Foreign exchange and oil price exposure in Thai energy stocks

Thaweerath Matthaweewongsa, Pard Teekasap*, Tusanee Tondee and Sombat Teekasap

Rattanakosin College for Sustainable Energy and Environment (RCSEE)
Rajamangala University of Technology Rattanakosin
96 moo 3 Puthamonthon Sai 5, Salaya, Puthamonthon, Nakhon Pathom 73170, Thailand
Tel: 02-441-6062 extend 2754, Fax: 02-441-6065
Email: thaweerath.mat@at.rmutr.ac.th, pard.tee@rmutr.ac.th, tusanee.ton@rmutr.ac.th
***Corresponding author:** pard.tee@rmutr.ac.th

Abstract

This research examines impacts of oil price and foreign exchange rate on stock prices of listed companies in oil-related sector of the stock exchange of Thailand (SET). Theoretical concept is based on multi-factor models including risk premium of market portfolio, oil price, and foreign exchange rate as factors determining risk premium of stock prices. The study employs traditional linear regression model, Autoregressive Conditional Heteroscedasticity (ARCH) model, and Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model as econometric models determining the impacts of oil price and exchange rate. Since the study employs daily data, the empirical results find significant Generalized Autoregressive Conditional Heteroscedasticity (GARCH) effects in all models. Focusing on impacts of oil price on stock prices, the estimated results of both aggregate and disaggregate level analyses provide significant estimated coefficients of oil price on oil-related industry which confirm hypothesis of this study. World oil price has significant impacts on oil-related stock prices both aggregate and disaggregate levels. The directions of the impacts vary according to industry. Positive significant impacts are found in Energy and Utilities sector index and oil-directly-related stock prices. While negative significant impacts are determined in Finance and Securities sector index, Properties Development sector indices, Banking sector index, and Information Communication Technology sector. However, the results show unclear direction and insignificant impacts of oil price on oil-substitute stock prices. As a result, the findings confirm hypothesis that oil price have significant impacts on oil-directly-related stock prices due to their business mainly and heavily relied on oil while inconclusively prove influences of oil price on stock prices of oil-substitute business listed companies. Concerning on impacts of exchange rate on stock prices, the empirical results show inconclusive evidences of the impacts since only few significant coefficients of exchange rate are determined. The findings can be explained by the fact that after Thai financial crisis in 1997, most listed companies in Thailand, especially the companies in oil-related sectors, have experience and learn to hedge their position from foreign exchange rate risk, thus, foreign exchange rate has less and insignificant impact on Thai stock prices in these sectors.

Keywords: *Oil prices, foreign exchange rate, CAPM, multi-factor model, GARCH model, stock exchange*

1. Introduction and motivation

Over half century, as major factor of production, oil price crises had played an important role in causing several significant world economic crises. As non-renewable resource, oil derived from fossil fuels that accumulate over millions of years, thus, price of oil, as commodities products, will fluctuate in accordance with supply and demand [1-2]. After the establishment of Organization of the Petroleum Exporting Countries (OPEC) in 1960 (Brief History, Organization of the Petroleum Exporting Countries (2017), www.opec.org), as major suppliers of world oil product, their restrictions in oil production agreements have been implemented several times causing oil price sharply increased and resulting oil price crises. World economic fluctuation causing by OPEC oil price policy was first introduced in 1973, then, 1979, and 1990. The Asian financial crisis was beginning from Thailand in July 1997, the spread throughout Asia and around the world and raised fears of a worldwide economic meltdown due to financial contagion. Thailand faced foreign debt crisis then the government announced float Thai Baht to foreign currency, the currency of Thailand peg to the U.S. Dollar. The crisis spread, most of Southeast Asia and Japan saw slumping currencies, devalued stock markets and other asset prices (such as commodities etc.). Later, world financial crisis led by U.S. subprime crisis during 2008-2009, also happened during the high fluctuation of oil price beginning with highly rising oil prices and sharply drop in oil prices [3-6]. Figure 1 illustrates the movement of crude oil price based on West Texas Intermediate (WTI spot price) during oil crisis and world economic events over the past two decades during 1995 to 2016.

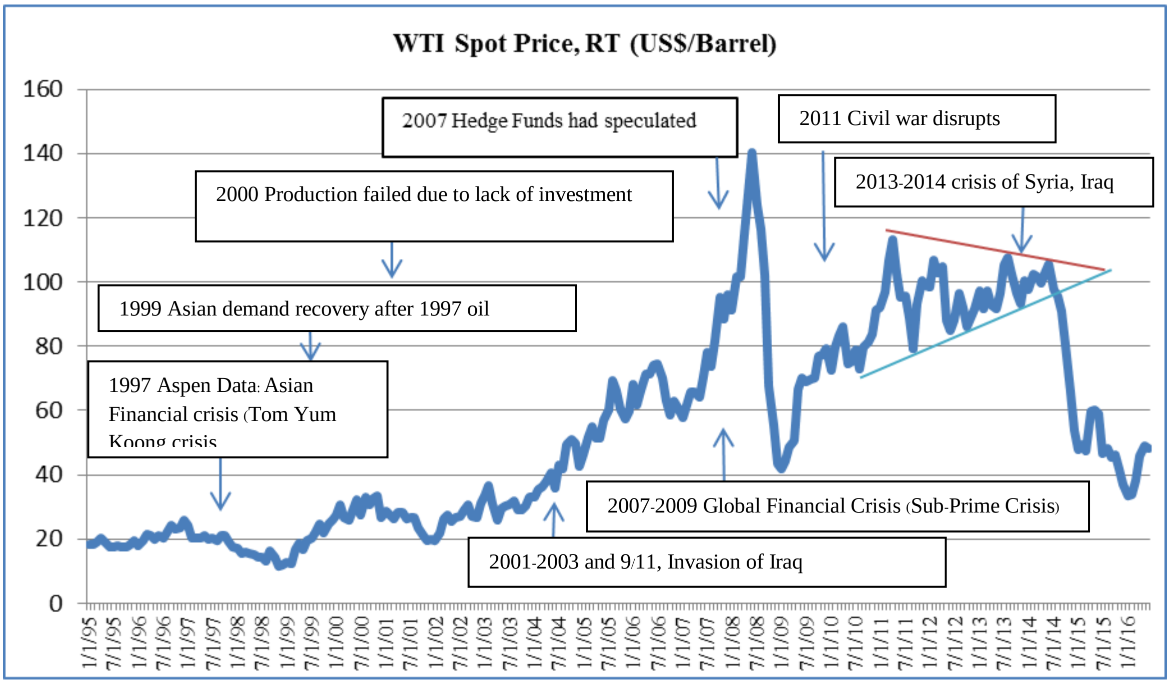

Figure 1 Oil Crisis and World Economy: (WTI Spot Price, RT; US Dollar/Barrel)

Source: Info Quest Limited (ASPEN Thailand)

Not because of supply and demand for crude oil [1-2], as major world trading commodity, investors' speculation in oil commodity [7-14] based on world economic conditions has also been another major cause of changing in oil price, such as hedge funds speculation during 2008, resulting in world economic fluctuation. Additionally, another aspect of oil price, as reflection of political conflicts, oil price had often and sensitively increased in responding to several world political conflicts [15-17], such as gulf war in Iraq during 2001 - 2003, and civil war in Libyan during 2011. As shown in Figure 1, regardless of its causes, the changing in oil prices had always and consistently affected world economic conditions, especially world financial markets. As an emerging and small capital market, SET has also been influenced frequently by changing in world oil since its establishment in 1975.

Over the past four decades, oil price shocks have continuously affected the SET in term of both aggregate (industrial sector indices) and disaggregate levels (single stock prices). The rising in world oil price during 2003 to 2008 led to increasing in SET index and energy and utilities sector index (ENERG). As the largest proportion in overall market capitalization of SET, with about 35 percent, all listed companies in Petroleum Authority of Thailand (PTT) group with major business in oil and energy markets had played an important role in leading the direction of the SET. Due to its main business highly relied on energy and crude oil markets, changing in world crude oil prices had direct impacts on their business performances, which then consequently affected, stock prices of the listed companies in PTT group, and then finally, largely influenced overall stock market in Thailand.

However, due to the rapidly expansion and recent development of SET during the past decade, the structure of SET, has continuously changed from heavily relied on stock prices of energy and utilities sector to moderately relied level since market capitalization proportion of energy and utilities sector has dropped from 30-35 percent during 1990s to about 16-17 percent during this current period, as shown in Figure 2. As a result, the question then arises whether world oil price, which in the past has highly, direct, and significant impacts on SET, still has significant impacts on the current SET or not.

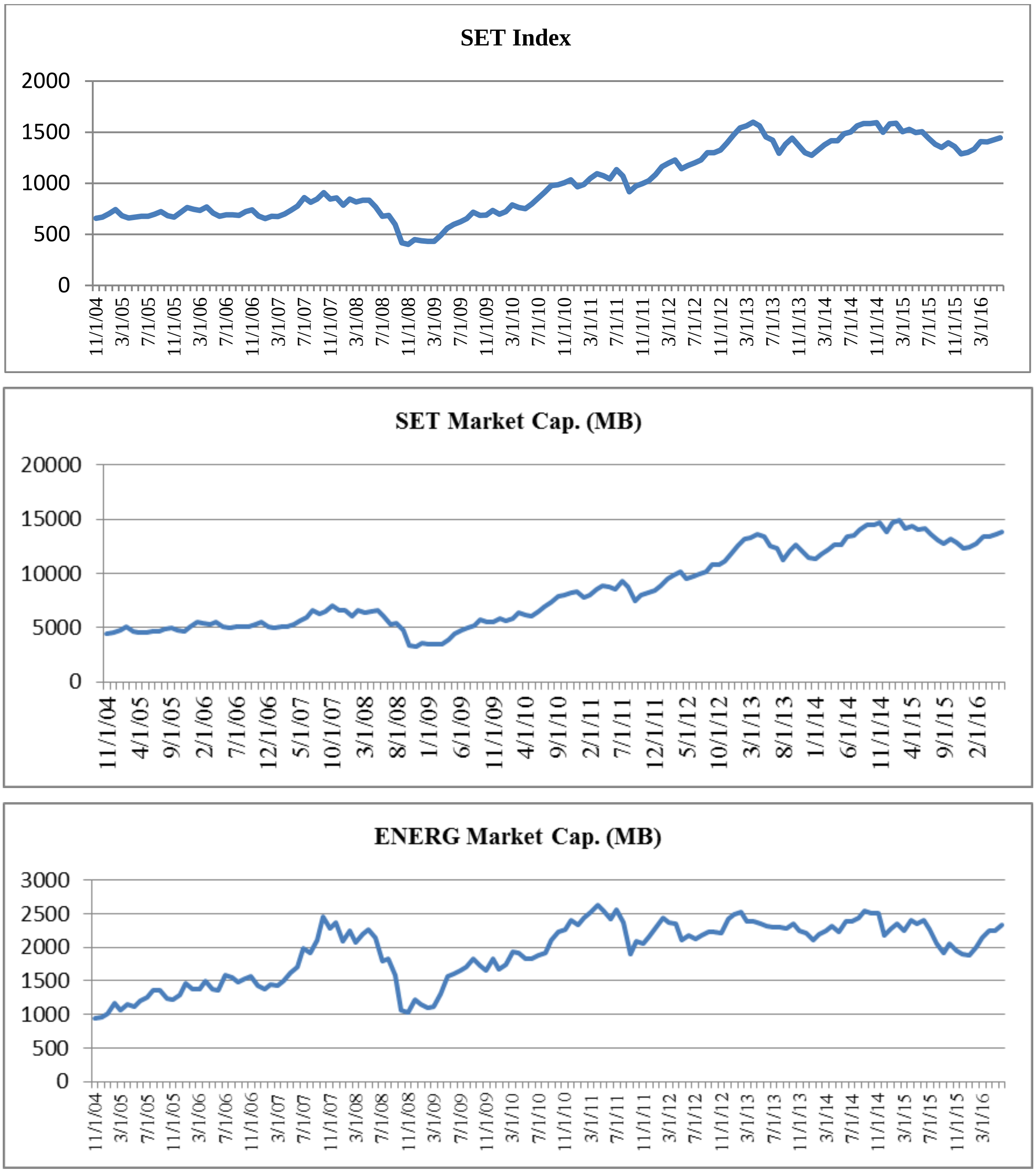

Figure 2 SET Index, Market Capitalization of SET, and Market Capitalization of Energy and Utilities

Source of Data: Info Quest Limited (ASPEN Thailand)

Furthermore, Thailand is oil imported country, as Production, Consumption and Import (Net) of Primary Commercial Energy data from Energy Statistics of Thailand. We will find that increase the production of energy for Commercial, Net Import increased and Consumption also increased as well. For example, in 2011, with Production 1,018,472 Barrels / Day, Net Import 1,017056 Barrels / Day by the imported Crude Oil 760904 Barrels / Day as Consumption 1,844,536 Barrels / Day of oil production in Thailand. That is insufficient to Consumption. Thailand exchange rate also has impacts on oil price in Thailand since crude oil imported prices are in form of foreign currency, which mostly are in term of U.S. dollar. As a result, not only world crude oil price, but also exchange rate that has impacts on the SET.

According the above mentioned, Thailand financial and capital markets had been relied heavily on and highly influenced by oil price and exchange rate for the past three decades. However, the continuously change in the structure of SET with more variety and diverse of businesses of the listed firms in the market might have changed the roles of oil price and exchange rate in influencing the market. Therefore, the objectives of this study intend to (i) sectoral analyze impacts of oil price and exchange rate on the SET categorized by industry, and (ii) determine influences of oil price and exchange rate on single stock price of energy related companies. The study emphasizes on the events period 2005 to 2016. Findings from this paper would benefit the Institutional investors, both domestic and international and individual investors, who are interesting in investing in Thailand capital market. The findings can also be used as a guideline for their investment decision in the SET, especially, listed companies in energy and utilities sector. At the same time, Thai policy makers can apply the results from this study to help issuing more appropriated rules and regulations, which can help enhancing the capital market as well as overall economy of Thailand.

This paper is organized as the follows, first section illustrates Introduction and motivation, second section identifies theoretical framework of the study, third section explains data and methods of the study, fourth section reveals estimated results of the study, and last section summarizes and discusses the findings of the study, then provide suggestion and recommendations.

2. Theoretical framework

Studies concerning on impacts of oil price and exchange rate on stock price mostly begin with the single factor model based on the concept of capital asset pricing model (CAPM), then, extend the model to multifactor model by including oil price and exchange rate as Arbitrage Pricing Theory (APT) [18-23]. Theoretical framework of this study first follows Markowitz's portfolio theory, then, concept of capital asset pricing model, and finally the extended multifactor model.

2.1 Theoretical concepts concerning on asset pricing

(1) Portfolio theory

Based on portfolio theory, two major factors determining investment decision in the capital market include risk and return. Investment risk represents the uncertainty of expected return or required rate of return, which can be higher or lower than what was expected by investors. [24], [25] Markowitz (1952), (1959) claimed that investors can lower their investment risk by diversifying their investment and hold their investment as portfolio of several securities. Since investors can also invest in risk free security, investing in risky asset should then be compensated with rate of return of risk free security as risk premium. Equation (1) illustrates rate of return of portfolio (r_p) of two classes of asset, risky asset and risk-free asset.

$$r_p = (1 - w_a)r_f + w_a r_a \quad (1)$$

where r_p is rate of return of portfolio p, r_a is rate of return of risky asset portfolio a, r_f is rate of return of risk-free asset, and w_a is the proportion of total funds invested in portfolio *a*.

Then, risk of portfolio *p* can be determined by variance of the return of portfolio *p*:

$$\sigma_p^2 = w_a^2 \sigma_a^2 + (1 - w_a)\sigma_f^2 + 2w_a(1 - w_a)\sigma_{af} \quad (2)$$

where σ_p^2 is variance of expected return of portfolio p, σ_a^2 is variance of expected return of portfolio a, σ_f^2 is variance of risk-free asset, and $\sigma_{a,f}$ is covariance of expected return of portfolio a and the risk-free asset.

According to its definition, risk free asset is asset without risk or the variance of return on risk free asset σ_f^2 is equal to 0 as well as $\sigma_{a,f}$ is also equal to 0. Therefore,

$$\sigma_p^2 = w_a^2 \sigma_a^2 \ or \ \sigma_p = w_a \sigma_a \quad (3)$$

Then, $w_a = \frac{\sigma_p}{\sigma_a}$ and $(1 - w_a) = 1 - \frac{\sigma_p}{\sigma_a}$, and the Expected return of portfolio (r_p) can be rewritten to present relationship between risk and return as:

$$r_p = r_f + \left(\frac{r_a - r_f}{\sigma_a}\right)\sigma_p \quad (4)$$

where σ_p represents the risk of portfolio *p*.

Based on portfolio theory, the risk and return of portfolio relationship in equation (4) can be used as the basic concept in capital asset pricing model (CAPM), which can be stated in the next section.

(2) Capital Asset Pricing Models (CAPM)

According to equation (4), if investor invests mainly on stock *j*, together with portfolio *a*, which can be assumed as the proxy of overall stock market portfolio (in this study represented by the SET Index), then the relationship can be shown as:

$$r_j = r_f + \left(\frac{r_m - r_f}{\sigma_m}\right)\sigma_j \quad (5)$$

Then, the relationship can be derived in form of risk premium of stock *j* and risk premium of market portfolio as follows:

$$\left(r_j - r_f\right) = \left(\frac{\sigma_j}{\sigma_m}\right)\left(r_m - r_f\right) \quad (6)$$

where r_j is rate of return of stock *j*, r_m is rate of return of market portfolio, σ_j is risk of stock *j*, and σ_m is risk of market portfolio.

Equation (6) illustrates relationship between risk-premium of stock *j* in compensated with increasing risk obtained from investing in stock *j* compared to risk-premium of market portfolio. Capital asset pricing model (CAPM) can then be stated as:

$$r_j - r_f = \beta_j(r_m - r_f) \quad (7)$$

where β_j represents systematic risk of stock *j*.

According to [26] Jensen (1968), intercept term should be included in order to identify the existence of risk premium of stock *j* or Jensen's Alpha:

$$\left(r_j - r_f\right) = \alpha_j + \beta_j\left(r_m - r_f\right) \quad (8)$$

where α_j represents Jensen's Alpha of stock *j*.

(3) Multifactor Asset Pricing Models

Arbitrage Pricing Theory (APT) was first introduced by [27] Ross (1976) who expanded concept of the CAPM by adding major economic variables into the model. Follow APT, [19-22], this study extends CAPM by including exchange rate and oil price as two major influenced factors in determining return of energy related stock *j*.

$$(r_j - r_f) = \alpha_j + \beta_{1j}(r_m - r_f) + \beta_{2j} r_{Oil} + \beta_{3j} r_{Fx} \quad (9)$$

where r_{Oil} is the returns of oil price (change in price) and r_{Fx} is the returns of exchange rate (change in exchange rate).

According to the above mentions, previous studies had employed CAPM and multifactor model in determining influences of oil prices and foreign exchange rate on stock prices (or stock return). For instance, Faff & Brailsford [18] applied two-factor model as their framework and analyzed by using monthly data during 1983 to 1996 and found significant positive relationship of oil price with stock prices of listed companies in oil, gas, and diversified resources industries and significant negative impact of oil price on stock prices of listed companies in paper, packaging, and transportation industries. , El-Sharif, et al [21] used multifactor model to analyze relationship between the crude oil prices and equity values and found positive relationship in the oil and gas sectors in United Kingdom (UK) stock market. Sadorsky [19] and Basher, S. A., & Sadorsky, P. [20] employed international multifactor model to determine relationship between four risk factors, including market risk, oil prices risk, interest rate risk, and exchange rate risk (FX). Both studies found positive impacts of oil prices risk and negative impacts of exchange rate risk and interest rate risk on stock returns of oil and gas companies in Canada and emerging markets. Additionally, Nandha & Faff [22] found significant impacts of oil price on global stock market. However, directions of relationship were varied based on industry, positive relationship for oil, gas, and mining industries but negative for global index.

Concerning on methods of study, previous studies mostly employed time series models, including traditional linear regression models, time varying volatility models, and inter-dependent and dynamic models. The first generation of the studies concerning on oil price and stock price simply employed traditional linear regression models [28-31]. Later, studies have been divided into two major areas of emphases including time varying volatility and dynamic relationship behavior. Studies emphasized on dynamic relationship behavior mostly employed Vector Autoregressive (VARs) models [1, 29, 32-34]. Finally, studies focused on time varying volatility mainly applied ARCH-type models, including Autoregressive Conditional Heteroscedasticity (ARCH), Generalize ARCH (GARCH), Exponential GARCH (EGARCH), and Multivariate GARCH (MGARCH) [35-38].

Similar to previous studies, this study employs theoretical framework based on the above model equation (9) in determining impacts of oil price and exchange rate on stock price in SET. The study also applies traditional linear regression model and time varying volatility models, including ARCH and GARCH models, in analyzing the relationships.

3. Methodology

3.1 Data selection

Daily data during January 2005 to June 2016 is employed in the analysis, we use data for the period 2005 - 6/2016, which is around 10 years - present, to provide up-to-date information on the current events and to examine the data according to research methodology to the most advanced, which emphasizes on oil prices, exchange rates, the rate of return of the stock price of the listed companies in the SET using six major sectoral indices returns and the single stock price of energy related business returns. Aggregate level analysis covers six major sectors, which represent more than half (about 55 percent) of the market capitalization of SET in 2016, consisted of Energy and Utilities sector (16.6%), Banking sector (14.4%), Information Communication Technology (ICT) sector (8.9%), Properties Development (PROP) sector (6.7%), Construction Material (CONMAT) sector (6.2%), and Finance and Securities sector (2.0%). Figure 3 illustrates movement of six major sectoral indices during 2005 to 2016.

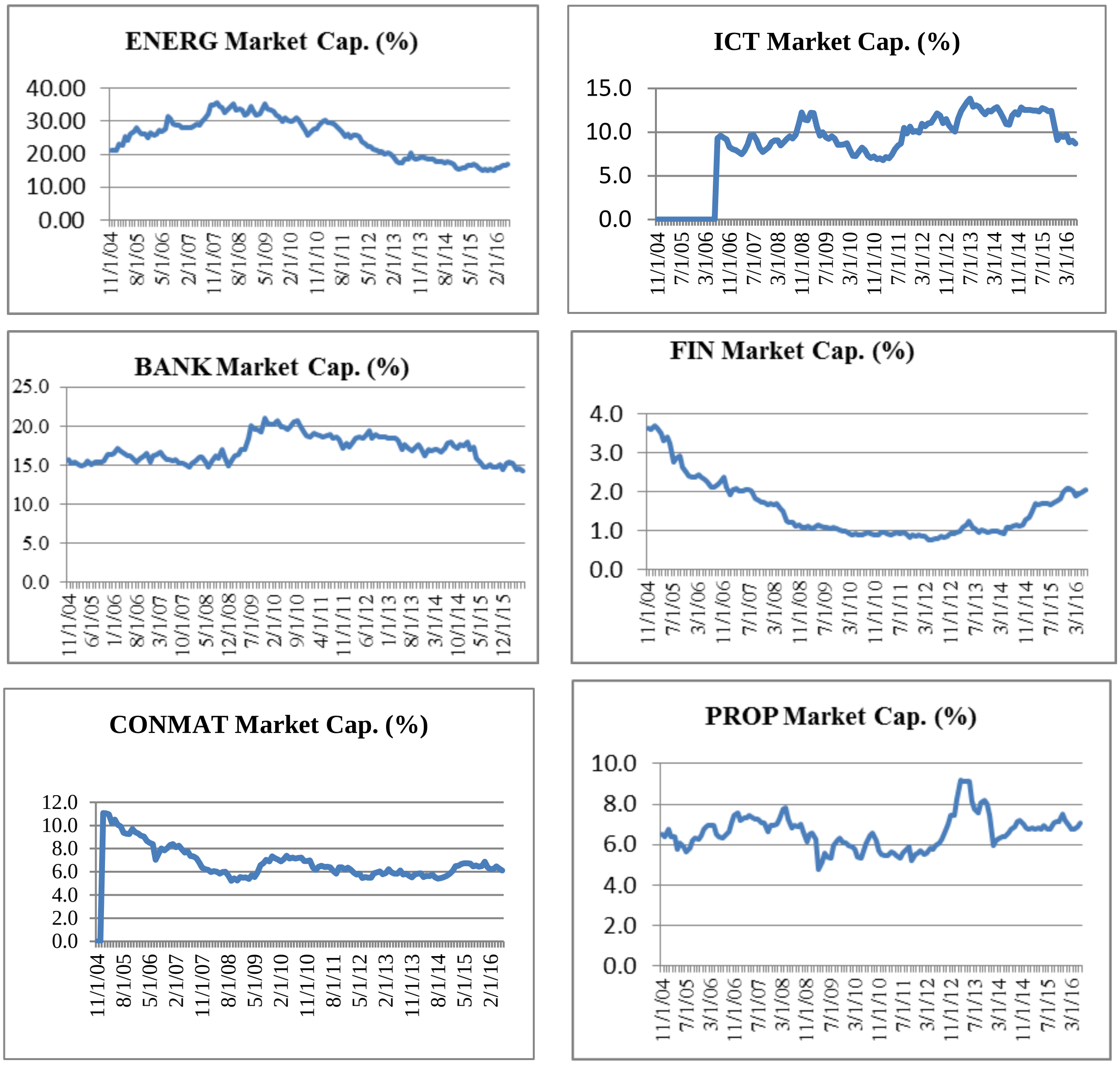

Figure 3 Six Main Sectors of SET and Its Proportion (%) Based on Market Capitalization

Source of Data: Info Quest Limited (ASPEN Thailand)

Disaggregate level analysis by implementing single stock price of energy related business analysis focuses on two major industries including (i) coal, gas, and electric services referred as oil-substitute industry (including Banpu Public Company Limited (BANPU), Electricity Generating Public Company Limited (EGCO), Glow Energy Public Company Limited (GLOW), Lanna Resources Public Company Limited (LANNA), M.D.X. Public Company Limited (MDX), and Ratchaburi Electricity Generating Holding Public Company Limited (RATCH)), (ii) oil-gas extraction and petroleum refinery referred as oil-related industry (including Bangkok Aviation Fuel Services Public Company Limited (BAFS), Bangchak Petroleum Public Company Limited (BCP), ESSO (Thailand) Public Company Limited (ESSO), IRPC Public Company Limited (IRPC), PTT Public Company Limited (PTT), PTT Exploration and Production Public Company Limited (PTTEP), PTT Global Chemical Public Company Limited (PTTGC), Thai Oil Public Company Limited (TOP), SUSCO Public Company Limited (SUSCO), Indorama Ventures Public Company Limited (IVL)).

3.2 Research process and research models

In order to confirm robustness of the results of the study, research process in this study is divided into two levels, (i) aggregate (sectoral analysis) level and (ii) disaggregate (single stock analysis) level. Each level consists of three models, traditional linear regression model, Autoregressive

Conditional Heteroscedasticity (ARCH) model, and Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model.

(1) Traditional linear regression model

Based on conceptual framework of this study equation (9), the model can be stated as:

$$y_{jt} = \alpha_j + \beta_{j1}x_{1t} + \beta_{j2}x_{2t} + \beta_{j3}x_{3t} + u_{jt} \quad (10)$$

where: $y_{jt} = r_{jt} - r_{ft}$ is risk premium of portfolio *j* (or sectoral index *j*, or stock *j*) at *t*, $x_{1t} = r_{mt} - r_{ft}$ is risk premium of market portfolio (SET) at time *t*, $x_{2t} = r_{oil,t}$ is the return of oil price at time *t*, and $x_{3t} = r_{Fx,t}$ is return of exchange rate at time *t*, and u_t is random error term at time *t*. Table 3-1 presents measurement of dependent and independent variables of the model equation (10) and its source.

Table 1 Measurement of dependent and independent variables

Variable	Source	Measurement of Variables
Daily Return of sector index *j* or stock *j* (y_{jt})	Info Quest Limited (ASPEN Thailand)	$y_{jt} = r_{jt} - r_{ft}$ $r_{jt} = (\frac{(P_{jt} - P_{jt-1}}{P_{jt-1}}) * 100$ $r_{ft} = \frac{Bond\ Annual\ Return}{260\ Days}$ $r_{jt} =$ the daily return of sector index j or stock j $P_{jt} =$ the closed price of sector index j or stock j at time t
Market Portfolio Return (x_{1t})	Info Quest Limited (ASPEN Thailand)	$x_{1t} = r_{mt} - r_{ft}$ $r_{mt} = \left(\frac{P_{mt} - P_{mt-1}}{P_{mt-1}}\right) * 100$ $P_{mt} =$ SET index at time t
Crude Oil prices Return[a] (x_{2t})	Info Quest Limited (ASPEN Thailand)	$r_{oil} = \left(\frac{(Price\ of\ WTI\ in\ \$US_t - Price\ of\ WTI\ in\ \$US_{t-1}}{Price\ of\ WTI\ in\ \$US_{t-1}}\right) * 100$
Foreign Exchange rate Return (x_{3t})	Info Quest Limited (ASPEN Thailand)	$r_{Fx,t} = \left(\frac{Exchange\ rate\left(\frac{Baht}{\$US}\right)_t - Exchange\ rate\left(\frac{Baht}{\$US}\right)_{t-1}}{Exchange\ rate\left(\frac{Baht}{\$US}\right)_{t-1}}\right) * 100$

[a] In this study, crude oil price is measured by West Texas price (WTI) instead of Dubai oil price since it well represents the whole world oil price movement. However, Dubai oil price, which is a good representative of Asia crude oil price, is also highly correlated with WTI with correlation coefficient of 94%.

(2) Autoregressive conditional heteroscedasticity (ARCH) model

Since daily data is employed in this study, it possible that variance of the error term of model equation (10) can be time volatile varied as claimed by [39] Engle (1979), thus, Autoregressive Conditional

Heteroscedasticity model should be employed. ARCH model has been employed by several studies [36, 38, 40].

This study employs ARCH (1) model, which can be stated as mean and variance equations models:

Mean Equation

$$y_{jt} = \alpha_j + \beta_{j1}x_{1t} + \beta_{j2}x_{2t} + \beta_{j3}x_{3t} + u_{jt} \tag{11}$$

Variance Equation

$$Var(u_t) = \sigma_{jt}^2 = \gamma_0 + \gamma_1\varepsilon_{jt-1}^2 + \varepsilon_{jt}$$

where σ_{jt}^2 is time-varying variance of error term u_{jt}, and ε_{jt} is white-noise process stochastic shock.

(3) Generalized autoregressive conditional heteroscedasticity (GARCH) model

However, according to Bollerslev [41], time-varying variance of error term behavior might also be generalized as determined by its previous variance, therefore, the model should be Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model. Several previous studies concerning on oil price, foreign exchange rate, and stock return have also applied GARCH model in their studies [1, 35-37, 40, 42-46]. The GARCH (1,1) model can be stated as:

Mean Equation

$$y_{jt} = \alpha_j + \beta_{j1}x_{1t} + \beta_{j2}x_{2t} + \beta_{j3}x_{3t} + u_{jt} \tag{12}$$

Variance Equation

$$Var(u_t) = \sigma_{jt}^2 = \gamma_0 + \gamma_1\varepsilon_{t-1}^2 + \gamma_2\sigma_{t-1}^2 + \varepsilon_t$$

Research processes of this study for each level analysis are (i) estimate traditional linear regression model (equation (10)) using Ordinary Least Squares (OLS), (ii) perform ARCH effects test to ensure time-vary volatility effects and estimate ARCH model (equation (11)) using Maximum Likelihood Estimation (MLE), and finally (iii) estimate GARCH model (equation (12)) using (MLE).

4. Empirical results

Empirical results of the two level analyses of the three models, traditional linear regression model, ARCH model, and GARCH model, are reported separately as (i) Aggregate level analysis, and (ii) Disaggregate level analysis:

4.1 Aggregate level analysis

As mentioned above, the aggregate level analysis reveals sectoral analysis of six major sectors of SET indices. The estimated results are divided into three estimated results of traditional linear regression models, ARCH models, and GARCH models.

(1) Estimated results of traditional linear regression model

The estimated results of linear regression models of six major sectors reveal positive significant impacts of oil price on Energy and Utilities sector index but negative significant impacts on Finance and Securities sector index and Properties Development sector indices, as shown in Table 2. Concerning on impacts of exchange rate, only negative significant impacts are found in Construction Material sector and Properties Development sector indices. However, according to ARCH effects tests of all models, significant ARCH effects are found in all models, thus, time-varying volatility ARCH model should be employed.

Table 2: Estimated results of traditional linear regression models of six major sectors indices

Variable		Ind1	Ind2	Ind3	Ind4	Ind5	Ind6
x_{1t}	β_1	1.1879 ***	0.9462 ***	1.1677 ***	0.9054 ***	0.9109 ***	1.0509 ***
x_{2t}	β_2	0.0290 ***	-0.0153	-0.0097	-0.0225 ***	0.0035	-0.0166 **
x_{3t}	β_3	0.0513	0.0508	-0.0347	-0.0139	-0.1168 **	-0.1335 **
Constant	α	-0.0110	-0.0068	-0.0035	0.0020	-0.0017	0.0058
N		2785	2785	2785	2785	2785	2785
RSS		1525.3746	4157.49	1689.98	2128.87	2264.58	1859.78
Log-L		-3113.5	-4509.7	-3256.2	-3577.6	-3663.7	-3389.5
F-test		4087.4442 ***	922.11 ***	3502.58 ***	1652.08 ***	1622.92 ***	2594.12 ***
R-square		0.8151	0.4987	0.7907	0.6406	0.6365	0.7367
Adj R2		0.8149	0.4981	0.7905	0.6402	0.6361	0.7364
ARCH Test		76.335 ***	9.155 ***	72.777 ***	195.522 ***	94.876 ***	52.608 ***

Note: * reveals statistically significant at 0.1, ** at 0.05, and *** at 0.01.

Where Ind1 represents estimated model of risk premium of Energy and Utilities sector, Ind2 represents estimated model of risk premium of Information Communication Technology (ICT) sector, Ind3 represents estimated model of risk premium of Banking sector, Ind4 represents estimated model of risk premium of Finance and Securities sector, Ind5 represents estimated model of risk premium of Construction Material (CONMAT) sector, and Ind6 represents estimated model of risk premium of Properties Development (PROP) sector.

(2) Estimated results of ARCH(1) models

Consistent with the ARCH effects tests, based on estimated variance ARCH equations of all sectors, the estimated results of ARCH models indicate significant estimated results of time-varying variance equations (all estimated coefficients of variance equations ($\hat{\gamma}_1$) of all six sectors are all statistical significant). Also, consistent with estimated results of traditional linear regression models in terms of same directions and magnitudes, the estimated results of ARCH models show positive significant impacts of oil price on Energy and Utilities sector index but negative significant impacts on Finance and Securities sector index, Properties Development sector indices, and Banking sector index as an additional significant sector, as shown in Table 3. Concerning on impacts of exchange rate, only negative significant impacts are found in Construction Material sector and Properties Development sector indices, which are similar to the results of traditional linear regression models.

Table 3: Estimated results of ARCH(1) models of six major sectors indices

Variable		Ind1	Ind2	Ind3	Ind4	Ind5	Ind6
Mean Equation							
x_{1t}	β_1	1.1901 ***	0.9240 ***	1.1477 ***	0.8987 ***	0.9111 ***	1.0398 ***
x_{2t}	β_2	0.0296 ***	-0.0141	-0.0105 *	-0.0184 ***	0.0038	-0.0177 ***
x_{3t}	β_3	0.0501	0.0213	-0.0605	0.0242	-0.1296 **	-0.1420 ***
Constant	α	-0.0163	0.0057	-0.0030	0.0045	-0.0131	0.0062
ARCH Equation							
arch	γ_1	0.2014 ***	0.1775 ***	0.1657 ***	0.1961 ***	0.1192 ***	0.1814 ***
_cons	γ_0	0.4389 ***	1.2477 ***	0.5063 ***	0.6152 ***	0.7130	0.5501 ***
N		2785	2785	2785	2785	2875	2875
ll		-3065.7	-4472.8	-3216.9	-3516.6	-3633.9	-3349.7
chi2		25532.63	10055.63	24380.85	14054.68	7032.98	14813.40

Note: * reveals statistically significant at 0.1, ** at 0.05, and *** at 0.01.

Where Ind1 represents estimated model of risk premium of Energy and Utilities sector, Ind2 represents estimated model of risk premium of Information Communication Technology (ICT) sector, Ind3 represents estimated model of risk premium of Banking sector, Ind4 represents estimated model of risk premium of Finance and Securities sector, Ind5 represents estimated model of risk premium of Construction Material (CONMAT) sector, and Ind6 represents estimated model of risk premium of Properties Development (PROP) sector.

However, ARCH(1) model only includes previous shock as only determinant of variance equation, as claimed by Bollerslev [41], its own lag term (or previous variance of error term) might also determine the current variance, thus, Generalized ARCH (GARCH) model should be employed and analyzed.

(3) Estimated results of GARCH(1,1) models

Similar to the estimated results of ARCH(1) models, based on estimated variance GARCH equations of all sectors, the estimated results of GARCH(1,1) models confirm significant time-varying impacts of variance of error terms (all estimated coefficients of variance equations ($\hat{\gamma}_1$ and $\hat{\gamma}_2$) of all six sectors are all statistical significant). Also, consistent with estimated results of traditional linear regression and ARCH(1) models in terms of same directions and magnitudes, the estimated results of GARCH(1,1) models illustrate positive significant impacts of oil price on Energy and Utilities sector index but negative significant impacts on Finance and Securities sector index, Properties Development sector indices, Banking sector index, and Information Communication Technology sector as an additional significant sector, as shown in Table 4. Concerning on impacts of exchange rate, only negative significant impacts are found in Construction Material sector and Properties Development sector indices, which are similar to the results of traditional linear regression and ARCH(1) models.

Table 4: Estimated results of GARCH(1,1) models of six major sectors indices

Variable		Ind1	Ind2	Ind3	Ind4	Ind5	Ind6
Mean Equation							
x_{1t}	β_1	1.1948 ***	0.949274 ***	1.159149 ***	0.880194 ***	0.906934 ***	1.032193 ***
x_{2t}	β_2	0.0269 ***	-0.01798 **	-0.01366 **	-0.0156 ***	-0.00233	-0.01661 ***
x_{3t}	β_3	0.0458	0.046348	-0.0581	0.013183	-0.14471 ***	-0.15574 ***
Constant	α	-0.0214	3.28E-05	0.001918	0.006408	-0.00888	0.006775
GARCH Equation							
arch	γ_1	0.1497 ***	0.109385 ***	0.074864 ***	0.12922 ***	0.07741 ***	0.105805 ***
garch	γ_2	0.6745 ***	0.821748 ***	0.871883 ***	0.741507 ***	0.843241 ***	0.813171 ***
_cons	γ_0	0.0924 ***	0.096969 ***	0.028748 ***	0.097777 ***	0.060827 ***	0.047277 ***
N		2785	2785	2785	2785	2785	2785
ll		-3021.1043	-4395.4	-3184.72	-3481.78	-3603.97	-3284.19
chi2		23595.6010	11215.07	18425.45	14632.98	6466.482	14721.44

Note: * reveals statistically significant at 0.1, ** at 0.05, and *** at 0.01.

Where Ind1 represents estimated model of risk premium of Energy and Utilities sector, Ind2 represents estimated model of risk premium of Information Communication Technology (ICT) sector, Ind3 represents estimated model of risk premium of Banking sector, Ind4 represents estimated model of risk premium of Finance and Securities sector, Ind5 represents estimated model of risk premium of Construction Material (CONMAT) sector, and Ind6 represents estimated model of risk premium of Properties Development (PROP) sector.

Based on the estimated results of the three models, concerning on properties of the data, the estimated results of GARCH(1,1) show that after including time-varying volatility impacts, both lag of itself and shock, impacts of oil price on sectoral stock returns can significantly and clearly be determined. The findings of GARCH(1,1) models confirm hypothesis of the study that oil price has significant impacts on stock returns. However, unclear evidences of the impacts of foreign exchange rate on stock returns are shown since only significant impacts on the returns of two sectors (Construction Material sector and Properties Development sectors) are found.

4.2 Disaggregate level analysis

In order to confirm and analyze the impacts of oil price and exchange rate on stock returns, single stock risk premium analyses are also analyzed by estimating single stock models of listed companies in two oil-related industries, including (i) oil-gas extraction and petroleum refinery as oil-directly-related industry and (ii) coal, electric, and gas services as oil-substitute industry. Similar to aggregate level analysis, the estimated results of disaggregate (single stock) level analysis can be divided into estimated results of traditional linear regression models, ARCH(1) models, and GARCH(1,1) models.

(1) Estimated results of traditional linear regression models

<u>Oil-directly-related Industry</u>

The estimated results of linear regression models of risk premium of each listed stocks in oil-directly-related industry reveal positive significant impacts of oil price on risk premium of ESSO (Thailand) Public Company Limited (ESSO), PTT Public Company Limited (PTT), PTT Exploration and Production Public Company Limited (PTTEP), Thai Oil Public Company Limited (TOP), PTT Global Chemical Public Company Limited (PTTGC), and Indorama Ventures Public Company Limited (IVL) but only negative impact on risk premium of Bangkok Aviation Fuel Services Public Company Limited (BAFS), as shown in Table 4-4. Concerning on impacts of exchange rate, the results show unclear evidences of the impacts. Only negative significant impacts are found on the risk premium of Bangchak Petroleum Public Company Limited (BCP) and PTT Exploration and Production Public Company Limited (PTTEP).

Oil-substitute Industry

The estimated results of linear regression models of risk premium of each listed stocks in oil-substitute industry illustrate positive significant impacts of oil price only on risk premium of Banpu Public Company Limited (BANPU) but negative impacts on Ratchaburi Electricity Generating Holding Public Company Limited (RATCH), as shown in Table 5. Concerning on impacts of exchange rate, the results show weak evidences of the impacts as only negative significant impact is found on the risk premium of Glow Energy Public Company Limited (GLOW).

However, according to ARCH effects tests of all single stock returns models, both oil-directly-related industry and oil-substitute industry, significant ARCH effects are detected in all estimated models, thus, time-varying volatility ARCH model should be applied.

Table 5: Estimated results of traditional linear regression models of single listed stocks in Oil-directly-related industry

Variable		S11	S12	S13	S14	S15
x_{1t}	β_1	0.4844 ***	0.8108 ***	1.110755 ***	1.260746 ***	1.313657 ***
x_{2t}	β_2	-0.0272 **	0.0138	0.048913 ***	0.01475	0.039831 ***
x_{3t}	β_3	-0.0725	-0.2003 *	0.211443	-0.03874	-0.00122
Constant	α	0.0658 **	0.0206	-0.0387	-0.00331	-0.00531
N		2779	2785	1982	2785	2782
RSS		6030.281	7406.202	7656.399	10185.02	4012.497
Log-L		-5019.68	-5313.71	-4151.61	-5757.36	-4456.93
F-test		164.0413	403.2544	371.1712	687.6897	1915.125
R-square		0.150629	0.303141	0.360184	0.425896	0.674073
Adj R2		0.149711	0.302389	0.359214	0.425277	0.673721
ARCH Test		54.268 ***	62.256 ***	21.338 ***	73.711 ***	113.489 ***

Variable		S16	S17	S18	S19	S110
x_{1t}	β_1	1.292943 ***	1.289713 ***	0.989782 ***	1.446934 ***	1.617618 ***
x_{2t}	β_2	0.053663 ***	0.030235 **	0.009029	0.063268 ***	0.084452 ***
x_{3t}	β_3	.179578*	0.020276	-0.14435	0.0444	-0.149
Constant	α	-0.0081	-0.01467	0.050034	-0.02924	0.026355
N		2785	2785	2781	2033	1552
RSS		7087.409	7306.811	20442.03	5446.153	8068.884
Log-L		-5252.44	-5294.89	-6719.81	-3886.36	-3481.41
F-test		1048.958	1007.974	213.2526	927.3557	321.6824
R-square		0.530861	0.520924	0.187241	0.578264	0.384015
Adj R2		0.530354	0.520407	0.186363	0.57764	0.382821
ARCH Test		122.706 ***	25.178 ***	28.791 ***	28.465 ***	29.139 ***

Note: * reveals statistically significant at 0.1, ** at 0.05, and *** at 0.01.

Where S11 represents estimated model of risk premium of Bangkok Aviation Fuel Services Public Company Limited (BAFS), S12 represents estimated model of risk premium of Bangchak Petroleum Public Company Limited (BCP), S13 represents estimated model of risk premium of ESSO (Thailand) Public Company Limited (ESSO), S14 represents estimated model of risk premium of IRPC Public Company Limited (IRPC), S15 represents estimated model of risk premium of PTT Public Company Limited (PTT), S16 represents estimated model of risk premium of PTT Exploration and Production Public Company Limited (PTTEP), S17 represents estimated model of risk premium of Thai Oil Public Company Limited (TOP), S18 represents estimated model of risk premium of SUSCO Public Company Limited (SUSCO), S19 represents estimated model of risk premium of PTT Global Chemical Public Company Limited (PTTGC), and S110 represents estimated model of risk premium of Indorama Ventures Public Company Limited (IVL).

Table 6: Estimated results of traditional linear regression models of single listed stocks in Oil-substitute industry

Variable		S21	S22	S23	S24	S25	S26
x_{1t}	β_1	1.197504 ***	0.439688 ***	0.653249 ***	1.153693 ***	1.237566 ***	0.452314 ***
x_{2t}	β_2	0.033187 **	0.009787	0.006665	0.022914	-0.0301	-0.02838 **
x_{3t}	β_3	0.17188	0.032591	-0.23784 *	0.092797	-0.3964	-0.01931
Constant	α	-0.00461	0.026292	0.048654	0.003718	0.047276	0.007391
N		2785	2785	2715	2785	2167	2785
RSS		9226.532	4681.004	10804.56	10821.51	31184.96	5764.978
Log-L		-5619.73	-4674.82	-5727.36	-5841.77	-5964.09	-4964.86
F-test		682.0366	181.5844	174.1096	539.3308	135.2112	150.1821
R-square		0.423879	0.163798	0.161545	0.36781	0.157918	0.139421
Adj R2		0.423257	0.162896	0.160617	0.367128	0.15675	0.138493
ARCH Test		11.752 ***	70.176 ***	62.158 ***	13.824 ***	26.748 ***	222.865 ***

Note: * reveals statistically significant at 0.1, ** at 0.05, and *** at 0.01.

Where S21 represents estimated model of risk premium of Banpu Public Company Limited (BANPU), S22 represents estimated model of risk premium of Electricity Generating Public Company Limited (EGCO), S23 represents estimated model of risk premium of Glow Energy Public Company Limited (GLOW), S24 represents estimated model of risk premium of Lanna Resources Public Company Limited (LANNA), S25 represents estimated model of risk premium of M.D.X. Public Company Limited (MDX), and S26 represents estimated model of risk premium of Ratchaburi Electricity Generating Holding Public Company Limited (RATCH).

(2) Estimated results of ARCH(1) models

Oil-directly-related Industry

Similar to aggregate (sectoral) level analysis, the estimated results of ARCH(1) models of single stocks are also consistent with the ARCH effects tests. Based on estimated variance ARCH equations of all listed stocks in oil-directly-related industry, the estimated results of ARCH(1) models reveal significant estimated results of time-varying variance equations (all estimated coefficients of variance equations ($\hat{\gamma}_1$) of all estimated models are all statistical significant). Also, similar to estimated results of traditional linear regression models in terms of same directions and magnitudes, the estimated results of ARCH(1) models illustrate positive significant impacts of oil price on risk premium of ESSO (Thailand) Public Company Limited (ESSO), PTT Public Company Limited (PTT), PTT Exploration and Production Public Company Limited (PTTEP), Thai Oil Public Company Limited (TOP), PTT Global Chemical Public Company Limited (PTTGC), and Indorama Ventures Public Company Limited (IVL) but only negative impact on risk premium of Bangkok Aviation Fuel Services Public Company Limited (BAFS), as shown in Table 7. Concerning on impacts of exchange rate, only negative significant impacts are found on on the risk premium of Bangchak Petroleum Public Company Limited (BCP) and PTT Exploration and Production Public Company Limited (PTTEP).

Table 7: Estimated results of ARCH(1) models of single listed stocks in oil-directly-related industry

Variable		S11		S12		S13		S14		S15	
Mean Equation											
x_{1t}	β_1	0.4642	***	0.7803	***	1.0969	***	1.2240	***	1.2966	***
x_{2t}	β_2	-0.0280	***	0.0034		0.0474	***	0.0007		0.0335	***
x_{3t}	β_3	-0.1216		-0.2806	***	0.1637		-0.0937		0.0042	
_cons	α	0.0556	**	0.0110		-0.0419		-0.0382		-0.0145	
ARCH: Variance Equation											
arch	γ_1	0.2362	***	0.2616	***	0.1586	***	0.3739	***	0.1912	***
_cons	γ_0	1.7021	***	2.0212	***	3.3079	***	2.4460	***	1.1587	***
N		2779		2785		1982		2785		2782	
ll		-4941.2		-5239.74		-4126.2		-5612.51		-4398.58	
chi2		1096.847		4475.196		1726.918		4631.049		9647.667	

Variable		s16		S17		S18		S19		S110	
Mean Equation											
x_{1t}	β_1	1.2861	***	1.3263	***	0.9029	***	1.4141	***	1.5941	***
x_{2t}	β_2	0.0548	***	0.0298	***	-0.0150		0.0685	***	0.1011	***
x_{3t}	β_3	0.1803	**	0.0343		-0.0635		0.0377		-0.1109	
_cons	α	-0.0411		-0.0379		-0.0051		-0.0470		0.0028	
ARCH: Variance Equation											
arch	γ_1	0.2497	***	0.1921	***	0.3969	***	0.1820	***	0.2572	***
_cons	γ_0	1.9146	***	2.1589	***	5.0458	***	2.2211	***	3.9680	***
N		2785		2785		2781		2033		1552	
ll		-5172.38		-5260.67		-6590.45		-3862.57		-3446.12	
chi2		5914.771		8575.283		909.8492		4558.122		1351.706	

Note: * reveals statistically significant at 0.1, ** at 0.05, and *** at 0.01.

Where S11 represents estimated model of risk premium of Bangkok Aviation Fuel Services Public Company Limited (BAFS), S12 represents estimated model of risk premium of Bangchak Petroleum Public Company Limited (BCP), S13 represents estimated model of risk premium of ESSO (Thailand) Public Company Limited (ESSO), S14 represents estimated model of risk premium of IRPC Public Company Limited (IRPC), S15 represents estimated model of risk premium of PTT Public Company Limited (PTT), S16 represents estimated model of risk premium of PTT Exploration and Production Public Company Limited (PTTEP), S17 represents estimated model of risk premium of Thai Oil Public Company Limited (TOP), S18 represents estimated model of risk premium of SUSCO Public Company Limited (SUSCO), S19 represents estimated model of risk premium of PTT Global Chemical Public Company Limited (PTTGC), and S110 represents estimated model of risk premium of Indorama Ventures Public Company Limited (IVL).

Oil-substitute Industry

The estimated results of ARCH(1) models of risk premium of each listed stocks in oil-substitute industry are also similar to the results of traditional linear regression models in terms of directions, magnitudes, and statistical significances, which reveal positive significant impacts of oil price only on risk premium of Banpu Public Company Limited (BANPU) but negative impacts on Ratchaburi Electricity Generating Holding Public Company Limited (RATCH), as shown in Table 8. Concerning on impacts of exchange rate, the results also show weak evidences of the impacts. Only negative significant impact is found on the risk premium of Glow Energy Public Company Limited (GLOW).

Table 8: Estimated results of ARCH(1) models of single listed stocks in oil-substitute industry

Variable		S21		S22		S23		S24		S25		S26	
Mean Equation													
x_{1t}	β_1	1.1792	***	0.4060	***	0.6630	***	1.0870	***	1.1924	***	0.4766	***
x_{2t}	β_2	0.0275	**	0.0127		0.0105		0.0094		0.0027		-0.0344	***
x_{3t}	β_3	0.1227		0.0197		-0.3575	***	0.0045		-0.1153		-0.0734	
_cons	α	-0.0203		0.0213		0.0455		-0.0232		0.0707		-0.0134	
ARCH: Variance Equation													
arch	γ_1	0.2422	***	0.2079	***	0.2560	***	0.4375	***	0.7213	***	0.3650	***
_cons	γ_0	2.6261	***	1.3470	***	3.0507	***	2.5296	***	7.6008	***	1.3363	***
N		2785.0000		2785.0000		2715.0000		2785		2167		2785	
ll		-5576.2700		-4620.8700		-5662.5300		-5693.07		-5763.76		-4760.76	
chi2		3477.712		1212.024		1460.808		4209.890		1246.631		2122.095	

Note: * reveals statistically significant at 0.1, ** at 0.05, and *** at 0.01.

Where S21 represents estimated model of risk premium of Banpu Public Company Limited (BANPU), S22 represents estimated model of risk premium of Electricity Generating Public Company Limited (EGCO), S23 represents estimated model of risk premium of Glow Energy Public Company Limited (GLOW), S24 represents estimated model of risk premium of Lanna Resources Public Company Limited (LANNA), S25 represents estimated model of risk premium of M.D.X. Public Company Limited (MDX), and S26 represents estimated model of risk premium of Ratchaburi Electricity Generating Holding Public Company Limited (RATCH).

(3) Estimated results of GARCH(1,1) models

Oil-directly-related industry

The estimated results of GARCH(1,1) of the single listed stock in oil-directly related industry also show significant evidences of time-varying impacts of variance of error terms (all estimated coefficients of variance equations ($\hat{\gamma}_1$ and $\hat{\gamma}_2$) of all models are all statistical significant). The estimated results also confirm positive significant impacts of oil price on risk premium of ESSO (Thailand) Public Company Limited (ESSO), PTT Public Company Limited (PTT), PTT Exploration and Production Public Company Limited (PTTEP), Thai Oil Public Company Limited (TOP), PTT Global Chemical Public Company Limited (PTTGC), and Indorama Ventures Public Company Limited (IVL) but only negative impact on risk premium of Bangkok Aviation Fuel Services Public Company Limited (BAFS), as shown in Table 9. Also, weak evidence of impacts of exchange rate are also found since only negative significant impacts are found on the risk premium of Bangchak Petroleum Public Company Limited (BCP) and PTT Exploration and Production Public Company Limited (PTTEP).

Table 9: Estimated results of GARCH(1,1) models of single listed stocks in oil-directly-related industry

Variable		S11		S12		S13		S14		S15	
Mean Equation											
x_{1t}	β_1	0.4406	***	0.7828	***	1.1086	***	1.2416	***	1.2931	***
x_{2t}	β_2	-0.0176	*	-0.0031		0.0360	**	-0.0074		0.0335	***
x_{3t}	β_3	-0.1380	*	-0.2820	***	0.1454		-0.0697		0.0030	
_cons	α	0.0634	***	0.0146		-0.0772	**	-0.0307		-0.0266	
GARCH: Variance Equation											
arch	γ_1	0.1666	***	0.1566	***	0.0708	***	0.2367	***	0.1477	***
garch	γ_2	0.7172	***	0.6873	***	0.8785	***	0.6395	***	0.7275	***
_cons	γ_0	0.2761	***	0.4119	***	0.1755	***	0.4935	***	0.1706	***
N		2779		2785		1982		2785		2782	
ll		-4886.680		-5202.800		-4100.650		-5525.220		-4330.470	
chi2		1016.699		3032.037		1840.638		5902.550		9160.811	

Variable		S16		S17		S18		S19		S110	
Mean Equation											
x_{1t}	β_1	1.2588	***	1.3132	***	0.8434	***	1.4255	***	1.5861	***
x_{2t}	β_2	0.0516	***	0.0266	***	-0.0149		0.0554	***	0.0591	***
x_{3t}	β_3	0.2096	**	0.0481		-0.1506		0.0301		-0.1313	
_cons	α	-0.0510	*	-0.0321		-0.0628	*	-0.0413		-0.0344	
GARCH: Variance Equation											
arch	γ_1	0.1761	***	0.1846		0.3174	***	0.1339	***	0.1280	***
garch	γ_2	0.6920	***	0.5549	***	0.6399	***	0.6219	***	0.7867	***
_cons	γ_0	0.3262	***	0.6913	***	0.8158	***	0.6185	***	0.4213	***
N		2785		2785		2781		2033		1552	
ll		-5098.99		-5227.49		-6472.12		-3844.56		-3413.05	
chi2		5126.828		6252.9		1258.694		4092.464		1472.33	

Note: * reveals statistically significant at 0.1, ** at 0.05, and *** at 0.01.

Where S11 represents estimated model of risk premium of Bangkok Aviation Fuel Services Public Company Limited (BAFS), S12 represents estimated model of risk premium of Bangchak Petroleum Public Company Limited (BCP), S13 represents estimated model of risk premium of ESSO (Thailand) Public Company Limited (ESSO), S14 represents estimated model of risk premium of IRPC Public Company Limited (IRPC), S15 represents estimated model of risk premium of PTT Public Company Limited (PTT), S16 represents estimated model of risk premium of PTT Exploration and Production Public Company Limited (PTTEP), S17 represents estimated model of risk premium of Thai Oil Public Company Limited (TOP), S18 represents estimated model of risk premium of SUSCO Public Company Limited (SUSCO), S19 represents estimated model of risk premium of PTT Global Chemical Public Company Limited (PTTGC), and S110 represents estimated model of risk premium of Indorama Ventures Public Company Limited (IVL).

Oil-substitute industry

The estimated results of GARCH(1,1) models of risk premium of each listed stocks in oil-substitute industry also illustrate similar to the results of traditional linear regression and ARCH(1) models in terms of directions, magnitudes, and statistical significances, which help confirming positive significant impacts of oil price only on risk premium of Banpu Public Company Limited (BANPU) but negative impacts on Ratchaburi Electricity Generating Holding Public Company Limited (RATCH), as shown in Table 10. Concerning on impacts of exchange rate, the results also confirm weak evidences of the impacts since only negative significant impact of exchange rate on the risk premium of Glow Energy Public Company Limited (GLOW) is shown in estimated results of all models.

Table 10: Estimated results of GARCH(1,1) models of single listed stocks in oil-substitute industry

Variable		S21		S22		S23		S24		S25		S26	
Mean Equation													
x_{1t}	β_1	1.1560	***	0.3962	***	0.6685	***	1.1049	***	1.1037	***	0.4524	***
x_{2t}	β_2	0.0335	***	0.0107		0.0010		0.0043		0.0211		-0.0145	*
x_{3t}	β_3	0.0657		0.0148		-0.2253	**	0.0905		-0.0819		-0.0732	
_cons	α	-0.0514	*	0.0204		0.0433		-0.0217		0.0455		-0.0076	
GARCH: Variance Equation													
arch	γ_1	0.1714	***	0.0897	***	0.1293	***	0.2988	***	0.4236	***	0.1601	***
garch	γ_2	0.7654	***	0.8084	***	0.8412	***	0.3739	***	0.4855	***	0.8109	***
_cons	γ_0	0.2333	***	0.1701	***	0.1537	***	1.3247	***	2.7246	***	0.1021	***
N		2785		2785		2715		2785		2167		2785	
ll		-5459.33		-4609.53		-5604.35		-5646.31		-5710.31		-4710.26	
chi2		3462.973		989.7247		1084.325		3840.872		826.3976		1312.421	

Note: * reveals statistically significant at 0.1, ** at 0.05, and *** at 0.01.

Where S21 represents estimated model of risk premium of Banpu Public Company Limited (BANPU), S22 represents estimated model of risk premium of Electricity Generating Public Company Limited (EGCO), S23 represents estimated model of risk premium of Glow Energy Public Company Limited (GLOW), S24 represents estimated model of risk premium of Lanna Resources Public Company Limited (LANNA), S25 represents estimated model of risk premium of M.D.X. Public Company Limited (MDX), and S26 represents estimated model of risk premium of Ratchaburi Electricity Generating Holding Public Company Limited (RATCH).

5. Discussion and conclusion

This study intends to reveal impacts of oil price and exchange rate on stock exchange of Thailand. Concerning on properties of econometric models, since this study employs daily data, the empirical findings found significant Generalized Autoregressive Conditional Heteroscedasticity (GARCH) effects in all models. Similar to previous studies [35-38, 40, 42-46], this study also confirms that GARCH models should be employed when estimating model using daily data since time-varying volatility pattern can occur. Taking in to account of GARCH effects can help correctly determine the impacts of all factors in the model.

Focusing on impacts of oil price on stock prices, the estimated results of both aggregate and disaggregate level analyses provide significant estimated coefficients of oil price on oil-related industry which confirm hypothesis of this study. Similar to Faff & Brailsford [18], Sadorsky [19], Basher, S. A., & Sadorsky, P.[20], El-Sharif, et al. [21] and Nandha & Faff [22], this study finds similar results that world oil price has significant impacts on oil-related stock prices both aggregate and disaggregate levels. Additionally, this study reveals that the directions of the impacts vary according to industry. Positive significant impacts are found in Energy and Utilities sector index and oil-directly-related stock prices while negative significant impacts are determined in Finance and Securities sector index, Properties Development sector indices, Banking sector index, and Information Communication Technology sector. However, the results show unclear direction and insignificant impacts of oil price on oil-substitute stock prices. As a result, the findings confirm hypothesis that oil price have significant impacts on oil-directly-related stock prices due to their business mainly and heavily relied on oil while inconclusively prove influences of oil price on stock prices of oil-substitute business listed companies.

Concerning on impacts of exchange rate on stock prices, unlike the findings from previous studies of Sadorsky [19], Basher, S. A., & Sadorsky, P. [20], El-Sharif, et al. [21] and Nandha & Faff [22], the empirical results in this study show inconclusive evidences of the impacts since only few significant coefficients of exchange rate are determined. The findings can be explained by the fact that after Thai financial crisis in 1997, most listed companies in Thailand, especially the companies in oil-related sectors, have experience and learn to hedge their position from foreign exchange rate risk, thus, foreign exchange rate has less and insignificant impact on Thai stock prices in these sectors.

According to the findings, fund managers and investors invested in SET should be aware of impacts of oil price on stock prices of oil-related business listed companies, which have clearly determined in this study, when making decision to invest in these particular companies. Alternatively, they should consider to lowering the risk from oil price volatility by hedging their position in the oil future market. Accordingly, this study has found less and insignificant impacts of exchange rate on prices of the stocks, which might be evidences of the implementation of exchange rate hedging strategy of the listed companies in SET after Thailand financial crisis in 1997. Therefore, executive officers of the oil-related listed companies should also consider implementing oil price hedging strategy through oil derivative markets, such as oil future market.

References

[1] Kilian L, "Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market," American Economic Review, 99 (2009) 1053-1069.

[2] Kilian L and Park, C, "The impact of oil price shocks on the U.S. stock market," INTERNATIONAL ECONOMIC REVIEW, 50 (2009) 1267–1287.

[3] Sinha A, "Nature of Energy Index Volatility in Post Financial Crisis Period: Evidences from India," Energy Procedia, 75 (2015) 2556-2562.

[4] Razmi F, Azali M, Chin L and Shah Habibullah M, "The role of monetary transmission channels in transmitting oil price shocks to prices in ASEAN-4 countries during pre- and post-global financial crisis," Energy, 101 (2016) 581-591.

[5] Morana C, "Oil price dynamics, macro-finance interactions and the role of financial speculation," Journal of Banking & Finance, 37 (2013) 206-226.

[6] Dungey M and Gajurel D, "Equity market contagion during the global financial crisis: Evidence from the world's eight largest economies," Economic Systems, 38 (2014) 161-177.

[7] Kaufmann RK and Ullman B, "Oil prices, speculation, and fundamentals: Interpreting causal relations among spot and futures prices," Energy Economics, 31 (2009) 550-558.

[8] Kaufmann RK, "The role of market fundamentals and speculation in recent price changes for crude oil," Energy Policy, 39 (2011) 105-115.

[9] Haase M, Seiler Zimmermann Y and Zimmermann H, "The impact of speculation on commodity futures markets – A review of the findings of 100 empirical studies," Journal of Commodity Markets, 3 (2016) 1-15.

[10] Dimpfl T, Flad M and Jung RC, "Price discovery in agricultural commodity markets in the presence of futures speculation," Journal of Commodity Markets, 5 (2017) 50-62.

[11] Cifarelli G and Paladino G, "A dynamic model of hedging and speculation in the commodity futures markets," Journal of Financial Markets, 25 (2015) 1-15.

[12] Huchet N and Fam PG, "The role of speculation in international futures markets on commodity prices," Research in International Business and Finance, 37 (2016) 49-65.

[13] Bouri E, Chen Q, Lien D and Lv X, "Causality between oil prices and the stock market in China: The relevance of the reformed oil product pricing mechanism," International Review of Economics & Finance, 48 (2017) 34-48.

[14] Gogolin F and Kearney F, "Does speculation impact what factors determine oil futures prices," Economics Letters, 144 (2016) 119-122.

[15] Antonakakis N, Chatziantoniou I and Filis G, "Oil shocks and stock markets: Dynamic connectedness under the prism of recent geopolitical and economic unrest," International Review of Financial Analysis, 50 (2017) 1-26.
[16] Chen H, Liao H, Tang B-J and Wei Y-M, "Impacts of OPEC's political risk on the international crude oil prices: An empirical analysis based on the SVAR models," Energy Economics. 57 (2016) 42-49.
[17] Monge M, Gil-Alana LA and Pérez de Gracia F, "Crude oil price behaviour before and after military conflicts and geopolitical events," Energy, 120 (2017) 79-91.
[18] Faff RW and Brailsford TJ, "Oil price risk and the Australian stock market," Journal of Energy Finance & Development, 4 (1999) 69-87.
[19] Sadorsky P, "Risk factors in stock returns of Canadian oil and gas companies," Energy Economics, 23 (2001) 17-28.
[20] Basher SA and Sadorsky P, "Oil price risk and emerging stock markets," Global Finance Journal, 17 (2006) 224-251.
[21] El-Sharif I, Brown D, Burton B, Nixon B and Russell A, "Evidence on the nature and extent of the relationship between oil prices and equity values in the UK," Energy Economics, 27 (2005) 819-830.
[22] Nandha M and Faff R, "Does oil move equity prices: A global view," Energy Economics, 30 (2008) 986-997.
[23] Boyer MM and Filion D, "Common and fundamental factors in stock returns of Canadian oil and gas companies," Energy Economics, 29 (2007) 428-453.
[24] Markowitz H, "Portfolio Selection," Journal of Finance, 7(1) (1952) 77–99.
[25] Markowitz H, "Portfolio Selection: Efficient Diversification of Investments," Cowles Foundation Monograph New York: John Wiley &Sons, Inc. 1959;Monograph No. 16. .
[26] M.C. J, "The Performance of Mutual Funds In The Period 1945-1964," Journal of Finance, 23 (1967) 389-416.
[27] Ross SA, "The arbitrage theory of capital asset pricing. Journal of Economic Theory," 13 (1976) 341-360.
[28] Jones CM and Kaul, G., "Oil and the Stock Markets" Journal of Finance 51 (1996) 463–91.
[29] Papapetrou E, "Oil price shocks, stock market, economic activity and employment in Greece," Energy Economics, 23 (2001) 511-532.
[30] Park J and Ratti RA, "Oil price shocks and stock markets in the U.S. and 13 European countries" Energy Economics, 30 (2008) 2587-2608.
[31] Driesprong G, Jacobsen B and Maat B, "Striking oil: Another puzzle," Journal of Financial Economics, 89 (2008) 307-27.
[32] Roger D, Huang Ronald W and Masulis HRS, "Energy Shocks and Financial Markets" Journal of Futures Markets, 16 (1996) 39–56.
[33] Cong R-G, Wei Y-M, Jiao J-L and Fan Y, "Relationships between oil price shocks and stock market: An empirical analysis from China," Energy Policy, 36 (2008) 3544-3553.
[34] Basher SA, Haug AA and Sadorsky P, "Oil prices, exchange rates and emerging stock markets," Energy Economics, 34 (2012) 227-240.
[35] Narayan PK, Narayan S and Prasad A, "Understanding the oil price-exchange rate nexus for the Fiji islands," Energy Economics, 30 (2008) 2686-2696.
[36] Narayan PK and Narayan S, "Modelling the impact of oil prices on Vietnam's stock prices," Applied Energy, 87 (2010) 356-361.
[37] Oberndorfer U, "Energy prices, volatility, and the stock market: Evidence from the Eurozone," Energy Policy, 37 (2009) 5787-5795.
[38] Hedi Arouri ME and Khuong Nguyen D, "Oil prices, stock markets and portfolio investment: Evidence from sector analysis in Europe over the last decade," Energy Policy, 38 (2010) 4528-4539.
[39] Engle RF, "Autoregressive Conditional Heteroscedasticity With Estimates of th Variance of United Kingdom Inflation," Econometrica, 50 (1982) 987-1008.
[40] Broadstock DC, Cao H and Zhang D, "Oil shocks and their impact on energy related stocks in China," Energy Economics, 34 (2012) 1888-1895.

[41] Bollerslev T, "Generalised Autoregressive Conditional Heteroskedasticity," Journal of Econometrics, 31 (1986) 307–327.
[42] Ghosh S, "Examining crude oil price – Exchange rate nexus for India during the period of extreme oil price volatility," Applied Energy, 88 (2011) 1886-1889.
[43] Efimova O and Serletis A, "Energy markets volatility modelling using GARCH," Energy Economics, 43 (2014) 264-273.
[44] Jiranyakul K, "Does oil price uncertainty transmit to the Thai stock market," Journal of Economic & Financial Studies, 2 (2014) 16.
[45] Aloui R and Ben Aïssa MS, "Relationship between oil, stock prices and exchange rates: A vine copula based GARCH method," The North American Journal of Economics and Finance, 37 (2016) 458-71.
[46] Sanusi MS and Ahmad F, "Modelling oil and gas stock returns using multi factor asset pricing model including oil price exposure," Finance Research Letters, 18 (2016) 89-99.