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分類能源消費與價格衝擊對金融市場之影響

The Impacts of Disaggregated Energy Consumption and Price Shocks on Financial Markets

研 究 生：林政勳

指導教授：胡均立 教授

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中文摘要

本篇論文以非對稱性的時間序列模型探討兩個與能源相關的議題。首先，近年來台灣的能源消費成長高於經濟成長率，顯示過多的能源消費卻無法有效提升國內產出，且隱含著能源效率持續惡化。能源消費與產出的脫鉤現象，在長期之下是否會仍存在共整合關係？對此，本研究利用非對稱性的門檻共整合檢定去探討經濟成長與各類型能源消費的長期均衡關係。實證結果發現，除了原油消費與經濟成長的組合之外，其他各類型能源消費與經濟成長之間存在非線性關係。此外，透過兩狀態向量誤差模型則顯示，當達到一定的門檻水準之後，能源消費將持續朝向長期均衡的調整。對此，決策者未來在進行經濟預測時，可考量能源消費與經濟成長間的非對稱模型，並且應建立一套有效的能源需求管理，以改善能源效率。

本篇論文的第二個議題，是探討原油價格衝擊對股價的影響。自從兩次能源危機之後，過去三十年間油價變動及其對經濟活動衝擊的相關研究蓬勃發展。然而，至今仍少有研究在探討油價變動與股票市場之間的動態關係。為了探究此議題，我們將股價、油價、工業生產指數和利率等變數結合成一個多變量的線性架構，探究六個已開發與開發中國家的股票市場中油價衝擊的傳遞行為。此外，我們以原油價格變動當作一個門檻變數區分為油價上漲與下跌狀態，檢視在不同狀

態之下油價衝擊對股價變動的影響。研究結果顯示，油價衝擊在解釋股票報酬的調整行為中是一個重要的因子。此外，我們也發現加拿大、法國和台灣第一個月的油價衝擊對股價變動具有規避效果，而對韓國股票市場則具有激勵效果，但這些衝擊效果並不太大。當非對稱性的效果存在時，衝擊反應分析顯示，當油價變動處於下跌狀態時，第一個月的油價衝擊對韓國的股價變動具有負向影響；然而，當油價變動處於上漲狀態時，油價衝擊能增加股票報酬。根據此發現，對於跨國投資機構而言，當油價變動增加時，可調整其投資組合成分，將資金轉投入低通膨、正報酬的新興股票市場中，以避免損害其投資績效。

關鍵詞：分類能源消費、油價衝擊、門檻共整、兩狀態誤差修正模型、衝擊反應分析、變異數分解、非對稱性

The Impacts of Disaggregated Energy Consumption and Price Shocks on Financial Markets

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Abstract

The dissertation considers the time series model with an asymmetric framework to investigate two energy issues. Firstly, energy consumption growth is much higher than economic growth for Taiwan in recent years, worsening its energy efficiency. It reveals that consuming more energy cannot effectively enhance domestic output. Do there still exist a long-run co-integrating relationship as energy-output behaves a decoupling phenomenon? We provide a solid explanation by examining the equilibrium relationship between disaggregated energy consumption and GDP with the threshold co-integration test. The empirical results indicate that there is asymmetric co-integration relationship between disaggregated energy consumption and GDP, except for oil consumption nexus. The two-regime vector error-correction models show that the adjustment process of energy consumption toward equilibrium is highly persistent when an appropriately threshold is reached. There is mean-reverting behavior when the threshold is reached, making aggregated and disaggregated energy consumptions grow faster than GDP in Taiwan. Based on these results, there would progressively get into the insight to the possibility of asymmetric effects, and policy-makers as a result may be interested in identifying the asymmetric expected mechanisms of energy dependencies of economic growth as concerning future policy actions. Policy-makers should also establish an effective energy demand side management (EDSM) to improve energy efficiency.

Secondly, since the global energy crises of the 1970s and their effects on the world economy, the impact of an oil price change and its shock on economic activities have been a focus of research over the past three decades. So far, few studies explore the relationship between oil price and stock market, particularly in the impacts of oil shocks on equity returns. In order to address this issue, we incorporate stock price, oil price, industrial production and interest rate into a multivariate system, highlighting the transmission channels of oil price shocks on six developed and developing stock markets. The asymmetric effects are detected when the oil price changes separated into decrease and increase regimes. The empirical results show that oil price shock plays a significant role in explaining adjustments in stock market returns. Moreover, oil price shocks lead to initial an adverse effect on stock returns for Canada, France, and Taiwan. However, the magnitude of these effects proves small. When the asymmetric effects exist, the impulse response analysis in Korea indicates that an oil price shock will decrease the stock price changes under oil price changes decrease regime, while stimulate the stock returns as oil price changes increase. Hence, institutional investors should promptly re-adjust their global portfolio flowing to those stock markets with low inflation and positive returns when oil prices strikingly increasing that can prevent harming their performance.

Keywords: Disaggregated Energy Consumption; Oil Price Shocks; Threshold Co-integration; Two-regime Error Correction Model; Impulse Response Analysis; Variance Decomposition; Asymmetry

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Table of Contents

1896

List of Tables

List of Figures

Chapter 1 Introduction

1.1 Research Background

Energy is one of the critical determinants in economic development process. To maintain higher economic growth, rapid growing developing economies are confronted with substantial demand of various energy sources. Since the early 1980s, energy demand on a national and international basis has been extensively analyzed, initially motivated by concerns about security due to energy supply in view of the twin oil price shocks in 1970s and later because concerns about climate change. Due to the growing pressure exerted on governments to reduce carbon dioxide (CO_2) emissions in order to ease up the rate of climate change, many countries worry about the negative impact on economic growth caused by the restricted use of fossil fuels. Hence, various economic policies and options have been studied to practice energy conservation without harming on economic growth.

Growing concerns over the effects of greenhouse gas emissions for global warming have placed pressure on the world's leading economies to improve their efficiency of energy use. In June 2005, the National Energy Conference in Taiwan took place and the objective was to establish an applicable energy policy that can conform to the newly developing trends under the Kyoto Protocol. The conference has given some directions for macro strategies of energy policy that have to be implemented in the future. First, carbon dioxide emissions are expected to reduce to levels of 38 million tons of oil equivalent (MTOE) in 2015 and to 78 MTOE in 2025, respectively. Second, the structures of energy allocation percentage in 2025 are expected to drop as follows: fuel 41% to 45%, oil 32% to 31%, natural gas 16% to 19%, nuclear energy to 4%, and renewable energy 5% to 7%. Third, Taiwan's government regulatory authority should establish a market mechanism to promote the rationalization of energy prices and consolidate the management of efficient energy use. Although economists have long argued that pricing policies are an effective instrument to improve the efficiency of energy use, the effectiveness of a pricing policy to promote the efficient use of energy depends on the price elasticity of energy demand. Finally, the legislative body should create energy enterprising laws that can accomplish energy market liberalization progressively.

Beginning in the 1980s, an enormous amount of change in Taiwan's economic structure took place. Financial liberalization and an internationalization policy were carried out in the middle part of the 1980s. The country's average annual economic growth was 7.59% and the average growth rate of energy consumption was 5.84% starting from 1980 until the end of 1996. This signifies that domestic output consumes a relative lower level of energy. However, some economic incidents have caused a substantial decline in economic growth, including military tension across the Taiwan Strait, Asian financial crisis (1997-1999), and recessions in the global business cycle in 2001. As shown in Figure 1.1, during the period from 1997 to 2002, the average annual economic growth dropped to 3.63%, while energy consumption still sustained at 5.58%, worsening Taiwan's energy efficiency. Energy over-consumption cannot effectively enhance economic growth and may generate disequilibrium between energy consumption and economic growth. Actions toward energy-saving and value-added promotion are needed to improve energy efficiency.

Among the most severe supply shocks hitting the world economies since World War II are sharp increases in the price of oil and other energy products. Since 1973, many researchers are focused on studying the oil prices-macroeconomy relationship. There is a consensus between economists that oil price shock reduces economic activity and increases inflation simultaneously.

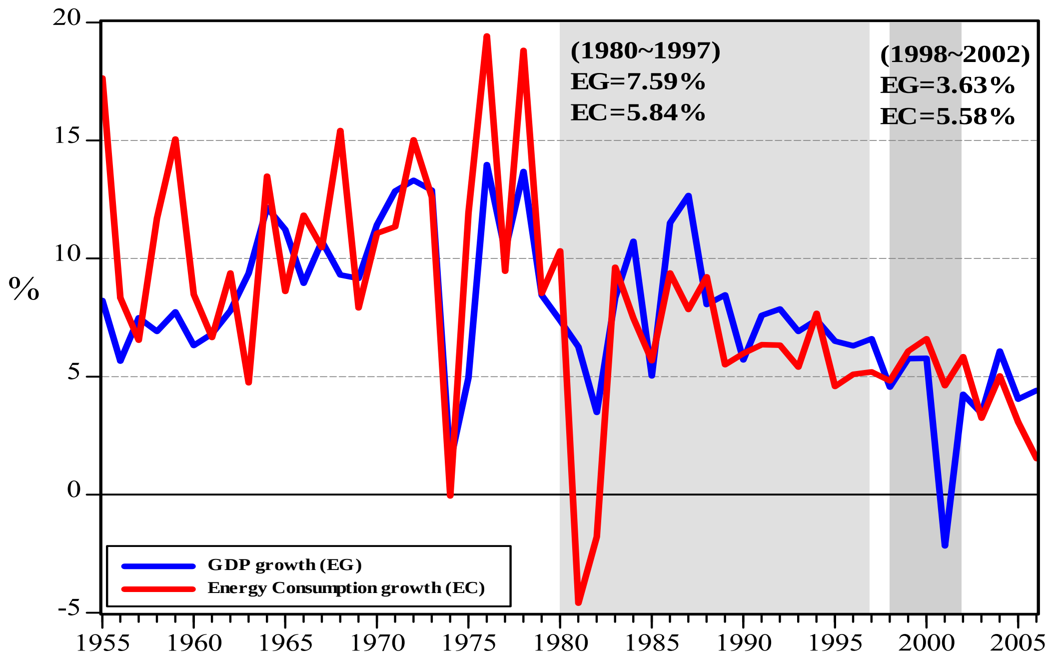


Figure 1.1 Historical Series of GDP and Energy Consumption Growth in Taiwan

The transmission mechanisms through which oil prices have impact on real economic activity include both supply and demand channels. Some studies explain this recession by the supply side as the principal channel by which the effects of the rising oil price are transmitted. In this case, the rise of the price affects the potential production in an economy. Indeed, oil price rising is interpreted as an indicator of increase in the scarcity and that means that oil will be less available on the market. Since oil is an input for the production, this latter and the labor productivity slow down.

In sharp contrast to the volume of studies investigating the link between oil price shocks and macroeconomic variables, there have been relatively few analyses on the relationship between oil price shocks and financial markets such as the stock market. Market participants want a framework that identifies how oil-price changes affect stock prices or stock market returns. On theoretical grounds, oil-price shocks affect stock market returns or prices through their effect on expected earnings.

1.2 Research Purpose

Because oil and various energy sources play critical role in determining economic growth, the main interest of this dissertation is therefore to address the issues of energy consumption and oil price fluctuation on financial markets with linear and asymmetric framework. There are two reasons to take into account asymmetric adjusting behavior between energy consumption and economic growth. The first one is that the topic of asymmetric properties of the adjustment process has been paid scant attention, while large numbers of recent studies provide evidence of the asymmetric adjustment of most macroeconomic variables (e.g., Ewing et al., 2006; Maki and Kitasaka, 2006). Neglecting an asymmetric adjustment among macroeconomic variables may lead to biased inferences and hence misleading results. As discussed by Balke and Fomby (1997), movement toward the long-run equilibrium is not necessarily constant, implying that the convergence to equilibrium may be faster under positive deviations than under negative ones (or vice versa). Therefore, if asymmetric co-integration is evident, then the conventional vector error-correction models (VECM) will be a mis-specification.

Another one is that several renowned recent studies have found an asymmetric relationship between energy consumption and economic growth in Taiwan. Lee and Chang (2005) argue that neglecting the structural break problem means being unable to uncover whether or not parameters are unstable within each of the sub-periods. They provide evidence that the co-integration relationship between energy consumption and GDP is unstable in Taiwan, and some economic events such as the oil crisis and Asian financial crisis significantly affect stability. Lee and Chang (2007) consider the possibility of both a linear and nonlinear effect of energy consumption on economic growth for Taiwan based on the conventional neoclassical one-sector aggregate production function. By conducting the threshold regression model during the two energy crisis periods, they indicate that the structural change due to the existence of an energy consumption threshold should be considered when constructing estimation and prediction models of economic growth. In addition, they also provide evidence that the relationship between energy consumption and economic growth in Taiwan can be characterized by an inverse U-shape. Most of these previous contributions suggest that there seems have an asymmetric relationship between energy consumption and economic growth in Taiwan.

Furthermore, Taiwan's economy faces scarcity in domestic energy resources and has to rely heavily on imports of energy. Yang (2000), Sari and Soytas (2004) and Wolde-Rufael (2004) employ disaggregate energy consumption data with respect to different energy sources; whereas, Hondroyiannis et al. (2002) distinguish between residential and industrial energy consumption. Moreover, Yang (2000) indicates that one shortcoming with the use of aggregated energy data is that countries may depend on different energy sources. Therefore, it is not possible to identify the impact of a specific type of energy with aggregated data. These concerns have encouraged us to investigate the relationship between disaggregated energy consumption and economic growth in order to identify the impact of different energy sources on GDP in Taiwan. Based on the aforementioned argument, the first purpose of this dissertation is to examine the asymmetric behavior between disaggregated energy consumption and GDP in Taiwan, using a threshold co-integration model proposed by Hansen and Seo (2002).

Oil prices do not affect asset prices in isolation, but through the perceived effect on the macroeconomy. An analysis of the linkages between oil and stock markets therefore requires a through examination of macroeconomic linkages. Hence, the second purpose of this dissertation is to assess the effects of oil price shocks on stock prices with the linear and asymmetric perspective for six developed and developing stock markets. We incorporate the four relevant variables (including stock returns, oil price, industrial production and interest rate) as a multivariate framework in the vector autoregression (VAR) model. Applying the impulse response analysis (IRF) can capture the effects of oil price shocks on stock market. Besides, due to the differences in the degree of economic development, energy dependence, and the efficiency of energy use, the speed of economic response in each country as a result of the impact of a positive oil price change and its shock are expected to be different. Therefore, we separate the oil price changes as a decrease (down) and increase (up) band to analyze the impacts of oil shock on equity returns.

1.3 Organization of the Dissertation

The dissertation is organized in the following manner as Figure 1.2 shows: Chapter 1 presents the motivations and purposes of the study. Chapter 2 reviews the related literature. Chapter 3 gives a brief introduction of research methods. Chapter 4 presents the empirical results. Chapter 5 concludes this dissertation and proposes policy implications.

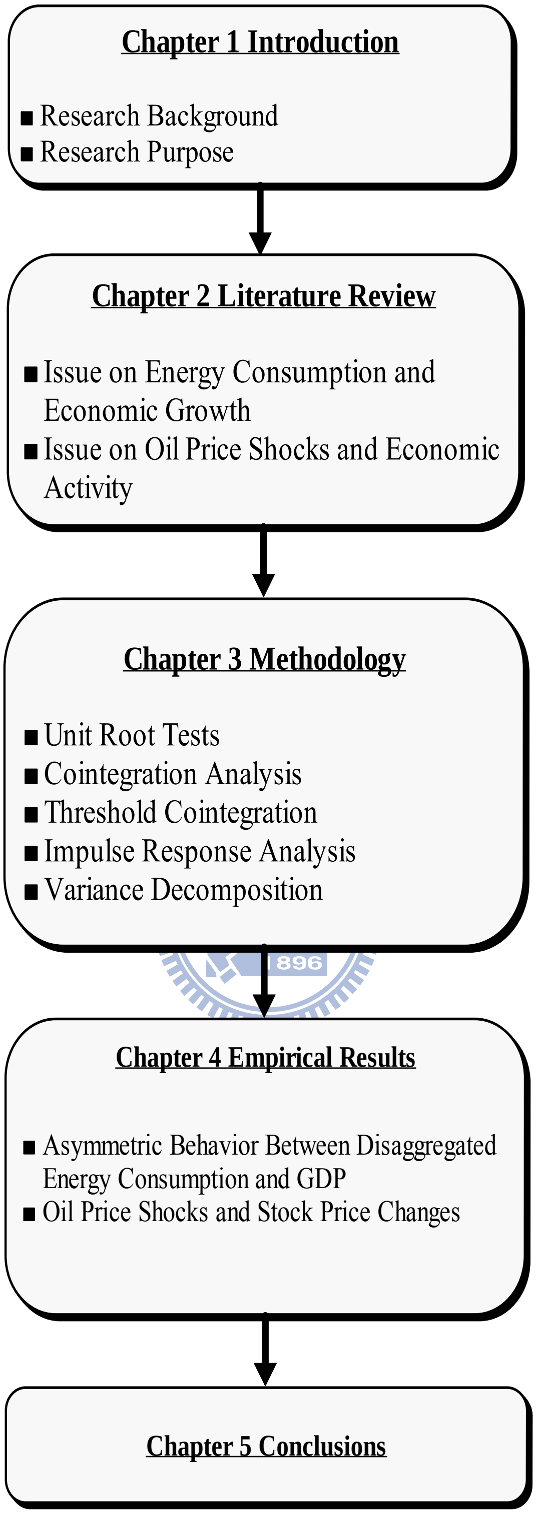


Figure 1.2 Research Flow Chart

Chapter 2 Literature Review

2.1 Issues on Energy Consumption and Economic Growth

Ever since 1970s numerous studies have examined the relationship between energy consumption and economic growth. A major question concerning this issue is which variable leads to the other: Is energy consumption a stimulus for economic growth or does economic growth lead to energy consumption? One of the time series methodologies to employ is the concept of Granger causality. Following Kraft and Kraft (1978) who provide pioneering evidence in support of causality from GNP to energy consumption in the United States, many empirical studies later extend to cover other industrial countries such as the United Kingdom, Canada, Germany, Italy, Japan, and France (e.g., Yu and Choi, 1985; Erol and Yu, 1987). However, the related literature on developed and developing countries, with diverse methodologies, and using various time periods fails to reach a unanimous conclusion.

Because of the critical role played by energy in the economic growth, an energy conservation policy (whether or not it can successfully be propagated within an individual country) has been a striking topic widely explored. The directions of the causal relationship between energy consumption and economic growth can be categorized into four types and evidence on either direction has important implications for an energy policy. First, if there is a unidirectional causality from economic growth to energy consumption, then policies for reducing energy consumption may be implemented with only little adverse or no effect on economic growth, such as in a less energy-dependent economy (Lise and Montfort, 2007; Oh and Lee, 2004; Yoo and Kim, 2006). Second, if there is unidirectional causality from energy consumption to economic growth, then restrictions on the use of energy may have significantly adverse effects on economic growth, while an increase in energy consumption may contribute to economic growth (Altinay and Karagol, 2005; Lee, 2005; Narayan and Singh, 2007; Shiu and Lam, 2004; Wolde-Rufael, 2004; Yuan et al., 2007). Third, if there is a bidirectional causal relationship, then economic growth may demand more energy whereas more energy consumption may also induce economic growth. Energy consumption and economic growth complement each other such that radical energy conservation measures may significantly hinder economic growth (Jumbe, 2004; Yang, 2000; Yoo, 2005). Finally, if there is no causality in either direction, which is known as the 'neutrality hypothesis', then neither conservative nor expansive energy consumption has any effect on economic growth (Asafu-Adjaye, 2000; Wolde-Rufael, 2005).

Another time series methodology explaining the relationship between energy consumption and economic growth is the co-integration technique with a bivariate (e.g., Yang, 2000; Zachariadis, 2007; Zamani, 2007) or multivariate (e.g., Masih and Masih, 1997; Oh and Lee, 2004; Soytas and Sari, 2007) framework. Stern (1993) adopts a multivariate vector autoregression (VAR) model to explore the causal relationship between GDP, energy use, capital, and labor inputs in the United States, where using a quality-adjusted index of energy input in place of gross energy use. Compared to the bivariate VAR analysis, the multivariate context is important because changes in energy inputs are more frequently countered by the substitution of other production factors, resulting in an insignificant overall impact on output. Stern (2000) further extends his previous analysis by incorporating the co-integration analysis with some relevant variables. The results show that there is co-integration in a relationship among GDP, capital, labor, and energy.

Ghali and El-Sakka (2004) employ the Johansen co-integration technique to analyze the relationship among output, capital, labor, and energy use in Canada on the basis of neo-classical one-sector aggregate production technology. Their results indicate that the long-run movements of output, capital, labor, and energy use are related by two co-integrating vectors.

Lise and Montfort (2007) undertake a co-integration analysis not only to explore the link between energy consumption and GDP, but also to take into account environmental protection and economic development for Turkey. Co-integration is found between energy consumption and GDP, while the energy Kuznets curve (EKC) hypothesis is rejected.

The aforementioned literature strengthens Stern's conclusions that energy can be considered a limiting factor in economic growth. Shocks to the energy supply tend to reduce output. Table 2.1 summarizes more details about these studies of causality and co-integration analysis between energy consumption and economic growth.

2.2 Issues on Oil Shocks and Economic Activity

The important role of crude oil in the global economy has attracted a great deal of attention among politicians and economists. Since the first oil shock in 1973-74, many studies have been undertaken into the oil price-macroeconomy relationship. These studies have reached different conclusions over time. As such, Hamilton (1983), Burbidge and Harrison (1984), Gisser and Goodwin (1986), Mork (1989), Hamilton (1996), Bernanke et al. (1997), Hamilton (2003), and several others have concluded that there is a negative correlation between increases in oil prices and the subsequent economic downturns in the United States. Nevertheless, the relationship seems to lose significance as data from 1985 onwards are covered. In fact, the declines in oil prices occur over the second half of the 1980s are found to have smaller positive effects on economic activity than predicted by linear models

Table 2.1 A Comparison of Earlier Studies about Causality and Co-integration Analysis Between Energy Consumption and GDP

Authors	Countries	Study period	Causality	Co-integration relationship
Cheng and Lai (1997)	Taiwan	1955-1993	GDP $\rightarrow$ EC	No co-integration
Ghali and El-Sakka (2004)	Canada	1961-1997	GDP $\leftrightarrow$ EC	Co-integration
Hondroyiannis et al. (2002)	Greece	1960-1996	No causality	Co-integration
Hwang and Gum (1992)	Taiwan	1955-1993	GDP $\leftrightarrow$ EC	
Lee (2005)	18 developing countries	1975-2001	EC $\rightarrow$ GDP	Co-integration
Lee and Chang (2005)	Taiwan	1954-2003	GDP $\leftrightarrow$ EC	No co-integration
Lise and Montfort (2007)	Turkey	1970-2003	GDP $\rightarrow$ EC	Co-integration
Masih and Masih (1997)	South Korea	1955-1991	EC $\rightarrow$ GDP	Two co-integrating vector
	Taiwan		No causality	One co-integrating vector
Oh and Lee (2004)	South Korea	1961-1990	No causality	Co-integration
Soytas and Sari (2003)	16 countries	1950-1992	EC $\rightarrow$ GDP in Turkey	Co-integration for 7 out of 16 countries
Stern (2000)	U.S.	1948-1994	EC $\rightarrow$ GDP	Co-integration
Yang (2000)	Taiwan	1954-1997	GDP $\leftrightarrow$ EC	
Zamani (2007)	Iran	1967-2003	GDP $\rightarrow$ EC	

considered up to then. After taking into account the role of the breakdate 1985-1986, some researchers argue that the instability observed in this relationship may be due to a mis-specification of the functional form used. The linear specification might mis-represent the relationship between economic growth and oil prices.

The mis-specification of linear function form has led to different attempts to reestablish the measures of the relationship between oil price changes and output. On the one hand, Mork (1989) separates out oil price changes into negative and positive oil price changes, concluding that the decreases are not statistically significant. Thus, the results confirm that the negative correlation between GDP growth and oil price increases remain when data from 1985 onwards are included. Mory (1993) follow Mork's (1989) measures and separated the oil price into negative and positive oil price changes. He finds that the positive oil price shocks Granger-caused the macroeconomic variables, but that negative shocks do not. Mork et al. (1994) also find the asymmetric effects for seven industrialized countries.

On the other hand, Lee et al. (1995) report that the response to an oil price shock by the economic growth depends on the environment of oil price stability. An oil shock in a price stability environment is more likely to have larger effects on GDP growth than those occur in a price volatile environment. These researchers propose a measure that takes the volatility into account through a GARCH-based on oil price transformation. This transformation scales estimated oil price shocks by their conditional variance. They find asymmetry in the effects of positive and negative oil price shocks, but they also reestablish the significance of the above-mentioned negative correlation. Using the same way, Hamilton (1996) shows that it seems more appropriate to compare the prevailing oil price with what it is during the previous year, rather than the previous quarter. Finally, Hamilton (2003) provides evidence of a non-linear representation and states that the functional form that relates GDP growth to oil price changes is similar what has been suggested in earlier studies. He specially analyzes the three non-linear transformations of oil prices proposed in the literature (i.e., Mork, 1989, Lee et al., 1995 and Hamilton, 1996), indicating that the formulation of Lee et al. (1995) has the best work of summarizing the non-linearity.

Afterwards, there are several works to study the impacts of oil price shocks, and the related issues can be divided into two parts. The first one part is related to macroeconomic level. Papapetrou (2001) analyzes the dynamic interactions among interest rates, real oil prices, real stock returns, industrial production and the employment for Greece. The evidence suggests that oil price changes affect real economic activity and employment. Cunado and Pérez de Gracia (2003) analyze the oil price-macroeconomy relationship by analyzing the impact of oil prices on inflation and industrial production for European countries. Using the transformation of oil price data, they find that oil prices have permanent effects on inflation and short run with asymmetric effects on production growth. More recently, Farzanegan and Markwardt (2009) find a strong positive relationship between positive oil price changes and industrial output growth in the Iranian economy.

As to the Asian developing countries studies, Cunado and Pérez de Gracia (2005) find that oil prices have a significant effect on both economic activity and price indexes, although the impact is limited to the short run and more significant when oil price shocks are measured in local currencies. Moreover, they find evidence of asymmetries in the oil price-macroeconomy relationship across some of the Asian countries. Chang and Wong (2003) suggest that the impact of an oil price shock on the Singapore economy is marginal and small.

Another part involves in stock markets. Asset prices are determined on the stock market depending on information about future prospects as well as current economic conditions facing firms. Jones and Kaul (1996) examine stock market efficiency, focusing on the extent to which stock prices change in response to oil price changes, (i.e., whether changes in stock prices reflect current and future real cash flows). By using a cash-flow/dividend valuation model, they find that oil prices can predict stock returns and output on their own. Sadorsky (1999) identifies that oil price shocks and its volatility play an important part in explaining US stock returns and the movements of oil price explained more than interest rates for the forecasting variance. Cong et al. (2008) find that oil price shocks do not show statistically significant impact on the real stock returns of most Chinese stock market indices.

Park and Ratti (2008) show that oil price shocks have s statistically significant impact on real stock returns contemporaneously and within the following month in US and 13 European countries. Besides, they show that there is little evidence of asymmetric effects on stock returns of positive and negative oil price shocks. Apergis and Miller (2009) also show that different oil market structural shocks play significant role in explaining the adjustment in stock returns. However, the magnitude of such effects proves small. Bjørnland (2009) analyzes the effect of oil price shocks on stock returns in Norway. He finds that following a 10% increase in oil prices, stock returns increase by 2.5%. Table 2.2 summarizes the aforementioned and existing literature about the effects of oil price changes on macroeconomic activities and stock markets.

Table 2.2 An Overview of Previous Studies of the Impacts of Oil Price Shocks on Stock Markets and Macroeconomics Activities

Authors	Periods	Countries	Variables	Methodology	Main Conclusions
Apergis and Miller (2009)	1981-2007	Australia Canada France Germany Italy Japan UK US	Oil Price; Stock Price; CPI; Global economic activity	Unit Root; Co-integration; VDC	International stock market returns do no respond in a large way to oil market shocks
Bjørnland (2009)	1993-2005	Norway	Oil Price; Stock Price; Interest rate; Unemployment CPI; Exchange rate	VDC; IRF	Following a 10% increase in oil prices, stock returns increase by 2.5%, after which the effect gradually dies out.
Chang and Wong (2003)	1978-2000	Singapore	Oil price; GDP; COI; Unemployment	Unit Root; Co-integration; VDC; IRF	The impact of an oil price shock on the Singapore economy is marginal.
Cunado and Pérez de Gracia (2005)	1960-1999	European countries	Oil price; Inflation rate; Industrial Production	Unit Root; Co-integration; Granger Causality; Nonlinear Transformation	Oil prices have permanent effects on inflation and asymmetric effects on production growth rates

Table 2.2 An Overview of Previous Studies of the Impacts of Oil Price Shocks on Stock Markets and Macroeconomics Activities (Continued)

Authors	Periods	Countries	Variables	Methodology	Main Conclusions
Cunado and Pérez de Gracia (2005)	1975-2002	Japan Singapore Korea Malaysia Thailand Philippines	Oil Price; CPI; Economic Activity	Unit Root; Co-integration; Granger Causality; Nonlinear Transformation	There is evidence of asymmetries in the oil prices-macroeconomy relationship for some of the Asian countries
Farzanegan and Markwardt (2009)	1975-2006	Iran	Oil Price; GDP; Public Consumption Expenditures; Imports; Exchange Rate; Inflation	VDC; IRF; Nonlinear Transformation	There is a strong positive relationship between positive oil price changes and industrial output growth.
Jbir and Zouari-Ghorbel (2009)	1993-2007	Tunisia	Oil price; Inflation rate; Exchange rate; Government spending; Industrial Production	Unit Root; Granger Causality; IRF; VDC	There is no direct impact of oil price shock on the economic activity.
Papapetrou (2001)	1989-1999	Greece	Oil Price; Stock Return; Industrial production; Industrial Employment;	Unit Root; Co-integration; VDC; IRF	Oil price changes affect economic activity and employment.
Huang et al. (2005)	1970-2002	US Canada Japan	Oil Price; Stock Return; Interest Rate; Industrial Production	Unit Root; Co-integration; VDC; IRF; Multivariate Threshold Tests	An oil price change or its volatility has a limited impact on the economies if the change is below the threshold levels.
Jiminez-Rodriguez (2008)	1975-1998	France Germany Italy Spain US UK	Oil price; Manufacturing industry; Eight individual manufacturing industries	IRF	Evidence on cross-industry heterogeneity of oil shock effects within the EMU countries is found.
Jiminez-Rodriguez (2009)	1947-2005	US	Oil Price; GDP; Unemployment; Interest Rate; Federal Fund Rate; Wage; CPI	Granger Causality; Nonlinear Transformation	There is evidence of existence of non-linearity with the use of data earlier than 1984

Note: VDC denotes the variance decomposition.

Chapter 3 Methodology

In this chapter the threshold co-integration and multivariate threshold autoregrresive models will be introduced to address two issues. To more clearly express the utilization of methods, we outline the research process with respect to each issue in Figure 3.1.

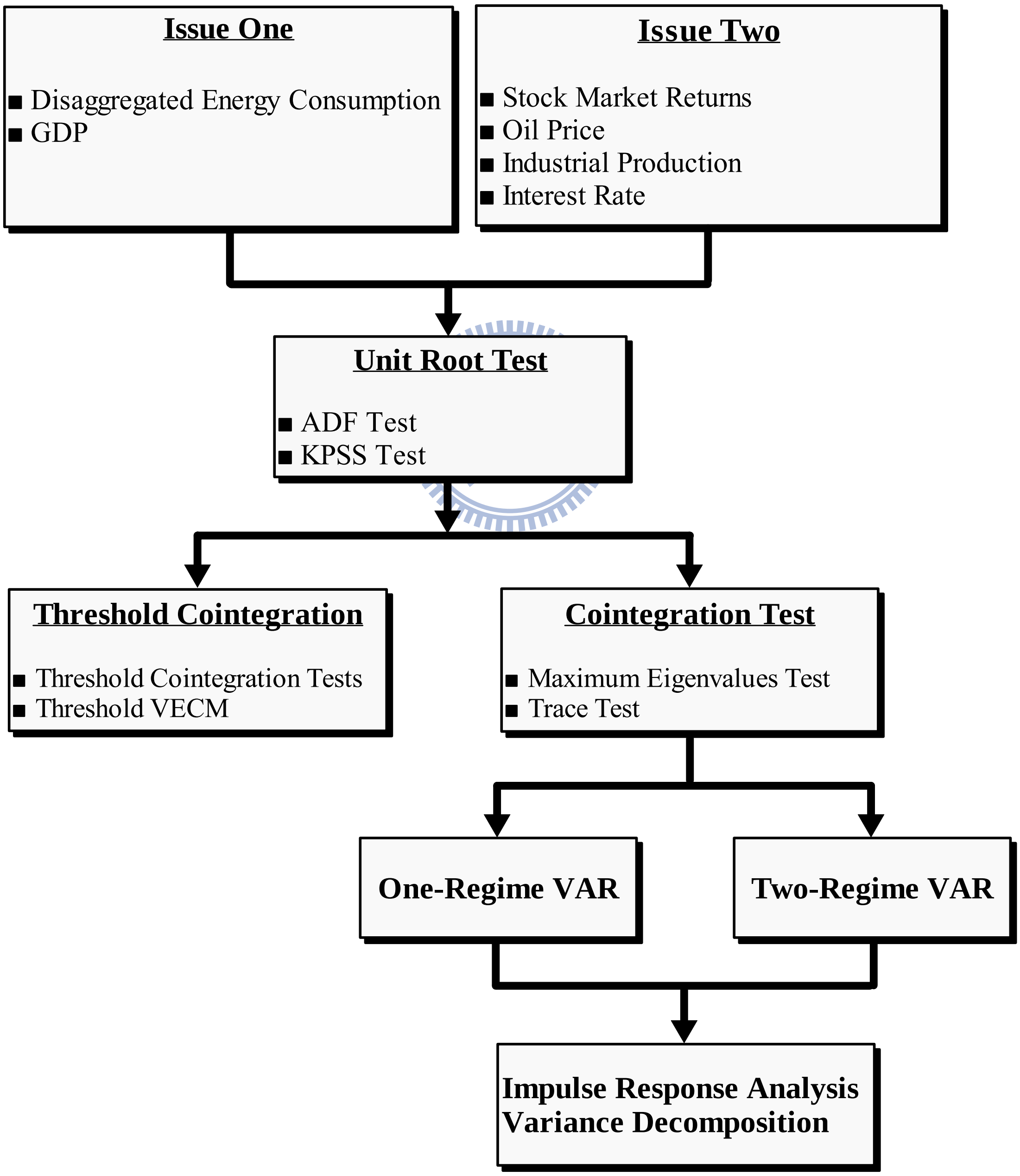


Figure 3.1 Methodology Flow Chart

3.1 Unit Root Tests

A time series is a set of y_t observations, each one being record at a specific time t with stochastic process. To aid in identification, we know that a covariance stationary series need to be satisfied:

(1) Exhibits mean reversion in that it fluctuates around a constant long-run mean.

(2) Has a finite variance that is time-invariant.

(3) Has a theoretical correlogram that diminishes as lag length increases.

On the other hand, a non-stationary series necessarily has permanent components. The mean and variance of non-stationary series are time-dependent. To aid in identification of a non-stationary series, we know that:

(1) There is no long-run mean to which the series returns.

(2) The variance is time-dependent and goes to infinity as time approaches infinity.

(3) Theoretical autocorrelations do not decay, but the sample correlogram dies out slowly in finite samples.

Although the traditional OLS approach often assumes the time series are stationary and its disturbances all white noise. If we assume the non-stationary time series as stationary, it may cause spurious regression proposed by Granger and Newbold (1974). Its result may have higher coefficient of determinant and much significant t value, implying non-reject the null hypothesis and though meaningless under spurious regression. Before proceeding analysis, we should test whether these variables have the stationarity property. If the time series variable is stationary with d-times differencing, it can be called the integrated of order d and denoted as $I(d)$. We adopt two applicable unit root methods for examining the existence of unit roots.

3.1.1 Augmented Dickey Fuller (ADF) Test

Dickey and Fuller (1979) consider a autoregressive process $AR(1)$,

$y_t = \alpha_1 y_{t-1} + \varepsilon_t$, where the disturbances are white noise. Begin by subtracting y_{t-1} from each side of the equation in order to write the equivalent from: $\Delta y_t = \gamma y_{t-1} + \varepsilon_t$, where $\gamma = \alpha_1 - 1$. Certainly, testing the hypothesis $\alpha_1 = 1$ is equivalent to testing the hypothesis $\gamma = 0$.

However, simple unit root test described above is valid only if the series is an $AR(1)$ process. If the series is correlated at higher order lags, the assumption of white noise disturbances is violated. Dickey and Fuller (1981) make a parametric correction for higher order correlation by assuming that the $\{y_t\}$ follows an $AR(p)$ process and adjusting the test methodology, the general form can be expressed as follows:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \cdots + \alpha_p y_{t-p} + \varepsilon_t \tag{1}$$

To best understand the methodology of the augmented Dickey-Fuller test, add and subtract $\alpha_p y_{t-p+1}$ to obtain:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \cdots + \alpha_{p-2} y_{t-p+2} + (\alpha_{p-1} + \alpha_p) y_{t-p+1} - \alpha_p \Delta y_{t-p+1} + \varepsilon_t \tag{2}$$

Next, add and subtract $(\alpha_{p-1} + \alpha_p) y_{t-p+2}$ to obtain:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \cdots - (\alpha_{p-1} + \alpha_p) \Delta y_{t-p+2} - \alpha_p \Delta y_{t-p+1} + \varepsilon_t \tag{3}$$

Continuing in this fashion, we get:

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \tag{4}$$

where $\gamma = -\left(1 - \sum_{i=1}^{p} \alpha_i\right)$ and $\beta_i = \sum_{j=1}^{p} \alpha_j$. The selection of lag order of Δy_{t-i} can be used by the Akaike information criterion (AIC):

$$\text{AIC} = T \ln(\text{residual sum of squares}) + 2n \tag{5}$$

where n is the number of parameters estimated and T is the number of usable observations.

Three ADF test actually consider three different regression equations that can be used to test for the presence of a unit root:

$$\Delta y_t = \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \tag{6}$$

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \tag{7}$$

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \alpha_2 t + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \tag{8}$$

The differences between the three regressions concerns the presence of the deterministic elements α_0 and $\alpha_2 t$. The first considers a pure random walk plus lagged dependent variables, the second adds an intercept (or drift term), and the third includes an additional linear time trend. The parameter of interest in all the regression equations is γ. If the null hypothesis $\gamma = 0$ cannot be rejected, then the $\{y_t\}$ sequence contains a unit root; otherwise, this sequence is stationary.

3.1.2 The Kwiatkowski, Phillips, Schmidt and Shin (KPSS) Test

The standard conclusion that is drawn from this empirical evidence is that many or most aggregate economic time series contain a unit root. However, it is important to note that in this empirical work the unit root is the null hypothesis to be tested, and the way in which classical hypothesis testing is carried out ensures that the null hypothesis is accepted unless there is strong evidence against it. Therefore, an alternative explanation for the common failure to reject a unit root is simply that most economic time series are not very informative about whether or not there is a unit root, or equivalently, that standard unit root tests are not very powerful against relevant alternatives.

Kwiatkowski et al. (1992) use a parameterization which provides a plausible representation of both stationary and non-stationary variables and which leads naturally to a test of the hypothesis of stationarity. Specifically, they choose a component representation in which the time series under study is written as the sum of a deterministic trend, a random walk, and a stationary error. The KPSS test differs from the other unit root tests described here in that the $\{y_t\}$ sequence is assumed to be (trend) stationary under the null. The KPSS statistic is based on the residuals from the OLS regression of y_t on the exogenous variables x_t:

$$y_t = x_t'\delta + \varepsilon_t$$

The Lagrange Multiplier (LM) statistic can be defined as:

$$LM = \sum_t S(t)^2 / (T^2 f_o)$$

where $S(t)$ is a cumulative residual function (i.e., $S(t) = \sum_{i=1}^{t} \hat{\varepsilon}_i, \quad t = 1, 2, \cdots, T$), and f_o is an estimator of the residual spectrum at frequency zero. We point out that the estimator of δ used in this calculation differs from the estimators for δ used by detrended GLS since it is based on a regression involving the original data and not on the quasi-differenced data.

3.2 Cointegration Analysis

Co-integration theory is definitely the innovation in theoretical econometrics that has created the most interest among economists in the last decade. Co-integration is an econometric property of time series variables. If two or more time series variables are non-stationary, but a linear combination of them is stationary, then the series are said to be co-integrated.

The Johansen co-integration method is provided by Johansen (1988) and Johansen and Juselius (1990). This procedure applying maximum likelihood to the vector autoregressive (VAR) model, and consider the relationships among more than two variables. Let y_t denotes an $(n \times 1)$ vector. The maintained hypothesis is that y_t follows a VAR(P) in levels and all of the elements for y_t are $I(1)$ process. In addition, the errors are Gaussian.

$$y_t = \mu + \Pi_1 x_{t-1} + \Pi_2 x_{t-2} + \cdots + \Pi_p x_{t-p} + \varepsilon_t, \quad t = 1, 2, \cdots, T \tag{9}$$

where μ is constant term and $\varepsilon_t \overset{i.i.d.}{\sim} N(0, \Omega)$. Moreover, VAR($p$) in levels can be written as:

$$\Delta y_t = \mu + \varsigma_1 \Delta y_{t-1} + \varsigma_2 \Delta y_{t-2} + \cdots + \varsigma_{p-1} \Delta y_{t-p+1} + \varsigma y_{t-1} + \varepsilon_t \tag{10}$$

where $\varsigma = -(I_n - \Pi_1 - \Pi_2 - \cdots - \Pi_p) = -\Pi(1)$

$\varsigma_i = -(I_n - \Pi_1 - \Pi_2 - \cdots - \Pi_i) \quad i = 1, 2 \cdots, p-1$

Suppose that each individual variable y_{it} is $I(1)$ and linear combinations of y_t are stationary. That implies ς can be showed as

$\varsigma = -\alpha\beta'$

where β is the cointegrating matrices, and α is the adjustment coefficients for both α and β $(r \times n)$ matrices. The number of cointegrating relations relies on the rank of ς, and the rank of ς is :

(1) $\text{rank}(\varsigma) = n$, ς is full rank means that all components of y_t is a stationary process.

(2) $\text{rank}(\varsigma) = 0$, ς is null matrix meaning that there is no co-integration relationships.

(3) $0 < \text{rank}(\varsigma) = r < n$, the variables for y_t are co-integrated and the number of cointegrating vectors is r.

To determine the number of co-integrating vectors, Johansen proposes two different likelihood ratio tests of the significance of these canonical correlations and thereby the reduced rank of the Π matrix: the trace test and maximum eigenvalue test, shown as follows:

(1) Trace test:

$H_0 : \text{rank}(\varsigma) \le r$, i.e., there are at most r cointegrating vectors

$H_1 : \text{rank}(\varsigma) > r$

The test statistic is $\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i)$,

where r is the cointegrating vector, T is the sample size, and $\hat{\lambda}_i$ is the ith largest canonical correlation. The statistic has a limit distribution which can be expressed in terms of a (n-r)-dimensional Brownian motion.

(2) Maximum eigenvalues test:

H_0: there are r co-integrating vectors

H_1: there are $r+1$ co-integrating vectors

The test statistic is $\lambda_{\max} = -T \ln(1-\hat{\lambda}_{r+1})$. If the absolute value of eigenvalue, $\hat{\lambda}_i$, is larger, then the test statistic will be higher and tend to reject the null hypothesis. Neither of these test statistics follows a chi-square distribution in general; asymptotic critical values can be found in Johansen and Juselius (1990). Since the critical values used for the maximum eigenvalue and trace test statistics are based on a pure unit-root assumption, they will no longer be correct when the variables in the system are near-unit-root processes. Thus, the real question is how sensitive Johansen's procedures are to deviations from the pure-unit root assumption.

3.3 Threshold Co-integration with Asymmetric Adjustment

The rationale behind threshold co-integration was introduced by Balke and Fomby (1997) as a feasible means to combine both non-linearity and co-integration. As pointed out by Balke and Fomby (1997), it is necessary to analyze the long-run equilibrium relationship by a co-integration test while assuming the feature of asymmetric adjustment. As is well known, variables are co-integrated to be characterized by an error correction model (ECM), which describes how the variables respond to deviations from the equilibrium. Therefore, it is possible that an asymmetric adjustment leads to poor results of the equilibrium relationship, because traditional approaches only take into account a tendency to move towards the long-run equilibrium for every time period.

Several studies have discussed co-integration with its corresponding ECM as the assumption of such a tendency to move toward a long-run equilibrium. Balke and Fomby (1997) emphasize the possibility that movement towards the long-run equilibrium need not occur in every period, because of the presence of some adjustment cost for the economic agent. In other words, there could be a discrete adjustment to equilibrium only when the deviation from the equilibrium exceeds a critical threshold, do the benefits of adjustment are higher than the costs. Therefore, economic agents act to move the system back to equilibrium. Threshold co-integration could characterize the discrete adjustment in terms of the case where the co-integrating relationship does not hold inside a certain band, but then remains active if the system gets too far from the equilibrium.

One of the most important statistical issues for threshold models in the econometric literature is testing for the presence of a threshold effect. Balke and Fomby (1997) propose applying several univariate tests (e.g., Hansen, 1996 and Tsay, 1989) to the known co-integrating residual (i.e., the error-correction term). Further related studies include Forbes et al. (1999), who develop a Bayesian estimation procedure for financial arbitrage, while Lo and Zivot (2001) extend Balke and Fomby's approach to a multivariate threshold co-integration model with a known co-integration vector, employing Tsay (1998) and multivariate extensions of Hansen's (1996) test. Hansen and Seo (2002) contribute further to the literature by examining the case of an unknown co-integration vector. In particular, these authors propose a vector error-correction model with one co-integrating vector and a threshold effect based on the error-correction term, and they develop a Lagrange Multiplier (LM) test for the presence of a threshold.

Hansen and Seo (2002) consider a two-regime threshold co-integration model, which can be treated as a non-linear VECM of order $l+1$ as the following form:

$$\Delta x_t = \begin{cases} A_1' X_{t-1}(\beta) + u_t, & \text{if } w_{t-1}(\beta) \le \gamma \\ A_2' X_{t-1}(\beta) + u_t, & \text{if } w_{t-1}(\beta) > \gamma \end{cases} \tag{11}$$

with

$$X_{t-1}(\beta) = \begin{pmatrix} 1 \\ w_{t-1}(\beta) \\ \Delta x_{t-1} \\ \Delta x_{t-2} \\ \vdots \\ \Delta x_{t-l} \end{pmatrix}$$

where x_t is a p-dimensional $I(1)$ time series which is co-integrated with one $p\times 1$ co-integrating vector β, $w_t(\beta) = \beta' x_t$ denotes the $I(0)$ error-correction term, the coefficients matrices of A_1 and A_2 describe the dynamics in each of the regimes, γ is the threshold parameter, and u_t is an error term. This may alternatively be written as:

$$\Delta x_t = A_1' X_{t-1}(\beta) d_{1t}(\beta,\gamma) + A_2' X_{t-1}(\beta) d_{2t}(\beta,\gamma) + u_t \tag{12}$$

where $d_{1t}(\beta,\gamma) = I(w_{t-1}(\beta) \le \gamma)$, $d_{2t}(\beta,\gamma) = I(w_{t-1}(\beta) > \gamma)$ and $I(\cdot)$ denotes the indicator function. The parameters of model (11) are estimated by maximum likelihood, under the assumption that the errors u_t are *i.i.d.* Gaussian.

As can be seen, the threshold model (11) or (12) composes two regimes, and the non-linear mechanism depends on deviations from the equilibrium below or above the threshold parameter, where A_1 and A_2 describe the dynamics in each of the regime. To achieve the identification, we need to impose some normalization on β. Since there is only one co-integrating vector, a convenient choice is to set one element of β equal to unity that has no cost in the bivariate system (p = 2). The condition of $p > 2$ only imposes the restriction that the corresponding element of x_t goes into the co-integrating relationship. Accordingly, there is no tendency for the variables x_t to revert to an equilibrium state (i.e., the variables are not co-integrated); on the contrary condition, there is a tendency for x_t to move towards the equilibrium states in another regime (i.e., the variables are co-integrated).

Hansen and Seo (2002) propose two heteroskedastic-consistent LM test statistics to test whether there is linear co-integration (i.e., the form of model (11)) under the null against the alternative threshold co-integration. This means that there is no threshold under the null, so that model (11) reduces to a conventional linear VECM. The first testing statistic would be used when the true co-integrating vector is known a priori and is denoted as:

$$\text{Sup LM}^0 = \sup_{\gamma_L \le \gamma \le \gamma_U} \text{LM}(\beta_0, \gamma), \tag{13}$$

where β_0 is the known value at fixed β (i.e., set β_0 at unity), while the second case can be used when the true co-integrating vector is unknown, and the test statistic is denoted as:

$$\text{Sup LM} = \sup_{\gamma_L \le \gamma \le \gamma_U} \text{LM}(\tilde{\beta}, \gamma) \tag{14}$$

where $\tilde{\beta}$ is the null estimate of β.

In both tests, $[\gamma_L, \gamma_U]$ is the search region so that γ_L is the π_0 percentile of $\tilde{w}_{t-1}$, and γ_U is the $(1-\pi_0)$ percentile. Andrews (1993) suggests that setting π_0 between 0.05 and 0.15 is a typically good choice. Finally, the bootstrap methods proposed by Hansen and Seo (2002) calculate the asymptotic critical values and p-values with 3000 replications.

3.4 Impulse Response Analysis

Impulse response analysis is used widely in the empirical literature to uncover the dynamic relationship between macroeconomic variables within VAR models. Impulse responses measure the time profile of the effect of a shock, or impulse, on the (expected) future values of a variable. By imposing specific restrictions on the parameters of the VAR model the shocks can be attributed an economic meaning.

Consider a bivariate structural VAR(1) system,

$$y_t = b_{10} - b_{12}z_t + \gamma_{11}y_{t-1} + \gamma_{12}z_{t-1} + \varepsilon_{yt} \tag{15}$$

$$z_t = b_{20} - b_{21}y_t + \gamma_{21}y_{t-1} + \gamma_{22}z_{t-1} + \varepsilon_{zt} \tag{16}$$

where it assumed that both y_t and z_t are stationary, ε_{yt} and ε_{zt} are white-noise disturbances with standard deviations of σ_y and σ_z, respectively. $\{\varepsilon_{yt}\}$ and $\{\varepsilon_{zt}\}$ are uncorrelated white-noise disturbances. Equations (15) and (16) are not reduced-form equations since y_t has a contemporaneous effect on z_t and z_t has a contemporaneous effect on y_t. Using matrix algebra, we can write the system in the compact form:

$$\begin{bmatrix} 1 & b_{12} \\ b_{12} & 1 \end{bmatrix}\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix}\begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$$

or

$$Bx_t = \Gamma_o + \Gamma_1 x_{t-1} + \varepsilon_t$$

where $B = \begin{bmatrix} 1 & b_{12} \\ b_{12} & 1 \end{bmatrix}$, $x_t = \begin{bmatrix} y_t \\ z_t \end{bmatrix}$, $\Gamma_0 = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix}$, $\Gamma_1 = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix}$, $\varepsilon_t = \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$.

Pre-multiplication by B^{-1} allows us to obtain the VAR model in standard form:

$$x_t = A_o + A_1 x_{t-1} + e_t \tag{17}$$

where $A_o = B^{-1}\Gamma_0$, $A_1 = B^{-1}\Gamma_1$, and $e_t = B^{-1}\varepsilon_t$. Using the brute force method to solve method to solve the system, iterate equation (17) backward to obtain:

$$x_t = A_o + A_1(A_o + A_1 x_{t-2} + e_{t-1}) + e_t$$
$$= (I + A_1)A_o + A_1^2 x_{t-2} + A_1 e_{t-1} + e_t$$

where $I = 2 \times 2$ identity matrix. After *n* iterations,

$$x_t = (I + A_1 + \cdots + A_1^n)A_o + \sum_{i=0}^{n} A_1^i e_{t-i} + A_1^{n+1} x_{t-n-1}$$

The stability requires that the roots of $(1 - a_{11}L)(1 - a_{22}L) - (a_{12}a_{21}L^2)$ lie outside the unit circle. For the time being, assume that the stability condition exist is net, so that we can write the particular solution for x_t as:

$$x_t = \mu + \sum_{i=0}^{\infty} A_1^i e_{t-i} \tag{18}$$

where $\mu = [\bar{y} \quad \bar{z}]'$, $\bar{y} = [a_{10}(1 - a_{22}) + a_{12}a_{20}]/\Delta$, $\bar{z} = [a_{20}(1 - a_{11}) + a_{21}a_{10}]/\Delta$, and $\Delta = (1 - a_{11})(1 - a_{22}) - a_{12}a_{21}$. In addition, if equation (18) can be performed as matrix form, we obtain:

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i + \begin{bmatrix} e_{1t-i} \\ e_{2t-i} \end{bmatrix} \tag{19}$$

Equation (19) express y_t and z_t in terms of the $\{e_{1t}\}$ and $\{e_{2t}\}$ sequences. However, it is insightful to rewrite equation (19) in terms of $\{\varepsilon_{yt}\}$ and $\{\varepsilon_{zt}\}$ sequences. According to the error terms in standard form of VAR(1), the vector of errors can be written as:

$$\begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} = [1/(1 - b_{12}b_{21})] \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix} \tag{20}$$

so that (19) and (20) can be combined to form

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + [1/(1 - b_{12}b_{21})] \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$$

Since the notion is getting unwieldy, we can simplify by defining the 2×2 matrix ϕ_i with elements $\phi_{jk}(i)$:

$$\phi_i = \left[A_1^i / (1 - b_{12} b_{21}) \right] \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix}$$

Hence, the moving average representation of (19) and (20) can be written in terms of the $\{\varepsilon_{yt}\}$ and $\{\varepsilon_{zt}\}$ sequences:

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \phi_{11}(i) & \phi_{12}(i) \\ \phi_{21}(i) & \phi_{22}(i) \end{bmatrix} \begin{bmatrix} \varepsilon_{yt-t} \\ \varepsilon_{zt-i} \end{bmatrix}$$

or more compactly,

$$x_t = \mu + \sum_{i=0}^{\infty} \phi_i \varepsilon_{t-i} \,. \tag{21}$$

The coefficients of ϕ_i can be used to generate the effects of ε_{yt} and ε_{zt} shocks on the entire time paths of the $\{y_t\}$ and $\{z_t\}$ sequences. It should be clear that four elements $\phi_{jk}(0)$ are impact multiplier. For instance, the coefficient $\phi_{12}(0)$ is the instantaneous impact of a one-unit change in ε_{zt} on y_t. In the same way, the elements $\phi_{11}(1)$ and $\phi_{12}(1)$ are the one period responses of unit changes in ε_{yt-1} and ε_{zt-1} on y_t, respectively. Updating by one period indicates that $\phi_{11}(1)$ and $\phi_{12}(1)$ also represent the effects of unit changes in ε_{yt} and ε_{zt} on y_{t+1}.

The accumulated effects of unit impulses in ε_{yt} or ε_{zt} can be obtained by the appropriate addition of the coefficients of the impulse response functions. Note that after n periods, the effect of ε_{zt} on the value of y_{t+n} is $\phi_{12}(n)$. Thus, the cumulated sum of the effects of ε_{zt} on the $\{y_t\}$ sequence is:

$$\sum_{i=0}^{n} \phi_{12}(i) \,.$$

Letting n approach infinity yields the long-run multiplier. Since the $\{y_t\}$ and $\{z_t\}$ sequences are assumed to be stationary, it must be the case that for all j and k, $\sum_{i=0}^{\infty} \phi_{jk}^2(i)$ is finite. The four sets of coefficients, $\phi_{11}(i)$, $\phi_{12}(i)$, $\phi_{21}(i)$, and $\phi_{22}(i)$, are called the impulse response functions. We can plot the impulse response functions (i.e., plotting the coefficients of $\phi_{jk}(i)$ against i) is a practical manner to visually present the behavior of the $\{y_t\}$ and $\{z_t\}$ series in response to the various shocks.

Knowledge of the various a_{ij} and variance/covariance matrix Σ is not sufficient to identify the primitive system. Hence, the econometricians have to impose an additional restriction on the two-variable VAR system in order to identify the impulse responses. One Possible identification restriction is to use Choleski decomposition. For example, it is possible to constrain the system such that the contemporaneous value of y_t, does not have a contemporaneous effect on z_t.

Formally, such restriction is represented by setting b_{21}=0 in the primitive system. In terms of (20), the error terms can be decomposed as:

$$e_{1t} = \varepsilon_{yt} - b_{12}\varepsilon_{zt} \tag{22}$$

$$e_{2t} = \varepsilon_{zt} \tag{23}$$

Thus, if we use (23), all the observed errors from the $\{e_{2t}\}$ sequence are attributed to ε_{zt} shocks. Although the Choleski decomposition constrains the system such that an ε_{yt} shock has no direct effect z_t, there is an indirect effect in that lagged values of y_t affect the contemporaneous value of z_t. The critical point is that the decomposition forces a potentially important asymmetry on the system since an ε_{zt} shock has contemporaneous effects on both y_t and z_t. Given this reason, (22) and (23) are said to imply an ordering of the variables. An ε_{zt} shock directly affect e_{1t} and e_{2t} but on ε_{yt} shock does not affect e_{2t}. Hence, z_t is prior to y_t.

3.5 Variance Decomposition

If we use the equation (21) to conditionally forecast x_{t+1}, the one-step ahead forecast error is $\phi_0\varepsilon_{t+1}$. In general,

$$x_{t+n} = \mu + \sum_{i=0}^{\infty} \phi_i \varepsilon_{t+n-i},$$

such that the n-period forecast error $x_{t+n} - E_t x_{t+n}$ is

$$x_{t+n} - E_t x_{t+n} = \sum_{i=0}^{n-1} \phi_i \varepsilon_{t+n-i}$$

Forecasting solely on the $\{y_t\}$ sequence, the n-step ahead forecast error is:

$$\begin{aligned} y_{t+n} - E_t y_{t+n} &= \phi_{11}(0)\varepsilon_{yt+n} + \phi_{11}(1)\varepsilon_{yt+n-1} + \cdots + \phi_{11}(n-1)\varepsilon_{yt+1} \\ &\quad + \phi_{12}(0)\varepsilon_{zt+n} + \phi_{12}(1)\varepsilon_{zt+n-1} + \cdots + \phi_{12}(n-1)\varepsilon_{zt+1} \end{aligned}$$

Denote the variance of the n-step ahead forecast error variance of y_{t+n} as $\sigma_y(n)^2$:

$$\sigma_y(n)^2 = \sigma_y^2\left[\phi_{11}(0)^2 + \cdots + \phi_{11}(n-1)^2\right] + \sigma_z^2\left[\phi_{12}(0)^2 + \cdots + \phi_{12}(n-1)^2\right].$$

Since all values of $\phi_{jk}(i)^2$ are necessarily nonnegative, the variance of the forecast error increases as the forecast horizon n increases. Note that it is possible to decompose the n-step ahead forecast error variance due to each one of the shocks. The proportions of $\sigma_y(n)^2$ due to shocks in the $\{\varepsilon_{yt}\}$ and $\{\varepsilon_{zt}\}$ sequences are:

$$\frac{\sigma_y^2\left[\phi_{11}(0)^2 + \phi_{11}(1)^2 + \cdots + \phi_{11}(n-1)^2\right]}{\sigma_y(n)^2} \tag{24}$$

and

$$\frac{\sigma_z^2\left[\phi_{12}(0)^2 + \phi_{12}(1)^2 + \cdots + \phi_{12}(n-1)^2\right]}{\sigma_y(n)^2} \tag{25}$$

Equations (24) and (25) are the forecast error variance decomposition (VDC), showing the proportion of the movements in a sequence due to its own shocks versus shocks to the other variable. If ε_{zt} shocks explain none of the forecast error variance of $\{y_t\}$ at all forecast horizons, we can say that the $\{y_t\}$ sequence is exogenous. In such a circumstance, the $\{y_t\}$ sequence would evolve independently of the ε_{zt} shocks and $\{z_t\}$ sequence. At the other extreme, ε_{zt} shocks could explain all the forecast error variance in the $\{y_t\}$ sequence at all forecast horizons, so that $\{y_t\}$ would be entirely endogenous.

However, the variance decomposition contains the ordering problem inherent in impulse response function analysis. In order to identify the $\{\varepsilon_{yt}\}$ and $\{\varepsilon_{zt}\}$ sequences, it is necessary to restrict the B matrix. The Choleski decomposition used in (22) and (23) necessitates that all the one-period forecast error variance of z_t is due to ε_{zt}. If we use the alternative ordering, all the one-period forecast error variance of y_t would be due to ε_{yt}. As n increases, the variance decompositions should converge. Moreover, if the correlation coefficient ρ_{12} is significantly different from zero, it is customary to obtain the variance decomposition under various ordering. Nevertheless, impulse response analysis and variance decompositions can be useful tools to examine the relationships among economic variables. If the correlations among the various innovations are small, the identification problem is not likely to be particularly important. The alternative orderings should yield similar impulse response and variance decompositions.

Chapter 4 Empirical Results

4.1 The Asymmetric Behavior of Disaggregated Energy Consumption and GDP in Taiwan

4.1.1 Data Sources

All the data used in the first study are quarterly frequencies and cover the period from 1982:Q1 to 2006:Q4 in Taiwan. The nominal gross domestic product series in the national currency is transformed into real gross domestic product in 2001 prices, using GDP deflators (2001=100). The original data for various energy usage categories are measured in terms of kiloliters of oil equivalent (KLOE). The variables used in the models are: GDP as the real gross domestic product; EC as the total final energy consumption; Coal as the coal consumption; Oil as the oil consumption; NG as the natural gas consumption; and ELEC as the electricity consumption. All the variables are in logarithms. The empirical data in this study are compiled from the AREMOS economic-statistic database, created and maintained jointly by Taiwan's Ministry of Education and National Taiwan University.

Energy consumption time series may have some forms of seasonality. For instance, the electricity usage in Taiwan has obvious seasonal patterns resulting from higher consumption in summer and higher natural gas in winter. In fact, the seasonal variation of some time series variables may account for the preponderance of its total variance. Forecasts that ignore important seasonal patterns will have a high variance. A basic test for the presence of seasonality in a time series is to regress the variable on four seasonal dummies. If there is no seasonality in the series, then the four coefficients associated with these dummies should be equal. This property can easily be tested with a standard F-test. The test regression equals:

$$\Delta y_t = \sum_{i=1}^{4} \beta_s D_{s,t} + \varepsilon_t \, , \qquad (26)$$

where $\Delta y_t = y_t - y_{t-1}$ and $D_{s,t}$=1 if t corresponds to season s, and 0 otherwise. If seasonal adjustment is properly done to eliminate seasonality, then the F-test should not reject the null hypothesis that $\beta_1 = \beta_2 = \beta_3 = \beta_4$. As Table 4.1 shows, the null hypothesis of no seasonality is rejected at the 1% level, implying that there exist seasonal patterns in all energy consumption variables. Therefore, we further adjust the seasonal characteristics by the moving average method and the regression results cannot reject the null hypothesis of no seasonality. Hence, the deseasonalized data are used for empirical work afterwards.

Before carrying out the time series analysis, it is necessary to determine the order of integration for each variable to ensure robust and reliable results. To this end, we employ univariate methods to test for the existence of unit roots and identify the properties of stationarity in each time series variable. We therefore investigate the stationarity process of all variables by using the Augmented Dickey and Fuller (1979, ADF) and KPSS (Kwiatkowski et al., 1992) tests for examining the existence of unit roots.

Table 4.1 Tests for the Presence of Seasonality

Dependent variable	No moving average adjustment		With moving average adjustment	
	F (3, 99)	p-values	F (3, 99)	p-values
△EC	257.11***	(0.00)	0.06	(0.98)
△Coal	8.96***	(0.00)	0.02	(0.99)
△Oil	32.27***	(0.00)	0.08	(0.97)
△NG	89.30***	(0.00)	0.04	(0.99)
△ELEC	833.14***	(0.00)	0.05	(0.98)

Note: '***' denotes significance at 1% level. Seasonal adjustments with moving average method are conducted by EViews5.0 program.

In general, most of the conventional unit root tests suffer from three problems: first, several approaches have severe size distortions when the moving average polynomial of the first differences series has a large negative autoregressive root (Schwert, 1989). Second, the testing statistics have low power when the root of the autoregressive polynomial is close to unity (DeJong et al., 1992; Kwiatkowski et al., 1992). Third, conducting the unit root tests often implies the selection of an autoregressive truncation lag, *k*, which is strongly related to the size distortions and the extent of power loss (Ng and Perron, 1995).

It is important to note that in the ADF test, the unit root hypothesis to be tested and that the way in which classical hypothesis testing is carried out to ensure the hypothesis are hard to be rejected. To address these critiques, we also employ KPSS tests, which can powerfully distinguish variables that appear to be stationary and be integrated, and those that are not very informative about whether they are stationary or have a unit root. Table 4.2 reports the results of the stationarity tests in the level as well as in first difference for all the variables. We include a constant and a trend term in these tests.

Table 4.2 Tests for Unit Root

Variables	ADF		KPSS	
	Level	First difference	Level	First difference
GDP	-0.9104	-3.7522**	0.3013***	0.0902
EC	-0.4569	-7.9656***	0.2954***	0.1141
Coal	-2.5146	-7.7002***	0.2593***	0.1129
Oil	-1.9997	-15.1758***	0.2217***	0.0759
NG	-1.5044	-4.1436***	0.2033**	0.0964
ELEC	-2.9445	-9.0106***	0.2789***	0.0899

Note: The optimal lag orders on the variables in ADF regressions are selected by Akaike Information Criterion. The 1%, 5%, and 10% asymptotic critical values for KPSS test statistic are 0.216, 0.146, and 0.119, respectively. The null hypothesis for the KPSS test is stationarity. '***' and '**' denote significance at 1% and 5% levels, respectively.

The optimal lag length of each case for the ADF tests is chosen by the Akaike Information Criteria (AIC) after testing for first and higher order serial correlation residuals. Table 4.2 reports the results of testing for unit roots in the level variables with the ADF test as well as against the alternative with the KPSS test. The first half of the table indicates that the null hypothesis contains a unit root, while it appears to be stationary after taking the first differences. The results of the KPSS tests show that the null hypothesis in all level variables is strongly rejected at the 1% significance level, which isin favor of a unit root, while the stationary under the null fails to be rejected after differencing once. Consequently, we suggest that all the variables are integrated of order $I(1)$.

4.1.2 Results of the Asymmetric Threshold Co-integration Tests

Firstly, we examine whether or not the energy consumption and GDP are co-integrated when allowing for asymmetric adjustments. We apply the tests of threshold co-integration proposed by Hansen and Seo (2002) with Sup LM^0 (given β at unity) and Sup LM (estimated β). Both of the two tests utilize a parametric bootstrap method with 3000 replications to calculate p-values. The lag length selection of the VAR model is determined by the Akaike and Bayesian information criteria, leading to the results of l = 3 on the case for total energy consumption, l = 1 on the case for coal consumption, l = 2 on the case of natural gas consumption, and l = 1 on the case for electricity consumption. Table 4.3 presents these tests results.

The threshold co-integration tests results appear at the 5% significant level of the Sup LM^0 test (i.e., the co-integrating vector is fixed at unity) between total energy consumption and GDP, while for electricity consumption and GDP combination, they appear at the 10% significant level of the Sup LM test (i.e., when co-integrating

Table 4.3 Results of the Asymmetric Threshold Co-integration Tests

	Sup LM^0	Sup LM
Panel A. GDP vs. Energy consumption		
Test statistic value	26.97 (0.04)**	16.30 (0.92)
Tests for ECM coefficient	23.58 (0.00)***	22.26 (0.00)***
Tests for dynamic coefficients	88.92 (0.00)***	90.39 (0.00)***
Threshold value	-0.008	-0.008
Estimate of the cointegration vector	1.00	1.03
Panel B. GDP vs. Coal consumption		
Test statistic value	18.34 (0.03)**	17.49 (0.08)*
Tests for ECM coefficient	10.46 (0.00)***	42.61 (0.00)***
Tests for dynamic coefficients	5.26 (0.26)	21.09 (0.00)***
Threshold value	-0.009	-0.017
Estimate of the cointegration vector	1.00	1.17
Panel C. GDP vs. Oil consumption		
Test statistic value	14.40 (0.83)	13.07 (0.46)
Tests for ECM coefficient	2.46 (0.29)	88.22 (0.00)***
Tests for dynamic coefficients	22.61 (0.00)***	47.70 (0.00)***
Threshold value	0.004	-0.014
Estimate of the cointegration vector	1.00	0.61
Panel D. GDP vs. Natural Gas consumption		
Test statistic value	22.72 (0.07)*	26.17 (0.01)**
Tests for ECM coefficient	1.38 (0.50)	4.66 (0.09)*
Tests for dynamic coefficients	19.39 (0.01)**	200.68 (0.00)***
Threshold value	0.026	-0.025
Estimate of the cointegration vector	1.00	1.01
Panel E. GDP vs. Electricity consumption		
Test statistic value	13.37 (0.37)	15.95 (0.08)*
Tests for ECM coefficient	7.24 (0.03)**	25.84 (0.00)***
Tests for dynamic coefficients	10.86 (0.03)**	17.60 (0.00)***
Threshold value	-0.0002	0.015
Estimate of the cointegration vector	1.00	0.58

Note: The values in parentheses are the bootstrapping *p*-values with 3000 times replications. The asterisks '***', '**', and '*' indicate rejection of the null hypothesis at 1%, 5% and 10% levels, respectively.

vector is estimated). Therefore, the null hypothesis of linear co-integration is strongly rejected. The alternative two collocations, GDP with respect to coal and natural gas consumption, both show that the null hypothesis of linear co-integration is respectively rejected at the 10% and 5% significant levels whether the co-integrating vector is prior given or estimated. We would prefer the result of the estimating co-integration vector β rather than being fixed at unity, because of a lack of economic information to obtain the co-integration vector of the prior known in general. Given these findings, we also test whether the adjustment back to equilibrium is symmetric when the threshold effect is confirmed in co-integrating equations- that is, whether the error-correction term is equal within the two regimes. To sum up, we reject the null hypothesis of symmetric adjustment for the basis of four out of the five energy consumption sources and GDP at least 10% significant level.

The empirical findings of co-integration with asymmetric adjustment justify and pave the way for the estimation of an asymmetric VECM between GDP and aggregated or various disaggregated categories of energy consumption as will be shown in the next section.

4.1.3 Results of the Two-Regime Error Correction Models

Based on the results of the co-integration tests used in the previous section, we have to employ the asymmetric vector error-correction models instead of the mis-specified convention vector error-correction models. That is, we estimate two-regime VECM in order to further investigate the asymmetric dynamic behavior between GDP and different categories of energy consumption. As mentioned before, the threshold vector error-correction models differ from the conventional vector error-correction models by allowing asymmetric adjustments toward the long-run equilibrium.

The estimates of the two-regime vector error-correction models for the four combinations between GDP and different energy consumption are given below. In each VECM equations, *NLL* represents the value of negative log-likelihood function. The optimal lag orders in each VEC model are determined by Akaike information criterion (AIC). $ObsR_1$ and $ObsR_2$ represent the percentages of sub-sample on total sample size when error-correction term below and above the certain threshold value, respectively. The *t*-statistics are reported in parentheses where the heteroskedasticity-consistent (Eicker-White) standard errors are considered here. When we have no formal distribution theory for the parameter estimates and standard errors, these should be interpreted somewhat cautiously.

4.1.3.1 GDP vs. Energy Consumption

$$\Delta GDP_t = \begin{cases} \underset{(1.69)}{0.01} + \underset{(1.31)}{0.75} w_{t-1} - \underset{(-2.68)}{1.12} \Delta GDP_{t-1} + \underset{(1.11)}{0.49} \Delta EC_{t-1} - \underset{(-3.28)}{1.07} \Delta GDP_{t-2} + \underset{(3.05)}{0.75} \Delta EC_{t-2} \\ - \underset{(-4.49)}{0.93} \Delta GDP_{t-3} + \underset{(3.36)}{0.40} \Delta EC_{t-3} + u_{1t}, \quad w_{t-1} \le -0.008 \\ \underset{(2.07)}{0.002} - \underset{(-7.21)}{1.24} w_{t-1} - \underset{(-0.36)}{0.05} \Delta GDP_{t-1} - \underset{(-5.50)}{0.89} \Delta EC_{t-1} - \underset{(-4.93)}{0.45} \Delta GDP_{t-2} - \underset{(-3.16)}{0.45} \Delta EC_{t-2} \\ - \underset{(-8.65)}{0.62} \Delta GDP_{t-3} - \underset{(-1.85)}{0.15} \Delta EC_{t-3} + u_{1t}, \quad w_{t-1} > -0.008 \end{cases}$$

$$\Delta EC_t = \begin{cases} - \underset{(-0.30)}{0.001} + \underset{(0.20)}{0.14} w_{t-1} - \underset{(-0.35)}{0.16} \Delta GDP_{t-1} - \underset{(-1.85)}{0.86} \Delta EC_{t-1} + \underset{(0.03)}{0.008} \Delta GDP_{t-2} - \underset{(-0.36)}{0.13} \Delta EC_{t-2} \\ + \underset{(1.18)}{0.23} \Delta GDP_{t-3} + \underset{(0.70)}{0.12} \Delta EC_{t-3} + u_{2t}, \quad w_{t-1} \le -0.008 \\ \underset{(0.29)}{0.001} + \underset{(2.88)}{1.16} w_{t-1} - \underset{(-3.18)}{0.97} \Delta GDP_{t-1} + \underset{(0.03)}{0.01} \Delta EC_{t-1} - \underset{(-3.54)}{0.73} \Delta GDP_{t-2} - \underset{(-0.13)}{0.03} \Delta EC_{t-2} \\ - \underset{(-3.07)}{0.40} \Delta GDP_{t-3} - \underset{(-0.44)}{0.06} \Delta EC_{t-3} + u_{2t}, \quad w_{t-1} > -0.008 \end{cases}$$

NLL=-963.537; AIC=-899.537; $ObsR_1$ *=27.37%;* $ObsR_2$ *=72.63%*

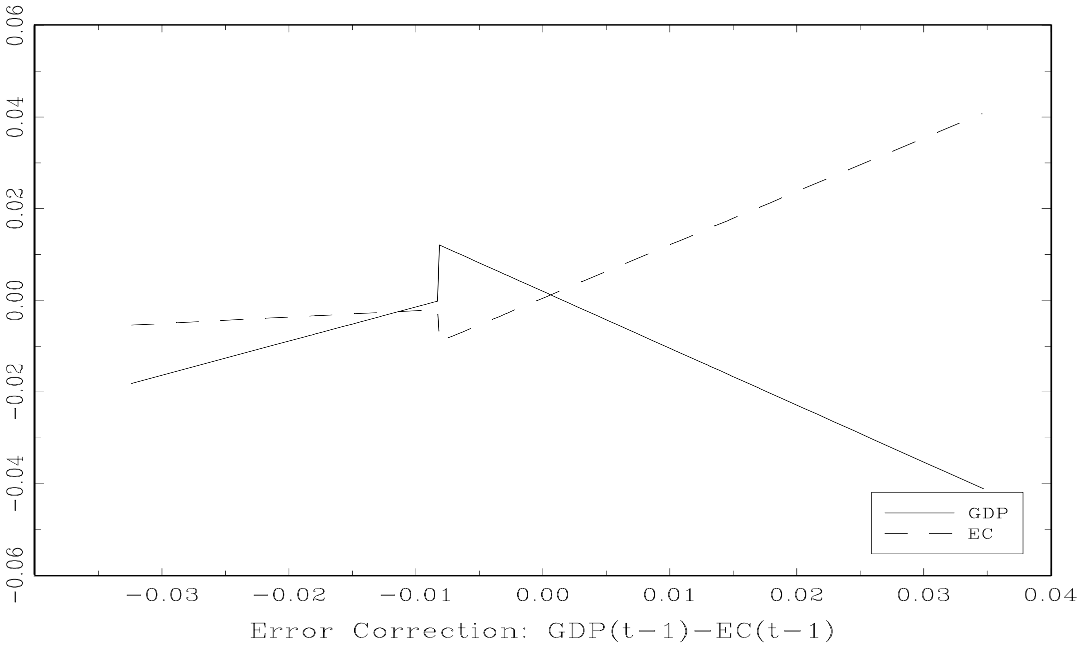


Figure 4.1 Response of GDP and Energy Consumption to Error Correction

The estimated VECM results between energy consumption and GDP are presented above. As can be seen, in the first regime error-correction effects are minimal both in terms of significance and size of the coefficients. On the contrary, the significant error-correction effects appear in the second regime (i.e., when GDP is larger than energy consumption). Figure 4.1 depicts the error-correction effect, i.e., the estimated regression functions of ΔGDP_t and ΔEC_t to the discrepancy between them as a function of w_{t-1} in the previous period when holding the other variables constant. In the figure, when the error-correction term is below the threshold value, we can see the flat near-zero error-correction effect on the left side of the threshold. Nevertheless, on the right side of the threshold, the responses of the energy consumption will increase sharply when the error-correction exceeds a threshold value- that is $\hat{\gamma} > -0.008$, while GDP is significant sharply decreasing afterwards.

These findings exhibit that the error correction terms respond much more to energy consumption than GDP when the error-correction exceeds a certain threshold, making the energy efficiency worse off. Under such a regime, energy consumption will diverge from the mean level due to exogenous shocks such as world oil market shocks or accidental economic events; whereas GDP converges toward the long-run equilibrium in this small open economy. When the response of energy consumption sharply exceeds GDP, the government should develop the energy demand side management (EDSM) to improve energy efficiency.

4.1.3.2 GDP vs. Coal Consumption

$$\Delta GDP_t = \begin{cases} \underset{(-0.33)}{-0.003} - \underset{(-1.83)}{0.91}\, w_{t-1} + \underset{(1.43)}{0.21}\,\Delta GDP_{t-1} - \underset{(-2.08)}{0.06}\,\Delta Coal_{t-1} + u_{1t}, & w_{t-1} \le -0.017 \\ \underset{(-7.22)}{-0.01} - \underset{(-10.07)}{1.74}\, w_{t-1} + \underset{(6.86)}{0.66}\,\Delta GDP_{t-1} - \underset{(-5.65)}{0.17}\,\Delta Coal_{t-1} + u_{1t}, & w_{t-1} > -0.017 \end{cases}$$

$$\Delta Coal_t = \begin{cases} \underset{(5.48)}{0.14} + \underset{(1.99)}{2.36}\, w_{t-1} - \underset{(-4.43)}{1.70}\,\Delta GDP_{t-1} - \underset{(-6.57)}{0.49}\,\Delta Coal_{t-1} + u_{2t}, & w_{t-1} \le -0.017 \\ \underset{(-0.22)}{-0.001} + \underset{(0.30)}{0.16}\, w_{t-1} + \underset{(0.42)}{0.15}\,\Delta GDP_{t-1} - \underset{(-6.81)}{0.66}\,\Delta Coal_{t-1} + u_{2t}, & w_{t-1} > -0.017 \end{cases}$$

NLL=-783.410; AIC=-751.410; $ObsR_1$*=20.62%;* $ObsR_2$*=79.38%*

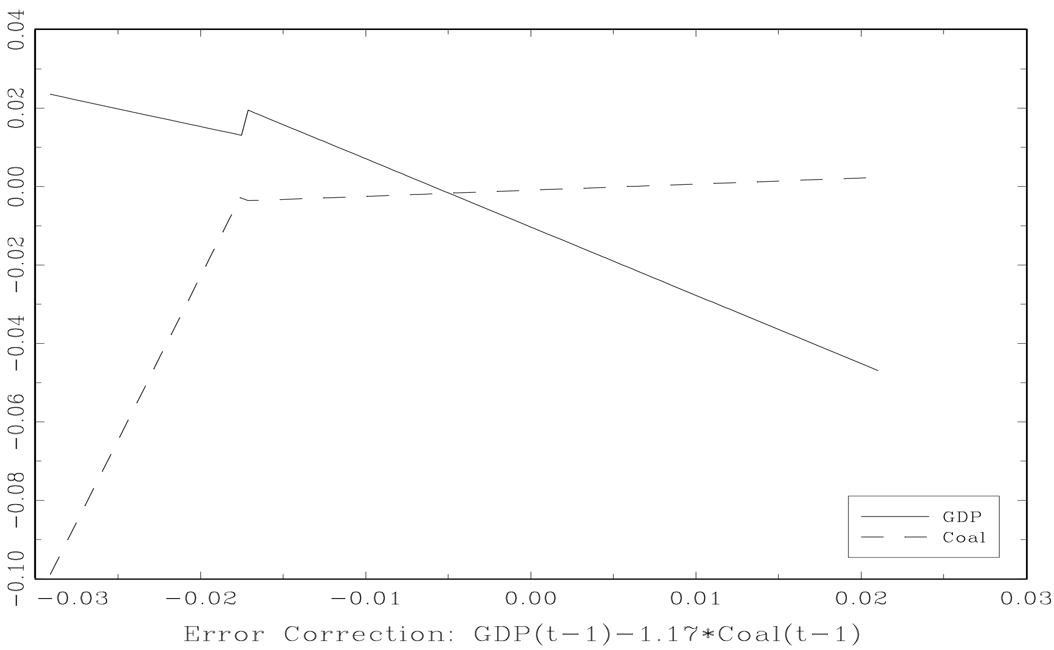


Figure 4.2 Response of GDP and Coal Consumption to Error Correction

The estimated VECM results between coal consumption and GDP are presented above. Figure 4.2 plots the error-correction effect. Similar to the estimated collocation between GDP and energy consumption, the response of the error-correction effects to GDP is significantly larger than the response of coal consumption in second regime, which contains 21% of the observations. However, a contrary condition can be found in that the adjusting speed in the error-correction to the response of coal consumption would lead to a stronger positive response when the deviation of coal-output is below the threshold value (i.e., $\hat{\gamma} \leq -0.017$). This signifies that over-consuming coal seems not to effectively enhance economic growth. At this situation, excessive energy consumption may also generate considerable pressure on the environment as the environmental Kuznets curve literature often mentions. Therefore, in order to maintain the long-run equilibrium relation of coal-output possess high quality environment, government authorities should make more effort to consolidate the implementation of coal demand-side management.

4.1.3.3 GDP vs. Natural Gas Consumption

$$\Delta GDP_t = \begin{cases} \underset{(2.50)}{0.03} - \underset{(-1.48)}{0.25}\, w_{t-1} - \underset{(-0.76)}{0.35}\, \Delta GDP_{t-1} + \underset{(3.38)}{0.63}\, \Delta NG_{t-1} - \underset{(-5.05)}{0.95}\, \Delta GDP_{t-2} + \underset{(2.52)}{0.45}\, \Delta NG_{t-2} \\ + \mathrm{u}_{1t}, \quad w_{t-1} \leq -0.025 \\ \underset{(0.04)}{0.0001} - \underset{(-2.51)}{0.22}\, w_{t-1} - \underset{(-2.34)}{0.17}\, \Delta GDP_{t-1} + \underset{(1.60)}{0.11}\, \Delta NG_{t-1} - \underset{(-4.99)}{0.40}\, \Delta GDP_{t-2} + \underset{(1.96)}{0.08}\, \Delta NG_{t-2} \\ + \mathrm{u}_{1t}, \quad w_{t-1} > -0.025 \end{cases}$$

$$\Delta NG_t = \begin{cases} -\underset{(-4.04)}{0.14} - \underset{(-4.21)}{2.40}\, w_{t-1} - \underset{(-2.75)}{3.48}\, \Delta GDP_{t-1} - \underset{(-0.89)}{0.40}\, \Delta NG_{t-1} - \underset{(-0.73)}{0.36}\, \Delta GDP_{t-2} - \underset{(-2.26)}{1.02}\, \Delta NG_{t-2} \\ + \mathrm{u}_{2t}, \quad w_{t-1} \leq -0.025 \\ \underset{(3.35)}{0.01} - \underset{(-6.01)}{1.65}\, w_{t-1} + \underset{(8.44)}{1.45}\, \Delta GDP_{t-1} + \underset{(2.61)}{0.45}\, \Delta NG_{t-1} + \underset{(3.94)}{0.78}\, \Delta GDP_{t-2} + \underset{(1.70)}{0.22}\, \Delta NG_{t-2} \\ + \mathrm{u}_{2t}, \quad w_{t-1} > -0.025 \end{cases}$$

NLL=-789.975; AIC=-741.975; $ObsR_1$ *=15.63%;* $ObsR_2$ *=84.37%*

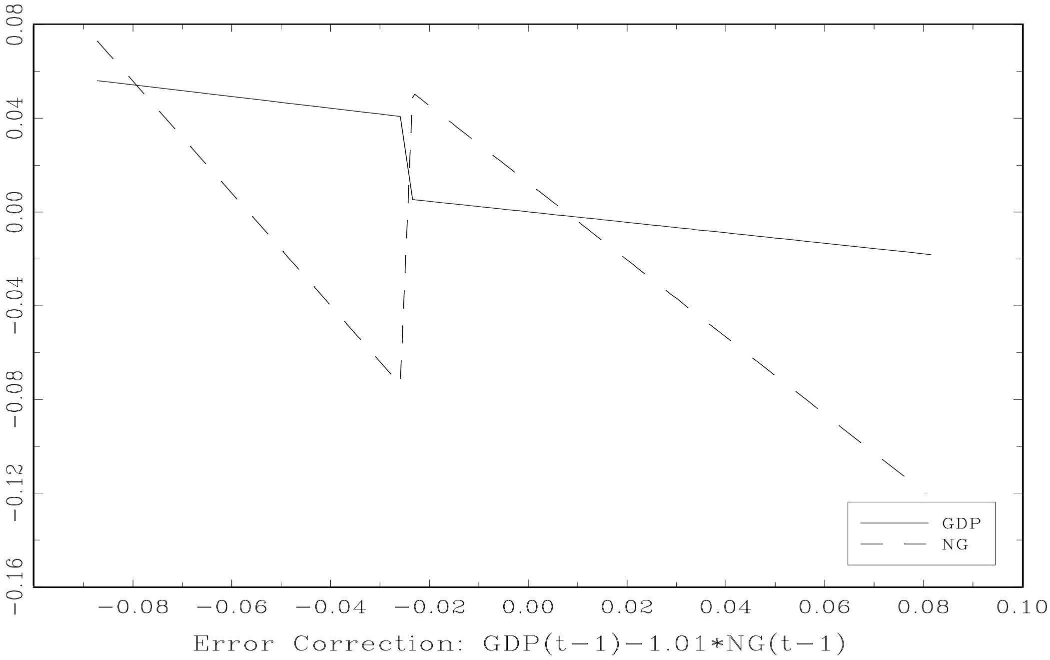


Figure 4.3 Response of GDP and Natural Gas Consumption to Error Correction

The estimated VECM results between natural gas consumption and GDP are presented above. The significant error-correction effect only appears in the response of natural gas consumption in first regime. On the contrary, in the second regime error-correction effects and dynamic structures are minimal both in terms of significance and size of coefficients. In contrast to the collocations of energy-output and coal-output, Figure 4.3 shows that the error-correction effects in response of GDP and natural gas consumption are both downward-adjusting, no matter for below or above the threshold. Note that both natural gas consumption and GDP have negative error correction terms. Since the size of the negative error-correction term for natural gas consumption is larger than that for GDP in both regimes, natural gas consumption is more efficient.

4.1.3.4 GDP vs. Electricity Consumption

$$\Delta GDP_t = \begin{cases} \underset{(3.38)}{0.003} - \underset{(-9.94)}{1.80}\, w_{t-1} + \underset{(6.91)}{0.64}\,\Delta GDP_{t-1} - \underset{(-7.00)}{0.51}\,\Delta Elec_{t-1} + u_{1t}, & w_{t-1} \le 0.015 \\ \underset{(-3.18)}{-0.02} + \underset{(0.36)}{0.14}\, w_{t-1} - \underset{(-0.06)}{0.01}\,\Delta GDP_{t-1} + \underset{(0.06)}{0.01}\,\Delta Elec_{t-1} + u_{1t}, & w_{t-1} > 0.015 \end{cases}$$

$$\Delta Elec_t = \begin{cases} \underset{(-0.55)}{-0.001} + \underset{(0.84)}{0.17}\, w_{t-1} - \underset{(-0.50)}{0.07}\,\Delta GDP_{t-1} - \underset{(-4.93)}{0.42}\,\Delta Elec_{t-1} + u_{2t}, & w_{t-1} \le 0.015 \\ \underset{(-4.90)}{-0.06} + \underset{(5.05)}{3.70}\, w_{t-1} - \underset{(-2.69)}{0.58}\,\Delta GDP_{t-1} + \underset{(0.55)}{0.15}\,\Delta Elec_{t-1} + u_{2t}, & w_{t-1} > 0.015 \end{cases}$$

NLL=-889.739; AIC =-857.739; $ObsR_1$ *=85.57%;* $ObsR_2$ *=14.43%*

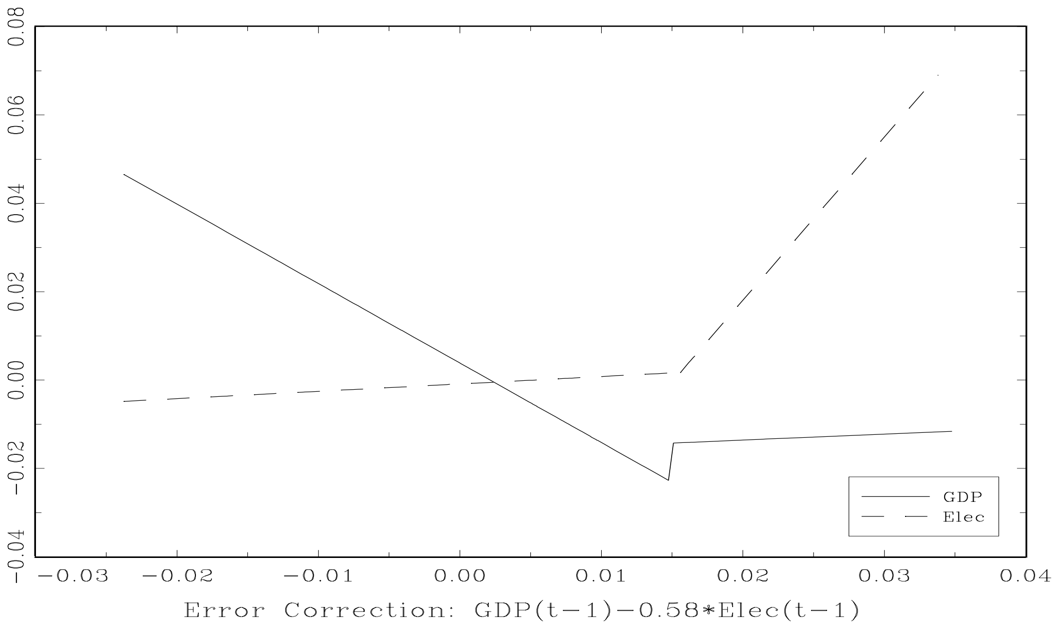


Figure 4.4 Response of GDP and Electricity Consumption to Error Correction

The estimated VECM results between electricity consumption and GDP are presented above. In Figure 4.4 the collocation of electricity consumption and GDP shows that the response of error-correction effect to electricity use on the left side of the threshold is flatly near zero, while to GDP the response has a decreasing adjusting pattern. In the electricity equation the point estimate for the error-correction term is moderately large and on the dash-line of statistical significance when the error-correction exceeds a threshold level (that is, $\hat{\gamma} > 0.015$). Hence, there is a disequilibrium relationship between electricity consumption and GDP in regime two. This result suggests that increases in electricity consumption and decreases in GDP are highly persistent, implying that the regime of electricity inefficiency is captured. Such a circumstance may have some serious policy implications as rationalizing electricity conservation policies are made to improve the electricity efficiency.

These results suggest decision-makers need to implement electricity conservation policies to improve efficiency and manage demand. In the near future, policy makers should aim to reduce wasted electricity, to improve the power infrastructures for the economy, and to enable users to enjoy higher quality of electricity.

4.2 The Impacts of Oil Price Shocks on Stock Markets

4.2.1 Data Sources

The countries in monthly data include Canada, Japan, France, Taiwan, Korea and Malaysia to be tested in this issue. With the exception of Taiwan, most partly of sample data are obtained from the IFS CD-ROM published by International Monetary Fund. The oil price (OIL) data are collected from the West Texas Intermediate (WTI) crude oil spot price index in the commodity prices section. Deposit rate (R) (line 60L) and industrial production (IP) (line 66) are used as a proxy for the domestic interest rate and output, respectively. In order to obtain longer periods data, stock price (SP) for Canada and Japan are compiled from Thomson Datastream database, while other three countries (i.e., France, Korea and Malaysia) are also taken from share price (line 62) of IFS CD-ROM. The data for Taiwan are taken from Taiwan Economic Journal (TEJ) database.

Table 4.4 Sample Sources and Research Periods

	Data sources				
	SP	OIL	IP	R	Sample periods
Canada	Datastream	IFS CD-ROM	IFS CD-ROM	IFS CD-ROM	1971:M1-2008:M6 (450)
Japan	Datastream	IFS CD-ROM	IFS CD-ROM	IFS CD-ROM	1970:M1-2008:M7 (463)
France	IFS CD-ROM	IFS CD-ROM	IFS CD-ROM	IFS CD-ROM	1970:M1-2007:M7 (451)
Taiwan	TEJ	IFS CD-ROM	TEJ	TEJ	1975:M7-2008:M7 (397)
Korea	IFS CD-ROM	IFS CD-ROM	IFS CD-ROM	IFS CD-ROM	1978:M1-2008:M5 (365)
Malaysia	IFS CD-ROM	IFS CD-ROM	IFS CD-ROM	IFS CD-ROM	1980:M1-2008:M5 (341)

Note: Values in the parenthesis are number of observation. SP denotes the stock price; OIL is the WTI crude oil spot price index; IP represents the industrial production index; R means the interest rate.

The data for oil price, stock price and industrial production are deflated by the base year 2000 consumer price index (CPI) and are taken natural logarithm (except for interest rate) before conducting the analysis. As a result, the periods of the available data in each country are different. Among these countries, Japan has the longest data (1970:1-2008:7 for 463 data points), while Malaysia has the shortest data (1980:1-2008:5 for 341 data points). More details of these research variables are displayed in Table 4.4.

As a first step of the empirical analysis, unit root tests have been carried out for all the variables. The ADF is used first to detect the existence of unit roots in the individual series. We also use the double-checked by performing the KPSS test. As Table 4.5 shows, the ADF statistic indicates that all of the individual series in first differences are stationary at the 5% significance level. This outcome suggests that all variables are integrated of order one, $I(1)$. With the exception of oil price series in Canada and Taiwan, the KPSS test rejects the null hypothesis of the series is stationarity but cannot reject in first differences. Although the ADF and KPSS tests have some inconsistent conditions, the combined results from both tests suggest that all the series appear to be $I(1)$ processes. Thus, we will use the differenced variables

Table 4.5 Results of Unit Root Tests

	Level		First Difference	
Canada	ADF	KPSS	ADF	KPSS
SP	-0.853 [1]	1.569 [16]**	-18.495 [0]**	0.104 [4]
OIL	-1.512 [1]	0.287 [16]	-17.395 [0]**	0.187 [1]
IP	-1.845 [8]	0.595 [17]**	-4.577 [7]**	0.076 [13]
R	-1.777 [8]	1.749 [16]**	-6.938 [7]**	0.070 [6]
	Level		First Difference	
Japan	ADF	KPSS	ADF	KPSS
SP	-1.738 [1]	0.969 [17]**	-20.031 [0]**	0.156 [6]
OIL	-0.920 [1]	0.786 [16]**	-17.938 [0]**	0.212 [0]
IP	-2.53 [17]	0.372 [17]*	-6.058 [15]**	0.278 [13]
R	-1.639 [7]	2.166 [17]**	-6.142 [6]**	0.049 [9]
	Level		First Difference	
France	ADF	KPSS	ADF	KPSS
SP	-0.478 [0]	1.988 [17]**	-21.657 [0]**	0.236 [7]
OIL	-1.954 [1]	0.278 [16]**	-17.547 [0]**	0.114 [1]
IP	-0.834 [13]	0.621 [17]**	-5.023 [12]**	0.144 [9]*
R	-0.839 [0]	1.603 [17]**	-21.147 [0]**	0.290 [0]
	Level		First Difference	
Taiwan	ADF	KPSS	ADF	KPSS
SP	-1.403 [0]	1.768 [16]**	-18.808 [0]**	0.093 [3]
OIL	-1.076 [1]	0.423 [16]	-15.447 [0]**	0.262 [4]
IP	-3.085 [14]	0.209 [16]*	-3.899 [13]*	0.028 [6]
R	-2.503 [3]	0.155 [16]*	-9.185 [2]**	0.045 [9]
	Level		First Difference	
Korea	ADF	KPSS	ADF	KPSS
SP	-1.360 [1]	0.775 [15]**	-13.787 [0]**	0.112 [7]
OIL	-1.512 [1]	1.064 [15]**	-12.253 [1]**	0.325 [4]
IP	0.144 [3]	2.096 [15]**	-9.387 [2]**	0.201 [9]
R	-2.819 [2]	0.152 [15]*	-16.087 [0]**	0.048 [2]
	Level		First Difference	
Malaysia	ADF	KPSS	ADF	KPSS
SP	-3.207 [1]	0.160 [15]*	-10.174 [2]**	0.038 [4]
OIL	-1.110 [2]	0.462 [15]**	-12.546 [1]**	0.037 [11]
IP	-2.801 [13]	0.288 [15]**	-4.482 [14]**	0.041 [16]
R	-2.184 [4]	1.067 [15]**	-6.601 [3]**	0.067 [10]

Note: SP denotes the stock price; OIL is the WTI crude oil spot price index; IP represents the industrial production index; R means the interest rate. Values in the brackets are the lag length selected by AIC in ADF tests and by Newey-West bandwidth in KPSS tests. The symbols '**' and '*' represent that the null hypothesis is rejected at a 1% and 5% level, respectively.

in the following analysis.

Since we are investigating the impact of an oil price change on stock price and the impact of an oil price shock on the interest rate and industrial production, all the $I(1)$ variables need to be examined regarding the existence of a co-integration relation. We apply the co-integration tests based on the methodology of Johansen and Juselius (1990) to identifying the long-run restrictions imposed on the co-integrating vectors. Two or more individual series may be non-stationary, but a linear combination of these individual series may be stationary. If such a stationary linear combination exists, then the non-stationary time series are said to be co-integrated. The stationary linear combination is called a co-integrating equation and may be interpreted as a long-run equilibrium relationship between the variables; that is, the variables have co-movement over time. If there is only one long-run relationship among the variables, then those variables will share a single route of convergence towards the equilibrium path. If there is more than one long-run relationship, there exist multiple forces pushing towards convergence paths among the variables.

As a pre-test, we estimate the VAR models with varying lag lengths to select the appropriate lag length by AIC statistic. The optimal lags of 2 is chosen in Canada, lags of 3 is chosen in Taiwan, lags of 4 is chosen in Japan, and the remaining cases are all one lag. The third column of Table 4.6 lists the estimated trace statistics; the four column consists of the maximum eigenvalues statistics; the fifth column lists the variables of $I(1)$ for which co-integration tests are needed. When the trace statistics and maximum eigenvalues reject the null hypothesis at 5% significance level, there exist co-integration relations among variables. It can be seen that Canada, France Taiwan, and Malaysia provide evidence of a co-integration relation and the VECM model is used for these four countries. The remaining two countries do not exhibit a co-integration relation and the VAR model is used for the purpose of the analysis.

Table 4.6 Results of the Johansen Co-integration Tests

Countries	Ho	Trace	Max-Eigen	*I*(1) variables	Model
Canada	r＝0	104.40 (0.00)***	71.90 (0.00)**	SP	
	r≤1	32.41 (0.10	19.17 (0.13)	OIL	VECM
	r≤2	13.24 (0.34)	10.30 (0.31)	IP	
	r≤3	2.94 (0.59)	2.94 (0.59)	R	
Japan	r＝0	33.59 (0.79)	14.90 (0.82)	SP	
	r≤1	18.69 (0.80)	10.54 (0.79)	OIL	VAR
	r≤2	8.16 (0.81)	6.82 (0.69)	IP	
	r≤3	1.34 (0.90)	1.34 (0.90)	R	
France	r＝0	136.42 (0.00)**	91.25 (0.00)**	SP	
	r≤1	45.18 (0.03)*	21.19 (0.07)	OIL	VECM
	r≤2	23.99 (0.11)	18.53 (0.12)	IP	
	r≤3	5.46 (0.24)	5.46 (0.24)	R	
Taiwan	r＝0	55.55 (0.04)*	34.52 (0.00)**	SP	
	r≤1	21.03 (0.66)	15.14 (0.36)	OIL	VECM
	r≤2	5.89 (0.95)	4.18 (0.95)	IP	
	r≤3	1.71 (0.83)	1.71 (0.83)	R	
Korea	r＝0	52.71 (0.07)	34.25 (0.00)**	SP	
	r≤1	18.46 (0.82)	11.29 (0.73)	OIL	VAR
	r≤2	7.17 (0.89)	3.89 (0.96)	IP	
	r≤3	3.28 (0.53)	3.28 (0.53)	R	
Malaysia	r＝0	60.78 (0.01)*	34.23 (0.00)**	SP	
	r≤1	26.55 (0.31)	14.21 (0.44)	OIL	VECM
	r≤2	12.35 (0.42)	7.22 (0.64)	IP	
	r≤3	5.13 (0.27)	5.13 (0.27)	R	

Note: Values in the parenthesis are the *p*-values. Asterisks '**' and '*' represent 1% and 5% significance levels. Ho indicates the null hypothesis of variables has none co-integrating relationship. r represents the co-integrating vector.

4.2.2 Results of the Variance Decomposition and Impulse Response Analysis in the One-Regime VAR

The precise interpretation of the VAR model is brought to light through the variance decomposition analysis and the estimation of impulse response functions to investigate the dynamic properties of the system. The VDC provides a tool of analysis to determine the relative importance of oil price shock in explaining the changes of the stock returns and other macroeconomic variables for three developed countries (i.e., Canada, Japan and France) and three developing countries (i.e., Taiwan, Korea and Malaysia). Table 4.7 illustrates proportions of impacts emanated from an oil price change in terms of VDC. For example, for the cases of developed countries, oil price changes explain a 0.74% change in stock price (Canada), slightly higher than 0.61% explained by the interest. In the case of Japan, oil price changes explain 1.88% of stock price change, 0.94% of industrial output, and 5.49% of interest rate change. Besides, oil price changes explain 2.29% of the stock returns of France. Taken together of three developed countries, oil price changes in France has the largest explanatory power on stock returns. Comparing to the other two developing countries (i.e., Korea and Malaysia), Taiwan has the largest explanatory power for oil price changes in explaining 1.82% of the stock price change, 4.76% of the industrial production change, and 0.82% of the interest rate change, respectively. Combining with these six countries, oil price change for France has the least explanatory power on stock price returns (2.29), while the largest for Malaysia by the industrial production (9.92%) and the interest rate (3.30%).

The orthogonalized impulse response functions of the macroeconomics and stock prices variables to oil price shocks are depicted in Figure 4.5. The responses of oil price shocks on each variable in these figures are quite controversial. For example, it appears that the effects of an oil price shock that increases oil prices by 8% in the first period in Canada. The figure shows that following an oil price shock, stock price returns decrease immediately by 0.3%. The maximum effect is reach after Period 3 when stock prices have increased by 0.2%. The results of impulse response of a one unit oil price changes are summarized: (i) oil prices change responds positively and significantly in Period 1 for all countries, where the values are up to

Table 4.7 Variance Decomposition of Forecast Error Variance in One-Regime VAR model (12 periods forward)

Countries		Shock sources ε^{SP}	ε^{OIL}	ε^{IP}	ε^{R}
Canada	△SP	98.42 (1.69)	0.74 (1.10)	0.23 (0.72)	0.61 (1.06)
	△OIL	0.41 (0.87)	99.01 (1.41)	0.55 (0.98)	0.03 (0.52)
	△IP	0.08 (0.59)	0.17 (0.75)	99.30 (1.28)	0.45 (0.82)
	△R	1.30 (1.39)	0.01 (0.65)	4.40 (2.47)	94.29 (2.82)
Japan	△SP	92.39 (2.60)	1.88 (1.38)	2.36 (1.61)	3.37 (1.77)
	△OIL	1.32 (1.11)	97.04 (1.75)	0.88 (0.95)	0.76 (1.10)
	△IP	2.25 (1.54)	0.94 (1.13)	94.85 (2.40)	1.96 (1.45)
	△R	0.92 (1.03)	5.49 (2.12)	0.39 (0.99)	93.20 (2.42)
France	△SP	97.38 (1.72)	2.29 (1.45)	0.10 (0.41)	0.23 (0.68)
	△OIL	0.01 (0.32)	99.88 (0.57)	0.01 (0.26)	0.10 (0.38)
	△IP	0.50 (0.85)	0.28 (0.73)	98.39 (1.47)	0.83 (1.04)
	△R	0.16 (0.53)	2.11 (1.35)	2.02 (1.41)	95.71 (1.91)
Taiwan	△SP	94.90 (2.52)	1.82 (1.60)	1.21 (1.25)	2.07 (1.61)
	△OIL	0.92 (1.17)	97.24 (2.14)	1.03 (1.27)	0.81 (1.30)
	△IP	3.28 (2.05)	4.76 (2.58)	91.39 (3.53)	0.57 (1.17)
	△R	1.78 (1.55)	0.82 (1.23)	1.16 (1.21)	96.24 (2.19)
Korea	△SP	95.89 (2.48)	1.15 (1.56)	2.82 (1.99)	0.14 (0.72)
	△OIL	0.03 (0.48)	99.64 (0.97)	0.28 (0.61)	0.05 (0.58)
	△IP	2.99 (1.53)	0.08 (0.56)	96.03 (2.08)	0.90 (0.89)
	△R	0.14 (0.51)	0.22 (0.75)	0.21 (0.82)	99.43 (1.39)
Malaysia	△SP	86.64 (3.53)	0.14 (0.82)	9.92 (2.82)	3.30 (2.39)
	△OIL	0.00 (0.51)	99.75 (0.88)	0.23 (0.53)	0.02 (0.42)
	△IP	0.20 (0.51)	0.93 (0.95)	98.72 (1.22)	0.15 (0.50)
	△R	0.05 (0.60)	0.45 (0.93)	0.53 (0.86)	98.97 (1.42)

Note: Values in the parenthesis are standard errors estimated through Monte Carlo 500 replications. Variance decomposition explaining variation in variables is due to stock price shocks (ε^{SP}), oil price shocks (ε^{OIL}), exchange rate shocks (ε^{EX}) and interest rate shocks (ε^{R}).

7-8%. After 3-5 Periods, the effects gradually die out; (ii) stock prices react negative and significantly to oil price change in Period 1 for Canada, France, and Taiwan. After that, the stock returns increased by 0.2% in Period 3 for France and by 0.6% in

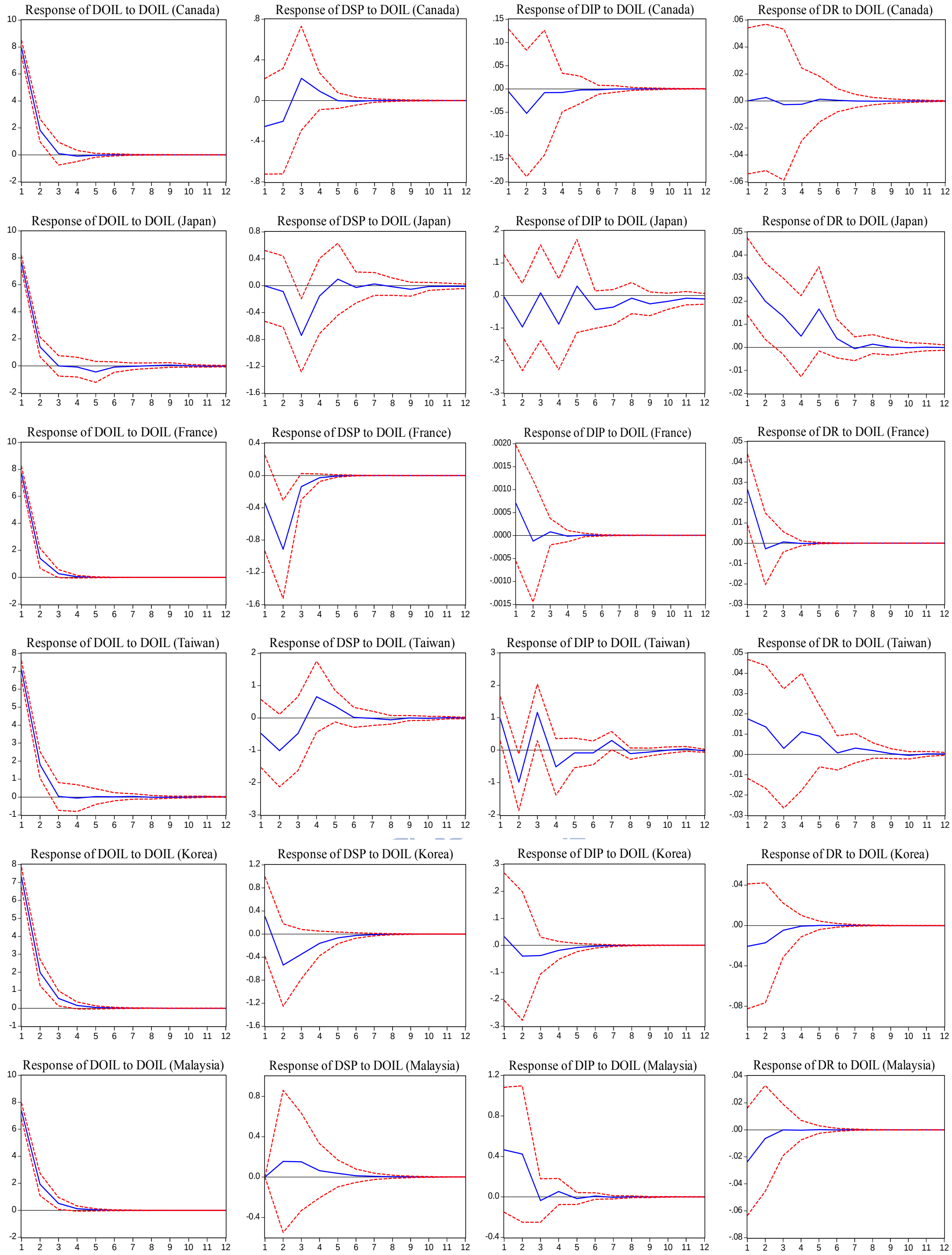


Figure 4.5 Impulse Responses to Oil Price Shock in the One-Regime VAR Model (12 Forward Periods). Note: DOIL=change in oil price, DSP=change in stock price, DIP=change in industrial production, DR=change in interest rate.

Period 4 for Taiwan. As a whole, the effects of stock prices change are persistently 4-6 months; (iii) the responses of industrial output change exhibit more volatiles such as Japan and Taiwan. (iv) interest rate react positive and significantly to oil price change in Periods 1 to 6 for Japan, France and Taiwan. While a negative response from interest rate is observed in Periods 1 to 4 for Korea and Malaysia, no significant responses are identified for Japan.

The above results are consistent with what is expected of macroeconomic theory in the one-regime model. In particular, our findings are comparable to that by Sadorsky (1999) who used quarterly data for US: an oil price change can satisfactorily explain stock returns in Period 1 (negatively). Moreover, Huang et al. (2005) who used monthly data for US: stock prices react negatively to oil price change in Period 2 and 12.

The one-regime model may well encounter the average-out problem emanated from positive and negative changes. Besides, each economy has a different level of dependence on oil and as such, should exhibit varying impulse responses. To circumvent the problem, we follow Mork (1989), Mork et al. (1994), Hooker (1996), Hamilton (1996) and Sadorsky (1999) to categorize the oil price change into two classifications: positive (up) and negative change (down). This way may reflect different dependence levels on oil and provide a statistical test on the necessity of using different regimes.

4.2.3 Results of the Variance Decomposition and Impulse Response Analysis in the Two-Regime VAR

The asymmetric relationship between oil price shocks and macroeconomic variable is investigated in many studies. For example, several studies find that rising oil prices seem to retard economic activity by more than falling oil prices stimulate it (e.g., Hamilton, 1996; Lee et al., 1995; Favies and Haltiwanger, 2001). So far, there are still few studies to explore the impacts of oil price changes on stock market, particularly in an asymmetric perspective. To test for the asymmetric effects, we define two additional proxy variables for oil price shocks. First, we follow Mork (1989), Mork et al. (1994) and Sadorsky (1999) to jointly enter oil price increases and decreases as separate variables into the same equation determining stock price changes. Defining the log level of real oil prices as OIL_t, and $\Delta OIL_t = (OIL_t - OIL_{t-1})$ as the monthly changes in oil prices, a proxy that considers oil price increases only can be defined as:

$$\Delta OIL_t^+ = \max(0, \Delta OIL_t) \tag{27}$$

That is, it equals the oil price growth rate when it is positive and it is zero otherwise. Equally, a proxy that considers oil price decreases only can be defined as:

$$\Delta OIL_t^- = \min(0, \Delta OIL_t) \tag{28}$$

That is, it equals the oil price growth rate when it is negative and it is zero otherwise. In this case, we treat in a different way oil price increases and decreases; that is, we separate oil price changes into negative and positive changes in a believe that oil price increases may have a significant effect on stock prices even though this might not occur for oil price decreases.

Second, Hamilton (1996) argues that if one wants a measure of how unsettling an increase in the price of oil is likely to be for the spending decisions of consumers and firms, it seems more appropriate to compare the current oil price with where it has been over the previous years rather than during the previous alone. To correctly measure the effect of oil price increases on the macro-economy, he suggests that one should compare the price of oil with where it has been over the previous year rather than with where it was the previous month alone. By constructing what he refers to as the net oil price (the maximum value of the oil price observed during the preceding year), Hamilton (1996) shows that once one defines oil price in terms of the net oil price, the historical correlation between oil price shocks and the macro-economy that is found prior to the mid-1980s remains intact. Net oil price increases (NOPI) therefore can be defined as:

$$\mathrm{NOPI}_t = \max[0, (\ln(\mathrm{OIL}_t) - \ln(\max(\mathrm{OIL}_{t-1}, \ldots, \mathrm{OIL}_{t-12})))] \tag{29}$$

Equation (29) describes how one can construct a net oil price measure as the increase from the previous year's monthly high price if that is positive, and zero otherwise. Since we are interested in exploring the impact of oil price shock on equity markets, we treat the oil price changes variable as a threshold variable and the multivariate relationship in stock price changes equation can be re-written as:

$$\begin{aligned}\Delta\mathrm{SP}_t &= \alpha_0 + \sum_{i=1}^{k}\beta_i \Delta\mathrm{SP}_{t-i} + \sum_{i=1}^{k}\gamma_i^{+}\Delta\mathrm{OIL}_{t-i}^{+} + \sum_{i=1}^{k}\gamma_j^{-}\Delta\mathrm{OIL}_{t-i}^{-} \\ &+ \sum_{i=1}^{k}\delta_j \Delta\mathrm{EX}_{t-i} + \sum_{i=1}^{k}\theta_i \Delta\mathrm{R}_{t-i} + \varepsilon_t\end{aligned} \tag{30}$$

$$\begin{aligned}\Delta\mathrm{SP}_t &= \alpha_0 + \sum_{i=1}^{k}\beta_i \Delta\mathrm{SP}_{t-i} + \sum_{i=1}^{k}\gamma_j^{+}\mathrm{NOPI}_{t-i} + \sum_{i=1}^{k}\gamma_j^{-}\Delta\mathrm{OIL}_{t-i}^{-} \\ &+ \sum_{i=1}^{k}\delta_i \Delta\mathrm{EX}_{t-j} + \sum_{i=1}^{k}\theta_i \Delta\mathrm{R}_{t-i} + \varepsilon_t,\end{aligned} \tag{31}$$

With this specification, we carry out conventional tests of the following hypothesis:

$$H_{01} : \sum_{i=1}^{k}\gamma_i^{+} = \sum_{i=1}^{k}\gamma_i^{-}$$

and $H_{02} : \sum_{i=1}^{k} NOPI_i = \sum_{i=1}^{k}\gamma_i^{-}$, $i = 1, 2, \cdots, k$.

The null hypothesis is that no asymmetry exists, in which cases the two parts coefficients should not be different from each other. A more specific version of this test is that there is no asymmetry and, indeed, the coefficient for both cases is jointly equal to zero. More formally, this test is:

$$H_{03}:\sum_{i=1}^{k}\gamma_i^{+}=\sum_{i=1}^{k}\gamma_i^{-}=0$$

and $H_{04}:\sum_{i=1}^{k}NOPI_i=\sum_{i=1}^{k}\gamma_i^{-}=0,\ i=1,2,\cdots,k$.

Table 4.8 displays the tests results of asymmetric effects by carrying out this test of pair-wise equality of the coefficients. As can be observed from Table 4.8, the null equality of $\sum_{i=1}^{k}\gamma_i^{+}=\sum_{i=1}^{k}\gamma_i^{-}$ is rejected at the 1% level for the cases of France and Korea, while the null equality of $\sum_{i=1}^{k}NOPI_i=\sum_{i=1}^{k}\gamma_i^{-}$ is only rejected in France.

Moreover, we estimate Equation (30) and (31) including net oil price increases (NOPI) together with oil price decreases and test whether each of the coefficients NOPI variables is equal to its corresponding coefficient of oil price decreases; that is, we test the null hypothesis of $\sum_{i=1}^{k}\gamma_i^{+}=\sum_{i=1}^{k}\gamma_i^{-}=0$ and $\sum_{i=1}^{k}NOPI_i=\sum_{i=1}^{k}\gamma_i^{-}=0$. In this case, as shown in Table 4.8, we also find evidence of an asymmetric relationship between stock returns and oil price changes in France and Korea.

Table 4.8 Testing for Asymmetric Effects of Oil Price Changes

	$\sum\gamma_i^{+}=\sum\gamma_i^{-}$	$\sum NOPI_i=\sum\gamma_i^{-}$	$\sum\gamma_i^{+}=\sum\gamma_i^{-}=0$	$\sum NOPI_i=\sum\gamma_i^{-}=0$
Canada	2.257 (0.133)	1.762 (0.185)	1.162 (0.314)	0.885 (0.414)
Japan	0.465 (0.496)	0.413 (0.521)	0.837 (0.433)	0.673 (0.511)
France	5.550 (0.019)**	7.865 (0.005)***	7.191 (0.001)***	7.103 (0.001)***
Taiwan	0.094 (0.760)	0.002 (0.967)	0.062 (0.940)	0.001 (0.992)
Korea	3.923 (0.048)**	1.295 (0.256)	3.858 (0.022)**	3.734 (0.025)**
Malaysia	1.122 (0.290)	0.012 (0.915)	0.572 (0.565)	0.169 (0.845)

Note: *** and ** indicate statistical significant at the 1% and 5% level. Values in the parenthesis are the *p*-value of *F*-test. γ^{+} is the coefficients with the oil price changes increases. γ^{-} is the coefficients with the oil price changes decreases. *NOPI* is the net oil price increases.

To sum up, the results reveals that the impact of oil price changes on the stock markets is partially asymmetric in the cases of France and Korea. The finding is consistent with Cunado and Pérez de Gracia (2005) who also find evidence of asymmetries in the oil prices and macroeconomy relationship in Korea.

Countries with insignificant coefficients suggest that the separated oil price changes have no asymmetric effects and the model can be reduced to a linear framework. According to the results of asymmetric tests, we subsequently carry out the two-regime impulse response analysis and variance decompositions when using the oil price changes variable as a threshold variable.

Table 4.9 presents the variance decomposition in the two-regime VAR model for France and Korea. The results of the VDC tend to suggest that each of the variables used in the empirical analysis can be explained by the disturbances in the other variables. All variables are mostly explained by their own shocks. Comparing the results of the two-regime VDC, the oil shocks can explain in the changes of industrial output and interest rate when oil price changes decrease is larger than decrease for the case of France. Beside, we also find that oil shock in explaining the stock returns as oil price changes decrease is larger than as oil price changes increase.

The two-regime impulse response functions for France are shown in Figure 4.6. When oil price changes decreases (i.e., Regime I), the responses to the oil price with one unit shock increases oil prices by 3.8% in Period 1 but decreases stock returns by 0.4%. Then stock returns sharply decreases by 1.0% when oil price change increases only by 1.4% in Period. Similar results can be found in Regime II (lower half in Figure 4.6): For instance, the oil price changes react by 5.8% (i.e., oil price changes increase) and by 4.5% (i.e., net oil price increase) to an oil price shock in first month. However, the effects of the response of stock returns decline in both Regime II cases.

Table 4.9 Variance Decomposition of Forecast Error Variance in Two-Regime VAR model (12 periods forward)

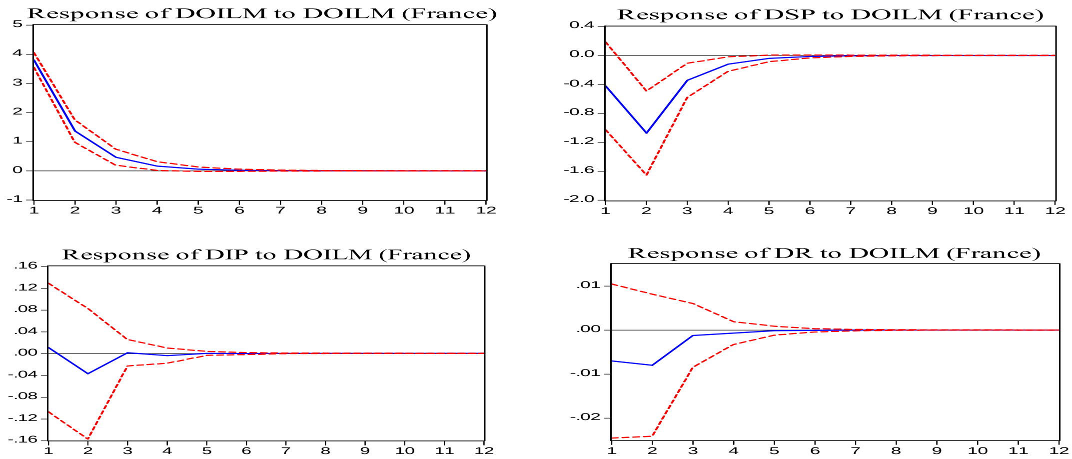
		Shock sources			
Countries		ε^{SP}	ε^{OIL}	ε^{IP}	ε^{R}
France	*Regime I* ($\triangle OIL^{-}$)				
	△SP	95.84 (1.88)	3.42 (1.64)	0.44 (0.78)	0.30 (0.57)
	△OIL	0.06 (0.40)	99.57 (0.81)	0.01 (0.26)	0.36 (0.69)
	△IP	0.00 (0.33)	0.08 (0.50)	99.67 (0.78)	0.25 (0.51)
	△R	0.11 (0.44)	0.35 (0.67)	2.55 (1.46)	96.99 (1.67)
	Regime II ($\triangle OIL^{+}$)				
	△SP	98.69 (1.30)	0.52 (0.74)	0.57 (0.84)	0.22 (0.63)
	△OIL	0.04 (0.37)	99.51 (0.80)	0.05 (0.36)	0.40 (0.59)
	△IP	0.00 (0.32)	0.49 (0.78)	99.20 (1.01)	0.30 (0.57)
	△R	0.09 (0.43)	5.11 (1.97)	2.41 (1.49)	92.39 (2.45)
	Regime II (NOPI)				
	△SP	99.10 (1.07)	0.06 (0.47)	0.53 (0.81)	0.31 (0.62)
	△OIL	0.03 (0.40)	99.01 (1.05)	0.27 (0.56)	0.69 (0.77)
	△IP	0.00 (0.31)	0.71 (0.86)	98.86 (1.09)	0.43 (0.64)
	△R	0.09 (0.40)	11.06 (2.63)	2.23 (1.40)	86.62 (2.87)
Korea	*Regime I* ($\triangle OIL^{-}$)				
	△SP	94.45 (2.73)	2.63 (1.89)	2.84 (1.91)	0.08 (0.62)
	△OIL	0.08 (0.54)	99.77 (0.92)	0.08 (0.48)	0.07 (0.54)
	△IP	2.91 (1.61)	0.07 (0.55)	96.10 (2.01)	0.91 (1.04)
	△R	0.17 (0.56)	0.56 (1.03)	0.22 (0.75)	99.06 (1.47)
	Regime II ($\triangle OIL^{+}$)				
	△SP	96.14 (2.43)	0.82 (1.11)	2.86 (2.04)	0.18 (0.80)
	△OIL	0.20 (0.67)	99.41 (1.09)	0.36 (0.69)	0.03 (0.47)
	△IP	3.07 (1.57)	0.08 (0.57)	95.98 (1.95)	0.87 (0.98)
	△R	0.16 (0.54)	0.02 (0.61)	0.20 (0.75)	99.62 (1.15)

Note: Values in the parenthesis are standard errors estimated through Monte Carlo 500 replications. Variance decomposition explaining variation in variables is due to stock price shocks (ε^{SP}), oil price shocks (ε^{OIL}), exchange rate shocks (ε^{EX}) and interest rate shocks (ε^{R}). △SP denotes the change in stock price; △OIL represents the change in oil price; △IP refers to the change in industrial production; △R is the change in interest rate. $\triangle OIL^{+}$ is the oil price changes increases. $\triangle OIL^{-}$ is the coefficients with the oil price changes decreases. NOPI is the net oil price increases proposed by Hamilton (1996).

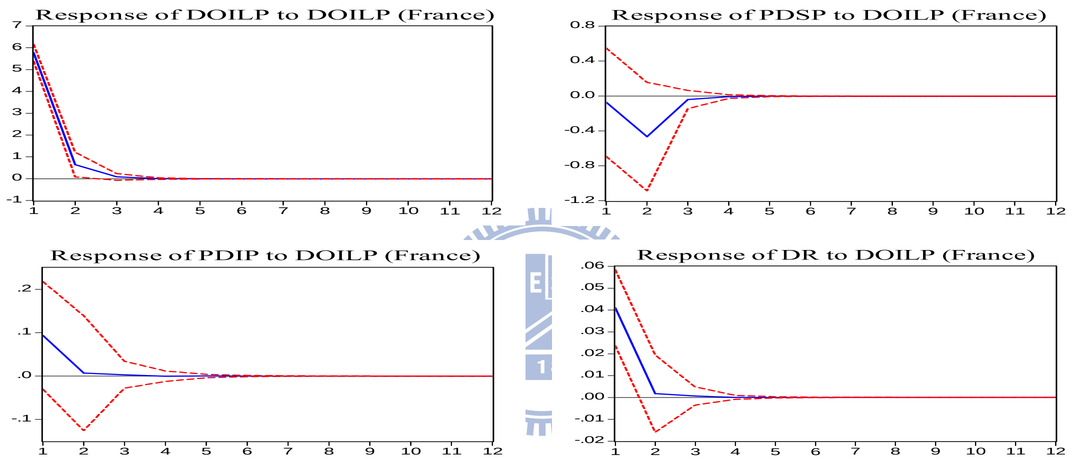
The upper (lower) half of Figure 4.7 presents the impulse responses of macroeconomic variables in Regime I (Regime II) for Korea. When oil price change is less than the threshold value of zero, the stock returns and industrial production have fewer responses in the first month. When oil price change exceeds the threshold level, the responses of oil price changes increase by 4.5% and stock returns increase immediately by 0.6%. Besides, oil shocks have a negative impact on industrial production in regime I.

As evident from the above findings, it seems to suggest that stock returns, industrial production and interest rates are adversely affected by an oil price shock as oil price changes decrease. When oil price changes increase, stock returns respond a positive effect to an oil shock only for Korea. At the same regime, an initial oil price shock will lead to an immediately increasing of industrial production and interest rates. Together with the IRF results of one-regime model, the two-regime model seems to offer more detailed response.

Regime I (changes in oil price decreases)



Regime II (changes in oil price increases)



Regime II (NOPI)

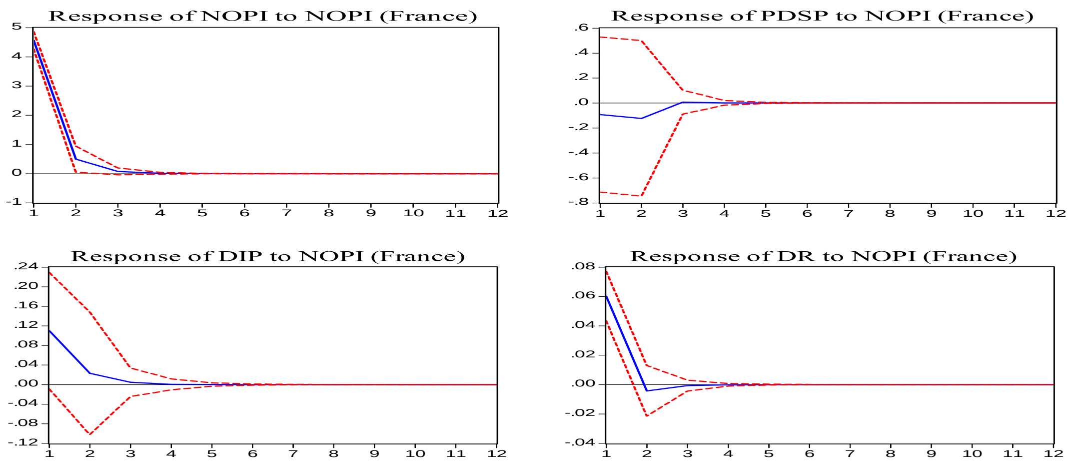
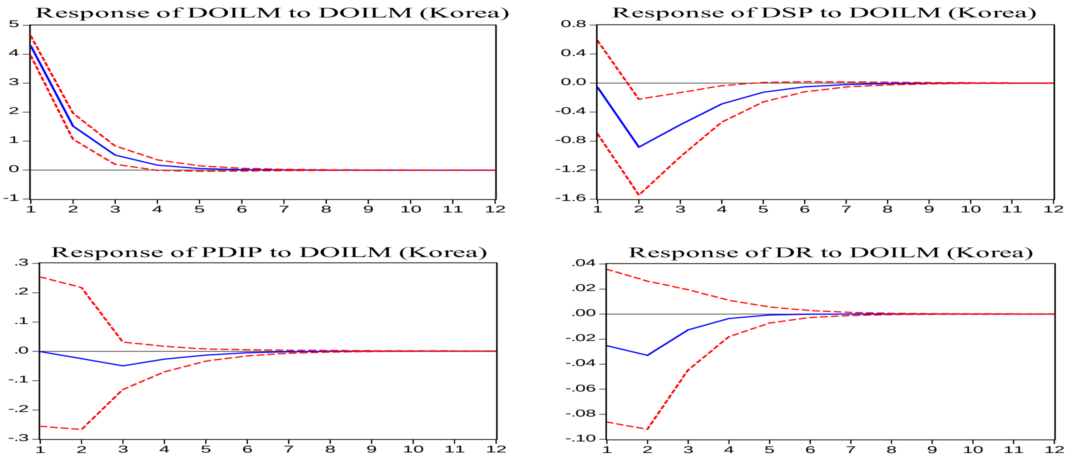


Figure 4.6 Impulse Responses to Oil Price Shock in the Two-regime VAR model for France (12 periods forward). Note: DOILM denotes the oil price changes decrease. DOILM denotes the oil price changes increase.

Regime I (changes in oil price decreases)



Regime II (changes in oil price increases)

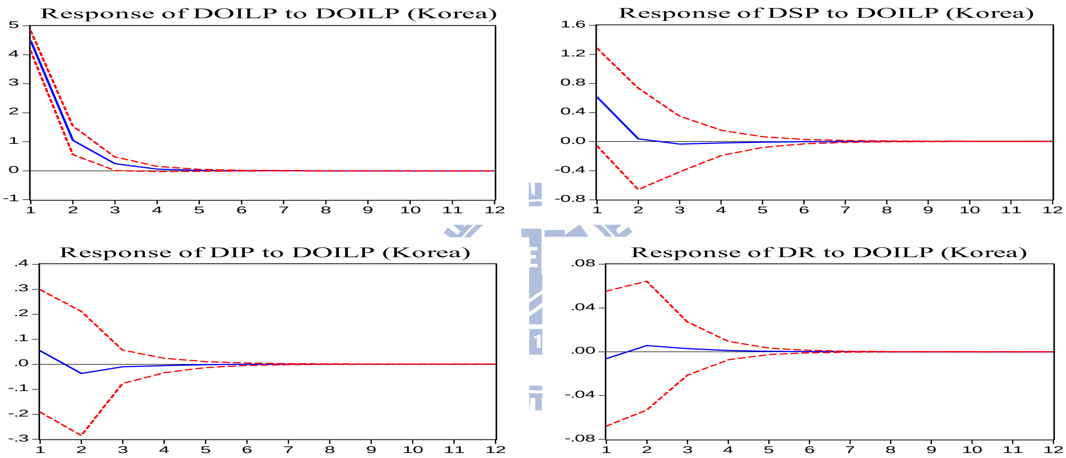


Figure 4.7 Impulse Responses to Oil Price Shock in the Two-regime VAR model for Korea (12 periods forward). Note: DOILM denotes the oil price changes decrease. DOILM denotes the oil price changes increase.

Chapter 5 Conclusions and Policy Implications

Energy consumption growth is much higher than economic growth for Taiwan in recent years, worsening its energy efficiency. This thesis therefore firstly aims to examine the long-run equilibrium relationship between GDP and disaggregated energy consumption with an asymmetric modeling in Taiwan, in order to shed some light on the unfavorable evidence of linear co-integration in the literature. The methodology uses a threshold co-integration test developed by the recent contribution of Hansen and Seo (2002), who consider the possibility of an asymmetric adjusting process among time series variables.

We reject the null hypothesis of linear co-integration either in the collocation between GDP and aggregate energy use or with several categories of energy consumption, which is consistent with the findings of Lee and Chang (2005) and Lee and Chang (2007). The threshold co-integration model confirms the asymmetric long-run equilibrium relationship between GDP and disaggregated energy consumption in Taiwan. There exist significantly asymmetric dynamic adjusting processes between macroeconomic and energy variables in Taiwan, implying important policy features. There would progressively get into the insight to the possibility of asymmetric effects, and policy-makers as a result may be interested in identifying the expectations mechanism of energy dependencies of economic growth as concerning future policy actions. The energy-inefficient periods in which energy consumption grows faster than GDP can be captured when disaggregated energy consumptions exceed a certain threshold level. Policy-makers should create an effective energy policy system to improve energy efficiency under disequilibrium regime, especially in which energy consumption may grow faster than GDP expands.

Developed and developing economies are facing the challenge of sustainable energy. Energy demand side management is a possibly tool to entail actions that influence the quantity or patterns of energy consumed by end-users such as actions targeting reduction of peak demand when energy-supply systems are constrained. EDSM activities ideally could bring the supply and demand closer to a perceived optimum in the market.

To promote greater energy efficiency, Taiwan's policy makers need to implement some strategies in energy markets. First, the energy market in Taiwan generally belongs to monopolies due to the policy regulations and law restrictions. Compared to neighboring East Asian economies such as Japan and South Korea, energy prices in Taiwan are relatively much lower, hence worsening its energy efficiency and producing environmental over-pollution. To raise the energy efficiency and cut down the production costs, the government should liberalize the energy market, impose carbon taxes, and the energy-savings be consciousness of both industries and consumers through the propagation and education. Second, investment in co-generation (i.e., simultaneously generate both electricity and useful heat) is a feasible scheme to stimulate the power users to install the co-generation system that helps reduce the load of power utilities. By the end of July in 2007, the installed power capacity of co-generation reached 2.75MWs (Million of Watts) by at least 64 companies. Therefore, to encourage users to install co-generation systems, the government should provide firms with tax deduction, favorable financing terms, and favorable rates for them to sell extra co-generated power. Third, the government should apply the capacity management to reduce peak load levels, for example, the seasonal price discrimination and peak load shifting of electricity. Fourth, a niche for energy development in Taiwan is to explore green (or renewable) energy, including waterpower, wind power, solar power energy, geothermal energy, and biomass energy, due to the suitable environment and advanced agriculture. Based on the planning of Taiwan's Bureau of Energy, Ministry of Economic Affairs, by 2010 renewable energy should account for no less than 10% of electric capacity. Taiwan's dependency of imported energy was up to 97.85% in 2005. Finally, developing an effective energy demand side management system can help restrain the growth of energy consumption and hence improve energy efficiency.

Among the most serve supply shocks hitting the world economies such as twice energy crisis and Gulf War are sharp increases in oil price and other energy products. Oil price shocks receive important consideration for their presumed role on macroeconomic variables. The vast literature establishing robust results across many countries on the nexus between oil price shocks and aggregate activity implies that the nexus between oil price shocks and stock market should also hold.

The second issue of the thesis is to explore the impact of oil price shocks on stock markets. Our paper provides that cross-country comparison of the effects of oil-market shocks on stock markets using a multivariate VAR analysis. In particular, we also detect the impacts with an asymmetric framework when oil price changes are separated as decrease and increase regimes. This study includes a sample of eight countries: Canada, Japan, France, Taiwan, Korea and Malaysia. The result indicates that oil price shock play a significant role in explaining the adjustments in stock-market returns. We also find that oil price shocks lead to initial an adverse effect on stock returns for Canada, France and Taiwan. But, the magnitude of these effects proves small. In the asymmetric tests, the evidence shows that there are asymmetric effects of oil price changes for the cases of France and Korea. In particular, a higher oil prices have a stimulating effect on the Korea country. The results show that following a 4.5% oil price, stock returns increase immediately by 0.6%. The fact that the magnitude of the effects of the structural shocks is displayed to be small could be an indication that other (control) variables, such as industrial output and interest rates, seem to be explanatory determinants of stock market returns. Based on these results, we can conclude that a well diversified portfolio can be achieved by considering initial oil price shocks and consisting some stock markets which have a positive reaction to these shocks. This could be the accurate way of hedging oil price risk. Besides, considering oil shock exposures also provide a broader perspective for relevant global institutional investors in their decision making processes.

Future research may extensively investigate: (1) the effect of such structural oil-market shocks on real stock returns through disaggregated industry or plant level data for a panel of countries; (2) the presence of structural breaks that take into consideration turbulent times and war events; (3) the validity of the decomposition methodology when more risk factors are allowed to play their role as well; (4) the validity of the decomposition methodology (without and with more risk factors) regarding exclusively stocks related to oil and gas firms; (5) the symmetry of oil price shocks for different industries and individual firms, (6) the long-run and short-run effect of oil price shocks on portfolio (such as value and growth stocks) or mutual fund returns. The findings may be useful to investors who are interested in the exact effect of international oil price changes on certain stocks across industries as well as for the managers of certain firms who need a more thorough evaluation about the efficiency of hedging policies affected by oil price changes.

There are still several limitations to this thesis: Due to the difficulty in collecting sample data of identical period, we merely consider the bi-variate relationship of energy-output (issue one) and multivariate nexus of oil price shocks and stock returns (issue two). Some exogenous factors such as inflation, exchange rate, unemployment or wage are left out. Future research may take into consideration these variables to detect whether the evidence are still robust. Besides, oil price shocks display a small effect on stock returns. Such an outcome can be highlighted through mediated or moderated factors. In fact, high oil prices affect open economies both directly and indirectly. The indirect effect works through the economy's trading partners (e.g., Abeysinghe, 2001). Future research can identify how the direct and indirect channel of oil price shocks on stock returns.

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