TRANSMISSION OF OIL PRICE VOLATILITY TO EMERGING STOCK MARKETS

A Master's Thesis

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TRANSMISSION OF OIL PRICE VOLATILITY TO EMERGING STOCK MARKETS

The Institute of Economics and Social Sciences
of
Bilkent University

by

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I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Economics.

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ABSTRACT

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Oil price volatility is a crucial factor that explains stock price movements. Recent studies show that oil price shocks and its volatility explain the stock market movements better than most of the variables. This thesis investigates the effects of oil price volatility and its asymmetry on emerging stock markets using bivariate asymmetric BEKK[1] model which was first introduced by Engle et al. (1993) and extended for asymmetric effects by Kroner and Ng (1998). The model is estimated using weekly returns on Malaysia, Mexico, South Korea, Taiwan and Turkey together with the measure of the world oil price. Over the sample period, 48th week of 1988 through 46th week of 2008, strong evidence of volatility spillover is found for Malaysia, Mexico, South Korea and Turkey. Weak evidence of volatility spillover is found for Taiwan. Although results of significant volatility spillovers are obtained, news impact surfaces show small quantitative implications. This thesis also examines whether volatility spillovers occur simultaneously. There is strong evidence of volatility spillover for Malaysia and South Korea, and weak evidence of volatility spillover for Mexico, suggesting that these countries' stock markets vary contemporaneously with oil price variations.

Keywords: Oil Price Volatility, GARCH, Asymmetric BEKK Model, Emerging Countries

[1]The BEKK acronym stems from the first letters of Y. Baba, R. Engle, D. Kraft and K. Kroner, Engle et al. (1993)

ÖZET

PETROL FİYATLARINDAKİ OYNAKLIĞIN GELİŞMEKTE OLAN ÜLKELERİN BORSA ENDEKSLERİNE AKTARIMI

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Petrol fiyatlarındaki oynaklık borsa endeksini etkileyen önemli etkenlerden biridir. Birçok araştırma ve makale borsa endeksindeki hareketlerin en iyi petrol fiyatlarında meydana gelen şokların açıkladığınıgöstermektedir. Bu çalışma, petrol fiyatlarındaki oynaklığın gelişmekte olan ülkelerin borsa endeksleri üzerindeki etkisini önce Engle et al. (1993), daha sonra Kroner and Ng (1998) tarafından geliştirilen iki değişkenli asimetrik BEKK modelini kullanarak ölçmektedir. Modelde Malezya, Meksika, Güney Kore, Tayvan ve Türkiye borsa endeksleri kullanılmıştır. İncelenen zaman aralığında Malezya, Meksika, Güney Kore ve Türkiye için kuvvetli oynaklık geçişkenliği, Tayvan için ise daha zayıf oynaklık geçişkenliği gözlenmektedir. Çalışma ayrıca, petrol fiyatlarındaki oynaklığın eşzamanda borsa endeksini etkileyip etkilemediğini ölçmektedir. Buna göre, Malezya ve Güney Kore'de kuvvetli oynaklık geçişkenliği gözlenirken, Meksika'da bu geçişkenlik daha zayıftır.

Anahtar Kelimeler: Petrol Fiyatlarındaki Oynaklık, GARCH, Asimetrik BEKK Modeli, Gelişmekte olan ülkeler

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CHAPTER 1

INTRODUCTION

Since the beginning of modern industrialization, oil is by far the most significant production function component along with capital and labor; a commodity which is vital for maintenance of civilization as we know it. Thus, fluctuations of the price and supply of oil is a major concern for all economies; developed and emerging or oil importing and exporting. It is so significant that, oil supply shapes countries' foreign international and military policies. Among major factors affecting oil prices are global demand and supply conditions, OPEC supply policies, market expectations and geopolitics.

According to the economic literature, there are several oil price transmission mechanisms effecting economies. Major means include real balances and monetary policy, and income transfer channels. The former is the real balances or monetary policy channel. Increases in the oil price drive up the cost of everything and this leads to an inflationary environment. Due to inflation, real wages and wealth of consumers-value of their homes and other assets-decreases and this reduces disposable income of consumers, hence transferring oil price increases through real balances. This also leads to increase in the cost of production in non-oil producing firms, since most companies can only partially pass the cost increases on to the customers. Firms' profit margins and dividends reduce, which are the main drivers of the stock prices. So, higher production costs dampen cash flows and reduce stock prices. Accordingly, values of non-oil producing companies are adversely affected. The monetary policy side of this transmission mechanism is that, as a response to the produced inflationary pressure, Central Banks tighten monetary policies, driving up the interest rates. Company shares further deteriorate since fixed income market becomes more attractive than stock markets.

Second channel concerns oil exporting firms. According to the literature oil exporting firms transfer income from oil importing firms, affected by fluctuations in oil price. The rise in oil prices increases the value of oil exports in relation to other commodities. This situation improves trade terms for net oil exporters and worsens the same for net oil importing firms. This leads a rise in stock market indices of oil exporting firms due to increasing profit margins and dividends. In direct contradiction, oil importing firms' stock market indices decrease due to the same reason.

Since 1970s, many researchers have focused on the relationship between oil price and economic activities. Prior to Hamilton's pioneering work Darby (1982), Pierce and Enzler (1974) and Rasche and Tatom (1977) suggested an inverse relationship between oil price increases and economic activity. In 1983, Hamilton (1983) indicated in his famous paper that most of the post war recessions in United States have been preceded by an increase in the price of oil. Since then, many scholars started to examine the linkage between oil price change and aggregate economy by using different econometric methods.

There is bulk of literature in energy economics studying the relationship between oil price level or volatility and stock markets for developed economies and it is surprising that there are few studies which focus on emerging ones. However, developed economies are more energy efficient than emerging economies due to technological innovation and more reliance on a diversified range of energy resources, such as combination of non-renewable and renewable energy resources. Therefore, these effects reduce the energy intensity in the production process. However, emerging economies tend to be more dependent to fossil energy than developed ones for that reason they are more sensitive to fluctuations in energy price. Therefore, oil price changes or volatility in oil prices are likely to have a greater impact on firms' profits and stock prices in emerging economies.

Risk is one of the main determinants of stock market. Not knowing the behavior of the price of oil is a risk for investors and this affects the feasibility of investments. According to Ferderer (1996), uncertainty in investments means that volatility in oil prices is more important than the level of oil prices, as regular changes in oil prices increase uncertainty whether to invest or not. Ferderer (1996) also endorsed Bernanke's opinion of postponing irreversible investments when there is an uncertainty in oil prices. Therefore, when there is an uncertainty in oil prices, in other words volatility in oil prices, investors worry about their future returns on the investments and postpone them, which leads to a decrease in stock prices.

Being motivated from the previous literature the aim of this thesis is to examine the effect and magnitude of transmission of oil price volatility to five emerging stock markets. I use Agren (2006)'s econometric methodology in my thesis. Agren (2006) utilizes an asymmetric BEKK model in order to analyze the conditional volatility of oil and stock markets in Japan, Norway, Sweden, U.K. and U.S. The asymmetric effects of oil price shocks are motivated empirically like Sadorsky (1999). We applied the above summarized methodology in our thesis, over the sample period from week forty-eight of 1988 to week forty-six of 2008. Strong evidence of volatility spillover is found for Malaysia, Mexico, South Korea and Turkey. Weak evidence of volatility spillover is found for Taiwan. Although results of significant volatility spillovers are obtained, news impact surfaces display small quantitative implications. The stock markets own shocks, which are related to other factors of uncertainty than the oil price, are more prominent than the effects of oil shocks.

While stock markets respond immediately to economic uncertainty, it might be that volatility spills over at a faster pace than first examined. Therefore, second set of estimations is performed where the weekly oil price data is leaded one period. By this way volatility spillover is tested within the week instead of testing from one week to the next. Now, the preceding evidence of volatility spillovers for Turkey and Taiwan no longer exists. There is a strong evidence of volatility spillover for Malaysia and South Korea, and weak evidence of volatility spillover for Mexico, suggesting that these countries' stock markets vary contemporaneously with oil price changes.

The remaining part of the thesis is organized as follows: Section 2 reviews the literature on oil price volatility and stock markets. Section 3 gives information about the countries that we analyzed. Section 4 presents the data set used. Section 5 provides an overview of the methodological issues. Section 6 reports empirical results and Section 7 concludes.

CHAPTER 2

LITERATURE SURVEY

There is bulk of studies in energy economics studying the relationship between oil price level or volatility and economic activities, and it is surprising there are only some studies focusing on the relationship between oil prices or oil price volatility and stock markets. There are some studies that we can consider but they are mostly done on developed countries. Sadorsky (1999) utilized vector autoregression model to show the link between the oil price volatility and real stock returns. He found that change in oil prices and oil price volatility both play important roles in affecting the real stock returns. Also, he showed that oil price volatility shocks have asymmetric effects on the economy.

Huang et al. (1996) examined the contemporaneous and lead-lag correlations between daily returns of oil futures contracts and stock returns by a VAR model in United States. Results of the paper suggest that oil future returns are not correlated with stock returns even contemporaneously, except in oil company returns. However, according to findings, oil price volatility is transmitted to real stock market. On the contrary, Odusami (2008) found that unexpected crude oil shocks have nonlinear effect on excess U.S. stock market return. Findings of the analysis indicate that contemporaneous and lagged returns on crude oil futures have significant effect on U.S. stock market returns. Nonetheless, Park and Ratti (2008) showed that oil price shocks have a significant impact on real stock returns contemporaneously and/or within the following month in the U.S. and 13 European countries. This paper also suggests oil price shocks account for a statistically significant 6 percent of the volatility in real stock returns. Also, there is little evidence of asymmetric effects on real stock returns of positive and negative oil price shocks for oil importing European countries. Jones and Kaul (1996) indicates that in the post-war period, the U.S. and Canadian stock prices were affected by oil shocks from cash flows. U.K. and Japan stock markets were also affected by oil shocks but in a different way. Kilian and Park (2007) suggested the response of aggregate stock returns in U.S. may differ greatly depending on whether the increase in oil price is driven by demand or supply shocks in the crude oil market.

As we mentioned previously, change in energy prices affects emerging economies more than the developed ones. Though not many, there are some studies which focused on emerging countries. Maghyereh (2004) examines the dynamic relationship between crude oil price shocks and stock market returns for 22 emerging economies by using VAR approach. The findings imply that oil shocks have no significant impact on stock returns. Like Maghyereh (2004), Nooreen Mujahid and Mustafa (2005) also found no significant effect of oil prices on stock returns in Pakistan. This is not surprising since, Pakistan consumes gas more than oil. When Mujahid applied the same model to the gas, they found a positive significant relationship between stock prices and gas prices. Papapetrou (2001) showed oil prices are crucial in stock market movements in Greece. Another empirical paper, Basher and Sadorsky (2004), used an international multi-factor model to investigate the relationship between oil price risk and emerging stock market returns. They found strong evidence of oil price risk which affects stock price returns in emerging countries.

Song-Zan (2007) examined the roles of macroeconomic variables, namely, money supply, oil price, exchange rate and inflation on four Asian stock markets, Taiwan, South Korea, Singapore and Hong Kong, using structural VAR model for the period after 1997 crisis. Finding of the study indicates that oil prices and exchange rate are found to be the main determinants of stock returns. Sawyer and Nandha (2006) suggested that an oil shock may cause an economic recession but it does not necessarily cause a recession in stock market by utilizing a hierarchical model.

Being inspired from the preceding literature, the aim of this thesis is to examine the effect and magnitude of transmission of oil price volatility to five emerging stock markets. We used Agren (2006)'s econometric methodology in our thesis. Agren (2006) utilized an asymmetric BEKK model in order to analyze the conditional volatility of oil and stock markets in Japan, Norway, Sweden, U.K. and U.S.. He found strong evidence of volatility spillover for all stock markets but weak evidence for that of Swedish. He used a bivariate GARCH model to specify conditional variances and covariances of oil price and stock returns so that, volatility spillover can be tested. Contrary to Agren we selected five emerging countries due to their higher energy dependence than developed ones.

Bollerslev et al. (1988) introduced multivariate GARCH modeling and proposed a general parameterization of the conditional covariance matrix called VECH [1]. The VECH model does not impose any restrictions on its parameters, implying that the positive definiteness of the conditional matrix is not guaranteed. The model is also quite computer-intensive in estimation, relative to other Multivariate-GARCH models, because of its large number of parameters. To solve these problems, Engle et al. (1993) present the BEKK[2] specification of the conditional covariance, and later on, Kroner and Ng (1998) extended this model to allow for asymmetry. The BEKK model is specified using quadratic forms, which guarantees positive definiteness.

This thesis adopts the asymmetric BEKK (ABEKK) model to examine if oil price volatility transmits to stock market volatility. A bivariate VAR(2)[3]-ABEKK model is estimated using weekly returns on five aggregate stock market indices and a measure of the oil world price. Parameter restrictions are imposed so that stock returns do not affect oil prices, due to the proposed exogenous property of oil shocks.

We chose mixture of oil importing and oil exporting countries from a sample of emerging economies intentionally, in order to see the impact of oil price volatility for these two groups' stock markets. The impact of changing oil prices on stock prices depends on whether a company is a consumer or a producer of oil and oil related products. Since there are more companies in the stock markets that consume oil than produce oil in all countries that we

[1] The name is originated from its use of the vech-operator, which stacks the lower-triangular elements of a square matrix into a vector.

[2] The BEKK acronym stems from the first letters of Y. Baba, R. Engle, D. Kraft and K. Kroner, Engle et al. (1993)

[3] VAR(2) is determined due to information criteria tests' results (AIC, SIC, LR).

analyzed, the overall impact of rising oil prices on stock markets is anticipated to be asymmetric.

CHAPTER 3

DATA

We employed the set of data consisting of aggregate stock market indices of five emerging economies, namely Malaysia, Mexico, South Korea, Taiwan and Turkey, together with a measure of the world oil price. The price per barrel Brent[1] crude measures the world oil price. Each stock market index describes the overall performance of large capitalization firms in the respective country.

All data are at the weekly frequency (last observation day of the week, Friday), and cover the 48th week of 1988 through 46th week of 2008, yielding a total of 1043 observations. However, I can just used the period between the first week of 1989 through first week of 2007. E-views program needs larger data set than that you want to analyze. Thanks to this we eliminate the oil price crises stating from the end of 2007 through 2009. Using a weekly stock market data saves the model from high frequency problems.

[1]The Brent blend is a light and sweet crude that ships from Sullom Voe in the Shetland Islands. It serves as a benchmark for pricing oil from regions such as Europe, Africa and the Middle East.

Table 3.1: Summary Statistics for Weekly Percentage Returns on Five Emerging Stock Market Indices and Oil Price-I

Variable	Mean	Max.	Min.	Std.	Sk.	Ku.
Malaysia	0.1092	24.5785	-19.0267	3.2340	0.0277	10.6006
Mexico	0.4620	17.5030	-17.7162	3.5931	-0.3137	5.1897
South Korea	0.0802	17.4359	-21.3446	4.1043	-0.2666	6.2409
Taiwan	-0.0127	24.7619	-24.6123	4.3724	-0.2035	7.9076
Turkey	0.8758	32.9513	-33.9783	6.8841	-0.1015	5.7401
Oil	0.1706	17.0625	-41.0020	4.6634	-1.1044	10.8492

The table displays summary statistics for weekly returns on the aggregate stock markets of Malaysia (KLCI), Mexico (BOLSA), South Korea (KOSPI), Taiwan (TWSE) and Turkey (ISE100) along with the price change of Brent crude oil. Mean=Sample mean; Max.=Maximum value of the sample; Min.=Minimum value of the sample; Std.=Standard deviation; Sk.=Skewness; Ku.=Kurtosis. Source: Datastream Sample period: 11/25/1988-11/14/2008 for Malaysia, Mexico, South Korea, Taiwan and Turkey.

The percentage return over one data period, denoted $r_{i,t}$ is derived as:

$$r_{i,t} = 100 \times log \frac{P_{i,t}}{P_{i,t-1}} \tag{3.1}$$

where P_{it} is the price level of market i at time t.

Table 3.1 reports on summary statistics of the return data on all five stock indices and the oil price. All stock markets except Taiwan have had a positive average weekly return over the sample period. All data display non-zero skewness and excess kurtosis. Table 3.2 shows the second set of statistical tests:

Due to highly significant Jarque-Bera statistics, the returns are non-normally distributed. Moreover, results of the Ljung Box Q test suggest that serial correlation exists in the Malaysia. Both the Ljung-Box Q test for squared returns and the ARCH Lagrange Multiplier test indicate strong presence of ARCH structure in all data series. Therefore, we define a GARCH

Table 3.2: Summary Statistics for Weekly Percentage Returns on Five Emerging Stock Market Indices and Oil Price-II

Variable	Malaysia	Mexico	South Korea	Taiwan	Turkey	Oil
JB	2341.58*	383.01*	686.862*	790.549*	310.262*	2446.191*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
LBQ	19.487*	5.978	7.1114	10.023	5.572	8.5402
	(0.012)	(0.650)	(0.715)	(0.263)	(0.695)	(0.383)
LBQ^2	287.07*	114.80*	234.67*	561.55*	252.71*	92.991*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ARCH LM	11.5786*	31.2347*	32.1733*	80.7566*	52.9290*	17.0456*
	(0.0006)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

JB is Jarque-Bera statistic under the null of normality. LBQ is the univariate Ljung-Box Q statistic for serial correlation in returns. LBQ^2 is the univariate Ljung-Box Q statistic for serial correlation in squared returns. ARCH LM is the Lagrange multiplier test of autoregressive conditional heteroskedasticity. All tests of correlation use ten lags. p-values are in parantheses. * indicates significance at five percent level. Source: Datastream Sample period: 11/25/1988-11/14/2008 for Malaysia, Mexico, South Korea, Taiwan and Turkey.

model in the following analysis.

Figure 3.1 and 3.2 illustrate the data. Figure 3.1 plots the weekly index of six data series. Observe that the oil price was rather stable at the beginning of the sample until the spike in 1990-91 Gulf war. In the 1990s, oil price shows small fluctuations in comparison with the 2000s. Especially, at the end of the sample period oil price climbed to record levels and plummeted to \$40s due to collapsing global demand. The aggregate stock market indices fluctuate with an upward trend. However, all stock markets deteriorate at the end of the sample period owing to global financial crisis. Figure 3.2 shows the weekly percentage returns of all data series derived according to (3.1). Notice that stock return conditional volatilities are historically large. The return series display volatility persistence in line with the previous statistical test results. It is, however, difficult to visually notice any comovements in conditional volatility between oil and stock markets. We leave this to statistical modeling and testing section of the study.

Figure 3.1: Weekly Indices of Five Emerging Stock Markets and the Oil Price

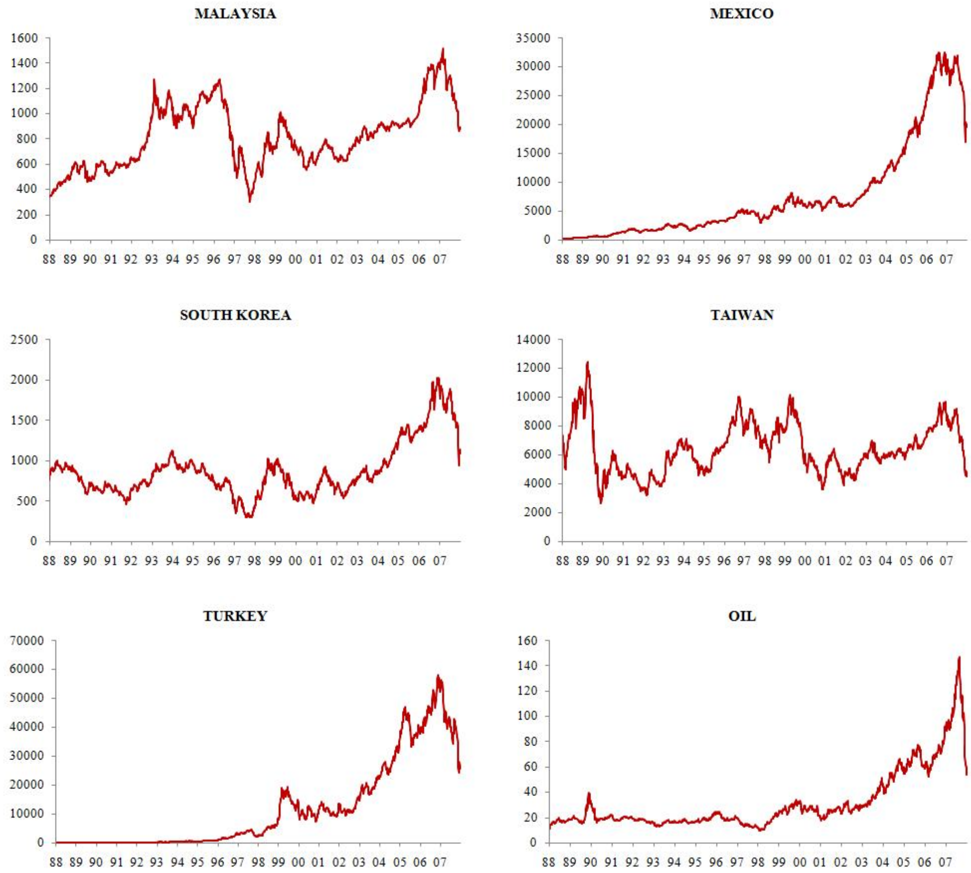
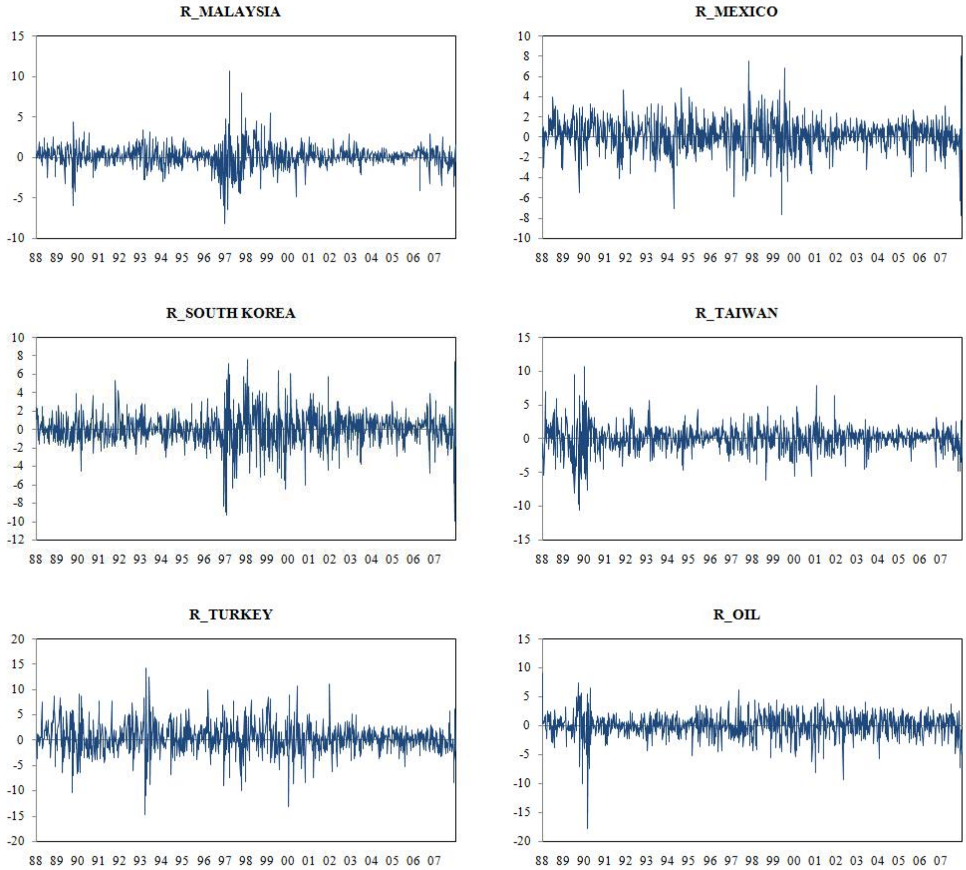


Figure 3.2: Weekly Returns of Five Emerging Stock Markets and Changes in the Oil Price



CHAPTER 4

MODELLING THE DATA

Our study employed the similar model that Agren (2006) used. Agren (2006) utilized an asymmetric BEKK model in order to analyze the conditional volatility of oil and stock markets in Japan, Norway, Sweden, U.K. and U.S.. Contrary to Agren (2006), we selected five emerging countries due to their higher energy dependence than developed countries. We analyzed Malaysia, Mexico, South Korea, Taiwan and Turkey over the sample period from week forty-eight of 1988 to week forty-six of 2008.

As Agren (2006) indicated in his paper: Consider a bivariate sequence of data $\{r_t\}_{t=1}^{T}$ consisting of oil price changes and stock market returns. The following statistical model is employed:

$$r_t = \mu + \delta r_{t-1} + \pi r_{t-2} + \epsilon_t \tag{4.1}$$

$$\epsilon_t = H_t^{1/2} v_t \tag{4.2}$$

and

$$H_t = \Omega'\Omega + A'\epsilon_{t-1}\epsilon'_{t-1}A + B'H_{t-1}B + \Gamma'\eta_{t-1}\eta'_{t-1}\Gamma \tag{4.3}$$

where ϵ_t is a 2x1 vector of residuals, υ_t is a 2x1 vector of standardized (i.i.d.) residuals, H_t is the 2x2 conditional covariance matrix, η_t is a 2x1 asymmetric term and μ, δ, π, Ω, A, Γ and B are model parameter matrices. The mean equation (4.1) is represented by a VAR(2) model. In this way, any existing serial correlation in the return series is removed, which is important since the parameter estimates of H_t would otherwise be biased. The conditional variance-covariance matrix of (4.3) is specified according to the ABEKK model of Kroner and Ng (Kroner and Ng, 1998). Notice that the structure consists of quadratic forms, which secures the positive definiteness of H_t. The statistical model of (4.1)- (4.3) is referred to as the VAR(2)-ABEKK model.

Like Agren (2006), our model includes an asymmetric term $\eta_t = (\eta_{1t}, \eta_{2t})'$, which elements are defined as: $\eta_{it} = max[\epsilon_{it}, 0]$, for oil price changes; and $\eta_{it} = min[\epsilon_{it}, 0]$, for stock returns. This specification of η_t emphasizes on the effects of positive oil shocks and negative stock returns.

4.1 Restrictions

To guarantee that the stock prices have no impact on oil prices, we defined some restrictions on the parameter matrices of (4.1)- (4.3), motivated by the proposed exogeneity of oil shocks literature Chi (1996) and Hamilton (1985). Explicitly, the restricted VAR(2)-ABEKK model has the following structure:

$$
\begin{bmatrix} r_{oil_t} \\ r_{stock_t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} \delta_{11} & 0 \\ \delta_{21} & \delta_{22} \end{bmatrix} \begin{bmatrix} r_{oil_{t-1}} \\ r_{stock_{t-1}} \end{bmatrix} + \begin{bmatrix} \pi_{11} & 0 \\ \pi_{21} & \pi_{22} \end{bmatrix} \begin{bmatrix} r_{oil_{t-2}} \\ r_{stock_{t-2}} \end{bmatrix} + \begin{bmatrix} \epsilon_{oil_t} \\ \epsilon_{stock_t} \end{bmatrix} \quad (4.4)
$$

and

$$
\begin{pmatrix} \epsilon_{oil_t} \\ \epsilon_{stock_t} \end{pmatrix} = \begin{pmatrix} h_{11,t} & h_{12,t} \\ h_{12,t} & h_{22,t} \end{pmatrix}^{1/2} \begin{pmatrix} v_{oil_t} \\ v_{stock_t} \end{pmatrix} \quad (4.5)
$$

where

$$
h_{11,t} = \omega_{11}^2 + \alpha_{11}^2 \epsilon_{oil,t-1}^2 + \beta_{11}^2 h_{11,t-1} + \gamma_{11}^2 \eta_{oil,t-1}^2, \quad (4.6)
$$

$$
\begin{aligned}
h_{12,t} &= \omega_{11}\omega_{12} + \alpha_{11}\alpha_{12}\epsilon_{oil,t-1}^2 + \alpha_{11}\alpha_{22}\epsilon_{oil,t-1}\epsilon_{stock,t-1} + \beta_{11}\beta_{12}h_{11,t-1} \\
&\quad + \beta_{11}\beta_{22}h_{12,t-1} + \gamma_{11}\gamma_{12}\eta_{oil,t-1}^2 + \gamma_{11}\gamma_{22}\eta_{oil,t-1}\eta_{stock,t-1}, \quad (4.7)
\end{aligned}
$$

$$
\begin{aligned}
h_{22,t} &= \omega_{12}^2 + \omega_{22}^2 + \alpha_{12}^2\epsilon_{oil,t-1}^2 + \alpha_{22}^2\epsilon_{stock,t-1}^2 + 2\alpha_{12}\alpha_{22}\epsilon_{oil,t-1}\epsilon_{stock,t-1} \\
&\quad + \beta_{12}^2 h_{11,t-1} + \beta_{22}^2 h_{22,t-1} + 2\beta_{12}\beta_{22}h_{12,t-1}
\end{aligned}
$$

$$+\gamma_{12}^2\eta_{oil,t-1}^2 + \gamma_{22}^2\eta_{stock,t-1}^2 + 2\gamma_{12}\gamma_{22}\eta_{oil,t-1}\eta_{stock,t-1}. \quad (4.8)$$

In (4.4), $r_{oil,t}$ and $r_{stock,t}$ represents the period t percentage change in oil and aggregate stock prices, respectively. Stock returns do not affect oil price changes by the restrictions, but oil price changes do affect stock returns in (4.4). Moreover, the conditional variance of oil price changes, $h_{11,t}$, is modeled by the univariate GJR(1,1) model of Glosten et al. (1993), while the conditional variance stock returns, $h_{22,t}$ and the conditional covariance, $h_{12,t}$, are modeled with more complexity. The ABEKK model allows, for instance, the conditional variance of stock returns to depend on its own lagged conditional variance and lagged shocks, the lagged conditional variance and lagged shocks of oil price changes, as well as cross terms. The parameter α_{12} in (4.8) captures the effect of an oil shock at $t-1$ on the conditional variance of stock returns at t, and β_{12} measures the impact of oil price conditional variance on the one-period ahead conditional variance of stock returns. Since parameters are squared or cross multiplied, the parameters of the ABEKK specification do not characterize impacts directly. This implies that the interpretation of the individual parameter estimates is not straightforward. Nevertheless, the statistical significance of the parameter estimates can be investigated.

4.2 Estimation

The bivariate restricted VAR(2)-ABEKK model is estimated using the quasi maximum likelihood (QML) method of (Bollerslev and Wooldridge, 1992). Given T observations of $r_t = (r_{oil,t}, r_{stock,t})'$, the following optimization is considered:

$$max_{\theta} log L_T(\theta) = \sum_{t=1}^{T} l_t(\theta) \quad (4.9)$$

where L_t is the sample likelihood function, θ is a vector of parameters,

$$l_t(\theta) = log(2\pi) - log\,|H_t| - \frac{1}{2}\epsilon_t' H_t^{-1} \epsilon_t \quad (4.10)$$

is the conditional log-likelihood function for a bivariate normally distributed variable, and $\epsilon_t = (\epsilon_{oil,t}, \epsilon_{stock,t})'$ and $vech(H_t) = (h_{11,t}, h_{12,t}, h_{22,t})'$ follow (4.4) and (4.6)-(4.8), respectively. QML robust standard errors of the parameter estimates are derived to account for the possibly false normality assumption.

The Berndt-Hall-Hall-Hausman (BHHH) algorithm is applied to do the optimization of (4.9). Since the parameter vector θ has a total of 20 parameters, the optimization is complex and sensitive to starting values. Statistical program EViews, uses distribution specific starting values which are based on the method of the moments. By the help of Eviews, convergence is achieved in all estimations.

4.3 Tests of Model Fitness: Multivariate Ljung Box and Squared Multivariate Ljung Box Tests

To test the model's fitness, the obtained estimated standardized residuals $\hat{v}_t = (\hat{v}_{oil,t}, \hat{v}_{stock,t})'$ are analyzed. These are derived as the inverse of the Cholesky decomposition of H_t times the estimated residual vector $\hat{\epsilon}_t$, in accordance with (4.5). The statistical model provides a good fit to the empirical data if a test of remaining serial correlation and ARCH-structure comes out insignificant. Two such tests are performed, namely the multivariate Ljung-Box Q test, and squared multivariate Ljung-Box Q test.

The multivariate Ljung-Box Q (MLBQ) test of Hosking is a test of serial correlation. Under the null that $\hat{v}_t$ is independent of $\hat{v}_{t-1}, \dots, \hat{v}_{t-K}$, where K is the maximum lag length, the test statistic

$$MLBQ = T(T+2)\sum_{j=1}^{K} \frac{1}{T-j} tr\left\{C_{0j}C_{00}^{-1}C_{0j}'C_{00}^{-1}\right\}, \tag{4.11}$$

where $C_{0j} = T^{-1}\sum_{t=j+1}^{T} \hat{v}_t\hat{v}_{t-j}'$ is derived. Applying the test to the squared standardized residuals, $\hat{v}_t^2$, the MLBQ test provides a test for ARCH-effects too, referred as the $MLBQ^2$ test. The statistic in (4.11) is χ^2 distributed with $(4(K-2))$ degrees of freedom. The lag length is arbitrarily set to $K = 8$, implying that serial correlation up to eight weeks is examined.

4.4 Testing for Volatility Spillover

Consider the statistical model's expression for the conditional stock return variance in equation (4.8). Oil price uncertainty transmits to stock volatility, $h_{22,t}$, through three channels; via the symmetric shock, $\epsilon_{1,t-1}$, the asymmetric shock, $\eta_{1,t-1}$, or the conditional oil price variance of the previous period, $h_{11,t-1}$. Thus volatility spillover is tested via the corresponding parameter estimates of α_{12}, γ_{12} and β_{12}. There is evidence of volatility spillover if a joint test of the three parameters being zero is rejected. Formally the null hypothesis

$$H_0 : \alpha_{12} = \beta_{12} = \gamma_{12} = 0, \tag{4.12}$$

is tested by deriving Wald statistics. The Wald test uses the obtained estimates of α_{12}, β_{12}, γ_{12} along with the corresponding estimated variance covariance matrix, and a Wald statistics is derived in the usual way. The LR test compares the maximum likelihood of the unconstrained estimation with the one obtained when the constraint (4.12) is accomplished.

CHAPTER 5

EMPIRICAL RESULTS

This section presents the results of the model estimation. Here we analyzed parameter estimates and news impact surfaces of Kroner and Ng (1998). Engle and Ng (1991) used the news impact curve concept, which is a tool for measuring the effects of news on conditional variances. They showed graphically the asymmetric reactions of the conditional variances to positive and negative shocks of equal magnitude and Caporin and McAleer (2006) developed News Impact Surfaces for multivariate conditional volatility models.

Graphical illustrations show the impact of an oil shock and a stock price shock on e.g., the one period ahead conditional stock price volatility, holding all past conditional variances and covariances constant at their unconditional averages. With this analysis, the magnitude of the impact of an oil shock on conditional stock volatility is illustrated. Then we performed a second set of estimation, where oil prices a leaded one period, to test for within-the-week effects of volatility spillover.

5.1 Estimation Results

Table 5.1: Restricted VAR(2)-ABEKK Estimation Results

	Malaysia	Mexico	South Korea	Taiwan	Turkey
Panel A: Conditional Mean Estimates					
μ_1	0.1719	0.1299	0.1057	0.1449	0.1418
μ_2	0.1003	0.3960*	0.0254	0.0331	0.5545*
δ_{11}	-0.0122	-0.0015	0.0008	0.0026	-0.0002
δ_{21}	-0.0070	0.0115	-0.0079	-0.0088	-0.0279
δ_{22}	0.0950*	0.0859*	-0.0082	0.0226	0.0577
π_{11}	0.0219	0.0110	0.0157	0.0119	0.0219
π_{21}	0.0100	-0.0160	0.0116	-0.0275	-0.0605
π_{22}	0.0518	0.0373	0.0626	0.0685*	0.0852*
Panel B: Conditional Variance-Covariance Estimates					
ω_{11}	1.1814*	1.0046*	1.1745*	1.0700*	1.1913*
ω_{12}	-0.0450	-0.1176	0.0882	-0.1154	0.0546
ω_{22}	0.2218*	0.6022*	0.4496*	0.5435*	1.2712*
α_{11}	0.2718*	0.3021*	0.3185*	0.2890*	0.2789*
α_{12}	0.0000	-0.0508	0.0366	0.0100	0.0204
α_{22}	0.2148*	0.1903*	0.2248*	0.2276*	0.3407*
β_{11}	0.9052*	0.9199*	0.9055*	0.9160*	0.9047*
β_{12}	0.0150	0.0358*	-0.0088	0.0107	0.0174
β_{22}	0.9526*	0.9202*	0.9455*	0.9393*	0.9112*
γ_{11}	0.3158*	0.2009*	0.1878*	0.2488*	0.3061*
γ_{12}	-0.1185*	-0.1999*	-0.1323*	-0.1124*	-0.2361*
γ_{22}	-0.2798*	-0.3928*	-0.3092*	-0.3150*	-0.2083*
Max L	-5227.85	-5467.60	-5551.73	-5566.20	-6079.16
Panel C: Tests of Model Fitness					
MLBQ	20.38	22.72	16.88	27.85	19.89
	(0.6747)	(0.5362)	(0.8537)	(0.2662)	(0.7025)
$MLBQ^2$	13.27	24.97	15.08	53.04*	24.30
	(0.9613)	(0.4071)	(0.9183)	(0.006)	(0.4441)
Panel D: Tests of Volatility Spillover					
Wald	49.83*	45.63*	16.36*	17.49*	14.19*
	(0.0000)	(0.0000)	(0.001)	(0.002)	(0.001)
LR	19.72*	23.38*	9.68*	7.46	8.32*
	(0.0010)	(0.0000)	(0.215)	(0.0586)	(0.0398)

Table 5.1 summarizes the restricted bivariate VAR(2)-ABEKK estimation results. Panel A shows the conditional mean parameter estimates. The estimated conditional stock return intercepts, μ_2, are all positive and significant for both Mexico and Turkey at the five percent level. Since Mexico is the seventh largest producer of oil in the world and Turkey is dependent on oil

imports, this result does not have a logical explanation. On the other hand, oil price changes intercepts are insignificant in conditional mean equations for all analyzed countries. This is because of the restriction that we made in the previous sections.

There is evidence of stock return serial correlation for Malaysia is found, as we suggested previously by the significant LBQ statistics of Table 3.2. Significant estimate of δ_{22} of Malaysia indicates serial correlation over one period and Mexico's estimation also shows that there is a serial correlation over one period. These both countries are oil producing countries, therefore any change in oil price effects the stock market within a week. I will show the contemporenous effects in the next section. This result can be explained by, any change in oil prices, increase or decrease, will lead investors to sell or buy oil producer companies' shares in order to hedge from the risk or to exploit from the opportunity immediately. The significant estimate of π_{22} of Taiwan and Turkey estimations indicates there is a correlation over two periods. Therefore, the investors in oil exporting emerging countries reacted to the oil shock a week later.

The stock return serial correlations are successfully removed by the VAR(2) model as the insignificant MLBQ statistics in panel C show. Besides, the insignificant $MLBQ^2$ statistic in panel C confirms that the employed statistical model fits to the data, except Taiwan.

Estimates of the conditional variance covariance parameters are shown in Panel B. We noticed that α_{11}, β_{11} and γ_{11} parameters of conditional oil price volatility are significant. Thus, oil price volatility is conditionally heteroscedastic with displaying asymmetric effects to oil price increases and decreases.

Panel B also reports evidence of time persistence in conditional stock market volatility by the significant estimates of β_{22} across all the five regressions. All the estimated symmetric and asymmetric shock parameters, α_{22} and γ_{22}, respectively, are significant across every stock market. In conclusion, time of capturing the oil shocks differs between oil exporters and importers. On the other hand, all types of oil shocks, symmetric and asymmetric, have persistent effect on all emerging stock markets that we analyzed.

The parameter β_{12}, which indicates volatility spillover from oil price changes to stock returns, is significant for Mexico and insignificant for other countries. This suggests that all stock markets respond asymmetrically to oil shocks which are shown via the respective significant estimates of γ_{12}. Evidence of time persistence between the conditional oil price volatility and the one period ahead conditional stock volatility, which is measured by β_{12} is present for Mexico.

Since the parameter β_{12} suggests that volatility spillover are not significant overall, the tests of volatility spillover reported on in Panel D of Table 5.1, show significant evidence of volatility spillover across all stock markets. The Wald and Likelihood Ratio (LR) statistics derived under the null in (4.12) are greater than critical values and significant across all countries but Taiwan, where LR statistic is insignificant at 7.46. The Wald statistic for Taiwan is significant though. Hence the results show strong evidence of volatility spillover for Malaysia, Mexico, South Korea and Turkey, but only weak evidence for Taiwan. Moreover, significant γ_{12} estimates suggest that oil prices have asymmetric volatility spillover effect on the stock markets of these economies. This statistical result can be explained by the dependence to oil.

Table 5.1, Panel D, shows evidence of volatility spillovers but gives no information about their magnitude. After verifying the evidence of volatility spillovers for all countries, we illustrated the news impact surfaces in order to see the magnitude of impacts of the oil price volatility on the aggregate stock markets. Figures 5.1-5.5 illustrate news impact surfaces for each country. The graphs show the implied conditional variances, the implied conditional covariances, and the implied conditional correlations following last period's shocks, with all previous conditional variances and covariances held constant at their unconditional averages.

Panel A of each figure presents the impact of oil shocks and stock shocks on the one-period ahead conditional stock variances. Graphs show that, although significant spillovers were previously presented by the statistical tests previously, the impacts of oil shocks on stock volatility are quite small in magnitude in comparison to the effect that stock returns' own shocks have on stock volatility. For example, in Panel A of Malaysia (Figure 5.1), negative shocks to the stock price cause the stock volatility to increase considerably. However, ten points decrease in the oil price has small effects on the Malaysian stock price volatility. A positive shock in the oil price affects the stock price volatility in Malaysia, illustrating the statistically suggested asymmetric volatility spillover. We suggested an asymmetry in the statistical tests for Turkey and Panel A of Figure 5.5 indicates that positive oil shocks increase the conditional stock variance, as expected.

Panels B of figures (5.1)-(5.5) show that, oil price volatility is only affected by its own shocks due to our ABEKK parameters restrictions.

Moreover, Panels C and D display the news impacts on the conditional covariances and the conditional correlations which show how oil shocks and stock shocks affect the one-period ahead conditional covariance and correlation, respectively, between stock price returns and oil price changes. Negative oil shocks and positive stock shocks cause a negative next period correlation for the all investigated economies.

Figure 5.1: News Impact Surfaces for Malaysia

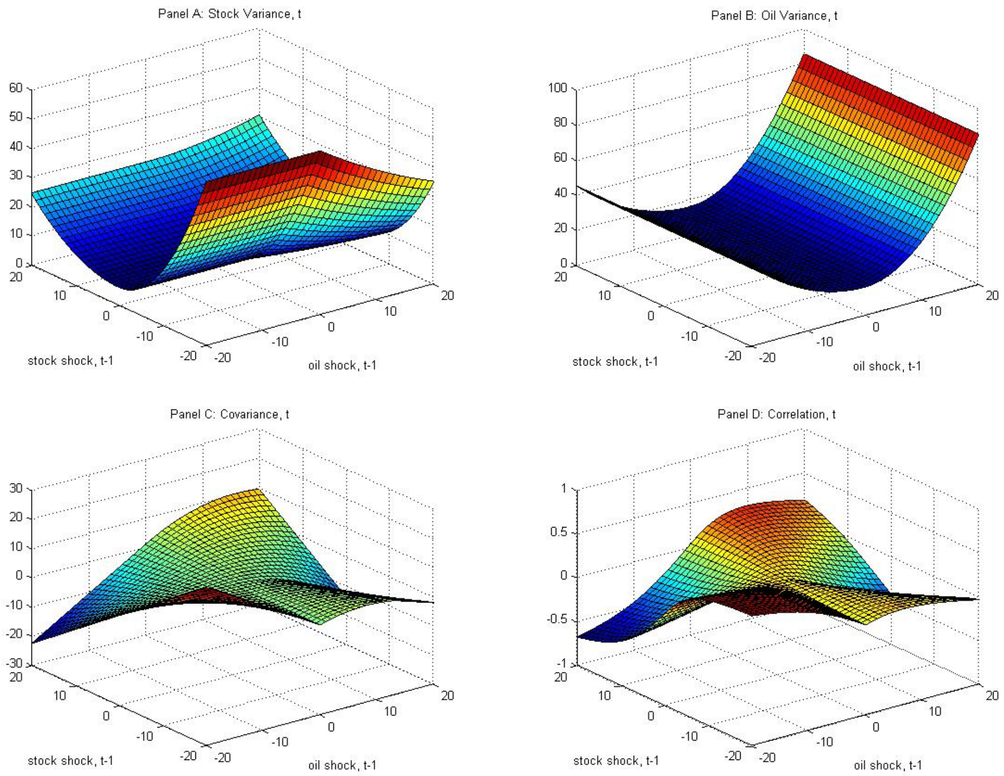


Figure 5.2: News Impact Surfaces for Mexico

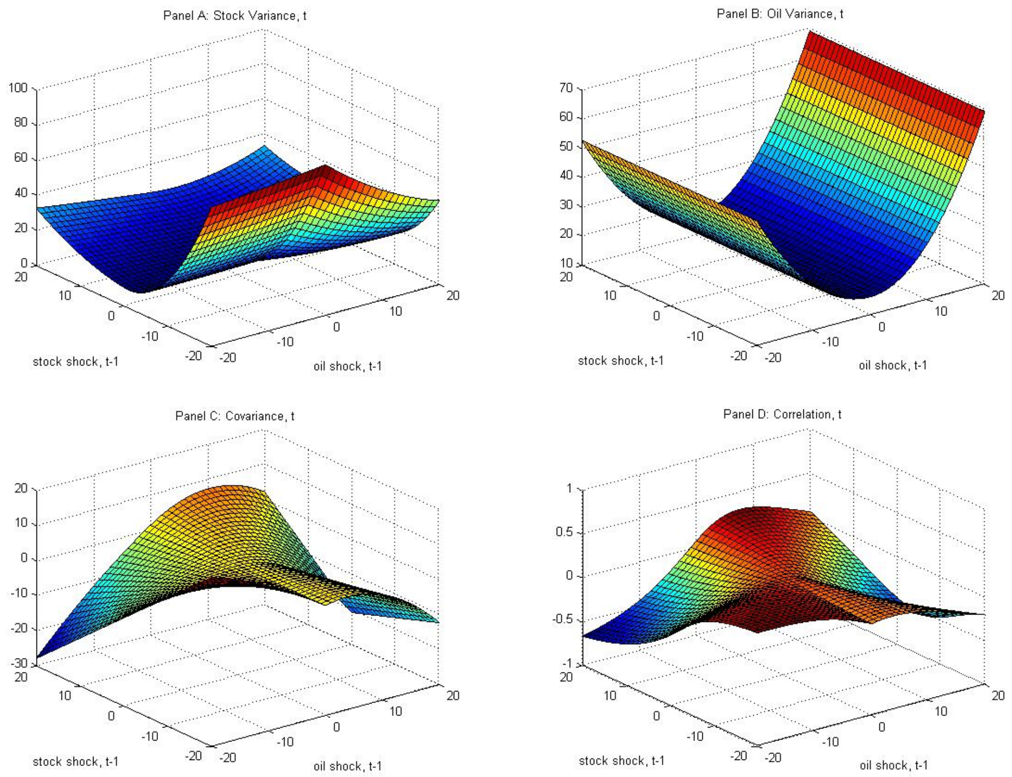


Figure 5.3: News Impact Surfaces for South Korea

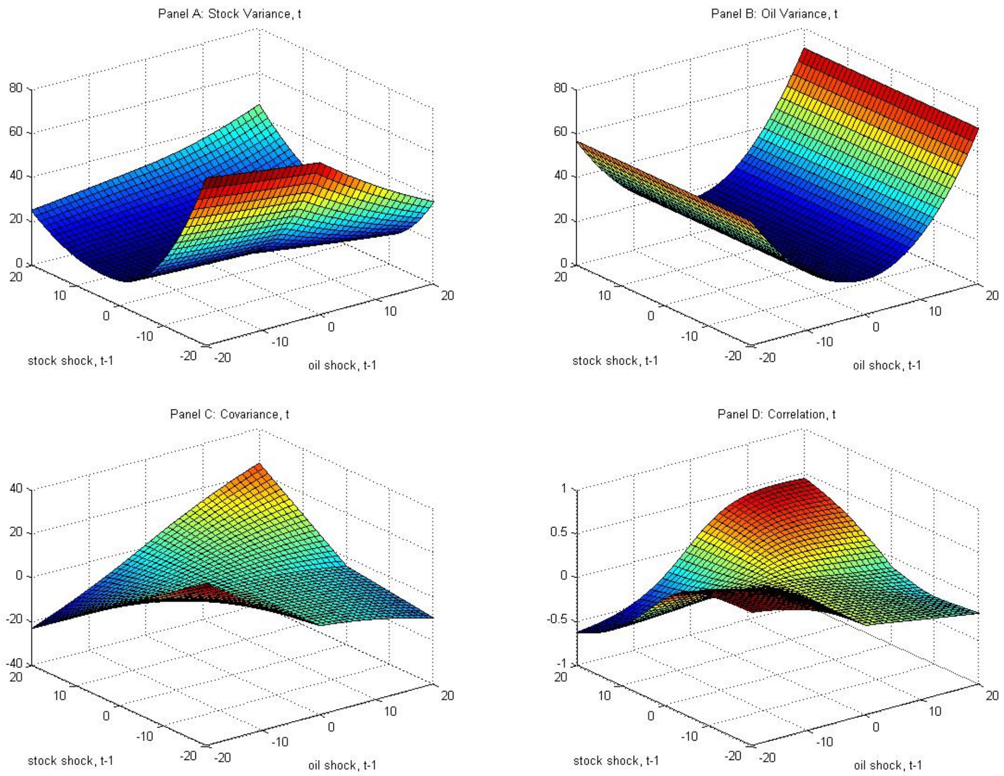


Figure 5.4: News Impact Surfaces for Taiwan

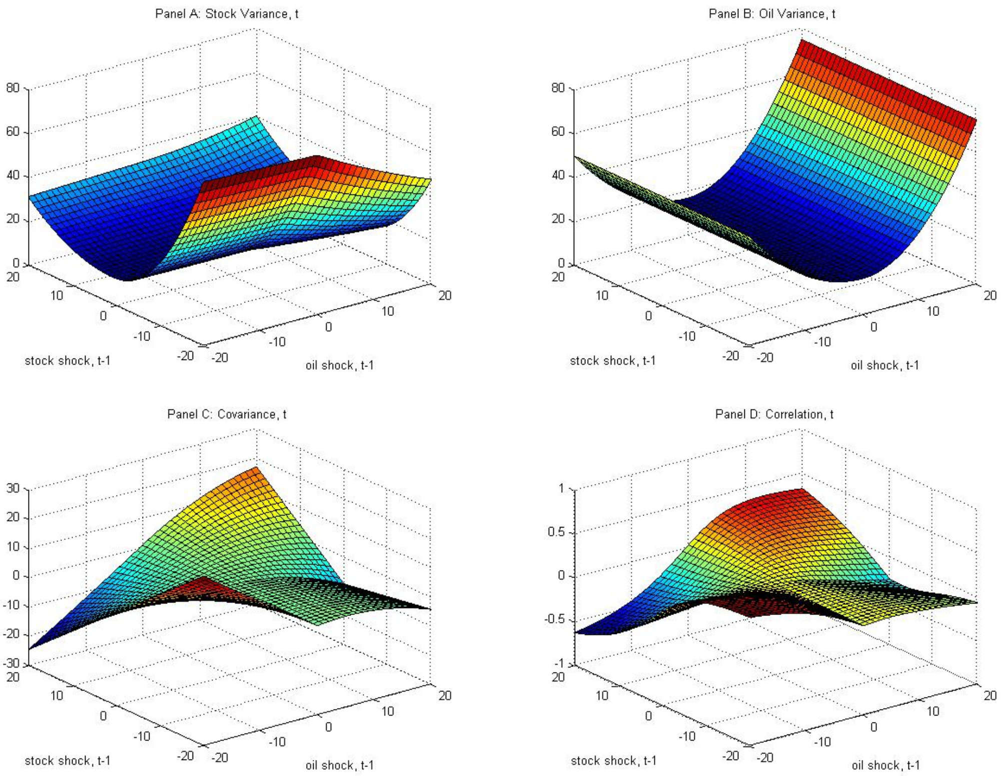
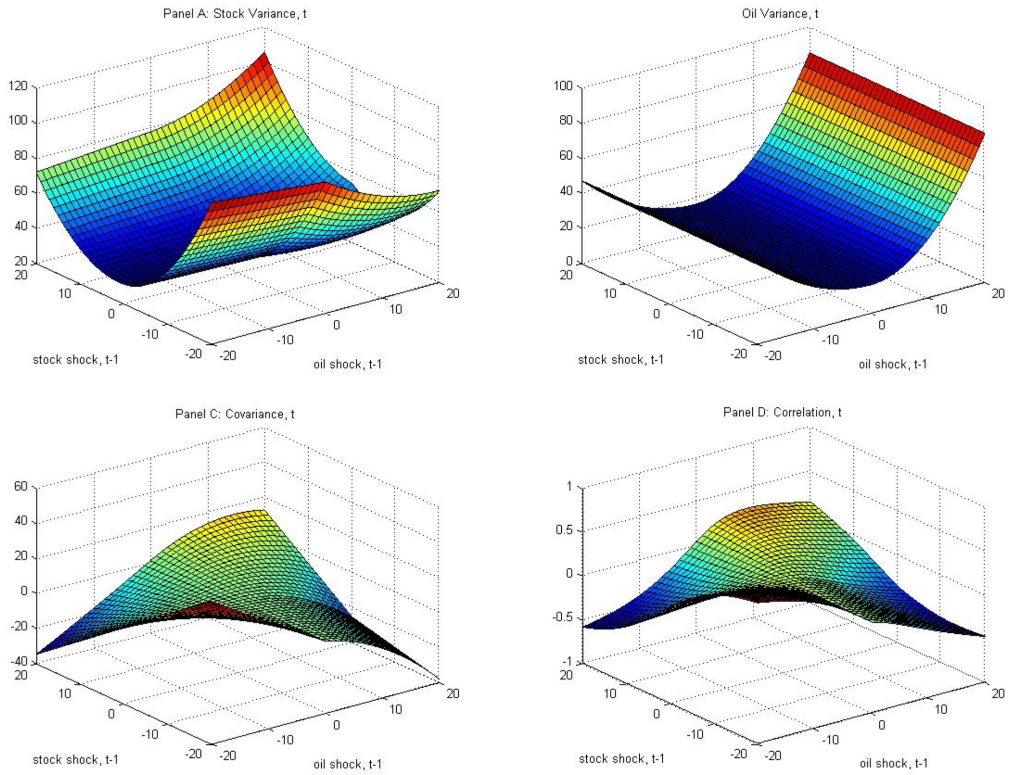


Figure 5.5: News Impact Surfaces for Turkey



5.2 Estimations with Leaded Oil Price

The previous set of empirical results show that strong evidence of volatility spillover is found from oil price changes to investigated stock markets. During the estimation we considered weekly data where oil price volatility spills over to stock market from one week to the next. However, volatility in oil prices could be transmitted to stock markets faster than a week. So, we applied a second set of estimation in order to see if stock markets respond simultaneously to the uncertainty of oil markets within the same week. In this set of estimations, we employed the same model where oil prices are leaded one period. Such a modification alters the presentation of the statistical model in (4.4)-(4.8), which becomes

$$\begin{bmatrix} \mathrm{r}_{oil_t} \\ \mathrm{r}_{stock_t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ \theta_{21} & 0 \end{bmatrix} \begin{bmatrix} \mathrm{r}_{oil_t} \\ \mathrm{r}_{stock_t} \end{bmatrix} + \begin{bmatrix} \delta_{11} & 0 \\ \delta_{21} & \delta_{22} \end{bmatrix} \begin{bmatrix} \mathrm{r}_{oil_{t-1}} \\ \mathrm{r}_{stock_{t-1}} \end{bmatrix} + \begin{bmatrix} \pi_{11} & 0 \\ 0 & \pi_{22} \end{bmatrix} \begin{bmatrix} \mathrm{r}_{oil_{t-2}} \\ \mathrm{r}_{stock_{t-2}} \end{bmatrix} + \begin{bmatrix} \epsilon_{oil_t} \\ \epsilon_{stock_t} \end{bmatrix} \tag{5.1}$$

and

$$\begin{pmatrix} \epsilon_{oil_t} \\ \epsilon_{stock_t} \end{pmatrix} = \begin{pmatrix} h_{11,t} & h_{12,t} \\ h_{12,t} & h_{22,t} \end{pmatrix}^{1/2} \begin{pmatrix} v_{oil_t} \\ v_{stock_t} \end{pmatrix} \tag{5.2}$$

where

$$h_{11,t} = \omega_{11}^2 + \alpha_{11}^2 \epsilon_{oil,t-1}^2 + \beta_{11}^2 h_{11,t-1} + \gamma_{11}^2 \eta_{oil,t-1}^2, \tag{5.3}$$

$$
\begin{aligned}
h_{12,t} &= \omega_{11}\omega_{12} + \alpha_{11}\alpha_{12}\epsilon^2_{oil,t} + \alpha_{11}\alpha_{22}\epsilon_{oil,t}\epsilon_{stock,t-1} + \beta_{11}\beta_{12}h_{11,t} \\
&\quad + \beta_{11}\beta_{22}h_{12,t-1} + \gamma_{11}\gamma_{12}\eta^2_{oil,t} + \gamma_{11}\gamma_{22}\eta_{oil,t}\eta_{stock,t-1}, \qquad (5.4)
\end{aligned}
$$

$$
\begin{aligned}
h_{22,t} &= \omega^2_{12} + \omega^2_{22} + \alpha^2_{12}\epsilon^2_{oil,t} + \alpha^2_{22}\epsilon^2_{stock,t-1} + 2\alpha_{12}\alpha_{22}\epsilon_{oil,t}\epsilon_{stock,t-1} \\
&\quad + \beta^2_{12}h_{11,t} + \beta^2_{22}h_{22,t-1} + 2\beta_{12}\beta_{22}h_{12,t-1} \\
&\quad + \gamma^2_{12}\eta^2_{oil,t} + \gamma^2_{22}\eta^2_{stock,t-1} + 2\gamma_{12}\gamma_{22}\eta_{oil,t}\eta_{stock,t-1}. \qquad (5.5)
\end{aligned}
$$

Notice the small differences of model (5.1)-(5.5) compared with the previous one of (4.4)-(4.8). Now, we consider simultaneous effects of oil shocks onto conditional stock returns and conditional stock volatility.

Table 5.2 summarizes the bivariate restricted VAR(2)-ABEKK model estimation results when oil prices are leaded one week.

5.2.1 Leaded Oil Price Results

Table 5.2: Restricted VAR(2)-ABEKK Leaded Oil Price Estimation Results

	Malaysia	Mexico	South Korea	Taiwan	Turkey
Panel A: Conditional Mean Estimates					
μ_1	0.1350	0.0786	0.1437	0.1257	0.1132
μ_2	0.1077	0.3555*	0.0213*	0.0657	0.6053*
θ_{21}	0.0116	-0.1949	-0.2103*	-0.3210*	-0.1945*
δ_{11}	-0.0059	-0.0085	-0.0033	0.0078	0.0109
δ_{21}	0.0008	0.0109	-0.0110	0.0013	-0.0191
δ_{22}	0.0558*	0.0786*	-0.0470	-0.0232	0.0138
π_{11}	0.0118	0.0121	0.0029	0.0388	0.0436
π_{22}	0.0570	0.0452	0.0450	0.0706*	0.0992*
Panel B: Conditional Variance-Covariance Estimates					
ω_{11}	1.0397*	1.0089*	1.1861*	0.8399*	0.6578*
ω_{12}	0.0101	0.1747	0.0786	0.2427	0.9313*
ω_{22}	0.2342*	0.6878*	0.2416	0.4368*	0.8279*
α_{11}	0.2828*	0.3235*	0.2569*	0.1665*	0.1142*
α_{12}	-0.0116	-0.0119	-0.0655*	0.0165	0.0226
α_{22}	0.2058*	0.0763	0.2479*	0.2301*	0.3590*
β_{11}	0.9254*	0.9222*	0.9143*	0.9507*	0.9593*
β_{12}	0.0093	0.0320*	0.0407*	0.0207	-0.0230
β_{22}	0.9542*	0.9262*	0.9328*	0.9391*	0.9188*
γ_{11}	0.1867*	0.0333	0.2745*	-0.2870*	0.3340*
γ_{12}	-0.1058*	-0.1135*	0.0010	-0.0516	0.0946
γ_{22}	-0.2854*	-0.4173*	-0.2975*	-0.2945*	0.0513
Max L	-5230.76	-5476.82	-5560.15	-5569.40	-6084.30
Panel C: Tests of Model Fitness					
MLBQ	21.61	26.93	16.35	29.09	21.20
	(0.6021)	(0.3077)	(0.8749)	(0.2167)	(0.6266)
$MLBQ^2$	13.06	40.34*	15.61	56.49*	25.54
	(0.9650)	(0.0196)	(0.9014)	(0.0002)	(0.3768)
Panel D: Tests of Volatility Spillover					
Wald	27.40*	11.30*	13.39*	5.49	2.80
	(0.000)	(0.0102)	(0.0039)	(0.1389)	(0.4229)
LR	8.40*	7.80	18.88*	4.72	2.96
	(0.0384)	(0.0503)	(0.0002)	(0.1935)	(0.3978)

Panel A displays the mean equation parameter estimates, where evidence of serial correlation in Mexico, South Korea and Turkey stock returns is shown. Mexico and Turkey estimates were significant in the previous estimation.

There is evidence of negative mean spillover from oil prices to South Korean, Taiwanese and Turkish stock indices that is implied by the significant estimate of θ_{21}, suggesting that these countries' stock markets respond negative to a contemporaneous oil shock. This result can be explained by the risk perception of oil importers. These countries reacted immediately to any kind of oil shock negatively.

The Malaysia and Mexico estimations give significant estimates of δ_{22}, just in the previous estimation, which indicates a serial correlation over one period. Like the previous estimation, Taiwan and Turkey results give significant estimate of π_{22}, suggesting a correlation over two periods.

Panel B of Table 5.2 presents the conditional variance-covariance parameter estimates and Panel D reports on the tests of volatility spillover. The prior evidence of volatility spillovers for the Turkey and Taiwan are no longer exists. The tests of volatility spillover for Malaysia and South Korea estimation results are still significant and there is a weak evidence for Mexico, which suggests that these countries' stock markets fluctuate contemporaneously with oil price changes. Yet again, Panel C shows that, by the insignificant MLBQ statistics, the stock return serial correlations are removed successfully by the VAR(2). Also, insignificant $MLBQ^2$ statistics of Malaysia, South Korea and Turkey suggest that the model fitted to the data successfully. Since there is a weak evidence of volatility spillover for Mexico, significant $MLBQ^2$ statistic supports this weak evidence of spillover. The volatility transmission is more robust in the first set of estimations where volatility spills over from one week to the next. We can say that, in general there is no empirical evidence of simultaneous volatility spillovers from oil market to stock markets within a week.

CHAPTER 6

CONCLUSION

The aim of this thesis is to investigate the volatility spillover from oil prices to stock markets empirically by an asymmetric BEKK model. The statistical model that we utilized includes a parameterization of the conditional variance-covariance of oil price changes and stock returns.

We applied some parameter restrictions in order to eliminate the effect of stock returns on oil prices. We used aggregate stock market data representing Malaysia, Mexico, South Korea, Taiwan and Turkey. Over the sample period from week forty-eight of 1988 to week forty-six of 2008, strong evidence of volatility spillover is found for Malaysia, Mexico, South Korea and Turkey. Weak evidence of volatility spillover is found for Taiwan. Although results of significant volatility spillovers are obtained, news impact surfaces show small quantitative implications. The stock markets' own shocks, which are related to other factors of uncertainty than the oil price, are more significant than the effects of oil shocks.

This thesis also investigates whether volatility spillover takes place simultaneously, within-the-week instead of from one week to the next, as in the leading estimation. Thereby, the oil price is leaded one week, and a second set of estimations is performed. Now, the prior evidence of volatility spillovers for Turkey and Taiwan no longer exists. There is strong evidence of volatility spillover found for Malaysia and South Korea, and weak evidence of volatility spillover for Mexico, suggesting that these countries' stock markets vary contemporaneously with oil price changes.

As we discussed earlier, emerging economies tend to be more dependent on fossil energy than developed countries due to developed countries' technological innovation and more reliance on a diversified range of energy resources. Accordingly emerging countries are more sensitive to fluctuations in energy price. Therefore, oil price changes or volatility in oil prices likely to have a greater impact on firms' profits and stock prices in emerging economies.

In addition, oil price volatility causes risk in investment and risk is one of the main determinants of stock market. Investors postpone their irreversible investments because they worry about their future returns on investments when there is an uncertainty in oil prices, which leads to a decrease in stock prices. Therefore, our statistical results confirm all policy implications that we discussed previously.

The overall impact of rising oil prices on stock prices depends on whether a company is a consumer or a producer of oil and oil related products. Since there are more companies that consume oil than produce oil in all countries that we analyzed, the overall impact of rising oil prices on stock markets is anticipated to be asymmetric. According to the news impact curves, both the oil importing and exporting countries show same asymmetric response to oil price shocks as we anticipated.

SELECT BIBLIOGRAPHY

Agren, M. (2006, October). Does Oil Price Uncertainty Transmit to Stock Markets? Working Paper Series 2006:23, Uppsala University, Department of Economics.

Basher, S. A. and P. Sadorsky (2004, October). Oil Price Risk and Emerging Stock Markets. International Finance 0410003, EconWPA.

Bollerslev, T., R. F. Engle, and J. M. Wooldridge (1988, February). A Capital Asset Pricing Model with Time-Varying Covariances. *Journal of Political Economy 96*(1), 116–31.

Bollerslev, T. and J. Wooldridge (1992). Quasi-maximum Likelihood Estimation and Inference in Dynamic Models with Time-Varying Covariances. *Econometric Reviews 11*(2), 143–172.

Caporin, M. and M. McAleer (2006). Dynamic Asymmetric GARCH. *Journal of Financial Econometrics 4*(3), 385–412.

Chi, H. (1996). Precedence and exogeneity of oil to the stock markets. *Seoul Journal of Business 2*(1), 39–53.

Darby, M. R. (1982, September). The Price of Oil and World Inflation and Recession. *American Economic Review 72*(4), 738–51.

Engle, R. F. and V. K. Ng (1991, April). Measuring and Testing the Impact of News on Volatility. NBER Working Papers 3681, National Bureau of Economic Research, Inc.

Engle, R. F., K. F. K. previously, Y. Baba, and D. F. Kraft (1993, July). Multivariate Simultaneous Generalized ARCH. University of California at San Diego, Economics Working Paper Series 89-57r, Department of Economics, UC San Diego.

Ferderer, P. J. (1996). Oil Price Volatility and the Macroeconomy. *Journal of Macroeconomics 18*(1), 1–26.

Glosten, L. R., R. Jagannathan, and D. E. Runkle (1993). On the Relation Between The Expected Value and The Volatility of The Nominal Excess Return on Stocks. Technical report.

Hamilton, J. D. (1983, April). Oil and the Macroeconomy since World War II. *Journal of Political Economy 91*(2), 228–48.

Hamilton, J. D. (1985). Historical Causes of Postwar Oil Shocks and Recessions. *Energy Journal 6*(2).

Huang, R. D., R. W. Masulis, and H. R. Stoll (1996). Energy Shocks and Financial Markets. *Journal of Futures Markets, Vol. 16, No. 1, pp. 1-27, 1996*.

Jones, C. M. and G. Kaul (1996, June). Oil and the stock markets. *Journal of Finance 51*(2), 463–91.

Kilian, L. and C. Park (2007, March). The Impact of Oil Price Shocks on the U.S. Stock Market. CEPR Discussion Papers 6166, C.E.P.R. Discussion Papers.

Kroner, K. F. and V. K. Ng (1998). Modeling Asymmetric Comovements of Asset Returns. *Review of Financial Studies 11*(4), 817–44.

Maghyereh, A. (2004). Oil Price Shocks and Emerging Stock Markets: A Generalized VAR Approach. *International Journal of Applied Econometrics and Quantitative Studies 1*(2), 27–40.

Nooreen Mujahid, R. A. and K. Mustafa (2005). Does Oil Price Transmit to Emerging Stock Returns: A case study of Pakistan Economy. Technical report.

Odusami, B. O. (2008). Crude Oil Shocks and Stock Market Returns. *Applied Financial Economics, Forthcoming*.

Papapetrou, E. (2001, September). Oil Price Shocks, Stock Market, Economic Activity and Employment in Greece. *Energy Economics 23*(5), 511–532.

Park, J. and R. A. Ratti (2008, September). Oil Price Shocks and Stock Markets in the U.S. and 13 European Countries. *Energy Economics 30*(5), 2587–2608.

Pierce, J. L. and J. J. Enzler (1974). The Effects of External Inflationary Shocks. *Brookings Papers on Economic Activity 5*(1974-1), 13–62.

Rasche, R. H. and J. A. Tatom (1977). The Effects of the New Energy Regime on Economic Capacity, Production, and Prices. *Review* (May), 2–12.

Sadorsky, P. (1999, October). Oil Price Shocks and Stock Market Activity. *Energy Economics 21*(5), 449–469.

Sawyer, K. R. and M. Nandha (2006). How Oil Moves Stock Prices. *SSRN eLibrary*.

Song-Zan, C. W. (2007). The Macroeconomic Determinants of Stock Price Volatility: Evidence from Taiwan, South Korea, Singapore and Hong Kong. Working paper series in economics and finance, Nan-Hua University, Taiwan.

APPENDIX A

ESTIMATION RESULTS I

A.1 Malaysia

	Coefficient	ML S.E.	p-value
μ_1	0.1719	0.1333	0.1974
μ_2	0.1003	0.0769	0.1922
δ_{11}	-0.0122	0.0352	0.7284
δ_{21}	-0.0070	0.0161	0.6650
δ_{22}	0.0950*	0.0352	0.0070
π_{11}	0.0219	0.0355	0.5375
π_{21}	0.0100	0.0204	0.6239
π_{22}	0.0518	0.0352	0.1410
ω_{11}	1.1814*	0.1816	0.0000
ω_{12}	-0.0450	0.1140	0.6929
ω_{22}	0.2218*	0.0883	0.0120
α_{11}	0.2718*	0.0330	0.0000
α_{12}	0.0000	0.0172	0.9978
α_{22}	0.2148*	0.0271	0.0000
β_{11}	0.9052*	0.0204	0.0000
β_{12}	0.0150	0.0116	0.1978
β_{22}	0.9526*	0.0061	0.0000
γ_{11}	0.3158*	0.0463	0.0000
γ_{12}	-0.1185*	0.0190	0.0000
γ_{22}	-0.2798	0.0303	0.0000
Max L	-5227.85		

Table A.1: Restricted VAR(2)-ABEKK Estimation Results for Malaysia

A.2 Mexico

	Coefficient	ML S.E.	p-value
μ_1	0.1299	0.1285	0.3124
μ_2	0.3960*	0.1059	0.0002
δ_{11}	-0.0015	0.0346	0.9648
δ_{21}	0.0115	0.0251	0.6452
δ_{22}	0.0859*	0.0363	0.0181
π_{11}	0.0110	0.0361	0.7593
π_{21}	-0.0160	0.0272	0.5547
π_{22}	0.0373	0.0362	0.3032
ω_{11}	1.0004*	0.1553	0.0000
ω_{12}	-0.1176	0.1794	0.5121
ω_{22}	0.6022*	0.1449	0.0000
α_{11}	0.3021*	0.0317	0.0000
α_{12}	-0.0508	0.0316	0.1084
α_{22}	0.1903*	0.0437	0.0000
β_{11}	0.9199*	0.0160	0.0000
β_{12}	0.0358*	0.0161	0.0266
β_{22}	0.9202*	0.0130	0.0000
γ_{11}	0.2009*	0.0604	0.0009
γ_{12}	-0.1999*	0.0316	0.0000
γ_{22}	-0.3928*	0.0398	0.0000
Max L	-5467.60		

Table A.2: Restricted VAR(2)-ABEKK Estimation Results for Mexico

A.3 South Korea

	Coefficient	ML S.E.	p-value
μ_1	0.1057	0.1300	0.4164
μ_2	0.0254	0.1071	0.8122
δ_{11}	0.0008	0.0346	0.9797
δ_{21}	-0.0079	0.0227	0.7275
δ_{22}	-0.0082	0.0352	0.8158
π_{11}	0.0157	0.0367	0.6676
π_{21}	0.0116	0.0270	0.6662
π_{22}	0.0626	0.0353	0.0758
ω_{11}	1.1745*	0.1713	0.0000
ω_{12}	0.0882	0.0929	0.3427
ω_{22}	0.4496*	0.1073	0.0001
α_{11}	0.3185*	0.0319	0.0000
α_{12}	0.0366	0.0224	0.1026
α_{22}	0.2248*	0.0370	0.0000
β_{11}	0.9055*	0.0197	0.0000
β_{12}	-0.0088	0.0101	0.3804
β_{22}	0.9555*	0.0085	0.0000
γ_{11}	0.1878*	0.0654	0.0041
γ_{12}	-0.1323*	0.0399	0.0009
γ_{22}	-0.3092*	0.0327	0.0000
Max L	-5551.73		

Table A.3: Restricted VAR(2)-ABEKK Estimation Results for South Korea

A.4 Taiwan

	Coefficient	ML S.E.	p-value
μ_1	0.1449	0.1351	0.2833
μ_2	0.0331	0.1105	0.7642
δ_{11}	0.0025	0.0344	0.9401
δ_{21}	0.0088	0.0262	0.7360
δ_{22}	0.0226	0.0354	0.5224
π_{11}	0.0119	0.0365	0.7441
π_{21}	-0.0275	0.0251	0.2734
π_{22}	0.0685*	0.0332	0.0390
ω_{11}	1.0700*	0.1635	0.0000
ω_{12}	-0.1154	0.2296	0.6151
ω_{22}	0.5435*	0.0933	0.0000
α_{11}	0.2890*	0.0314	0.0000
α_{12}	0.0100	0.0344	0.7715
α_{22}	0.2276*	0.0279	0.0000
β_{11}	0.9160*	0.0176	0.0000
β_{12}	0.0107	0.0208	0.6059
β_{22}	0.9393*	0.0086	0.0000
γ_{11}	0.2488*	0.0570	0.0000
γ_{12}	-0.1124*	0.0384	0.0034
γ_{22}	-0.3150*	0.0373	0.0000
Max L	-5566.20		

Table A.4: Restricted VAR(2)-ABEKK Estimation Results for Taiwan

A.5 Turkey

	Coefficient	ML S.E.	p-value
μ_1	0.1418	0.1373	0.3017
μ_2	0.5545*	0.1894	0.0034
δ_{11}	-0.0002	0.0359	0.9944
δ_{21}	-0.0279	0.0429	0.5151
δ_{22}	0.0577	0.0359	0.1081
π_{11}	0.0219	0.0351	0.5333
π_{21}	-0.0605	0.0416	0.1465
π_{22}	0.0852*	0.0320	0.0077
ω_{11}	1.1913*	0.1903	0.0000
ω_{12}	0.0546	0.3210	0.8649
ω_{22}	1.2712*	0.2073	0.0000
α_{11}	0.2789*	0.0326	0.0000
α_{12}	0.0204	0.0427	0.6320
α_{22}	0.3407*	0.0280	0.0000
β_{11}	0.9047*	0.0200	0.0000
β_{12}	0.0174	0.0327	0.5926
β_{22}	0.9112*	0.0121	0.0000
γ_{11}	0.3061*	0.0558	0.0000
γ_{12}	-0.2361*	0.0739	0.0014
γ_{22}	-0.2083*	0.0649	0.0013
Max L	-6079.16		

Table A.5: Restricted VAR(2)-ABEKK Estimation Results for Turkey

APPENDIX B

ESTIMATION RESULTS II

B.1 Malaysia

	Coefficient	ML S.E.	p-value
μ_1	0.1350	0.1387	0.3304
μ_2	0.1077	0.0801	0.1789
θ_{21}	0.0116	0.0894	0.8966
δ_{11}	-0.0059	0.0342	0.8622
δ_{21}	0.0008	0.0172	0.9628
δ_{22}	0.0558	0.0356	0.1170
π_{11}	0.0118	0.0357	0.7405
π_{22}	0.0570	0.0347	0.1009
ω_{11}	1.0397*	0.1579	0.0000
ω_{12}	0.0101	0.1163	0.9304
ω_{22}	0.2342*	0.0750	0.0018
α_{11}	0.2828*	0.0320	0.0000
α_{12}	-0.0116	0.0113	0.3037
α_{22}	0.2058*	0.0273	0.0000
β_{11}	0.9254*	0.0161	0.0000
β_{12}	0.0093	0.0111	0.4003
β_{22}	0.9542*	0.0061	0.0000
γ_{11}	0.1867*	0.0605	0.0020
γ_{12}	-0.1058*	0.0223	0.0000
γ_{22}	-0.2854*	0.0310	0.0000
Max L	-5230.76		

Table B.1: Restricted VAR(2)-ABEKK Leaded Oil Price Estimation Results for Malaysia

B.2 Mexico

	Coefficient	ML S.E.	p-value
μ_1	0.0786	0.1278	0.5384
μ_2	0.3555*	0.1144	0.0019
θ_{21}	-0.1949	0.1100	0.0764
δ_{11}	-0.0085	0.0346	0.8047
δ_{21}	0.0109	0.0255	0.6669
δ_{22}	0.0786*	0.0399	0.0488
π_{11}	0.0121	0.0341	0.7219
π_{22}	0.0452	0.0353	0.2002
ω_{11}	1.0089*	0.1795	0.0000
ω_{12}	0.1747	0.1708	0.3062
ω_{22}	0.6878*	0.1215	0.0000
α_{11}	0.3235*	0.0302	0.0000
α_{12}	-0.0119	0.0201	0.5537
α_{22}	0.0763	0.0451	0.0911
β_{11}	0.9222*	0.0170	0.0000
β_{12}	0.0320*	0.0148	0.0316
β_{22}	0.9262*	0.0117	0.0000
γ_{11}	0.0333	0.0700	0.6340
γ_{12}	-0.1135*	0.0504	0.0245
γ_{22}	-0.4173*	0.0370	0.0000
Max L	-5476.82		

Table B.2: Restricted VAR(2)-ABEKK Leaded Oil Price Estimation Results for Mexico

B.3 South Korea

	Coefficient	ML S.E.	p-value
μ_1	0.1437	0.1349	0.2868
μ_2	0.0213	0.1192	0.8580
θ_{21}	-0.2103*	0.0874	0.0161
δ_{11}	0.0033	0.0347	0.9236
δ_{21}	-0.0110	0.0252	0.6606
δ_{22}	-0.0470	0.0372	0.2065
π_{11}	0.0029	0.0348	0.9327
π_{22}	0.0450	0.0349	0.1974
ω_{11}	1.1861*	0.1867	0.0000
ω_{12}	0.0786	0.1669	0.6375
ω_{22}	0.2416	0.3150	0.4430
α_{11}	0.2569*	0.0331	0.0000
α_{12}	-0.0655*	0.0204	0.0013
α_{22}	0.2479*	0.0328	0.0000
β_{11}	0.9143*	0.0200	0.0000
β_{12}	0.0407*	0.0138	0.0033
β_{22}	0.9328*	0.0102	0.0000
γ_{11}	0.2745*	0.0491	0.0000
γ_{12}	0.0010	0.0400	0.9785
γ_{22}	-0.2975*	0.0354	0.0000
Max L	-5560.15		

Table B.3: Restricted VAR(2)-ABEKK Leaded Oil Price Estimation Results for South Korea

B.4 Taiwan

	Coefficient	ML S.E.	p-value
μ_1	0.1257	0.1383	0.3635
μ_2	0.0657	0.1251	0.5996
θ_{21}	-0.3210*	0.0966	0.0009
δ_{11}	0.0078	0.0323	0.8091
δ_{21}	0.0013	0.0277	0.9607
δ_{22}	-0.0232	0.0375	0.5365
π_{11}	0.0388	0.0321	0.2277
π_{22}	0.0706*	0.0335	0.0355
ω_{11}	0.8399*	0.1340	0.0000
ω_{12}	0.2427	0.2296	0.2905
ω_{22}	0.4368*	0.1353	0.0013
α_{11}	0.1665*	0.0277	0.0000
α_{12}	0.0165	0.0284	0.5603
α_{22}	0.2301	0.0262	0.0000
β_{11}	0.9507*	0.0109	0.0000
β_{12}	0.0207	0.0139	0.1362
β_{22}	0.9391*	0.0079	0.0000
γ_{11}	-0.2870	0.0399	0.0000
γ_{12}	-0.0516	0.0545	0.3436
γ_{22}	-0.2945	0.0364	0.0000
Max L	-5569.40		

Table B.4: Restricted VAR(2)-ABEKK Leaded Oil Price Estimation Results for Taiwan

B.5 Turkey

	Coefficient	ML S.E.	p-value
μ_1	0.1132	0.1409	0.4215
μ_2	0.6053*	0.2020	0.0027
θ_{21}	-0.1945*	0.0972	0.0455
δ_{11}	0.0109	0.0330	0.7405
δ_{21}	-0.0191	0.0432	0.6572
δ_{22}	0.0138	0.0376	0.7124
π_{11}	0.0436	0.0335	0.1932
π_{22}	0.0992*	0.0317	0.0018
ω_{11}	0.6578*	0.1202	0.0000
ω_{12}	0.9313*	0.3447	0.0069
ω_{22}	0.8279*	0.4226	0.0501
α_{11}	0.1142*	0.0236	0.0000
α_{12}	0.0226	0.0283	0.4236
α_{22}	0.3590*	0.0243	0.0000
β_{11}	0.9593*	0.0078	0.0000
β_{12}	-0.0230	0.0188	0.2210
β_{22}	0.9188*	0.0110	0.0000
γ_{11}	0.3340*	0.0360	0.0000
γ_{12}	0.0946	0.0756	0.2109
γ_{22}	0.0513	0.1106	0.6426
Max L	-6084.30		

Table B.5: Restricted VAR(2)-ABEKK Leaded Oil Price Estimation Results for Turkey