach points to a clear story. Oil import demand does not depend on a single oil price shock but depends on multiple oil price shocks resulting from oil supply shocks, aggregate demand shocks, and precautionary demand shocks. Supply-driven oil price shocks cause mild transitory decrease in oil import demand. Demand-driven oil price shocks (aggregate demand and precautionary demand shocks) trigger strong increases in oil import demand.

4.6 Conclusion

In this chapter, I disentangle the underlying causes of oil price shocks and estimate their impact on oil import demand for a sample of 30 oil-importing countries. The central message of the chapter has been that the standard approach to modeling oil import demand as a function of oil price and GDP is not well-defined because it implicitly assumes that fluctuations in the real price of oil is exogenous to oil-importing countries.

Using the structural VAR model of the global oil market, I endogenize the real price of oil and decompose oil price shocks into three distinct components: oil supply shocks, aggregate demand shocks, and precautionary demand shocks. I then model oil import demand as a function of the shocks and provide the short-run oil import demand elasticity estimates to each shock as well as the time path of the elasticities for a sample of 30 oil-importing countries using panel ARDL model.

Empirical results from the structural VAR model of the global crude oil market reveal that an unexpected oil supply disruption causes a modest transitory increase in the real price of oil; an unanticipated increase in aggregate demand causes a strong increase in the real price of oil; and an unanticipated increase in precautionary demand for oil triggers an immediate and large increase in the real price of oil. Empirical results from the panel ARDL model show that import demand for oil is less sensitive to oil price shocks driven by supply disturbances but highly sensitive to oil price shocks driven by aggregate demand and precautionary demand shocks. Dividing the sample into OECD and non-OECD, I find that while OECD and non-OECD oil-importing countries are identical in their response to oil supply shocks, they differ in their response to aggregate demand and precautionary demand shocks.

My main contribution to the literature is that I model oil import demand as a function of the decomposed oil price shocks and provide new evidence that contrary to the standard modeling approach in existing literature, changes in the demand for imported oil do not depend on a single oil price shock but depend on multiple oil price shocks resulting from oil supply shocks, aggregate demand shocks, and precautionary demand shocks. Supply-driven oil price shocks cause mild transitory decrease in oil import demand. Demand-driven oil price shocks (aggregate demand and precautionary demand shocks) trigger strong increases in oil import demand.

Table 4.1

List of oil-importing countries

Countries	Crude Import	Petroleum Import	Oil Import	Crude Export	Petroleum Export	Oil Export	Net Oil Import	Oil Export % Oil Import
OECD								
Austria	61	31	91	0	9	10	82	0%
Belgium	248	117	365	18	140	157	207	7%
Chile	54	20	75	0	4	4	71	0%
Finland	82	31	112	0	33	33	79	0%
France	597	209	806	3	137	140	665	0%
Germany	761	308	1069	5	122	127	942	1%
Ireland	18	38	56	0	7	7	49	1%
Israel	79	18	97	0	19	19	78	0%
Italy	633	134	768	7	153	161	607	1%
Japan	1527	369	1895	0	52	52	1843	0%
South Korea	638	142	780	1	183	183	596	0%
Netherlands	422	369	791	8	499	508	283	2%
Portugal	86	26	113	0	16	16	97	0%
Spain	418	113	531	1	77	79	453	0%
Sweden	139	58	197	3	67	70	127	2%
Switzerland	36	63	98	0	3	3	95	0%
Turkey	151	55	206	0	25	25	181	0%
United States	3224	530	3754	42	390	432	3322	1%
Non-OECD								
Bangladesh	9	14	23	0	1	1	22	0%
Dominican Rep.	14	19	33	0	0	0	33	0%
El Salvador	6	6	12	0	1	1	11	0%
India	511	92	603	4	127	131	471	1%
Jordan	24	8	32	0	0	0	32	0%
Kenya	15	9	24	0	3	3	21	0%
Morocco	44	18	62	0	5	5	57	0%
Pakistan	43	54	96	1	5	6	91	2%
Philippines	82	26	108	2	7	9	99	3%
South Africa	118	15	133	1	19	20	113	1%
Sri Lanka	14	9	23	0	1	1	22	0%
Thailand	194	27	220	10	29	39	182	5%
China	547	177	724	108	90	198	526	20%

Notes: Data on crude and petroleum import and export is obtained from the International Energy Agency (IEA) Energy Balances database. Crude denotes raw crude oil; Petroleum denotes petroleum products such as petroleum oils, oils from bitumen, bituminous minerals, and residual petroleum products; Oil is the sum of raw crude and petroleum products. All figures are expressed in million barrels of oil per year (*mbpy*) based on based on Brent crude conversion factor of 1 ton of oil equivalent equals 7.57 barrels of oil equivalent and averaged for the period 1980-2013. A country is classified as an oil importer if its average volume of raw crude exports is less than 15% of its average volume of raw crude imports during 1980-2013 period. I estimated a separate model for China because it does not fit the sample selection criteria. China was a net oil-exporter from 1980-1992 before it became a net oil-importer in 1993 and thereafter. In addition, its average oil export as a share of average oil import is more than twice the highest in the sample.

Table 4.2

Cross-section dependence test

Pesaran (2004) CD Test *Null: cross-section independence*		
Variable	Test statistic	*p*-value
CRUDE IMP DD	88.33***	0.000
PETRO IMP DD	66.69***	0.000
OIL IMP DD	96.42***	0.000

Notes: CRUDE IMP DD = Crude import bill as share of GDP. PETRO IMP DD = Petroleum products import bill as share of GDP. OIL IMP DD = Oil (crude plus petroleum products) import bill as share of GDP. *p*-values: *** denotes 1% level of significance, ** 5%, and * 10%.

Table 4.3

Panel unit root test with cross-sectional dependence

Pesaran (2007) CIPS Test *Null: series not stationary*		
Variable	Test statistic	*p*-value
Crude import	-5.773***	0.000
Petroleum import	-4.295***	0.000
Oil import	-5.336***	0.000

Notes: CRUDE IMP DD = Crude import bill as share of GDP. PETRO IMP DD = Petroleum products import bill as share of GDP. OIL IMP DD = Oil (crude plus petroleum products) import bill as share of GDP. *p*-values: *** denotes 1% level of significance, ** 5%, and * 10%.

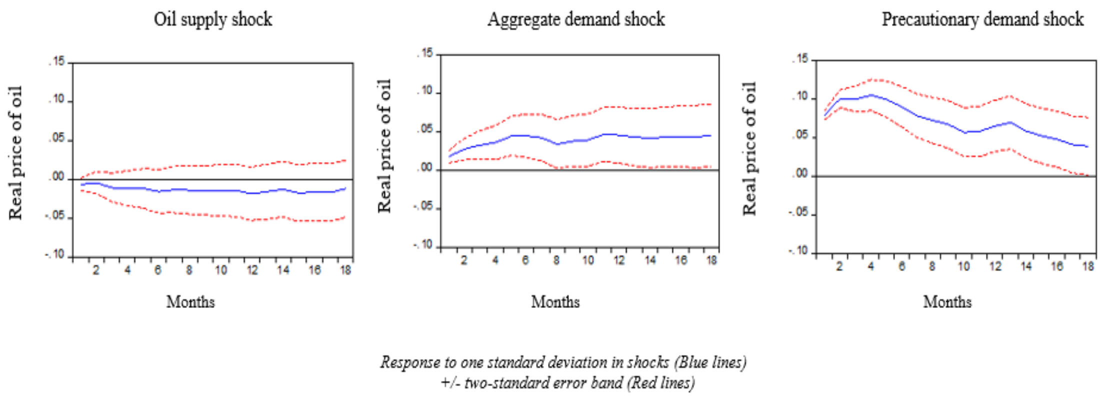


Figure 4.1 Response of real price of oil to supply and demand shocks

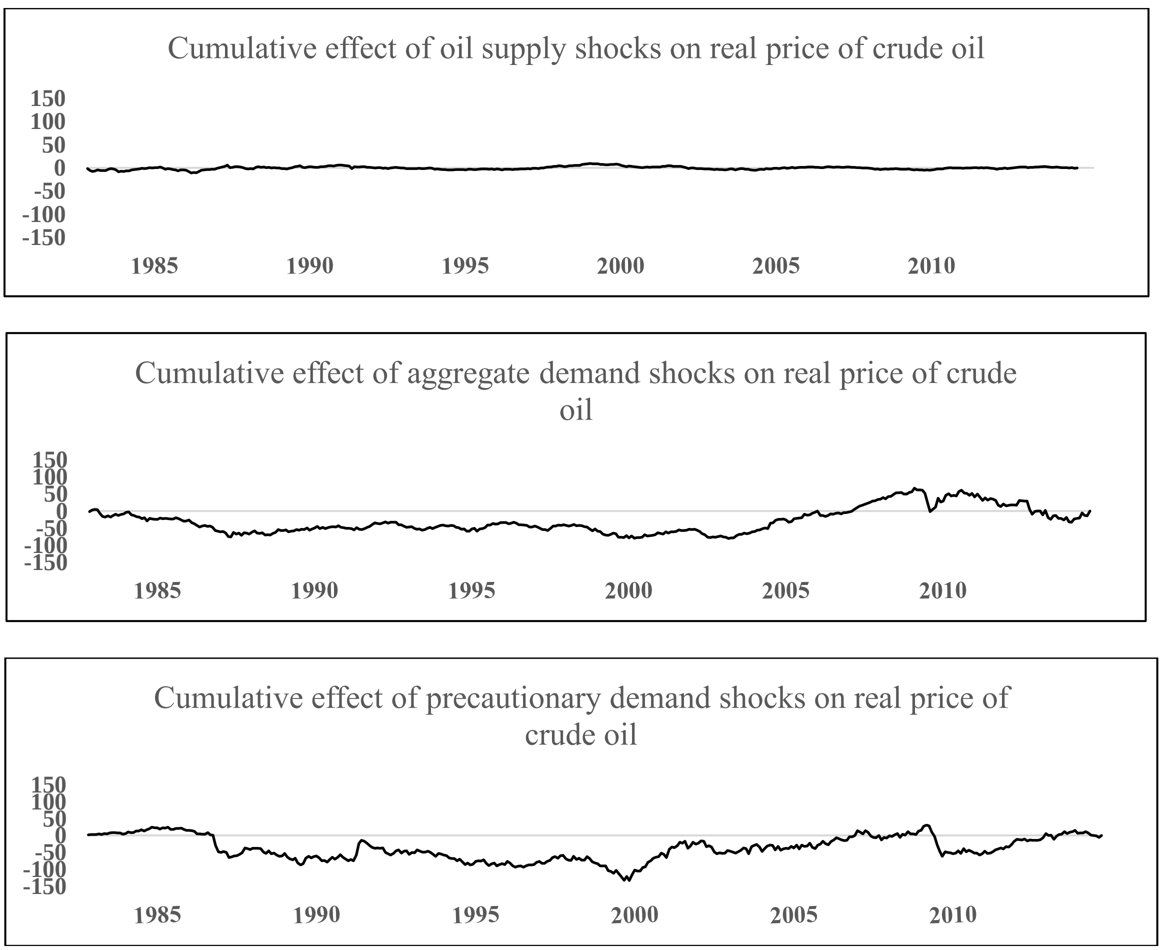


Figure 4.2 Cumulative effect of oil demand and oil supply shocks on the real price of oil

Table 4.4

Panel cointegration tests

Variable combination	Johansen-Fisher statistic	Pedroni ADF	Kao ADF
	Oil supply shock		
CRUDE IMP DD & Oil SS SHOCK	173.4***	-2.942***	-1.493*
	(0.000)	(0.002)	(0.068)
PETRO IMP DD & OIL SS SHOCK	143.0***	0.162	3.064***
	(0.000)	(0.565)	(0.001)
OIL IMP DD & OIL SS SHOCK	163.0***	-1.282*	-1.098
	(0.000)	(0.099)	(0.136)
	Aggregate demand shock		
CRUDE IMP DD & AGG DD SHOCK	337.2***	-2.739***	0.244
	(0.000)	(0.003)	(0.404)
PETRO IMP DD & AGG DD SHOCK	304.4***	0.835	3.394***
	(0.000)	(0.798)	(0.000)
OIL IMP DD & AGG DD SHOCK	294.9***	-1.455*	1.023
	(0.000)	(0.072)	(0.153)
	Precautionary demand shock		
CRUDE IMP DD & PREC DD SHOCK	251.2***	-2.794***	-1.179
	(0.000)	(0.003)	(0.119)
PETRO IMP DD & PREC DD SHOCK	213.6***	0.1026	2.856***
	(0.000)	(0.541)	(0.002)
OIL IMP DD & PREC DD SHOCK	246.9***	-1.826**	-0.899
	(0.000)	(0.034)	(0.184)

Notes: Fisher statistic, Pedroni ADF, and Kao ADF null hypotheses: no cointegration. *p*-values in parenthesis: *** denotes 1% level of significance, ** 5%, and * 10%.

Table 4.5

Elasticities of respective fuel import demand to oil supply shock (panel)

ARDL(1,5)
Dynamic regressors (5 lags, fixed): OIL_SS_SHOCK

	Model 1 *Dependent variable:* Δ(CRUDE IMP DD)	Model 2 *Dependent variable:* Δ(PETRO IMP DD)	Model 3 *Dependent variable:* Δ(OIL IMP DD)
	Long-run Equation		
OIL SS SHOCK	-0.0223 (0.443)	-0.0223 (0.314)	-0.0250 (0.695)
	Short-run Equation		
COINTEQ01	-0.4414*** (0.000)	-0.0006** (0.018)	-0.4191*** (0.000)
Δ(OIL SS SHOCK)	-0.0126*** (0.000)	-0.0064* (0.051)	-0.0253*** (0.001)
Δ(OIL SS SHOCK(-1))	-0.0173*** (0.000)	-0.0061*** (0.001)	-0.0279** (0.027)
Δ(OIL SS SHOCK(-2))	0.0139*** (0.003)	0.0190*** (0.000)	0.0295 (0.904)
Δ(OIL SS SHOCK(-3))	0.0387*** (0.000)	0.0278*** (0.000)	0.0654*** (0.000)
Δ (OIL SS SHOCK(-4))	0.0289*** (0.000)	0.0144*** (0.000)	0.0437*** (0.000)
@TREND	0.0004*** (0.000)	0.0003*** (0.000)	0.0008*** (0.000)
Durbin-Watson statistic	2.092	2.053	2.074

Notes: Elasticity estimates based on ARDL model with robust standard errors. *p*-values in parenthesis: *** denotes 1% level of significance, ** 5%, and * 10%. Durbin-Watson statistic: no serial autocorrelation if test statistic ≈ 2.

Table 4.6

Elasticities of respective fuel import demand to aggregate demand shock (panel)

ARDL(1,5)
Dynamic regressors (5 lags, fixed): AGG_DD_SHOCK

	Model 4 *Dependent variable:* Δ(CRUDE IMP DD)	Model 5 *Dependent variable:* Δ(PETRO IMP DD)	Model 6 *Dependent variable:* Δ(OIL IMP DD)
	Long-run Equation		
AGG_DD_SHOCK	-0.0336	-0.0286	-0.1600*
	(0.391)	(0.208)	(0.059)
	Short-run Equation		
COINTEQ01	-0.3672***	-0.2478***	-0.3118***
	(0.005)	(0.000)	(0.000)
Δ(AGG_DD_SHOCK)	-0.0277***	-0.0191***	-0.0266**
	(0.005)	(0.001)	(0.018)
Δ(AGG_DD_SHOCK(-1))	0.0807***	0.0231**	0.1125***
	(0.002)	(0.015)	(0.000)
Δ(AGG_DD_SHOCK(-2))	0.1408***	0.0365***	0.1796***
	(0.001)	(0.000)	(0.000)
Δ(AGG_DD_SHOCK(-3))	0.0902***	-0.0012**	0.0898***
	(0.011)	(0.019)	(0.003)
Δ(AGG_DD_SHOCK(-4))	0.0186***	-0.0194	0.0033
	(0.258)	(0.136)	(0.806)
@TREND	0.0004***	0.0003***	0.0007***
	(0.000)	(0.000)	(0.000)
Durbin-Watson statistic	2.030	2.006	1.994

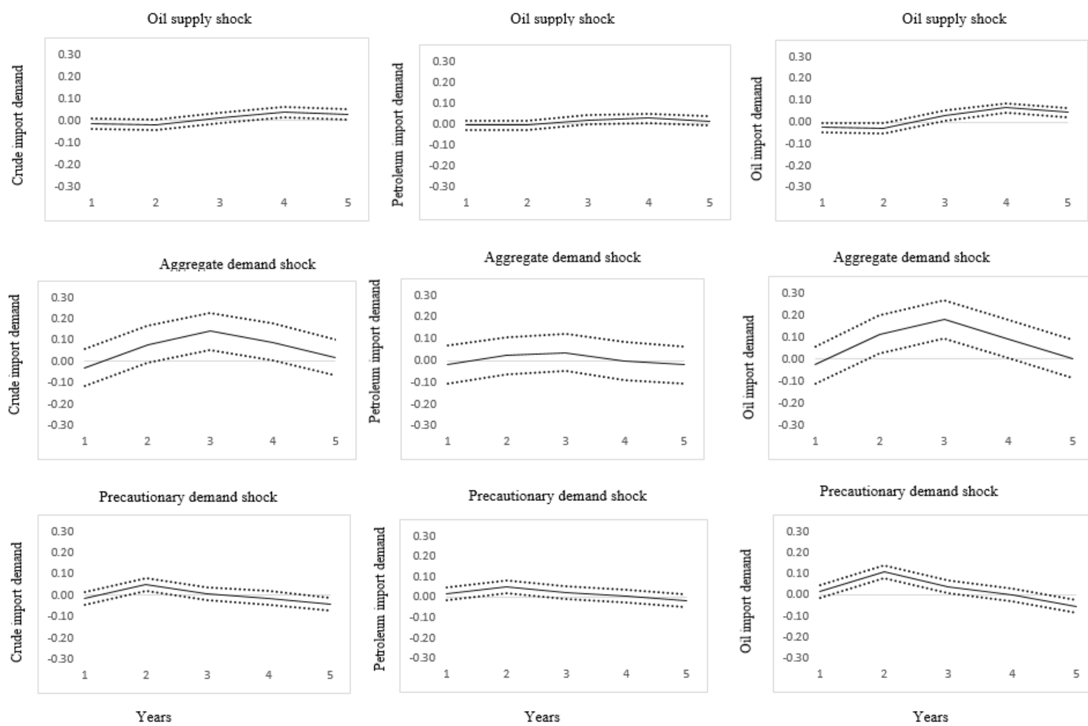
Notes: Elasticity estimates based on ARDL model with robust standard errors. *p*-values in parenthesis: *** denotes 1% level of significance, ** 5%, and * 10%. Durbin-Watson statistic: no serial autocorrelation if test statistic ≈ 2.

Table 4.7

Elasticities of respective fuel import demand to precautionary demand shock (panel)

ARDL(1,5) *Dynamic regressors (5 lags, fixed): PREC_DD_SHOCK*			
	Model 7 *Dependent variable:* Δ(CRUDE IMP DD)	Model 8 *Dependent variable:* Δ(PETRO IMP DD)	Model 9 *Dependent variable:* Δ(OIL IMP DD)
Long-run Equation			
PREC_DD_SHOCK	0. 09897*	-0. 0211	-0. 0502
	(0.073)	(0.406)	(0.695)
Short-run Equation			
COINTEQ01	-0.3532***	-0.3041***	-0.4191***
	(0.000)	(0.000)	(0.000)
Δ(PREC_DD_SHOCK)	-0.0140	0.0188**	0.0150***
	(0.143)	(0.013)	(0.000)
Δ(PREC_DD_SHOCK(-1))	0.0517***	0.0490***	0.1102***
	(0.002)	(0.000)	(0.000)
Δ(PREC_DD_SHOCK(-2))	0.0065	0.0231**	0.0384***
	(0.425)	(0.002)	(0.000)
Δ(PREC_DD_SHOCK(-3))	-0.0116*	0.0043	-0.0007***
	(0.092)	(0.178)	(0.000)
Δ(PREC_DD_SHOCK(-4))	-0.0403***	-0.0171***	-0.0535***
	(0.000)	(0.000)	(0.000)
@TREND	0.0003***	0.0003***	0.0008***
	(0.000)	(0.000)	(0.000)
Durbin-Watson statistic	2.220	2.128	2.199

Notes: Elasticity estimates based on ARDL model with robust standard errors. *p*-values in parenthesis: *** denotes 1% level of significance, ** 5%, and * 10%. Durbin-Watson statistic: no serial autocorrelation if test statistic ≈ 2.



Elasticity estimates based on ARDL model with robust standard errors
Dotted lines represent two-standard error band

Figure 4.3 Elasticities of respective fuel import demand to decomposed oil price shocks (panel)

Table 4.8

Hausman-Durbin–Wu regressor endogeneity test

Null: oil price shocks are exogenous

Country	Oil supply shock	Aggregate demand shock	Precautionary demand shock
	Difference in J-stats (Probabilities in parenthesis)	*Difference in J-stats* (Probabilities in parenthesis)	*Difference in J-stats* (Probabilities in parenthesis)
Austria	2.4091 (0.121)	0.0001 (0.990)	0.0008 (0.976)
Bangladesh	2.3028 (0.129)	0.0007 (0.979)	0.0008 (0.978)
Belgium	2.8222 (0.093)	0.0552 (0.814)	0.0573 (0.811)
Chile	2.7479 (0.097)	0.1396 (0.780)	0.1195 (0.729)
Dominican Rep.	1.3457 (0.246)	0.1822 (0.669)	0.1628 (0.686)
El Salvador	0.9742 (0.324)	0.2433 (0.622)	0.2113 (0.646)
Finland	2.2433 (0.134)	0.0001 (0.997)	0.0005 (0.992)
France	1.9979 (0.158)	0.0103 (0.919)	0.0085 (0.927)
Germany	2.3017 (0.129)	0.0043 (0.945)	0.0053 (0.942)
India	3.4951 (0.062)	1.3389 (0.247)	1.3995 (0.238)
Ireland	2.8109 (0.094)	0.0081 (0.929)	0.0134 (0.908)
Israel	2.3077 (0.129)	0.0002 (0.998)	0.0004 (0.985)
Italy	2.5208 (0.112)	0.0209 (0.885)	0.0214 (0.884)
Japan	2.5310 (0.112)	0.0804 (0.777)	0.0848 (0.771)
Jordan	2.4072 (0.121)	0.0304 (0.862)	0.0218 (0.883)
Kenya	1.5766 (0.209)	0.0701 (0.791)	0.0723 (0.788)
Morocco	2.8951 (0.088)	0.0278 (0.867)	0.0263 (0.871)
Netherlands	3.6224 (0.057)	0.4332 (0.510)	0.4420 (0.506)
Pakistan	2.9108 (0.088)	0.3084 (0.579)	0.2942 (0.588)
Philippines	1.8300 (0.176)	0.0314 (0.859)	0.0384 (0.844)
Portugal	2.2421 (0.134)	0.0053 (0.942)	0.0031 (0.955)
South Africa	3.2536 (0.071)	0.2213 (0.638)	0.2349 (0.628)
South Korea	3.6224 (0.057)	0.4331 (0.510)	0.4420 (0.506)
Spain	4.5334 (0.033)	0.0288 (0.865)	0.0209 (0.885)
Sri Lanka	1.0815 (0.298)	0.2318 (0.630)	0.2298 (0.632)
Sweden	3.1296 (0.077)	0.1808 (0.671)	0.1848 (0.667)
Switzerland	2.1003 (0.147)	0.0003 (0.987)	0.0008 (0.978)
Thailand	3.1009 (0.078)	0.7234 (0.395)	0.6949 (0.405)
Turkey	1.3898 (0.238)	0.1954 (0.658)	0.1842 (0.668)
United States	3.9852 (0.046)	0.9765 (0.323)	0.9879 (0.320)
China	1.9493 (0.163)	0.5632 (0.453)	0.5188 (0.471)

Notes: Exogeneity here means predeterminess of the oil price shocks, i. e., the oil price shocks are determined outside the panel ARDL model. *Difference in J-stats* is the difference between the restricted and unrestricted test equations.

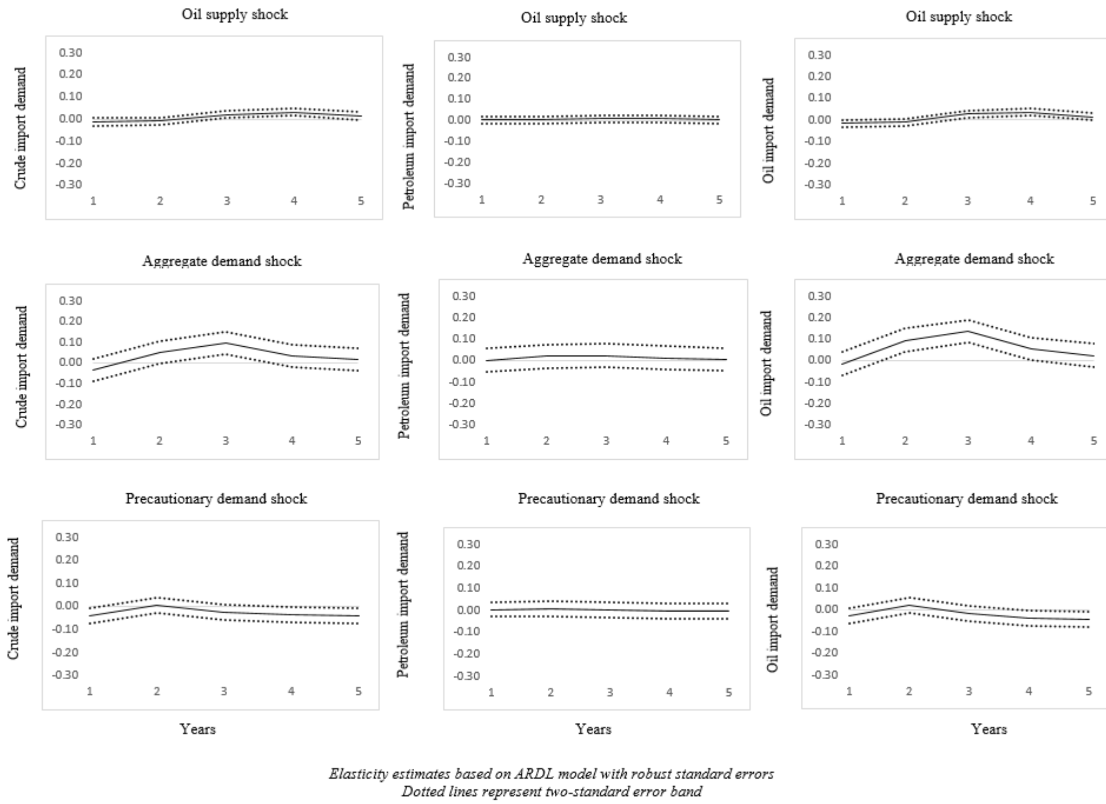


Figure 4.4 Elasticities of fuel import demand to decomposed oil price shocks (United States)

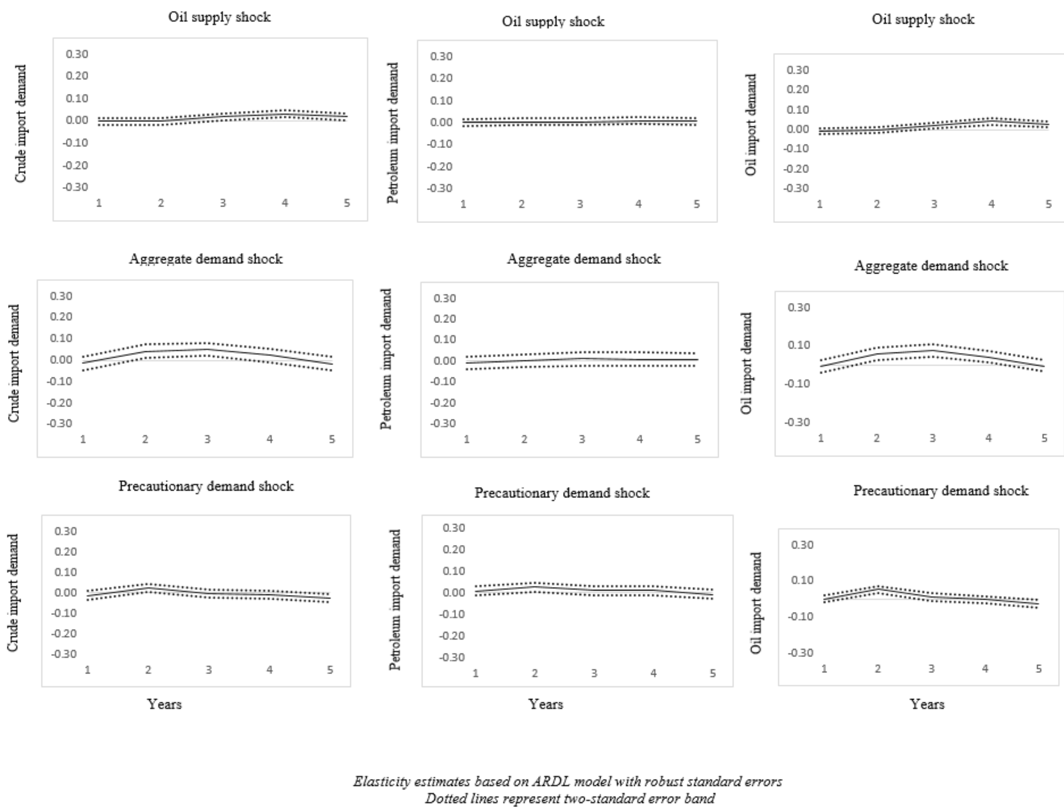


Figure 4.5 Elasticities of fuel import demand to decomposed oil price shocks (Germany)

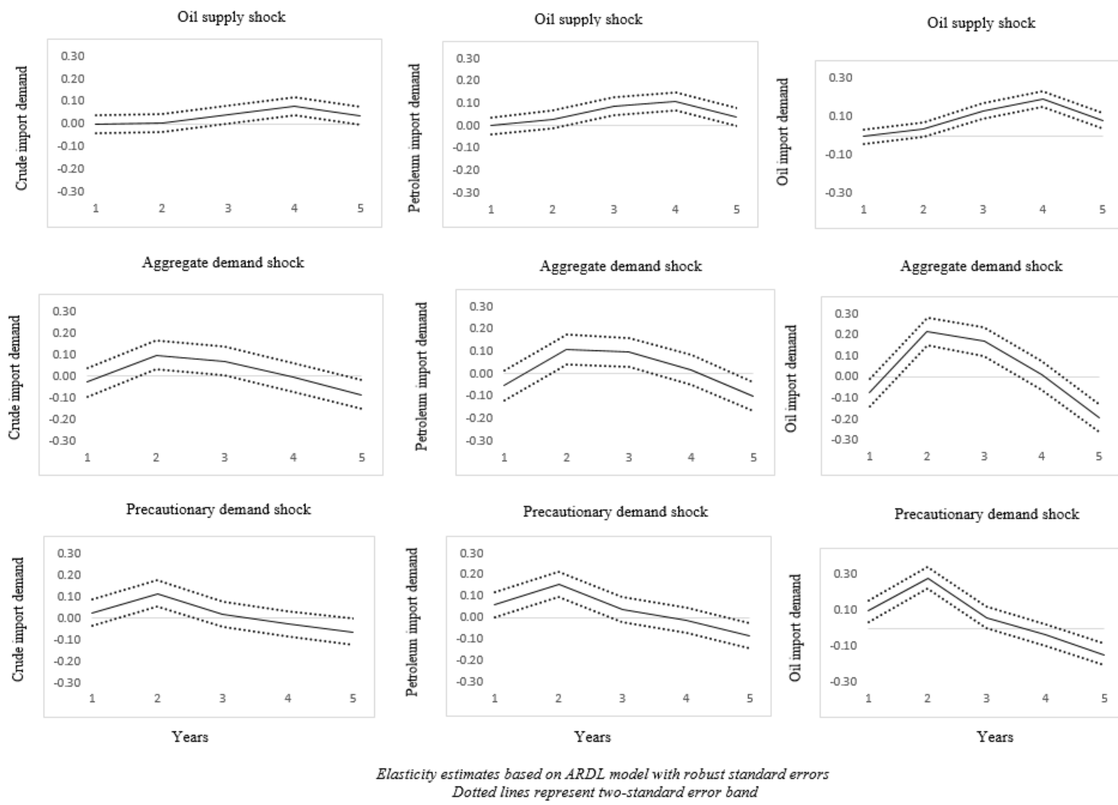
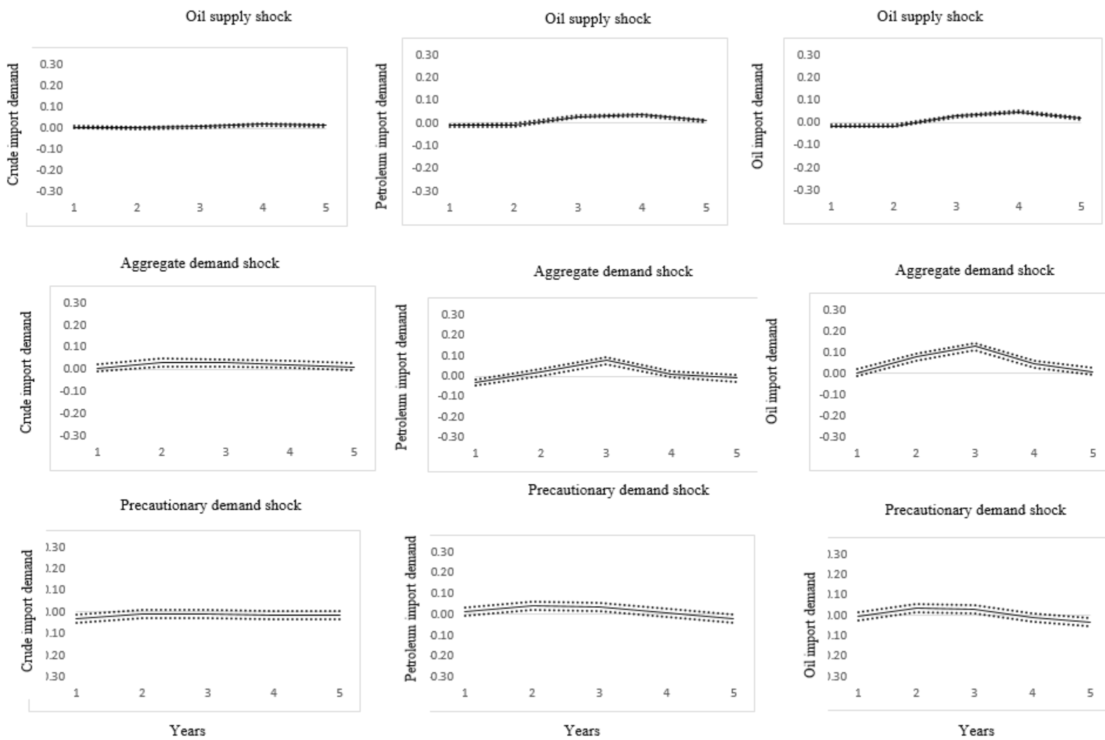


Figure 4.6 Elasticities of fuel import demand to decomposed oil price shocks (The Netherlands)



Elasticity estimates based on ARDL model with robust standard errors
Dotted lines represent two-standard error band

Figure 4.7 Elasticities of fuel import demand to decomposed oil price shocks (Bangladesh)

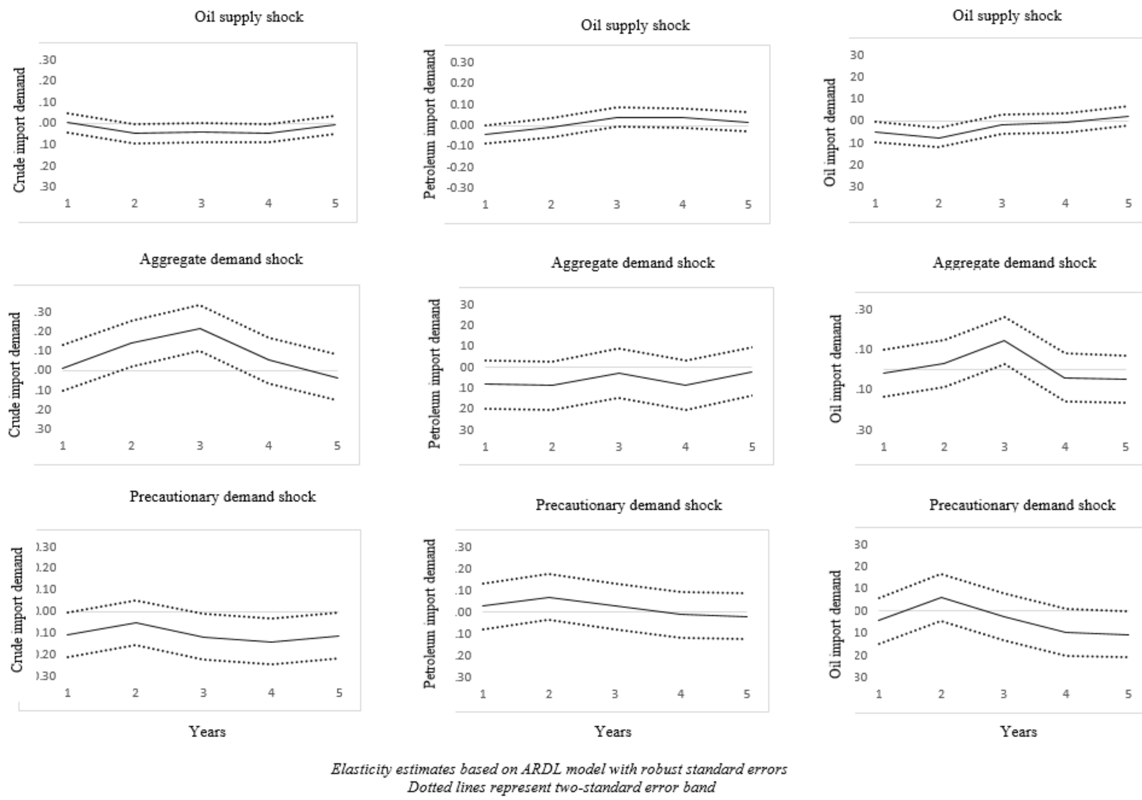


Figure 4.8 Elasticities of fuel import demand to decomposed oil price shocks (Kenya)

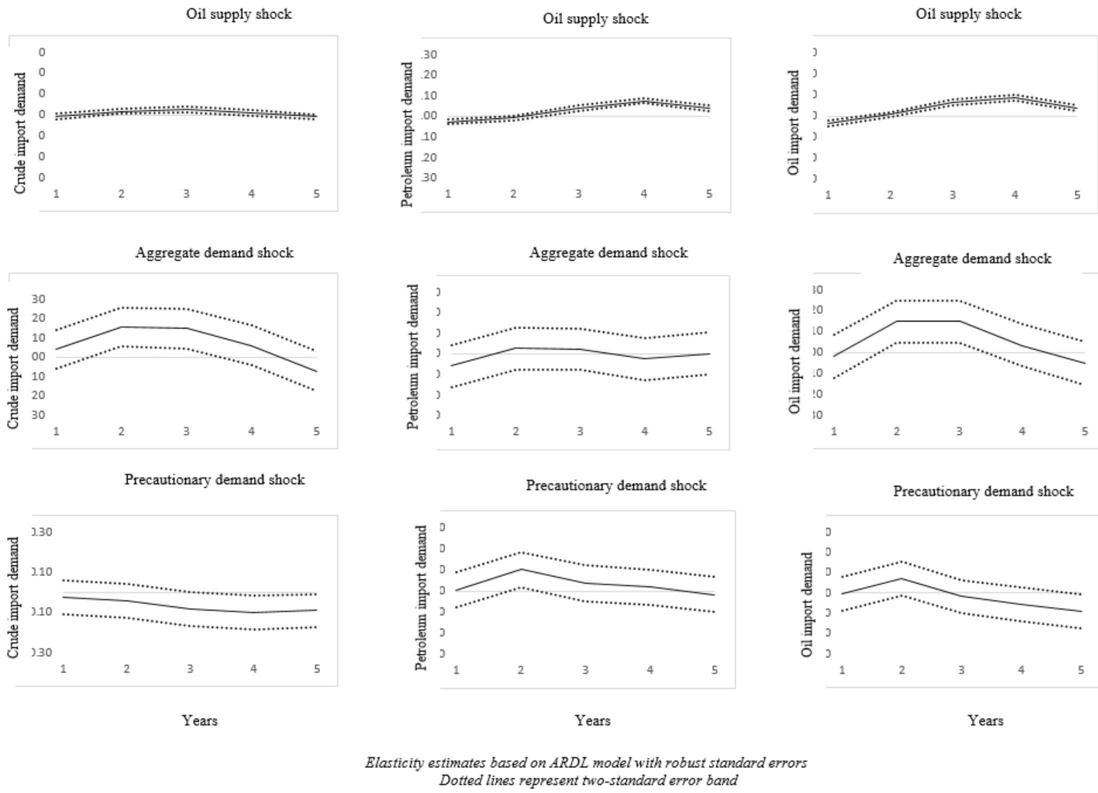


Figure 4.9 Elasticities of fuel import demand to decomposed oil price shocks (El Salvador)

CHAPTER 5

MACROECONOMIC EFFECTS OF OIL PRICE SHOCKS: EVIDENCE FROM OECD OIL-IMPORTING COUNTRIES

5.1 Introduction

Since the oil shocks of the 1970s, a growing number of studies have been examining the macroeconomic effects of oil price shocks on oil-importing countries. These studies generally find that oil price shocks are inflationary and reduce the rhythm of economic activity. In this chapter, I also examine the macroeconomic effects of oil price shocks. However, I depart from existing literature in two key respects. First, I compare the macroeconomic consequences of several types of oil price shocks exclusively for OECD oil-importing countries that constitute 41% of global oil demand. More specifically, I used a structural VAR model to distinguish between three different types of oil price shocks and estimate the effects of the shocks on inflation and output for 14 OECD oil-importing countries. Second, I evaluate whether structural differences matter for the impact of oil price shocks across countries, focusing on the role of oil intensity defined as the share of oil consumption in total energy consumption.

My decomposition of the structural disturbances in the global oil market show that fluctuations in the price of oil are driven by three distinct shocks, that is, an oil supply shock caused by disruptions in global oil production, an aggregate demand shock driven by global economic activity, and an oil-specific demand shock driven by precautionary demand motives. While each shock is associated with an increase in the price of oil, the macroeconomic effects of the shocks on oil-importing OECD countries crucially depend on the source of the shift: increases in the price of oil driven by oil supply shocks and precautionary demand shocks are inflationary and unfavorable to economic growth while increases in the price of oil driven by aggregate demand shocks are inflationary and favorable to economic growth.

Regarding the role of oil intensity, I find that, after an unfavorable oil supply shock, low oil-intensive OECD countries typically face modest inflationary pressures, whereas the inflationary pressures are strong and persistent in high oil-intensive OECD countries. The recessionary effects are also lower in the former group. In contrast to the differential effects of oil supply shocks, the effects of oil demand shocks driven by global economic activity and precautionary demand motives turn out to be very similar across the two groups. When the oil price shock is caused by increased global economic activity or a rise in precautionary demand, both groups experience respectively a temporary increase and transitory decline in real economic output. The inflationary effects of the demand shocks are strong and identical for both groups. These findings suggest that oil-intensity can explain the differences in the effects of oil supply shocks across oil-importing OECD countries but it cannot explain the difference in the effects of oil demand shocks.

The rest of the chapter is organized as follows. Section 5.2 summarizes the literature on the causes and macroeconomic effects of oil price shocks. Section 5.3 lays out the empirical methodology and describes the data. Results are presented and discussed in Section 5.4. Section 5.5 concludes the chapter.

5.2 Literature Review

Reflecting the preoccupation of many economists with the 1970s oil crises, much of the literature on the causes and transmission of oil price shocks focused on models with exogenous oil price shocks. These studies emphasized that historical oil price shocks are the result of oil supply disruptions caused by military conflicts in the Middle East or changes in the production quotas set by oil-exporting countries (see Bruno & Sachs, 1982; Burbige & Harrison, 1984; Hamilton, 1983, 2003; Malinvaud, 1977; among others).[10]

However, after a closer examination of the seemingly identical political events in the Middle East and other major oil producing regions, many observers began to cast doubt on the oil supply shock view and shifted their attention to the demand side. Barsky and Kilian (2002) was first to identify demand shocks as major determinants of movements in the price of oil and Kilian (2009) decomposed the underlying shocks to the price of oil into three components: shocks caused by disruptions in global oil supply (*oil supply shocks*); shocks to global economic activity (*aggregate demand shocks*); and shocks specific to the oil market driven by precautionary demand motives (*oil-specific demand shocks*). His decomposition provided compelling evidence that demand-driven oil price increases tend to be stronger and persistent whereas supply-driven oil price increases tend to be milder and transitory.

Building on Kilian's novel approach, researchers begun to explore the underlying causes of oil price shocks. Peersman and Van Robays (2009), Peersman and Van Robays (2012), and Kilian and Murphy (2014); all concluded that demand conditions collectively

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[10] Other studies with exogenous oil price shocks include Atkeson and Kehoe (1999), Bohi (1989), Cologni and Manera (2008), Cuado and Pres de Gracia (2003), Daniel (1997), Dogrul and Soytas (2010), Gisser and Goodwin (1986), Jimnez-Rodrguez and Snchez (2005), Kilian (2007), Kim and Loungani (1992), Lardic and Mignon (2008), Leduc and Sill (2004), Mork et al. (1994), Raymond and Rich (1997), Rotemberg and Woodford (1996), and Santini (1985).

explain major oil price shocks since 1973 and especially in more recent decades. The idea that demand shocks can explain major oil price fluctuations was initially met with skepticism but it is now commonly accepted that the role of global demand for oil is indispensable in understanding the causes of oil price shocks. Consequently, the prevailing conventional view is that oil price shocks are driven by exogenous oil supply shocks as well as endogenous demand conditions due to changes in global economic activity and precautionary demand for oil.

Production disturbances in oil-producing countries can be considered as adverse oil supply shocks and hence result in a decline in oil production, rising oil prices, increased inflationary pressures, and depressed global economic activity. The opposite effect of adverse oil supply shocks on inflation and output is well-documented in the literature (see Kilian, 2014 for a survey on earlier studies). Recent studies such as Cashin, Mohaddes, Raissi, and Raissi (2012) find that, adverse oil supply shocks trigger strong inflationary pressures on major energy-importing countries (Euro Area, Japan, China, and the United States). Another study by Peersman and Van Robays (2012) find that a negative oil supply shock results in a permanent fall in economic activity across a set of industrialized countries. This opposite impact of supply-driven oil price disturbances on inflation and output tend to complicate appropriate monetary policy reaction as monetary authorities in oil-importing countries are continuously confronted with a trade-off between price stability and output stabilization.

Alternatively, spikes in oil price could be caused by increased demand for oil. In this case, monetary authorities are also confronted with inflationary pressures but the output situation can be very different. In particular, in the event of increased global economic activity, oil-importing countries could themselves be in a boom, or because they indirectly gain from trade with the rest of the world. This differential impact of demand-driven oil price shocks on inflation and output is echoed by Baumeister & Peersman (2010), Cashin et al. (2012), Kilian (2009), and Peersman and Van Robays (2012). Even if the oil price shock is purely driven by speculations in the oil futures market, as Peersman and Van Robays (2012) and Arezki and Hasanov, (2013) argued, part of the petrodollars to oil-producing countries can be recycled through increased trade, thereby reducing the negative impact on output. Consequently, monetary authorities are not necessarily confronted with a trade-off between price stability and output stabilization.

Yet again, increases in the price of oil could be driven by precautionary demand for oil due to fears concerning future oil supply shortfalls. This shock is found to be associated with inflationary pressures and output decline. Kilian (2009) and Ansuini and Pisani (2015) concluded that shocks to precautionary oil demand almost completely explain the US recession of the early 1990s and contributed significantly to the recession in the early 2000s although during the most recent slump their contribution was more muted. Peersman and Van Robays (2009) found similar results for the Euro Area. Like supply-driven oil price shocks, the opposite effect of precautionary demand shocks on inflation and output complicates appropriate monetary policy response.

In summary, the oil shocks literature suggests that fluctuations in the price of oil originate from distinct supply and demand shocks and that not only are the source and magnitude of the shocks relevant to policymakers, but also the time-path and the exact pass-through to inflation and economic activity are important. Thus, in this study, I build on the recent advances in the literature to distinguish between supply-driven and demand-driven oil price shocks and examine their macroeconomic effects on output and inflation exclusively for oil-importing OECD countries.

5.3 Methodology and Data

To disentangle the oil price shocks and examine their macroeconomic effects on output and inflation, I follow Peersman and Van Robays (2012) and consider a VAR model with the following general specification:

$$\begin{bmatrix} X_t \\ Y_{j,t} \end{bmatrix} = \alpha + A(L) \begin{bmatrix} X_{t-1} \\ Y_{j,t-1} \end{bmatrix} + B \begin{bmatrix} \varepsilon_t^X \\ \varepsilon_{j,t}^Y \end{bmatrix} \tag{5.1}$$

The vector of variables included in the VAR are divided into two groups. The first group, X_t, captures the supply and demand conditions in the global oil market and includes world oil production (Q_{oil}), real oil price (P_{oil}), and a measure of global real economic activity (Y_w). The second group of variables, $Y_{j,t}$, is oil-importing OECD specific and contains real GDP (Y_j) and inflation (P_j). α is a matrix of constants and linear trends; $A(L)$ is a matrix polynomial in the lag operator L; B is the contemporaneous impact matrix of the vector of orthogonalized error terms $\varepsilon^X{}_t$ and $\varepsilon^Y{}_{j,t}$; $\varepsilon^X{}_t$ captures the structural shocks in the oil market; and $\varepsilon^Y{}_{j,t}$ captures the shocks specific to OECD oil-importers.

I distinguish between three different types of shocks in the oil market block, that is, an oil supply shock caused by disruptions in global crude oil production, an aggregate demand shock driven by global real economic activity, and an oil-specific demand shock driven by precautionary motives. To identify the structural disturbances, I impose sign restrictions on the estimated impulse responses of oil market variables in X_t. I assume that contemporaneous fluctuations in oil production, global economic activity, and oil prices are only driven by the three different types of shocks in $\varepsilon^X{}_t$ which corresponds to restricting the *B* matrix to be block lower triangular.

To disentangle the three oil shocks, I apply the following sign restrictions in Table 5.1. The sign restrictions are derived from a simple supply-demand scheme. First, an *oil supply shock* is an exogenous shift of the oil supply curve, and therefore moves oil price and oil production in opposite directions. Following an unfavorable oil supply shock, global economic activity will not increase.

Second, shocks to the demand side of the oil market will result in a shift of oil production and oil prices in the same direction, as demand-driven increases in oil prices are typically accommodated by increasing oil production in oil-exporting countries. I refer to such a shock as an *aggregate demand shock*. Accordingly, this shock is characterized by a positive co-movement between global real economic activity, oil prices, and oil production.

Finally, I attribute shifts in demand for oil that are not driven by changes in global real economic activity to oil market specific events driven by fears concerning the availability of future oil supply and label this shock as *precautionary demand shock*. In contrast to aggregate demand shocks, precautionary demand shocks will not have a positive effect on global economic activity. In fact, the final impact of precautionary demand on global economic activity could even be negative due to the associated oil price increase. Thus, I imposed the sign conditions to hold the first four quarters after the shocks to allow for sluggish responses. These sign restrictions on the global oil market uniquely identify the three oil shocks. Since the oil-importing OECD variables are not constrained in the estimations, the direction and magnitude of these responses are determined by the data. Also, I do not further identify the oil-importing OECD specific shocks in ε^{Y}_{t} since only the oil shocks are of interest.

The VAR model was estimated using quarterly data from the first quarter of 1980 to the fourth quarter of 2013. The oil market variables, oil production, global real economic activity, and real oil price are expressed in detrended logs. Inflation and real GDP are expressed in percent changes. The list of countries and summary statistics are reported in Tables 5.2 and 5.3, respectively. For all variables, I reject the null hypothesis of the existence of unit root at the 10% level using Augmented Dicky-Fuller test (Table 5.4). Also, I reject the null of no cointegration at the 1% level based on the Johansen cointegration test (Table 5.5). Per the standard lag selection criteria results in Table 5.6, I included two lags of the endogenous variables in the model. The results are, however, robust to different choices of lag length (see Appendix C).

Since I allow for feedback from the country-specific variables to the variables of the oil market in the VAR model, the magnitude and the dynamics of the identified oil price shocks could differ depending on the country included in $Y_{j,t}$, which could impair the comparability of the cross-country effects. To check the significance of this feedback factor, I imposed strict exogeniety between the oil market and country variables by estimating a near-VAR model and find that the feedback factor is insignificant. [11] Thus, the results reported in this chapter are not affected by the feedback factor and cross-country comparisons can be made simply by normalizing the oil shocks from the structural VAR in Eq. (5.1) to a 10% oil price increase.

Data on all oil-related variables are obtained from the U.S. EIA. The oil price variable used is the nominal refiner acquisition cost of imported crude oil deflated by the

[11] Results from the near-VAR estimation is summarized in Appendix C.

US GDP deflator, which is considered to be the best proxy for global price of oil in the literature. The world economic activity indicator is proposed in Kilian (2009) and available on his research webpage. Inflation and real GDP data for the 14 OECD oil-importers are obtained from OECD Main Economic Indicators (MEI) database.

5.4 Results

5.4.1 Decomposed Oil Price Shocks

Figure 5.1 shows the impulse response pattern of real oil price to the supply and demand shocks in the global oil market. The plots show that fluctuations in the real price of oil originate from different sources: oil supply shock, aggregate demand shock, and precautionary demand shock. Consistent with Kilian (2009) and Peersman and Van Robays (2009), the study finds that an unexpected oil supply disruption causes a modest transitory increase in the real price of oil; an unanticipated increase in aggregate demand causes a strong increase in the real price of oil; and an unanticipated increase in precautionary demand triggers an immediate and large increase in the real price of oil.

My estimates from the structural VAR model provide further evidence that not all price shocks are the same; they originate from different sources, and thus their macroeconomic effects crucially depend on the source of the shock.

5.4.2 Macroeconomic Effects of Oil Price Shocks

Figures 5.2 and 5.3 show the estimated impulse responses of inflation and real GDP growth to the three oil price shocks together with the standard error bands. The main results are the following. First, after a supply-driven oil price shock, oil-importing OECD countries experience mild inflationary pressures as inflation rises modestly and remains slightly above its baseline for an extended period. Economic activity declines three quarters after the shock but the decline is transitory and not statistically significant. My finding regarding the mild inflationary pressures of oil supply shocks contrasts those of Cashin et al. (2012) who find strong inflationary pressures on major energy-importing countries (Euro Area, Japan, China, and the United States) for an adverse oil supply shock. With respect to economic activity, my finding also contrasts Peersman and Van Robays (2012), who show that a negative oil supply shock results in a permanent fall in economic activity of net oil-importing countries.

The macroeconomic effects of an aggregate demand-driven oil-price shock is substantially different from those of an oil-supply disturbance. Following an aggregate demand shock, oil-importing OECD countries experience strong inflationary pressures and a short-run increase in economic activity. The short-run increase in real output following an aggregate demand shock is also echoed by Cashin et al. (2012) and Peersman and Van Robays (2012) and are not surprising given that the oil-price spike is assumed to be endogenously driven by a shift in global economic activity. Indeed, output can rise because the country itself is in a boom, or because the country indirectly gains from trade with the rest of the world.

Finally, a precautionary demand shock triggers strong inflationary pressures and sharp decline in economic activity across the 14 oil-importing OECD countries. While the inflationary impact of precautionary demand shock is not persistent as it wears off four quarters after the shock, the recessionary impact is relatively persistent and wears off eighteen quarters after the shock. This finding is consistent with Kilian (2009) and Ansuini and Pisani (2015), who find that shocks to precautionary oil demand almost completely explain the US recession of the early 1990s and contributed significantly to the recession in the early 2000s.

Overall, my findings reveal that oil price shocks are inflationary and detrimental to economic growth if driven by oil supply shocks and precautionary demand shocks but inflationary and favorable to economic growth if driven by aggregate demand shocks. The postestimation diagnostic tests results shown in Tables 5.7, 5.8, and 5.9 confirm the absence of major diagnostic problems like serial correlation, heteroskedasticity, and nonnormality. In addition, stability test results in Figure 5.4 indicates that the parameters in the models are stable over time. As robustness checks, I estimated alternative specifications of the structural VAR by changing the order of the variables and find that responses of economic activity and inflation to the three oil price shocks are not sensitive to the ordering of the variables in the model.

5.4.3 Structural Differences: The Role of Oil-Intensity

Table 5.10 summarizes the role of oil and total energy use across oil-importing OECD countries. All figures are obtained from the IEA and are calculated as averages per unit of Purchasing Power Parity-weighted GDP from 1980-2013 for each country. To evaluate whether structural differences matter for the impact of oil shocks, I focus on the role of oil intensity defined as the percent of oil consumption in total energy consumption. I divided the sample into two groups using an average oil-intensity of 54% as cut-off.[12] As

[12] Given the small oil-intensity margin between low and high oil-intensive countries, from 52% to 57%, I test whether the difference is statistically significant and find that the null hypothesis of no difference can be rejected at the 10% level (Appendix C).

shown in Table 5.7, OECD oil importers with low oil-intensity include Austria, Finland, Germany, Sweden, Belgium, France, Italy, and the United States. Those with high oil-intensity include Japan, Netherlands, Switzerland, Ireland, Spain, and Portugal.

Estimating a VAR model in Eq. (5.1) with *j* representing the two groupings, I find that, after an unfavorable oil supply shock, low oil-intensive OECD countries typically face modest inflationary pressures, whereas the inflationary pressures are strong and persistent in high oil-intensive OECD countries. The recessionary effects are also lower in the former group (Figure 5.5). In contrast to the differential effects of oil supply shocks, the effects of oil demand shocks driven by global economic activity and precautionary demand motives turn out to be very similar across the two groups (Figures 5.6 and 5.7). When the oil price shock is caused by increased global economic activity or a rise in precautionary demand, both groups experience a temporary increase and transitory decline in real economic output, respectively. The inflationary effects of the demand shocks are strong and identical for both groups. These findings suggest that oil-intensity can explain the differences in the effects of oil supply shocks across oil-importing OECD countries but it cannot explain the difference in the effects of oil demand shocks.

5.5 Conclusion

In this chapter, I investigated the causes and macroeconomic effects of oil price shocks on 14 OECD oil-importing countries using quarterly data from 1980-2013. In particular, I used the structural VAR model to disentangle oil price shocks and examine their macroeconomic effects on inflation and real GDP. My decomposition of structural shocks in the global oil market show that fluctuations in the price of oil are driven by three distinct shocks. While each shock is associated with an increase in the price of oil, the macroeconomic effects of the shocks on oil-importing OECD countries crucially depend on the source of the shift. I find that increases in the price of oil driven by oil supply shocks and precautionary demand shocks are inflationary and unfavorable to economic growth while increases in the price of oil driven by aggregate demand shocks are inflationary and favorable to economic growth.

Also, I evaluated whether structural differences matter for the impact of oil shocks across the countries focusing on the role of oil-intensity defined as the percent of oil consumption in total energy consumption. My findings reveal that OECD oil-importing countries with relatively high oil-intensity are vulnerable to supply-driven oil price shocks as they experience stronger inflationary pressures and decline in real output. Since monetary accommodation could exacerbate the inflationary pressures, supply-oriented policies that target the production side of the economy appear more appropriate as they could provide price relief while augmenting real output. These policies include reduction in employers' payroll taxes and depreciation allowances for energy-conserving investments. The latter could lead to substantial energy savings, reduction in oil consumption per unit of real output, and promote the development of alternative energy sources.

Table 5.1

Sign restrictions

Structural shocks	Q_{oil}	Y_w	P_{oil}	Y_j	P_j
Oil supply shock	< 0	≤ 0	> 0		
Aggregate demand shock	> 0	> 0	> 0		
Oil-specific demand shock	> 0	≤ 0	> 0		

Table 5.2

List of 14 OECD countries

Country	Average Real GDP Growth	Average Inflation
Austria	3.21%	2.70%
Belgium	1.92%	2.98%
Finland	2.31%	3.52%
France	1.84%	3.42%
Germany	1.73%	2.27%
Ireland	4.19%	4.48%
Italy	1.28%	5.44%
Japan	2.10%	1.00%
Netherlands	2.13%	2.44%
Portugal	1.97%	7.91%
Spain	2.25%	5.39%
Sweden	2.07%	3.88%
Switzerland	1.83%	1.93%
United States	2.65%	3.52%
Average	*2.25%*	*3.63%*

Notes: Averages based on annual inflation and real GDP data from 1980-2013 obtained from OECD Main Economic Indicators (MEI) database.

Table 5.3

Summary statistics of real GDP growth and inflation

	Real GDP Growth	Weighted Real GDP Growth	Inflation Rate	Weighted Inflation Rate
Mean	2.24%	2.16%	3.63%	3.64%
Median	2.37%	2.29%	2.48%	2.51%
Max	10.86%	10.94%	28.38%	28.32%
Min	-8.27%	-8.32%	-4.50%	-4.51%
Std. dev	2.39%	2.39%	3.97%	3.98%
Skewness	-0.401	-0.343	2.571	2.510
Kurtosis	5.150	5.262	11.075	11.051

Notes: Real GDP and inflation rate data from OECD Statistics. Weighted real GDP growth and weighted inflation rate are based on author's calculations. Weighted Real GDP growth is calculated using PPP-GDP country weights in percentage of OECD total. Weighted inflation rate is calculated using PPI country weights in percentage of OECD total.

Table 5.4

Unit root test

Augmented Dickey-Fuller Test
Null: series not stationary

Variables	Test statistics
Oil-related	
Oil production ($\boldsymbol{Q_{oil}}$)	-6.319*** (0.000)
Real economic activity ($\boldsymbol{Y_w}$)	-3.103** (0.039)
Real oil price ($\boldsymbol{P_{oil}}$)	-6.023*** (0.000)
OECD oil-importers	
Real GDP ($\boldsymbol{Y}$)	-5.741*** (0.000)
Inflation ($\boldsymbol{P}$)	-2.867* (0.052)

Notes: Data on all oil-related variables are obtained from the US Energy Information Administration (EIA). The oil price variable used is the nominal refiner acquisition cost of imported crude oil, which is considered to be the best proxy for the global price of imported crude oil in the literature. The world economic activity indicator is proposed in Kilian (2009) and available on his research webpage. Inflation and real GDP data for the 14 OECD oil-importers are obtained from OECD Main Economic Indicators (MEI) database. The oil market variables, oil production, global real economic activity, and real oil price are expressed in detrended logs. Inflation and real GDP are expressed in percent changes. Probabilities in parenthesis. For all the variables, we can reject the null hypothesis of the existence of unit root at the 10% level

Table 5.5

Cointegration test

Johansen Cointegration Test *Null: no cointegration*	
Hypothesized # of cointegrating equations	Test statistic
None *	118.332*** (0.000)
At most 1 *	70.487*** (0.000)
At most 2 *	39.548*** (0.003)
At most 3 *	19.874*** (0.010)

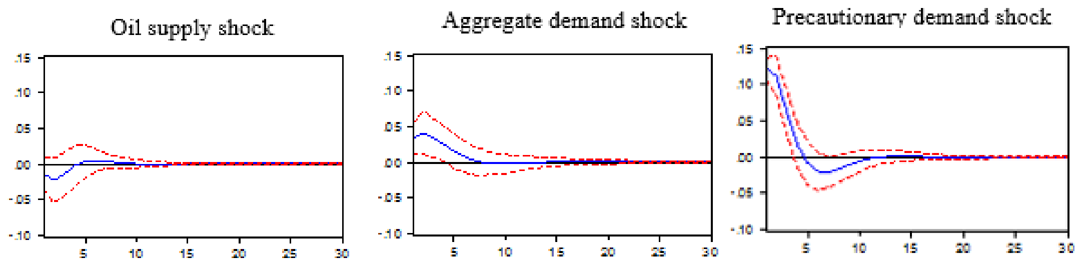
Notes: Probabilities in parenthesis. Null of no cointegration rejected at the 1% level.

Table 5.6

VAR lag length by country

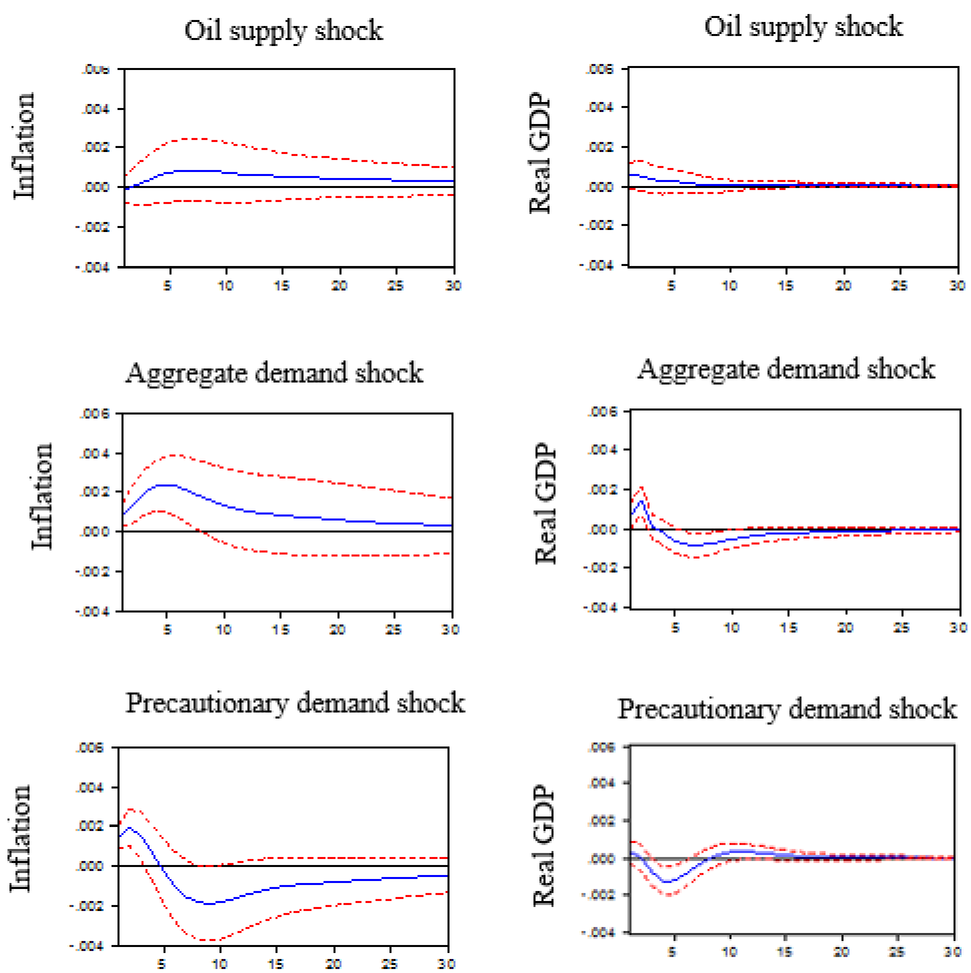
Country	Optimum lag length
Austria	3
Belgium	2
Finland	2
France	3
Germany	2
Ireland	3
Italy	2
Japan	2
Netherlands	2
Portugal	2
Spain	2
Sweden	2
Switzerland	2
United States	3
Average	*2*

Notes: Optimum lag length selected based on AIC, SIC, and HQC.



Response to one standard deviation in shocks (Blue lines)
+/- two-standard error band (Red lines)

Figure 5.1 Response of real price of oil to one-standard deviation structural shocks



Response to one standard deviation in shocks (Blue lines)
+/- two-standard error band (Red lines)

Figure 5.2 Impulse response of macroeconomic variables to oil price shocks (All-countries average)

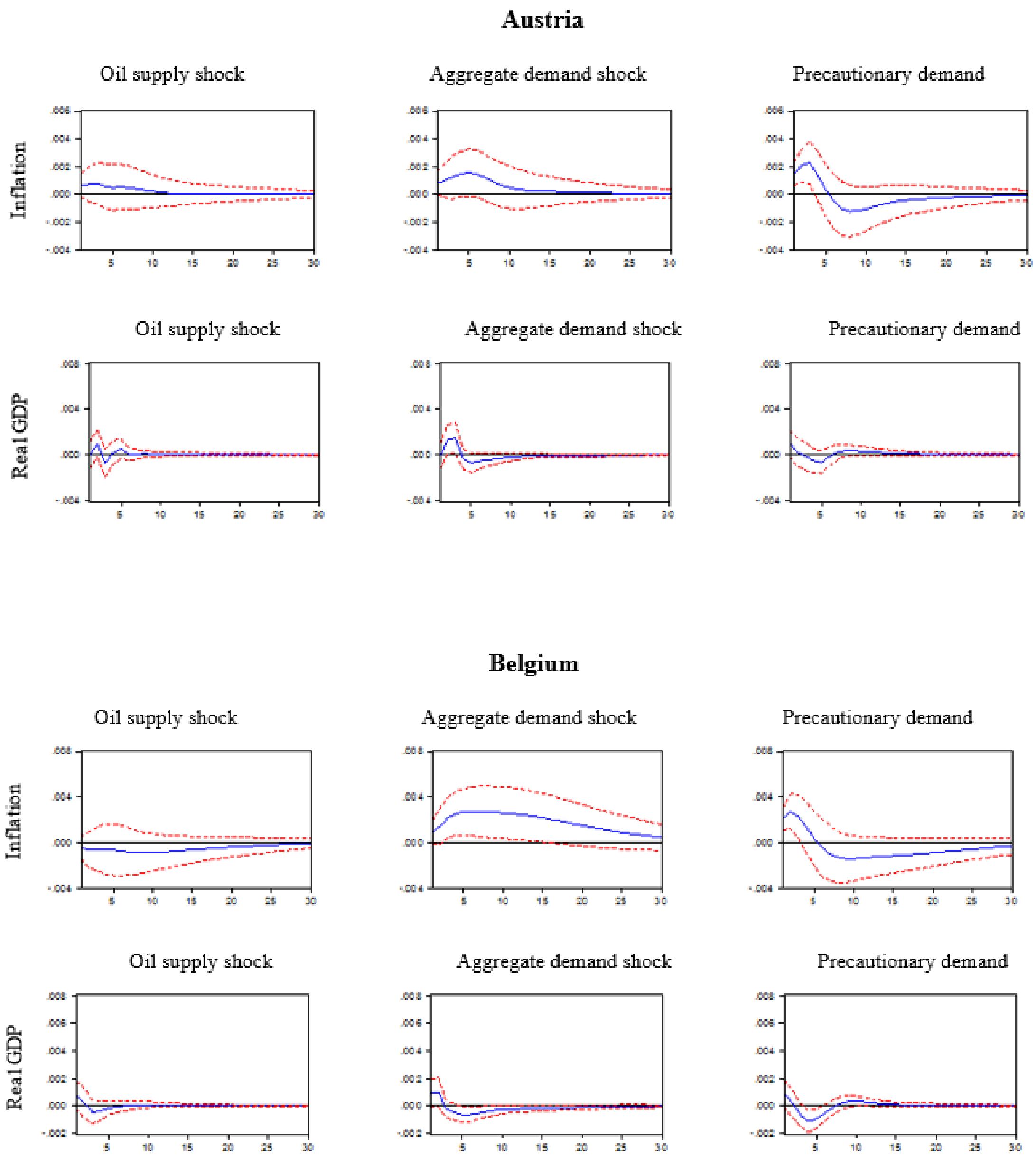


Figure 5.3 Cross-country impulse responses

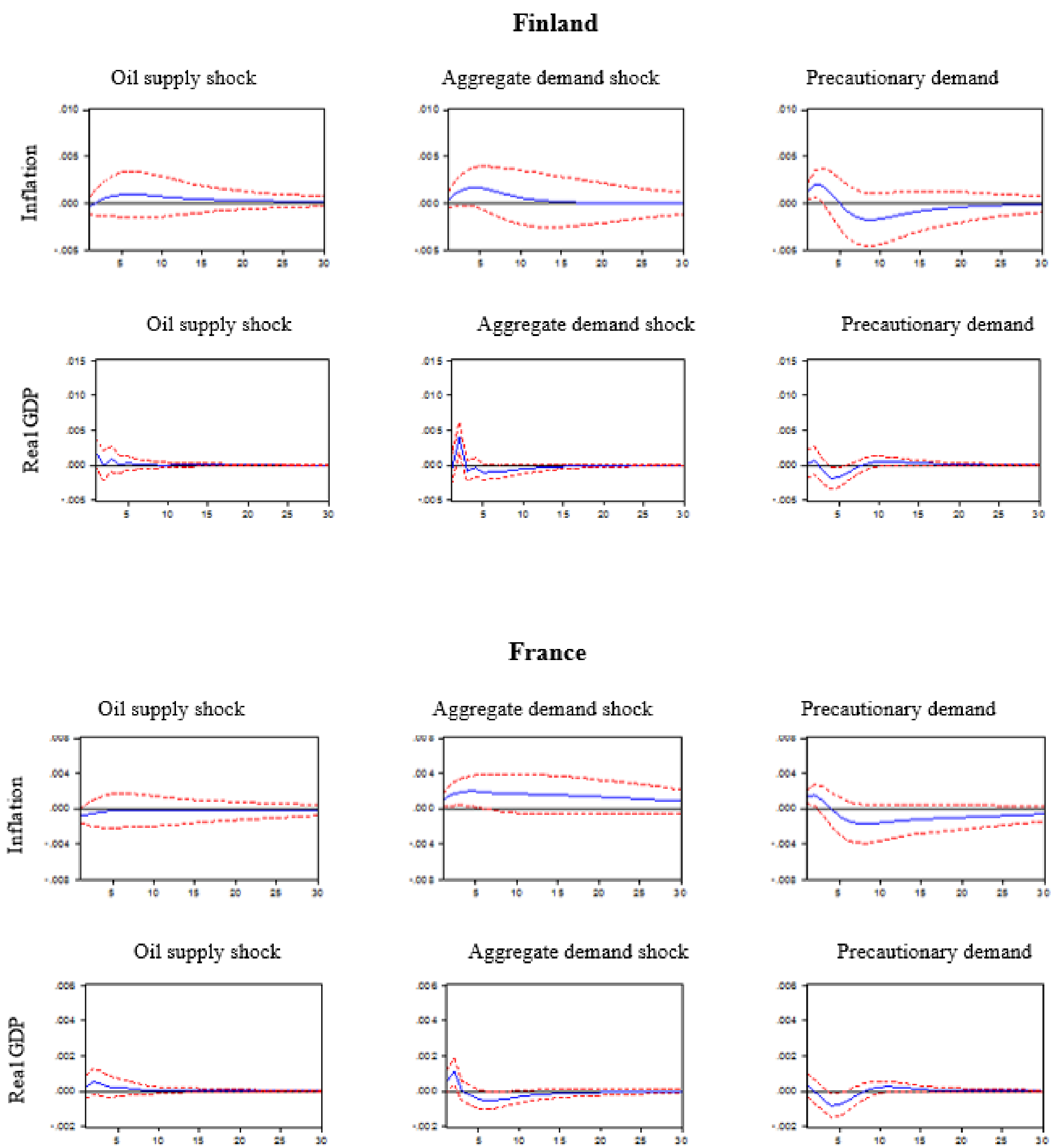


Figure 5.3 continued

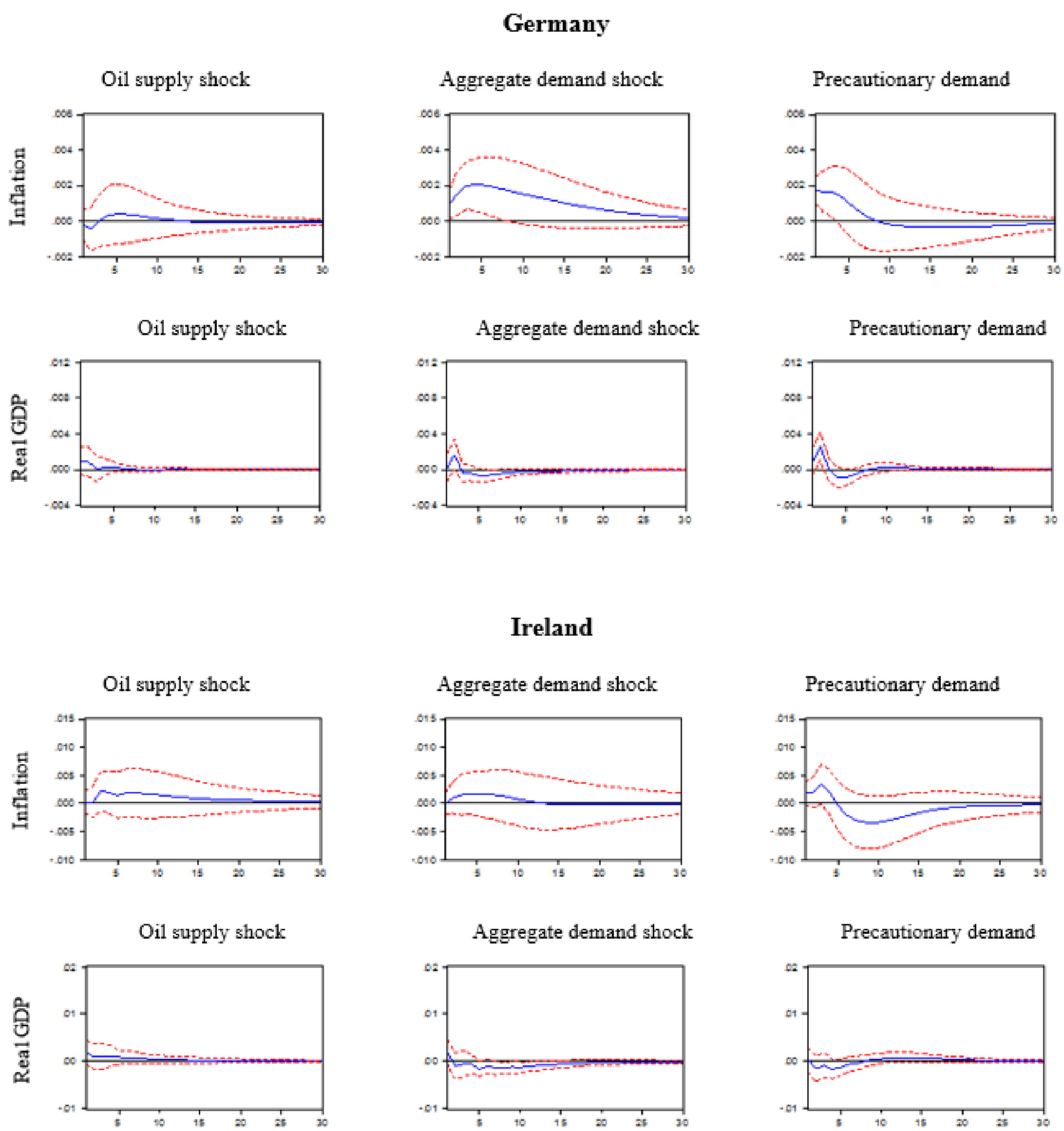


Figure 5.3 continued

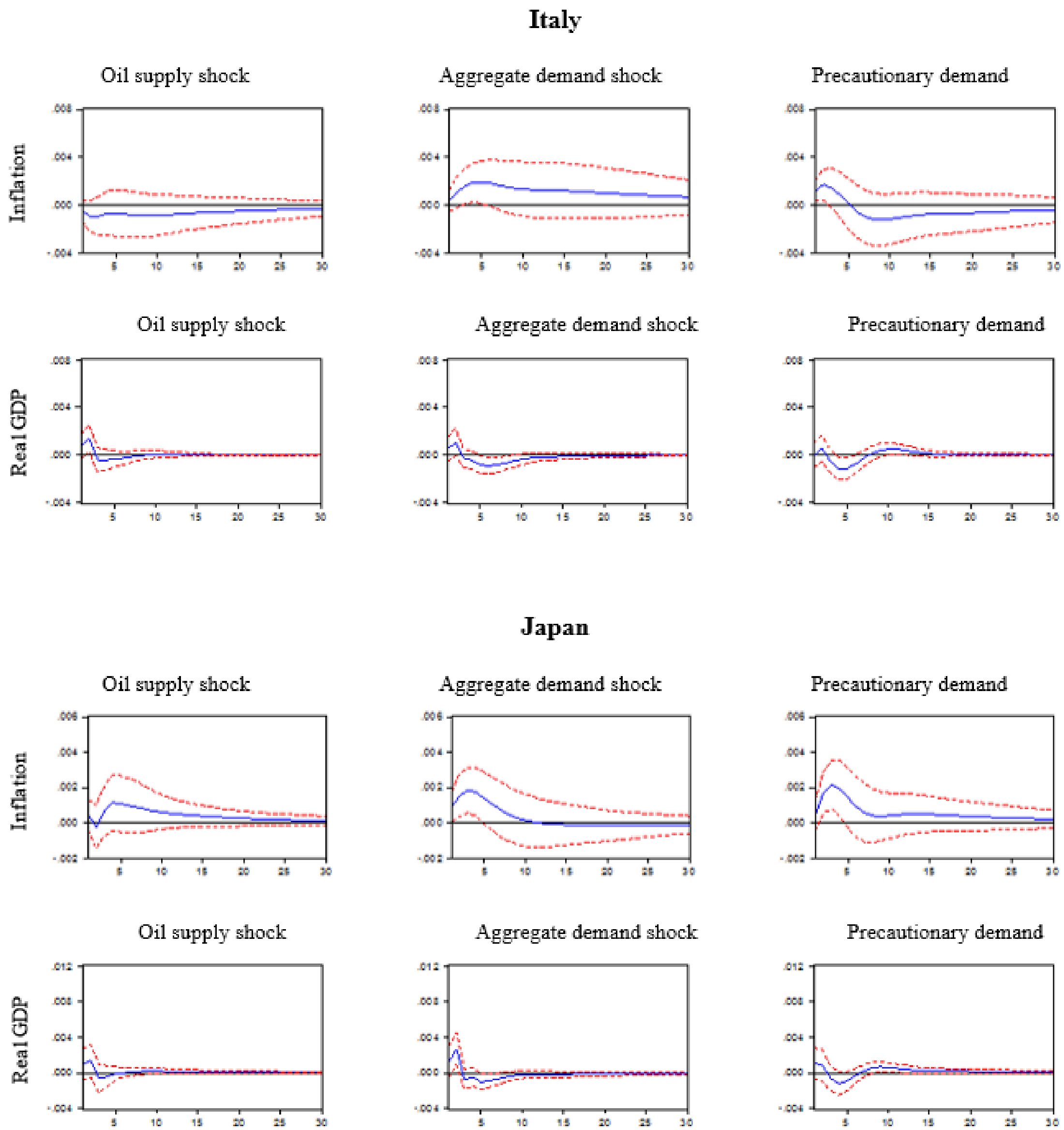
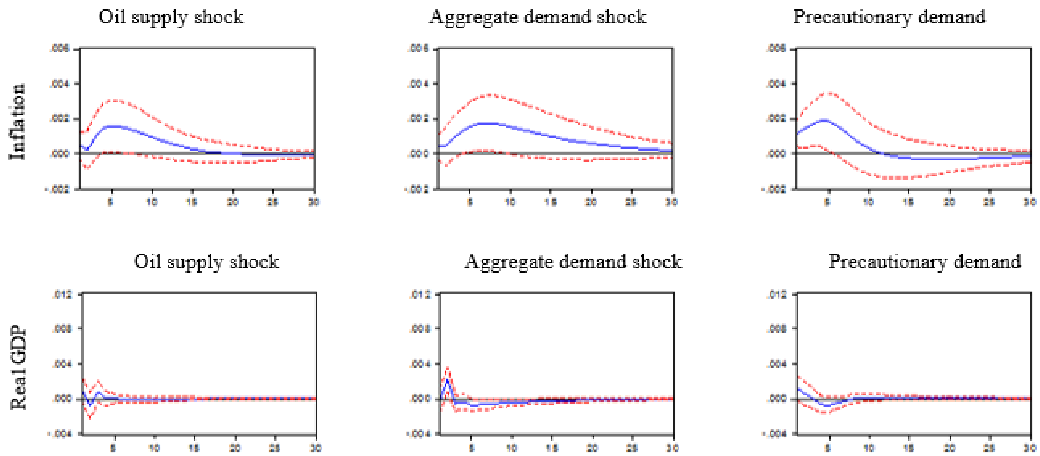
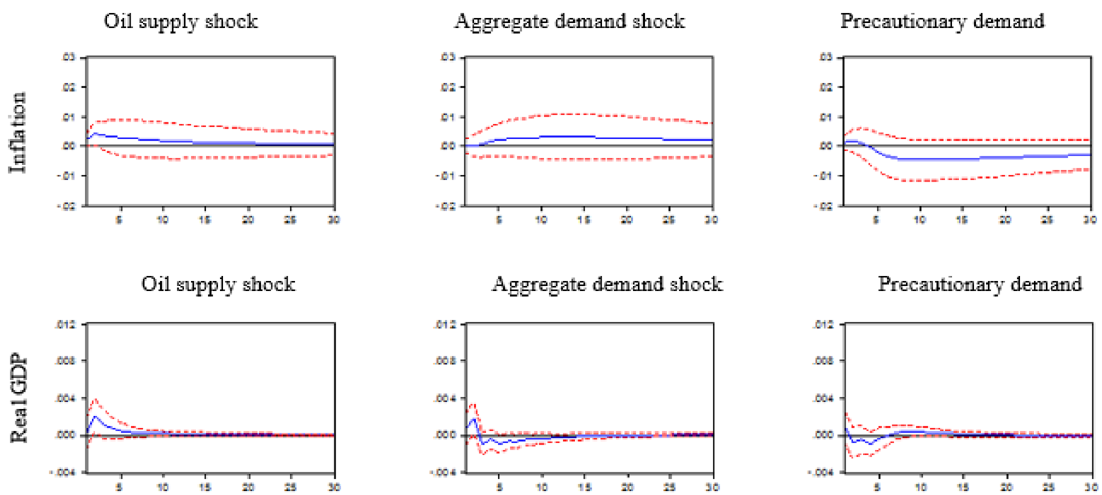


Figure 5.3 continued

Netherlands



Portugal



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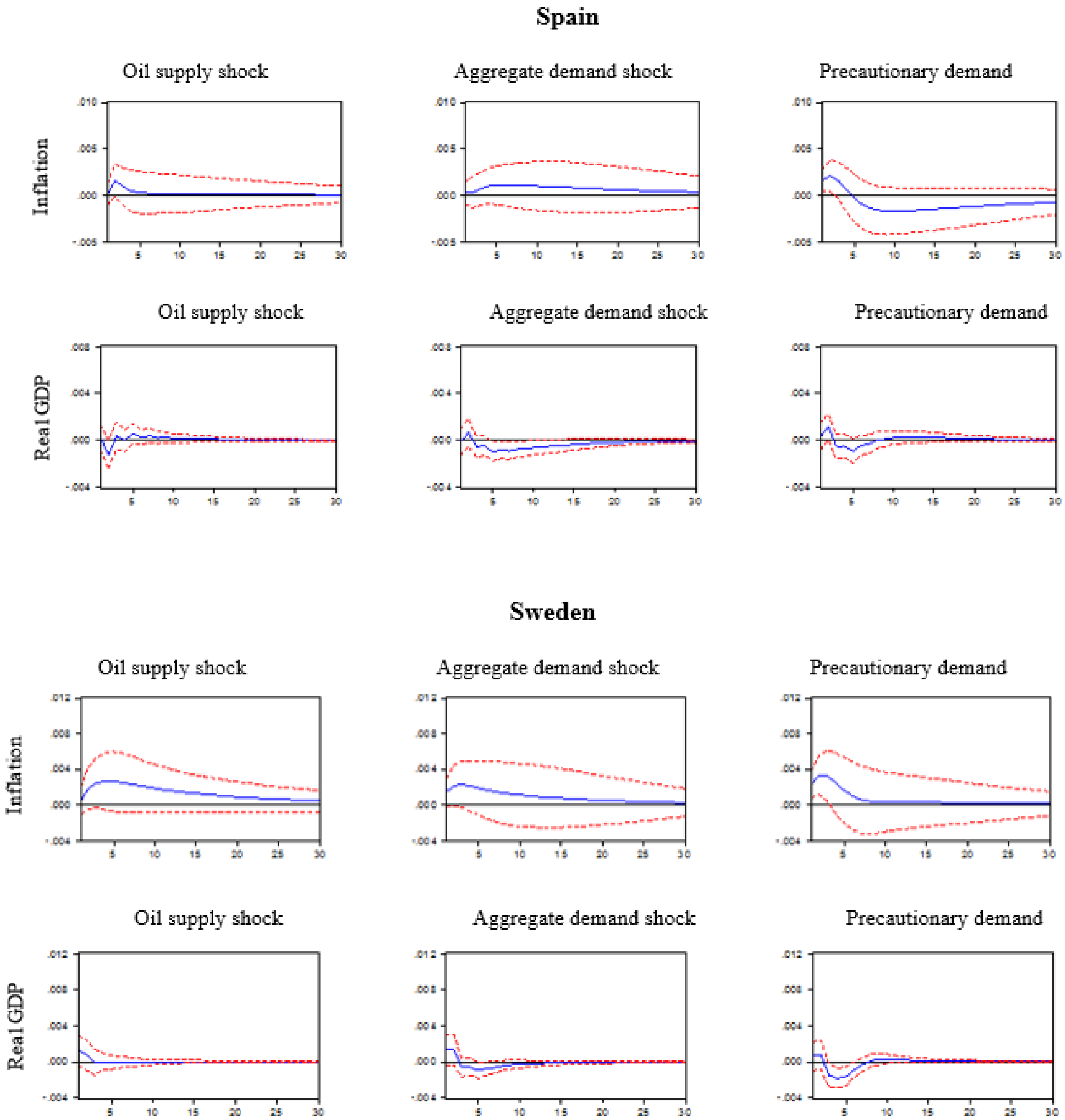
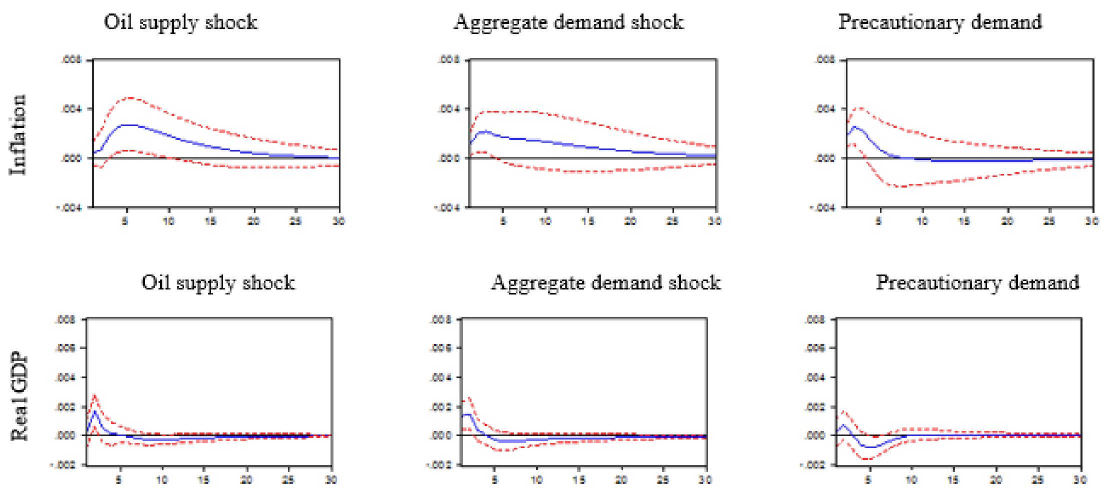


Figure 5.3 continued

Switzerland



United States

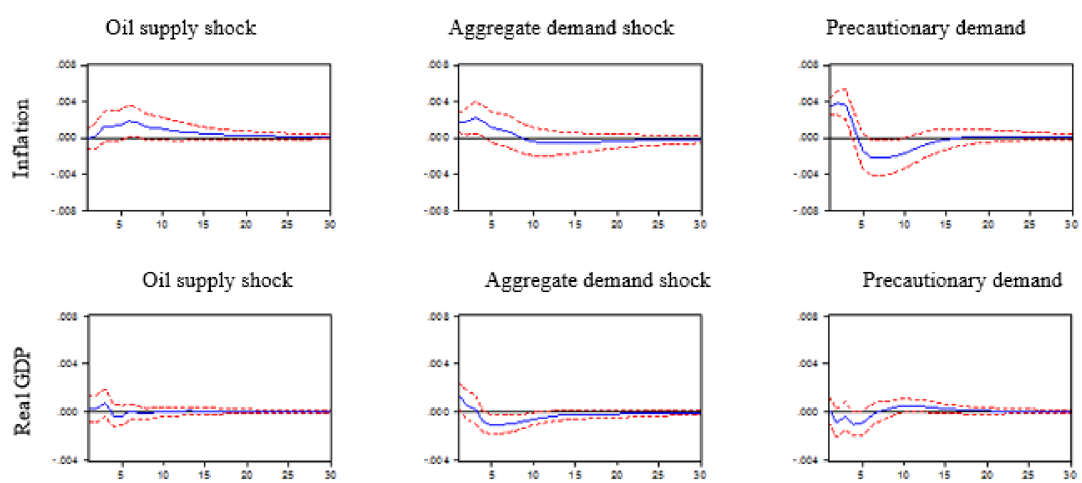


Figure 5.3 continued

Table 5.7

VAR residual serial correlation LM tests

Null: no serial correlation at lag order h

Lags	*LM-Stat*
1	32.138
	(0.154)
2	34.31
	(0.101)
3	35.584
	(0.078)
4	51.134†
	(0.001)
5	36.523
	(0.064)
6	31.075
	(0.187)

Notes: Probabilities in parenthesis. † denotes first acceptance of the null hypothesis at 5% level of significance.

Table 5.8

VAR residual normality tests

Null: residuals are multivariate normal

Jarque-Bera	428.4370
joint test statistic	(0.000)

Notes: Probabilities in parenthesis. Null rejected at 1% level of significance indicating the presence of non-normality in the residuals.

Table 5.9

VAR residual heteroskedasticity tests

Null: no heteroskedasticity

Chi-square joint test statistic	5079.841 (0.000)

Notes: Probabilities in parenthesis. Null rejected at 1% level of significance suggesting that the residuals are heteroskedastic.

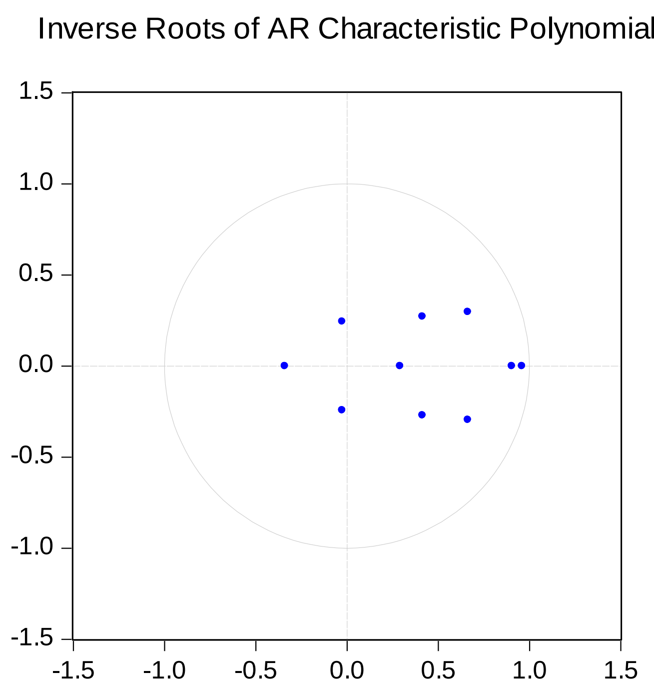


Figure 5.4 Inverse roots of AR (Unit circle)

Notes: Eigenvalues represented by blue dots. Parameters in the models are stable over time if all the eigenvalues of the companion matrix lie inside the unit circle

Table 5.10

Energy-related structural differences across countries

	Net Oil Import[a]	Oil Consumption[b]	Total Energy Consumption[c]	Oil Intensity[d]
Low oil-intensity				
Finland	70.41	58.31	150.23	38%
Sweden	60.05	51.35	119.43	42%
Austria	40.45	38.1	84.72	45%
Germany	48.4	42.72	91.33	47%
Italy	45.32	33.77	66.45	51%
France	48.38	42.61	82.73	51%
Belgium	80.57	56.44	109.61	51%
United States	39.55	69.84	133.96	52%
High oil-intensity				
Ireland	60.24	47.58	85.08	57%
Japan	68.45	48.1	99.43	58%
Netherlands	39.44	35.15	58.36	60%
Portugal	55.98	41.84	67	62%
Spain	56.85	40.75	65.09	63%
Switzerland	67.13	76.75	104.77	77%

[a,b,c]Averages for the period 1980–2013 based on International Energy Agency (IEA) data measured as (tons of oil equivalent)/GDP (million USD, PPP weighted).
[d]Averages for the period 1980–2013 calculated as oil consumption in percent of total energy consumption, all PPP GDP weighted.

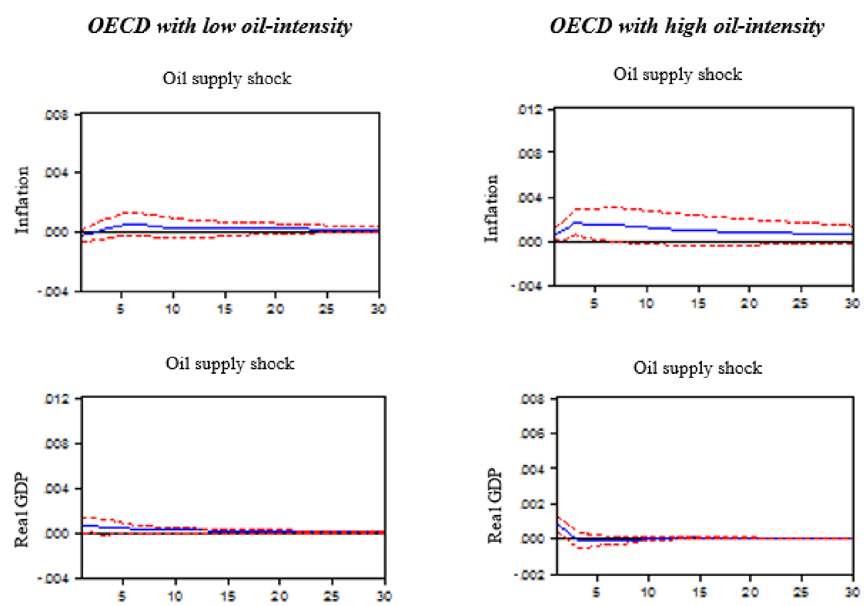


Figure 5.5 Impulse response by oil supply shock and oil-intensity

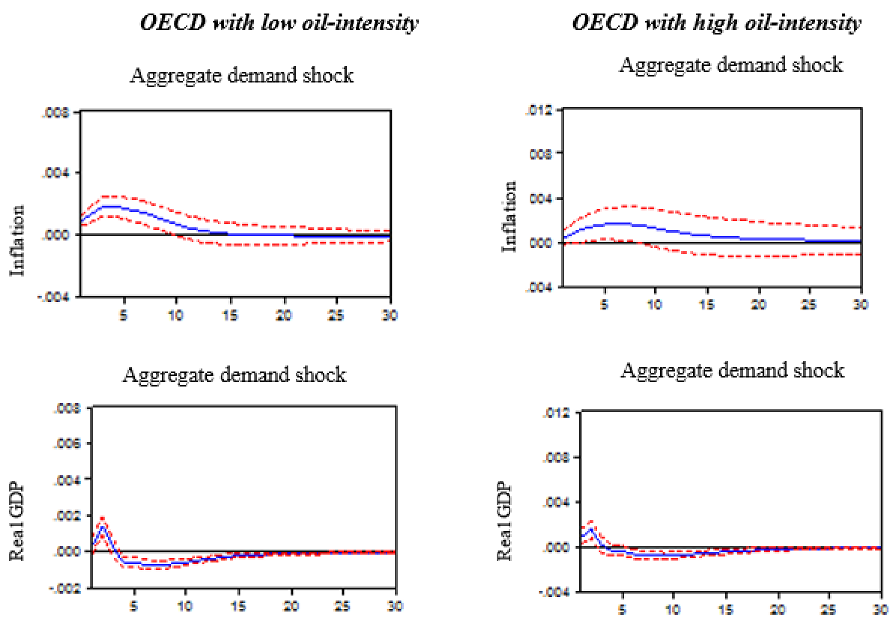


Figure 5.6 Impulse response by aggregate demand shock and oil-intensity

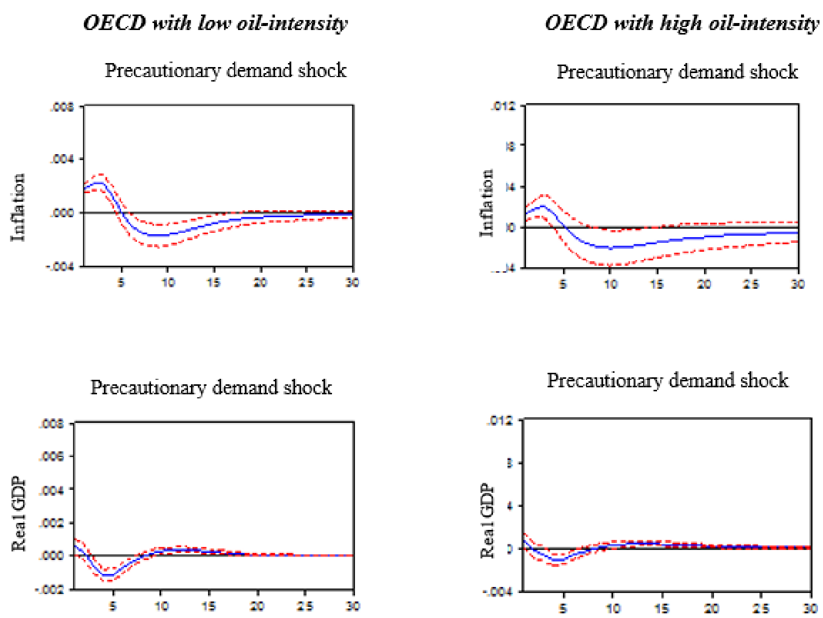


Figure 5.7 Impulse response by precautionary demand shock and oil-intensity

CHAPTER 6

CONCLUSION

This dissertation extends recent advances in the oil shocks literature to investigate the underlying causes of oil price shocks and examines the macroeconomic effects of the shocks on oil-importing countries. Several interesting results emerge from the analysis. First, oil price shocks are found to be caused by distinct supply and demand shocks: an oil supply shock caused by disruptions in global oil production, an aggregate demand shock driven by global economic activity, and an oil-specific demand shock driven by precautionary motives. An unexpected oil supply disruption causes a modest transitory increase in the real price of oil; an unanticipated increase in aggregate demand triggers a strong increase in the real price of oil; and an unanticipated increase in precautionary demand for oil triggers an immediate and large increase in the real price of oil.

Second, for a sample of 30 oil-importing countries (OECD and non-OECD), import demand for oil is found to be less sensitive to oil price shocks driven by supply disturbances but highly sensitive to oil price shocks driven by aggregate demand and precautionary demand shocks. Dividing the sample into OECD and non-OECD, the findings reveal that while OECD and non-OECD oil-importing countries are identical in their responses to oil supply shocks, they differ in their response to aggregate demand and precautionary demand shocks.

Third, for a subsample that constitute 14 oil-importing OECD countries, the dissertation finds that increases in the price of oil driven by oil supply shocks and precautionary demand shocks are inflationary and unfavorable to economic growth while increases in the price of oil driven by aggregate demand shocks are inflationary and favorable to economic growth. Examining whether structural differences matter for the impact of oil shocks across countries focusing on the role of oil intensity, the findings show that, after an unfavorable oil supply shock, low oil-intensive OECD countries typically face modest inflationary pressures, whereas the inflationary pressures are strong and persistent in high oil-intensive OECD countries. The recessionary effects are also lower in the former group. In contrast, when the oil price shock is caused by increased global economic activity or a rise in precautionary demand, both groups experience a temporary increase and transitory decline in real economic output, respectively. The inflationary effects of the demand shocks are strong and identical for both groups.

The dissertation contributes to the literature in three key respects. First, the decomposition of the structural disturbances to the real price of oil provides new evidence that the increase in the real price of oil between 2009 and 2010 is driven in most part by aggregate demand shocks despite the sluggish global economic activity post-2008 recession. However, the increase in the real price of oil from 2011 to 2013, is driven mainly by precautionary demand motives due to uncertainties about future oil supply shortfalls. Supply disturbances played a marginal role during these two periods.

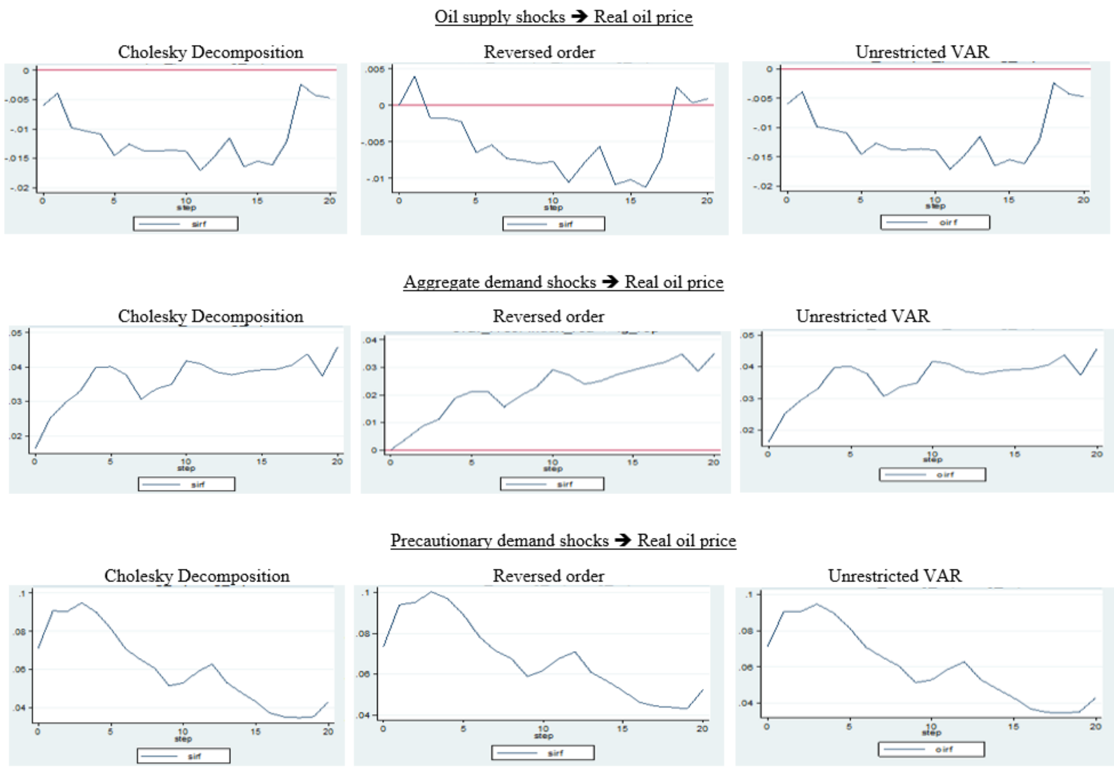
Second, the dissertation provides new evidence that changes in oil import demand across oil-importing countries (OECD and non-OECD) is not only responsive to supply-driven oil price shocks as commonly believed, but also responsive to aggregate demand-driven and precautionary demand-driven oil price shocks. In particular, supply-driven oil price shocks cause mild transitory decrease in oil import demand whereas demand-driven oil price shocks (aggregate demand and precautionary demand shocks) trigger a strong increase in oil import demand.

Finally, the dissertation adds to the literature by providing new evidence that oil intensity – defined as the percent of oil consumption in total energy consumption – can explain the differences in the effects of oil supply shocks across oil-importing OECD countries but it cannot explain the differences in the effects of aggregate demand and precautionary demand shocks.

At a more general level, the essential gist of the dissertation is that oil price shocks originate from distinct supply and demand shocks and that the macroeconomic effects of the shocks and the appropriate policy responses crucially depend on the sources of the shocks.

APPENDIX A

APPENDIX TO CHAPTER 3



Note: Estimates based on model (1) and the two alternative specification: reversed order restrictions and no restrictions basic VAR. Point estimates (with 95% confidence interval) shows the responses of real price of oil to one-standard deviation structural innovations. All shocks have been normalized such that an innovation will tend to raise the price of oil.

Figure A.1 Cross-comparisons of supply and demand shocks on real price of oil

APPENDIX B

APPENDIX TO CHAPTER 4

Table B.1

Elasticity of crude import demand to oil supply shock (by country)

Model 1

Dependent variable: Δ(CRUDE IMP DD)

Short Run Equation							
Country	COINTEQ01	Δ(OIL SS SHOCK)	Δ(OIL SS SHOCK) (-1)	Δ(OIL SS SHOCK) (-2)	Δ(OIL SS SHOCK) (-3)	Δ(OIL SS SHOCK) (-4)	@TREND
Austria	-0.3824***	-0.0039***	-0.0039***	0.0107***	0.0199***	0.0127***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Bangladesh	-0.5567***	0.0047***	0.0022***	0.0065***	0.0173***	0.0129***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Belgium	-0.432***	-0.0130***	-0.0285***	0.0124***	0.0717***	0.0401***	0.0006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Chile	-0.3372***	-0.0224***	-0.0622***	-0.0209***	0.0153***	0.0232***	0.0002***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dominican Rep.	-0.3339***	-0.0060***	0.0121***	0.0191***	0.0379***	0.0429***	-0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
El Salvador	-0.2388***	-0.0059***	0.0181***	0.0255***	0.0089***	-0.0089***	-0.0001***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Finland	-0.3566***	-0.0102***	-0.0105***	0.0238***	0.0463***	0.0339***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
France	-0.5209***	-0.0030***	-0.0112***	0.0056***	0.0243***	0.0150***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Germany	-0.3364***	-0.0013***	-0.0020***	0.0183***	0.0329***	0.0179***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
India	-0.3794***	-0.0487***	-0.0860***	-0.0085***	0.0698***	0.0427***	0.0013***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ireland	-0.4636***	0.0009***	0.0032***	0.0057***	0.0115***	0.0108***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Israel	-0.2523***	-0.0207***	-0.0089***	0.0211***	0.0460***	0.0281***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Italy	-0.4481***	-0.0058***	-0.0064***	0.0164***	0.0366***	0.0172***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Japan	-0.3191***	-0.0343***	-0.0233***	0.0206***	0.0366***	0.0288***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jordan	-0.3847***	0.0100**	-0.0259***	0.0708***	0.1494***	0.1256***	0.0003***
	(0.000)	(0.012)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)
Kenya	-0.7300***	0.0043***	-0.0476***	-0.0422***	-0.0448***	-0.0048***	0.0001***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
South Korea	-0.5151***	-0.0291***	-0.0469***	0.0065***	0.0826***	0.0650***	0.0013***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Morocco	-0.5089***	-0.0539***	-0.0167***	0.0611***	0.0787***	0.0632***	0.0006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Netherlands	-0.30471***	-0.0009***	0.0055***	0.0398***	0.0785***	0.0391***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pakistan	-0.36131***	-0.0086***	-0.0266***	-0.0035***	0.0235***	0.0182***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Philippines	-0.6961***	-0.0203***	-0.0356***	-0.0040***	0.0305***	0.0146***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Portugal	-0.3053***	-0.0284***	0.0080***	0.0306***	0.0759***	0.0581***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
South Africa	-0.6795***	-0.0390***	-0.0743***	-0.0334***	0.0068***	0.0235***	0.0009***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Spain	-0.2829***	-0.0033***	-0.0018***	0.0263***	0.0566***	0.0376***	0.0003***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sri Lanka	-0.4136***	-0.0048***	-0.0224***	0.0403***	-0.0005***	0.0292***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.075)	(0.000)	(0.000)	(0.000)
Sweden	-0.5553***	0.0077***	-0.0020***	-0.0012***	0.0264***	0.0110***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Switzerland	-0.5308***	0.0002***	0.0003***	0.0059***	0.0073***	0.0057***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Thailand	-0.4696***	-0.0139***	-0.0013	0.0630***	0.1027***	0.0572***	0.0017***
	(0.000)	(0.000)	(0.122)	(0.000)	(0.000)	(0.000)	(0.000)
Turkey	-0.4458***	-0.0194***	0.0005***	0.0158***	0.0178***	0.0118***	0.0001***
	(0.000)	(0.000)	(0.008)	(0.000)	(0.000)	(0.000)	(0.000)
United States	-0.4157***	-0.0120***	-0.0094***	0.0208***	0.0313***	0.0133***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: Elasticity estimates based on ARDL model with robust standard errors. *p*-values in parenthesis: *** denotes 1% level of significance, ** 5%, and * 10%.

Table B.2
Elasticity of crude import demand to oil supply shock (by country)
Model 2
Dependent variable: Δ(PETRO IMP DD)

Short Run Equation							
Country	COINTEQ01	Δ(OIL SS SHOCK)	Δ(OIL SS SHOCK) (-1)	Δ(OIL SS SHOCK) (-2)	Δ(OIL SS SHOCK) (-3)	Δ(OIL SS SHOCK) (-4)	@TREND
Austria	-0.4001***	0.0006***	0.0078***	0.0146***	0.0167***	0.0057***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Bangladesh	-0.5830***	-0.0100***	-0.0096***	0.0282***	0.0359***	0.0092***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Belgium	-0.2906***	-0.0223***	-0.0047***	0.0274***	0.0337***	0.0157***	0.0006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Chile	-0.3295***	-0.0241***	-0.0476***	-0.0063***	0.0211***	0.0112***	0.0004***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dominican Rep.	-0.7212***	0.0025***	-0.0491***	-0.0047***	0.0365***	0.0570***	0.0012***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
El Salvador	-0.1383**	-0.0259***	-0.0079***	0.0406***	0.0763***	0.0401***	0.0005***
	(0.007)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Finland	-0.2865***	-0.0085***	-0.0052***	0.0085***	0.0115***	0.0032***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
France	-0.1983***	-0.0012***	0.0041***	0.0142***	0.0152***	0.0037***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Germany	-0.31876***	0.001***	0.0053***	0.0054***	0.0105***	0.0075***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
India	-0.3329***	-0.0050***	0.0015***	0.0193***	0.0276***	0.0113***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ireland	-0.4504***	-0.0044***	-0.0047***	0.0040***	0.0096***	0.0082***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Israel	-0.3060***	0.0012***	0.0006***	0.0245***	0.0442***	0.0215***	0.0002***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Italy	-0.5890***	0.0079***	0.0065***	0.0087***	0.0084***	0.0081***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Japan	-0.2167***	-0.0029***	0.0026***	0.0131***	0.0138***	0.0084***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jordan	-0.1858***	0.0254***	0.0234***	0.1525***	0.1220***	0.0197***	0.0007***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Kenya	-0.3131***	-0.0426***	-0.0096***	0.0399***	0.0357***	0.0169***	0.0008***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
South Korea	-0.1585***	-0.0090***	-0.0182***	-0.0070***	-0.0002***	0.0110***	0.0002***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Morocco	-0.0582***	-0.0244***	-0.0221***	0.0184***	0.0396***	-0.0039***	0.0004***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Netherlands	-0.1358***	-0.0013***	0.0274***	0.0858***	0.1103***	0.0375***	0.0007***
	(0.001)	(0.007)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pakistan	-0.4914***	-0.0394***	-0.0405***	0.0096***	0.0148***	0.0282***	0.0007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Philippines	-0.2431***	0.0097***	0.0087***	-0.0011***	-0.0017***	0.0246***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Portugal	-0.6686***	0.0066***	-0.0084	0.0000***	0.0026***	-0.0023***	0.0001***
	(0.000)	(0.000)	(0.528)	(0.000)	(0.000)	(0.000)	(0.000)
South Africa	-0.1821***	-0.0324***	-0.0302***	0.0050***	0.0114***	0.0115***	0.0002***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Spain	-0.4198	0.0002***	-0.0029***	0.0124***	0.0127***	0.0011***	0.0002***
	*** (0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sri Lanka	-0.6849***	-0.0065***	-0.0093***	0.0388***	0.1029***	0.0490***	0.0011***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sweden	-0.3278***	0.0005***	-0.0006***	0.0046***	0.0034***	-0.0028***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Switzerland	-0.3426***	0.0052***	0.0004***	0.0025***	0.0166***	0.0116***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Thailand	-0.1895***	-0.0032***	0.0050***	0.0114***	-0.0056***	0.0038***	0.0001***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Turkey	-0.1281***	0.0056***	-0.0069***	0.0093***	0.0168***	0.0130***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
United States	-0.2548***	0.0020***	0.0034***	0.0091***	0.0081***	0.0028***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: Elasticity estimates based on ARDL model with robust standard errors. *p*-values in parenthesis: *** denotes 1% level of significance, ** 5%, and * 10%.

Table B.3

Elasticity of crude import demand to oil supply shock (by country)

Model 3

Dependent variable: Δ(OIL IMP DD)

Short Run Equation							
Country	COINTEQ01	Δ(OIL SS SHOCK)	Δ(OIL SS SHOCK) (-1)	Δ(OIL SS SHOCK) (-2)	Δ(OIL SS SHOCK) (-3)	Δ(OIL SS SHOCK) (-4)	@TREND
Austria	-0.3846***	-0.0097***	-0.0011***	0.0210***	0.0332***	0.0165***	0.0003***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Bangladesh	-0.5347***	-0.0150***	-0.0143***	0.0293***	0.0480***	0.0183***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Belgium	-0.3674***	-0.0397***	-0.0355***	0.0397***	0.1066***	0.0559***	0.0010***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Chile	-0.3717***	-0.0504***	-0.1140***	-0.0341***	0.0302***	0.0315***	0.0006***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dominican Rep.	-0.5230***	-0.0087***	-0.0410***	0.0218***	0.0792***	0.1019***	0.0008***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
El Salvador	-0.2761***	-0.0363***	0.0065***	0.0639***	0.0866***	0.0383***	0.0006***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Finland	-0.3173***	-0.0229***	-0.0188***	0.0299***	0.0558***	0.0356***	0.0006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
France	-0.3979***	-0.0099***	-0.0109***	0.0186***	0.0401***	0.0195***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Germany	-0.335***	-0.0056***	-0.0010***	0.0204***	0.0408***	0.0240***	0.0004***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
India	-0.4315***	-0.0580***	-0.0897***	0.0028**	0.0917***	0.0544***	0.0015***
	(0.000)	(0.000)	(0.000)	(0.011)	(0.000)	(0.000)	(0.000)
Ireland	-0.4515***	-0.0110***	-0.0073***	0.0049***	0.0174***	0.0169***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Israel	0.2319***	-0.0233***	-0.0106***	0.0441***	0.0881***	0.0464***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Italy	-0.4553***	-0.0078***	-0.0076***	0.0190***	0.0400***	0.0226***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Japan	-0.2960***	-0.0413***	-0.0237***	0.0316***	0.0489***	0.0365***	0.0025***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jordan	-0.5269**	-0.0114***	-0.0603***	0.1642***	0.2695***	0.1756***	0.0017***
	(0.035)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Kenya	-0.7771***	-0.0491***	-0.0750***	-0.0151***	-0.0063***	0.0230***	0.0016***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
South Korea	-0.4398***	-0.0369***	-0.0610***	0.0014	0.0830***	0.0739***	0.0016***
	(0.000)	(0.000)	(0.000)	(0.129)	(0.000)	(0.000)	(0.000)
Morocco	-0.2455***	-0.0643***	-0.0045**	0.1071***	0.1298***	0.0667***	0.0012***
	(0.000)	(0.000)	(0.011)	(0.000)	(0.000)	(0.000)	(0.000)
Netherlands	-0.1905***	-0.0052***	0.0318***	0.1259***	0.1899***	0.0766***	0.0011***
	(0.000)	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pakistan	-0.5906***	-0.0563***	-0.0810***	-0.0128***	0.0231***	0.0396***	0.0014***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Philippines	-0.5203***	-0.0126***	-0.0137***	0.0118***	0.0359***	0.0372***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Portugal	-0.3531***	-0.0323***	-0.0088***	0.0275***	0.0764***	0.0555***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
South Africa	-0.4945***	-0.0746***	-0.1090***	-0.0284***	0.0226***	0.0365***	0.0011***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Spain	-0.3664***	-0.0116***	-0.0106***	0.0345***	0.0660***	0.0390***	0.0005***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sri Lanka	-0.4623***	-0.0156***	-0.0297***	0.0804***	0.1002***	0.0655***	0.0007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sweden	-0.4586***	0.0026***	-0.0064***	0.0008**	0.0291***	0.0070***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.011)	(0.000)	(0.000)	(0.000)
Switzerland	-0.3880***	-0.0033***	-0.0056***	0.0034***	0.0197***	0.0150***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Thailand	-0.4699***	-0.0195***	-0.0003	0.0704***	0.0971***	0.0603***	0.0016***
	(0.000)	(0.000)	(0.737)	(0.000)	(0.000)	(0.000)	(0.000)
Turkey	-0.3664***	-0.0195***	-0.0071***	0.0232***	0.0328***	0.0252***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
United States	-0.3877***	-0.0149***	-0.0099***	0.0270***	0.0373***	0.0149***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: Elasticity estimates based on ARDL model with robust standard errors. *p*-values in parenthesis: *** denotes 1% level of significance, ** 5%, and * 10%.

Table B.4
Elasticity of crude import demand to aggregate demand shock (by country)
Model 4
Dependent variable: Δ(CRUDE IMP DD)

Short Run Equation							
Country	COINTEQ01	Δ(AGG DD SHOCK)	Δ(AGG DD SHOCK) (-1)	Δ(AGG DD SHOCK) (-2)	Δ(AGG DD SHOCK) (-3)	Δ(AGG DD SHOCK) (-4)	@TREND
Austria	-0.2632***	-0.0121***	0.0115***	0.0354***	0.0153***	-0.0048***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Bangladesh	-0.4378***	0.0068***	0.0321***	0.0299***	0.0220***	0.0122***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Belgium	-0.2940***	-0.0426***	0.0901***	0.0776***	0.0390***	-0.0467***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Chile	-0.4728***	0.0292***	0.1604***	0.2795***	0.2007***	0.0893***	0.0004***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dominican Rep.	-0.3795***	0.0226***	0.1434***	0.1933***	0.1518***	0.0830***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
El Salvador	-0.2129***	0.0415***	0.1570***	0.1497***	0.0623***	-0.0707***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Finland	-0.2871***	-0.0254***	0.0049***	0.0164***	0.0077***	-0.0191***	0.0004***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
France	-0.4207***	-0.0104***	0.0389***	0.0692***	0.0381***	0.0121***	0.0007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Germany	-0.2010***	-0.0141***	0.0420***	0.0519***	0.0227***	-0.0159***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
India	-0.2673***	-0.1624***	-0.0613***	0.0766***	0.0033	-0.0012	0.0010***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.138)	(0.381)	(0.000)
Ireland	-0.3685***	-0.0103***	0.0059***	0.0100***	0.0034***	-0.0065***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Israel	-0.1671***	-0.0539***	0.0540***	0.1304***	0.0989***	0.0496***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Italy	-0.2862***	-0.0203***	0.0541***	0.0503***	0.0177***	-0.0260***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Japan	-0.2339***	-0.0456***	0.0310***	0.0970***	0.0682***	0.0745***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jordan	-0.5246***	0.0247***	0.7333***	1.2283***	1.0397***	0.3885***	0.0013***
	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Kenya	-0.6484***	0.0155***	0.1415***	0.2162***	0.0548***	-0.0341***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
South Korea	-0.3707***	-0.2222***	-0.1263	0.0012***	-0.0625***	-0.0382***	0.0009***
	(0.000)	(0.000)	(0.567)	(0.000)	(0.000)	(0.000)	(0.000)
Morocco	-0.3230***	-0.0502***	0.0677***	0.0661***	-0.0402***	-0.1107***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Netherlands	-0.1499***	-0.0290***	0.0974***	0.0688***	-0.0065***	-0.0853***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)
Pakistan	-0.3583***	-0.0029***	0.1274***	0.1572***	0.1287***	0.0494***	0.0004***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Philippines	-0.8116***	-0.0054***	0.1910***	0.3381***	0.2998***	0.1570***	0.0002***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Portugal	-0.1649***	-0.0499***	0.0263***	0.0457***	0.0198***	-0.0058***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)
South Africa	-0.5851***	-0.0842***	-0.0502***	0.0416***	0.0287***	0.0334***	0.0008***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Spain	-0.1156***	-0.0352***	0.0127**	-0.0020***	-0.0321***	-0.0702***	0.0003***
	(0.001)	(0.000)	(0.018)	(0.000)	(0.000)	(0.000)	(0.000)
Sri Lanka	-0.6119***	0.0425***	0.1725***	0.2994***	0.2633***	0.1317***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sweden	-0.3401***	-0.0509***	0.0172***	0.0402***	0.0213***	-0.0400***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Switzerland	-0.4245***	0.0002***	0.0093***	0.0272***	0.0229***	0.0261***	0.0001***
	(0.000)	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Thailand	-0.3847***	-0.0652***	0.2035***	0.3807***	0.2337***	0.0538***	0.0017***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Turkey	-0.4445***	0.0238***	0.0818***	0.0758***	0.0267***	-0.0272***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
United States	-0.2562***	-0.0362***	0.0526***	0.0945***	0.0328***	0.0148***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: Elasticity estimates based on ARDL model with robust standard errors. *p*-values in parenthesis: *** denotes 1% level of significance, ** 5%, and * 10%.

Table B.5
Elasticity of crude import demand to aggregate demand shock (by country)
Model 5
Dependent variable: Δ(PETRO IMP DD)

Short Run Equation							
Country	COINTEQ01	Δ(AGG DD SHOCK)	Δ(AGG DD SHOCK) (-1)	Δ(AGG DD SHOCK) (-2)	Δ(AGG DD SHOCK) (-3)	Δ(AGG DD SHOCK) (-4)	@TREND
Austria	-0.2479***	-0.0106***	0.0280***	0.0298***	0.0236***	0.0107***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Bangladesh	-0.3470***	-0.0310***	0.0188***	0.0756***	0.0095***	-0.0096***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Belgium	-0.1422***	-0.0606***	0.0065***	0.0543***	-0.0013***	0.0182***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.037)	(0.000)	(0.000)
Chile	-0.2285***	-0.0563***	0.0312***	0.0578***	0.0003***	0.0051***	0.0004***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.441)	(0.000)	(0.000)
Dominican Rep.	-0.7306***	-0.0128***	0.0973***	0.1756***	0.1246***	0.0395***	0.0013***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
El Salvador	0.02478	-0.0588***	0.0266***	0.0227***	-0.0232***	0.0025***	0.0002***
	(0.457)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Finland	-0.2303***	-0.0220***	-0.0153***	0.0079***	-0.0193***	-0.0015***	0.0001***
	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
France	-0.0796***	-0.0120***	0.0077***	0.0118***	0.0048***	-0.0151***	0.0007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Germany	-0.2782***	-0.0096***	0.0008***	0.0108***	0.0097***	0.0073***	0.0001***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
India	-0.2949***	-0.0345***	-0.0018***	0.0365***	0.0431***	0.0503***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ireland	-0.3519***	-0.0210***	0.0054***	0.0211***	0.0079***	-0.0134***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Israel	-0.0875***	0.0182***	0.0506***	-0.0115***	-0.0423***	-0.0701***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Italy	-0.6984***	0.0143***	0.0097***	0.0089***	0.0036***	0.0003***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Japan	-0.1128***	-0.0024***	0.0138***	0.0206***	0.0062***	0.0002***	0.0003***
	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Jordan	0.0229***	0.0457***	0.1524***	0.0803***	-0.1651***	-0.3619***	0.0004***
	(0.333)	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Kenya	-0.2385***	-0.0818***	-0.0877***	-0.0275***	-0.0843***	-0.0193***	0.0006***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
South Korea	-0.1246***	-0.0539***	-0.0452***	-0.0119***	-0.0110***	-0.0096***	0.0001***
	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Morocco	0.00511***	-0.0320***	0.0571***	0.0735***	-0.0020***	0.0174***	0.0003***
	(0.447)	(0.000)	(0.000)	(0.000)	(0.012)	(0.000)	(0.000)
Netherlands	-0.0148***	-0.0512***	0.1073***	0.0950***	0.0184***	-0.1027***	0.0005***
	(0.139)	(0.000)	(0.000)	(0.004)	(0.001)	(0.000)	(0.000)
Pakistan	-0.5995***	-0.0927***	-0.1035***	-0.1022***	-0.1093***	-0.0367***	0.0007***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Philippines	-0.2379***	0.0008***	0.0653***	0.0832***	0.0557***	0.0211***	0.0002***
	(0.001)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Portugal	-0.4923***	0.0133***	0.0384***	0.0558***	0.0036***	-0.0312***	0.0001***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
South Africa	-0.1393***	-0.0368***	-0.0146***	0.0071***	-0.0365***	0.0049***	0.0001***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Spain	-0.3527***	0.0117***	0.0419***	0.0441***	0.0146***	-0.0012***	0.0002***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sri Lanka	-0.4377***	-0.0059***	0.1338***	0.1288***	0.0304***	-0.1127***	0.0008***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sweden	-0.2323***	-0.0060***	0.0143***	0.0295***	0.0092***	0.0031***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Switzerland	-0.2280***	-0.0062***	0.0235***	0.0378***	0.0305***	-0.0028***	0.0001***
	(0.000)	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Thailand	-0.1964***	0.0004***	0.0148***	0.0425***	0.0398***	0.0112***	0.0000***
	(0.000)	(0.007)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Turkey	-0.1098***	0.0052***	0.0048***	0.0027***	-0.0131***	-0.0286***	0.0001***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
United States	-0.1589***	0.0023***	0.0197***	0.0244***	0.0123***	0.0054***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: Elasticity estimates based on ARDL model with robust standard errors. *p*-values in parenthesis: *** denotes 1% level of significance, ** 5%, and * 10%.

Table B.6
Elasticity of crude import demand to aggregate demand shock (by country)
Model 6
Dependent variable: Δ(OIL IMP DD)

Short Run Equation							
Country	COINTEQ01	Δ(AGG DD SHOCK)	Δ(AGG DD SHOCK) (-1)	Δ(AGG DD SHOCK) (-2)	Δ(AGG DD SHOCK) (-3)	Δ(AGG DD SHOCK) (-4)	@TREND
Austria	-0.2516***	-0.0017***	0.0592***	0.0823***	0.0504***	0.0115***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Bangladesh	-0.3414***	0.0036***	0.0783***	0.1270***	0.0447***	0.0081***	0.0004***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Belgium	-0.2325***	-0.0837***	0.1115***	0.1412***	0.0452***	-0.0260***	0.0009***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Chile	-0.3062***	-0.0103***	0.1838***	0.3040***	0.1551***	0.0640***	0.0007***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dominican Rep.	-0.5391***	0.0537***	0.2892***	0.4086***	0.2968***	0.1314***	0.0010***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
El Salvador	-0.1738***	-0.0174***	0.1479***	0.1484***	0.0346***	-0.0508***	0.0006***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Finland	- -0.2542***	-0.0259***	0.0108***	0.0425***	0.0003	-0.0157***	0.0004***
	(0.001)	(0.000)	(0.001)	(0.000)	(0.741)	(0.000)	(0.000)
France	-0.2741***	0.0003	0.0649***	0.0926***	0.0470***	0.0010***	0.0003***
	(0.001)	(0.155)	(0.000)	(0.000)	(0.000)	(0.020)	(0.000)
Germany	-0.2205 ***	-0.0063***	0.0595***	0.0778***	0.0430***	-0.0030***	0.0002***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
India	-0.3274***	-0.1700***	-0.0534***	0.1217***	0.0608***	0.0619***	0.0003***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ireland	-0.3474***	-0.0022***	0.0393***	0.0552***	0.0273***	-0.0124***	0.0001***
	(0.001)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Israel	-0.1226***	-0.0229***	0.1221***	0.1351***	0.0656***	-0.0181***	0.0003***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Italy	-0.3018***	0.0117***	0.0815***	0.0815***	0.0280***	-0.0250***	0.0004***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Japan	-0.2064***	-0.0290***	0.0630***	0.1336***	0.0855***	0.0807***	0.0004***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jordan	-0.4687***	0.0009	0.6616***	1.1269***	0.8274***	0.1229***	0.0003***
	(0.001)	(0.917)	(0.000)	(0.000)	(0.000)	(0.006)	(0.000)
Kenya	-0.6569***	-0.0175***	0.0328***	0.1475***	-0.0379***	-0.0475***	0.0001***
	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
South Korea	-0.3177***	-0.2502***	-0.1498***	0.0064	-0.0637***	-0.0376***	0.0011***
	(0.001)	(0.000)	(0.000)	(0.101)	(0.000)	(0.000)	(0.000)
Morocco	-0.1001***	-0.0703***	0.1464***	0.1237***	-0.0867***	-0.1399***	0.0006***
	(0.008)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Netherlands	-0.0531**	-0.0727***	0.2172***	0.1683***	0.0092*	-0.1941***	0.0009***
	(0.014)	(0.000)	(0.000)	(0.000)	(0.086)	(0.000)	(0.000)
Pakistan	-0.4736***	-0.0446***	0.0936***	0.1352***	0.0850***	0.0508***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Philippines	-0.56389***	0.0397***	0.2833***	0.4176***	0.3382***	0.1679***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Portugal	-0.2031***	-0.0223***	0.0786***	0.1067***	0.0136***	-0.0447***	0.0005***
	(0.003)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
South Africa	-0.4129***	-0.1054***	-0.0633***	0.0375***	-0.0267***	0.0241***	0.0009***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Spain	-0.2467***	-0.0060***	0.0567***	0.0462***	-0.0083***	-0.0553***	0.0004***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Sri Lanka	-0.4036***	0.0684***	0.3249***	0.4108***	0.2488***	-0.0212***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)
Sweden	-0.2789***	-0.0338***	0.0569***	0.0904***	0.0423***	-0.0336***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Switzerland	-0.5308***	0.0002***	0.0003***	0.0059***	0.0073***	0.0057***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Thailand	-0.3687***	-0.0447***	0.2281***	0.4352***	0.2861***	0.0829***	0.0017***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Turkey	-0.2999***	-0.0194***	0.0005***	0.0158***	0.0178***	0.0118***	0.0015***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
United States	-0.4157***	0.0417***	0.0829***	0.0601***	-0.0060***	-0.0632***	0.0004***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: Elasticity estimates based on ARDL model with robust standard errors. *p*-values in parenthesis: *** denotes 1% level of significance, ** 5%, and * 10%.

Table B.7
Elasticity of crude import demand to precautionary demand shock (by country)
Model 7
Dependent variable: Δ(CRUDE IMP DD)

Short Run Equation							
Country	COINTEQ01	Δ(PREC DD SHOCK)	Δ(PREC DD SHOCK) (-1)	Δ(PREC DD SHOCK) (-2)	Δ(PREC DD SHOCK) (-3)	Δ(PREC DD SHOCK) (-4)	@TREND
Austria	-0.2681***	-0.0082***	0.0212***	0.0129***	0.0008***	-0.0101***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Bangladesh	-0.4235***	-0.0293***	-0.0104***	-0.0087***	-0.0154***	-0.0129***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Belgium	-0.3227***	0.0007*	0.1140***	0.0277***	0.0041***	-0.0437***	0.0005***
	(0.000)	(0.056)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Chile	-0.2940***	0.0005	0.0593***	0.0338***	0.0158***	0.0031***	0.0001***
	(0.001)	(0.100)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dominican Rep.	-0.2907***	-0.0088***	-0.0070***	-0.0175***	-0.0098***	-0.0001***	-0.0001***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
El Salvador	-0.2829***	-0.0246***	-0.0417***	-0.0816***	-0.1002***	-0.0911***	-0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Finland	-0.2690***	0.0118***	0.0683***	0.0335***	0.0060***	-0.0035***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
France	-0.3850***	-0.0314***	0.0168***	-0.0056***	-0.0153***	-0.0210***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Germany	-0.2518***	-0.0135***	0.0240***	-0.0035***	-0.0108***	-0.0279***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
India	-0.3345***	-0.0571***	0.0749***	0.0252***	0.0035***	-0.0347***	0.0012***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.007)	(0.000)	(0.000)
Ireland	-0.3086***	-0.0136***	0.0099***	0.0027***	-0.0020***	-0.0117***	0.0001***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Israel	-0.2032***	-0.0139***	0.0468***	0.0051***	0.0070***	-0.0261***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Italy	-0.3182***	-0.0169***	0.0382***	-0.0102***	-0.0178***	-0.0447***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Japan	-0.2330***	-0.0107***	0.0476***	0.0329***	0.0225***	-0.0025***	0.0003***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jordan	-0.2651***	0.2077***	0.3770***	0.1579***	0.0583***	-0.1507***	0.0002***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Kenya	-0.7084***	-0.1083***	-0.0514***	-0.1167***	-0.1382***	-0.1105***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
South Korea	-0.4309***	-0.0819***	0.0414**	0.0039***	-0.0424***	-0.0821***	0.0012***
	(0.000)	(0.000)	(0.014)	(0.000)	(0.000)	(0.000)	(0.000)
Morocco	-0.3534***	0.0523***	0.1421***	0.0636***	-0.0076***	-0.1081***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Netherlands	-0.2087***	0.0252***	0.1137***	0.0177***	-0.0259***	-0.0638***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pakistan	-0.2796***	-0.0313***	0.0454***	-0.0061***	0.0020***	-0.0312***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Philippines	-0.5537***	-0.0042***	0.1013***	0.0362***	0.0028***	-0.0341***	0.0000***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Portugal	-0.2142***	0.0216***	0.0967***	0.0508***	0.0231***	-0.0100***	0.0004***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
South Africa	-0.5988***	-0.0659***	0.0372***	0.0271***	0.0565***	-0.0009**	0.0008***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.013)	(0.000)
Spain	0.0186***	0.0818***	0.0294***	0.0122***	-0.0259***	0.0003***	0.0003***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sri Lanka	-0.3952***	0.0048***	0.0604***	-0.0224***	-0.0137***	-0.0361***	0.0000***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sweden	-0.4544***	-0.0523***	0.0022***	-0.0339***	-0.0277***	-0.0545***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Switzerland	-0.3867***	-0.0351***	-0.0172***	-0.0163***	-0.0115***	-0.0030***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Thailand	-0.4097***	-0.0708***	0.0439***	-0.0274***	-0.0653***	-0.1141***	0.0015***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Turkey	-0.4099***	-0.0140***	0.0119***	0.0066***	-0.0234***	-0.0320***	0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
United States	-0.3397***	-0.0401***	0.0044***	-0.0242***	-0.0367***	-0.0413***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: Elasticity estimates based on ARDL model with robust standard errors. *p*-values in parenthesis: *** denotes 1% level of significance, ** 5%, and * 10%.

Table B.8
Elasticity of crude import demand to precautionary demand shock (by country)
Model 8
Dependent variable: Δ(PETRO IMP DD)

Short Run Equation							
Country	COINTEQ01	Δ(PREC DD SHOCK)	Δ(PREC DD SHOCK) (-1)	Δ(PREC DD SHOCK) (-2)	Δ(PREC DD SHOCK) (-3)	Δ(PREC DD SHOCK) (-4)	@TREND
Austria	-0.3157***	0.0035***	0.0206***	-0.0006***	-0.0014***	-0.0112***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Bangladesh	-0.5394***	0.0150***	0.0411***	0.0374***	0.0079***	-0.0183***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Belgium	-0.2238***	0.0051***	0.0608***	0.0199***	0.0003*	-0.0157***	0.0004***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.061)	(0.000)	(0.000)
Chile	-0.3402***	-0.0330***	0.0075***	-0.0081***	-0.0050***	-0.0351***	0.0004***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dominican Rep.	-0.7012***	0.0577***	0.1347***	0.0803***	0.0362***	-0.0165***	0.0012***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
El Salvador	-0.0147	0.0042***	0.1006***	0.0361***	0.0183***	-0.0181***	0.0003***
	(0.485)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Finland	-0.2622***	0.0120***	0.0224***	0.0074***	0.0015***	-0.0113***	0.0001***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
France	-0.1660***	0.0120***	0.0224***	0.0074***	0.0015***	-0.0113***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Germany	-0.2898***	0.0101***	0.0249***	0.0183***	0.0050***	-0.0007***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
India	-0.2795***	0.0023***	0.0276***	0.0123***	0.0124***	-0.0059***	0.0000***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ireland	-0.4042***	0.0294***	0.0558***	0.0227***	0.0095***	-0.0097***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Israel	-0.2271***	0.0143***	0.0458***	0.0161***	0.0085***	-0.0176***	0.0003***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Italy	-0.7204***	0.0193***	0.0230***	0.0144***	0.0092***	0.0037***	0.0000***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Japan	-0.1649***	0.0102***	0.0178***	0.0116***	0.0038***	-0.0024***	0.0001***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jordan	-0.1676***	0.2180***	0.2815***	0.2156***	0.0733***	-0.0514***	0.0006***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Kenya	-0.2740***	0.0274***	0.0701***	0.0269***	-0.0104***	-0.0196***	0.0007***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
South Korea	-0.1818***	0.0093***	0.0275***	0.0191***	0.0165***	-0.0035***	0.0002***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Morocco	-0.0395***	-0.0066***	0.0568***	0.0108***	-0.0169***	-0.0037***	0.0006***
	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pakistan	-0.4781***	0.0372***	0.0837***	0.0167***	0.0008***	-0.0327***	0.0006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.021)	(0.000)	(0.000)
Philippines	-0.2900***	-0.0369***	-0.0252***	-0.0338***	-0.0277***	-0.0282***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Portugal	-0.6729***	0.0222***	0.0375***	0.0256***	0.0094***	-0.0113***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
South Africa	-0.1846***	-0.0117***	0.0096***	0.0188***	0.0023***	-0.0107***	0.0009***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Spain	-0.3328***	0.0062***	0.0208***	-0.0023***	-0.0138***	-0.0157***	0.0003***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sri Lanka	-0.5456***	0.0200***	0.0760***	0.0499***	-0.0043***	-0.0861***	0.0009***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sweden	-0.3212***	0.0058***	0.0147***	0.0028***	-0.0066***	-0.0058***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Switzerland	-0.3098***	0.0118***	0.0275***	0.0167***	0.0092***	-0.0089***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Thailand	-0.1619***	0.0340***	0.0236***	0.0092***	0.0120***	-0.0049***	0.0000***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Turkey	-0.1296***	0.0168***	0.0279***	0.0098***	-0.0034***	-0.0038***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
United States	-0.2164***	0.0034***	0.0081***	0.0001***	-0.0039***	-0.0054***	0.0000***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: Elasticity estimates based on ARDL model with robust standard errors. *p*-values in parenthesis: *** denotes 1% level of significance, ** 5%, and * 10%.

Table B.9
Elasticity of crude import demand to precautionary demand shock (by country)
Model 9
Dependent variable: Δ(OIL IMP DD)

Short Run Equation							
Country	COINTEQ01	Δ(PREC DD SHOCK)	Δ(PREC DD SHOCK) (-1)	Δ(PREC DD SHOCK) (-2)	Δ(PREC DD SHOCK) (-3)	Δ(PREC DD SHOCK) (-4)	@TREND
Austria	-0.2899	-0.0002***	0.0456***	0.0152***	0.0015***	-0.0203***	0.0003***
	(0.153)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Bangladesh	-0.4406***	-0.0069***	0.0370***	0.0309***	-0.0084***	-0.0323***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Belgium	-0.2757***	0.0196***	0.1865***	0.0545***	0.0086***	-0.0576***	0.0009***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Chile	-0.3486***	-0.0327***	0.0647***	0.0253***	0.0110***	-0.0324***	0.0006***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dominican Rep.	-0.4558***	0.0441***	0.1603***	0.0488***	-0.0025*	-0.0394***	0.0007***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.052)	(0.000)	(0.000)
El Salvador	-0.2319***	-0.0038***	0.0718***	-0.0185***	-0.0577***	-0.0912***	0.0006***
	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Finland	-0.2491***	0.0319***	0.1026***	0.0578***	0.0114***	0.0060***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
France	-0.3018***	-0.0007***	0.0562***	0.0140***	-0.0059***	-0.0276***	0.0003***
	(0.000)	(0.012)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Germany	-0.2576***	0.0015***	0.0528***	0.0103***	-0.0042***	-0.0279***	0.0003***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
India	-0.3760***	-0.0501***	0.1029***	0.0418***	0.0200***	-0.0377***	0.0013***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ireland	-0.3739***	0.0185***	0.0681***	0.0275***	0.0094***	-0.0203***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Israel	-0.1644***	0.0081***	0.0993***	0.0230***	0.0158***	-0.0446***	0.0003***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Italy	-0.3365***	0.0022***	0.0590***	0.0004***	-0.0110***	-0.0421***	0.0003***
	(0.000)	(0.001)	(0.000)	(0.054)	(0.000)	(0.000)	(0.000)
Japan	-0.2188***	0.0073***	0.0721***	0.0496***	0.0296***	-0.0033***	0.0003***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jordan	-0.4149***	0.3929***	0.6808***	0.4752***	0.2482***	-0.1209***	0.0013***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Kenya	-0.7367***	-0.0437***	0.0620***	-0.0259***	-0.0963***	-0.1040***	0.0015***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
South Korea	-0.3823***	-0.0547***	0.0868***	0.0364***	-0.0173***	-0.0795***	0.0014***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Morocco	-0.1563***	0.0755***	0.2093***	0.0608***	-0.0467***	-0.1299***	0.0009***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Netherlands	-0.1255***	0.0973***	0.2795***	0.0603***	-0.0379***	-0.1458***	0.0010***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pakistan	-0.4708***	-0.0109***	0.1064**	-0.0023***	-0.0066***	-0.0683***	0.0011***
	(0.000)	(0.000)	(0.034)	(0.001)	(0.000)	(0.000)	(0.000)
Philippines	-0.4187***	-0.0094***	0.0957***	0.0009***	-0.0304***	-0.0659***	0.0004***
	(0.001)	(0.000)	(0.213)	(0.000)	(0.000)	(0.000)	(0.000)
Portugal	-0.2777***	0.0348***	0.1244***	0.0642***	0.0221***	-0.0274***	0.0005***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
South Africa	-0.4459***	-0.0436***	0.0784***	0.0631***	0.0721***	-0.0095***	0.0010***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Spain	-0.2618***	0.0242***	0.1037***	0.0320***	0.0032***	-0.0375***	0.0004***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sri Lanka	-0.3400***	0.0486***	0.1570***	0.0296***	-0.0264***	-0.1285***	0.0006***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sweden	-0.4031***	-0.0315***	0.0289***	-0.0241***	-0.0302***	-0.0596***	0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Switzerland	-0.3097***	-0.0087***	0.0228***	0.0092***	0.0034***	-0.0090***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Thailand	-0.4017***	-0.0211***	0.0889***	0.0029*	-0.0380***	-0.1088***	0.0014***
	(0.000)	(0.000)	(0.000)	(0.068)	(0.000)	(0.000)	(0.000)
Turkey	-0.2966***	0.0264***	0.0593***	0.0312***	-0.0191***	-0.0318***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
United States	-0.3296***	-0.0262***	0.0207***	-0.0182***	-0.0370***	-0.0453***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: Elasticity estimates based on ARDL model with robust standard errors. *p*-values in parenthesis: *** denotes 1% level of significance, ** 5%, and * 10%.

APPENDIX C

APPENDIX TO CHAPTER 5

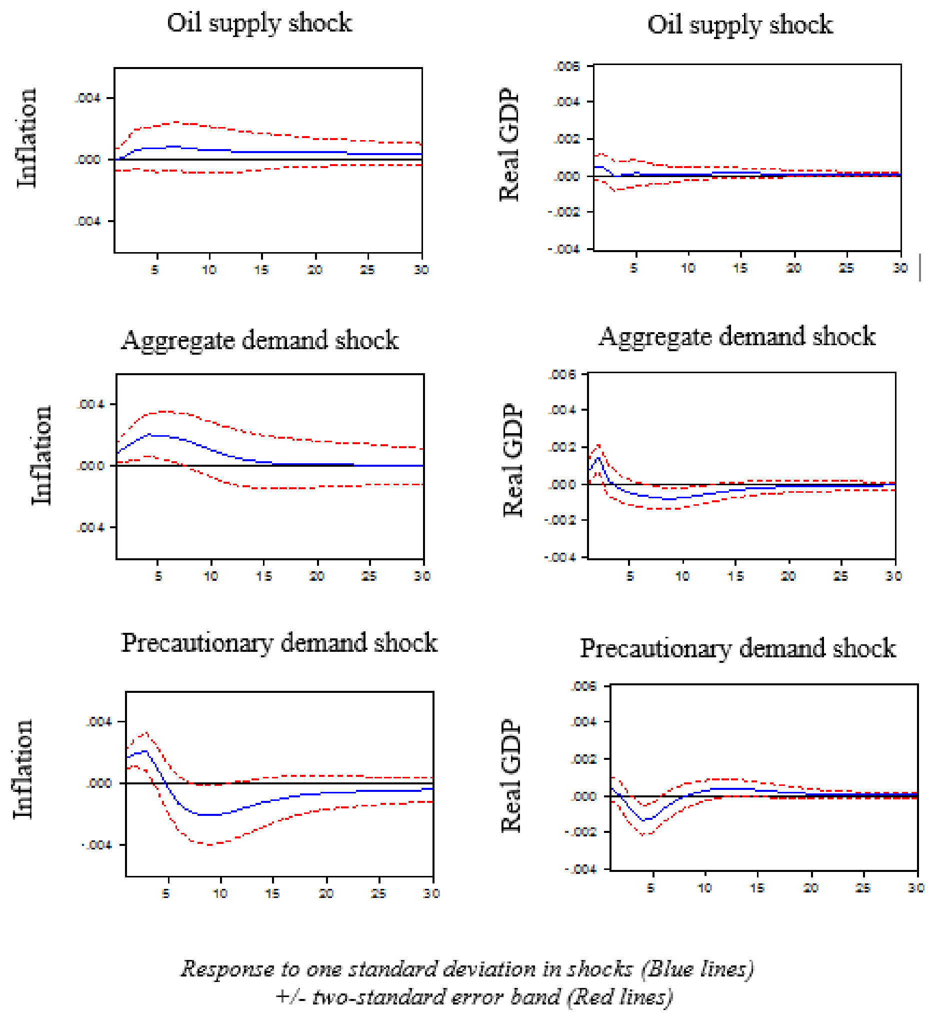
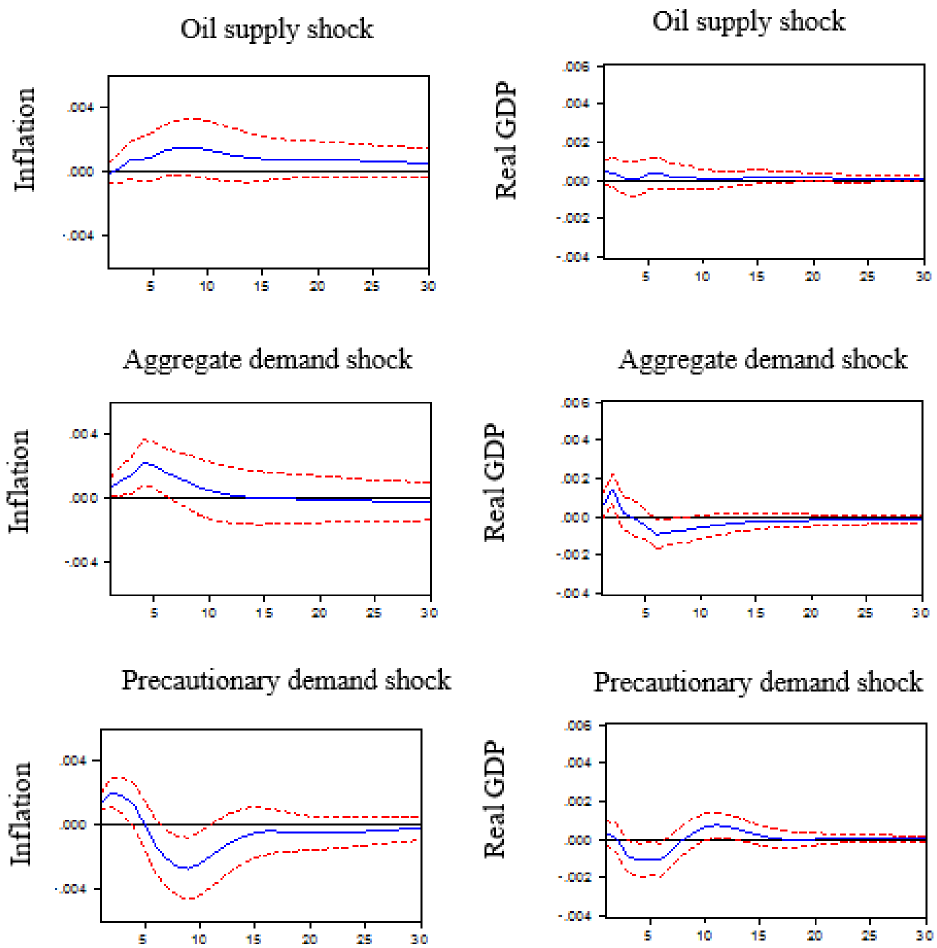
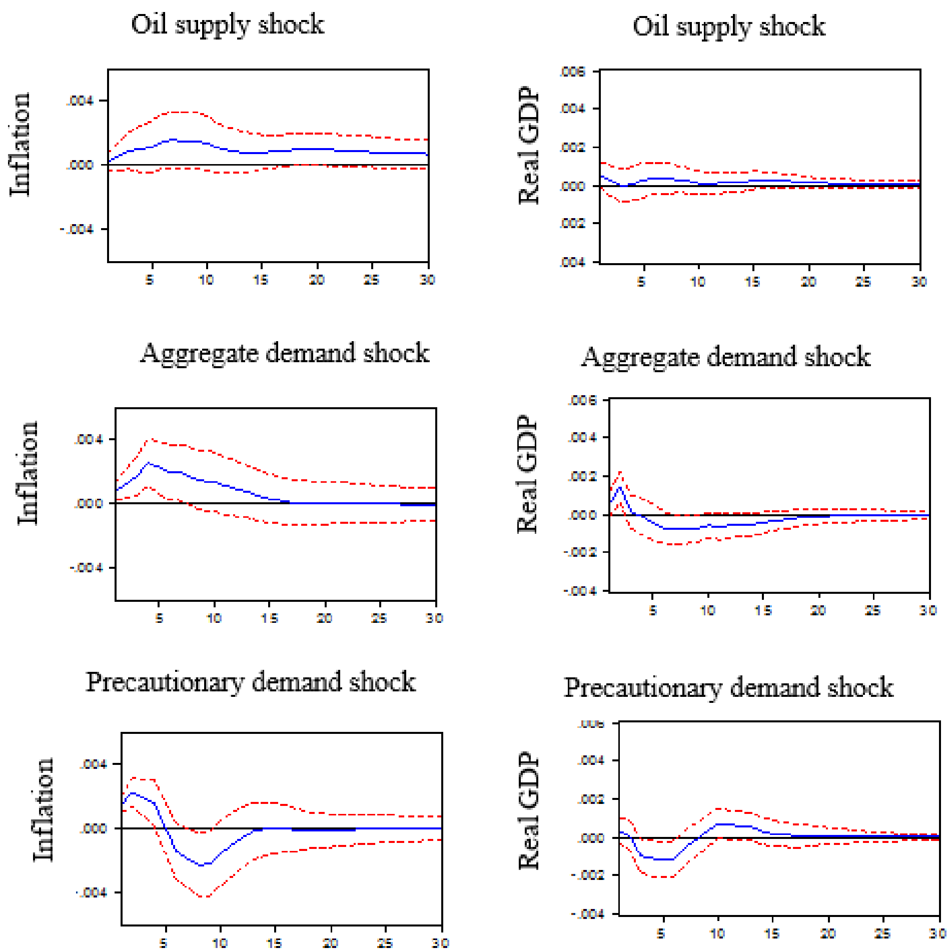


Figure C.1 Robustness check using 3 lags



Response to one standard deviation in shocks (Blue lines)
+/- two-standard error band (Red lines)

Figure C.2 Robustness check using 4 lags



Response to one standard deviation in shocks (Blue lines)
+/- two-standard error band (Red lines)

Figure C.3 Robustness check using 5 lags

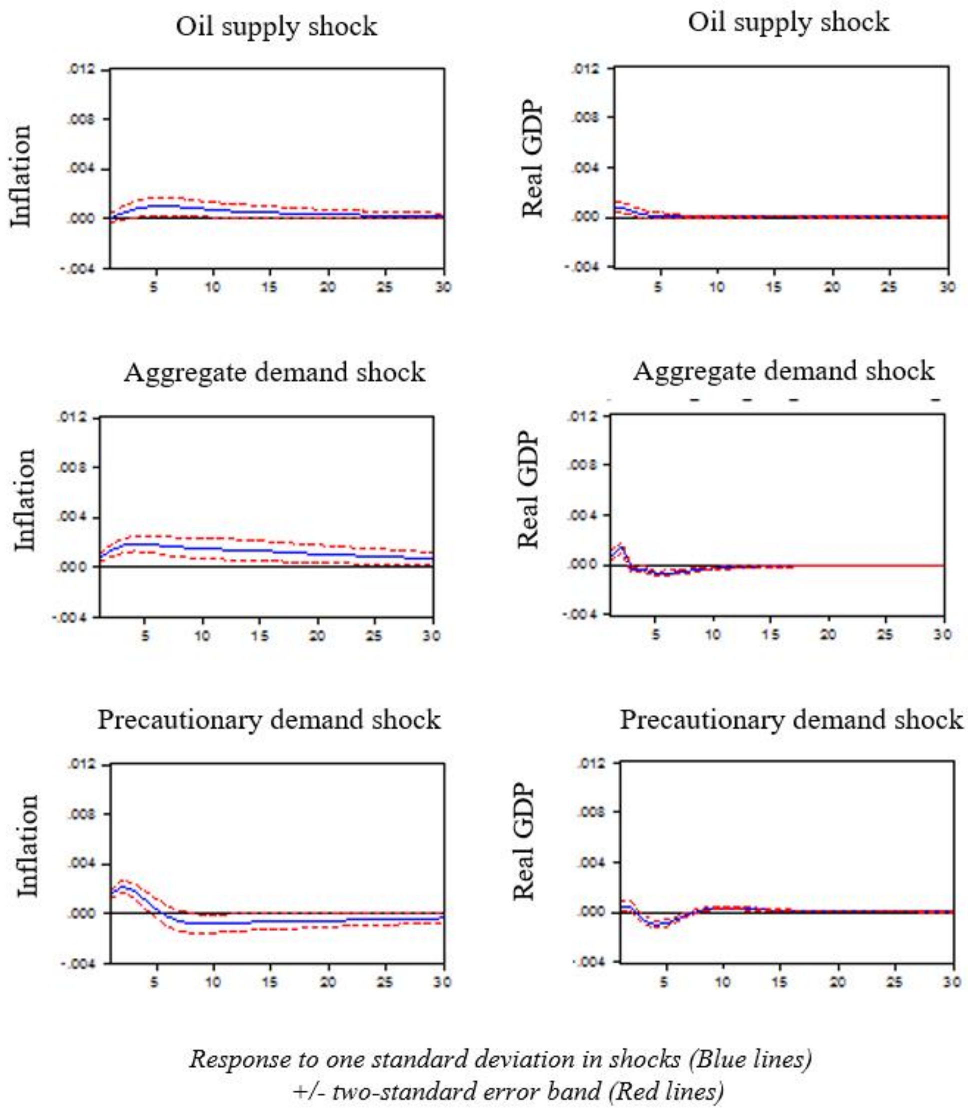


Figure C.4 Near-VAR impulse response of macroeconomic variables to oil price shocks

Table C.1

Statistical difference test on oil-intensity margin

Covariance Analysis	
Covariance	24.1888
t-Statistic	2.3997
Prob.	0.074

Notes: The oil-intensity margin between low and high oil-intensive countries is small: from 52% to 57%. Based on the t-statistic of the covariance analysis, the null hypothesis of no difference can be rejected at the 10% level.

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