Essays on the Economic Effects of Oil Price Shocks on Oil-Exporting Developing Countries

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

By

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Abstract

This thesis aims to examine the relationship between different types of oil shocks and macroeconomic indicators, central bank reaction functions, and the efficiency scores of manufacturing firms in oil-exporting developing countries. To accomplish the thesis's objectives and arguments, this thesis contains of five chapters, including three empirical ones. Chapter 1 provides a general introduction to the thesis. In Chapter 2, we empirically examine Kilian's (2009) arguments that treating oil prices as exogenous is misleading. We disentangle them into three structural shocks: oil supply, aggregate demand, and oil-specific demand shocks. We utilize Kilian's (2009) decomposition method for oil shocks within a global oil-market Structural Vector Autoregression (SVAR) model framework. The findings support the validation of Kilian's assumptions for recent episodes of oil price fluctuations. We show that the primary sources of oil movements are from oil demand sides, while oil supply shocks have a muted and limited influence. We contribute to the literature by examining the symmetric and asymmetric relationships of structural oil shocks and selected macroeconomic indicators, such as aggregate government expenditure, aggregate government revenue, and the government budget of oil-exporting countries. The results suggest that these fiscal indicators respond to oil shocks depending on their sources. Moreover, we find that the impact of aggregate demand shocks is asymmetric in oil producers' fiscal indicators. In Chapter 3, we investigate the response of central bank reaction functions in selected oil-producing developing countries, Bahrain, Kuwait, Oman, and Saudi Arabia, to the three sources of oil shocks. To achieve this, we utilize the Generalized Mothed of Moments (GMM) model. Our results show that in symmetric augmented Taylor rule estimations, the policy rates do not react to the structural oil shocks, and there are different preferences in the central bank decisions of GCC. However, the asymmetric Taylor rule estimations explain how some of GCC countries react to our structural oil shocks. Chapter 4 investigates how the three structural oil shocks affect the firm performance by measuring the efficiency scores of the manufacturing sector in Kuwait, an oil-producing country. We use a confidential dataset of Kuwaiti manufacturing firms from 2003-2019 and a two-stage DEA model. Our findings suggest that the efficiency scores of Kuwaiti manufacturing sectors significantly respond to structural oil shocks, with evidence of asymmetric associations between firm efficiency scores and two structural oil shocks, namely, oil supply and aggregate demand shocks.

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List of Abbreviations

ADF	Augmented Dickey-Fuller test
ADS	Aggregate demand shock
AIC	Akaike information criterion
AMG	Augmented mean group
ARDL	Autoregressive distributed lag model
BCC	Banker, Charnes and Cooper model
CBB	Central Bank of Bahrain
CBK	Central bank of Kuwait
CBO	Central Bank of Oman
CCA	Caucasus and Central Asia region
CCR	Charnes, Cooper and Rhodes DEA model
CDP	Common dynamic process
CRS	Constant returns to scale model
CSD	Cross-section dependence
CPI	Consumer prices index
CSB	Kuwaiti Central Statistics Bureau
DEA	Data envelopment analysis
DF-GLS	Dickey-Fuller Generalised Least Squares
DMU	Decision-making unit
ECB	Europe Central Bank
EIA	US Energy Information Administration (EIA)
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
GCC	Gulf Co-operation Council
GDP	Gross domestic product
GFC	Global financial crisis
GMM	Generalised method of moments
HP	Hodrick-Prescott filter
IMF	International Monetary Fund
ISIC	International Standard Industrial Classification

KDIPA	Kuwait Direct Investment Authority
KISR	Kuwait Institute for Scientific Research
KPSS	Kwiatkowski, Phillips, Schmidt and Shin test
Max.	Maximum
MENA	Middle East and North Africa region
MEOE	Middle Eastern Oil-Exporting countries
Min.	Minimum
MG	Mean group
N	Number of observations
NARDL	Non-linear autoregressive distributed lag model
N.E.C.	Not elsewhere classified
OLS	Ordinary least squares
OPEC	Organisation of the Petroleum Exporting Countries
OSDS	Oil-specific-demand shock
OSS	Oil supply shock
PP	Phillips-Perron test
Q1-Q4	First to fourth quarters of a year
RER	Real exchange rate
RGDP	Real GDP
RMSE	Root mean square error
SAMA	Saudi Arabian Monetary Authority (the Saudi central bank)
SD	Standard deviation
SFA	Stochastic frontier analysis
SORM-DEA	Semi-orientated radial measure
SVAR	Structural vector auto-regression model
UAE	United Arab Emirates
US	United States (of America)
USA	United States of America
USD	US Dollars ($)
VAR	Vector auto-regression model
VECM	Vector error correction model
VRS	Variable returns to scale model
2SLS	Two-stage least squares

Chapter 1

Introduction

In the economies of oil-exporting developing countries, oil commodity is considered a main driver of their economic growth. As the oil exports provide the primary source of income for these nations, it will create both benefits and challenges. It well known in literature that there is a significant impact on the stability of the global economy when oil prices fluctuate due to global market dynamics and geopolitical factors. Literature has long established that major recessions are accompanied by fluctuations in oil prices. According to Hamilton (2011a), the majority of recession periods in the US economy are associated with fluctuations in oil prices. This profound influence, however, may have a variety of effects on the economies of oil producers, particularly the less developed ones. Therefore, understanding the effects of oil shocks on macro and micro economies is essential for policymakers, economists, and investors in these countries.

While the majority of papers have examined the impact of oil price shocks on the economy of oil-importing developed countries (e.g., Barsky and Kilian, 2001; Blanchard and Gali, 2007; Hamilton, 1983, 1996, 2009; Kilian, 2009; Kilian and Vigfusson, 2017), there is a growing body of literature that focuses on the effects of oil shocks on oil-exporting developing countries (See for example, Alley, 2016; Bjørnland, 2009; El Anshasy and Bradley, 2012; Koh, 2017; Mehrara, 2008; Moshiri and Banihashem, 2012). This thesis concentrates entirely on these economies, as energy plays a critical role in shaping their economic development. Thus, the purpose of each chapter is to examine the effects of oil price shocks on the economies of oil-exporting developing countries.

Hamilton (2003) believed that the fluctuations in oil prices are mainly caused by exogenous shocks, specifically disruptions in the oil supply. However, recent economic studies have challenged this conventional belief. In an influential paper, Kilian (2009) has shown that oil prices should be considered endogenous to changes in global macroeconomic conditions. Kilian's findings revealed that demand side shocks are the primary drivers of oil price movements, making a significant shift in our understanding of the causes of oil price shocks. As a result, analysing the underlying causes of oil price shocks has become critical for obtaining a comprehensive understanding of their dynamics. A number of researchers have also demonstrated that the response of economic performance in oil-importing countries depends on the specific sources of oil shocks (e.g., Abhyankar et al., 2013; Kilian and Park, 2009; Lorusso and Pieroni, 2018). However, there is a notable research gap regarding the influence of the main sources of oil shocks on oil-exporting developing countries, leading to the need for further investigation.

In addition, previous studies have mostly examined the impact of oil shocks under the assumption of symmetry, disregarding evidence that suggests oil shocks can have asymmetric effects. This recognition came up as a result of the mid-1980s oil-price collapse, which failed to produce the expected economic upturn in oil-importing countries. As a result, researchers began to consider the possibility that the impact of changes in oil prices could differ and depending on oil shocks direction. For example, Mork (1989) observed that oil shocks had an asymmetrical impact on the US economy. However, much of the existing literature investigates the asymmetric effects of oil shocks without considering the underlying sources of oil price movements. This thesis aims to address this gap by offering insights into the asymmetrical impact of oil shocks while considering their original causes. Each chapter of this thesis examines the reasons behind our expectation that the sources of oil shocks may lead to asymmetrical effects on oil-exporting developing economies.

In the current thesis, Chapter 2 focuses on extending Kilian's (2009) approach to analyze the recent drivers of oil-price movements. This is achieved by decomposing oil prices into three distinct oil shocks: oil supply shocks, aggregate demand shocks, and oil-specific demand shocks. Moreover, the decomposed oil shocks are utilized to assess both the symmetric and asymmetric impacts of these shocks on fiscal indicators in a large sample of oil-exporting developing countries. Building on the findings from Chapter 2, Chapter 3 examines the effects of the structural oil supply and demand shocks on central bank reaction functions. This analysis is conducted in selected countries of oil-exporting less developed nations, providing valuable insights into how these structural oil shocks influence central bank policies. Lastly, in Chapter 4, the objective is to investigate how different types of oil shocks impact the efficiency scores of manufacturing firms in oil-rich countries, specifically focusing on Kuwait. To accomplish this, we use a confidential and rich dataset of firms to provide the first comprehensive examination of the relationship between the structural oil shocks and the efficiency of manufacturing firms in Kuwait.

In Chapter 2, we aim to answer the research questions: What are the main recent drivers of oil price movements? And do the responses of fiscal variables in oil-exporting developing countries to the oil shocks depend on the original sources of oil shocks, including whether the impact of different shocks is asymmetrical? First, we extend Kilian's structural vector autoregression (SVAR) model using economic global indicators in order to evaluate recent drivers of oil price fluctuations by disentangling the oil prices into three structural shocks: oil supply shock, aggregate demand shocks, and oil-specific demand shocks. Our sample of the first stage covers the period from 1974-2019. In the second step, we examine the symmetric and asymmetric impact of the three structural oil shocks on the fiscal variables of 20 oil-exporting developing countries. Our variables of interest are total government expenditure, total government revenue, and government budget. The results of the first stage indicate that the aggregate demand and oil-specific demand shocks are the dominant factors in oil price movements, while oil supply shocks have a muted impact. Furthermore, our impulse response functions (IRFs) reveal that while oil supply shocks have negligible effects on oil price movements, the different oil demand shocks exhibit substantial and persistent effects. In the second stage, we apply the augmented mean group (AMG) estimator for Cross-sectional Dependence (CSD) in panel data. In general, we find that the fiscal indicators of developing oil producers' response to oil price fluctuations depend on the original sources. We show that the aggregate demand and oil-specific demand shocks are the shocks that improve the fiscal balances in oil-exporting developing countries. Additionally, we observe an asymmetrical relationship between the aggregate demand shocks and fiscal indicators across oil-exporting developing countries.

The results of Chapter 2 help us to understand the consequences of the three structural oil shocks on oil-exporting developing economies. Based on this knowledge, in Chapter 3, we contribute to the literature by examining the role of structural oil shocks on central bank reaction functions for selected oil producers. We focus on the Gulf Cooperation Council (GCC) block, which is the most interesting to examine for many reasons. First, the GCC countries play a critical role in the oil market because they possess large oil reserves, making them major players in global oil production. Countries such as Saudi Arabia, the United Arab Emirates, Kuwait, and Qatar have substantial oil reserves, which contribute to their prominent position in the global oil market. Second, the economies of GCC countries rely on oil exports as a primary source of revenue and economic growth. Oil exports form a substantial portion of their total exports and contribute significantly to their national income. As a result, fluctuations in oil prices directly impact the economic stability and development prospects of these countries. Third, during periods of oil shocks, the GCC countries face inflationary pressures. Following the Global Financial Crisis of 2008, studies, including one by the International Monetary Fund (IMF) in 2012 by authors Espinoza and Prasad, have documented that some GCC countries allow changes to deviate from those by the Fed Funds rate, although these countries conduct a managed exchange rate regime to the US dollar. Understanding how these countries' monetary policy responds to the impact of structural oil shocks is crucial for modelling their policy rates during unprecedented periods. We seek to address two questions: (i) to what extent do the three structural oil shocks help model the monetary policy of central banks in oil-exporting less-developed countries, and (ii) is the response of the policy rate asymmetrical in relation to the decomposed oil shocks? We use the augmented Taylor rule approach, using available quarterly data for the period up to Q4 2019. We employ the Generalized Method of Moments (GMM) regressions. The results show that the policy rates in our symmetric augmented Taylor rule estimations do not respond to our structural shocks and reveal that the output gap matters in the central bank's reaction functions of Kuwait and Saudi Arabia, while Bahrain and Oman prefer to follow the Fed Funds rate. On the other hand, the asymmetric augmented Taylor rule analysis indicates that there are interactions between the structural oil shocks and the policy rates in our selected GCC countries, and the monetary authorities react differently depending on the sources of oil shocks.

The last empirical essay in this thesis is Chapter 4. We contribute to the literature by examining the impact of the three structural oil shocks on the micro economy of an oil-exporting developing economy, with a specific emphasis on the manufacturing sector. While there is extensive literature exploring the relationship between oil price shocks and macroeconomic variables, the understanding of their specific effects on the microeconomy remains relatively limited. Given that oil is an important input of production in many manufacturing firms, as well as a significant determinant of production costs and profitability, understanding the effects of oil shocks on firm performance becomes crucial for policymakers and investors. Economic theories like ‘irreversible investment’ (Bernanke, 1983) have highlighted that firms tend to postpone their investments amidst oil price uncertainties, contributing to a growing body of empirical evidence demonstrating a negative correlation between oil shocks and firm performance in oil-producing nations. Furthermore, the concern over the resource curse phenomena in oil-rich countries, and particularly its effect on slow growth in this crucial sector during periods of high oil prices, motivates this chapter. Efficiency measurement is a crucial indicator of firm performance as it influences productivity and profitability, and which has received no attention in oil shocks and microeconomics literature. Therefore, in this chapter, we aim to answer the research question: how do structural oil shocks impact the efficiency scores of manufacturing firms in oil-exporting developing countries? To accomplish this objective, we utilize confidential, rich micro-level data from manufacturing firms in Kuwait spanning the period from 2003 to 2019. Our analysis employs a two-stage approach. In the first stage, we employ the mathematical linear programming model known as Data Envelopment Analysis (DEA) to calculate the efficiency scores of manufacturing firms. In the second stage, we employ bootstrap random effect Tobit regressions to investigate the role of decomposed oil shocks on manufacturing firms' performance. The findings of our study suggest that aggregate demand shocks are the only kind of oil shock that can make manufacturing firms more efficient. Conversely, oil-specific demand shocks tend to dampen efficiency scores, highlighting the presence of the resource curse phenomenon in oil-rich countries, particularly in relation to this type of shock. Additionally, we observe that oil supply and aggregate demand shocks have asymmetric impacts on the efficiency scores of manufacturing firms in Kuwait.

Chapter 2

The Impact of Oil Price Shocks on Macro-Economic Indicators in Oil-Exporting Developing Countries: Does the Origin of Oil Shocks Matter?

Abstract

The commonly held assumption that oil supply shocks are the primary driver of oil price fluctuations has been challenged by Kilian's (2009) oil market model. This study seeks to extend Kilian's argument by capturing the main determinants of recent oil price shocks, up to 2019, empirically. Moreover, our study argues that the macro-economic indicators of oil-exporting developing countries are influenced by the original sources of oil shocks. To achieve this, we utilise a two-stage approach. In the first stage, we use a structural vector auto-regression (SVAR) oil market model to disentangle oil price changes into three sources of oil shocks, namely oil supply shocks, aggregate demand shocks and oil-specific demand shocks, and to capture recent oil shock episodes. In the second stage, we utilise the augmented mean group (AMG) estimation for cross-sectional dependence panel data to examine the response of fiscal policy indicators in oil-exporting developing countries to decomposed oil shocks. In general, the findings of the first stage emphasise Kilian's argument that demand shocks are the primary driver of oil price fluctuations, while oil supply shocks have muted effects. Furthermore, the second stage results indicate that the behaviour of fiscal indicators is dependent on the source of oil shocks. We also find evidence of asymmetric impact from aggregate demand shocks. These findings have important implications for policy makers in oil-exporting countries and provide new insights into the behaviour of fiscal indicators in response to oil shocks.

2.1 Introduction

The oil market has witnessed massive swings in oil prices since 1971. As oil is such an important part of the economies of most oil-exporting developing countries, an increase in oil prices is positive as far as those countries and their government revenues are concerned, and a decrease affects them negatively. Similarly, oil-importing countries are affected negatively by oil price rises and benefit from price drops. According to the literature, after a sudden drop in oil prices in the early 1970s and the subsequent world recession, various countries started analysing the performance of their economies during oil price shocks and measuring the economic consequences of these shocks. In this context, the impact of fluctuations in oil prices on the macro-economic outlook has been examined extensively in a number of studies. Examples of these studies include research by Hamilton (1983;1996; 2003; 2009; 2011a), Mork et al. (1994), Hooker (2002), Blanchard and Galí (2007), Zhang (2008), Kilian (2008a; 2009), Rafiq et al. (2009), Lorde et al. (2009) and Elder and Serletis (2010).

These research studies have indicated a direct relationship between oil price increases and economic performance. In this regard specifically, the early paper by Hamilton (1983) assumed that oil prices were exogenous to economic performance without considering diverse oil price fluctuation sources. Therefore, in accordance with Kilian (2009), it is proposed that global macro-economic factors should be taken into account when considering the endogeneity of the real oil price. This paper emphasises the significance of considering the origins of oil price variations when assessing their consequences for the economy. According to Kilian (2009), Hamilton's approach is invalid because, first, macro-economic factors actually affect oil prices and, second, oil prices are influenced by structural supply-and-demand shocks that not only have direct effects on the macro-economy, but also have indirect effects that operate through the price of oil. Therefore, Kilian (2009) considered real oil prices to be endogenous in response to world economic circumstances. A rise in oil prices due to a demand shock affects the macro-economy considerably more than a rise from an oil supply shock. Hence, exploring actual oil shock sources is crucial for understanding their effects and reducing their impact on the economy, as many economists suggest.

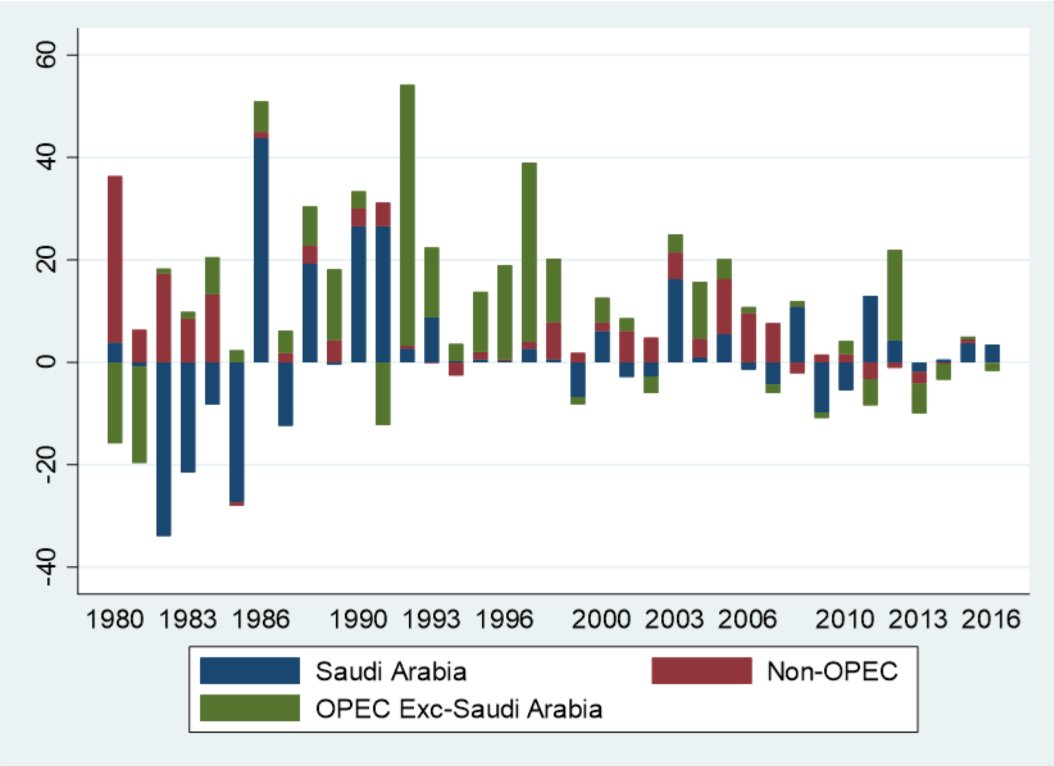
The aim of our paper is two-fold. Firstly, we investigate the recent drivers of oil price changes by extending Kilian's approach to capture recent episodes of oil price movements. Secondly, we examine the impact of supply-and-demand oil shocks on macro-economic indicators of oil-exporting economies. To achieve our aims, we employ a two-stage method. In the first stage, we evaluate the causes of oil price changes based on the underlying source of the shock. We use a structural vector auto-regression (SVAR) model to allocate oil price changes to three kinds of structural oil shock: oil supply shocks, driven by oil production disruptions, aggregate demand shocks, driven by strong global economic activity, and oil-specific demand shocks, induced by uncertainty regarding future oil supply. In the second stage, we analyse the effects of the structural shocks identified in the first stage in a large sample of oil-exporting countries, taking into account the empirical problem of panel cross-sectional dependence (CSD), on various macro-economic indicators, such as total government expenditure, total government revenue and government budget. CSD refers to the correlation of variables or residuals across different panel members, such as countries, due to common shocks, like oil price fluctuations, recessions and spill-over effects. These factors typically go unobserved, are common to all countries and can have varying impacts on different panel members.

On the other hand, previous studies have assumed that oil price shocks and macro-economic performance have a symmetrical relationship. Nevertheless, this assumed linear relationship began to be questioned in the mid-1980s. Falling oil prices were found to have more positive, but smaller effects on economic activity than predicted by linear models, suggesting that the symmetric relationship may be misleading. At this point, the asymmetric concept was established by Mork (1989), Lee et al. (1995) and Hamilton (1996). These authors studied non-linear transformations and found asymmetry in the effects of positive and negative oil price shocks.

Prior studies have examined the impact of shocks due to increases and decreases in oil prices and are well established in oil-importing countries, such as the USA. Nevertheless, less attention has been given to studying asymmetric oil price shocks in oil-exporting, developed and developing countries, in relation to the original sources of those shocks. Recently, a few studies have attempted to examine the asymmetry impacts of oil shocks on macro-economic indicators whilst distinguishing the shocks' origins, whether in supply or demand (see, for example, Atems et al., 2015; Jibril et al., 2019; Sheng et al., 2020).

There are several factors which support our hypothesis that the effects of oil shocks on oil-exporting economies depend on the different sources of those shocks and that this impact may be asymmetric. We argue in the current study that the impact of oil supply shocks is muted if it comes from oil disruption, because of the role of big oil producers in offsetting the shortage in oil production capacity. Fattouh and Economu (2019) found that geopolitical supply disruption has no significant impact on oil prices, because production by other producers increases, and that demand-side shocks are associated with large and persistent impacts on oil prices. Figure 2.1 shows that oil production responses from Saudi Arabia have covered some of oil supply disruptions periods in OPEC and non-OPEC countries.

Figure 2.1: Percentage change in oil production in Saudi Arabia, OPEC and non-OPEC countries



Source: Author’s calculation

In addition, we believe that oil price rises have stronger effects on fiscal balances if they come from stronger aggregate demand shocks. The International Monetary Fund (IMF) (2010)[1] described the fiscal policy responses by oil producers to the oil boom in the 2000s, which was due to a strong global economy. The IMF’s analysis showed that, during the period of rising oil prices and higher revenues from 2000 to 2005, oil-exporting countries increased their public spending rapidly and the internal balance of payments changed from a deficit of 3.5% of gross domestic product (GDP) in 1999 to a surplus of 12% of GDP in 2005. On the other hand, Jibril et al. (2019) showed that times of lower oil prices, from weak global demand, are associated

[1] See: https://www.imf.org/external/pubs/ft/wp/2010/wp1028.pdf.

with US recessions at the same time as demand growth in China. Likewise, the USA maintained robust growth rates during the Asian crisis, which coincided with one of the sharpest declines in oil prices.

Furthermore, the current study claims that the impact of oil-specific demand shocks on fiscal balance indicators in oil-producing countries is plausible and may have an asymmetric impact. A large body of evidence suggests that oil-specific demand shocks have a crucial role in oil price movements (Ebrahim et al., 2014). Studies such as Hamilton (2003), Barsky and Kilian (2004) and Kilian (2009) have shown that political events in the Middle East and North Africa have mainly been driven by oil-specific demand shocks and that such geopolitical events, which induce high oil prices, have a large impact on the stability of economic growth in oil-exporting countries. As a result, strong, positive oil-specific demand shocks may have a larger impact than weak oil-specific demand shocks.

This scenario gives rise to questions that are worth investigating concerning the asymmetric relationship between fiscal balances and the three structural oil price shocks, especially in cases of limited prior research. If these relationships do exist and are shown to be strong, then conclusions and inferences made from models that assume oil shocks to be exogenous are probably misleading.

This study offers two main contributions to the literature. First, it extends the global oil market structural vector auto-regression (structural VAR or SVAR) model of Kilian's methodology into recent years in order to investigate the recent drivers of oil price fluctuations. Second, it aims to analyse the effect of symmetric and asymmetric oil price shocks and their impact on various macro-economic indicators for a large sample of oil-exporting economies, and to examine how the impact on macro-economic indicators in oil-exporting countries depends on the nature of the oil shocks. To the best of our knowledge, this is the first study to examine these effects comprehensively. Overall, this research aims to provide new insights into the factors that contribute to oil price fluctuations and their impact on the macro-economies of oil-exporting countries.

The analysis in this chapter has two stages. In the first stage, we adopt Kilian's (2009) approach, using SVAR to allocate oil price change events to three sources of oil shocks. In this stage we use monthly data for global oil variables with a sample period of 1974-2019. In the second stage, we use the recently developed, heterogenous panel technique, augmented mean group (AMG), to examine the symmetric and asymmetric impacts of the oil shocks, as categorised in the first stage, on such fiscal indicators as total government expenditure, total government revenue and government budget, in less developed oil-producing countries. The importance of the econometric methodology is that it tackles the issue of panel cross-section dependence (CSD). Accordingly, if CSD exists in panel data from more than one country, then conventional panel data estimators are inconsistent. In this context, the study uses recently developed, cross-sectional dependence diagnostic tests, such as the weak cross-sectional dependence test of Pesaran (2015) and the exponential cross-sectional dependence test of Bailey et al. (2016). In order to investigate the effects of structural oil shocks, this chapter focuses entirely on the major oil-exporting developing economies[2] and their macro-economic responses to oil shocks from different origins, and takes its data from the period 1980-2019.[3]

The findings of this chapter's empirical analysis are in line with Kilian's (2009) findings that the causes of oil price fluctuations are mainly from demand shocks and that the previous assumption about oil supply shocks is invalid. Kilian's paper had a limited time frame that ended in 2007, but, because our sample extends to the end of 2019, we are able to explain more recent oil price fluctuations. Our findings indicate that the primary cause of significant and persistent fluctuations in the real price of oil since the mid-1970s is oil demand shocks, rather than oil supply shocks. However, it is important to note that political events in oil-producing regions can still affect the real price of oil by changing expectations about future oil supply shortages in relation to oil demand. Our model captures these expectations as oil-specific demand shocks. For example, the results show that, during the geopolitical events known as the Arab Spring in 2011 and 2014, there was a significant and sustained increase in oil prices. Overall, this study provides a deeper understanding of the factors driving movements in the real price of oil, thus clarifying the potential impacts of the three kinds of structural oil shock in oil-producing regions.

Turning to the impact of the three kinds of structural oil shocks on oil-exporting countries' economies, this chapter provides evidence that the effects of oil price shocks on fiscal balances in oil-producing developing countries are real and depend on the sources of the shocks. The findings show that oil supply disruption has a muted effect on fiscal indicators, whereas oil demand shocks play a crucial role in increasing total government revenues and government budgets as a proportion of GDP. As a result, total government expenditure as a proportion of

[2] For a list of the oil-exporting countries in the sample, see Table 2.7 in the Chapter Appendices.
[3] Our sample starts from 1980 due to the availability of data for less developed oil-exporting countries.

GDP falls during periods of high oil prices. Moreover, the results show that this impact has an asymmetric relationship in the case of oil booms due to increases in global aggregate demand.

This chapter is organised as follows. Section 2.2 presents a review of pertinent theoretical and empirical literature. Section 2.3 discusses the methodological framework using Kilian's (2009) model and describes the data used in the study. The empirical results are presented in section 2.4. Conclusions are drawn and policy recommendations are made in section 2.5. An appendix to this chapter presents the diagnostic tests.

2.2 Literature review

After the first oil price shock in 1973, the study of macro-economic activity became essential for both oil-exporting and oil-importing countries across the world. An increase in oil prices is directly associated with the performance of macro-economic indicators. According to Hamilton (1983), a change in oil price affects all macro-economic indicators. In the literature, great attention has been given to developed, oil-importing countries, whereas only a few studies have investigated the macro-economic impact of oil shocks in oil-exporting, developing countries. The majority of these studies are country-specific and few use panel data, e.g. Spatafora and Warner (1999), Eltony and AlAwadi (2001), Mehrara and Oskoui (2007), Farzanegan and Markwardt (2009), Omojolaibi and Egwaikhide (2014), Ftiti et al. (2016) and Koh (2017). Oil shocks have a significant impact on the macro-economy. The consequences of oil price shocks vary between oil-importing and -exporting countries. When the price of oil rises, the economy of oil-importing countries is affected adversely, but oil-exporting countries' economic performance is in a much better position. According to Kilian (2008a), an increase in oil prices is hugely beneficial for exporting countries, whereas a decline in oil prices affects their economic position adversely.

It is appropriate to start the literature review by considering research studies about the symmetric relationships between oil shocks and macro-economic indicators in oil-exporting, developing countries. Eltony and Al-Awadi (2001) confirmed that symmetric oil shocks are key to understanding fluctuations in macro-economic variables in Kuwait, where the most significant impact of oil shocks was on government expenditure, which is the central role of Kuwait's economic activity level because Kuwait's economy is heavily reliant on oil exports. Berument et al., (2010) examined the effects of symmetric oil price shocks on output for a group of developing countries. Their results suggested that the effects are positive and significant for some countries, such as Algeria, Iraq, Jordan, Kuwait, Oman, Qatar, Syria, Tunisia and UAE. For other countries, such as Bahrain, Egypt, Lebanon, Morocco and Yemen, the effects are positive but not statistically significant. Chuku (2012) found that oil price shocks played an important role and had a significant positive impact on Nigeria's macro-economic variables. El-Anashasy and Bradley (2012) evaluated a panel of 19 oil exporters using annual data from 1957 to 2008. Their results showed that, in the short run, government expenditure rises as oil revenue increases. Nasir et al. (2019) employed the SVAR model to examine the linear impacts of oil shocks on Gulf Co-operation Council (GCC) macro-economic indicators, such as economic growth, inflation and trade balance. They concluded that there is a strong relationship between oil price shocks and these variables. However, there are considerable differences in responses between different oil-rich countries. Recently, Yildirim and Arifli (2021) investigated the impact of oil price shocks on a small oil-exporting country, Azerbaijan, when oil prices decline. Their findings suggested that the recent oil bust has had a dramatic negative impact on Azerbaijan's macro-economy.

As regards asymmetric studies, there are few which have examined the impact of positive and negative oil shocks on macro-economic indicators in oil-producing developing countries. For instance, Mehrara (2008) carried out a asymmetry panel analysis of thirteen oil exporting countries. He found that output growth was affected by negative shocks, but that positive shocks have a limited effect. Farzanegan and Markwadt (2009) examined the role of asymmetric oil shocks on the Iranian economy by applying a VAR approach. They found a significant impact from oil price shocks on real government expenditure and evidence of the Dutch Disease phenomenon through significant real effective exchange rate appreciation. Iwayemi and Fowowe (2011) showed that linear oil-price shocks do not affect output, government expenditure, inflation or real exchange rates in Nigeria. However, their tests showed the existence of asymmetric impacts from oil price shocks and that negative shocks have significantly higher effects on Nigeria's macro-economic indicators than do positive shocks. Moshiri and Banihashem (2012) applied a VAR model to six OPEC members, finding no significant linear relationship between oil price shocks and economic growth. When allowing for asymmetry, however, the results showed different, significant relationships for positive and negative shocks. In addition, oil price decline leads to major revenue cuts and stagnation in the economy, whereas positive shocks do not have significant effects on output growth in all countries. Emami and Adibpour (2012) examined the asymmetric effects of oil revenue shocks on the economic growth of Iran, concluding that negative oil revenue shocks have a larger impact than positive shocks on output growth in the Iranian economy. Moshiri (2015) investigated the impact of asymmetric oil shocks in nine oil-exporting countries using VAR and GARCH models. The findings indicated that oil price drops reduced government revenue significantly, while higher oil prices do not increase economic growth. Nusair (2016) investigated the impact of asymmetric oil shocks using a panel data analysis of GCC countries. This study proved the asymmetric relationship between oil shocks and output, and the results suggested that increases in oil prices have a considerably larger impact on real GDP than decreases. Abdel-Latif et al. (2018) investigated the asymmetric impact of oil price shocks on government expenditure in Saudi Arabia. They employed a non-linear, auto-regressive, distributed lag model (NARDL), finding a non-linear association between oil prices and government expenditure. However, a negative oil shock has a significantly different effect to that of a positive shock in the long-run.

Jibril et al. (2019) examined the asymmetric effects of oil price shocks on trade balance for three shock sources. They used a large sample of oil-exporting and -importing countries, and applied a SVAR methodology. Their findings suggested an asymmetric relationship between oil shocks and trade balance, which depended on the source of the shocks. Charfeddine and Barkat (2020) investigated the short- and long-run, asymmetric impacts of oil and gas shocks on the total real GDP and non-oil GDP of a small, oil-exporting country, Qatar. The results showed that negative oil shocks have a higher impact than positive shocks, but the effects do not last long. Hassan (2021) applied the non-linear panel ARDL technique to 32 oil-exporting, developing countries to test the linear and non-linear relationships between oil price shocks and total government and health expenditure. He showed that linear oil shocks have a positive impact on these two government expenditure indicators. He found asymmetry, in that oil booms have a larger impact on total government expenditure than oil busts, and positive oil shocks enhance health expenditure, while negative oil prices reduce it.

Overall, the relationship between oil price shocks and fiscal variables has not been thoroughly researched, as there are few studies on the subject. Of those which do exist, and have looked at the effects of oil prices on fiscal balances and at symmetric and asymmetric effects on the economy, none consider whether the sources of the oil price shocks studied are from supply or demand. This chapter contributes to the literature by filling this gap.

2.3 Empirical analysis

The methodology is presented in two sections. Section 2.3.1 describes the disaggregation of oil price shocks into oil supply shocks, aggregate demand shocks and oil-specific demand shocks, as defined by Kilian (2009). Section 2.3.2 describes the empirical examination of the symmetric and asymmetric impacts of these shocks on the fiscal indicators of major oil-exporting, less developed countries.

2.3.1 Causes of oil price shocks: SVAR model – stage one

In this stage, we follow the Kilian (2009) approach to categorise oil price changes according to the three types of oil shock using the SVAR model. First, we define a vector M_t consisting of global index variables, where M_t can be defined as:

$$M_t = (\Delta prod_t, rea_t, rop_t)'$$

where:

$\Delta prod_t =$ % change in global crude oil production

$rea_t =$ index of real economic activity

$rop_t =$ real price of oil

$M_t =$ vector of three variables.

The three global indices used in this study are defined and constructed as follows. Firstly, the change in global crude oil production $(\Delta prod_t)$ is derived by taking the logarithmic differences in global crude oil production, measured in millions of barrels per day, on a monthly average basis. Secondly, the index of real economic activity (rea_t)[4] is an index prepared by Kilian (2009) and calculated by the detrending growth rate of dry cargo single voyage rate of freight, and this is considered as a global index. This is assumed to provide a measurement of the

[4] The real economic activity index (rea_t) was updated by Kilian (2019).

worldwide, real economic activity that drives demand for all manufacturing resources, including petroleum (Kilian, 2009). As claimed in Klovland (2002), the world's economic activity is the primary determinant of transport service demand. Thus, according to Kilian's original concept, freight prices rise to imply significant combined global market pressures. Thirdly, the real price of oil ($\mathrm{rop_t}$) is obtained from the cost of imported crude oil once refined, retrieved from the US Energy Department. The US CPI data then deflate the nominal price of oil. The rea_t and rop_t series are stated in logarithmic form, and the data period for the three global indices runs from January 1974 to December 2019.[5]

The SVAR model is expressed as:

$$A_0 M_t = \gamma + \sum_{i=1}^{T} A_i M_{t-i} + \mu_t \tag{2.1}$$

where μ_t represents a vector of mutually and serially uncorrelated structural innovations. This study assumes that A_0^{-1} has a recursive structure and, therefore, the reduced form errors e_t can be disaggregated as follows (obtained from multiplying A^{-1} to the above equation).

$$e_t = A_0^{-1} \mu_t \tag{2.2}$$

To identify the structural shocks vector e_t from the reduced-form error u_t in equation 2.2, we employ a Cholesky factorisation as our identification strategy. This approach allows us to recover the structural shocks vector based on the following framework.

$$\begin{pmatrix} e_t^{\Delta prod} \\ e_t^{rea} \\ e_t^{rop} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} \mu_t^{OSS} \\ \mu_t^{ADS} \\ \mu_t^{OSDS} \end{pmatrix} \tag{2.3}$$

where:

μ_t^{OSS} denotes crude oil supply shock

μ_t^{ADS} denotes aggregate demand shock

μ_t^{OSDS} refers to the demand shocks specific to the oil market.

The Cholesky ordering in equation 2.3 is based on a set of assumptions. Firstly, it assumes that crude oil supply shocks (OSS) are independent of oil demand shocks, such as aggregate

[5] See the Chapter Appendices for data details and sources.

demand shocks and oil-market-specific demand shocks. This assumption is reasonable as adjusting oil production is costly and the short-term crude oil market is difficult to forecast, resulting in slow responses from oil-producing countries to oil demand shocks.

Secondly, shocks to global real economic activity, not accounted for by oil supply shocks, are identified as shocks to the demand for industrial commodities. These shocks are labelled as aggregate demand shocks (ADS). It is assumed that oil-market-specific demand shocks do not influence global real economic activity in the same month, as there is typically a delay in the response of global economic activity to oil price increases.

Lastly, shocks to the real price of oil, excluding those explained by OSS or ADS, reflect changes in the demand for oil specifically, distinct from the demand for all industrial commodities. These shocks are defined as oil-specific demand shocks (OSDS), representing fluctuations in the precautionary demand for oil due to uncertainty regarding future oil supply.

We employ the least squares method to estimate the reduced-form equation 2.1 of our VAR model[6]. These estimated coefficients are then utilised to construct the SVAR representation of the model. To perform inference and obtain reliable statistical results, we follow the inference method proposed by Gonçalves and Kilian (2004). This method involves implementing a recursive-design wild bootstrap with 2000 replications, allowing for robust statistical inference. Following Kilian (2009), we apply the SVAR model with lag 24 months.

2.3.2 Consequences of structural oil shocks – stage two

The topic of how systemic developments in the model (equation 2.1) apply to oil-exporting developing countries' macro-economic indicators, such as total government expenditure (ΔTGE_t), total government revenue (ΔTGR_t) and government budget (ΔGB_t), is of great importance. The critical issue in addressing this query is that the data for macro-economic aggregates are not available on a monthly basis, while an equivalent VAR model may be built on data aggregated to a yearly interval. To address this issue, we calculate the monthly change by averaging annual shocks for each year.

[6] I run the structural VAR model (SVAR) using two software programs: MATLAB and STATA. We have identical results of SVAR to construct the structural oil shocks in both software programs.

$$\hat{\gamma}_{jt} = \frac{1}{12}\sum_{i=1}^{12}\hat{\vartheta}_{j,t,i}, \quad \text{where } j = 1,2,3 \tag{2.4}$$

The above equation, further elaborated as the term $\hat{\vartheta}_{j,t,i}$, denotes the estimated residuals refer to structural shock number 'j' in month 'i', in year 't' of the data.

These shocks can be viewed as predetermined and their impacts on oil-exporting countries' macro-economic indicators can be tested using a recently developed heterogenous panel method. The augmented mean group (AMG) estimator was developed by Eberhardt and Teal (2010) and Bond and Eberhardt (2013). This technique is important in that it accounts for slope heterogeneity and cross-sectional dependency in panel data estimation. The latter concern has been highlighted recently in the literature of macro-economic panel data. Cross-sectional dependence (CSD) refers to the correlation of variables or residuals across different panel members, such as countries, due to common shocks like oil price fluctuations, recessions and spill-over effects. These factors typically go unobserved, are common to all countries and can have varying impacts on different panel members. However, widely used panel data methods, such as Fixed Effects, Random Effects, Mean Group, Pooled Mean Group and certain classes of GMM estimators, assume absence of CSD. Unfortunately, this assumption is often invalid, which can lead to imprecise estimates or even identification issues if CSD is disregarded. As a result, researchers must account for CSD to be able to estimate the effects of various factors on different panel units accurately. In the AMG approach, the set of unobserved common factors is considered as a common dynamic process (CDP). The estimator uses a two-step calculation method. First, it augments the equation with time dummies and makes an estimation using the first difference OLS. The estimated coefficients of the time dummies are collected to form a new variable, which depicts the CDP. This new variable is used as an additional regressor for each group-specific regression model to capture time-invariant fixed effects. Second, as in the mean group (MG) method, the group-specific model parameters are averaged across the panel.

2.3.2.1 Cross-sectional dependence tests

In panel data analysis, it is important to avoid spurious estimation results by testing for the presence of cross-section dependence (CSD) across countries. According to a research paper by Urbain and Westerlund (2006), the assumption of cross-sectional independence is invalid based on the financial and macro-economic data linked to the economy. The paper highlights the need to account for this dependence when analysing panel data. Therefore, the present study applies multiple CSD tests to identify any possible presence of standard shocks and unobserved components. We test CSD by adopting two recently developed methods. The first test is the weak CSD test developed by Pesaran (2015). The CSD test statistic in Pesaran (2015) is calculated as follows.

$$CSD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \qquad i,j = 1,2,\ldots.,N \quad (2.5)$$

$$\hat{\rho}_{ij} = \frac{\sum_{t-1}^{T}\hat{\mu}_{it}\,\hat{\mu}_{jt}}{\left(\sum_{t=1}^{T}\hat{\mu}^{2}{}_{it}\right)^{1/2}\left(\sum_{t=1}^{T}\hat{\mu}^{2}{}_{jt}\right)^{1/2}}$$

where $\hat{\rho}_{ij}$ is the estimated correlation between the individual units *i* and *j*.

In addition, we use the exponent of CSD test, developed by Bailey et al. (2016), to estimate whether the dependence is weak or strong, with the latter causing a problem for inference (Chudik et. al., 2011; Pesaran, 2015). Calculating the Bailey et al. (2016) test for CSD and estimating the bias-corrected exponent (α) for all variables are useful because they provide a quantitative measure of the degree of CSD in panel data. The exponent of CSD test helps researchers assess the level of interdependence between the individual units in the panel.

Using this test, researchers can better understand the strength and significance of CSD in their datasets. This measure helps in evaluating the extent to which the observations within the panel are related to each other, beyond what can be explained by chance or random variation.

The measure of the degree of CSD is alpha (α) and it is calculated as being between 0 and 1. The definition of weak and strong CSD using bias-corrected estimators (α) is as follows.

$$0 \leq \alpha < 0.5 \qquad The\ CSD\ is\ Weak$$

$$0.5 \leq \alpha < 1 \qquad The\ CSD\ is\ Strong \qquad (2.6)$$

2.3.2.2 Panel regression

The baseline symmetric regression model is:

$$\Delta TG_i = \beta_1 \, \hat{\xi}_{t-1}^{OSS} + \beta_2 \, \hat{\xi}_{t-1}^{ADS} + \beta_3 \, \hat{\xi}_{t-1}^{OSDS} + \beta_4 \, \Delta log \, (RER)_{i,t-1} + \beta_5 \, \Delta log \, (RGDP)_{i,t-1} + \mu_t \quad (2.7)$$

where ΔTG_i is the change in government spending, government revenue and government budget of country 'i' at year 't', all measured as a proportion of GDP.

We include a one-year time lag to reduce the contemporaneous correlation between fiscal balance indicators in oil-exporting countries and oil shocks.[7] The terms for lagged oil shocks are $\hat{\xi}_{t-1}^{OSS}$, $\hat{\xi}_{t-1}^{ADS}$ and $\hat{\xi}_{t-1}^{OSDS}$ for oil supply shocks, oil aggregate demand shocks and oil-specific demand shocks, respectively. μ_t is the error term. Furthermore, following El Anshasy and Bradley (2012), we use two control variables in our panel regression which are linked with the growth of budget variables in oil exporting countries. The real USD exchange rate variable for country 'i' is represented by the term $\Delta log \, (RER)_{i,t-1}$, while the real GDP for country 'i' is expressed by the term $\Delta log \, (RGDP)_{i,t-1}$.

However, in order to estimate the asymmetric regressions, the oil shocks have to be defined as positive or negative, using Mork's (1989) definition, thus:

$$\xi_{t-1}^{i+} = \begin{cases} \xi_{t-1}^{i} \; if \; \xi_{t-1}^{i} > 0, \\ 0 \; if \; \xi_{t-1}^{i} \leq 0 \end{cases} \quad \text{and} \quad \xi_{t-1}^{i-} = \begin{cases} \xi_{t-1}^{i-} \; if \; \xi_{t-1}^{i} \leq 0 \, , \\ 0 \; if \; \xi_{t-1}^{i} > 0 \end{cases} \quad (2.8)$$

where ξ_{t-1}^{i+} is the value of shocks when the shocks are positive and 0 otherwise, and ξ_{t-1}^{i-} represents the value of shocks when the shocks are negative, and 0 otherwise.

Then, the baseline asymmetric regression model is:

$$\Delta TG_i = \beta_1 \, \hat{\xi}_{t-1}^{OSS+} + \beta_2 \, \hat{\xi}_{t-1}^{OSS-} + \beta_3 \, \hat{\xi}_{t-1}^{ADS+} + \beta_4 \, \hat{\xi}_{t-1}^{ADS-} + \beta_5 \, \hat{\xi}_{t-1}^{OSDS+} + \beta_6 \, \hat{\xi}_{t-1}^{OSDS-} + \beta_7 \, \Delta log \, (RER)_{i,t-1} + \beta_8 \, \Delta log \, (RGDP)_{i,t-1} + \mu_t \quad (2.9)$$

[7] Following the Jibril et al. (2019) argument that it is challenging to entirely exclude the possibility of contemporaneous relation between oil supply shocks and trade balances of oil-exporting countries. Adding a one-year time lag to the shock variable can help reduce the contemporaneous correlation between fiscal balance indicators in oil-exporting countries and oil shocks. By introducing a lag, it allows for a time delay between the occurrence of oil shocks and their impact on fiscal balance indicators. This temporal gap helps to minimise the potential simultaneous effects and correlations between these variables.

Where the positive and negative oil supply shocks are represented by the terms $\hat{\xi}_{t-1}^{OSS+}$ and $\hat{\xi}_{t-1}^{OSS-}$, respectively,

$\hat{\xi}_{t-1}^{ADS+}$ and $\hat{\xi}_{t-1}^{ADS-}$ are positive and negative shocks to aggregate demand shocks, and

$\hat{\xi}_{t-1}^{OSDS+}$ and $\hat{\xi}_{t-1}^{OSDS-}$ are positive and negative shocks to oil-specific demand,

while other variables are defined in the previous equation (2.7).

2.4 Empirical results

2.4.1 SVAR auto-regressive analysis – stage one

Figure 2.2 shows the historical evolution of annual structural shocks from 1976 to 2019[8]. Overall, our estimates align with the findings of Kilian (2009) for the years 1976 to 2007, but this study extends the sample until the end of 2019, capturing oil price shocks in recent years. The figure shows that the real price of oil responds to numerous events. For example, we note that the large fall of oil supply in 1980 is associated with the Iran-Iraq war. Episodes such as the Iranian revolution in 1979 and the Arab Spring in 2011 are associated with an increase in oil-specific demand caused by concern about future oil supply. We find that the increase in real oil prices from 2002 to the middle of 2008 is due to strong economic activity (an increase in aggregate demand). The drop of real oil prices in late 2008 indicates the decline in aggregate demand shock.

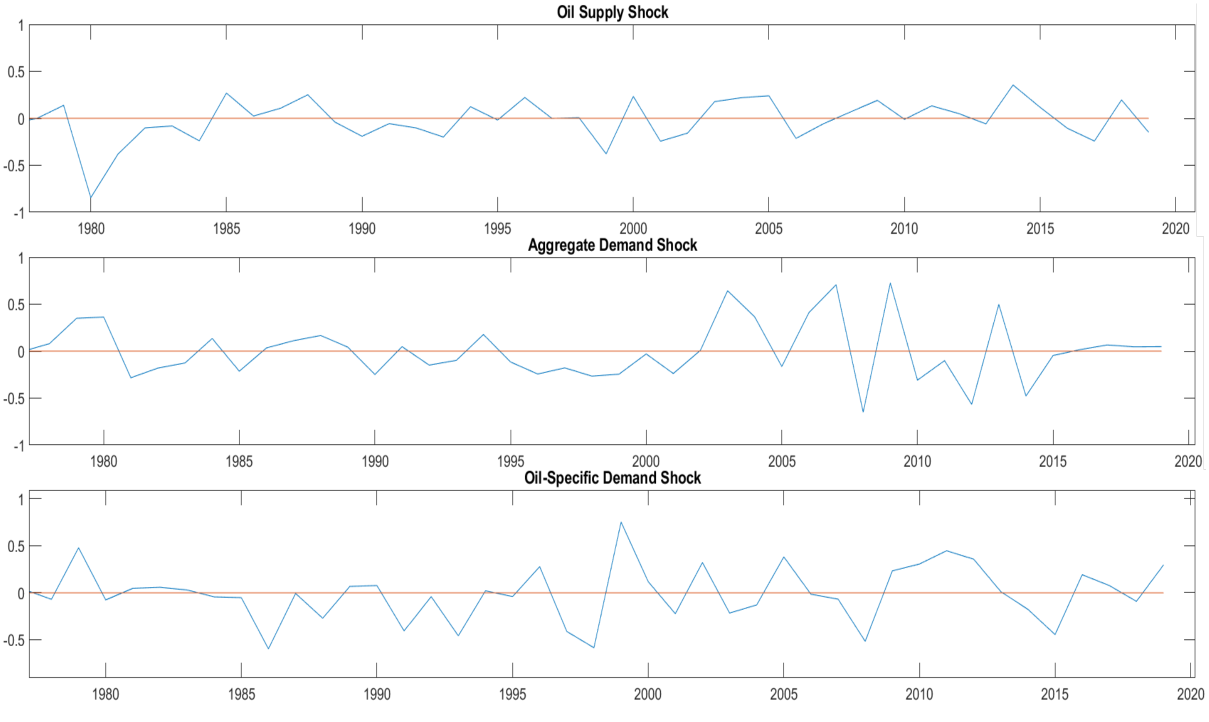


Figure 2.2: Historical evolution of structural shocks, 1976-2019 (annual data)

[8] In this figure, we transformed the monthly structural oil shocks, constructed from SVAR, into annual oil shocks similar to the plotted figure in Kilian's (2009) paper. This transformation helps us to make the figure readable and to align each episode year of oil shocks with its associated type of oil shocks.

Figure 2.3, below, illustrates the impulse response analysis for global crude oil production, real economic activity and the real price of oil to the one-standard-deviation structural shock. Graph (a) demonstrates that an unexpected decrease in oil supply caused by political instability leads to an instant sharp decline in global oil production. In addition to this, a slight recovery of global oil production is seen after one year. In the presence of a negative shock in oil production in one area, other oil-exporting countries worldwide raise their production levels.

Graph (b) shows that an unanticipated disruption in oil supply does not significantly affect real economic activity. Simultaneously, an unexpected disruption causes a minor rise in the real price of oil (graph (c)). Graph (d) shows that an unexpected surge in aggregate demand leads to an upsurge in global oil production and, hence, becomes vital right after the occurrence of the shock. Graph (e) demonstrates that there is a substantial and statistically significant, unexpected increase in global real economic activity.

Graph (f) explains a pronounced and statistically significant unanticipated upsurge in global real economic activity, which has subsequently contributed to a substantial and persistent increase in real oil prices. Graph (g) shows that an unexpected rise in oil-specific demand does not affect global oil production, and outcomes remain stable over the period. It can be clearly seen from graph (h) that an unexpected increase in oil-market-specific demand causes a temporary increase in real economic activity, which is observable up to the tenth month.

Finally, graph (i), illustrating an unexpected rise in oil-specific demand, indicates an enormous instant surge in the real price of oil, which is substantial and noteworthy. In aggregate, the overall outcomes shown in Figure 2.3 further validate the results of Alquist and Kilian (2010) and Kilian (2009).

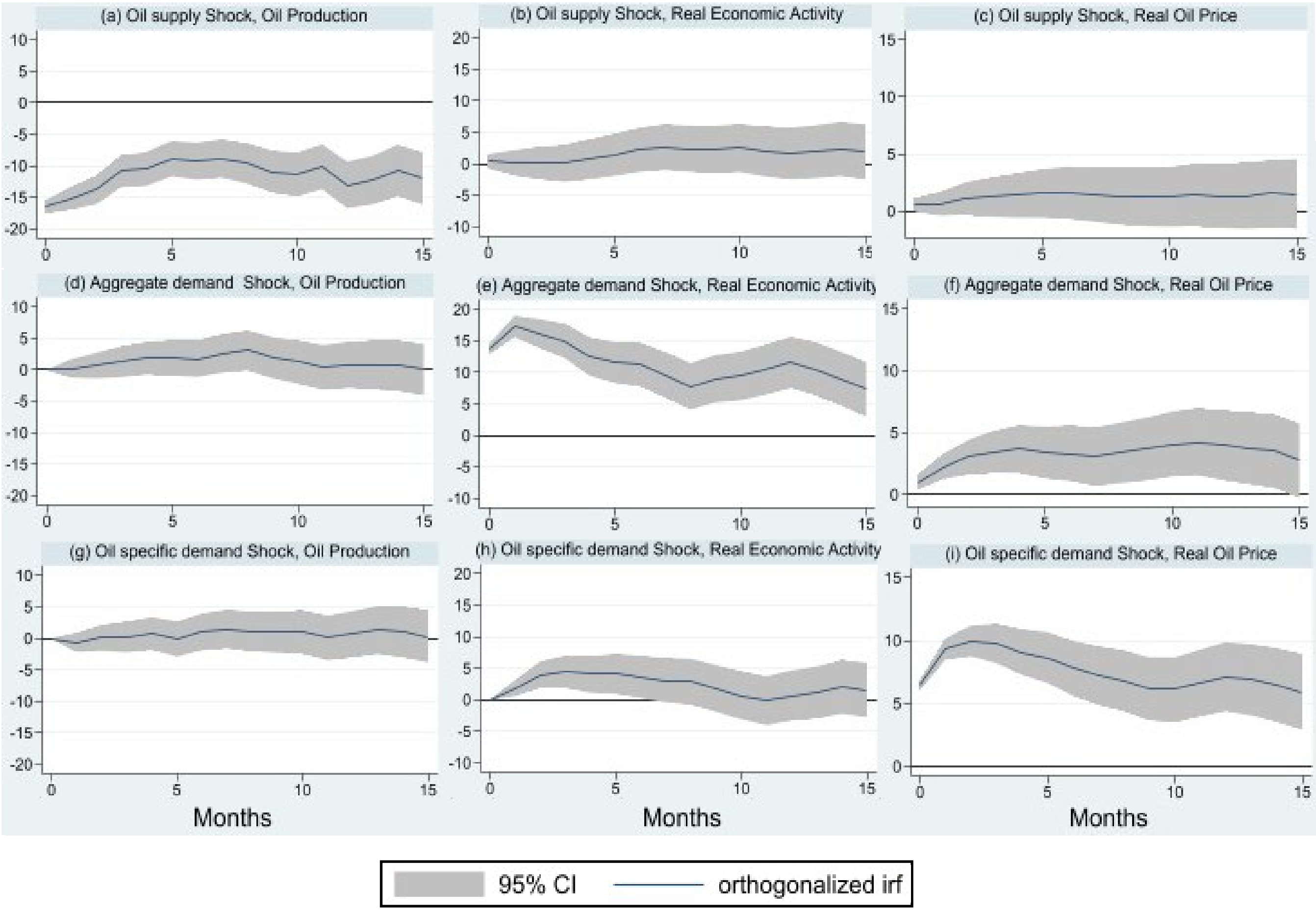


Figure 2.3: Impulse response analysis to a one-standard-deviation shock (Oil supply shock a, b, c; aggregate demand shock d, e, f; and oil-specific demand shock g, h, i)

Overall, from Figure 2.3, our results show that aggregate demand and oil-specific demand shocks play a crucial role in explaining the majority of the fluctuations in oil prices. However, the most significant result arises from impulse response analysis of the oil supply shortfalls that have a small and partial effect on oil price changes. Disruptions in oil production in one country are balanced by changes in surplus oil availability from other parts of the world. However, a question arises as to whether the substantial fluctuations in current oil prices can be explained by the recent political events in the Middle East. The findings presented in Figure 2.3 support the notion of a significant increase in the demand for oil. Recent changes in precautionary demand may be the result of shifting expectations about future oil supply. These changes in demand are directly influenced by external policy developments in the Middle East, which ultimately lead to a sharp rise in oil prices.

It is important to investigate in detail how oil price shocks impact on the macro-economies of major oil-exporting countries and how their economies respond according to different oil shock causes. This will be discussed in the next section.

2.4.2 Consequences of oil shocks on oil-exporting economies - stage two

2.4.2.1 Cross-sectional dependence

Before running the panel regression, it is important to test for the presence of cross-sectional dependency (CSD) among the panel units. Table 2.1, below, presents the weak CSD test and the measured α of CSD for the dependent and independent variables. The results show that the null hypothesis of weak CSD cannot be rejected for all of the variables and we therefore accept that there is strong CSD for these variables in oil-exporting countries. The results of Bailey et al.'s (2016) exponent of CSD test show that all of the variables have strong exponents, with α greater than 0.5 for most of the variables. However, based on the results in Table 2.1, we should choose an appropriate diagnostic test for panel data which can deal with the presence of strong CSD.[9] As a result, to eliminate the estimation bias from the models with strong CSD, we adopt the augmented mean group (AMG) method in the next section, as this is a powerful estimator under conditions of CSD and heterogeneity.

2.4.2.2 Symmetric model

In this section, we use our panel regression specified according to equation 2.7. We examine the effects of structural shocks on government expenditure, revenue and budget balance in oil-exporting countries, each as a proportion of GDP. Table 2.2 shows the results using the augmented mean group (AMG) model.

[9] We apply the first and second generation of cross-sectional panel unit to estimate the stationary and non-stationary time series variables. We use the wasteland co-integration tests. All the tests are presented in the Chapter Appendices.

Table 2.1: Pesaran (2015) cross-sectional dependence tests and Bailey et al. (2016) exponent of cross-sectional dependence test

Variable	CD	P-Value	$\hat{\alpha}_{0.05}$	$\hat{\alpha}$	$\hat{\alpha}_{0.95}$
ΔTGE_t	7.798	0.000	0.7260615	0.701283	0.7609693
ΔTGR_t	25.010	0.000	0.5876792	0.6534879	0.7192966
ΔGB_t	25.536	0.000	0.7518178	0.6551834	0.7436776
$\Delta\ln(RER_t)$	6.381	0.000	0.4007599	0.3370979	0.4644218
$\Delta\ln(RGDP_t)$	41.245	0.000	0.9477875	1.014208	1.080629
ξ^{OSS}	117.000	0.000	0.9465752	1.003641	1.060706
ξ^{ADS}	117.000	0.000	0.8279413	1.003247	1.178553
ξ^{OSDS}	117.000	0.000	0.9413149	1.003696	1.066078

H_0: errors are weakly cross-sectionally dependent (Pesaran, 2015), $0.5 <= \hat{\alpha} < 1$ implies strong cross-sectional dependence (Bailey et al., 2016).

Table 2.2: Symmetric effects of price shocks on macro-economic indicators in oil-exporting countries

	ΔTGE_t	ΔTGR_t	ΔGB_t
$\hat{\xi}^{OSS}_{t-1}$	-0.00464	-0.01133	-0.00388
	[0.00726]	[0.01257]	[0.02007]
$\hat{\xi}^{ADS}_{t-1}$	-0.00789	0.02094***	0.02548***
	[0.00482]	[0.00557]	[0.00929]
$\hat{\xi}^{OSDS}_{t-1}$	-0.02736***	0.08913***	0.14552***
	[0.00862]	[0.01599]	[0.03005]
$\Delta \ln(rer_{t-1})$	0.06362**	0.03375**	-0.03228*
	[0.02846]	[0.01721]	[0.01921]
$\Delta \ln(rgdp_{t-1})$	0.07286***	0.01183	-0.04917*
	[0.02035]	[0.02037]	[0.02551]
CDP	0.28260***	0.93968***	0.59723***
	[0.09656]	[0.14551]	[0.12248]
cons	-0.00850	-0.02254***	-0.01591
	[0.00784]	[0.00611]	[0.01206]
RMSE	0.0530	0.0398	0.0713
N	521	527	520

* p<0.1; ** p<0.05; *** p<0.01. AMG is the Eberhardt and Teal (2010) and Bond and Eberhardt (2013) model. CDP is common dynamic process. RMSE is the root mean square error. N is the number of observations. All the variables are defined in equation 2.7.

The response of fiscal indicators to symmetric oil supply shocks

The symmetric results support the evidence that oil supply disruption shocks, which lead to increased oil prices, have negative but statistically insignificant impact on the three fiscal indicators in oil-exporting, developing countries. The findings are in line with previous studies which show that oil supply disruptions have an insignificant impact on oil price movements and at the same time have minimal impact on internal and external balances in oil-exporting developing countries, as is shown by Kilian (2009) and Kilian et al. (2009). This estimation supports the role of big oil producer, Saudi Arabia, in offsetting any production shortfalls in the oil market (Fattouh and Economu, 2019). As a result, the impact of oil supply disruption on the fiscal balance of oil-exporting developing countries is muted.

Response to symmetric aggregate demand shocks (ADS)

The findings presented in Table 2.2 indicate a significant relationship between aggregate demand shocks and both total government revenue and the government budget, but not in the case of government expenditure. During the periods of strong aggregate demand for oil, we observe a decrease of 0.8% in government expenditure as a proportion of GDP, although this result does not reach statistical significance.

Furthermore, the results indicate a significant impact on total government revenue as a proportion of GDP, with positive coefficient of 0.02094, which leads to a government budget surplus of 0.02548% of GDP in oil exporting countries. The finding of a significant impact on total government revenue as a proportion of GDP, resulting in a government budget surplus in oil-exporting countries, are understandable considering the unique characteristics of these nations. Oil-exporting countries rely heavily on oil-related revenues as a main source of government income. Therefore, when oil prices increase or remain at high levels due to strong global economic activity, it naturally leads to a corresponding rise in total government revenue, driven by higher earnings from oil exports. This additional revenue contributes to a budget surplus. Our findings align with previous studies that highlight the strong economic growth experienced by oil-exporting countries during periods of robust global demand for fuel, particularly observed between 2000 and the onset of the global financial crisis in 2008 (e.g. International Monetary Fund, 2010).

Response to symmetric oil-specific demand shocks

Kilian's (2009) research findings shed light on the primary drivers of oil price fluctuations, highlighting the significant role played by oil-specific demand shocks. These shocks are typically observed during periods of political instability in the Middle East, triggering concerns about potential future oil shortages in the region. The results from our panel regression further support these findings, with all the dependent variables showing significant relationships at the 1% level. This suggests that fiscal indicators in oil-exporting countries are extremely sensitive to changes in precautionary demand shocks.

Specifically, positive oil-specific demand shocks have a substantial impact on total oil revenue, increasing it by 8.9% of GDP. This implies that when oil prices rise due to such demand shocks, oil-exporting countries observe a significant increase in their overall revenue. Consequently, we observe a decline in government spending as a proportion of GDP, indicating how these countries respond to the surge in oil prices resulting from oil-specific demand shocks. These results align with previous studies in the literature that examine fiscal policy behaviour in oil-exporting countries. For instance, El Anshasy and Bradley (2012) also found evidence that positive oil price shocks can lead to a decline in the ratio of government spending to the size of the economy. The authors argue that the negative relationship between government expenditure as a ratio of GDP and oil price shocks may reflecting some increasing prudence in fiscal policy in oil producing countries.

The behaviour of governments in response to positive oil-specific demand shocks mirrors their response to positive aggregate demand shocks. It is evident that governments tend to save a portion of their oil revenues in the short term, as reflected in the improved government budgets in oil-exporting countries. This strategic approach enables governments to take advantage of the temporary rise in oil prices and efficiently handle their budgets, benefiting from the positive effects on government revenue and GDP.

Overall, our findings from symmetric estimation suggest that fiscal policy in oil-producing developing countries responds differently depending on the source of the oil shock. The results are consistent with governments ensuring their long-run economic sustainability by not increasing the size of government spending as a proportion of GDP during revenue windfall periods resulting from structural demand shocks. According to the International Monetary Fund (2010), policymakers in oil-producing countries might aim to align fiscal policy with broader macroeconomic developments better by moderating procyclical spending – both by limiting bursts of spending when oil prices rise and by refraining from painful cuts when they drop. On the other hand, the results show that oil supply shocks have a negligible impact on the fiscal indicators, supporting the role of big producers in stabilising market shortages in oil production. These findings contribute to a better understanding of the factors influencing fiscal indicators in the context of oil price shocks.

2.4.2.3 Asymmetric model

In this section, we use our panel regression, specified according to equation 2.9, to examine the effects of structural shocks on government expenditure, revenue and budget balance, each as a proportion of GDP. Table 2.3 shows the regression results using the augmented mean group (AMG) model.

Response to asymmetric structural oil shocks

Table 2.3 shows the results for asymmetric impacts of the three structural oil shocks. There is evidence that the total government expenditure, total government budget and the government budget do not respond to oil supply shocks and oil-specific demand shocks.

Turning to aggregate demand shocks, our results suggest that it is positive aggregate demand shocks that matter for explaining significant changes in the fiscal balances in oil-exporting developing countries. This type of shock encompasses unexpected changes in general demand for industrial commodities that are linked with movements in the global business cycle, and economic theory predicts that positive flow demand shocks enhance real global economic activity and real oil prices. The findings suggest that in response to a positive aggregate demand shock, government expenditure as a proportion of GDP decreases on average by 5.1%, while government revenue as a proportion of GDP rises by 22.4%, and the budget balance as a proportion of GDP improves by 28.4% as a proportion of GDP (all statistically significant at the 1% level). The economic intuition from the results of the asymmetric regression is that, in periods of strong global economic activity, oil revenue increases in oil-exporting developing countries and, as a result, government spending shrinks relative to the size of the economy, as their expectation is that oil prices will continue to rise. This result is in line with the findings of the IMF (2010), which examined the response to recent oil price booms and busts of fiscal policy in oil-producing countries. The IMF results

Table 2.3: Asymmetric effects of price shocks on macro-economic indicators in oil-exporting countries

	ΔTGE_t	ΔTGR_t	ΔGB_t
$\hat{\xi}_{t-1}^{OSS+}$	-0.00666	0.00274	0.00039
	[0.02470]	[0.02049]	[0.02188]
$\hat{\xi}_{t-1}^{OSS-}$	0.01712	-0.02134	-0.03430
	[0.03611]	[0.01939]	[0.04518]
$\hat{\xi}_{t-1}^{ADS+}$	-0.05148**	0.22491***	0.28414***
	[0.02129]	[0.04054]	[0.06646]
$\hat{\xi}_{t-1}^{ADS-}$	-0.02174	0.00504	0.00882
	[0.01377]	[0.01335]	[0.02105]
$\hat{\xi}_{t-1}^{OSDS+}$	-0.00998	0.00315	0.02449
	[0.02597]	[0.00757]	[0.03126]
$\hat{\xi}_{t-1}^{OSDS-}$	-0.00731	0.00018	0.02331
	[0.02502]	[0.01005]	[0.03331]
$\Delta\ln(rer_{t-1})$	0.07447***	0.01329	-0.03470
	[0.02801]	[0.01970]	[0.03783]
$\Delta\ln(rgdp_{t-1})$	0.08468***	0.01091	-0.06905**
	[0.02110]	[0.01986]	[0.02784]
CDP	0.30531**	0.94432***	0.57052***
	[0.12531]	[0.15697]	[0.12609]
cons	0.02994	-0.10545***	-0.18433***
	[0.02767]	[0.02525]	[0.05949]
RMSE	0.0491	0.0382	0.0680
N	521	527	520

CDP is common dynamic process. RMSE is the root mean square error. N is the number of observations. All the variables are defined in equation 2.9.

showed that, during the 2003-2008 commodity price booms, resulting from strong global demand and strong economic growth in advanced countries, such as the USA and emerging countries, such as China, oil-exporting countries tended to reduce government expenditure as proportion of GDP. However, the impact of negative aggregate demand is statistically insignificant and has no impact on our variables of interest in oil exporting countries. One plausible explanation for the lack of significant results observed during periods of weak aggregate demand shocks, as highlighted by Jibril et al. (2019), is the correlation between economic recessions in the United States and increased demand from emerging countries such as China. Specifically, when there is a decrease in oil demand from the US due to weak global demand, emerging countries exhibit strong demand for oil. Conversely, when the US experiences robust economic growth, emerging countries may face a period of recessions.[10]

Allison (2019) emphasises that a disaggregation of variables into positive and negative values should be followed by post-regression tests to examine whether any differences between positive and negative coefficients are statistically significant. The test hypotheses are:

$$H_0: \beta_{ti}^{+} = \beta_{ti}^{-}$$
$$H_1: \beta_{ti}^{+} \neq \beta_{ti}^{-}$$

where β_{ti}^{+} represents the positive coefficients, with i representing supply, aggregate demand or oil-specific demand shocks. β_{ti}^{-} represents the negative coefficients for the shocks.

We use a Wald test to examine the hypothesis for the aggregate demand shocks (ADS), as shown in Table 2.4.

Table 2.4: Wald test

Hypothesis test	ΔTGE_t		ΔTGR_t		ΔGB_t	
	Test Stat	P-Value	Test Stat	P-Value	Test Stat	P-Value
H_0: $\beta_{t,ADS}^{+} = \beta_{t,ADS}^{-}$	3.84	0.0499 **	26.54	0.0000***	15.60	0.0001***

* p<0.1; ** p<0.05; *** p<0.01

[10] In the study conducted by Jibril et al. (2019), it was revealed that certain periods of US economic recessions coincided with robust global demand from emerging countries. Notable instances include the recessions occurring in the years 1990/1991, 2000/2001 and during the Global Financial Crisis (GFC) of 2008/2009. Conversely, during the Asian financial crisis in 1997/1998, the United States experienced a period of strong economic growth, displaying a contrasting pattern.

The results from the asymmetric test presented in Table 2.4 provide compelling evidence of an asymmetric relationship between aggregate demand shocks and our variables of interest. The p-values, which are highly significant at the 5% level for ΔTGE_t and the 1% level for ΔTGR_t and ΔGB_t, indicate that we can reject the null hypothesis of equal coefficients for positive and negative aggregate demand shocks. This finding implies the presence of an asymmetric response, highlighting that the impact of aggregate demand shocks on our variables of interest differs depending on the direction of the shock.

Overall, there are asymmetric relationships between oil shocks and fiscal variables and these are highly significant in the case of positive aggregate demand shocks. The results suggest that positive aggregate demand shocks are the most favourable for the improvement of internal fiscal balances in oil-exporting, developing countries. Unexpectedly, oil supply expansion has an insignificant impact and suggesting that when other producers, such as US shale oil extraction, expand their oil production, fiscal policy in oil exporting countries does not respond to the fall in oil prices.

2.6 Conclusion

This chapter examines the main and recent drivers of oil prices movement and studies the effect of disaggregated oil-price shocks on the fiscal indicators of oil-exporting, developing countries. The study contributes to the large body of work in this area by considering disaggregated shocks and asymmetries in the effects of those shocks on total government expenditure, total government revenue and government budgets as a proportion of GDP.

The research uses monthly and yearly data obtained from various national and international sources. The empirical analysis has two stages. The first stage disaggregates structural shocks using the SVAR methodology developed by Kilian (2009), disaggregating shocks to global oil prices according to their origins: oil supply shocks, aggregate demand shocks and oil-specific demand shocks. The analysis uses data up to the end of 2019 to capture recent variations in oil prices. Our analysis reveals several key findings. Firstly, we observe that there has been a limited impact on oil price changes due to shortages in oil supply since the mid-1970s. This contrasts with the conventional belief that significant fluctuations in oil prices are primarily driven by disruptions in oil supply caused by external political events in the Middle East.

The findings of the first stage confirm the results from previous studies that the main cause of oil-price variation is from oil-specific demand shocks. For instance, between 2011 and mid-2014 the main driver of oil price fluctuations was oil-specific demand shocks due to geopolitical instability in the Middle East, such as the Arab Spring. However, the analysis also shows that the drop in oil prices in mid-2014 was mainly driven by the oil supply expansion resulting from the US boom in shale oil production.

In stage 2 of the analysis, we assess the macro-economic consequences of structural oil shocks on fiscal indicators using a panel analysis of 20 oil-exporting developing economies over the period 1980-2019. The analysis of data in this second part starts by examining cross-sectional dependency, using an approach developed by Pesaran (2015) and Bailey et al. (2016) to test for weak and exponent cross-sectional dependence. The results show strong cross-sectional dependency between panel members. These outcomes pave the way for the use of a recently developed panel regression, the augmented mean group (AMG) model, to identify the symmetric-asymmetric analysis.

Results from the symmetric analysis of the AMG model support the short-run association between aggregate and oil-specific demand shocks and total government spending, total revenue and budget balance (all as a proportion of GDP). The symmetric analysis illustrates the behaviour of policy-makers in oil-exporting, developing countries when there is a revenue windfall and explains that governments tend to be more prudent in respect to oil-specific demand shocks, so that the increased revenue which comes from increased oil prices in aggregate shocks and oil-specific demand shocks is saved in the short run.

Turning to the asymmetric relationships between the variables, the analysis suggests that only positive aggregate demand shocks affect fiscal indicators. The analysis shows a significant, positive relationship between positive aggregate demand shocks and fiscal balances in the short term. The results emphasise that fiscal responses depend on the source of shocks (i.e. supply or demand side) and support the proposition that, in oil-exporting countries, the response of fiscal balances, whether symmetric or asymmetric, depend mainly on the type of demand shocks experienced, while the oil supply shocks have a muted impact. However, the results support the hypothesis of the current study about the existence of asymmetric relationships between fiscal indicators and the aggregate demand shocks only.

Overall, in this chapter, we contribute to the literature in two main ways: first, The Kilian (2009) data end by 2007, in this chapter we extend the SVAR methodology until 2019 and we emphasise the findings that the recent episodes of oil fluctuations depend on the sources of oil shocks and mainly comes from aggregate demand shocks and oil-specific demand shocks. Second, our findings of this chapter extend the scope of previous research papers in oil exporting developing countries (e.g., Eltony and AlAwadi, 2001; El-Anashasy and Bradley, 2012) by examining the impact of the three classical structural oil shocks on macroeconomic indicators in symmetric and asymmetric investigations using the cross-sectional panel estimators (AMG), which were ignored in the previous research work.

2.6 Appendices to Chapter 2

2.6.1 Panel unit root test

There are two forms of panel unit root tests, first generation and second-generation tests, Maddala and Wu (1999) unit root tests and Pesaran (2007) unit root tests. The null hypothesis of both tests is that the panel has a unit root against the alternative that a panel is stationary. Both tests perform well for heterogenous parameters across panel numbers, while the second-generation unit root tests can be used in the presence of cross-sectional dependence. This study applied the first- and second-generation tests for unit root to the dependent and explanatory variables. For testing the stationarity of the three innovation shocks, we use tests developed by Maddala and Wu (1999) and Im et al. (2003). This is because the structural shocks are identical across countries in each year and are equal to their cross-section averages. The results show that we cannot ignore the non-stationarity in government spending, total revenue, government budget among countries. On the other hand, the oil supply shocks and aggregated demand and oil-specific shocks are stationary in both tests. (See Table 2.5).

Table 2.5: First- and second-generation panel unit root tests

Variable	Maddala and Wu (1999) Unit root tests (MW)		Pesaran (2007) Unit root tests (CIPS)		Im et al. (2003) Unit root test – oil shocks
	Level	1st difference	Level	1st difference	
TGE	48.839	211.742***	-0.754	-6.127***	-
TGR_t	33.201	151.406***	0.481	-4.913***	-
GB_t	52.151*	201.511***	-2.985	-5.381***	-
$\ln(RER)_t$	48.775	132.114***	-3.186***	-6.217***	-
$\ln(RGDP)_t$	34.658	132.114***	-0.358	-5.592***	-
ξ^{OSS}	373.237***	-	-	-	-23.9795***
ξ^{ADS}	229.271***	-	-	-	-33.4502***
ξ^{OSDS}	399.307***	-	-	-	-24.0066***

Notes: All of the tests conducted in this study assume a null hypothesis that the series have unit roots, indicating non-stationarity, and the alternative hypothesis is that the series are stationary. To account for any potential time trends, a time trend variable is included in all the tests except for oil shocks. The number of lags that minimizes the Akaike Information Criterion (AIC) is selected for each test.

2.6.2 Short-run and long-run estimation method

In this study, the Westerlund bootstrap method proposed by Westerlund (2007) is employed to conduct the co-integration tests. This test is powerful for dealing with cross-sectionally dependent units and solves the problem of heterogeneity. The null hypothesis of Westerlund (2007) is no co-integration among variables, with the alternative hypothesis suggesting otherwise. For panel statistics, it is indicated by P_a and P_t and mean group statistics through G_a and G_t. The results in the table below show that there is no co-integration among the variables.

Table 2.6: Westerlund (2007) CSD robust co-integration tests

	TGE		TGR		GB	
Statistic	Value	P-Value	Value	P-Value	Value	P-Value
Gt	-2.884	0.380	-2.736	0.440	-3.124	0.220
Ga	-7.528	0.800	-7.294	0.910	-5.913	0.970
Pt	-9.844	0.610	-13.555	0.020	-9.633	0.610
Pa	-5.592	0.930	-8.774	0.230	-5.265	0.870

Notes: Bootstrapping regression with 100 repetitions; H0: no co-integration and Ga test the co-integration for each country individually, and Pt and Pa test the co-integration of the panel as a whole.

Table 2.7: List of oil-exporting developing countries in the sample

Algeria	Iran	Nigeria
Angola	Iraq	Oman
Azerbaijan	Kazakhstan	Saudi Arabia
Bahrain	Kuwait	United Arab Emirates
Brunei	Libya	Russia
Congo, Republic of	Malaysia	Venezuela
Gabon	Mexico	

Table 2.8: Variable definitions and sources

Abbreviation	Variable	Source
$prod_t$	Global oil production	US Energy Information Administration (EIA)
rea_t	Global real economic activity	Lutz Kilian's website
rpo_t	Real oil prices	US Energy Information Administration (EIA)
TGE_t	Total government expenditure (% of GDP)	International Monetary Fund
TGR_t	Total government revenue (% of GDP)	International Monetary Fund
GB_t	Government budget balance (% of GDP)	Central bank of each country
(RER_t)	Real exchange rate	Author's calculation
$(RGDP_t)$	Real GDP (in current US $)	World Bank
ξ^{OSS}	Oil supply shock	Author's calculation
ξ^{ADS}	Aggregate demand shock	Author's calculation
ξ^{OSDS}	Oil-specific demand shock	Author's calculation

Table 2.9: Descriptive statistics

Variable	Observations	Mean	Standard Deviation	Min.	Max.
Stage 1					
Global Oil Production	540	.945	18.112	-118.887	77.983
Economic Activity Index	540	-.878	53.876	-159.644	190.729
Real Oil Prices	540	-.443	49.129	-128.396	103.978
Stage 2					
Total Government Expenditure (as a proportion of GDP)	563	.325	.167	.1	2.042
Total Government Revenue (as a proportion of GDP)	571	.321	.136	.06	1.04
Total Government Budget (as a proportion of GDP)	562	-.001	.145	-1.513	.433
Real Exchange Rate (Logarithm)	708	3.632	3.229	-.779	15.962
Real GDP(Logarithm)	743	24.61	1.684	21.257	31.906
ξ^{OSS}	800	-.022	.225	-.845	.355
ξ^{ADS}	800	-.008	.312	-.651	.728
ξ^{OSDS}	800	-.02	.295	-.597	.753

Chapter 3

The Impact of Oil Shocks on Monetary Policy in Gulf Countries: What Drives Their Central Banks' Reaction Functions During Oil Price Fluctuations?

Abstract

This chapter investigates the monetary policy reaction functions of selected oil-rich developing countries in the Gulf Cooperation Council (GCC), with a focus on the role decomposed supply and demand oil shocks play in determining interest rates. The paper employs an augmented Taylor rule approach to incorporate three types of oil shocks and examines both symmetric and asymmetric effects of these shocks in modelling interest rates. The findings demonstrate that the impact of decomposed oil shocks on interest rates is relatively muted in symmetric augmented Taylor rule estimations and shows that the central banks in GCC countries take into account interest rate smoothing and foreign policy rates in Bahrain and Oman, while in Kuwait and Saudi Arabia the output gap is important. However, the asymmetric augmented Taylor rule highlights the significance of structural oil shocks in the central bank's reaction functions of Kuwait, Oman, and Saudi Arabia. Additionally, the results indicate that although the GCC economies follow a fixed exchange rate regime, there is evidence that the central banks of Kuwait, Oman and Saudi Arabia assign less weights to the US Fed policy rate in their policy modelling. In contrast, Bahrain's reaction functions strictly align with the US policy rate. These findings contribute to the literature on monetary policy and have implications for oil-developing countries with similar characteristics.

3.1 Introduction

The primary objective of central banks is to maintain price stability and promote economic growth through the implementation of monetary policy, typically achieved by adjusting short-term interest rates. However, during oil price fluctuations, central bankers face the challenge of determining the optimal policy rate. Oil-producing developing countries, in particular, struggle to maintain stable inflation in the face of positive oil price shocks (Choi et al., 2018; Lacheheb and Sirag, 2019; Nasir et al., 2019; Nusair, 2019). Given the essential role of monetary policy in ensuring macroeconomic performance (Mehra, 1999), understanding the reaction functions of central banks becomes crucial. These functions model how central banks set interest rates and analyse the effects of economic shocks on the economy. Our previous study, which investigated the behaviour of fiscal policy in oil exporting developing countries in response to various oil shocks, has motivated this current study. However, there is a significant gap in the literature regarding the impact of oil price shocks on central banks' reaction functions and their response to structural supply and demand oil shocks. Addressing this gap is critical to better comprehend the actual behaviour of central banks and assist monetary policy authorities in understanding the effects of different oil shocks on their policy decisions. Therefore, this study aims to fill this significant research gap by examining how decomposed oil supply and demand shocks influence the determination of policy rates in oil-producing economies, specifically the Gulf Cooperation Council (GCC) countries.

Oil-rich countries often face a condition of “oil dominance” where their macroeconomic indicators are heavily influenced by oil exports, as noted by (Da Costa and Olivo, 2021). According to the literature, the GCC countries experience high inflation rates during periods of rising oil prices. After oil-price shocks in 1990 during the first Gulf War, inflation soared to 9% in Kuwait while it remained below 5% in the other GCC countries. Furthermore, prior to the GFC, the GCC countries faced inflationary pressures. In Qatar, Kuwait, and the United Arab Emirates (UAE), for example, the highest inflation rates were 15.05%, 12.3%, and 12.2%, respectively. To combat the impact of inflationary pressures, GCC governments implemented several policy measures to maintain financial stability. As part of one of these economic reforms, the central banks of Gulf economies raised policy rates to the highest levels in the region, ranging from 6.25 to 5.75 percent.

On the other hand, during periods of low oil prices, the GCC countries suffered from pressures in three periods of the 2000s. The first one was the Global Financial crisis of 2008, when oil prices dropped sharply from $150 per barrel in mid-2008 to around $40 per barrel at the turn of 2009. Consequently, inflation rates in GCC countries decreased rapidly, leading to periods of deflation and negative growth in some regions such as Bahrain and Qatar. As a result, the central banks in GCC countries took action to ease monetary policy by lowering policy rates. The second episode of low oil prices was in 2014-2016, after the shale oil revolution. Although the GCC countries saw a significant drop in inflation rates, central banks did not change their policy rates and monetary policy makers observed that this deflation could be temporary. The most recent collapse of oil prices was in 2020 during the Covid-19 pandemic. According to The Energy Information Agency (EIA)[11], the price of oil sank to levels not seen since 2002 as demand for crude oil collapsed amid the pandemic. As a result, many central banks including those in the GCC countries eased policy rates to levels ranging between 1 and 1.5 percent and adopted expansionary monetary policies[12] to counteract the negative effects of the pandemic-induced economic slowdown and low oil prices. It is evident from the preceding information that central banks in oil-rich countries adapt their policies in response to fluctuations in oil prices, adjusting monetary tightness or easing during periods of both increases and decreases in oil prices. Thus, the research question raised in this paper is how best to model the interest rate setting behaviour of GCC central banks.

A common rule used to estimate policy rates is the Taylor rule. The original Taylor Rule was developed by economist John Taylor in 1993. It is a monetary policy guideline that models the behaviour of central banks in both developed and developing economies. The concept of the baseline Taylor Rule model is that the central bank's primary objectives should be to stabilize inflation and output if there is a deviation of either from target. However, the power of this rule has diminished since the 2000s, and many economists advise that applying the original Taylor Rule is not enough to capture actual central bank behaviour (e.g., Clarida et al., 2000; Svensson, 2003; 2010). Thus, researchers have developed extended reaction functions to capture central bank behaviour with additional variables, such as exchange rates, financial stability indicators, and natural disaster indices (e,g., Ghosh et al., 2016; De Gregorio, 2010; Klomp, 2020; Apergis, 2021). Nevertheless, previous studies have not focused much on exploring the application of augmented Taylor rules specifically in relation to oil shocks, especially in

[11] To read the report: https://www.eia.gov/energyexplained/oil-and-petroleum-products/prices-and-outlook.php.
[12] For more details, see (Mehdi et al., 2022).

economies with rich oil resources. Bernanke et al. (1997) show that the responses of central of central banks to oil price fluctuations has a significant impact on policy variables such as the inflation rate and output growth. Kilian (2010) argues that monetary policymakers should focus on the underlying supply and demand shocks, as these are the global factors driving oil price movements. Consequently, the behaviour of the reaction function might be sensitive to the primary sources of oil price shocks in oil-exporting developing countries, which their economies heavy relay on oil income. In this chapter, we employ three structural oil shocks derived from the global oil SVAR model proposed by Kilian (2009), as presented in the previous chapter. These three significant structural oil shocks are oil supply shocks, aggregate demand shocks, and oil-specific demand shocks.

Existing research indicates that asymmetric Taylor rules could provide a better explanation of central bank behaviour compared to symmetric ones. Empirical studies have consistently shown that central banks tend to react differently when considering Taylor rule indicators like the inflation gap and output gap (e.g., Dolado et al., 2005; Taylor and Davradakis, 2006; Castro, 2011; Martin and Milas, 2013; Caporale et al., 2018). However, our main objective in this chapter is different. We aim to investigate whether the asymmetric augmented Taylor rule can help us understand how structural oil shocks impact the policy rates behaviours in oil-exporting developing countries. In this analysis, we will specifically explore asymmetries in relation to the decomposed oil shocks rather than relying solely on Taylor rule indicators.

In this chapter, we argue that the observed asymmetric preferences in GCC central banks' responses to oil shocks can be attributed to several factors. First, it’s crucial to consider the unique challenge posed by the GCC countries' exchange rate policy—pegging their currencies to the US dollar. This commitment ties their monetary decisions to the movement of the US dollar, which often moves in the opposite direction to oil prices. For example, Setser's research (2007) highlights that when oil prices surge, the US dollar tends to weaken, and vice versa. This mismatch in directions presents a significant challenge for GCC economies, where central banks aim to maintain their fixed exchange rate regime even in the face of unprecedented shocks. Additionally, Hakro and Omezzine (2014) explain the disadvantages of fixed exchange rates in GCC countries, including the contradiction between the US and GCC economies. During oil price fluctuations, while the US may experience recession fears, the GCC nations often enjoy robust growth. This disparity in economic trajectories between the US and GCC during oil price movements inevitably leads to distinct central bank decisions regarding policy rates. Thus, we argue that the response of GCC central banks in setting policy rates could exhibits significant asymmetry in response to various oil shocks. Secondly, it's crucial to differentiate between the sources of oil shocks, whether they are caused from oil supply disruptions or demand shocks. Kilian's research (2009) highlights that oil supply disruptions tend to have a limited impact on oil price movements and we confirm this argument in the previous chapter for recent periods of oil-price fluctuations. As a result, the impact of such disruptions in oil on central bank reaction functions is likely to be limited. In contrast, when an expansion in oil supply leads to a decrease in oil prices, it can potentially slow down the economy in oil-rich countries. In such cases, central banks play a pivotal role in influencing interest rates to stimulate economic growth. Furthermore, we assert that there will be inherent differences in central bank preferences during structural demand shocks. For example, Jibril et al. (2019) find that the impact of positive or negative aggregate demand shocks will be different depending on the sources of recession. For instance, periods of strong economic activity in emerging countries such as China may associated with US recessions, and vice versa. In addition, the authors show that positive oil-specific demand shocks that increase demand due to uncertainty about future shortages may have a greater impact than negative oil-specific demand shocks that result from less uncertainty about future oil supply and may not affect the price of oil. However, we expect that these asymmetric preferences of central banks responses to the structural oil shocks are based on their objectives, such as their declared goal of maintaining exchange rate stability.

The findings of this study contribute to the existing literature in several significant ways. Firstly, using the symmetric augmented Taylor rule, we find evidence that our symmetric augmented Taylor rule estimations can capture the behaviour of the GCC central bank's reaction functions. Secondly, results show that Bahrain's reaction function behaviour strictly follows the US Fed interest rate to protect the stability of the exchange rate. On the other hand, Oman, Kuwait, and Saudi Arabia exhibit different preferences in their reaction functions. These countries assign less weight to the US Fed interest rate and place greater emphasis on smoothing interest rates and considering the output gap. However, our structural oil shocks in symmetric analysis play a limited role in the GCC reaction functions. The asymmetric augmented Taylor rule analysis indicates the importance of considering decomposed oil shocks in adjusting the interest rate in some GCC countries. In particular, we find that oil supply disruptions matter only in Kuwait, and monetary policymakers take action by lowering policy rates during shortages in oil production. In the case of Oman and Saudi Arabia, positive and negative aggregate demand shocks play a significant role in central banks' decisions in determining their policy rates and the central banks take action during the positive aggregate demand shocks larger than the negative side. On the other hand, our asymmetric augmented Taylor rule estimations confirm that the central bank in Bahrain closely aligns its policy rate with the US Fed interest rate.

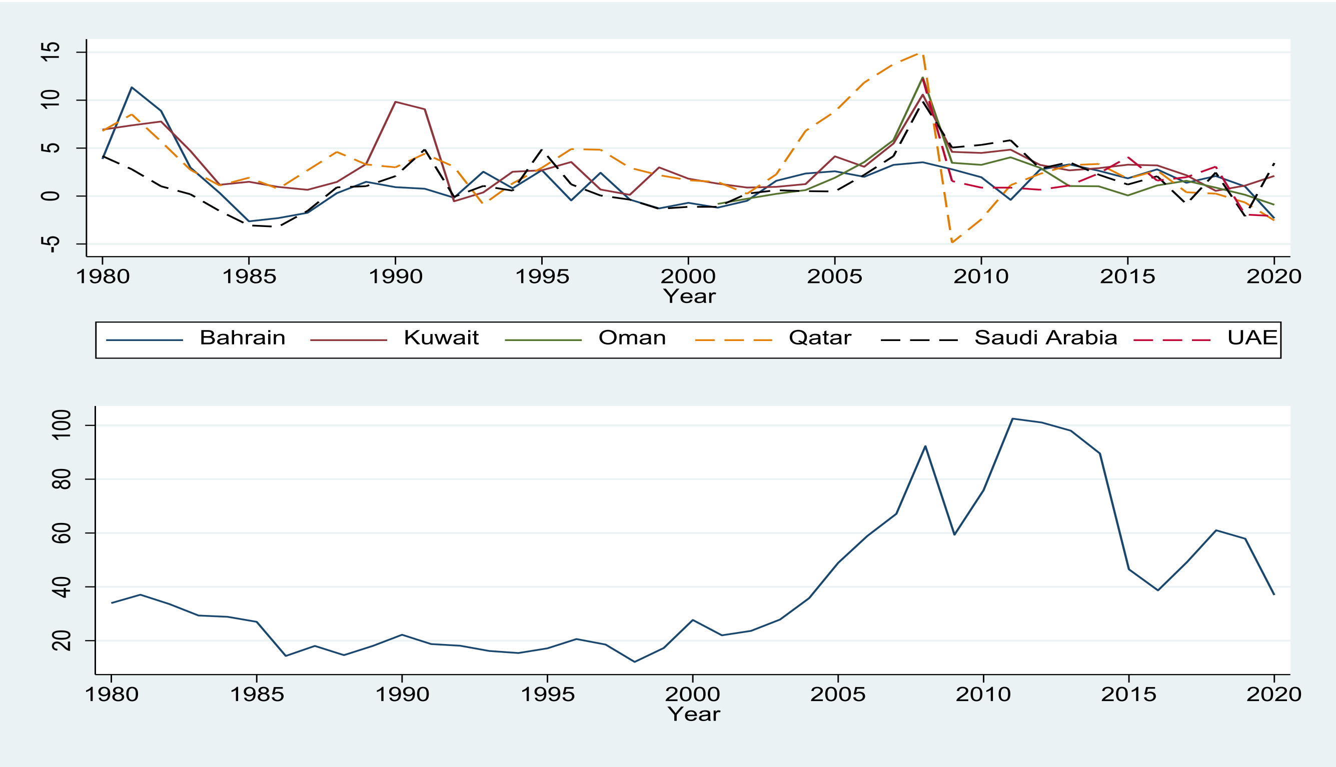
This paper is structured as follows. Section 3.2 provides a review of relevant literature. Sections 3.3, 3.4, and 3.5 set out the methodology, describes the explanatory variables, and discusses the data used, respectively. Section 3.6 presents the results of the study, with a conclusion provided in Section 3.7.

3.2 Literature review

3.2.1 GCC monetary policy background

The Cooperation Council of Gulf Arab States, originally known as the Gulf Co-operation Council (GCC), which is a regional political and economic union, consists of six countries, namely Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. The prime stated objective of monetary policy in the GCC is to maintain exchange rate stability with the aim of mitigating the impacts of inflation, promoting sustainable economic growth, and maintaining low unemployment. All GCC countries have adopted a fixed exchange rate against the US dollar, except Kuwait, which pegs its national currency to a basket of major world currencies. During events such as oil shocks and before the Global Financial Crisis (GFC) in 2008, these countries faced inflationary pressure. Figure 3.1 shows the historical changes in the inflation rates of GCC countries.

Figure 3.1: Annual Inflation Rate (%) in GCC economies and global Crude oil Price (nominal, USD)[13]



Sources: World Bank, Energy Information Administration (EIA)

[13]In this graph, we use data of U.S. Crude Oil Imported Acquisition Cost by Refiners (Dollars per Barrel) at U.S as a proxy of global oil prices, Kilian (2009).

Figure 3.1 illustrates a trend observed between global oil prices and inflation rates in GCC countries. The fluctuations in oil prices affect the inflation rate in these countries in similar patterns. The GCC countries all experienced high inflation during times of high oil price shocks, such as in 1980 during the Iran-Iraq war, in 1990 during the Kuwait Invasion, and before the GFC of 2008. Qatar had the highest inflation rate during the 2008 spike at 15.1%, followed by Oman and UAE at 12.2%, Kuwait at 10.5%, and Saudi Arabia at 9.8%, while Bahrain had the lowest rate at 3.5%.

The graph reveals that the GCC countries are under pressure due to inflation during times of high oil price. On the other hand, when oil prices decrease, the inflation rates in GCC economies tend to decrease, with some countries experiencing periods of deflation. For example, during the Global Financial Crisis, Qatar had the lowest negative inflation rate of 4.8%. Furthermore, during the COVID-19 pandemic in 2020, when oil prices dropped significantly, GCC countries faced deflation. Qatar, Saudi Arabia, and the UAE had negative inflation rates of -0.66%, -2.09%, and -1.93%, respectively. After the Global Financial Crisis in 2007-2008, an IMF article IV consultation in 2008 revealed that the United Arab Emirates (UAE) and Qatar experienced a prolonged period of negative real interest rates. On the other hand, the other members of the GCC experienced notably low real interest rates throughout that period.

In summary, the increase or decline in oil prices significantly impacts domestic prices in oil-rich countries. The graph suggests that the GCC economies are sensitive to oil price changes, with high inflation rates during periods of high oil prices and deflation during low oil prices, as noted by Setser (2008). These findings highlight the need for GCC countries to adopt effective monetary policies to mitigate the adverse effects of oil price fluctuations on their economies.

Researchers observed that after the GFC, the GCC countries have at times let policy rates changes deviate from the interest rate changes set by the US Federal Reserve. According to Espinoza and Prasad (2012), the GCC rates have diverged from the US Federal Reserve rates, the GCC rates have diverged from the US Federal Reserve rates in several situations, and some countries have delayed reducing their interest rates. The study also found that the behaviour of GCC domestic inter-bank rates deviates from US rates to varying degrees, except for Bahrain and Saudi Arabia, which have a similar domestic interest rate pattern to the US. In contrast, Alshewey (2014) highlights a significant deviation of Saudi Arabia, and confirm the deviation for Qatar, and the UAE from the US after the collapse of Lehman Brothers. Following the GFC in 2008, the United States decreased its interest rates. In contrast, Qatar, Saudi Arabia, and the UAE encountered high inflation rates during that period (15%, 10%, and 13% respectively). To tackle inflation, the monetary authorities in Qatar, Saudi Arabia, and the UAE pursued a different path from the United States by avoiding a reduction in interest rates. More recently, Nakibullah (2016) investigates the existence of the trilemma for Bahrain, Kuwait, Oman, and Qatar. The findings suggest that Kuwait has short-term independence in its monetary policy, while Qatar did not follow the US interest rate when setting its policy rate after the GFC. However, Bahrain strictly follows the US policy rate. The findings of these studies highlight challenges for monetary policymakers in GCC economies. They emphasize the importance of accurately understanding the behaviour of policy rates and identifying the factors that influencing rate setting in the face of economic shocks.

3.2.2 Monetary policy, oil shocks, augmented Taylor Rule background

This chapter is related to two strands of literature concerning (i) the response of monetary policy indicators to oil shocks in oil-rich countries, and (ii) the effective implementation of monetary policy rules in the framework of an augmented Taylor rule.

Starting with the first strand in the literature, in economies heavily reliant on oil resources, such as the GCC countries, monetary policy indicators, including output, the inflation rate, and interest rates, are vital for ensuring economic stability and promoting overall welfare. Empirical evidence demonstrates that these indicators are highly sensitive to fluctuations in oil prices. Specifically, concerning the output variable, studies such as Mehrara (2008), used a sample of oil-exporting countries, including Kuwait, Qatar, Saudi Arabia, and the UAE in a panel framework. The findings indicated that negative oil shocks had an adverse impact on output growth, while positive shocks had a relatively limited effect. Similarly, Moshiri and Banihashem (2012), using a VAR model and OPEC data from 1979 to 2009, found that positive oil shocks had an insignificant impact on OPEC economic growth. Conversely, Alkhathlan (2013) showed that oil revenues have a strong positive impact on real Gross Domestic Product (GDP) in both the short and the long run in Saudi Arabia. Nusair (2016) found that increase of oil shocks will lead to increasing output growth in GCC countries. The study highlighted that the GCC countries experienced large swings in real GDP growth due to oil price fluctuations.

On the other hand, the inflation rate is a key indicator for monetary policymakers, who monitor and aim to keep it stable within a range. Few studies have examined how oil shocks affect the inflation rate in GCC countries. Kandil and Morsy (2011) showed that oil revenues can add to inflationary pressures by making credit grow and increasing aggregate spending. Mohaddes and Williams (2011) adopted a pairwise approach to investigate the main drivers of inflation differentials in the GCC regions. The findings revealed that fluctuations in the oil cycle significantly impact inflation rates in the GCC countries. Nusair (2019) examined the effects of oil price changes on inflation in GCC countries. The results suggested that rising oil prices have a significant positive effect on inflation in all countries, while falling oil prices have either an insignificant or negative effect on inflation. The study also found that positive oil price changes have a larger impact than negative ones.

Although previous research has acknowledged the significant and substantial impact of oil shocks on GCC economies, there is a lack of exploration into how these shocks affect the reaction functions of GCC central banks and whether incorporating structural shocks into reaction functions can enhance prediction accuracy. This study aims to address this gap in the literature by investigating the role of structural oil shocks on selected GCC central bank reaction functions and assessing the potential improvement in predictive power when incorporating these structural shocks.

Turning to the second strand of the literature relevant to this chapter, most central banks aim to achieve price stability. Estimating reaction functions to the model the factors that central banks consider is one of the methods us to understand central bank behaviour. In this context, the simple symmetric Taylor rule, originally formulated by Taylor (1993), serves as a valuable tool for researchers to understand how the policy interest rate responds to the gap between inflation and its intended target, as well as the gap between output and its potential level. However, economists argue that although the original Taylor Rule might be an effective approach for predicting monetary policy, this approach fails to give a sufficient understanding to the movement of policy rates to different economic shocks. Svensson (2003) suggested that adding more variables than just the inflation gap and output gap could help researchers to better capture the behaviour of central banks in reaction functions. As a result, researchers have investigated the reaction function of central banks by augmenting the Taylor Rule with different indicators.

For instance, Taylor (2001) emphasised the importance of the exchange rate on monetary policy, a position supported by many empirical studies which examine the role of exchange rates in the reaction functions of central banks. Lubik and Schorfheide (2007) showed that exchange rate movements are important for understanding the behaviour of the central banks of England and Canada, but not important in Australia and New Zealand. In the case of emerging economies, Ghosh et al. (2016) found strong evidence that the nominal exchange rate affects the path of policy rates in emerging market economies' (EME) central banks. After the GFC, many studies examine the role of financial stability indicators in capturing the behaviour of interest rates in advanced economies (e.g., Borio and Lowe., 2004; De Graeve et al., 2008; Martin and Milas, 2013; Gross and Zahner, 2021), and in developing and emerging countries (e.g., Camlica (2016) for Turkey; Nair and Anand (2020) for India). Recently, Elsayed et al. (2023) examined the role of financial indicators in GCC reaction functions. The findings for these papers prove that adding external factors to the Taylor Rule method can improve the accuracy of modelling the behaviour of an economy's policy rate.

However, only a few papers have examined reaction functions in terms of oil price fluctuations using the approach of the Taylor rule. For example, L'œillet and Licheron (2012) explored the reaction function of the European Central Bank (ECB) to changes in oil prices using an augmented Taylor rule approach. They found that oil prices have a significant impact on the interest-rate setting process of the ECB, particularly in relation to inflation concerns, with the bank reacting asymmetrically by being more responsive to oil price increases than decreases. Furthermore, Korhonen and Nuutilainen (2017) examined the reaction function of Russia during oil shocks. Their findings show that the oil price plays a crucial role in predicting Russia's policy rate. Recently, Ogiji et al. (2022) showed that asymmetric oil price movements help explain the behaviour of Nigeria's interest rate. These papers, however, do not account for the sources of oil shocks, and that the effects of oil supply shocks may differ from that of oil demand shocks. The current chapter is motivated by the lack of empirical studies on how monetary policy, as reflected by central bank reaction functions, interacts with the original sources of oil shocks in oil-rich countries such as the GCC region.

3.3 Empirical analysis

3.3.1 Symmetric augmented Taylor Rule

Many empirical studies estimate the reaction functions of central banks in developed and developing countries using the baseline Taylor Rule (1993), which assumes that nominal interest rates are determined by a weighted average of deviations of inflation from the inflation target and output from potential output. The simple Taylor Rule is represented by the following equation:

$$i_t = \alpha_0 + \alpha_1(\pi_t - \pi_t^*) + \alpha_2(y_t - y_t^*) + \epsilon_t \qquad (3.1)$$

where i_t is the short-term nominal interest rate, π_t is inflation rate, y_t is the log of real GDP, and π_t^* and y_t^* are the inflation target and log potential output respectively.

However, Clarida et al. (1998) and Svensson (2000) have emphasised that adding external factors to the simple Taylor Rule is important for open economies.

In addition, adding the lagged interest rate is important because in practice central banks adjust the current interest rate from the past one. So, in the present chapter, we augment Equation 3.1 by adding the lagged interest rate, Fed funds rate and the structural oil shocks, i.e. oil supply shocks, aggregate demand shocks and oil-specific demand shocks[14]:

$$i_t = \alpha_0 + \alpha_1 i_{t-1} + \alpha_2 \sum_{k=1}^{4}(E\pi_{t+4} - \pi_t^*) + \alpha_3(y_t - y_t^*) + \alpha_4 fr_t + \alpha_5 \xi_t^{OSS} + \alpha_6 \xi_t^{ADS} + \alpha_6\, \xi_t^{OSDS} + \varepsilon_t \qquad (3.2)$$

where, i_{t-1} is the lagged policy rate. The difference between the expected inflation over the next four quarters and the target inflation rate is represented as $(E\pi_{t+4} - \pi_t^*)$[15] is calculated as the inflation gap, whereas the output gap $(y_t - y_t^*)$ is the difference between the logarithm of real GDP and potential output. The inflation target π_t^* and potential output y_t^* are estimated from a rolling Hodrick-Prescott filter (HP Filter). The term fr_t represents the US Federal Reserve effective policy rate. The variables ξ^{OSS}, ξ^{ADS} and ξ^{OSDS} are oil supply shocks, aggregate demand shocks, and oil-specific demand shocks respectively.

[14] In the next section (3.2), we will explain the description and construction of our explanatory variables.

[15] In our model we calculate the inflation gap by using the expected inflation rate not the current inflation rate as in Taylor rule original model, for more details see Section 3.4.

3.3.2 Asymmetric Augmented Taylor Rule

We extend the augmented Taylor Rule of Equation 3.2 to allow for asymmetric structural oil shocks as follows:

$$i_t = \alpha_0 + \alpha_1 i_{t-1} + \alpha_2 \sum_{k=1}^{4}(E\pi_{t+4} - \pi_t^*) + \alpha_3(y_t - y_t^*) + \alpha_4 fr_t + \alpha_5 \xi_t^{OSS+} + \alpha_6 \xi_t^{OSS-} + \alpha_7 \xi_t^{ADS+} + \alpha_8 \xi_t^{ADS-} + \alpha_9 \xi_t^{OSDS+} + \alpha_{10} \xi_t^{OSDS-} + \varepsilon_t \quad (3.3)$$

In order to analyse the impact of positive and negative shocks, we employ a decomposition method to separate each shock into its positive and negative components. This allows us to examine the effects of positive and negative shocks separately, as we described in the previous chapter. Hence, the terms ξ_t^{OSS+}, ξ_t^{OSS+} , ξ_t^{ADS+}, ξ_t^{OSS-}, ξ_t^{OSDS-} and ξ_t^{OSDS-} represent the positive and negative shocks associated with oil supply shocks, aggregate demand shocks, and oil-specific demand shocks, respectively.

The current study implements the generalised method of moments (GMM) to analyse the augmented Taylor Rules of equations 3.2 and 3.3. The GMM estimator control for any potential endogeneity. Also, GMM estimators utilise orthogonality conditions to permit efficient estimation. Moreover, in the literature, many scientific papers use the GMM model to estimate the original and extended Taylor Rules. We follow Clarida et al. (2000), Taylor and Davradakis (2006), and Caporale et al. (2018) in choosing the instruments for quarterly data. Therefore, the instruments in this model are up to four lags and the constant. It is very important to examine the validity of the instruments, since our model in this study is over-identified. This paper applies the Sargan test to confirm that the over-identified restrictions are valid.

3.4 Explanatory variables description

This section elaborates on the construction of the explanatory variables which we use it on augmented Taylor rule equations for central banks in GCC countries.

3.4.1 Lagged interest rate

Evidence suggests that in practice, central banks smooth interest rates (Amato and Laubach, 1999; Rudebusch, 2002). The importance of adding the lagged interest rate i_{t-1} is highlighted by Clarida et al. (2000), who pointed out that the lagged interest rate can help explain and capture the actual behaviour of central bank decisions and enhance the prediction. In the current chapter, we allow that past interest rates influence the current interest rate and that policymakers in GCC countries adjust their interest rate slowly. Also, adding the lagged interest rate controls for observed serial correlation.

3.4.2 Inflation gap

The monetary policy rule in many developed and developing countries pursues implicit or explicit inflation targets. A key variable in the Taylor Rule concept is the inflation gap, estimated by the difference between the expected inflation rate and the inflation target. We assume in the present chapter that the central banks in GCC countries react to expected inflation one year ahead. This assumption draws support from recent research conducted by Elsayed et al. (2023), which reveals that the interest rates in GCC reaction functions react to inflation gap which is construct it by the difference between expected inflation rate over next four quarters and inflation target. To establish the inflation target, we employ the Hodrick-Prescott filter (HP), a methodology we adopt in alignment with their guidance.

3.4.3 Output Gap

The other variable in the original Taylor Rule is the output gap. This variable can be estimated by the difference between actual output and its potential. It is thought that, over time, actual and potential output should converge in the absence of nominal price rigidities and technological shocks. The economy is said to be in a boom when the output gap is positive, meaning that actual output is higher than potential. A negative output gap indicates that monetary policy should be looser when real output falls below its potential, as per the Taylor Rule. The output gap is a key component of monetary policy strategy. First of all, one of the goals of central banks is to maintain full employment, broadly equivalent to an output gap of zero. Second, the output gap is one of the major variables influencing inflation. A positive output gap indicates an economy that is overheating and pushing inflation higher. A negative output gap indicates a weak economy and pressure on inflation to decline. In the present chapter we detrend the potential output using the popular filter called Hodrick-Prescott filter (HP)[16] with smoothing parameter λ=1600 for quarterly data. The smoothing parameter (λ) in HP is crucial for separating macroeconomic time series data into trend and cyclical components. Therefore, choosing an appropriate value of lambda plays an important role for getting accurate and meaningful results from the detrending procedure. The filter specific value of λ=1600 for quarterly data is a common and appropriate choice in empirical research for quarterly data which is recommended by Hodrick and Prescott (1997). They found that λ=1600 allows the trend line to smooth enough to represent long term growth pattern of economy while still being responsive enough to capture meaningful quarter-to-quarter variation that may be related to the business cycle of US GDP. Consequently, the choice of λ=1600 for quarterly data is widely used and accepted in many empirical studies.[17] We run the HP filter to the selected GCC real GDP variables using a built-in program in Excel.

3.4.4 Foreign Interest Rate

Svensson (2000) argues that optimal reaction functions in open economies should incorporate foreign variables to provide more comprehensive information. He demonstrates that the inflation rate responds not only to domestic factors but also to foreign variables such as foreign inflation, foreign interest rates, and global shocks. In economic theory, countries with fixed exchange rates often adjust their policy rates based on the behaviour of the foreign interest rate. The GCC countries, except for Kuwait, peg their exchange rates to the US dollar, while Kuwait pegs its exchange rate to an undisclosed international basket of currencies that includes the US dollar. Therefore, it is plausible that the US Federal Reserve rate plays a crucial role in the

[16] We use the HP filter due to its adaptability in trend output tracking and its ability to minimise the sum of the squares of the actual output and the potential output (Konuki, 2010). However, Hamilton (2018) developed a new trend technique. Instead of using the HP filter, his filter is a regression filter dependent on forecasting OLS errors. There is still a debate in the literature between the HP filter and Hamilton's Filter. However, one drawback of Hamilton's filter is the loss of two years' observations from the cycle (Schüler, 2020).
[17] See Flaig (2015).

reaction functions of GCC central banks. Empirical studies, such as Frankel et al. (2004) and Shambaugh (2004), have shown that many countries, regardless of their exchange rate regimes, have policy rates that are highly sensitive to changes in the US Fed interest rate.

3.4.5 Structural Oil Shocks

We extend the baseline Taylor Rule in Equation 3.1 (see Section 3.3.1, above) by adding the structural Kilian shocks, namely oil supply shocks (ξ_t^{OSS}), aggregate demand shocks (ξ_t^{ADS}) and oil-specific demand shocks (ξ_t^{OSDS}).We assume that these shocks can improve the ability of the reaction functions to explain the interest-rate setting behaviour of GCC central banks. These shocks were calculated from the global structural VAR model which was developed by Kilian (2009) and estimated including recent episodes of oil shocks in Chapter 2. In addition, we decompose these oil shock into positive and negative shocks to investigate the presence of asymmetric impact of these structural oil shocks on the behavior of the policy rate.

3.5 Data

We estimate the behaviour of the central banks in Bahrain, Kuwait, Oman, and Saudi Arabia because of the availability of long data series for these countries. The quarterly data used are Q4 2008 to Q4 2019 for Bahrain, Q4 2010 to Q4 2019 for Kuwait, Q3 2007 to Q4 2019 for Oman, and Q1 2007 to Q4 2019 for Saudi Arabia. We collect the data from Thomson Reuters DataStream[18].

Table 3.1 presents the descriptive statistics, and it shows that the number of observations for each country varies. The highest mean inflation rates are in Saudi Arabi and Oman, at 3.21% and 2.92% respectively. The policy rate is most volatile in Oman and the least volatile in Kuwait.

Table 3.1: Descriptive statistics

	Bahrain		Kuwait		Oman		Saudi Arabia	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD
i_t	0.97	0.73	2.42	0.37	2.06	1.31	2.58	1.19
π_t	2.08	1.29	2.71	1.35	2.92	3.41	3.21	3.05
y_t	0.00	0.01	0.00	0.06	0.00	0.04	0.00	0.05
fr_t	0.55	0.74	0.63	0.80	0.90	1.29	0.99	1.42
ξ_t^{OSS}	0.04	0.29	0.04	0.30	0.04	0.29	0.04	0.29
ξ_t^{ADS}	-0.07	0.76	-0.06	0.64	-0.02	0.77	0.00	0.77
ξ_t^{OSDS}	0.18	2.05	0.26	1.91	0.18	1.99	0.14	1.99
No.	45		37		51		52	

[18] The main sources of data collection for the variables differ. The quarterly policy rates are obtained from the central bank of each country, while real GDP data is available quarterly, and the inflation rate is available on a monthly basis, with both variables sourced from local statistics bureaus.

3.6 Empirical results

3.6.1 Unit root

The analysis estimates the behaviour of GCC central banks using the GMM estimator. This estimator requires that the variables should be stationary to avoid any spurious regressions. We apply the Augmented Dickey-Fuller (ADF), Dickey-Fuller generalised least squares detrend (DF-GLS), Phillips-Perron (PP) and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests for our variables of interest to check for stationarity. The results are shown in Table 3.2. We found mixed stationary results in different unit root tests for each variable. However, the policy rates in Bahrain and Kuwait are not stationary in the four-unit root tests. According to Gerlach-Kristen (2003), the assumption of stationarity is more likely to be rejected when analysing samples shorter than 20 years. Additionally, it is widely recognized in the empirical literature on reaction functions that many studies overlook the possibility of non-stationarity in the data (e.g., Clarida et al., 2000; Castro, 2011; Martin and Milas, 2004, 2013; Caporale et al., 2018; Guizani and Wierzbowska, 2022). In practice, a central bank typically sets a target interest rate consistent with its inflation objectives, or it may consider other target variables. When inflation deviates from its target, the central bank adjusts the interest rate to mitigate the inflation gap. If the central bank is credible and achieves its goals consistently over long periods, the interest rate should return to the target once shocks are resolved and other variables return to their target levels. As a result, the series becomes stationary as deviations from the mean are eliminated over time. Hence, in this research, we will assume that the interest rates of Bahrain and Kuwait exhibit stationarity.

Table 3.2: Unit root stationary tests

Country	Variable	ADF	DF-GLS	PP	KPSS
Bahrain	i_t	-2.341	-1.740	-0.216	2.133**
	π_t	-3.098**	-3.013*	-2.968**	0.373
	y_t	-6.214***	-5.462***	-6.214***	0.050
	fr_t	-4.738***	-3.719**	-0.562	0.694
Kuwait	i_t	-1.058	-1.503	-0.825	4.417***
	π_t	-2.998**	-3.063*	-2.107	1.407*
	y_t	-2.794*	-2.656	-2.294	0.115
	fr_t	-4.639***	-3.420**	-0.617	0.682
Oman	i_t	-2.532	-1.729	-3.956***	5.807***
	π_t	-4.711***	-3.663**	-2.627*	0.104
	y_t	-4.302***	-3.712**	-4.168***	0.053
	fr_t	-2.576 *	-2.162	-3.742**	2.390**
Saudi Arabia	i_t	-3.055**	-1.731	-2.446	6.632***
	π_t	-4.623***	-4.569***	-3.084**	0.133
	y_t	-3.145**	-3.054*	-3.054 **	0.088
	fr_t	-2.837*	-2.137	-3.326**	2.672***

Notes: $i_t, \pi_t, y_t, and\ fr_t$ represent the policy rate, inflation gap, output gap and US Federal Reserve policy rate respectively. The lag length for the ADF, DF-GLS and PP tests is chosen based on AIC criteria: * p<0.1; ** p<0.05; *** p<0.01. The null hypothesis of the ADF, DF-GLS and PP tests is that the time series is not stationary, but in case of the KPSS test, the null hypothesis is stationary against the alternative of a non-stationary series. Note: The three structural oil shocks are stationary using the unit roots tests (See appendix).

3.6.2 Symmetric augmented Taylor Rule estimation

In this section, we use GMM to estimate the reaction functions of GCC central banks and examine the effects of the three structural oil shocks. Table 3.3 shows the symmetric regressions of the augmented Taylor Rule (equation 3.2) and it can be clearly seen that the coefficients are different in term of magnitude, sign, and significance between the countries. Nonetheless, the findings indicate that the reaction functions of GCC central banks exhibit significant coefficients at a p-value of 0.01 when responding to the lagged interest rate and the US Federal Reserve policy rate, albeit with varying weights.

The results show that the Central Bank of Bahrain (CBB) puts a higher positive weight on the US Federal Reserve interest rate than on the lagged interest rate. The results are plausible since the objective of Bahrain's monetary policy is to stabilise the exchange rate against fluctuations and the country pegs its exchange rate closely to the US dollar. Consequently, the movement of interest rates in Bahrain tends to prioritize the protection of the exchange rate peg regime. However, when examining the response of the Central Bank of Bahrain (CBB) to the inflation gap, we find that it is positive but insignificant. On the other hand, the CBB response aggressively to the output gap with negative and significant weight of 1.852. This suggests that the central bank's reaction in Bahrain deviates from the expected response according to the Taylor rule. This finding is consistent with the research conducted by Elsayed et al. (2023), who also found that the central bank in Bahrain reacts negatively to the output gap. One possible explanation for this result is that during periods when the US is experiencing a recession, while Bahrain is experiencing an oil boom and expansion, the Central Bank of Bahrain choose to align its policy rate with the US by reducing its own interest rates to maintain the exchange rate peg. According to Hakro and Omezzine's book published in 2014, during the period of 2008-2009, while the US was facing the threat of a recession, the GCC countries were experiencing strong and resilient growth. In order to maintain exchange rate stability, the CBB took measures to reduce the interest rate from 4.4% to 1.6% between the years 2007-2009. This decision aimed to support the stability of the exchange rate during a period of economic uncertainty in the United States. In the case of the structural shocks, we conclude that the symmetrical augmented Taylor Rule estimation shows that these shocks have an insignificant impact on the CBB's reaction function and this implies that the objective of central bank in Bahrain is consistent in closely following changes in the US interest rate.

In the case of Kuwait, the findings reveal important insights about its reaction function. Firstly, the reaction function demonstrates a significant response to the lagged interest rate, indicating that past interest rate movements have a notable influence on the current policy rate decision. This is evident from the relatively high weighting coefficient of $\alpha_1 = 0.59$ assigned to the lagged interest rate variable. Secondly, the analysis also highlights the significant and positive impact of the US Fed policy rate ($\alpha_4 = 0.13$) on Kuwait's policy rate. Thirdly, the reaction function shows a small but highly significant negative coefficient of -0.04 for the inflation gap, implying that changes in inflation have a minimal but negative effect on the policy rate in Kuwait. While the impact is statistically significant, it suggests that monetary policy makers in Kuwait are not heavily reliant on inflation considerations when determining the policy rate. Fourthly, the reaction function exhibits a positive response to the output gap, as indicated by the coefficient of 0.63. This signifies that when there is a positive output gap (actual output exceeds potential output), the central bank in Kuwait tends to increase the policy rate. This response aims to maintain inflationary pressures that may arise from an overheating economy. Furthermore, the symmetric augmented Taylor Rule analysis reveals that structural oil shocks have an insignificant impact on the Kuwaiti policy rate. This implies that unexpected changes or events in the global economy do not significantly alter the decision-making process of monetary policy makers in Kuwait.

In Oman, we find that the response coefficient to the lagged interest rate is higher than that of the foreign interest rate. This result confirms the results of Espinoza and Prasad (2012), which indicated a deviation from the US Fed interest rate in Oman. It suggests that the Central Bank of Oman (CBO) places more emphasis on domestic factors and local interest rate dynamics when determining its policy rate. On the other hand, the estimation of our extended Taylor Rule shows that the Central Bank of Oman does not react to inflation and output gaps. In the case of our structural oil shocks, our symmetric augmented Taylor rule estimation finds oil-specific demand shocks, have a significant impact on Oman's interest rate and the response is positive but with a small coefficient value of 0.02.

For Saudi Arabia, the policy rate of the central bank (SAMA) responds aggressively to the deviation of output from its potential level, with a positive coefficient of 1.13 at the 1% significance level, which shows that the output gap plays a crucial role in setting the interest rate in Saudi Arabia. The coefficient of inflation gap is positive but insignificant. The findings provide evidence that the output gap is SAMA's preference in determining their policy rate.

The results are consistent with and corroborate the results of Elsayed et al. (2023), demonstrating that Saudi Arabia tightens monetary policy in response to a positive output gap, and vice versa. Also, the central bank in Saudi Arabia (SAMA) puts a greater weight on the lagged interest rate than on the US Fed interest rate. Both of these variables are highly significant at the 1% level. The symmetric estimation implies that the structural supply and demand oil shocks do not affect the policy rate in Saudi Arabia.

Table 3.3: Symmetric augmented Taylor Rule estimation

Variable	Bahrain	Kuwait	Oman	Saudi Arabia
i_{t-1}	0.293181*** [0.036568]	0.591096*** [0.118545]	0.783716*** [0.047517]	0.813606*** [0.052199]
π_t	0.000633 [0.001325]	-0.043514*** [0.011252]	-0.006561 [0.004927]	0.004199 [0.003870]
y_t	-1.852387*** [0.474717]	0.633408** [0.291420]	0.673820 [0.521619]	1.131016*** [0.435657]
fr_t	0.711212*** [0.031772]	0.135988*** [0.039964]	0.183671*** [0.042752]	0.142806*** [0.016613]
ξ_t^{OSS}	0.013395 [0.013430]	-0.037955 [0.035899]	-0.054975 [0.078135]	0.043170 [0.079611]
ξ_t^{ADS}	-0.009988 [0.009477]	-0.001281 [0.020976]	.0.025618 [0.033673]	0.028120 [0.028204]
ξ_t^{OSDS}	-0.002871 [0.002176]	0.004030 [0.006535]	0.021952** [0.010850]	0.003312 [0.011610]
Cons	0.296855*** [0.016928]	0.874758*** [0.252062]	0.236891*** [0.049527]	0.333385*** [0.105079]
Obsv	41	33	47	48
R-squared	0.99676	0.9390	0.9404	0.8985
Sargan-J- stat P-value	26.8267 0.1767	16.4974 0.7411	30.4502 0.0833	17.8192 0.6604

*p<0.1; ** p<0.05; *** p<0.01. The null hypotheses of the Sargan test, that the over-identified model is valid and the group of instruments are exogenous, are accepted in all countries at p-value 5%.

Figure 3.2: Actual and predicted policy rates – symmetric model

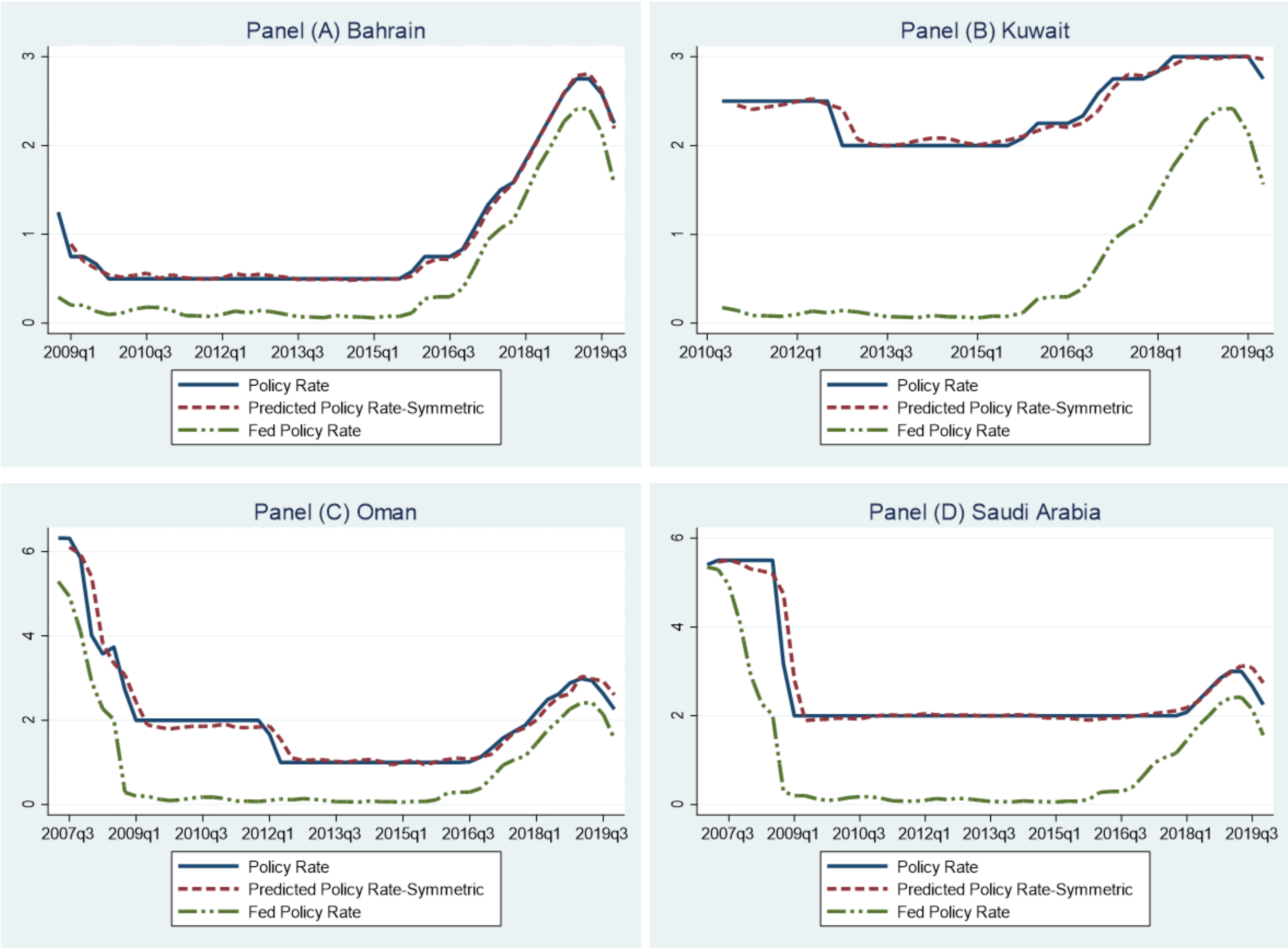


Figure 3.2 presents the actual policy rates in GCC countries, the predicted policy rates and the US Fed policy rate using the symmetric augmented Taylor Rule calculated from Equation 3.2. Panel A shows that the symmetric augmented Taylor Rule can explain the behaviour of the Bahrain Central Bank most of the time. We observe that the decision of the CBB to set its interest rate has a similar pattern to the foreign policy rate and is in line with Al-Raisi et al. (2007) who suggested that the trends in real interest rates of GCC countries and the real interest rates in the US generally move in the same direction. Overall, our symmetric augmented Taylor Rule estimation does an excellent job in explaining the behaviour of reaction functions in Bahrain.

In panel B, the graph illustrates that changes in the Kuwaiti interest rate often deviate from changes in the policy rate set by the US Federal Reserve, despite the fact that Kuwait maintains a pegged exchange rate to an undeclared international basket of currencies, including the US dollar. This indicates that Kuwait's monetary policy tends to exhibit different behaviour compared to the policy rate of the US Federal Reserve across different observed time periods. However, the estimated symmetric augmented Taylor Rule can explain the behaviour of the CBK decisions from Q4 2017 until Q4 2019. In this period, we find that the actual and the predicted policy rates are quite similar. On the other hand, during the period of the Arab Spring from 2011 to 2013, which coincided with an increase in oil prices, the estimated policy rate was higher than the actual policy rate and our augmented Taylor Rule estimations would recommend that the interest rate should have been reduced more slowly during this period, whereas it was actually cut aggressively, from 2.5% to 2%.

Panel C shows the actual policy rate in Oman and the rate predicted by using the augmented Taylor Rule. The actual policy rate moves with the same behaviour as the predicted reaction function. It can be seen clearly that our predicted symmetric augmented Taylor Rule gives an accurate explanation of policy rate setting by Oman's central bank between Q1 2013 and the first two quarters of 2019. Interestingly, our predicted policy rate recommends a slightly lower interest rate than the actual one during the period of weak aggregate demand from 2009-2010. During the oil shocks of Q4 2011 to Q4 2012, which coincided with the Arab Spring and a surge in oil prices, the graph illustrates a deviation of Oman's central bank's decisions from the US Fed rate. The Omani policy rate was cut and remained closer to that of the US Fed policy rate for the remainder of the period. However, our predicted policy rate suggests rates could have been cut slightly less aggressively. This discrepancy could be attributed to various factors. One possible reason is likely that the Omani economy was experiencing a slowdown in economic activity and a low inflation rate during that time. Initially, the central bank may have intended to implement a more substantial interest rate reduction to address these challenges and to support economic growth and maintain price stability.

Lastly, the behaviour of the actual policy rate and that predicted by the symmetric augmented Taylor Rule estimation in Saudi Arabia can be seen in Panel D in Figure 3.2. Notably, the predicted and actual policy rates exhibit a similar pattern from the third quarter of 2009 until the end of the period. This alignment indicates that the central bank's actions in Saudi Arabia were in line with the recommendations derived from the augmented Taylor Rule during this period. The predicted policy rates closely track the actual policy rates, suggesting that the central bank's decisions were consistent with the model's framework. However, there is a slight deviation observed in the estimated policy rate from the first quarter of 2007 to the first quarter of 2009, which coincided with the Global Financial Crisis. During this period, the estimated Taylor Rule recommends that the policy rates should have been cut a year or so earlier, but then slightly less aggressively, implying that the central bank should have pursued a more accommodative monetary policy.

3.6.3 Asymmetric augmented Taylor Rule estimation

In this section we want to examine the impact of positive and negative structural shocks on the central bank reaction functions of these GCC countries. Table 3.4 shows the estimates of Taylor Rules augmented with terms capturing asymmetries in the reaction to structural oil shocks.

In the case of Bahrain, the asymmetric augmented Taylor rule estimation shows that US FED interest rate plays a crucial role in setting the policy rate with high significant coefficient of 0.72. The lagged interest rate is also important, with a highly significant coefficient of 0.29. We find that asymmetric oil supply shocks have a muted impact on Bahrain's policy rate. Our analysis implies that positive aggregate demand shocks will reduce the interest rate of Bahrain, although, the coefficient is small and only significant at the 10%. However, a Wald test accept the null hypothesis that the asymmetric coefficients are equal. This finding suggests that the assumption of asymmetry in terms of aggregate demand shocks holds in the context of our analysis. The analysis suggests decomposed oil-specific demand shocks are significant, although the suggested impact on the policy rate is very small and relatively limited comparing to the other factors. The Wald test indicates that the positive and negative oil-specific demand shocks are significantly different and not equal zero.

Contrary to expectations, our estimation indicates that during periods of oil supply disruptions that lead to an increase in oil prices, the Central Bank of Kuwait (CBK) takes action to reduce the policy rate by a coefficient value of -0.17. This unexpected and complex behaviour might be explained by the findings of Maghyereh and Abdoh (2021a), who conclude that oil supply disruptions increase bank risk in Kuwait which may threaten the bank's liquidity position. As a result, the central bank takes actions to ease monetary policy to maintain financial stability.

In the cases of Oman and Saudi Arabia, our asymmetric augmented Taylor rule show that the Central Bank of Oman (CBO) and the Central Bank of Saudi Arabia (SAMA) react significantly and asymmetrically to the aggregate demand shocks. Regarding the policy rate response to demand shocks, we conclude that the positive aggregate demand shocks have a significant and negative impact on setting Omani and Saudi Arabian policy rates, with coefficients of -0.24 and -0.21, respectively. While, for negative aggregate demand shocks, the result shows that the CBO and SAMA have a milder response, with coefficients of 0.18 and 0.14, respectively. The Wald test confirms that there is a significant difference between the positive and negative aggregate demand in both countries. The economic intuition for these behaviours in CBO and SAMA in terms of our findings in asymmetric augmented Taylor rule analysis, are due to the nature of their exchange rate regimes, which at times force the monetary policy makers to follow foreign interest rates, specifically the Federal Fund rate. The pressure in international capital markets for capital to flow to where it will receive the highest return may necessitate monetary policy interventions in Oman and Saudi Arbia to defend their currency peg.

The results of our asymmetric augmented Taylor rule analysis show an interesting pattern in how some GCC, like Oman and Saudi Arabia, central banks react asymmetrically to oil-price changes caused by aggregate demand shock which confirm our arguments about the presence of asymmetric preferences in GCC central banks' decisions during oil demand shocks. In periods of oil price booms from strong global economic activity, we observe that CBO and SAMA central banks tend to take what may seem like adverse actions by lowering their policy rates. The economic rationale behind this behaviour is to maintain a pegged exchange rate to the US dollar following a depreciation that can accompany high oil prices. Hakro and Omezzine (2014) claim that the mismatched movement between US economic growth and

GCC countries may have an adverse effect especially with an exchange rate pegged to the US dollar. Such fixed arrangements may restrict the autonomy of their central banks during periods of robust economic growth.

Conversely, during periods of oil price busts or downturns from negative aggregate demand shock, central banks in Oman and Saudi Arabia raise policy rates. One possible explanation for this action is that the fixed exchange rate forces central banks to align with the US Federal Reserve interest rate, especially during periods of a robust US dollar. For example, during periods of weak aggregate demand, which can induce low oil prices, there may be a divergence in economic performance between emerging countries, including GCC countries, and the United States. Research such as Jibril et al. (2019) found that during such recessions in emerging countries, the US often experiences strong and robust economic growth. For instance, the authors explained that episodes such as Asian Financial crises coincided with strong US growth which led to strength the dollar. In this context, GCC central banks may adjust their policy rates in response to economic conditions and external factors such as the strength of the US economy, which can influence their decision-making in setting the policy rate due to the need to maintain the desired exchange rate peg.

Table 3.4: Asymmetric augmented Taylor Rule estimation

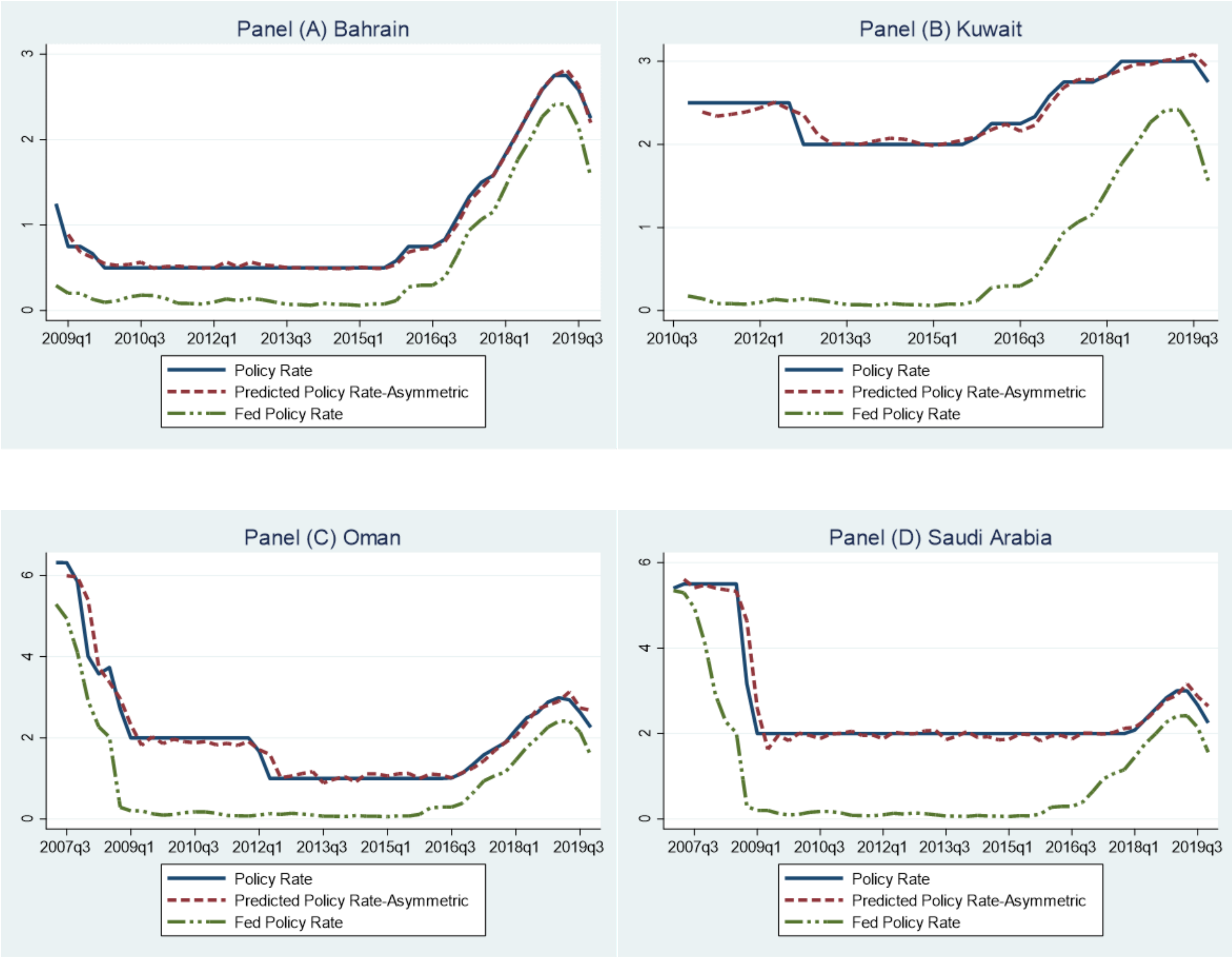
Variable	Bahrain	Kuwait	Oman	Saudi Arabia
i_{t-1}	0.287755*** [0.039012]	0.452377*** [0.093960]	0.804274*** [0.029660]	0.875195*** [0.042413]
π_t	-0.000027 [0.000474]	-0.053665*** [0.010469]	-0.006660** [0.003042]	-0.003973 [0.002598]
y_t	-1.993*** [0.193860]	0.622196*** [0.170720]	0.644513 [0.457134]	1.381296** [0.546572]
fr_t	0.718871*** [0.033221]	0.189445*** [0.027180]	0.193994*** [0.030891]	0.124101*** [0.017320]
ξ_t^{OSS+}	0.011713 [0.005257]	-0.004246 [0.034215]	.0324686 [0.048320]	-0.100893 [0.075647]
ξ_t^{OSS-}	-0.002779 [0.034357]	-0.179128*** [0.068846]	-0.132751 [0.091719]	0.119193 [0.101859]
ξ_t^{ADS+}	-0.019391* [0.007077]	-0.031187 [0.019488]	-0.244935*** [0.050645]	-0.213483*** [0.061896]
ξ_t^{ADS-}	-0.002286 [0.004004]	0.009992 [0.023776]	0.176396*** [0.030479]	0.139151** [0.063044]
ξ_t^{OSDS+}	-0.012199*** [0.002554]	0.006724 [0.008276]	0.009213 [0.017200]	0.015845 [0.014063]

ξ_t^{OSDS-}	0.003881*** [0.000937]	0.002431 [0.006834]	0.027431*** [0.008585]	0.000435 [0.008526]
Cons	0.312536*** [0.017716]	1.140759*** [0.192571]	0.324344*** [0.043681]	0.294471*** [0.091742]
Obs	41	33	47	48
R-squared	0.9969	0.9431	0.9531	0.9117
Sargan-J- stat	31.6145	22.3974	29.5242	24.3771
P-value	0.3857	0.4364	0.4902	0.7547
The Wald Test (Joint Significance)				
H_0: $\alpha_5 = \alpha_6 = 0$	0.06	6.36**	0.70	0.25
H_0: $\alpha_7 = \alpha_8 = 0$	1.37	0.85	47.82***	11.23***
H_0: $\alpha_9 = \alpha_{10} = 0$	32.32***	0.01	2.39	1.32

*p<0.1; ** p<0.05; *** p<0.01. The null hypotheses of the Sargan test that the over-identified model is valid and the group of instruments are exogenous is accepted by the results for all countries, which means that our instruments are valid. The null hypothesis in the Wald tests is that the positive and negative coefficients of the oil structural shocks are equal.

Figure 3.3 below presents the optimal policy rates for selected GCC countries estimated using the asymmetric augmented Taylor Rule (equation 3.3), alongside the actual policy rates and the US Fed policy rate. From Panel A, it can be clearly seen that our predicted policy rate which is calculated by asymmetric augmented Taylor rule has a similar pattern to the actual policy rate in Bahrain. In Panel B, there is a clear deviation between Kuwait's actual policy rate and our predicted one from asymmetric augmented Taylor rule at the beginning of the period, while starting from the first quarter of 2013, we can see that our predicted policy rate behaves similarly to the Kuwaiti central bank policy rate through to the end of the period. In Panel C, our predicted policy rate, which is estimated from our asymmetric augmented Taylor rule, can capture effectively the actual one in Oman, especially during the period of the Global Financial Crisis between 2009-2010. In Panel D, our analysis reveals that the predicted policy rate based on the asymmetric augmented Taylor rule estimation in Saudi Arabia can capture the behaviour of the actual one more accurately compared to the predicted policy rate derived from the symmetric estimation, particularly at the beginning of the period under consideration. In addition, we observed that between 2016q1 and the beginning of 2018q1, the Federal Reserve started to increase the policy rate, while the Central Bank of Saudi Arabia chose to keep it stable until the start of 2018q1. This suggests an attempt to deviate from following the Federal Reserve's interest rate Interestingly, during the period of the Global Financial Crisis in 2009, our predicted policy rate suggests a lower interest rate recommendation than the actual interest rate implemented in Saudi Arabia.

Figure 3.3: Actual and predicted policy rates – asymmetric model



3.7 Conclusion

The primary objective of this chapter is to examine the factors driving central bank reaction functions in selected oil-rich developing countries during periods of oil shocks. Specifically, the study seeks to investigate whether augmenting the Taylor Rule with the inclusion of the foreign interest rate and three structural oil shock variables (oil supply shocks, aggregate demand shocks, and oil-specific demand shocks) can effectively explain the policy rate decisions of these countries, all of which have managed exchange rates. In addition, we examine a Taylor rule augmented with asymmetric structural oil shocks.

During periods of positive oil shocks, the Gulf Cooperation Council (GCC) countries faced inflationary pressures, and previous studies have identified both domestic and external factors as significant determinants of inflation in these countries. Domestic factors, such as domestic interest rates, and external factors, such as fluctuations in oil prices, have been highlighted as key drivers of inflation in the GCC (Al-Qenaie and Alshammari, 2016; Nusair, 2019). Therefore, in this chapter, the focus is on understanding how these countries respond to the challenges posed by oil shocks and whether the augmented Taylor Rule framework can capture their policy rate behaviour in the presence of managed exchange rates. By analysing the role of various factors and incorporating them into the model, the study aims to provide insights into the decision-making processes of central banks in oil-rich developing countries during the periods of supply and demand oil shocks.

We can summarise our findings as follows. The symmetric augmented Taylor rule estimations demonstrate that the central banks in selected GCC countries exhibit varying considerations and weights assigned to smoothing the policy interest rate and following changes to the US Fed interest rate. Notably, the central banks in Kuwait and Saudi Arabia take into account the deviation of the output gap in their policy decisions. However, the symmetric analysis suggests that the three structural oil shocks examined in this study have a limited impact on the central bank reaction function in the GCC countries.

Using the asymmetric augmented Taylor rule, we conclude the presence of asymmetric preferences in terms of oil shocks GCC central banks. Our findings suggest that the Central Bank of Bahrain reacts to asymmetric oil-specific demand shocks but with tiny coefficients, which we consider negligible.

In the case of Kuwait, we find evidence that the policy rate reacts to oil supply disruptions by easing monetary policy. This distinctive approach taken by Kuwait's monetary authority, in contrast to other GCC countries, may reflect the heightened bank risk associated with supply disruptions as noted in Maghyereh and Abdoh (2021a).While the asymmetric analysis suggests aggregate demand shocks matter for the setting of interest rates in Oman and Saudi Arabia. Further, it seems that considerations, perhaps related to managing their respective exchange rates, dominates the direction of the monetary policy response.

To summarize, our estimated augmented Taylor Rules capture the observed path of interest rates in our selection of GCC economies. While all selected economies state that managing their exchange rate is a key policy goal, we find significant variation in the extent to which the Fed Funds Rate matters. Further, we see periods when monetary policy decisions deviate considerably from simply following changes in the Fed Funds Rate, notably for Kuwait, Oman, and Saudi Arabia. It is only when we consider asymmetries that the Kilian decomposed oil shocks seem to matter for monetary policy, although with different shocks seeming to matter more for different GCC central banks.

The results of this chapter contribute to the existing body literature in different ways. To start with, this chapter is the first attempt to explore the factors that driving the reaction functions of central banks in oil developing rich countries like GCC countries using the extended Taylor rule with oil shocks framework. There are only two papers examine the behaviour of policy rate in GCC countries (see, Almounsor, 2015; Elsayed et al., 2023) and ignoring the behaviour of policy rates in GCC countries during the oil shocks periods. Additionally, most previous papers focus on inflation rates as a monetary policy indicator and examine how oil price shocks affect them in GCC countries without addressing the sources of oil shocks (e.g., Kandil and Morsy, 2011; Mohaddes and Williams, 2011; Nusair, 2019). In summary, the key findings of our current paper help us to understand the decisions of central banks of selected rich developing nations during the oil supply and demand oil shocks, as well as, enhance the literature review by understanding the economic dynamics of monetary policies behaviour in selected GCC countries.

3.8 Appendices to Chapter 3

Table 3.5: Unit root tests for structural oil shocks

	ADF			PP		
Variables	OSS_t	ADS_t	$OSDS_t$	OSS_t	ADS_t	$OSDS_t$
Bahrain	-3.889***	-5.646***	-6.680***	-4.371***	-7.801***	-8.351***
Kuwait	-3.638***	-2.998***	-6.680***	-3.935***	-5.646***	-6.680***
Oman	-4.483***	-4.905 ***	-7.033***	-5.160***	-6.414***	-7.033***
Saudi Arabia	-5.242 ***	-4.874***	-7.215 ***	-4.850***	-6.519***	-7.215***

The lag length for the ADF and PP tests is chosen based on AIC criteria: * $p<0.1$; ** $p<0.05$; *** $p<0.01$. The null hypothesis of the ADF and PP tests is that the time series is not stationary.

Chapter 4

Oil Shocks and Firm Efficiency: A Two-Stage Analysis of Kuwait's Manufacturing Firms

Abstract

This study explores the impact of oil price shocks on Kuwaiti manufacturing firms' efficiency. Kilian (2009) disentangled three sources of oil price shocks: oil supply shocks, aggregate demand shocks and oil-specific demand shocks. Using confidential disaggregate data from Kuwaiti manufacturing firms for the period 2003-2019, we first estimate firm-level efficiency scores using data envelopment analysis (DEA). In the second stage, we investigate if and how structural oil shocks affect firms' efficiency. Our results show that the types of oil- demand shocks are dominant in improving or dampening the efficiency scores of the manufacturing sector, while oil supply shocks have an imputed impact. The analysis of asymmetric shocks confirms the existence of asymmetry in the impact of structural oil shocks. Episodes of oil supply expansion dampen firms' efficiency significantly, while during the periods of positive aggregate demand shocks, the Kuwaiti manufacturing firms can improve their efficiency.

4.1 Introduction

Oil price shocks are frequently experienced by oil-producing countries, characterised by their boom-and-bust cycles that have a significant impact on economic activity. In this chapter, we are interested in whether their influence extends to performance at the level of the firm in oil-rich nations that aim to diversify their economic strengths, especially in major sectors like manufacturing, while simultaneously reducing their dependence on the oil industry. Oil is a key factor in manufacturing production processes, so that oil price shocks can affect various aspects of firms' performance, including productions costs, profitability and productivity. Therefore, understanding the relationship between oil price shocks and firm performance is vital for firms aiming to maintain competitiveness and profitability, and crucial for policy-makers and investors seeking to adapt to fluctuations in energy prices in oil-rich countries. While some existing literature explores how oil price shocks affect the cost of commodities, company investments, corporate decisions and firms' profitability, there remains a significant gap in understanding their influence on the measure of firm efficiency. This chapter addresses this gap by looking at how unexpected changes in structural oil shocks affect manufacturing firms' efficiency scores in Kuwait, an oil-rich country, in both symmetric and asymmetric ways.

There is a growth in the productivity firm literature about the benefits of using firm-level data in performing productivity analysis. It allows researchers to emphasise firm-level productivity as a significant driver of aggregate productivity. Increasing firm-level productivity increases a country's living standards (Acemoglu et al., 2006), wages (Konings and Vanormelingen, 2015) and employment (Dachs and Peters, 2014). However, it has been suggested that traditional productivity indicators cannot provide a broader picture of firm performance than efficiency scores can. The concept of efficiency is broader than the concept of productivity because firm efficiency implies productivity, but the opposite definition does not always hold. Therefore, many researchers have developed econometric and mathematical methods to measure the efficiency scores of units such as firms, hospitals or banks, and to explore the environmental factors that affect the concept of efficiency units.

A key determinant which has received less attention in the literature and may affect efficiency scores is the price of energy, especially in industrial and manufacturing sectors in oil-exporting countries, which depend heavily on oil revenue. The manufacturing sector plays a crucial role in economic growth in oil-rich economies. Oil price fluctuations, in particular, contribute significantly to manufacturing sector instability and have direct and indirect effects on manufacturing firms. For example, Riaz et al. (2016) noted that oil is the primary raw material used in many manufacturing firms, particularly those in the chemicals, plastics and petroleum refining industries. Due to variations in production costs caused by oil price uncertainty, firms do not operate at full capacity. Additionally, oil price shocks can lead to inflation and high interest rates, which can affect manufacturing firms in non-petrochemical industries. Alshammari and Aldhafeeri (2020) found that oil rent is the main determinant of value added in manufacturing sectors of Kuwait. Therefore, oil price movements could affect firm performance in the manufacturing sector in different ways, such as production, investment and profit, and as a result affect firm efficiency.

The uncertainty surrounding oil prices is believed to have a negative impact on real economic activity. Bernanke's (1983) theory of irreversible investment suggests that firms delay investment in the face of high oil price uncertainty as they prefer to wait until additional data on future prices and demand becomes available. Empirical studies have provided support for this theory. For example, Hamilton (2009) found that oil price volatility has a direct and negative impact on the income of both vehicle consumers and manufacturers. In the context of oil-rich countries, Alhassan (2019) examined a sample of 356 firms in Gulf Cooperation Council (GCC) countries and found that firms in these countries tend to invest less during periods of high oil price volatility. Moreover, Bugshan et al. (2021) found that high oil price volatility dampens the profitability of non-financial firms in the GCC significantly. These findings suggest that firms in oil-rich countries cannot improve their performance during periods of high oil prices, which supports the theory of irreversible investment. The fact that these findings are evident in oil-rich countries may raise the issue of a common concept in economics: the resource curse.

However, new strands in the literature, such as Kilian (2009), show that investigating the impact of oil shocks on economic activities without distinguishing the sources of oil shocks, i.e. whether they come from the supply or demand sides, could be misleading. Kilian's structural oil shocks model explains the sources of oil price variations effectively and captures all the episodes that may cause supply or demand shocks in oil prices. There are three classic oil shocks: oil supply shocks caused by shortages in oil production, aggregate demand shocks caused by shifts in the global economy, and oil-specific demand shocks due to expectations of shortfalls in oil supply in the future. Kilian's global oil model has received much attention in the literature, and many studies[19] reveal that the response of economic activities in oil-importing or -exporting countries depends on the source of oil shocks. In this chapter, we claim that the effects of oil shocks on the efficiency scores of Kuwaiti manufacturing firms occur and vary depending on the origins of the shocks. Kuwaiti manufacturing firms can be efficient despite oil price shocks. It is common knowledge that oil exporters benefit from rising oil prices, but importers face risks and higher production costs. Both Jiménez-Rodríguez and Sánchez (2005) and Bjørnland (2009) claim that an increase in the price of oil results in an immediate shift of income from oil-importing countries to oil-exporting countries. Thus, firms in oil-rich countries may benefit from rising oil prices, which could have a positive impact on efficiency scores. Furthermore, Kang and Ratti's (2013) research findings provide valuable insights into the relationship between oil prices, economic policy uncertainty and investment decisions. They show that rising oil prices driven by aggregate global commodity demand are associated with lower economic policy uncertainty, while an increase in oil prices resulting from oil-specific demand shocks could cause an increase in economic policy uncertainties. As a result, the firm’s decision to invest will vary based on the sources of the oil shock.

We also claim in this chapter that there are reasons to support the hypothesis that the effects of Kilian’s structural oil shocks on firm efficiency could be asymmetric. First, negative oil supply shocks could have a muted impact on oil-exporting countries because of the crucial role of big producers in covering any shortages in oil production. In contrast, episodes of oil supply expansion will affect oil-exporting economies negatively. For instance, the discovery of US shale oil, which played a central role in the oil market and led to decreased oil prices, negatively affected the economic stability of oil-exporting countries such as those in the GCC. Westphal et al. (2014) show that the shale oil expansion resulted in a decline in oil and gas exports from the Gulf region economies, which rely heavily on oil exports, in order to keep prices up. Second, strong global economic activity, which induces increasing oil demand, improves the economic growth of oil-exporting countries while worsening it for oil-importing countries. Nusair (2016) shows that the sharp increase in oil prices due to the increase in oil demand from emerging countries between 2002 and 2008 improved economic growth dramatically in oil-exporting countries, especially in oil-rich countries such as those of the GCC. Increases in oil prices can lead to higher revenue and improved economic activity, which can be beneficial for manufacturing firms and improve their efficiency, including investment in up-to-date

[19] SeeAbhyankar et al. (2013), Chen et al. (2020), Maghyereh and Abdoh (2021b), Wang et al. (2014) and Ziadat (2019).

technology. By investing in the latest technology, such as advanced machinery and automation systems, firms may increase production, reduce costs and improve efficiency. On the other hand, weak aggregate demand, which generates low oil prices, may have a different impact on manufacturing firms' performance in oil-exporting countries. Baffes et al. (2015) show that recessions in developed countries are not necessarily related to recessions in emerging markets, such as China and India, which are the most important trading partners for oil-rich countries like GCC nations. Third, oil-specific demand shocks may have an asymmetric impact on firm efficiency in oil-exporting countries. The definition of a positive oil-specific demand shock is an increase in precautionary demand for oil as a response to reduced expectations of future oil supply during geopolitical events, such as the Iraqi invasion of Kuwait, the Arab Spring and, recently, the COVID-19 pandemic. This type of shock may affect manufacturing firm efficiency depending on the country's political stability. For example, Kuwait did not benefit from high oil prices during 1990 because the war with Iraq caused significant damage to its oil refineries and harmed productivity growth at the firm level. As a result, we expect positive oil-specific demand shocks to have a stronger impact than weak oil-specific demand shocks.

In this chapter, we examine the impact of Kilian's three structural oil shocks on firm efficiency. The aim is to investigate how the effects of oil price fluctuations on manufacturing firm efficiency differ depending on the causes of oil shocks and whether the effects of these oil shocks are asymmetrical. We use a unique, firm-level manufacturing sector panel dataset from Kuwait.

The empirical analysis in this chapter is divided into two stages. In the first stage, we use the data envelopment analysis (DEA) technique to calculate the efficiency scores of Kuwaiti manufacturing firms in 21 industries. In stage two, we apply bootstrap random-effect Tobit regressions to identify magnitude and direction (positive or negative) of the impact of our three structural oil shocks on firm efficiency, using both symmetric and asymmetric analyses, as well as identifying the main determinants, such as ownership, firm size and firm age, on firm efficiency in the Kuwaiti manufacturing sector.

The present study contributes to the literature in two ways. First, to the best of our knowledge, this is the first study that uses confidential disaggregated data at the firm level to examine the efficiency of the Kuwaiti manufacturing sector from 2003 to 2019. Second, this is the first study to explore the symmetric and asymmetric relationships between firm performance, in terms of efficiency scores, and the sources of oil shocks in an oil-exporting, rich country.

The study's key findings reveal important new insights regarding the relationship between oil shocks and manufacturing firm efficiency in Kuwait. The dominant factors affecting efficiency scores are found to be from demand shocks. As a starting point, aggregate demand shocks play a significant positive role, indicating that increased oil demand from emerging countries like China and India enhances the performance of manufacturing firms. Conversely, oil-specific demand shocks have a negative impact on efficiency scores in manufacturing firms. This type of oil shock is caused by unstable geopolitical events in oil-producing countries, which could lead to delays in investment by manufacturing firms in Kuwait. Additionally, the analysis highlights an asymmetric relationship between structural oil shocks and the efficiency of manufacturing firms, with increased efficiency scores observed during periods of increased aggregate economic activity. Our results show that positive oil supply shocks, such as the discoveries of US shale oil, affect manufacturing firm efficiency negatively. However, we show that oil-specific demand shocks do not have an asymmetrical association with the efficiency scores of manufacturing firms in Kuwait. These findings provide a fresh perspective on the complex dynamics between oil shocks and firm efficiency in the manufacturing sector of oil-rich countries.

The chapter is organised as follows. Section 4.2 reviews the literature and section 4.3 describes the empirical analysis and methodologies. Sections 4.4 and 4.5 provide the empirical results and conclusion.

4.2 Background and existing literature

This section is in two parts. In the first, we review previous studies which calculate efficiency scores for manufacturing firms and explain briefly the importance of this sector in Kuwait. In the second part, we review the impact of oil shocks on economic activities and address the gaps in existing research.

4.2.1 Overview of the manufacturing sector in Kuwait

Efficiency is a widely discussed concept in the literature of economics. The formal concept of efficiency was established by the seminal work of Farrell (1957), who defined efficiency as the ratio of outputs to inputs, such that efficiency is achieved when the highest amount of output is produced using a given amount of input. Any deviation from this optimal state indicates inefficiency. Measuring firm efficiency is considered to be the most important factor in measuring firm performance and a critical aspect of understanding economic growth and, following Farrell's work, researchers developed parametric and non-parametric methods to measure firm efficiency scores.[20] Recently, a review by Moradi-Motlagh and Emrouznejad (2022) has shown that data envelopment analysis (DEA) is the most common non-parametric approach applied to the calculation of firm efficiency scores and the exploration of the influence of environmental factors on those scores.

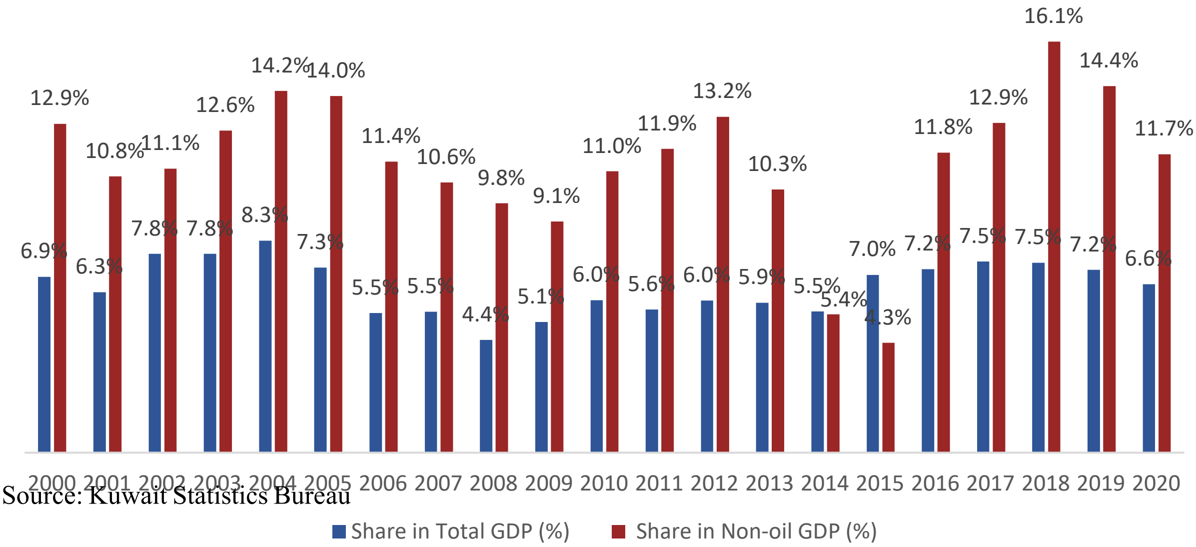
Manufacturing firms play a critical role in the economy by producing goods and services that are essential for economic growth and development. As such, understanding the efficiency of manufacturing firms can provide insights into the overall productivity and competitiveness of the economy, help to identify areas for improvement within firms and improve their profitability. Therefore, researchers investigate the efficiency scores of manufacturing firms in developed and developing nations and explore their main determinants.

There is no research in the literature measuring the manufacturing sector's efficiency scores at the disaggregate firm level in the oil-rich country of Kuwait. The primary aim of the present study is to fill this gap. There are many reasons to examine the efficiency scores of the manufacturing sector in Kuwait. First, the mining and fuel extraction industries have a significant impact on Kuwait's economy, which can be characterised by its high degree of dependence on a single sector, i.e. oil. This vital sector has contributed to growth in Kuwait's gross domestic product (GDP) by between 41% and 90% (Burney et al., 2006). Additionally, Kuwait has experienced a significant increase in energy demand, especially in the manufacturing and petroleum industries (Salahuddin et al., 2018). Second, one of the main objectives of Kuwait's Vision 2035 is to increase the contribution to GDP from the manufacturing sector, especially non-oil industries. As a result, the government formed the Kuwait Direct Investment Authority (KDIPA), which encourages international investors to invest in and own projects (up to 100%) in Kuwait. This is intended to assist in increasing investment opportunities and attracting more investors to the Kuwaiti market. In addition, on average, the manufacturing sector, excluding oil refineries, contributes approximately 10% of the country's GDP. This sector is crucial for exploiting the value-added of the country's

[20] The difference between parametric and non-parametric techniques has been discussed intensively in the literature. Each technique has pros and cons. In this study, we prefer to use the non-parametric approach for reasons explained in the empirical analysis section.

resources and increasing employment and investment (Shehabi, 2020). In addition, we have access to unique and confidential disaggregate data at the firm level from the manufacturing sector of Kuwait, which allows us to calculate efficiency scores from 2003 to 2019. Figure 4.1 shows the contribution of the manufacturing sector to Kuwait's GDP.

Figure 4.1: Manufacturing's share of GDP and non-oil GDP, Kuwait, 2000-2020



Source: Kuwait Statistics Bureau

Figure 4.1 represents a consistent improvement in the manufacturing sector's contribution to Kuwait's economic growth in the early years of the period. However, during the Global Financial Crisis (GFC) around 2008, both the manufacturing sector's percentage share of total GDP and non-oil GDP declined sharply, dropping from 8.3% to 4.4% and from 14.1% to 9.1%, respectively. Additionally, the manufacturing sector experienced a significant decline in its share of both total GDP and non-oil GDP as a result of the US shale oil discoveries and the subsequent substantial decrease in oil prices around 2014. This resulted in a substantial drop, to 5.5% and 4.3% at their lowest, in the manufacturing sector's contribution to total GDP and non-oil GDP, respectively. The COVID-19 pandemic, which started in late 2019, caused a decline in the manufacturing sector's contribution to total GDP from 7.2% to 6.6%. Similarly, the sector's contribution to non-oil GDP decreased from 14.4% to 11.7%.

4.2.2 Oil shocks and efficiency scores

The second objective of this chapter is to investigate our main claims and to look at how oil price shocks affect the efficiency scores of manufacturing firms in oil-producing countries. The majority of previous papers examine various external factors pertaining to efficiency scores, but ignore the most important factor, which is energy price. A number of authors study efficiency determinants based on external factors, e.g., market competition (Caves and Barton, 1990; Hay and Liu, 1997), technology and openness (Bartelsman and Doms, 2000). Other studies focus on internal factors, such as firm characteristics, like size, ownership and age (Gumbau-Albert and Maudos, 2002; Aggrey et al., 2010; Amornkitvikai and Harvie, 2010; Alhamdani, 2019; Walheer and He, 2020), or human capital and workforce skills (Batra and Tan, 2003; Vu, 2003). In general, it is noteworthy that none of these studies consider oil price as an external factor in manufacturing firms' efficiency scores and there is a significant lack of literature on the relationship between oil shocks and efficiency scores of manufacturing firms in developing and developed countries.

Theoretical papers support the link between oil price fluctuations and firm performance. For example, Friedman (1977) showed that volatilities or uncertainties arising from higher inflation rates (which can result from an oil price shock) can potentially lower economic growth and economic efficiency. Huang et al. (1996) claimed that the impact of oil price volatility can be transmitted to firms through changes in their expected cash flow or the components of their capital costs, namely interest and inflation rates. This means that when oil prices fluctuate, firms may experience changes in their expected cash flow and the cost of capital, which can impact their profitability and investment decisions. Furthermore, Huang et al. (1996) provided an intuitive theoretical justification for how oil prices may affect firms in the market. Since oil is an input in the production process, future corporate cash flow is likely to be sensitive to oil price fluctuations. Moreover, an increase in oil prices may lead to higher inflation rates, which can raise the cost of capital for firms. As a result, firms may face higher interest rates, which can reduce their investment and profitability. Hamilton (2003) argued influentially that oil price shocks have a negative impact on corporate profit in industries for which the main input is oil. On the other hand, oil producers benefit during positive oil shocks.

A growing body of empirical research has explored the relationship between oil price shocks and economic activity at the firm level. The majority of papers focus on micro-indicators, such as corporate decisions (Alhassan, 2019; Maghyereh and Abdoh, 2020), corporate investment (Wang et al., 2017; Phan et al., 2019), stock market returns (Sadorsky, 1999, 2014; Eraslan and Menla Ali, 2018) and profitability (Dayanandan and Donker, 2011; Bugshan et al., 2021). However, the association between oil price shocks and non-financial firm efficiency has not been examined.

There are very few studies that explore the relationship between oil shocks and efficiency scores in oil-rich countries, and these studies rely solely on aggregate financial data available from banks or insurance companies. Said (2016) studied the impact of oil prices on the efficiency scores of Islamic banks during the financial crisis in the Middle East and North Africa (MENA) region. The author uses data from 32 Islamic banks in the MENA region and employs a two-stage approach that combines data envelopment analysis (DEA) and regression analysis. The findings show that no direct relationship exists between oil shocks and banks' technical efficiency scores. Alshammari et al. (2019) analysed the impact of oil prices and financial market indicators on the cost efficiency of insurance and Takaful (Islamic insurance) sectors in selected countries from the Gulf Cooperation Council (GCC) region. The authors employ stochastic frontier analysis (SFA) to estimate the cost efficiency of these sectors and examine the impact of oil prices and financial market indicators on their efficiency. The findings show that, as oil prices rise, the relationship between oil prices and efficiency scores shifts from positive to negative and the paper sheds light on the presence of a resource curse phenomenon. In contrast, Kaffash et al. (2020) examined the impact of oil price changes on the efficiency of banks in Middle Eastern Oil-Exporting (MEOE) countries using a semi-orientated radial measure (SORM-DEA) approach. The authors use data from 98 banks in MEOE countries and analyse the impact of oil price changes on the efficiency of these banks. The results show that higher oil prices have a positive impact on the efficiency of banks in the MEOE countries. Accordingly, banks in these countries seem to be more efficient during times of higher oil prices, which may be due to the benefits of oil revenues on the economy and the financial sector in general.

However, these papers did not account for the sources of oil shocks. Kilian (2009) and Kilian and Park (2009) argue that the effects of oil shocks on economic activity have different mechanisms depending on their different sources, i.e. whether they derive from supply or demand sides. Rising oil prices from supply shocks, due to a shortage in oil production, could have a muted impact because of the role of globally significant producers,[21] while increasing oil prices from the demand side could transfer income from oil-importing to oil-exporting countries, as noted in Scholtens and Yurtsever (2012). At the micro-factor level, most previous studies adopted the Kilian SVAR model to investigate the relationship between the three structural oil shocks and stock return at the firm level, whether in oil-importing or -exporting nations.[22] Generally, the literature appears to agree on the following. First, oil supply shocks are not significant in most markets. Second, aggregate demand shocks increase stock returns. Third, there is debate regarding the impact of oil-specific demand shocks.

Additionally, the significance of asymmetric oil shocks should not be disregarded. Economists recognise the importance of considering the impact of oil price declines on economic activity in oil-exporting countries, particularly through the concept of asymmetric oil shocks. The evidence from the financial channel suggests that two recent oil price declines (in 2008 and 2014) slowed the growth of firm leverage in many resource-dependent countries, which could have affected firm efficiency significantly (see Kurronen, 2018). Mehrara (2008) investigated the relationship between oil revenue shocks and industrial production in 13 oil-exporting countries including Kuwait. The study concluded that negative oil revenue shocks are more significant than positive shocks and suggested that the policy-makers in these countries should take into account the asymmetric nature of the relationship when designing economic policies. The current chapter investigates the impact of asymmetric oil shocks on manufacturing firm efficiency.

To the best of our knowledge, no study examines the impact of oil shocks on firm-level efficiency scores in oil-exporting countries whilst disentangling the sources of those shocks. Motivated by the literature on firm efficiency factors and oil price shocks, this chapter addresses this gap in the research. In order to achieve our aims, we use a rich source of confidential micro-data from 21 Kuwaiti manufacturing sectors to measure efficiency scores and investigate the impact of structural shocks on firm efficiency using the non-parametric, DEA two-stage estimation.

[21] The role of big oil producers in offsetting any shortage in oil production has been explored widely in the literature. Fattouh (2014) and Fattouh and Sen (2015) show that Saudi Arabia has a considerable amount of spare oil capacity and balances out supply interruptions from OPEC and non-OPEC oil producers.

[22] See Basher et al. (2012; 2018), Wang et al. (2013), Doko Tchatoka et al. (2019) and Mokni (2020).

4.3 Empirical analysis

In many scientific papers, researchers use common parametric and non-parametric techniques to calculate efficiency scores. For the following reasons, we use the classic non-parametric method called data envelopment analysis (DEA), rather than parametric methods, such as stochastic frontier analysis (SFA). Firstly, DEA is an approach that focuses on frontiers instead of central tendencies (Cooper et al., 2000). Secondly, because DEA is a non-parametric technique, it does not require distributional assumptions for residuals (Abbott and Doucouliagos, 2003). Finally, DEA has the advantage over traditional methods based on predefined model structures, such as the SFA, in that it eliminates the need to make assumptions about the functional form of the best practice frontier in advance (Cooper et al., 2000).

4.3.1 Data envelopment analysis (DEA) – first stage

This section describes the data envelopment analysis (DEA) methodology, which was defined by Farrell (1957) to estimate the efficiency scores of decision-making units (DMUs) by comparing the relative efficiency of each DMU to a set of best-performing DMUs, which form the production frontier. A DMU located on such a frontier is considered efficient. The DEA technique is a mathematical programming approach that requires several DMUs, and every DMU has at least one strictly positive input and one positive output to estimate its efficiency. There are two main forms of the DEA model which are typically applied: input-orientated DEA and output-orientated DEA. Input-orientated DEA can be defined as minimising the input variations for given constant output quantities, whereas output-oriented DEA aims to maximise output quantities while holding input quantities constant at their present values.

The DEA model developed by Charnes, Cooper and Rhodes (CCR) (1978) expands upon prior research by Farrell (1957). In the CCR model, the presence of constant returns to scale (CRS) is assumed. Under the assumption of CRS, we assume that, under optimal operating conditions, when the input levels are scaled by a factor α, then the output levels will also be scaled by α. However, CRS is an unrealistic assumption. For instance, it is impossible to keep CRS when input and output variables include averages, indices or arbitrary measurement scales. As a result, the work by Banker, Charnes and Cooper (1984), known as the BCC model, was developed using variable returns to scale (VRS). VRS allows changes in output to be disproportionate to change in input. The VRS model is widely used and a more common assumption than CRS in the literature, it being argued that the assumption of CRS is only appropriate when all firms are operating at the optimal scale – for instance, this is probably the case for the large Canadian banks (Schaffnit et al., 1997). Fethi and Pasiouras (2010) found that many recent studies assumed VRS.

In the current study, we utilise the input-orientation and assume VRS. The formula to obtain the DEA-VRS model is: assume a set of observed DMUs $\{DMU\ k, k = 1, \dots \dots \dots \dots . n\}$ is associated with m inputs, $\{x_{jk} = j, 1, \dots \dots \dots \dots . m\}$ and s output $\{y_{ik} = i, 1, \dots \dots \dots \dots . s\}$. Charnes et al. (1978) proposed the original method to calculate the efficiency of kth DMU as follows:

$$\max(eff_{k_0}) = \frac{\sum_i u_i\, y_{ik_0}}{\sum_j z_j\, x_{jk_0}} \tag{4.1}$$

Subject to,

$$\frac{\sum_i u_i y_{ik}}{\sum_j z_j x_{jk}} \le 1, \forall\, k, k = 1,2, \dots ., n \tag{4.2}$$

$$u_i, z_j \ge 0, \forall i, j \tag{4.3}$$

Where eff_{k_0} is the efficiency scores for the unit k_0 , $y_{ik_0}$are the ith estimated output by each unit variable with optimal weight value u_i. At the same time, the x_{jk_0} are the jth input utilized by each decision-making unit k_0. With weight z_j, where the values of u_i,z_j should be positive or equal to zero.

The fractional ratio in equation 4.1 can be transformed to linear mathematical programming problem as follows:

$$Max_{u,z=} \sum_i u_i\, y_{ik_0} \tag{4.4}$$

Subject to

$$\sum_i u_i\, y_{ik_0} - \sum_j z_j\, x_{jk_0} \le 0$$

$$\sum_j z_j \, x_{jk_0} \; = 1$$

$$u_i, z_j \geq 0$$

Because our objective using the input-oriented VRS DEA, then based on the linear programming Duality theorem suggested by Farrel (1957), Eq 4.4 will be transformed into:

$$\hat{\theta} = \text{Min } \theta_{k_0} \qquad (4.5)$$

Subject to:

$$\sum_k \lambda_k x_{jk_0} \leq \theta_{k_0} \, x_{k_0}$$

$$\sum_k \lambda_k \, y_{ik} \geq y_{ik_0}$$

$$\sum_k \lambda_k = 1$$

$$\lambda_k \geq 0$$

The efficiency term of DMU is θ_{k_0}, λ_k represents the weights of DMUs when the efficiency scores are measured. In variance return scale (VRS) model, we impose the convexity constraint $\sum_k \lambda_k = 1$ for λ_k.

4.3.2 Double bootstrap DEA – second stage

Various papers examine the factors and external variables that influence efficiency scores significantly to find whether their impacts are positive or negative. However, there is a debate about the DEA second stage regressions and using the second stage regression by regressing the DEA efficiency score on regression models has been criticised by Simar and Wilson (2007) due to the presence of serial correlation between the efficiency scores and the independent variables. Consequently, standard second-stage inference methods are not valid, and they argue that the valid inference could be solved by applying the single and double bootstrap. The latter procedure increases statistical inference of efficiency scores in the second-stage regression. Therefore, various estimators have been applied in several studies after correcting the efficiency scores.

Simar and Wilson (2007) develop the double bootstrap truncated regression to estimate the DEA second stage regression. The double bootstrap truncated model is built for cross section data and will ignore the panel data structure. Therefore, many studies tend to apply suitable panel estimators, such as the generalised least square (GLS) (Alhamdani, 2019), logistic regression (Eling and Jia, 2018) or ordinary least squares (OLS) (Letza et al., 2001). Recent studies apply the Tobit regression or random effect Tobit model in the DEA second stage (Bampatsou and Halkos, 2019; Wang and Wang, 2022).

The current study aims to utilise the DEA estimators for unbalanced panel data from Kuwaiti manufacturing firms from 2003 to 2019. We cannot ignore the characteristics of the unbalanced panel data, such as the potential of unobserved individual effects and time-invariant should be considered. In addition, the nature of efficiency scores data also takes into consideration upper-censored data. This is due to the fact that the maximum efficiency that can be achieved is 1, and certain firms are fully efficient in certain years. Hence, we use the random effect Tobit estimators. Furthermore, we examine the robustness of our conclusions when considering alternative estimation techniques and specifications. First, we run the random effect estimators excluding the fully efficient DMUs, with scores equal to one, from the regression analysis. According to Simar and Wilson (2007), the fully efficient DMUs with a score of one may reflect finite sample bias and should be excluded in the second stage. Second, we apply the Simar and Wilson (2007) truncated regressions for cross-sectional data for robustness and consistency checks.

Based on the random effect Tobit bootstraps regression method, we conducted our second-stage DEA efficiency analysis as follows.

$$\hat{\theta}_{it} = \beta_0 + \beta M_{it} + \beta Z_{it} + \varepsilon_{it} \quad (4.5)$$

where $\hat{\theta}_{it}$ is the bootstrapped efficiency score for each firm, which is estimated from DEA – first stage, b is constant parameter, M is a 2×3 matrix of variables including oil supply shock, aggregate demand shock and oil-specific demand shocks in both current and lagged forms, and

Z is a vector of environmental variables, including the characteristics of the firm, i, that may associate to the firm's efficiency scores.

In order to examine the potential asymmetric impacts of structural oil shocks, we utilise equation 4.5 and construct a 12×12 matrix M that includes positive and negative shocks for oil supply, aggregate demand and oil-specific demand shocks, and both current and lagged variables. We add one lag for the three structural oil shocks in the analysis to capture the potential persistence of the impact of oil shocks on the efficiency scores over time.

4.3.3 Description of data and variables

The main aim of this study is to examine the relationship between manufacturing firms' efficiency scores and structural oil shocks. We use a confidential and rich micro-dataset for unbalanced panel data from manufacturing firms of Kuwait. The input and output variables and firm characteristics data come from the Central Statistical Bureau (CSB) in Kuwait. The data were collected annually in the Annual Statistical Survey from 2003 to 2019.

In the first stage, to calculate the efficiency scores, we need to choose the input and output variables correctly. To be more precise, the first-stage measurement of a firm's efficiency is highly sensitive to the variables chosen for the study. In this chapter, we select three inputs and one output, in keeping with the selection of variables in the majority of studies which use input-orientated DEA linear programming. Our study uses fixed assets, number of workers (labour) and total costs of consumption and materials as input variables, while total revenue is our output variable. In Table 4.1, we summarise the selection of input and output variables in previous studies, i.e. common firm characteristics which are expected to influence efficiency scores.

In the DEA second stage, the dependent variable is the efficiency score. Our independent variables are oil supply, aggregate demand and oil-specific demand shocks, as described in equations (4.5) and (4.6). In terms of control variables, we choose the firm characteristics ownership, age and size. These variables are commonly employed in other studies and are selected based on the data availability. In terms of the ownership variable, the majority of papers compare the efficiency scores of firms which are in domestic or foreign ownership However, in our study the data for this variable are divided into public and private ownership, and we adopt the classification of ownership based on the guidelines provided by the Kuwait Central Statistical Bureau.

Table 4.1: The selection of input-output variables for the manufacturing sector

Paper	Input	Output
Roudaut (2006)	Capital Labour Raw materials	Sales values
Mostafa (2007)	Assets Employees	Net profit
Hanrui and Xun (2011)	Capital expenditure Exploration costs Extraction costs Operating costs	Crude oil revenues
Lee et al. (2013)	Capital Number of employees Selling Administrative expenses	Total revenue
Ngo et al. (2019)	Number of employees Value of total assets Cost of materials	Total revenue
Huang (2021)	Fixed assets Operating expenses Employees	Revenue
Sanchez-Robles et al. (2022)	Total assets Number of employees	Operational revenues

4.3.4 Descriptive statistics

We use rich micro-economic data at the level of manufacturing firms in Kuwait to estimate the efficiency scores and to investigate the relationship between the three structural oil shocks and technical efficiency scores. The database includes 21 manufacturing activities, and input and output variables are converted to US dollars (USD). We calculate the technical efficiency scores by industry activities and year using within a VRS, input orientated DEA framework.

We start with the statistical information on the variables used to calculate firm efficiency scores in the DEA stage one analysis. Table 4.6 (see the Appendix) provides information on various industries in Kuwait's manufacturing sector based on the International Standard Industrial Classification (ISIC) code. Each row represents a specific industry's input (fixed assets, cost of raw materials, total workers) or output (total revenue) variables and the columns show the mean and standard deviation for each of these. It is clear that the largest fixed assets, costs of raw materials and total workers are under two main industry activities: extraction of crude petroleum and natural gas and incidental services, and refined petroleum products. These two activities represent Kuwait's largest industries and have the highest total revenues in this oil-dependent country.

Table 4.2 presents the descriptive statistics for the six explanatory variables in the second-stage DEA. The data set includes 18,110 observations from various types of industrial firms. The first three variables are related to oil shocks and show that the oil supply shock variable has a mean value of 0.051 and a standard deviation of 0.166, indicating a low level of volatility in the data. The aggregate demand shock variable has a higher mean value of 0.069 and a larger standard deviation of 0.423. The oil-specific demand shock variable has a mean value of 0.041 and a standard deviation of 0.277.

The ownership variable has a mean value of 0.011, indicating that on average, only a small proportion of the firms in the sample are publicly owned. The firm age variable has a mean value of 3.294, indicating that, on average, the firms in the sample have been in operation for 3.294 years. Finally, the firm size variable has a mean value of 3.129 and a standard deviation of 1.448, indicating some variability in the size of the firms in the sample.

Table 4.2: Statistical description of independent and control variables (DEA second stage)

Variable	Observations	Mean	Std. Dev.	Min.	Max.
Oil supply shock	18,110	0.051	0.166	-0.242	0.355
Aggregate demand shock	18,110	0.069	0.423	-0.651	0.728
Oil-specific demand shock	18,110	0.041	0.277	-0.517	0.447
Ownership	18,110	0.011	0.103	0	1.000
Firm age	18,110	3.294	0.423	0	7.610
Firm size	18,110	3.129	1.448	0	9.659

Author's calculations

4.4 Empirical results

4.4.1 Efficiency estimation

In the first stage of DEA[23], we measure the efficiency scores for manufacturing firms in Kuwait during the period 2003-2019. As described above, we use three inputs and one output and the assumption underlying the measurement of the technical efficiency of the linear programming is input orientation with variable returns to scale (VRS). We calculate the efficiency score frontiers by industry to improve the validity and reliability of the DEA results. By grouping DMUs into homogenous industries, we can avoid comparing DMUs that operate under different environments and face different trade-offs. This approach is consistent with the literature that calculate the efficiency scores by industry (e,g.Din et al., 2007, Wang et al., 2017, Walheer and He, 2020). Table 4.3 describes the statistical efficiency scores of Kuwait's manufacturing sector.[24] This table presents a summary of the statistics for manufacturing efficiency scores in Kuwait from 2003 to 2019. For each year, the table shows the median, standard deviation (SD), minimum, maximum, and number of observations (N), which represents the number of manufacturing firms for which data was available in a given year. The median efficiency score ranges from 0.498 in 2012 to 0.562 in 2008. The standard deviation (SD) ranges from 0.277 to 0.299, reflecting the dispersion or variability of the efficiency scores around the median. One possible explanation for this variability is that some industry activities were very efficient, while others were very inefficient, resulting in a wide range of efficiency scores. However, despite this variability, the maximum efficiency score for every year was 1,

[23] I run the DEA model using the commercial software called: Performance Improvement Management (PIM-DEA). This program helps us to run the DEA with big database in efficient time. For more information see the website: https://deazone.com/en/software.

[24] The table of descriptive statistics of efficiency scores for each industry activity can be found in the Appendix.

indicating that there were some fully efficient firms in the sample. Furthermore, Figure 4.2 depicts the histogram of calculated efficiency scores of Kuwaiti manufacturing firms. A large number of DMUs analysed are operating at maximum efficiency (score = 1). This implies that these firms are utilizing their resources optimally, without any inefficiencies. The graph shows that the DMUs spread all over the 0 to 1 score range with slightly higher density between efficiency scores of 0.2 and 0.4 and lower density between the scores 0.7 and 0.9. This indicates that there is a subset of firms that are operating at lower efficiencies. The distribution is skewed to the right[25] suggesting that there is a higher concentration of DMUs at lower score levels than there are at higher score levels.

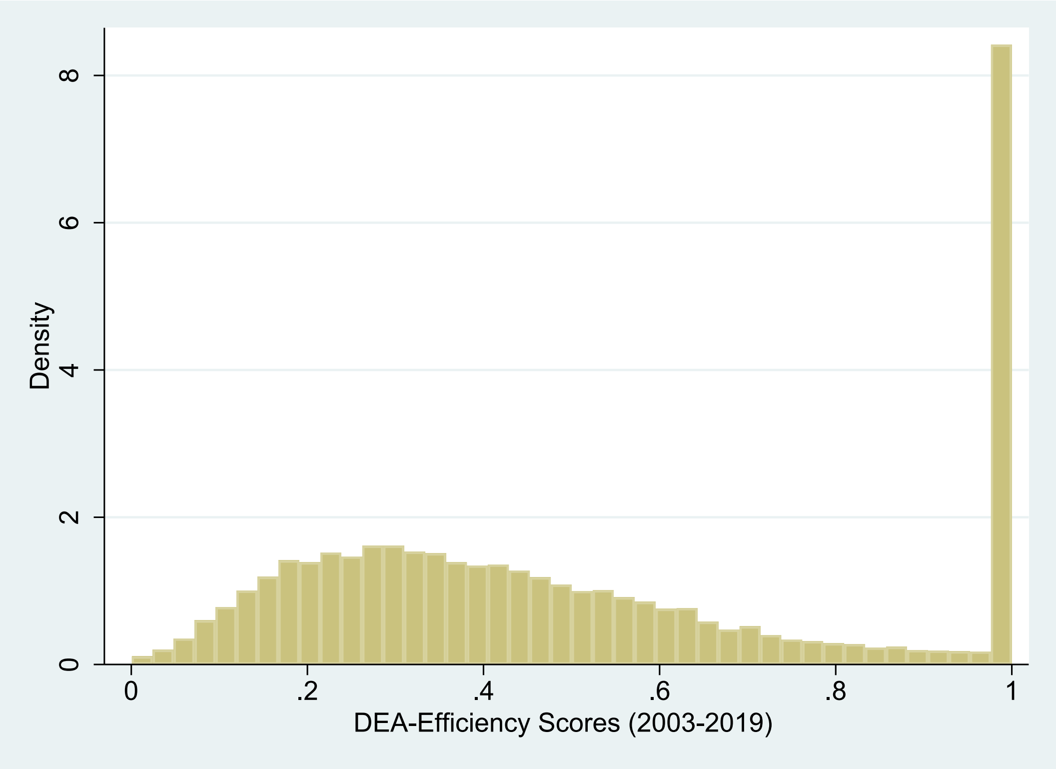
[25] The median of the panel data of efficiency scores is less than the mean (median= .43985 < mean= .51697)

Table 4.3: Summary statistics of manufacturing efficiency scores in Kuwait by year

Year	Median	SD	Min	Max	N
2003	0.576	0.281	0.090	1	1035
2004	0.554	0.277	0.087	1	1037
2005	0.514	0.288	0.059	1	1050
2006	0.508	0.284	0.080	1	1063
2007	0.525	0.286	0.049	1	1096
2008	0.562	0.282	0.063	1	1101
2009	0.535	0.280	0.073	1	1083
2010	0.531	0.284	0.054	1	1086
2011	0.506	0.299	0.034	1	1090
2012	0.498	0.299	0.033	1	1088
2013	0.527	0.287	0.061	1	1016
2014	0.501	0.295	0.064	1	1015
2015	0.506	0.291	0.067	1	1017
2016	0.508	0.292	0.040	1	1076
2017	0.498	0.289	0.052	1	1087
2018	0.515	0.294	0.036	1	1082
2019	0.520	0.292	0.032	1	1088

Author's calculation

Figure 4.2 Histogram of calculated efficiency scores, 2003-2019.



4.4.2 Oil shocks and efficiency

We present the results from symmetric and asymmetric models estimated using equation (4.5). We apply different econometric tools such as random effect Tobit and Simar and Wilson truncated regressions to present estimates, where the coefficients of efficiency scores are bootstrapped 1000 times.

4.4.2.1 Symmetric analysis

Table 4.4 presents the symmetric results for three models. Model I is the full-sample bootstrap random effects Tobit regression. Model II is the bootstrap random effects Tobit regression excluding fully efficient firms from the sample. The result from a Simar and Wilson (2007) truncated regression is represented in Model III for robustness check.

The results show that, in the three models, the oil supply disruption at level and the lagged shocks have insignificant effects on the efficiency scores of manufacturing firms in Kuwait. There may be several reasons for this. First, this type of shock has insignificant impact on government oil revenue in oil-exporting countries because of the role of big oil producer Saudi Arabia in covering any shortage in oil production. Additionally, recent research by Kim and Vera (2019) confirms the findings of Kilian's earlier work, indicating that oil supply disruption shocks are not a significant driver of oil market variations. Therefore, it is possible that the insignificant effects of oil supply disruption shocks on manufacturing firm efficiency scores may be due to the limited impact of these shocks on oil prices and economic activities in oil-exporting countries.

The results in the table reveal that aggregate demand shocks have a significant positive impact on the efficiency scores of manufacturing firms in Kuwait. This is evident through positive percentages of 1.112%, 1.262% and 1.907% in models I, II and III, respectively, at the 5% and 1% significance levels. The results also indicate a positive and robust coefficient for the lagged aggregate demand shocks in all three models. As expected, the results in the three models indicate in that, during periods of high oil revenue in oil-exporting countries and strong aggregate demand from emerging countries, manufacturing firms experience an increase in their efficiency scores, with the effect appearing to persist over time. The increase in oil prices, driven by strong global economic activity, plays a pivotal role in boosting the productivity and efficiency of manufacturing firms in Kuwait. During periods of robust global economic activity, there is an increased demand for oil and oil-related products, which not only enhances the revenue of these firms but also encourages them to invest in technological advancements and expand their operations. Consequently, the rise in oil prices creates a favourable environment for Kuwaiti manufacturing firms to grow, resulting in increased productivity and efficiency. Our findings are in line with the findings of Ziadat (2019), who concluded that, during times of positive aggregate demand shocks, stock markets in oil-rich countries such as those of the GCC (Gulf Cooperation Council) experience project and improvements.

Another possible way to interpret the findings, shedding light on why manufacturing firms in Kuwait tend to enhance their efficiency during periods of high oil prices, is that the high energy subsidies provided by the government play a crucial role in the efficiency scores of manufacturing firms. For instance, Kuwaiti energy subsidies reached 5% of GDP in 2014, with an average subsidy of around 78% of the price (Shehabi, 2016). These government energy subsidies in Kuwait can aid manufacturing firms significantly during periods of increased oil prices by lowering the cost of energy inputs for these entities. This cost reduction empowers them to manufacture goods and services at a more competitive price. Consequently, manufacturing firms could observe an upsurge in demand for their products, potentially leading to higher revenues and improved efficiency scores. Many studies[26] in the literature have highlighted the significant role of government subsidies in stimulating economic development and fostering increased productivity and investment in developing countries. For instance, Li et al. (2022) emphasised the positive impact of government subsidies on the productivity of manufacturing firms in China. Their research was based on panel data from 24,098 manufacturing firms spanning the period from 1998 to 2007.

Interestingly, the impact of oil-specific demand shocks associated with higher oil prices has a negative and statistically significant impact on Kuwaiti firms' manufacturing efficiency scores. The percentages of -1.468%, -1.070% and -1.414% in the three models, at significance levels of 5% and 10%, illustrate the reduction in manufacturing firms' efficiency from the frontiers. Moreover, the persistence of these adverse effects is evident from the findings of lagged shocks. One possibility interpretation that can explain the negative coefficients between oil-specific demand shocks and efficiency scores, is, when faced with high oil price fluctuations, firms would prefer to delay some of their investment projects until more information is

[26] See Bernini and Pellegrini (2011), Domadenik et al. (2018) and Skuras et al. (2006).

available, which is consistent with the predictions of irreversible theory (Bernanke, 1983). We conclude that during uncertainty about future oil prices, manufacturing firms in Kuwait prefer to delay investment, which then causes a decline in their revenue. As a result, their efficiency scores are also reduced. These findings are in line with Aye et al. (2014), who showed that the associated between oil price uncertainty and manufacturing firm production is negative and significant in South Africa. Also, our results are supported by the research of Alhassan (2019), which demonstrates that firms in GCC countries also tend to delay investments during periods of high oil price volatility. Moreover, Bugshan et al. (2021) have documented that when faced with oil price volatility resulting from positive oil price shocks, non-financial firms in GCC countries experience profit losses.

Next, considering the control variables, the results in the three models show that public firms are significantly more efficient than private firms in the Kuwaiti manufacturing sector. The results are probably due to the low level of private investment in Kuwait and the unattractive environment for foreign investment. Most foreign companies cannot set up a business without a Kuwaiti agent. Moreover, most firms in Kuwait are owned by Kuwaiti partners with a share of at least 51% (KISR, 2016)[27]. From the control variable of firm age in the random effect Tobit regression of the whole sample and the Simar and Wilson (2007) truncated results, we conclude that there is a positive relationship between manufacturing efficiency and the age of firms, which means that old firms are more efficient than mature or young firms. This result is consistent with other studies (Pitt and Lee, 1981; Faruq and Yi, 2010; Anh and Gan, 2020), which found that well established firms have higher efficiency scores.

[27] Research report from Kuwait Institute for Scientific Research (KISR).

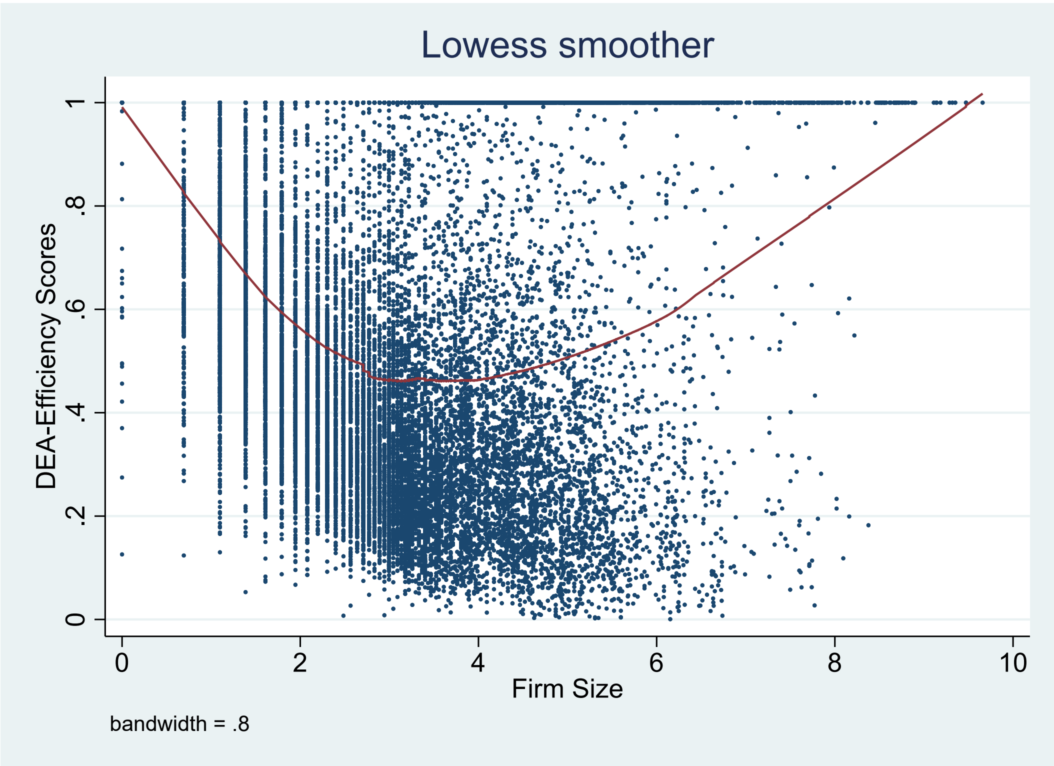
Table 4.4: Symmetric analysis of random effect Tobit and truncated regressions

Efficiency Scores	I Tobit	II Tobit	III Truncated regression
OSS	-0.01082	-0.01408	-0.01927
	[0.01074]	[0.00965]	[0.01431]
ADS	0.01112**	0.01262***	0.01907***
	[0.00500]	[0.00441]	[0.00625]
OSDS	-0.01468**	-0.01079**	-0.01414*
	[0.00573]	[0.00498]	[0.00791]
OSS_{t-1}	0.00550	-0.00252	-0.00339
	[0.01064]	[0.00895]	[0.01432]
ADS_{t-1}	0.01180***	0.01274***	0.02122***
	[0.00414]	[0.00366]	[0.00561]
$OSDS_{t-1}$	-0.01558**	-0.01368**	-0.01547*
	[0.00689]	[0.00578]	[0.00905]
Firm age	0.01100**	0.00218	0.01828***
	[0.00516]	[0.00477]	[0.00492]
Dummy Public	0.20283***	0.08672***	0.14625***
	[0.04267]	[0.03105]	[0.03082]
Firm size	-0.06590***	-0.06168***	-0.08947***
	[0.00286]	[0.00252]	[0.00186]
Cons	0.85138***	0.67342***	0.58647***
	[0.03993]	[0.01631]	[0.01616]
No. Firms	1193	1136	1136
Observations	16,709	13,455	13,455
T-Bar	15.1802	12.7975	-
Upper-Censored Data	3,254	0	-
Uncensored-Data	13,455	13,455	-

* $p<0.1$; ** $p<0.05$; *** $p<0.01$. The dependent variable is efficiency scores. Model I is the full-sample, Model II is excluding fully efficient firms from the sample and Model III is the truncated Simar and Wilson (2007). It is noteworthy that, in the case of symmetric analysis, excluding all the oil firms from the analysis in different specifications does not change the final result. I use the STATA command xttobit with option ul(1) for the first column only of results ,to run the random effect Tobit regression. For Simar&Wilson truncated regression, I use the STATA command simarwilson. T-bar is average number of years for an unbalanced panel data.

The measure of firm size used in this study is the number of workers. The results from all three models suggest that firm size has a negative effect on firm efficiency, with highly significant coefficients of -0.06590, -0.06168 and -0.08947 respectively. The results show a negative relationship between the number of workers and the efficiency of firms, so that having a higher workforce seems to make firms less efficient. This is consistent with Alhamdani (2019), who looked at the manufacturing sector in UAE and found that firms with more workers were less efficient. Figurer 4.3 represents the lowess smoother scatter plot between the calculated efficiency scores and firm size. The graph illustrates that the relationship between efficiency scores and firm size in Kuwaiti manufacturing firms has a U-shape, indicating that the relationship began to be negative until the firm size exceeded 6, at which point the relationship began to be positive between efficiency score and firm size.

Figure 4.3 Lowess scatter smoother plot, DEA-efficiency scores and firm size



4.4.2.2 Asymmetric analysis

Table 4.5 presents the results of the asymmetric oil shock analysis. Models IV and V represent the Tobit regressions with the whole sample, and the sample excluding the efficient firms, respectively. While Model VI is the Simar and Wilson (2007) truncated regression for cross-sectional data.

In all three models, positive oil supply shocks, which lead to lower oil prices, reduce the efficiency scores of manufacturing firms in Kuwait significantly, with magnitude values of -0.03924, -0.05228, and -0.06191 in models IV, V and VI respectively, at 10% and 5% levels of significance. This finding suggests that episodes of oil supply expansion dampen the efficiency of manufacturing firms. For instance, an oil supply expansion shock happened during the exploitation of US oil shale. At this time, in 2014, there was a large increase in the supply of oil and gas and a massive decline in oil prices. As a result, the revenue of oil-exporting countries declined, which may have led to less investment in the manufacturing sector in Kuwait. Mohaddes and Raissi (2019) show that the US oil supply expansion affected global macro-economic indicators significantly. Furthermore, following the US shale discoveries and according to the World Bank, GDP growth in Kuwait slowed, from an average of 6.6% in the years prior to 2014 to just 0.6% in 2015. The result is consistent with the findings of Kurronen (2018), who found that, during the episode of oil price collapse in 2014, both resource-based and non-resource-based firms in resource-dependent countries slowed the growth of their borrowing. Thus, when firms face financial constraints, it may affect their efficiency adversely, as they may be forced to reduce their investment, which can lead to a decline in productivity and efficiency. Additionally, the findings indicate that the response to positive oil supply shocks persists in models V and VI for Kuwaiti manufacturing firms.

Table 4.5: Asymmetric analysis of random effect Tobit and truncated regressions

Efficiency Scores	IV Tobit	V Tobit	VI Truncated regression
OSS_P	-0.03924*	-0.05228**	-0.06191**
	[0.02312]	[0.02044]	[0.03070]
OSS_N	-0.01313	-0.01399	-0.00676
	[0.04493]	[0.03821]	[0.06093]
ADS_P	0.03511***	0.02420**	0.03520**
	[0.01245]	[0.01050]	[0.01739]
ADS_N	0.01135	0.00132	0.00476
	[0.01569]	[0.01306]	[0.02089]
OSDS_P	0.03327	0.00875	-0.00428
	[0.02088]	[0.01813]	[0.02844]
OSDS_N	-0.05978**	-0.02072	-0.01790
	[0.02701]	[0.02378]	[0.03602]
OSS_P_{t-1}	-0.03125	-0.04319**	-0.05899*
	[0.02223]	[0.01966]	[0.03133]
OSS_N_{t-1}	0.04778	0.04436	0.09083
	[0.05053]	[0.04361]	[0.07241]
ADS_P_{t-1}	0.02434*	0.03403***	0.03369*
	[0.01299]	[0.01089]	[0.01860]
ADS_N_{t-1}	-0.00206	-0.01805	-0.00038
	[0.01996]	[0.01761]	[0.02716]
$OSDS\_P_{t-1}$	-0.02358	-0.02866	-0.04023
	[0.02693]	[0.02207]	[0.03426]
$OSDS\_N_{t-1}$	0.00454	0.00094	0.00520
	[0.02106]	[0.01670]	[0.02806]
Firm age	0.00315	0.00840*	0.01355**
	[0.00537]	[0.00483]	[0.00539]

Efficiency Scores	IV Tobit	V Tobit	VI Truncated regression
Dummy Public	0.20909***	0.07347**	0.15194***
	[0.04187]	[0.02970]	[0.03034]
Firm size	-0.06573***	-0.06716	-0.08919***
	[0.00287]	[0.00235]	[0.00192]
_cons	0.86982***	0.64685***	0.60879***
	[0.04283]	[0.02063]	[0.02731]
No. Firms	1193	1136	1136
Observations	16,709	13,455	13,455
T-Bar	15.1802	12.7975	-
Upper-Censored Data	3,254	0	-
Uncensored-Data	13,455	13,455	-

* *p*<0.1; ** *p*<0.05; *** *p*<0.01. * p<0.1; ** p<0.05; *** p<0.01. The dependent variable is efficiency scores. Model IV I is the full-sample, Model V is excluding fully efficient firms from the sample and Model VI is the truncated Simar and Wilson (2007). It is noteworthy that, in the case of asymmetric analysis, excluding all the oil firms from the analysis in different specifications will not change the final results. I use the STATA command xttobit with option ul(1) for the first column only of results ,to run the random effect Tobit regression. For Simar&Wilson truncated regression, I use the STATA command simarwilson.T-bar is average number of years for an unbalanced panel data.

Regarding asymmetric aggregate demand shocks, our results shed further light on the findings of the symmetric analysis. Positive aggregate demand shocks at the level and lagged oil-price shocks increase the efficiency scores of manufacturing firms. The results in the three models are robust: positive and significant at 1% and 5% significance levels, with coefficients of 0.03511 in Model IV, 0.02420 in Model V and 0.03520 in Model VI. The findings indicate the presence of an asymmetric association between firm efficiency and in terms of positive aggregate demand shocks, and that this effect persists over time.

On the other hand, the results of Model IV indicate that weak oil-specific demand shocks only dampen efficiency scores by coefficients of -0.05978, at a level of significance of 5%. However, the asymmetric test shows that the coefficients of positive and negative oil-specific demand shocks are equivalent, which means that there is no evidence of an asymmetric relationship between firm efficiency and this type of oil demand shock.

4.5 Conclusion

This study investigates the effects of the structural oil shocks on the efficiency scores of manufacturing firms in Kuwait, a developing oil-rich country, by utilising non-parametric DEA techniques and unique disaggregate data from the manufacturing sector during the period from 2003 to 2019. The chapter employs econometric tools in two stages. The first stage measures the efficiency scores of firms in 21 main manufacturing industry sectors, and the second stage examines the impact of structural oil shocks on efficiency scores, as well as considering ownership, firm age and firm size. The study examines both symmetric and asymmetric structural oil shocks and reveals significant findings.

Previous research has raised concerns that, during periods of high oil price uncertainty, firms will be unable to invest or profit in oil-rich countries. Our symmetric analysis suggests that aggregate demand shocks make manufacturing firms more productive and efficient. In contrast, oil-specific demand shocks which is resulting from geopolitical events have a negative effect on efficiency scores. The present study suggests that when high oil prices are associated with strong aggregate demand shock episodes, manufacturing firms in oil rich countries can increase their revenue and then improve their efficiency scores, but when high oil prices result from oil-specific demand shocks, manufacturers cannot boost their efficiency. One possible reason for this is that firms tend to postpone investment, which is consistent with the irreversible theory and the challenge of the resource curse phenomenon in oil rich countries. Moreover, the results indicate that oil supply disruptions have limited impact on firm efficiency. Therefore, policymakers and manufacturing firms in oil-rich countries may not need to focus much on the potential effects of oil supply shocks on firm efficiency, as these shocks may not have a significant impact on their productivity.

In addition, asymmetric relationships exist among our variables of interest. The asymmetric estimations suggest that only positive oil supply shocks matter, representing low oil prices due to the expansion of oil supply from other suppliers, which reduces the efficiency of Kuwaiti manufacturing firms. On the other hand, positive aggregate demand shocks are an essential factor in improving the efficiency scores of manufacturing firms. However, there is no evidence of asymmetric impact of oil-specific demand shocks on manufacturing sector efficiency in Kuwait.

In terms of firm characteristics, we find that public ownership is more efficient than private in the Kuwaiti manufacturing sector, firm age has a positive effect on efficiency scores and firm size has a negative impact on firm efficiency.

In this chapter, our results have policy recommendations to present it for policymakers and investors in Kuwait's manufacturing sector. First, our findings emphasize the importance of understanding the effects of different sources of oil shocks, as well as the asymmetric effects of theses oil shocks on firm's efficiency scores. Second, policymakers and investors should implement appropriate strategies such as the diversification of the economy and minimizing the reliance on oil exports , these strategies can help the policymakers to dampen the impact of oil shocks on firms' performance, particularly if the oil shocks are caused by oil-specific demand shocks or lower oil prices due to the expansion in oil production from foreign suppliers Furthermore, policymakers should build a healthy business environment to attract foreign direct investment and provide incentives for both domestic and foreign investment, also they should review the regulations for the private sector. The previous recommendations will help the manufacturing firms in Kuwait, an oil-rich country, become more competitive and efficient and deal with the adverse effects of oil shocks.

Overall, in this chapter, the contribution to the literature review is twofold. To the best of our knowledge, this is the first paper to examine the efficiency scores of manufacturing firms of disaggregate rich microeconomic confidential data in oil-exporting developing countries. Secondly, previous research examines the impact of oil shocks and economic activity indicators (see for example Alhassan (2019), Bugshan et al. (2021), Maghyereh and Abdoh (2020), Ziadat (2019)) and ignores the relationship between oil price shocks and efficiency scores, which play a crucial role in a firm's productivity. This paper explores the effects of oil shocks on manufacturing firms' efficiency scores of Kuwaiti firms using the decomposed oil supply and demand shocks for the first time. Furthermore, we examine this relationship using both symmetric and asymmetric approaches.

4.6 Appendices to Chapter 4

Table 4.6: Statistical description of input and output variables by industry activity (DEA first stage)

Industry Activity		Mean	SD
Petroleum & natural gas extraction & incidental services			
Input	Fixed assets	128,400,000	299,200,000
	Cost of raw materials	1,659,503,9	37,305,721
	Total workers	2447.412	2670.762
Output	Total revenue	961,900,000	1,888,000,000
Medical instruments			
Input	Fixed assets	584,366.51	1,276,856.1
	Cost of raw materials	263,409.02	488,323.97
	Total workers	724.797	1089.647
Output	Total revenue	2,318,997.4	3,198,656.2
Base metals			
Input	Fixed assets	1,439,192.8	5,418,841.6
	Cost of raw materials	129,288.85	267,905.12
	Total workers	194.765	359.38
Output	Total revenue	5,388,501.2	13,081,539
Chemicals and chemical products			
Input	Fixed assets	4,360,308.9	20,793,611
	Cost of raw materials	732,941.21	3,988,788.1
	Total workers	156.538	299.513
Output	Total revenue	11,215,854	41,646,321
Electrical machinery and apparatus N.E.C.			
Input	Fixed assets	645,931.83	1,956,801.2
	Cost of raw materials	267,359.5	646,579.29
	Total workers	315.393	564.178
Output	Total revenue	4,557,381.7	8,834,162.2
Fabricated metal products except machinery & equipment			
Input	Fixed assets	48,855.174	486,227.69
	Cost of raw materials	13,420.918	52,937.416
	Total workers	44.087	98.314
Output	Total revenue	268,350.23	1033421.5
Machinery and equipment N.E.C.			
Input	Fixed assets	122,282.24	34,8471.16
	Cost of raw materials	26,955.065	62,853.158
	Total workers	210.486	569.065
Output	Total revenue	782,210.93	1,865,185.4
Motor vehicles, trailers and semi-trailers			
Input	Fixed assets	43,805.931	155,522.16
	Cost of raw materials	11,495.225	23,114.692
	Total workers	44.564	64.778
Output	Total revenue	304,856.18	624,291.71
Non-metallic mineral products			
Input	Fixed assets	228,352.24	1,423,401.4
	Cost of raw materials	39,579.408	129,942.33
	Total workers	81.235	139.067
Output	Total revenue	878,590.21	2,407,564.4
Rubber and plastic products			
Input	Fixed assets	194,215.25	379,747.15
	Cost of raw materials	51,470.89	115,520.69
	Total workers	110.833	111.585
Output	Total revenue	915,629.18	1,044,984.6

Industry Activity		Mean	SD
Manufacture of other transport equipment			
Input	Fixed assets	422,756.22	1,457,495.5
	Cost of raw materials	590,616.45	2,047,837
	Total workers	755.382	2455.487
Output	Total revenue	2,497,823	8,105,448.5
Food products and beverages			
Input	Fixed assets	137,267.15	53,2051.35
	Cost of raw materials	62,611.278	286,752.66
	Total workers	114.826	276.182
Output	Total revenue	752,057.53	2,607,138.9
Furniture manufacturing N.E.C.			
Input	Fixed assets	14,690.831	50,035.817
	Cost of raw materials	10,586.396	42,738.891
	Total workers	29.558	44.162
Output	Total revenue	157,573.18	767,769.16
Textiles			
Input	Fixed assets	10,495.695	42,119.954
	Cost of raw materials	4,432.976	10,415.451
	Total workers	16.219	35.04
Output	Total revenue	62,901.058	168,570.1
Paper and paper products			
Input	Fixed assets	220,117.13	488,447.01
	Cost of raw materials	38,868.227	62,359.943
	Total workers	78.844	88.886
Output	Total revenue	799,723.98	1,203,239.5
Publishing, printing and production of recorded media			
Input	Fixed assets	116,165.5	369,786.12
	Cost of raw materials	46,975.333	166,390.48
	Total workers	59.481	105.299
Output	Total revenue	335,556.91	875,385.65
Refined petroleum products			
Input	Fixed assets	147,800,000	17,4200,000
	Cost of raw materials	11,649,222	10,619,294
	Total workers	3680.889	2847.471
Output	Total revenue	1,646,000,000	1,424,000,000
Recycling			
Input	Fixed assets	367,968.02	377,315.49
	Cost of raw materials	358,786.2	771,985.12
	Total workers	278.371	506.297
Output	Total revenue	1,350,490.1	1,729,685.9
Tanning and leather products			
Input	Fixed assets	42,893.395	69,227.447
	Cost of raw materials	12,228.42	15,629.186
	Total workers	47.342	29.847
Output	Total revenue	205,363.57	193,232.4
Wearing apparel			
Input	Fixed assets	2,614.327	12,277.336
	Cost of raw materials	2,773.985	6,072.736
	Total workers	15.93	41.593
Output	Total revenue	28,413.381	65,698.578
Wood, wood products and cork			
Input	Fixed assets	9,977.152	28,283.347
	Cost of raw materials	5,811.325	21,087.836
	Total workers	19.858	28.61
Output	Total revenue	91,904.314	183,922.15

Author's calculations

Table 4.7: Definitions of variables

Variables	Definition	Source
Efficiency score	Measure of efficiency scores using PIM-DEA software (Output: Total Revenue; Input: fixed assets, cost of raw materials, number of workers).	Central Statistics Bureau (CSB), Annual Economic Survey (2003-2019), Kuwait.
Oil supply shock (OSS)	Defined as an exogenous shift in oil supply, unaffected by macroeconomic conditions.	Author's calculation.
Aggregate demand shock (ADS)	Defined as a global rise in real economic activity.	Author's calculation.
Oil-specific-demand shock (OSDS)	Defined as a rise in precautionary oil demand as a result of future supply uncertainty.	Author's calculation.
Ownership	Dummy variable: '1' when the ownership is classified as public in the establishment survey, '0' otherwise.	Author's calculation based on data from CSB.
Firm age	Logarithm of number of years.	Author's calculation based on data from CSB.
Firm size	Logarithm of number of workers.	Author's calculation based on data from CSB.

Table 4.8: Average efficiency scores by industry activity of Kuwaiti manufacturing firms (2003-2019)

Industry Activity	Mean	SD	N	% of efficient firms
Extraction of crude petroleum and natural gas and service activities incidental to oil and gas	0.833	0.300	97	72.16%
Medical instruments	0.936	0.164	128	80.47%
Base metals	0.862	0.219	132	62.88%
Chemicals and chemical products	0.668	0.299	626	34.50%
Electrical machinery and apparatus N.E.C.	0.754	0.299	191	48.17%
Fabricated metal products, except machinery and equipment	0.548	0.255	3160	11.68%
Machinery and equipment N.E.C.	0.828	0.256	292	52.74%
Motor vehicles, trailers and semi-trailers	0.817	0.266	140	56.43%
Non-metallic mineral products	0.483	0.273	2134	11.95%
Rubber and plastic products	0.656	0.282	677	29.39%
Manufacture of other transport equipment	0.939	0.131	157	75.16%
Food products and beverages	0.463	0.283	2608	12.77%
Furniture manufacturing N.E.C.	0.444	0.282	2304	10.16%
Textiles	0.672	0.233	999	22.42%
Paper and paper products	0.647	0.307	475	29.05%
Publishing, printing and production of recorded media	0.640	0.250	1333	21.53%
Refined petroleum products	1.000	0.000	27	100.00%
Recycling	0.942	0.193	35	91.43%
Tanning and leather products	0.968	0.097	79	82.28%
Wearing apparel	0.621	0.235	1859	15.55%
Wood, wood products and cork	0.680	0.272	657	30.59%
Total (All industries)	0.573	0.288	18,110	19.70%

Author's calculations.

Table 4.9: Wald tests for asymmetry

$$H_0: \beta^{+} = \beta^{-}$$

$$H_1: \beta^{+} \neq \beta^{-}$$

	IV Tobit	V Tobit	VI Simar & Wilson
Type of Oil Shocks	Test-Stat	Test-Stat	Test-Stat
OSS	0.16	4.60**	3.19*
ADS	5.15**	7.41***	17.03***
OSDS	0.15	-	-
OSS_{t-1}	-	3.99**	1.37
ADS_{t-1}	0.3782	4.14**	0.65

Chapter 5
Conclusions

5.1 An overview of the findings

The oil shocks topics are an essential and interesting research subject in the literature because of their significant impact on the global economy. Therefore, researchers and policymakers have devoted considerable attention to monitoring and analysing the effects of fluctuations in oil prices. Most studies have focused on oil-importing developed countries; however, a growing body of literature has examined the impact of oil shocks on oil-exporting developing countries. This thesis focuses on the role of different sources of oil shocks on oil-exporting countries from a macroeconomic and microeconomic perspective.

This thesis empirically investigated the primary sources of oil price fluctuations and the effects of these sources on oil-rich exporting developing economies. Specifically, the thesis examined the role of three structural shocks: oil supply shocks, aggregate demand shocks, and oil-specific demand shocks. The analysis is conducted in three dimensions: causes of recent oil price movements and macroeconomic indicators of oil exporting countries; the role of the structural oil shocks to capture the behaviour of central bank reaction functions in selected oil-rich countries; and finally, how the structural shocks affect manufacturing firm efficiency in an oil-rich economy.

Chapter 2 is the first empirical essay, which examined, in the first stage, the primary causes of recent oil shock episodes using the innovative methodology developed by Kilian (2009). The methodology employed a structural autoregressive regression (SVAR) approach with three global indicators from 1974 to 2019. The results aligned with existing research, indicating that demand shocks play a dominant role in driving oil price fluctuations. On the other hand, the impact of oil supply shocks appears to be less pronounced, probably due to the ability of major oil producers to offset any production shortfalls. In the second stage, we applied the augmented mean group estimator (AMG) for cross-sectional panel data and a large sample of 20 oil-exporting developing countries of periods 1980-2019 to investigate the role of symmetric and asymmetric of the main structural oil shocks on macroeconomic indicators within oil-exporting developing economies. Our variables of interest are aggregate government expenditure, aggregate government revenue, and government budget. We can summarize our findings into two conclusions: First, the symmetric analysis results found that aggregate demand shocks and oil-specific demand shocks are the main sources of improvements in our fiscal indicators. Second, in asymmetrical estimations, we observed the asymmetric relationships between fiscal indicators and positive aggregate demand shocks only. In both symmetric and asymmetric estimations, the oil supply shocks have a muted impact on the fiscal indicators of oil-developing producers.

In Chapter 2, we examined the role of the three structural shocks on the reaction functions of selected oil-exporting countries in the Gulf region. The GCC countries can face challenges setting their policy rates during periods of high inflation following positive oil-price shocks, while also managing their exchange rates. Estimating a Taylor Rule is a standard way of modelling central bank behaviour. We augment the Taylor rule with our three structural oil shocks to investigate whether adding the structural oil shocks could help to understand the behaviour of the central banks' decisions in oil-exporting economies. We focus on four countries, namely Bahrain, Kuwait, Oman, and Saudi Arabia, due to data availability. We apply the Generalized Method of Moments (GMM) regressions, and our data are quarterly with different start dates, endingQ4 2019. The symmetric results showed that augmented Taylor rule estimations help us to understand the behaviour of policy rates in GCC countries. However, the symmetric estimations found that the policy rate does not react to the three oil shocks, and the main preferences of monetary policy for Kuwait and Saudi Arabia are the output gap, while Bahrain strictly follows the U.S. Fed interest rate. In Oman, the central bank puts a greater weight on the lagged interest rates than Fed Funds rate. In terms of asymmetric analysis, we concluded that the sources of oil shocks matter; the Central Banks of Oman and Saudi Arabia respond more strongly to positive aggregate demand shocks by lowering policy rates and positively to negative aggregate demand shocks by raising policy rates. In Kuwait, we found that only oil supply disruptions matter, and the central bank reacts negatively to this type of oil shock. These adverse behaviours are due to the fact that a key objective of GCC central banks is to manage the exchange rate following U.S. Fed decisions. The discrepancy in economic trends between the United States and GCC nations is discussed by Hakro and Omezzine (2014), who note periods of robust GCC growth during U.S. economic downturns, and vice versa. This provides an underlying rationale for understanding how GCC central banks respond to both positive and negative structural oil shocks. However, in Bahrain, the asymmetric analysis showed that the central bank does not react to the structural oil shocks and puts higher weight on the U.S. Fed interest rate. These findings make a meaningful contribution to the literature as they offer empirical evidence that structural oil shocks are a matter of concern for monetary policy authorities in the GCC countries when it comes to determining policy rates.

In the last empirical essay (Chapter 4), we examined the external factors that have an impact on the firms' efficiency scores in the manufacturing sector in oil-rich countries, such as Kuwait. This sector is vital and plays a crucial role in Kuwait's economic growth. The chapter used confidential firm-level data from the period 2003-2019, and we applied a DEA technique with a two-stage analysis. In the first stage, we estimated the efficiency scores for 21 different manufacturing sectors. We applied the bootstrap random effect Tobit regression to examine the response of firms' efficiency to the three structural oil shocks. The analysis indicates that manufacturing firms' efficiency can improve during the aggregate demand shocks, while shocks from oil-specific demand will lead to a deterioration. There is the presence of an asymmetric relationship between a firm's efficiency and positive aggregate demand shocks. The results confirmed the silence of oil supply shock in terms of symmetric analysis. On the other hand, in our asymmetric estimation, we conclude that the oil supply expansion shocks, which lead to a plunge in oil prices, will deteriorate the manufacturing firms' efficiency scores. The results of this chapter indicate that the sources of shocks matter for a firm's performance, based on efficiency scores. It sheds light that not all oil shocks will negatively affect firm performance, as previous studies have found, and investors and policymakers in oil-rich countries will need to take economic reforms to dampen the impact of oil shocks, such as seeking diversification and improving the private sector.

Motivated by these findings of the thesis, it is interesting to shed light on the importance of the beginning of the transition to a clean (or renewable) energy agenda and the phasing out of fossil fuels, which lead the fossil fuel producers to take action and prepare for this transition and adjusts their implication policies appropriately. The International Energy Agency (2022) predicts that prices will fall by 60% by 2050 in a net-zero carbon emissions scenario due to reduced fossil fuel consumption. However, the results of the whole thesis suggest that the sources of oil price fluctuations and the effects of oil price shocks on oil exporting developing countries come mainly from aggregate demand and oil-specific demand shock. In contrast, the oil supply shocks have imputed and limited impact. These findings raise the question of the consequence of the announcement of "net zero" on oil exporting to less developed economies.

Furthermore, the “net-zero” target will decrease the oil demand. In the long term, this reduced demand could force oil prices to a long period of decline. Consequently, the long-term reduction of oil prices will lead to macroeconomic instability of oil producers, and potentially, these economies will suffer from economic stagnation. The policy implication is that the oil producer should accelerate the economic reforms and diversify their income to curb the risks from the transition to a clean energy agenda.

Overall contributions of the current thesis, to the best of our knowledge, this study is the first attempt to investigate the impact of structural oil shock on macroeconomic and microeconomic aspects of oil exporting developing countries. This is the first contribution that this thesis makes to the field as a whole. The majority of research papers in these economies (Alley, 2016; Adedokun, 2018; Bjørnland, 2009; El Anshasy and Bradley, 2012; Koh, 2017; Mehrara, 2008; Moshiri and Banihashem, 2012) investigate the impact of shocks by using oil prices as an exogenous variable. However, they ignore the fact that there are supply and demand factors that have an impact on the movements of oil prices. All of these aspects have to be taken into account, and the price of oil should be considered as an endogenous variable. Oil supply shocks, aggregate demand shocks, and oil-specific demand shocks are the three original sources that cause fluctuations in oil prices, according to Kilian (2009) and his decomposition technique of the oil prices. As a second step, we broaden the scope of the literature review by investigating the effects of three structural oil shocks on fiscal policy, monetary policy, and firm efficiency using two distinct methodologies: symmetric analysis and asymmetric analysis. The existence of asymmetrical effects of decomposed oil shocks on oil exporting developing economies, particularly from demand shocks, indicates that we contribute to the review of the relevant literature.

5.2 Future research

The chapters of this thesis contribute to the literature on the importance of disentangled oil shocks, and we will publish the resulting papers. The thesis considers oil-shock data until 2019. An important extension in future work will be to consider the interim years, covering the COVID-19 pandemic and the invasion of Ukraine – both significant global shocks associated with large shifts in oil prices. The chapters suggest Kilian's (2009) shocks matter for policymakers in many ways. Further extensions could involve the consideration of further countries, for example, oil importers.

Chapter 2 could be extended to consider both the longer time period and a broader range of countries to better understand the effect of disentangled global shocks on measures of government expenditure. Chapter 3 provides some evidence that global shocks can matter for monetary policy, even for countries who apparently peg their exchange rates. Chapter 4 could be extended both to consider further economies – subject to the availability of firm-level data – but also to consider the role of foreign direct investment in dampening the effect of oils shocks and specifically oil-specific demand shocks in oil-exporting countries. Throughout, considering asymmetries in responses to shocks appears to play an important role in fully understanding economic responses to disentangled oil shocks.

Furthermore, in this thesis, the asymmetric technique used for Kilian's structural oil shocks decomposed the structural oil shocks into positive and negative ones after aggregating the oil shocks into different data frequencies. This decomposing could lead to massification in distinguishing between the positive and negative oil shocks within a specific period, and with the aggregated data, both positive and negative shocks can occur in the same year. For example, let's assume that we have quarterly data, and in a specific year, we have four shocks: +20, +20, +20, and -20. Then, to represent that year with a single shock and transition to annual data, the oil shocks are averaged, providing an annual shock of +10. In this case, the shock would be treated as a positive shock in subsequent analyses; however, if we can calculate the positive oil shock for the previous example to be (20+20+20+0)/4 = 15 and negative oil shocks to be (0+0+0+(-20))/4 = -10. For further research in the asymmetric research area, it is vital to decompose the original frequency of the structural oil shocks into positive and negative values before performing any transition between different data frequencies. This methodology will consider the misleading of any calculations from averaging the structural oil shocks across different frequencies. Thank you to the examiners, Professor Peter Moffatt and Professor Steve Cook, for raising this crucial point that has been ignored in previous literature.

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