The Effects of oil price on Thailand's SET Index: Quantile regression case study

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ผลกระทบของราคาน้ำมันต่อดัชนีราคาหุ้นตลาดหลักทรัพย์ฯด้วยควอนไทล์รีเกรสชั่น

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จุฑินันท์ เรืองโอภาษ : ผลกระทบของราคาน้ำมันต่อดัชนีราคาหุ้นตลาดหลักทรัพย์ฯ ด้วยควอนไทล์รีเกรสชั่น . (The Effects of oil price on Thailand’s SET Index: Quantile regression case study) อ.ที่ปรึกษาหลัก : นิพิฐ วงศ์ปัญญา

การวิจัยนี้ได้พยายามหาความความสัมพันธ์ระหว่างราคาหุ้นของประเทศไทยและราคาน้ำมันโดยการใช้ควอนไทล์ รีเกรสชั่นและข้อมูลเศรษฐกิจของประเทศไทย การวิจัยนี้ได้ค้นพบว่าราคาน้ำมันและราคาหุ้นมีความสัมพันธ์เชิงบวกในขณะที่ดอกเบี้ยระยะสั้นอัตราแลกเปลี่ยนเงินตราระหว่างประเทศและดัชนีราคาผู้บริโภคมีความสัมพันธ์เชิงลบกับราคาหุ้นไทย

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This paper attempts to explore the relationship between oil price and stock price using quantile regression for Thailand's economic data to generate several models. The main findings are that Thailand's oil price has a positive relationship with stock price. Increase in oil price result in increase of stock price. Additionally, short term interest rates, nominal exchange rate and CPI have a negative relationship with stock price. An increase in these variables cause stock prices to fall.

Field of Study:	Business and Managerial Economics	Student's Signature ....
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TABLE OF CONTENTS

List of Equations

List of Figures

List of Tables

1. Introduction

It is well known that COVID 19 has disrupted supply chains globally. Delays and disruptions caused by reasons such as lockdowns has thrown the global economy into chaos. In addition, the recent conflict between Russia and Ukraine has disrupted supply chains even further. The conflict between these two countries has limited global supply of natural gas and crude oil due to sanctions imposed on Russia by other nations such as the US and EU, causing prices of various products to rise drastically because of inflation and rising oil prices. Hence, it can be inferred that oil price does have an effect on the global economy. On the other hand, stock prices are believed to be a representation of economic performance from various empirical research papers. A fall in stock prices suggests that an economy is having poorer economic performances recently and vice versa.

Therefore, it can be inferred that stock prices and oil prices share a common link that is economic performance. In addition, empirical research suggests that there is a relationship between oil price and stock prices. In one of the research papers, it was mentioned that "Oil is a key source of energy in the economy and is often measured an indicator of economic steadiness due to its high dependence on oil products" (Alamgir & Gamin, 2021).

If we were to approach this relationship from the supply point of view, an increase in oil price leads to higher production cost of both direct and indirect oil dependent goods which lowers the availability of inputs available in production of goods and services. Similarly, from the demand point of view, increase in oil prices lowers their consumption and decrease their purchasing power. The fact that oil price is a determinant of economic performance suggests that fluctuations in oil price can have an effect on stock price that is an indicator of economic performance. It also allows us to infer to what extent does a country's economy rely on oil.

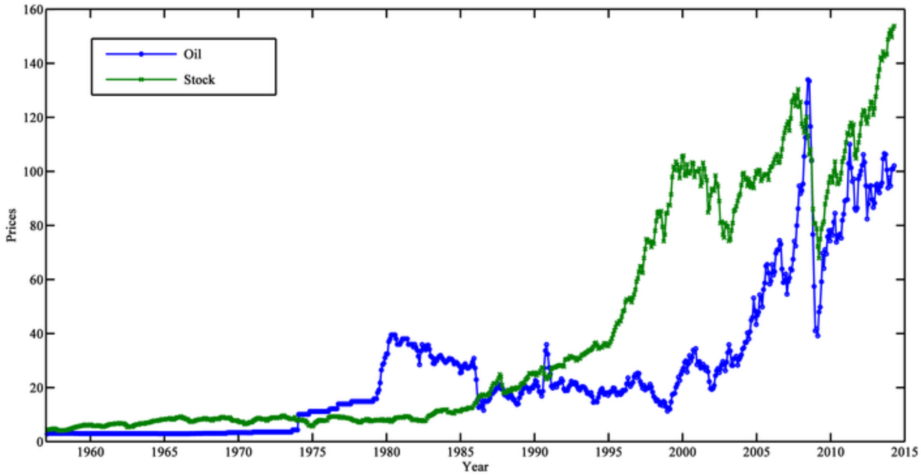

Figure 1 Oil Price and Stock Price Relationship

This relationship can be observed in the real world as well. Naser, H., & Alaali, F. (2017) have created a graph mapping WTI Oil price and S&P 500 stock prices. Between 1980 and 1990, it can be observed that decrease in oil price is followed by an increase in stock prices. However, beyond 1990, the relationship became positive. Increase in oil price leads to increase in stock prices.

In order to test out these various hypothesis and theories, this paper will attempt to measure the effect of oil price on stock market index values to measure the strength of the relationship between oil price and stock market index using Thailand's economic data as a case study. This paper uses only Thailand's data because most of the previous research conducted measures the effects of oil price shocks on stock prices on the global economy or on rich countries such as the United States, United Kingdom and G7 economies. There were little amount of research containing results related to South East Asian countries in general.

2. Literature Review

This section contains all the relevant research papers and sources that were used to help shape this research paper's methodology.

As mentioned earlier, there has been many research conducted to discover the relationship between oil price and stock price. To summarize the vast amount of information and discoveries related to stock and oil prices, the research written by Degiannakis (2018) will be referred to. This paper summarizes the findings of various empirical research into 1 paper. They summarized their major findings into 5 separate points. Degiannakis et al first major finding was that the majority of empirical studies which use aggregate stock market indices suggest that for oil importing countries, increase in oil price causes a decrease in stock returns and vice versa. Secondly, they discovered that another factor other than a country being an oil importer or oil exporter, oil dependency of the Industrial in a particular country is another key factor. If a country's industrial sector relies heavily on oil, they are more prone to have negative relationship between oil and stock prices while countries' industrial sector that rely on oil substitutes and oil related goods show positive relationship between oil price and stock price. Thirdly, the relationship between oil price and stock price is time varying and is also driven by economic and geopolitical events around the world. Fourthly it is found that oil price volatility has significant effect on a stock market's volatility except for the US. Lastly, their fifth major finding is that the evidence from forecasting researches suggests that including stock market information into oil price and oil price volatility forecasting models improves the model's performance.

The main research paper that serves as the backbone of this research is the paper the paper Young. C Joo and Sung. Y Park (2021). They used bond return and unemployment return across the 10 highest oil importing countries (China, France, Germany, India, Italy, Japan, Korea, the Netherlands, Spain, and the U.S.) and Oil Volatility Index (OVX) as their data. Their data covered from May 2007 to December 2019 in monthly intervals and were collected from online sources including the OECD database, stock indices from Datastream and OVX from Chicago board options exchange (CBOE). Their major finding was that the more volatile oil price is, the more negative impact there is on stock returns causing stock returns to decrease. The relationship is at its strongest for the top four oil importing countries that are: United States of America, Japan, India and Korea.

Similarly, another study has also conducted quantile regression to find the relationship between exchange rate and oil price and oil price volatility. A study attempted to measure this relationship was conducted by Salah. A Nuzair and Dennis Olson (2018) in which they performed quantile regression between real exchange rate returns and oil price returns of countries in Asia including: Indonesia, Japan, Korea, Malaysia, Philippines, Singapore and Thailand. Quarterly data of Nominal exchange rate, CPI and Dubai oil price from the Asian countries mentioned was obtained from IMF's International Financial Statistics Online Database. The time period of this data set was between 1973 2nd quarter and 2016 4th quarter. Their main finding was that regardless of whether the oil price shock is positive or negative, oil price shocks has asymmetric effects on currency markets although results vary from country to country.

Another factor often associated with stock price is real GDP. Zmami and Ben-Salha (2020) have also performed quantile regression between oil prices and real GDP of GCC (Gulf Cooperation Council) oil exporting countries including: Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates using data from 1960 to 2018 from online sources. Unlike the previous quantile regression papers, their findings from the quantile regression approach can be broken down into 2 categories, symmetric and asymmetric effects on economic growth. Their symmetric results found that real GDP and oil price have significant and positive relationship. The country with the strongest relationship was Oman. As for their asymmetric results, it was found that only the United Arab Emirates' and Oman economies will be negatively affected if there is a decrease in oil prices. The other countries' economies will not be negatively affected by reduction in oil prices.

A rather unusual variable namely precious metal prices relationship with oil price was explored by Shafiullah. This was unlike most of the paper in this field of study since most researchers are concerned with economic indices rather than price of other assets. Shafiullah et al (2020) utilized quantile regression like other papers earlier to discover the long run dependence and causality between oil and precious metal prices. Their precious metal prices consisting of gold, silver, platinum, palladium, steel and titanium were obtained from World Metal Statistics, World Bureau of Metal Statistics and World Bank staff estimates (World Bank, 2019), oil prices were obtained from the U.S. Energy Information Administration (EIA). The data ranged from January 1990 to September 2019; monthly data was collected. Their compiled monthly data was seasonally adjusted with the X12 approach unlike other quantile regression papers that at most took log form or logarithmic first differences. Shafiullah et al (2020) believed that the relationship between oil price and precious metal price is a positive one. Their results do support their initial hypothesis for most of the precious metal prices. This relationship was not supported only in the lower quantiles of gold and silver only.

Alternatives to quantile regression used in this field of study is VAR (vector autoregressive) model and the GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model. These methods were employed by Elena Maria Diaz, Juan Carlos Molero, Fernando Perez de Gracia (2014). Their data consisted of short term interest rates, seasonally adjusted Industrial Production Index, oil prices and stock prices that were obtained from International Financial Statistics, Federal Reserve Bank of St. Louis economic data (FRED) and US energy information administration. Certain variables in this paper overlap with quantile regression paper's variable as well. Their data set was collected in monthly intervals and their results are similar to Joo and Park (2021) that an increase in oil price volatility has negative results on the G7's stock market and that "world oil price volatility is generally more significant for stock markets than the national oil price volatility" (Diaz et al, 2014, p 417).

Inflation is another common factor often related to oil price. Siok Kun Seka, Xue Qi Teoa and Yen Nee Wonga (2015) conducted an empirical study to measure the effects of change in oil prices on inflation of 2 groups of countries; countries that are highly dependent on oil and countries with low oil dependency. Their chosen empirical method was the autoregressive distributed lag model (ARDL), another alternative to quantile regression. Sion Kun Seka et al (2015) collected their data from world bank and OECD.org. Similar to the quantile regression papers, the variables included in this model includes: GDP, CPI, Real effective exchange rate (REER, index), oil dependency index, producer price index (PPI) and world oil price (US dollar per barrel) again, all variables similar to other previously mentioned research. For highly oil dependent countries, the main determinants for domestic inflation are real exchange rate and production cost in the long run while in the short run, domestic output and real exchange rate are the main contributors. As for countries with low dependency on oil, the 2 major factors are domestic output and producer costs.

Amalgir and Amin (2021) also used the ARDL model to find the link between stock and oil prices in 4 South Asian countries including: Bangladesh, Sri Lanka, India and Pakistan. They used return on asset of stocks as their dependent variable and as for their independent variables, it consists of: Unconditional expected returns, vectors that measure the response of each asset return to each risk factor and oil price shocks which were separated into positive and negative shocks. These factors are very different to what Siok et al (2015) has used, as a user of the ARDL model. Their data set was collected from Bloomberg and US Energy Information and Association Website (EIA). Overall, across the several models they developed, it was concluded that the positive relationship between oil price and stock market index affects both short run and long run. The explanation for this was that there could be common factors between oil price and stock market index that makes them react in the same direction.

To summarize the literature review, table 1 shown below displays the variables that authors in the literature review has used in their research, their methodology and variables that they have used in their analysis

Authors	Variables used	Methodology
Joo, Y. C., & Park, S. Y. (2021)	Stock return, bond price, oil price volatility, unemployment	Quantile Regression
Diaz, E. M., Molero, J. C., & De Gracia, F. P. (2016)	Short term interest rates, industrial production index, oil price, oil price volatility, stock price	VAR & GARCH
Sek, S. K., Teo, X. Q., & Wong, Y. N. (2015)	GDP, CPI, REER, PPI, Oil Price	ARDL
Alamgir, F., & Amin, S. B. (2021)	ROA, Expected Returns, Oil Price	ARDL
Nusair, S. A., & Olson, D. (2019)	Nominal exchange rate, CPI, Oil price	Quantile Regression
Zmami, M., & Ben-Salha, O. (2020)	Oil price, real GDP	Quantile regression

Table 1 Summary of Literature Review

3. Methodology

This section outlines how the empirical results of this research paper was achieved and what steps were taken to achieve the results. As mentioned in the introduction, the chosen method for conducting this research is quantile regression, the same method which Joo and Park (2021) and several other authors have conducted.

Quantile regression is an extension of the regular linear regression. Regular linear regression estimates the relationship between a set of input variables and an output variable based on the conditional mean while quantile regression estimates the relationship between input variables based on the conditional median. OLS assumes a certain type of parametric distribution of the response variable is present and that the variance of the response variable is constant while quantile regression does not do so. By relaxing the assumptions, quantile regression can describe the continuous distribution of the response variable entirely as they are split into quantiles. Quantiles in statistics are defined as the points which divide the probability distribution are separated into continuous intervals that have equal probabilities. In other words, they are points where the ordered samples are divided equally into a certain number of groups. This means that a set of coefficients are generated for the independent variable depending on the data spread of the independent variable.

$$Q_r(y_i) = \beta_0(\tau) + \beta_1(\tau) \cdot x_{i1} + \cdots + \beta_p(\tau) \cdot x_{ip}$$

Equation 1 Quantile Regression equation

The equation for a typical quantile regression result is shown above. $Q_r(y_i)$ stands for the output value at each quantile, the symbol β represents the coefficient of each variable, τ represents quantile level, p stands for the number of regressor variables.

In OLS, the coefficients (β) are generated using the least square minimization while in quantile regression, only standard minimization. Least square minimization attempts to minimize the sum of the residues and the curve generated while the standard minimization method runs through all the feasible solutions and chooses the best possible solution.

$$\min_{\beta_0(\tau),\ldots,\beta_p(\tau)} \sum_{i=1}^{n} \rho_\tau \left(y_i - \beta_0(\tau) - \sum_{j=1}^{p} x_{ij} \beta_j(\tau) \right)$$

Equation 2 Standard Minimization Equation

To summarize the theory, Rodrigue et al (2017) has mentioned that quantile regression “uses a general linear model to fit conditional quantiles of the response without assuming a parametric distribution” (p.17) and that it “estimates the entire conditional distribution of the response, and it allows the shape of the distribution to depend on the predictors” (p.17) and shows the “effects of predictors on different parts of the response distribution” (p.17).

The results from quantile regression will span from the 10th percentile to 90th percentile with increments in 10 percent each time. The lower quantiles will represent the economy under poor conditions, i.e. a bear market while higher quantiles represent a good performing economy, i.e. a bull market.

Quantile regression was chosen as the method for this paper because we are exploring the correlation between SET Index and oil price; we want to know how strong is this relationship is. Moreover, quantile regression has the benefit of being able to relax the assumptions that OLS has including: Assumption of linearity, homoscedasticity, autocorrelation, normality of errors and no multicollinearity. This will ensure that the results generated from this research is valid and as mentioned in the literature review, quantile regression will ignore bias caused by market conditions. Additionally, quantile regression allows for analysis of data outside the mean data allowing non-linear data to be analyzed easily. Lastly, quantile regression has the advantage of having the tendency to be able to resist outlier data. In this paper, we will still conduct OLS to serve as a benchmark, similar to what authors mentioned in the literature review that have conducted quantile regression has done.

Variables that were chosen for the regression were chosen based on previous researches mentioned in the literature review. Therefore, stock returns/price is chosen as the dependent variable while on the other end, the independent variables will include: short term interest rates, oil price and CPI. Equation 2 shown below is the regression model that serves as the base model.

$$y = \beta_1 \cdot x_1 + \beta_2 \cdot x_2 + \varepsilon$$

Equation 3 Base Model

The beta symbols shown in equation 3 above describes the coefficients that will be obtained from the regression. β_1 is the coefficient for the short-term interest rates and β_2 is coefficient for oil price. ε stands for the error term and y stands for stock price. x_1 and x_2 represent the input value if we were to substitute in a value for short term interest rates and oil price respectively.

Additional models will be created to visualize the effect of each additional variable. Firstly, nominal exchange rate will be added into equation to generate model 2. Equation of model 2 is shown below.

$$y = \beta_1 \cdot x_1 + \beta_2 \cdot x_2 + \beta_3 \cdot x_3 + \varepsilon$$

Equation 4 Base Model with Nominal Exchange Rate taken into account

The additional variable nominal exchange rate is noted as β_3 as shown in equation 4. The other symbols remain the same as in equation 1 as described earlier. Similarly, x_3 is the input value if we were to substitute in a value of nominal exchange rate to obtain value for stock price.

The next variable to be added into the model is domestic inflation, which is shown below in the equation 5 for model 3 down below.

$$y = \beta_2 \cdot x_2 + \beta_3 \cdot x_3 + \beta_4 \cdot x_4 + \varepsilon$$

Equation 5 Model 2 with domestic inflation taken into account

The additional variable domestic inflation which will be measured with CPI is represented by the symbol β_4. The other symbols remain the same as in equation 4 as described above. Each variable is added into the equation one at a time so that it is possible to observe their individual effects on the regression. β_1 was removed from equation 5 because in domestic inflation, interest rates are likely to be taken into account since nominal exchange rate is derived from nominal exchange rate minus expected inflation. x_4 represents the input value of CPI that if inputted will estimate.

To conclude, table 2 shown below summarizes all the variables and their respective symbols.

Variable Name	Symbol
Short term interest rates	β_1
Oil Price	β_2
Nominal Exchange Rate	β_3
CPI	β_4
Stock Price	y
Input value	x_1, x_2, x_3, x_4
Error Term	ε

Table 2 Summary of Variables

However, prior to conducting quantile regression, the unit root test will be conducted first. This is because all of the data that this experiment is using are all time-series data. According to Andrew Ozborn (2021) and George Athanasopoulos, G. & Hyndman, R. (2018) which Ozborn has quoted, a unit root test is described as to "determine the stochasticity of the model using statistical Hypothesis testing. 'These are statistical hypothesis tests of stationarity that are designed for determining whether differencing is required.'" In other words, the unit root test's purpose is to test whether a set of time series data is non-stationary and possess a unit root or not.

A stationary time series data is defined as a set of data that has constant statistical properties over time such as: mean, variance, median, standard deviation, range and etc. This means that a non-stationary data has statistical properties that fluctuate or change over time. The problem with non-stationary data sets is that the results from this kind of data is unreliable.

As for the unit root, it can be defined as a unit of measurement of stationarity for time series data while stochasticity can be classified as uncertainty within data set. Compared to "randomness", stochasticity is used as the correct terminology "when probability of a feature is important" (Athanasopoulosas & Hyndman (2018) as cited in Ozbun, 2021) if the data contains a unit root, spikes and shocks occur in the data without the effect being caused by seasonality. Moreover, if stochasticity is included in the data, the effects of the large shock caused by the unit root will disappear over time. There are many variations of the unit root test, for example: The Dickey Fuller Test, Elliott–Rothenberg–Stock Test and its sub variations and the Zivot-Andrews test. This paper will utilize the Augmented Dickey Fuller Test, a variation of the regular Dickey Fuller Test that deals with augmented data. This method of unit root test was chosen as it is one of the few methods available in gretl, the software that was used to process the sample data. The ADF test identifies whether a unit root exist in the data set or not. In addition, the KPSS (Kwiatkowski–Phillips–Schmidt–Shin tests) unit root test which is also available will be conducted as well to verify whether the Augmented Dickey Fuller test results are reliable. Compared to ADF, the KPSS test does not test for a unit root but rather, it tests whether a data set is stationary or not. A combination of unit root tests is often used to verify for one another's results.

If the unit root test yield positive results several methods such as differencing and log transformation has to be conducted on that respective data set. Differencing is calculating the change in value between the previous observation and the current observation. It is used to turn non-stationary data into stationary data. On the other hand, "Transformations such as logarithms can help to stabilize the variance of a time series. Differencing can help stabilize the mean of a time series by removing changes in the level of a time series, and therefore eliminating (or reducing) trend and seasonality." (Athanasopoulosas & Hyndman (2018) as cited in Ozbun, 2021)

As Heiko Onnen (2021) has stated, in the case that the results from the unit root tests contradicts each other or both confirm that data set is non-stationary (KPSS) and contains a unit root (ADF), logarithmic form of first differences ($\ln(X_t\text{-}X_{t-1})$) of that variable will be used for quantile regression.

However, it should be noted that this paper will not deal with panel data but the paper includes results from the unit root test in the case that it can help to explain unusual results in case they appear.

An OLS estimate will also be provided for all 3 models prior to quantile regression. This will serve as a model for providing estimates of coefficients prior to quantile regression. OLS estimates will be conducted at level difference rather than first difference. To summarize the methodology into simple steps:

1) Generate OLS estimate results
2) Conduct Augmented Dickey Fuller unit root test and KPSS test
3) Conversion to logarithmic form of first differences, $\ln(X_t\text{-}X_{t-1})$
4) Generate Quantile Regression Results

4. Data

Similar to what other authors in the literature has done, the data was collected from several online sources. The time frame of the data set will be from 2014 quarter 1 to 2021 quarter 4, approximately 8 years of quarterly data. Since this paper attempts to capture the most recent effects possible so there are only 32 observations which is slightly above the minimum number of readings required to comply with the central limit theorem (30 observations). Summary statistics of the data is shown in the table below. Each subheading below describes the sources of each country's website and their summary statistics derived from their raw data.

4.1 Data Sources

Domestic inflation will be represented by consumer price index (CPI). This data was gathered from Thailand's Bureau of Trade and Economic Indices' website. However, the frequency of this data set was monthly. As a result, the average for every 3 months was taken to represent the quarterly CPI. Oil price was taken as the monthly average price of 1 barrel crude oil in US dollars, the Europe Brent Spot price was used. Again, since the frequency of data is monthly, a 3-month average is taken as a representation of quarterly oil price. This data was retrieved from U.S. Energy Information Administration's (EIA) website. Nominal exchange rate data was collected from OFX.com, a website that compiles monthly averaged nominal exchange rates of one currency to another. Again, because quarterly was not available, the average of every 3 months was taken instead. Exchange rate will be presented in terms of how much local currency for 1 US dollar. Next, short term interest rate was collected from quarterly 3-month yield of government bond. This data was obtained from Thai Bond Market Association's website. Stock Market Index of each market will represent stock prices of their respective country. For example, SET Index for Thailand. This data set was obtained from Yahoo Finance website. Stock index value will be taken from January of each month at their adjusted closing value. Since this is monthly data, 3-month average was used.

4.2 Summary Statistics

Variable	Mean	Median	Standard Deviation	Minimum value	Maximum Value
Quarterly Real GDP (in million baht)	3.817×10^6	3.854×10^6	3.346×10^5	3.243×10^6	4.338×10^6
CPI (Baht)	98.80	98.68	1.174	96.81	102
BRENT Oil Price (US Dollars)	62.13	61.61	19.15	29.34	109.7
Nominal Exchange Rate (How many baht for 1 US Dollar)	32.83	32.68	1.641	30.28	35.83
3-month government bond yield	0.01293	0.01400	0.005628	0.002900	0.02900
SET Index	1532	1558	138.8	1292	1811

Table 3 Summary Statistic of level difference data

Variable	Mean	Median	Standard Deviation	Minimum value	Maximum Value
CPI (Baht)	0.0014	-0.00030	0.0075	-0.021	0.019
BRENT Oil Price (US Dollars)	-0.010	0.024	0.200	-0.54	0.38
Nominal Exchange Rate (How many baht for 1 US Dollar)	0.00072	-0.0048	0.025	-0.043	0.057
3-month government bond yield	-0.050	-0.015	0.22	-0.81	0.23
SET Index	0.0064	0.0056	0.057	-0.18	0.12

Table 4 Summary statistic of logarithmic form of first differences

As expected from oil price, the range between the minimum and maximum value is very high. This is because of major events across the 8-year time period such as the pandemic in 2020 and the discovery of more oil supply in 2014. 3-month government bond yield has a wide spread of data from 0.29% yield to 2.9% interest rate. Over the past 8 years, 3-month government bond yield was on a steady decline. This was likely due to worsening economic situation in Thailand as each time period pass by. Another causation may be due to political instability over the past 8 years. Standard deviation for SET index and 3-month government yield were relatively high relative to their range. The remaining variable including CPI had data that seemed rather normal, nothing stands out in particular for CPI.

5. Results & Analysis

5.1 Expected Results

According to economic theory, we can expect either a positive or negative relationship with stock price for each variable. Table 5 shown below indicates this expected relationship of each relationship with stock price.

Variable	Expected Relationship with stock price
CPI (Baht)	Negative
BRENT Oil Price (US Dollars)	Can be either
Nominal Exchange Rate (for 1 US Dollar)	Positive
3-month government bond yield (also known as short term interest rates)	Negative

Table 5 Expected Relationships with stock prices

According to theory, CPI is expected to have a negative relationship with stock prices. This is because stock prices are based on the expected future earnings of a company while CPI is an indicator for inflation. A company’s total cost should increase due to higher levels of inflation. As a result, the company would be expected to have less earnings in the future causing stock price to drop. As for the relationship between oil price and stock price, it can have either a positive or negative relationship. Although the introduction mentioned that increase in oil price should worsen economic performance, other researchers results mentioned in the literature review and based on others that these researchers have cited, the results are ambiguous. Sometimes positive results are obtained while other times, negative results are obtained. A possible reason for the positive relationship was provided by an online article written by Bernake (2016). Bernake (2016) said that there are common factors between oil and stock that made them react in the same way. These factors include: change in aggerate demand and change in overall uncertainty and risk aversion. Additionally, referring to some of Degiannanis et al (2018) major findings, whether a country import or export oil and reliance of the country's industrial sector on oil also plays a major role. Nominal exchange rate is expected to have a positive relationship with stock prices. If stock prices of a certain country rise because of economic growth, there should be more investors that would be interested to invest into that country. Hence, the demand for that country's currency increases and nominal exchange rate increases. Lastly, 3-month government bond yield (short term interest rates) is expected to have a negative relationship with stock price. This is because both are competing for capital and interest rate is the key determinant of choosing which one investors are going to invest in. If bond yields are low compared to interest rates, people are more likely to invest in stock rather than bonds since the interest rate is higher and vice versa.

5.2 Unit Root Test Results

As mentioned, the Augmented Dickey Fuller (ADF) and KPSS unit root tests are a form of statistical test. Its null and alternative hypothesis are presented below:

$$Null\ Hypothesis: Time\ Series\ Data\ contains\ unit\ root, data\ is\ nonstationary$$

$$Alternative\ Hypothesis: Time\ series\ dat\ does\ not\ contain\ unit\ root, data\ is\ stationary$$

Equation 6 Null and Alternative Hypothesis for Augmented Dickey Fuller Unit Root test and KPSS test

The ADF unit root test is a type of unit root test that utilizes the autoregressive (AR) model that is adjusted for autocorrelation which is shown in equation 6 shown below. The AR model is generated based on the input variable's data set that is to be tested.

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \cdots + \delta_{t-1} \Delta y_{t-p+1} + \varepsilon_t$$

Equation 7 Equation for Augmented Dickey Fuller Test

In equation 6, Δy_t stands for the first difference operator variable of interest, α is a constant value, β and γ are coefficients generated, δ is $\delta_{t-1}\Delta y_{t-p+1}$the additional lag term to adjust for autocorrelation and ε is the error term.

After the AR model based on input data is generated, it compares the γ term coefficient with the t-value to see whether it reject the null hypothesis or not. If the γ term is less than or equal to zero, the null hypothesis is rejected in favor of the alternative hypothesis shown above in equation 5.

The ADF tests conducted in this were tested at 10% significance. If the p-value is greater than 5% significance, it has failed to rejects the null hypothesis and data is non-stationary (conversion to first difference is required). On the other hand, if p-value is less than or equal to the 5% significance value, reject the null hypothesis and data is stationary.

Meanwhile, the KPSS unit root test is a type of unit root test that tests whether time series data is stationary or non-stationary because of the existence of a unit root. The KPSS test is based on regular linear regression that contains 3 main components. This equation is shown below in equation 7. The coefficients of this equation are created from the input time series data provided.

$$x_t = r_t + \beta_t + \varepsilon_t$$

Equation 8 KPSS unit root test formula

In equation 7, β_t stands for the determinant trend term, r_t stands for random walk and ε term is the error term. If the data is stationary, the error term will remain constant or either the determinant trend and random walk component remain constant. This can be measured using the LM statistics instead of p-values or t-statistics. LM statistics or otherwise known as the Lagrange Multiplier test is a type of test statistic used for testing whether constraints on statistical parameters are violated or not.

For the KPSS test, the key value at 10% significance is 0.354 at 10% significance (Reject null hypothesis if p value is greater than 0.354). This is because the KPSS test uses a one sided LM statistics method.

Table 6 and 7 shown below summarizes the results for the Augmented Dickey Fuller unit root test and KPSS test of all the variables in time series. Any data set that yield positive results from the unit root test were converted to first difference form prior to OLS estimates and quantile regression.

Variable	ADF p-value	Contain Unit Root?
CPI (Baht)	5.50x10^{-5}	No
BRENT Oil Price (US Dollars)	0.218	Yes
Nominal Exchange Rate (for 1 US Dollar)	0.109	Yes
3-month government bond yield	0.00220	No
SET Index	6.10x10^{-5}	No

Table 6 Summary of Augmented Dickey Fuller unit root test on all independent variables

Variable	KPSS one sided LM statistical value	Is data non-stationary?
CPI (Baht)	0.725	No
BRENT Oil Price (US Dollars)	0.156	Yes
Nominal Exchange Rate (for 1 US Dollar)	0.434	No
3-month government bond yield	0.660	No
SET Index	0.143	Yes

Table 7 Summary of KPSS unit root test on all independent variables

Table 4 and Table 5 shows the results of the ADF unit root test and KPSS unit root test respectively. As seen in table 6, there are variables that contain unit roots (fail to reject null hypothesis) namely quarterly real GDP, oil price and nominal exchange rate. When conducting the KPSS unit root test, not all variables were able to reject the null hypothesis suggesting that certain variables are not stationary (SET index and oil price). As a result, all variables will be converted to natural logarithmic first differences due to the fact that not all variables were able to reject null hypothesis for the ADF test. After conducting the ADF and KPSS test for all natural logarithm first difference form, all the data set is stationary and contains no unit root.

5.3 OLS Estimates and Quantile Regression results

Table 8 to Table 10 shown below contains the coefficient estimates obtained from ordinary least square regression and results obtained from quantile regression of all models. Additionally, graphical representation of the results of quantile regression are also provided below as shown in figures 2, 3 and 4

Variable	OLS Coefficient Estimates	Quantile regression coefficients								
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Constant (ε)	0.0123	-0.0711	-0.432	-0.00191	0.00979	0.0151	0.0250	0.0298	0.0395	0.0667
3-month government bond yield (β_1)	0.0615	0.110	-0.0280	-0.00973	-0.0635	-0.0537	-0.0335	-0.0241	-0.0530	-0.0602
BRENT Oil Price (US Dollars) (β_2)	0.0957	0.0962	0.0463	0.00116	0.0781	0.0783	0.0866	0.0862	0.122	0.180

Table 8 OLS estimates and Quantile Regression results for model 1 with natural log first difference

Variable	OLS Coefficient Estimates	Quantile regression coefficients								
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Constant (ε)	0.0143	-0.0737	-0.0331	-0.0120	0.00200	0.0170	0.0248	0.0263	0.0490	0.0715
3-month government bond yield (β_1)	0.0808	0.00883	0.0675	0.0713	-0.0434	-0.0362	-0.0153	-0.0133	-0.0304	-0.0317
BRENT Oil Price (US Dollars) (β_2)	0.0641	0.0748	-0.0493	0.0445	0.152	0.0846	0.0806	0.0841	0.0440	0.121
Nominal Exchange Rate (β_3)	−0.929	-0.619	-1.03	-0.748	-0.669	-0.280	-0.400	-0.372	-0.396	-1.03

Table 9 OLS estimates and Quantile Regression results for model 2 with natural log first difference

Variable	OLS Coefficient Estimates	Quantile regression coefficients								
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Constant (ε)	0.0119	-0.0359	-0.0250	-0.00366	0..00863	0.0193	0.0272	0.0423	0.0482	0.0710
BRENT Oil Price (US Dollars) (β_2)	0.1489	0.303	0.224	0.254	0.253	0.0984	0.125	0.189	0.180	0.106
Nominal Exchange Rate (β_3)	−0.725	-1.17	-1.05	-0.510	-0.340	-0.481	-0.208	0.0311	-0.175	-1.02
CPI (β_4)	−1.835	-6.99	-5.83	-7.03	-3.60	-0.704	-1.91	-2.82	-2.52	-0.408

Table 10 OLS estimates and Quantile Regression for model 3 with natural log first difference

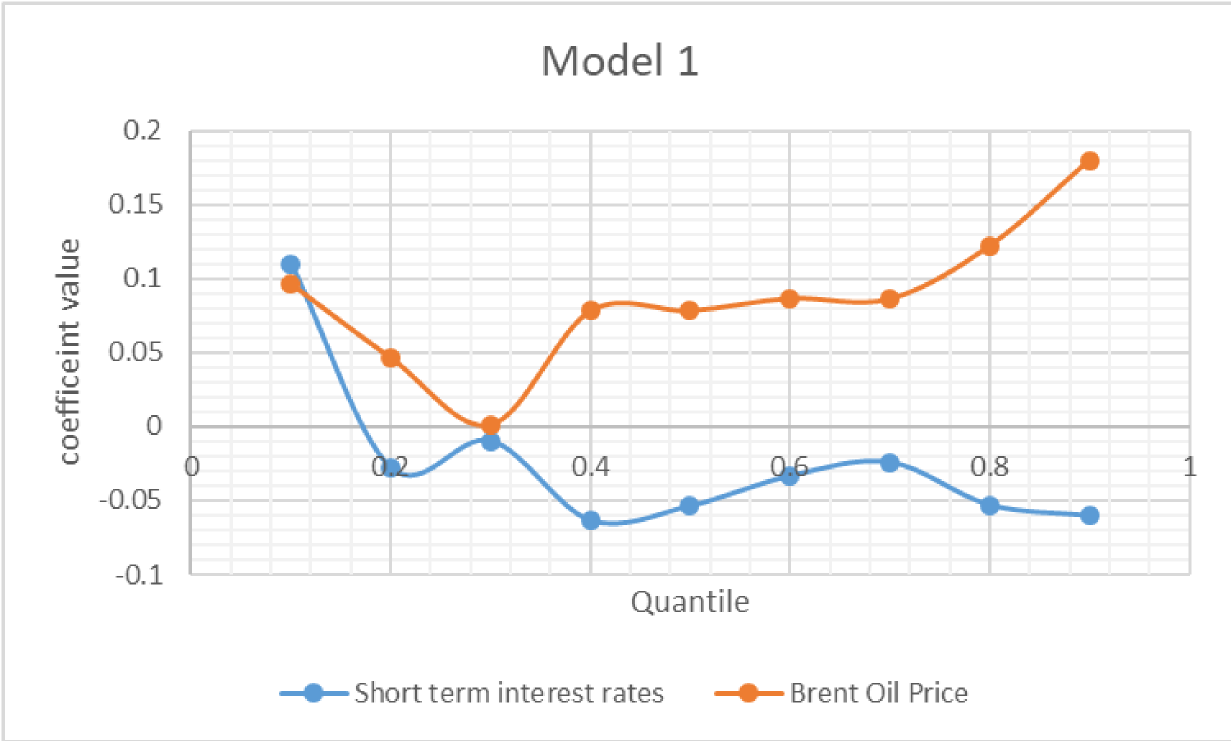

Figure 2 Graphical Representation of Model 1 Quantile Regression

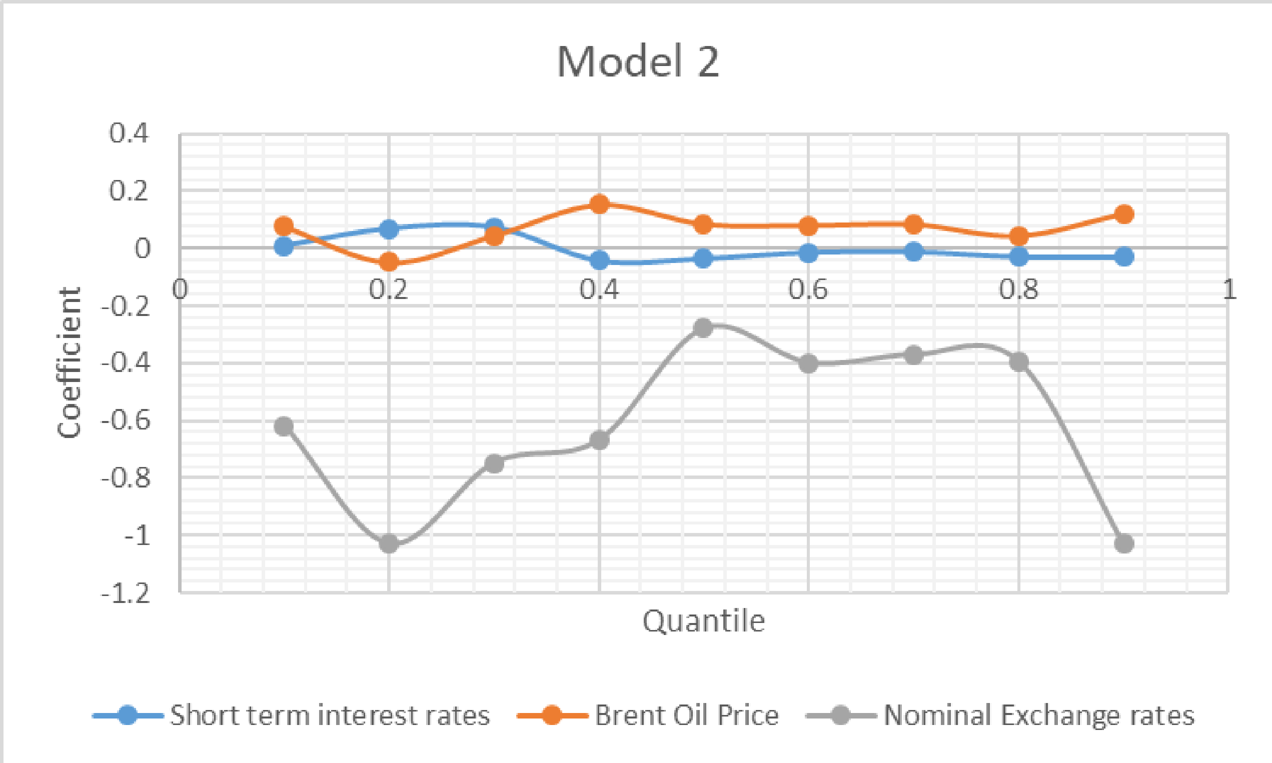

Figure 3 Graphical Representation of Model 2 Quantile Regression

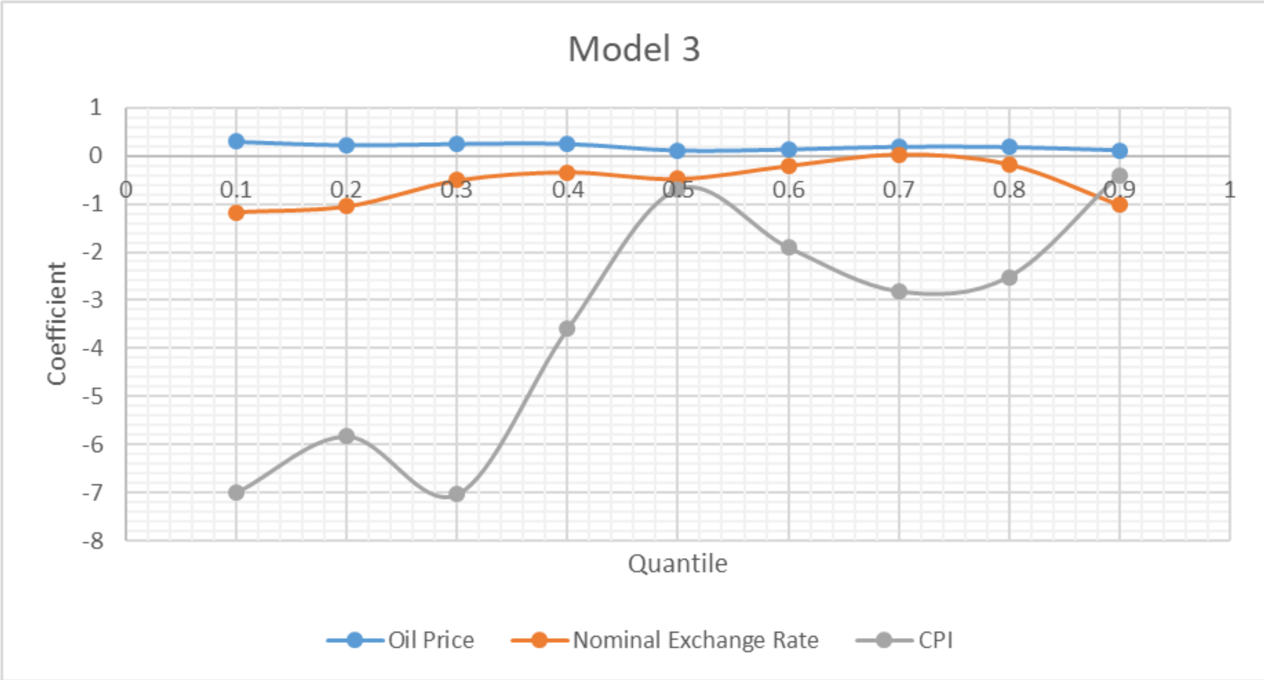

Figure 4 Graphical Representation of Model 3 Quantile Regression

5.4 Model 1 (Table 8 & Figure 2) analysis

From the results of OLS, it can be seen that OLS estimates for short term interest did not match our predictions. This could have been due to the fact that assumptions of OLS were violated. Meanwhile, oil price has a positive relationship with stock price.

As for quantile regression, table 8 shows that at lower quantiles, quantile regression shows a positive relationship but at higher quantile (above 20th percent quantile), the relationship turns negative matching our expected results. Oil Price showed positive results for both OLS and quantile regression.

Figure 2 shows that the general trend for short term interest trend is that the relationship gets more positive over time. Oil price's coefficient also increase as the graph shifts from lower to higher quantiles.

5.5 Model 2 (Table 9 & Figure 3) analysis

From Table 9's OLS estimates it can be seen that short term interest rates and oil price has positive relationship with stock price while nominal exchange rates had a negative relationship. As for the quantile regression results, Short term interest had positive relationships at lower quantiles (30th percent quantile and below) but shifted to a positive relationship at higher quantile levels. Oil price relationship remained positive across nearly all quantile levels except for 20th percent quantile. Lastly, nominal exchange rate has negative relationship with stock price at all quantile levels which is an unexpected relationship. This could have been due to the fact that Thailand's economy is highly reliant on exports; It is a major exporter of agricultural products, machinery and electronics. As the Thai baht weakens, countries that import Thai products would purchase more goods from Thailand because the price per unit of goods are cheaper and in turn, improve the economy due to money flowing into the country hence, the increase in stock prices.

Figure 3 shows that across all quantiles, the coefficient of short term interest rates and oil price remained weak (coefficient values are all near zero). Meanwhile, nominal exchange rates displayed a rather unusual as the quantiles transit from lower to higher levels. Between the 10th percent quantile and 50th percent quantile, the relationship became less negative but then returned back to being very negative beyond the 50th percent quantile.

5.6 Model 3 (Table 10 & Figure 4) analysis

According to Table 10 it can be seen that OLS estimates show that oil price has positive relationship with stock price while nominal exchange rate and CPI has negative relationship with stock price. For quantile regression, oil price has positive relationship at all quantile levels, nominal exchange rate has negative relationship at all quantile levels except for 70th percent quantile and lastly, CPI's relationship with stock price remained negative at every quantile levels. The unexpected negative relationship for nominal exchange rates can use the same explanation as provided in equation 2 analysis in which Thailand benefits from the Thai baht weakening causing its exports to increase and improving its domestic economy.

As shown in figure 4, oil price maintained a slight positive relationship across all quantiles (values between 0 and 1). Similar to nominal exchange rates, where it had a slight negative relationship at all quantile levels. CPI has a trend of its coefficient becoming less negative as the quantile level rise. However, the extent of the initial negative coefficient for CPI is rather drastic compared to all other coefficients in model 3 as well as models 1 and 2.

6. Overall Analysis

According to the results from quantile regression, it can be said that for all 3 sets of results from table 8, most of the results match with what traditional economic theories would have predicted except for nominal exchange rate in table 10. Most notably, the variable oil price has a positive relationship with stock price for all 3 models. As mentioned earlier, Bernake mentioned that three factors that could have caused this to happen includes: Aggerate demand, change in overall uncertainty and risk aversion. For aggerate demand, Bernake (2016) has mentioned under economic crisis, past events such as the 2008 US housing crisis has shown patterns where aggregate demand increased in the economy. The increase in aggregate demand lead to temporary economic growth and increased oil consumption increasing both stock and oil prices. As for change in overall uncertainty and risk aversion, it is described that when uncertainty is high in the market for various commodities such as oil, investors tend to sell away their commodities. Moreover, during these high period of uncertainty, investors tend to sell away their stocks as well. Since both oil and stocks are being sold, they have a positive relationship. In this scenario, oil and stocks are both treated as assets. Lastly, in Bernake's (2016) appendix, Bernake (2016) has mentioned that energy stock price tends to have a heavier weight within the stock market rather than in the real economy which could help explain the positive relationship.

7. Conclusion

In conclusion, this paper has tried to find the relationship of stock price to various independent variables including: Oil price, CPI, Nominal exchange rate and short term interest rates through the use of quantile regression which generated 3 models in total. The majority of the results obtained aligned with what traditional economic data predicted while the remaining minority namely nominal exchange rates did have an alternative explanation that could have been used to explain why the results diverged from theoretical predictions. Stock investors can benefit from this paper since the models generated this paper can predict how a change in each variable can affect stock prices under various market conditions ranging from bull to bear economy allowing them to adjust their portfolio accordingly.

8. Recommendations

This research does have some weaknesses. As seen in tables 8 and table 10, there are still outliers in the results due to the low number of readings that barely managed to comply with the central limit theorem. An increase in number of readings would help to make results more reliable. Doing this research several years in the future will be interesting in finding the extent of current geopolitical events around the world at the time of writing this research on the results of this experiment set up.

For further research, testing with other important variables such as real GDP, industrial production index, oil price volatility and other various economic indices may provide more insight why relationship between oil price and stock price is positive for all 3 models generated. Additionally, find out to what extent is Thailand's economy is reliant on oil. This may help explain the positive relationship between stock and oil prices as Degiannakis (2018) has mentioned as one of their key findings. If Thailand is not that oil dependent, it will be possible to use Degiannakis' (2018) explanation to help explain the positive relationship for Thailand's oil price and stock price further. Moreover, test whether Bernake's explanations is applicable to Thailand. Further research on the following questions may provide more insight on the positive relationship discovered:

- Does previous economic crisis in Thailand lead to a temporary shock increase in aggregate demand?
- Is oil treated as an asset or consumer product in the Thai market?
- To what extent does Thailand energy stock price affect the SET index?
- Do energy stock prices really have a heavier weighting in the stock market rather than in the real economy?

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Appendix A

All Data for OLS estimates

Model 1: OLS, using observations 2014:2-2021:4 (T = 31)
Dependent variable: ld_StockIndex
HAC standard errors, bandwidth 2 (Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*
const	0.00971199	0.00937766	1.036	0.3092
ld_OilPriceUSD	0.0820279	0.0597707	1.372	0.1808
ld_InterestRate	0.0494214	0.0714034	0.6921	0.4945

Mean dependent var	0.006409	S.D. dependent var	0.057035
Sum squared resid	0.081429	S.E. of regression	0.053927
R-squared	0.165617	Adjusted R-squared	0.106018
F(2, 28)	3.177613	P-value(F)	0.057058
Log-likelihood	48.11415	Akaike criterion	−90.22831
Schwarz criterion	−85.92634	Hannan-Quinn	−88.82597
rho	0.085430	Durbin-Watson	1.761891

Model 2: OLS, using observations 2014:2-2021:4 (T = 31)
Dependent variable: ld_StockIndex

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0107205	0.00932546	1.150	0.2604	
ld_OilPriceUSD	0.0485135	0.0546505	0.8877	0.3825	
ld_InterestRate	0.0636713	0.0478572	1.330	0.1945	
ld_ExchangeRate	−0.860000	0.382167	−2.250	0.0328	**

Mean dependent var	0.006409	S.D. dependent var	0.057035
Sum squared resid	0.068568	S.E. of regression	0.050394
R-squared	0.297393	Adjusted R-squared	0.219326
F(3, 27)	3.809446	P-value(F)	0.021311
Log-likelihood	50.77854	Akaike criterion	−93.55707
Schwarz criterion	−87.82112	Hannan-Quinn	−91.68729
rho	0.111429	Durbin-Watson	1.704529

Model 3: OLS, using observations 2014:2-2021:4 (T = 31)
Dependent variable: ld_StockIndex
HAC standard errors, bandwidth 2 (Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0115176	0.00936796	1.229	0.2295	
ld_OilPriceUSD	0.152800	0.0726487	2.103	0.0449	**
ld_ExchangeRate	−0.685734	0.308620	−2.222	0.0349	**
ld_CPI	−2.26952	2.09097	−1.085	0.2873	

Mean dependent var	0.006409	S.D. dependent var	0.057035
Sum squared resid	0.069669	S.E. of regression	0.050797
R-squared	0.286112	Adjusted R-squared	0.206791
F(3, 27)	7.868128	P-value(F)	0.000626
Log-likelihood	50.53164	Akaike criterion	−93.06327
Schwarz criterion	−87.32732	Hannan-Quinn	−91.19349
rho	0.214042	Durbin-Watson	1.450374

Quantile Regression results

```
Model 1: Quantile estimates, using observations 2014:2-2021:4 (T = 31)
Dependent variable: ld_StockIndex
Asymptotic standard errors assuming IID errors

                    tau    coefficient   std. error      t-ratio
  --------------------------------------------------------------
  const            0.100   -0.0710668    0.0167394     -4.24549
                   0.200   -0.0431739    0.0238984     -1.80656
                   0.300   -0.00191144   0.00648971   -0.294534
                   0.400    0.00978918   0.00673443    - 1.45360
                   0.500     0.0150694   0.00707682     -2.12940
                   0.600     0.0249586   0.00732162     -3.40889
                   0.700     0.0297502   0.00441442     -6.73932
                   0.800     0.0394968   0.00251917     -15.6785
                   0.900     0.0666833   0.00757415     -8.80407

  ld_OilPriceUSD   0.100     0.0962126    0.0944948     -1.01818
                   0.200     0.0463477     0.134908     0.343550
                   0.300    0.00116327    0.0366348    0.0317533
                   0.400     0.0781020    0.0380163      2.05444
                   0.500     0.0783423    0.0399491      1.96105
                   0.600     0.0866770    0.0413310      2.09714
                   0.700     0.0861495    0.0249197      3.45709
                   0.800      0.122486    0.0142209      8.61314
                   0.900      0.179970    0.0427566      4.20918

  ld_InterestRate  0.100      0.109622    0.0852476      1.28592
                   0.200    -0.0279748     0.121706    -0.229856
                   0.300    0.00973336    0.0330497     0.294506
                   0.400    -0.0635002    0.0342960     -1.85153
                   0.500    -0.0536731    0.0360397     -1.48928
                   0.600    -0.0335449    0.0372864    -0.899656
                   0.700    -0.0240680    0.0224810     -1.07059
                   0.800    -0.0526929    0.0128292     -4.10726
                   0.900    -0.0602365    0.0385724     -1.56165

Median depend. var   0.005587   S.D. dependent var   0.057035
```


40

Model 2: Quantile estimates, using observations 2014:2-2021:4 (T = 31)

Dependent variable: ld_StockIndex
Asymptotic standard errors assuming IID errors

	tau	coefficient	std. error	t-ratio
const	0.100	-0.0736572	0.0109491	-6.72726
	0.200	-0.0331140	0.0160588	-2.06205
	0.300	-0.0119917	0.00774620	-1.54807
	0.400	0.00198552	0.00656956	0.302230
	0.500	0.0169829	0.00414160	4.10058
	0.600	0.0247968	0.00987322	2.51153
	0.700	0.0263351	0.00372272	7.07416
	0.800	0.0489963	0.00725927	6.74948
	0.900	0.0715317	0.0112194	6.37571
ld_OilPriceUSD	0.100	0.0748043	0.0641653	1.16581
	0.200	-0.0492871	0.0941104	-0.523716
	0.300	0.0445305	0.0453955	0.980947
	0.400	0.152427	0.0384999	3.95914
	0.500	0.0845710	0.0242712	3.48442
	0.600	0.0806180	0.0578605	1.39332
	0.700	0.0840573	0.0218165	3.85293
	0.800	0.0440328	0.0425419	1.03505
	0.900	0.121120	0.0657497	1.84213
ld_InterestRate	0.100	0.0882656	0.0561893	1.57086
	0.200	0.0674716	0.0824120	0.818710
	0.300	0.0713446	0.0397526	1.79472
	0.400	-0.0434332	0.0337142	-1.28828
	0.500	-0.0362295	0.0212542	-1.70458
	0.600	-0.0152688	0.0506682	-0.301348
	0.700	-0.0132973	0.0191046	-0.696027
	0.800	0.0304477	0.0372537	0.817305
	0.900	-0.0317334	0.0575767	-0.551150
ld_ExchangeRate	0.100	-0.618871	0.448704	-1.37924
	0.200	-1.03274	0.658107	-1.56925
	0.300	-0.747687	0.317447	-2.35531
	0.400	-0.668772	0.269227	-2.48404
	0.500	-0.279664	0.169727	-1.64773
	0.600	-0.399633	0.404615	-0.987687
	0.700	-0.372471	0.152561	-2.44145
	0.800	-0.397537	0.297492	-1.33629
	0.900	-1.02788	0.459783	-2.23558

Median depend. var 0.005587 S.D. dependent var 0.057035

Model 3: Quantile estimates, using observations 2014:2-2021:4 (T = 31)

Dependent variable: ld_StockIndex
Asymptotic standard errors assuming IID errors

	tau	coefficient	std. error	t-ratio
const	0.100	-0.0359209	0.00307551	-11.6796
	0.200	-0.0250255	0.0168578	-1.48450
	0.300	-0.00366443	0.00579616	-0.632217
	0.400	0.00863041	0.00523579	1.64835
	0.500	0.0193357	0.00388706	4.97437
	0.600	0.0271822	0.00489879	5.54876
	0.700	0.0423212	0.00711747	5.94610
	0.800	0.0482818	0.00252727	19.1043
	0.900	0.0709518	0.0123266	5.75601
ld_OilPriceUSD	0.100	0.302690	0.0246730	12.2681
	0.200	0.223728	0.135240	1.65431
	0.300	0.253941	0.0464990	5.46120
	0.400	0.252794	0.0420036	6.01839
	0.500	0.0984098	0.0311835	3.15582
	0.600	0.125466	0.0393000	3.19251
	0.700	0.189349	0.0570991	3.31615
	0.800	0.180084	0.0202748	8.88217
	0.900	0.105690	0.0988885	1.06878
ld_ExchangeRate	0.100	-1.16622	0.124712	-9.35126
	0.200	-1.05077	0.683585	-1.53715
	0.300	-0.509864	0.235034	-2.16932
	0.400	-0.339739	0.212311	-1.60019
	0.500	-0.481267	0.157620	-3.05333
	0.600	-0.208026	0.198646	-1.04722
	0.700	0.0311638	0.288613	0.107978
	0.800	-0.175412	0.102481	-1.71166
	0.900	-1.02154	0.499842	-2.04373
ld_CPI	0.100	-6.98537	0.627834	-11.1261
	0.200	-5.82844	3.44135	-1.69365
	0.300	-7.02864	1.18323	-5.94024
	0.400	-3.59957	1.06883	-3.36776
	0.500	-0.704145	0.793503	-0.887388
	0.600	-1.91091	1.00004	-1.91084
	0.700	-2.82394	1.45296	-1.94358
	0.800	-2.51508	0.515916	-4.87498
	0.900	-0.407904	2.51634	-0.162102

Median depend. var 0.005587 S.D. dependent var 0.057035

Appendix B

Augmented Dickey Fuller Unit Root tests Logarithmic form

```
Augmented Dickey-Fuller test for ld_CPI
testing down from 8 lags, criterion modified AIC, Perron-Qu
sample size 30
unit-root null hypothesis: a = 1

  test with constant
  including 0 lags of (1-L)ld_CPI
  model: (1-L)y = b0 + (a-1)*y(-1) + e
  estimated value of (a - 1): -0.95013
  test statistic: tau = -4.942
  approximate p-value 0.000
  1st-order autocorrelation coeff. for e: 0.004


Augmented Dickey-Fuller test for ld_ExchangeRate
testing down from 8 lags, criterion t-statistic
sample size 25
unit-root null hypothesis: a = 1

  with constant and trend
  including 5 lags of (1-L)ld_ExchangeRate
  model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  estimated value of (a - 1): -0.425427
  test statistic: tau_ct(1) = -0.882406
  asymptotic p-value 0.9565
  1st-order autocorrelation coeff. for e: -0.044
  lagged differences: F(5, 17) = 1.639 [0.2034]


Augmented Dickey-Fuller test for ld_OilPriceUSD
testing down from 8 lags, criterion t-statistic
sample size 30
unit-root null hypothesis: a = 1

  with constant and trend
  including 0 lags of (1-L)ld_OilPriceUSD
  model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  estimated value of (a - 1): -1.04581
  test statistic: tau_ct(1) = -5.47495
  asymptotic p-value 1.894e-005
  1st-order autocorrelation coeff. for e: -0.002


Augmented Dickey-Fuller test for ld_InterestRate
testing down from 8 lags, criterion t-statistic
sample size 26
unit-root null hypothesis: a = 1

  with constant and trend
  including 4 lags of (1-L)ld_InterestRate
  model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  estimated value of (a - 1): -1.53952
  test statistic: tau_ct(1) = -3.65729
  asymptotic p-value 0.02523
  1st-order autocorrelation coeff. for e: -0.172
  lagged differences: F(4, 19) = 2.429 [0.0833]
```

```
Augmented Dickey-Fuller test for ld_StockIndex
testing down from 8 lags, criterion t-statistic
sample size 23
unit-root null hypothesis: a = 1

  with constant and trend
  including 7 lags of (1-L)ld_StockIndex
  model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  estimated value of (a - 1): -1.77175
  test statistic: tau_ct(1) = -2.32876
  asymptotic p-value 0.4177
  1st-order autocorrelation coeff. for e: -0.159
  lagged differences: F(7, 13) = 1.123 [0.4059]
```

KPSS Unit root test Logarithmic First Difference Form

```
KPSS test for ld_CPI

T = 31
Lag truncation parameter = 2
Test statistic = 0.3985476

                   10%      5%      1%
Critical values: 0.354   0.462   0.712
P-value < 0.10


KPSS test for ld_OilPriceUSD

T = 31
Lag truncation parameter = 2
Test statistic = 0.3559573

                   10%      5%      1%
Critical values: 0.354   0.462   0.712
P-value < .10


KPSS test for ld_ExchangeRate

T = 31
Lag truncation parameter = 2
Test statistic = 0.3787454

                   10%      5%      1%
Critical values: 0.354   0.462   0.712
P-value < .10
```

```
KPSS test for ld_InterestRate

T = 31
Lag truncation parameter = 2
Test statistic = 0.4059013

                   10%      5%      1%
Critical values: 0.354   0.462   0.712
P-value < .10


KPSS test for ld_StockIndex

T = 31
Lag truncation parameter = 2
Test statistic = 0.3623921

                   10%      5%      1%
Critical values: 0.354   0.462   0.712
P-value < .10
```

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