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The Effects of Oil and Gas Risk Factors on Malaysian Oil and Gas Stock Returns: Do They Vary?

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Abstract: This study explores Malaysian oil and gas stocks' exposure to oil and gas risk factors, paying special attention to subindustry classification, stock size, book-to-market value, and volatility state. The study employs firm-level weekly frequency data of oil and gas firms and several multi-asset pricing models within a GARCH (1,1)-X and Markov-switching framework. The empirical findings reveal that oil price, gas price, and exchange rate exhibit positive effects on the stock returns of all oil and gas sub-industries, but they exhibit negative effects on gas utilities sub-industry stock returns. The empirical findings also reveal that the extent of this effect varies across sub-industry, stock size, book-to-market value, and volatility states. Thus, the findings suggest the existence of asymmetric, heterogeneous, and non-linear exposures.

Keywords: oil and gas risk factor; oil and gas industry; asset pricing; Malaysian stock market

1. Introduction

Oil and gas are important sources of energy to the global economy. In most countries, the energy sector contributes a relatively modest share of a country's GDP, and the sector significantly influences economic development by spurring growth in other sectors [1]. The oil and gas industry can be an important driver of economic growth in rich energy resource-endowed countries. The industry contributes to the overall economy by creating jobs and value through its broad supplier networks and long supply chain, ranging from various upstream to downstream activities, such as oil and gas (O and G) exploration and production, drilling, equipment and services, refining and marketing, storage and transportation, coal and consumable fuels, and gas utilities, all of which comprise the oil and gas sub-industries.

It has been widely recognized that the stock returns of any industry are driven to a large extent by industry-specific risk factors alongside market-wide factors. The oil and gas industry is no exceptional. The industry's business and stock performance are very much dependent on changes in oil and gas prices, because oil and gas are crucial inputs for many goods and services in the economy (see [2–8]). Lower prices of oil and gas reduce the input costs and expenses of oil and gas firms' business operations, thereby increasing corporate earnings and cash flows. The converse is also true when oil and gas prices increase. Thus, oil and gas prices are considered as industry-specific risk factors and the stock price of oil and gas firms are therefore highly responsive to the changes in oil and gas prices. Additionally, the exchange rate factor has also been identified as a potential risk factor for the oil and gas industry's business and stock performances since the industry's business activities are subject to export and import activities and the exchange rate is an important risk factor to oil-exporting countries [6,9,10]. Numerous studies have also separately reported that gas prices [11] and exchange rates [12,13] are important risk factors influencing the stock returns of oil and gas firms. Given that, it is, therefore, crucial to understand how oil and gas risk factors affect the stock returns of oil and gas sub-industries.

Unlike studies that examine the aggregate stock market, this study focuses on firm-level analysis investigating whether oil and gas risk factors affect the returns of different oil and gas sub-industries in an emerging and oil-exporting economy. Examples of firm-level studies on the oil price–stock returns relationship are Mohanty et al. [14], Narayan and Sharma [15,16], Phan et al. [17], Sanusi and Ahmad [7], and Swaray and Salisu [18]. Firm analysis at the sub-industry level is needed to gain a better understanding of the effects of oil and gas risk factors on stock returns (see [18,19]). Furthermore, Phan et al. [18] and Swaray and Salisu [18] highlighted that analysis at the sub-industry level provides insights on whether oil and gas sub-industries are heterogeneous in their responses to price changes in oil and gas risk factors. Investors care about the exposure of firms to oil and gas risk factors because firms' values and stock returns change with changes in the prices of the risk factors. The findings would be of great interest to investors for formulating hedging and trading strategies for oil and gas stocks.

Additionally, firm-level analysis also allows us to examine whether small versus large firms and value versus growth stocks behave differently with regard to price changes in oil and gas risk factors. Past studies on firm-level oil and gas industry stocks have investigated the exposure to oil price risk within sub-industries and across firm size [7,13,15–17,20,21]. However, these studies have ignored one important unexploited aspect of stock attributes, i.e., book-to-market value, which has been popularly used to categorize stocks into value versus growth stocks. Therefore, it would be interesting to examine if value and growth stocks respond differently to price changes in oil and gas risk factors, and if they do, whether the effects are heterogeneous. The literature has also highlighted that oil price effects on stock returns vary with time period, suggesting the relationship between oil price and stock return is not constant over the time [22–26]. In other words, the oil price–stock return nexus has been found to be asymmetric, time varying, and non-linear [14,22,24,26–35]. Despite that, none of the extant empirical studies have explored whether the effects of other oil-related risk factors, such as gas price and exchange rate, on stock returns of oil and gas firms vary across different time periods alongside the oil price factor. Similar effects may possibly be observed in the relationship between unexplored oil and gas risk factors and returns of oil and gas firms. Therefore, it is conjectured that the relationship between oil and gas risk factors (oil price, gas price, and exchange rate factor) and returns of oil and gas firms vary across different time periods. The findings of Moya-Martinez et al. [24] and Zhu et al. [25] on the effects oil price uncertainty on the oil industry stock return of different sub-samples using a break least square approach indicate that the effects of oil and gas risk factors vary with the time period, however, they did not take the volatility state into consideration. Thus, the current study attempts to bridge the empirical gap by examining whether the effects of oil and gas risk factors are regime and time varying by employing multifactor models within a Markov switching framework.

Based on the above premise, in this study, we investigate the heterogenous exposures of oil price, gas price, and exchange rate factor on stock returns of oil and gas sub-industries and examine whether the effects of oil and gas risk factors vary across firm size, book-to-market ratio, and volatility state. This study employs a multifactor asset pricing theory building on the premise that asset prices have impacts on the stock returns of firms that are associated with that asset. Henceforth, this study contributes in several ways. Firstly, this study is related to Mohanty et al. [13], Narayan and Sharma [15,16], Phan et al. [17], Sanusi and Ahmad [7], and Swaray and Salisu [18], which focused on the effects oil price risk factors on oil and gas stocks at the firm level, but this study purely focuses on the oil and gas stocks of an emerging and oil-exporting economy. Henceforth, the findings of this study facilitate the understanding of the behavior of oil and gas stocks with oil price changes. The empirical findings, in support of the positive exposure to oil price risk factors, suggest that oil price changes have positive effects on oil and gas industry stock performance, regardless of the existence of an oil and gas firm in the oil-exporting and the oil-importing country (e.g., [6,7,9,10,13,15,36]). Therefore, our findings add new insights to the energy finance literature.

Secondly, this study is again related to Narayan and Sharma [15,16] and Phan et al. [17], as it examines the variability in risk factor effects across sub-industries and stock sizes. However, they did not included gas price and exchange rate risk factors, which are important risk factors of oil and gas stocks, in their investigations. Our findings show that oil price, gas price, and exchange rate have a positive effect on the stock returns of all oil and gas sub-industries, excluding stock in the gas utilities sub-industry, which is negatively affected. Despite that, the effect of oil and gas risk factors varies across the sub-industries. We discover that the impacts of oil price and exchange rate risk factors on stock returns vary across oil and gas stock sizes, where small stocks exhibit a higher coefficient for both oil price and exchange rate risk factors. The findings are theoretically predicted, as it is believed that the performance of stock depends on its size, which is determined by market capitalization, and it is also believed that small stocks produce higher returns for the investor. Henceforth, the findings add some new insight, that the effects of oil price, gas price, and exchange rate risk factors on stock returns depend on their sub-industry classifications and stock size, into the literature of energy economics and finance.

Thirdly, we bring the book-to-market value of oil and gas stock into the investigation, and we detect that the effect of oil and gas risk factors varies with the book-to-market value of oil and gas stock. Thus, our findings add brand new evidence that the impacts of oil price, gas price, and exchange rate vary across the book-to-market value of oil and gas stocks and establish an additional hypothesis of the difference in performances among stocks. In this instance, this study extends the literature in oil and gas stock and risk effects. Fourthly, unlike other studies on this subject matter [10,12,13,15–17], we investigate the time and volatility state variable effects of oil and gas risk factors, employing the multifactor asset pricing model with a Markov switching framework. The empirical findings show that exposure to oil and gas risk factors are regime and time varying. Hence, the empirical findings add new evidence to the literature regarding the regime variable relationship between oil and gas risk factors and the stock returns of oil and gas stock performance. These findings improve the findings of Moya-Martínez, et al. [24] and Zhu et al. [25], as they suggested that the effects of oil price risk factors vary with time period without considering volatilities in stock returns, which develop from exogenous factors like changes in oil price, gas price, and exchange rate. Hence, this study takes forward the idea that the effects of oil price, gas price, and exchange rate risk factors on the firm level stock return are also changeable with time and regime. Hence, these pieces of evidence provide valuable insights to the researcher to consider the effect of the time variation of oil and gas risk factors on the stock performance of net oil-exporting economies.

The rest of the paper is organized as follows. Section 2 presents the related literature and hypotheses of the study. The section that follows presents the data description and empirical models employed to test the hypotheses. Section 4 discusses the empirical results. The final section concludes the study with a summary of the empirical results and implications.

2. Literature Support and Hypothesis Development

The oil and gas industry has a long value chain and firms within the industry do not operate similar business activities. There are generally several sub-industries in the oil and gas industry [3,18,37]. Therefore, the profit generation process of each sub-industry is not the same, even though all the sub-industries are connected with each other. This implies that oil and gas price changes affect the cash flows and stock prices of each sub-industry differently. It follows that if stock price is affected differently, the performance of the stock will also be affected differently. Sanusi and Ahmad [7] showed that oil price changes affect the stock return of oil and gas firms differently and that the direction of the impacts is not similar for each stock, and it varies across firms. Furthermore, Mohanty and Nandha [14] revealed that the effect of oil risk varies over time and across the sub-industries. Therefore, it can be postulated that oil and gas stock exposure to oil and gas risk factors depends on sub-industry classifications, and hence we hypothesize the following:

Hypothesis 1 (H1). *Oil and gas risk factors affect the stock returns of oil and gas sub-industries differently.*

The performance differences between small and large stocks have always inspired researchers to establish relationships between risk factors and stock returns. In most cases, researchers have observed that small firms tend to exhibit higher returns than large firms [36,38,39]. Such evidence indicates that the behavior of small stocks is indeed different from the behavior of large stocks. Therefore, it is conjectured that the effects of oil and gas risk factors on stock returns may also vary across firm size. While past studies have shown that oil price effects vary with firm size [15–17,39], little research has examined if gas price and exchange rate are also subject to such a relationship. The current study conjectures that the effects of oil and gas risk factors vary across firm size. Hence, we hypothesize the following:

Hypothesis 2 (H2). *Oil and gas risk factors affect the returns of oil and gas stocks differently, based on firm size*.

Similar to the firm size factor, the observed performance differences between low and high book-to-market value firms have also encouraged researchers to examine the relationship between risk factors and stock returns. In most of the cases, firms with a high book-to-market value, also known as value stocks, exhibit higher returns than those with a low book-to-market value, known as growth stocks [40–44]. The findings suggest that the behavior of value stocks is different from that of growth stocks. However, such a relation has been ignored in empirical studies on the relationship between oil price and stock performances. This study conjectures that the price impacts of oil and gas risk factors vary across the book-to-market value of oil and gas firms, as hypothesized below.

Hypothesis 3 (H3). *Oil and gas risk factors affect the returns of oil and gas stocks differently, based on book-to-market value*.

The behavior of oil price is complex and unpredictable, and so is the volatile behavior of stock price, which is driven by the up and down market conditions. Hence, the stock price response to oil price uncertainty depends on the degree of uncertainty created by the volatility of oil price. Such responses lead to dynamic and constantly changing relationships between oil price and stock returns. That explains why structural changes in oil prices and the financial market have received much research attention [24,25,33,35,45–49]. These studies empirically documented that the effects of risk factors on the returns of oil and gas stocks are continuously changing over time. Particularly, Moya-Martínez et al. [24] and Zhu et al. [25] found that the oil price risk exposure of industry stock returns is time- and structure-dependent. Arouri et al. [50] examined the relationship between stock market returns and oil returns and examined volatility transmission, using a VAR–GARCH approach. They found evidence of shock and volatility spillovers between the oil price and stock returns of GCC countries, and the transmission of shock and volatility depends on the economic period and country. More recently, Hoque and Zaidi [51,52] have presented that oil price effects on the Malaysian stock return vary across volatility regime. In support of these empirical studies, this study conjectures that the effects of oil and gas risk factors change over time and vary across volatility state. We thus hypothesize the following:

Hypothesis 4 (H4). *The effects of oil and gas risk factors on stock returns are volatility state-dependent*.

3. Empirical Methodology

3.1. Theoretical View

There is a huge number of empirical studies that investigate the role of macroeconomic variables as a source of systematic risk using multifactor pricing models [5–7,10,13,17,39,52–56]. Extant empirical studies have established that market factor, size factor, value factor, and momentum factor are important risk factors that can influence stock returns significantly (see [5–7,13,52–56]). As the extant studies advocate that firm- or stock-specific factors can affect equity returns, this study conjectures that oil and gas industry-specific risk factors can potentially have effects on oil and gas stock returns.

There are several reasons to believe that oil and gas industry-specific risk factors have influences on oil and gas stock prices. Firstly, oil and gas are both primary inputs in the business operations of the oil and gas industry. Thus, changes in oil and gas prices directly affect oil and gas firms' earnings, leading to changes in earnings and cash flows, which in turn act as inputs for stock valuation models. Therefore, oil and gas prices directly affect the stock returns of the oil and gas industry (see [5–7,13]). Secondly, when investing in the oil and gas industry, investors pay close attention to oil price fluctuations because they believe that changes in oil price influence other macroeconomic variables, such as interest rates, exchange rates, and commodity prices, which indirectly impact firms' discounted cash flows and consequently have a knock-on effect on stock prices. Thirdly, as highlighted in Demirer et al. [57], "*volatility in oil prices can contribute to risk premiums required by investors on assets that have greater risk exposures concerning oil price fluctuations. Depending on the sign of the risk premium associated with a firm's exposure to oil price, oil price sensitivity can positively or negatively affect stock prices*" (p. 132). Fourthly, exchange rate and oil price move together and generally the exchange rate of net oil-exporting countries appreciate with positive oil price changes (see [58]). Exchange rate appreciation can negatively affect the oil and gas stock price of net oil-exporting countries, as exchange rate appreciation reduces oil and gas firms' revenues and profits. Thus, stock prices experience downward trends and thereby lead to unfavorable stock returns. In additon, exchange rate appreciation due to oil price increases will also reduce export competitiveness of other sectors, and as a result, adversely affect stock price. Guided by the above discussions, the multifactor model for the current study is expressed as follows.

3.2. Empirical Model for Sub-Industry

The nature and established characteristics of oil and gas stock returns data are believed to be volatile and non-normal. In such cases, GARCH-type models are superior in capturing the behavior of the stock returns. Therefore, a large number of studies on oil and gas industry risk–return have considered Generalized Autoregressive Conditional Heteroskedasticity GARCH (1,1)-X type specifications with asset pricing models (see [6,7,13,17,50]). Therefore, this study considers Generalized Autoregressive Conditional Heteroskedasticity (GARCH) (1,1)-X type specifications with a multifactor model framework, which is presented in Equation (1), for finding the effects of oil and gas risk factors since volatilities and non-normality exist in oil and gas stock returns.

Hence, the following Equation (1) is modeled with GARCH (1,1) for the effects of oil and gas risk factors on different sub-industries. This model can also be employed as a baseline for designing new multifactor models with the time varying components as risk factors.

$$\begin{aligned}(R_{jt} - rf_t) = \alpha_j + \; & \beta_{1,j}(R_{mt} - rf_t) + \beta_{2,j}\mathrm{SMB}_t + \beta_{3,j}\mathrm{HML}_t + \beta_{4,j}\mathrm{WML}_t + \beta_{5,j}\Delta OilPrice_t \\ & + \beta_{6,j}\,\Delta GasPrice_t + \beta_{7,j}\,\Delta FOREX_t + \varepsilon_{jt}\,;\ j = 1,\ \ldots,\ J;\ \text{and}\ = 1,\ \ldots,\ T.\end{aligned} \tag{1}$$

The variance equation in this model is of the following form

$$\sigma^2_{jt} = \gamma_{0j} + \gamma_{1,j}\varepsilon^2_{t-1} + \gamma_{2,j}\sigma^2_{t-1};$$

$$\varepsilon_{j,t} \rightarrow N\left(0, \sigma^2_{j,t}\right)$$

where R_{jt} are the returns of each sub-industry *j* for each week *t*, respectively (for minimizing repetition, subscript *j* denotes each oil and gas stock/sub-industry). rf_t stands for the risk-free rate for each week. R_{mt} are the returns of the market portfolio for each week *t*. SMB, HML and WML are the size factor, book-to-market value factor, and momentum factor, respectively. $\Delta OilPrice$, $\Delta Gasprice$, and $\Delta FOREX$. are the log difference in oil prices, gas prices, and exchange rates, respectively. ε_{jt} symbolizes the pricing error. σ^2_{jt} is the conditional volatility. γ_{0j} is constant in volatility. ε^2_{t-1} refers to the ARCH terms that are the volatilities from the previous periods, measured as the lag of the squared residual from the mean equation. σ^2_{t-1} denotes the GARCH term that is the previous period (*t*-1) forecast variance.

Concerning coefficients, $\beta_{1,j}$ represents the sensitivity to market fluctuation of the *j*-th sub-industry. $\beta_{2,j}$, $\beta_{3,j}$, and $\beta_{4,j}$ denote the sensitivity to size factor, book-to-market value factor, and momentum factor of the *j*-th sub-industry, respectively. $\beta_{5,j}$ and $\beta_{6,j}$ signify the sensitivity to oil price and gas price variation of the *j*-th sub-industry, respectively. $\beta_{7,j}$ signifies the sensitivity to exchange rate uncertainties of the *j*-th sub-industry.

3.3. Empirical Model for Size and Book-to-Market Value-Based Portfolios

The following multifactor asset pricing model is employed for testing the effects of oil and gas risk factors on stock returns based on firm size and book-to-market value. In this model, size factor (SMB) and book-to-market value factor (HML) were excluded, as the estimations are now made on firm size and book-to-market value based portfolios.

$$\begin{aligned}(R_{jt} - rf_t) = \alpha_j + \;& \beta_{1,j}\left(R_{mt} - rf_t\right) + \beta_{2,j}\mathrm{WML}_t + \beta_{3,j}\Delta OilPrice_t \\ & + \beta_{4,j}\,\Delta Gasprice_t + \beta_{5,j}\,\Delta FOREX_t + \varepsilon_{jt}\;\; ;\; j = 1, \ldots, J;\ \text{and } t = 1, \ldots, T.\end{aligned} \quad (2)$$

The variance equation of this model is in the following form

$$\sigma_{jt}^2 = \gamma_{0j} + \gamma_{1,j}\varepsilon_{t-1}^2 + \gamma_{2,j}\sigma_{t-1}^2\,;$$

$$\varepsilon_{j,t} \rightarrow N\left(0, \sigma_{j,t}^2\right)$$

where, R_{jt} is the returns of each size-based portfolio and book-to-market-based portfolio j for each week t, respectively. The remaining variables are as defined as in Equation (1).

3.4. Empirical Model for Volatility Period Varying Effects of Oil and Gas Risk Factors

In investigating the regime variable effects of risk factors on stock returns, the Markov regime switching model of Hamilton [59,60] is considered, as it is one the most prevalent non-linear time series models. Markov regime switching regression allows and captures the time varying effects of risk factors across volatility regimes. This model is very efficient when most of the adjustments are driven by exogenous events. Recently, Hoque and Zaidi [51] and Basher et al. [58] have employed the Markov switching multifactor model for estimating the effects of economic/market shocks and oil price stock returns on the Malaysian stock market and oil-exporting economies, respectively. Therefore, this study adopts a Markov switching multifactor model which considers the influences of transition variables (oil price) on oil and gas stock returns as state (s_t)-dependent. Henceforth, as shown below, Equation (1) is re-formulated for the Markov switching multifactor model.

$$\begin{aligned}(R_{jt} - rf_t)_{s,t} = \;& \alpha_{o,j,\,s_t} + \varnothing_{1,\,j,\,s_t}\,(R_m - rf)_t + \varnothing_{2,\,j,\,s_t}\,\mathrm{SMB}_t + \varnothing_{3,\,j,\,s_t}\Delta\mathrm{HML}_t + \varnothing_{4,j,\,s_t}\,\mathrm{WML}_t + \\ & \varnothing_{5,\,j,\,s_t}\,\Delta OilPrice_t + \varnothing_{6,j,\,s_t}\,\Delta GasPrice_t + \varnothing_{7,j,\,s_t}\,\Delta FOREX_{t-1} + \varepsilon_{j,t};\; \varepsilon_{j,t} \sim N\left(0, \sigma_{j,s}^2\right)\end{aligned} \quad (3)$$

where s_t denotes regime states and all other specifications are the same as in the specification of Equation (1). In this model, the estimation allows all coefficients of the variables to move between the different regimes.

The process and formulation of the Markov switching regressions employed are as recommended in Hamilton [59–61] and Agnello [62]. In terms of regime shift, this study conjectures two states which are low and high volatility regimes. It also conjectures that the stochastic regime generating process follows the unobservable first-order Markov chain with a two-state regime and time varying transition probabilities. The time varying transition probability Markov switching models are jointly estimated with maximum likelihood [63,64]. The conditional probability of a given state, t, depends on the state's observed prior time, $P\{s_t|s_{t-1}\}$, and transition from one regime to another depends on the observation of a transition variable (oil price), m_t, so that $P\{S_t|S_{t-1}\} = P\{S_t|S_{t-1}, m_t\}$. Hence, this study defines the time varying transition probability of a two-state Markov switching model as follows.

$$Z_t = \begin{cases} p_{11}(m_{t-k}) = \dfrac{\exp(a_1 + b_1 m_{t-k})}{1 + \exp(a_1 + b_1 m_{t-k})}\,; p_{22}(m_{t-k}) = \dfrac{\exp(a_2 + b_2 m_{t-k})}{1 + \exp(a_2 + b_2 m_{t-k})} \\ p_{12}(m_{t-k}) = 1 - p_{11}(m_{t-k})\,;\; p_{21}(m_{t-k}) = 1 - p_{22}(m_{t-k}) \end{cases} \quad (4)$$

where $p_{ij}(m_{t-k})$ is the probability of moving from regime i to regime j and is conditional on the dynamics of the transition variable, k periods before. The transition probability $p_{ij}(z_{t-k})$ facilitates in estimating the expected duration of each regime, which is presented below in Equation (5).

$$D_{ij} = (1/1 - p_{ij}) \quad (5)$$

3.5. Data

As the objective of the present study is to examine the variability in the effects of oil and gas risk factors, this study uses weekly firm-level data of publicly listed oil and gas firms on the Bursa Malaysia Stock Exchange. The sample of the study covers the period of January 2010 to December 2017. Before the year 2010, there were less than 17 listed oil and gas companies. It was only after the year 2010 that more oil and gas companies sought listing in the stock market. This study comprises a sample of 33 oil and gas stocks categorized into seven sub-industry portfolios based on a GSIC (global standard of industry classification) structure. The total sample firms are then used to construct portfolios based on firm size and the book-to-market value of the firms. With weekly data, the sample has 417 weekly data points for each variable, which is considered substantial for estimating a time series model.

This study utilizes the return of the 90-day T-bill as a proxy for risk-free rate compiled from the website of Bank Negara, the Malaysian Central Bank. Following extant empirical studies, this study employs international oil prices and gas prices [7,20,54]. The Brent oil price is used as a proxy for the global oil price and liquefied natural gas (LNG) in the Asia-Pacific region is used as a proxy for gas price. Moreover, the study employs the rate of Malaysian Ringgit per unit of USD as a proxy for the exchange rate factor. The following equations are used to generate usable data series, such as stock returns, market returns, oil price changes, gas price changes, and exchange rate changes, for the estimations.

Additionally, to calculate size and the book-to-market value factor, this study follows the procedure recommended by Fama and French [65]. Hence, we define the SMB factor as the average of the difference between a small portfolio and big portfolio for each week, and the HML factor as the average of the difference between high portfolios and low portfolios. Henceforth, this study employs Equations (6) and (7) to obtain the SMB and HML factors, respectively. Similarly, to calculate the momentum factor (WML), this study follows the procedure employed by Fama and French [66]. This study defines the WML factor as the difference between the average returns on winner portfolios and loser portfolios. Equation (8) is employed to obtain the WML factor.

$$\text{SMB} = \frac{1}{3}\{(\text{SL} + \text{SM} + \text{SH}) - (\text{BL} + \text{BM} + \text{BH})\} \quad (6)$$

$$\text{HML} = \frac{1}{2}\{(\text{SH} + \text{BH}) - (\text{SL} + \text{BL})\} \quad (7)$$

$$\text{WML} = \frac{1}{2}\{(\text{SW} + \text{BW}) - (\text{SL} + \text{BL})\} \quad (8)$$

where SL, SM, SH, BL, BM, and BH represent small–low, small–medium, small–high, big–low, big–medium, and big–high portfolios, respectively. SW, BW, SL, and BL represent small winner, big winner, small loser, and big loser portfolios, respectively.

4. Empirical Results and Discussion

4.1. Preliminary Analysis

Preliminary analyses such as normality and unit root tests were performed on the data series before proceeding to the main empirical estimations. The results for normality and the unit root tests are presented in Table 1. As shown in Table 1, we observe that all data series do not fulfill the normality assumptions. Thus, the use of a GARCH (1,1) regression for estimations helps to take care of the non-normal distribution. Furthermore, both PP and ADF unit test results suggest that the returns and growth series are stationary. Therefore, the current form of the asset pricing models does not require re-formulations of error-correction or integrated equation.

4.2. Do Oil and Gas Risk Exposure Vary with Sub-Industry?

To observe whether the effects of oil and gas risk factors on oil and gas stock returns vary across the sub-industry classifications of the oil and gas industry, this study estimated Equation (1) within a GARCH (1,1)-X type regression framework. The estimated results of Equation (1) are reported in Table 2.

As the main focus is to observe the variability of the effects of oil and gas risk factors on returns across the oil and gas sub-industry, we put less attention on interpreting the effects of common risk factors on the stock returns. As expected, for coefficients related to common risk factors, we find that the market, SMB, HML, and WML risk factors exert significant influences on stock returns of oil and gas sub-industries. Hence, common risk factors have explained some of the variations in oil and gas stock returns. The findings of the significant effects of the market, SMB, HML, and WML risk factors on the oil and gas industry stock returns are consistent with many extant empirical studies related to the oil and gas industry (e.g., [5–7,10,13,14,39]).

Now, we focus our attention on the main oil and gas risk factors of the study. First, on the oil price risk factor, we find that changes in oil price have significant positive effects on the stock returns of all oil and gas sub-industries, with the exception of stock returns of the gas utilities sub-industry. These findings suggest that the stock returns of sub-industries increase when oil prices increase, and vice versa. One possible explanation is that the earnings and cash flows of oil and gas firms directly depend on oil price changes, where increases in oil prices boost oil and gas firms' business and financial performances (see [5]). Thus, the stock prices of oil and gas firms tend to increase with positive changes in oil price. Such an explanation is grounded in the theories of energy and financial economics that oil price factors affect cash flows and the profitability of oil and gas firms (see [52,67]). Furthermore, we also find that an increase in oil price has negative effects on stock returns of the gas utilities sub-industry, suggesting that stocks of this sub-industry perform better in times of negative oil price changes. The possible explanation for this finding is that, since this industry provides services and sells products related to oil and gas, a rise in oil price is usually passed down to consumers and thus rising oil prices cause demand to drop due to a lower usage of oil- and gas-related utilities. The business performance of firms in the gas utilities sub-industry falls with an oil price increase and hence has a negative effect on stock returns.

Moreover, our findings show that the effects of oil price on the returns of oil and gas stocks vary across sub-industry along the oil and gas supply chain. The coefficients range from −0.048 to 0.113 and the gas utilities sub-industry has a negative coefficient of −0.048. The O and G exploration and production sub-industry has the highest coefficient at 0.113, suggesting that the stock returns of this sub-industry are affected the most by oil price changes. A 1% rise in oil price increases the return of the oil and gas exploration and production sub-industry by 0.113%. Changes in oil price have the least positive impacts on the O and G drilling sub-industry. Drilling companies normally contract their services to O and G exploration and production firms to extract oil and hence drillers do not generate revenue that is tied directly to oil production, as is the case for exploration and production firms. The stocks in the coals and consumable fuels sub-industry also respond strongly to oil price changes, with a coefficient of 0.108, which is the second highest. Our findings indicate that the effects of oil price changes on the returns of oil and gas sub-industries are heterogeneous. This is due to the diverse business activities along the oil and gas supply chain which make the profit generation processes unique for each sub-industry, hence each sub-industry responds differently to oil price changes. Such findings are broadly consistent with empirical evidence of diverse relationships between oil price changes and the stock returns of the oil and gas industry (see [20]).

Table 1. Descriptive statistics and normality.

	Mean	SD	Skewness	Kurtosis	Jarque—Bera Test	*p*-Value	PP Unit Root Test	ADF Unit Root Test
Panel A: Sub-industry								
Oil and gas drilling	−0.009	0.483	−0.091	10.262	479.366	0.000	−13.59 ***	−13.56 ***
Oil and gas equipment and services	0.007	0.229	0.949	6.965	335.740	0.000	−15.98 ***	−6.56 ***
Oil and gas refining and marketing	0.002	0.360	1.233	13.028	1853.016	0.000	−17.08 ***	−10.58 ***
Oil and gas storage and transportation	0.003	0.164	0.375	6.437	215.001	0.000	−18.48 ***	−18.53 ***
Oil and gas exploration and production	0.000	0.347	1.195	8.356	597.669	0.000	−19.62 ***	−19.02 ***
Coal and consumable fuels	−0.001	0.424	0.556	4.450	25.038	0.000	−12.40 ***	−12.39 ***
Gas utilities	0.002	0.145	0.216	6.700	241.089	0.000	−23.25 ***	−23.47 ***
Panel B: Portfolio								
Large Size	0.009	0.196	0.793	4.373	76.397	0.000	−14.14 ***	−4.53 ***
Small Size	0.002	0.360	1.233	13.028	1853.016	0.000	−19.62 ***	−19.02 ***
High BE/ME	0.002	0.153	0.952	6.826	317.288	0.000	−17.24 ***	−8.51 ***
Medium BE/ME	0.010	0.252	0.861	5.804	188.157	0.000	−14.29 ***	−5.43 ***
Low BE/ME	0.000	0.257	0.671	5.591	147.897	0.000	−18.84 ***	−18.76 ***
Panel C: Risk Factors								
MKT	0.000	0.093	−0.165	4.964	68.899	0.000	−20.43 ***	−23.29 ***
SMB	0.009	1.295	−1.690	21.211	5960.437	0.000	−22.01 ***	−23.31 ***
HML	0.014	1.699	6.407	84.344	117,821.500	0.000	−20.22 ***	−22.08 ***
WML	0.069	0.446	−1.072	8.455	596.94	0.000	−20.00 ***	−20.57 ***
OIL	0.000	0.300	−0.262	4.486	43.143	0.000	−12.09 ***	−20.55 ***
GAS	0.007	0.932	5.443	61.142	60,794.960	0.000	−19.95 ***	−20.53 ***
FOREX	0.001	0.080	0.113	5.232	87.469	0.000	−20.43 ***	−23.29 ***

This table reports the results of normality tests along with some summary statistics. The test results exhibit whether firms' returns are normally distributed with their statistical significance level. Column 1 lists the sub-industries in the oil and gas sector, portfolio, and risk factors. Columns 2 and 3 report mean and annualized mean returns of each sub-industry and portfolio over the sample period, respectively. Column 4 informs about standard deviation. Columns 5 through 8 report the Jarque—Bera test estimated for each sub-industry and portfolio as JB: N[s2/6+(k−3)2/24], where s, k, N are the value of skewness, the value of kurtosis, and the number of data applied in the test, respectively. Column 9 shows the estimated *p*-values of the Jarque–Bera test, where a value lower than 0.05 describes the rejection of the null hypothesis of the independent test at the significance level of 0.05. *** denote *p*-values 1%. Market represents the market return. Some of the descriptive statistics of this table were published in Table 2 of Hoque et al. [3].

Table 2. Results for sub-industries.

Sub-Industry	Constant	MKT	SMB	HML	WML	OIL	GAS	FOREX	Gamma (0)	Gamma (1)	Gamma (2)	DW	LM Test	Hetero Test	Reset Test
Oil and gas drilling	−0.006 (−3.87) ***	1.239 (7.11) ***	0.017 (2.80) ***	0.008 (1.19)	−0.008 (−2.97) ***	0.001 (1.96) **	0.027 (1.21)	0.323 (2.01) **	9.8×10^{-5} (0.88)	0.108 (1.68) *	0.843 (10.44) ***	1.96	0.701	0.232	0.424
Oil and gas equipment and services	0.002 (1.89) *	1.044 (12.10) ***	0.027 (3.89) ***	0.020 (3.07) ***	−0.001 (1.02)	0.085 (2.96) ***	0.003 (2.32) ***	0.075 (1.97) **	4.7×10^{-5} (1.82) *	0.136 (2.14) **	0.816 (12.6) ***	2.01	1.289	1.507	1.782
Oil and gas refining and marketing	2.0×10^{-5} (0.03)	0.340 (7.24) ***	−0.005 (−1.04)	0.001 (0.03)	2.1×10^{-5} (0.02)	0.004 (1.99) **	0.001 (1.62)	0.115 (1.97) **	1.2×10^{-5} (1.52)	0.129 (2.61) ***	0.861 (18.19) ***	2.10	0.241	0.299	1.446
Oil and gas storage and transportation	0.002 (2.91) ***	1.019 (5.78) ***	0.562 (6.13) ***	0.510 (7.00) ***	−0.491 (−1.88)*	0.094 (2.02) **	0.011 (0.69)	0.090 (2.33) ***	2.01×10^{-5} (−1.52)	0.066 (1.99) **	0.603 (12.59) **	1.99	1.690	0.779	1.723
Oil and gas exploration and production	−0.003 (−2.16) **	0.761 (7.06) ***	0.017 (2.30) **	0.301 (5.13) ***	0.014 (1.58)	0.113 (3.33) ***	0.002 (2.02) **	0.099 (2.79) ***	8.7×10^{-5} (1.96) **	0.119 (2.49) **	0.845 (16.68) ***	1.94	1.445	0.6880	1.710
Coal and consumable fuels	−0.004 (−1.49)	0.851 (3.89) ***	0.690 (2.21) **	−0.005 (−0.76)	−0.002 (−0.52)	0.108 (1.97) **	0.103 (2.09) **	0.362 (1.86) *	0.003 (1.98) **	0.229 (1.41)	0.716 (5.08) ***	1.89	1.427	0.319	0.880
Gas utilities	0.009 (1.42)	0.501 (9.71) ***	−0.002 (−0.72)	−0.002 (−0.59)	0.002 (1.31)	−0.048 (−2.46) ***	−0.037 (−1.98) **	−0.243 (−3.82) ***	1.7×10^{-5} (−1.472)	0.046 (1.46)	0.90 (16.27) ***	2.22	1.333	1.42	1.260

This reports the estimated results of Equation (1) with the GARCH (1,1)-X type regression approach. *MKT, SMB, HML, WML OIL, GAS, and FOREX are market, size, value,* momentum, *oil price, gas price, and exchange rate risk factors, respectively.* Gamma (1) and gamma (2) present ARCH and GARCH terms, respectively. *, **, and *** denote *p*-values at 10%, 5%, and 1%, respectively. This table was published as table 6 in our first paper, Hoque et al. [3], of the series. The table was presented for the purpose of the robustness checking of a two-stage panel regression.

On gas price, except for the gas utilities sub-industry, we find that gas price changes do not positively affect all other sub-industries, and where they do, the effects are also heterogeneous. The stock returns of sub-industries that are positively affected by gas price changes are the O and G equipment and services, O and G exploration and production, and coal and consumable fuels sub-industries, with coefficient values ranging from 0.002 to 0.103. Unsurprisingly, the stock returns of the coal and consumable fuels sub-industry benefits the most from rising gas prices, where a 1% rise in gas price increases the returns of this sub-industry by 0.103%. The results for the exchange rate risk factor show that, with the exception of the gas utilities sub-industry, the stock returns of all sub-industries are positively and differently affected by changes in the exchange rate. The positive impacts of exchange rate changes suggest that positive changes in exchange rate (exchange rate depreciation) bring in additional revenue to firms in the oil and gas industry of oil-exporting countries. The finding of a negative effect of exchange rate changes on the stock returns of the gas utilities sub-industry is surprising. A possible reason could be that policymakers use international oil and gas market prices as a benchmark in setting domestic oil and gas prices. Thus, a depreciation in exchange rate will lead to an increase in oil and gas prices in local currency terms and thereby negatively affect the business performance and stock returns. Overall, our findings provide support for hypothesis H1, that the stock returns of oil and gas sub-industries are differently affected by oil and gas risk factors. The results are in line with the findings of Mohanty et al. [14], Narayan and Sharma [15,16], Phan et al. [17], and Sanusi and Ahmad [7].

4.3. Do Oil and Gas Risk Exposure Vary with Stock Size?

We estimate Equation (2) within a GARCH (1,1)-X type regression framework to investigate whether the effects of oil and gas risk factors on oil and gas stocks vary across firm size. The estimated results of Equation (2) for size-based portfolios are reported in Table 3. For oil prices, we find that the stock returns of oil and gas firms are positively affected by oil price changes regardless of whether they are small or large firms. However, the impacts on small firms are greater than for large firms. The coefficient for small firms is 0.122, which is 2.5 times greater than 0.048, the coefficient for large firms. This suggests that, while both small and large firms respond positively to changes in oil price, the stock returns of small firms are more responsive than those of large firms. The stocks of small firms tend to be more volatile and thus changes in oil price can lead to bigger stock price jumps. Our findings are consistent with the pioneering work of Banz [37] on firm size effects and many other subsequent studies indicating that small and large firms behave differently and small firms have higher stock returns than large firms. Empirical studies on the oil price–stock returns relationship have also documented the presence of firm size effects (e.g., [10,15–17,38]).

For gas prices, the results show that the coefficients are not significant across the small and large portfolios, suggesting that the stock returns of small and large firms are not affected by the gas price risk factor. For the exchange rate factor, the empirical results show that, while the exchange rate risk factor has positive and significant effects on large oil and gas stocks, the effect on small oil and gas stocks is negative. The findings indicate that small firms lack capability and resources and hence are less able to cope with changes in the exchange rate factor. Our empirical results on firm size provide support for hypothesis H2, that oil and gas risk factors, with regard to oil price and the exchange rate factor, affect stock returns differently based on firm size.

Table 3. Results for size-based portfolios.

Portfolio	Constant	MKT	WML	OIL	*GAS*	FOREX	Gamma (0)	Gamma (1)	Gamma (2)	DW	LM Test	Hetero Test	Reset Test
Large	0.003 (2.50) **	0.781 (12.38) ***	0.001 (0.12)	0.048 (2.26) **	0.001 (0.10)	0.112 (2.01) **	1.08×10^{-5} (1.62)	0.165 (3.45) ***	0.829 (18.27) ***	1.99	1.470	0.891	1.277
Small	−0.002 (0.83)	0.928 (6.40) ***	0.003 (0.63)	0.122 (2.37) **	−0.004 (−0.29)	−0.101 (−1.97) **	9.6×10^{-5} (3.00) ***	0.159 (5.67) ***	0.763 (27.70) ***	1.96	1.684	1.238	1.885

This reports the estimated results of Equation (2) with a GARCH (1,1)-X type regression approach. *MKT, WML OIL, GAS, and FOREX are market*, momentum, *oil price, gas price, and exchange rate risk factors, respectively.* Gamma (1) and gamma (2) present ARCH and GARCH terms, respectively. ** and *** denote *p*-values at 5%, and 1%, respectively.

4.4. Do Oil and Gas Risk Exposure Vary with firm Book-to-Market Value?

We estimate Equation (2) within a GARCH (1,1)-X type regression framework to investigate whether the effects of oil and gas risk factors on oil and gas stock returns vary across book-to-market value. The estimated results of Equation (4) for book-to-market value-based portfolios are reported in Table 4.

The coefficients of the oil price risk factor indicate that oil price changes have positive effects on the returns of oil and gas stocks regardless of their book-to-market values. However, the impacts of oil price risk factor are not similar, as indicated by the coefficients that vary in terms of their magnitude, suggesting that the oil price effects on stock returns are heterogeneous. High book-to-market value stocks (value stocks) are shown to be more responsive than low book-to-market (growth stocks) to changes in oil price. For gas prices, the results show that the returns of value and growth stocks are affected differently by changes in gas price. While value stocks react negatively to increases in gas prices, growth stocks respond positively. Value stocks typically have stock prices that are relatively lower than the prices of comparable firms in the same industry. Our findings on gas price suggest that investors who follow a value investing strategy should stay alert to rising gas prices. The findings are broadly consistent with past evidence that the effects of risk factors on stock returns vary across their classifications (e.g., [10,15–17]). For the exchange risk factor, the findings show that the effects of the exchange risk factor on the returns of high and low book-to-market value firms are also not the same. The returns of value stocks are positively affected by changes in exchange rate. However, the return impacts are negative for growth stocks.

Overall, the empirical results lend support to hypothesis H3, that oil and gas risk factors affect the returns of oil and gas stocks differently based on book-to-market value. Our results also confirm that the stock behavior of value stocks is different from that of the growth stocks. The findings have some consistency with previous studies with regard to the stock performance of different book-to-market value stocks (e.g., [40–44]). Furthermore, these findings suggest that investors can use the book-to-market values of oil and gas stocks in building portfolios and hedging against oil and gas risk factors.

Table 4. Results for book-to-market value-based portfolios.

Portfolio	Constant	MKT	WML	OIL	*GAS*	FOREX	Gamma (0)	Gamma (1)	Gamma (2)	DW	LM Test	Hetero Test	Reset Test
High BE/ME	−0.001 (−0.79)	1.099 (9.75) ***	−0.004 (−1.04)	0.039 (1.99) **	−0.011 (−2.02) **	0.151 (1.98) **	0.001 (2.59) ***	0.121 (2.27) **	0.578 (3.84) ***	1.97	1.552	1.428	1.219
Medium BE/ME	0.003 (2.12) **	1.044 (11.16) ***	−0.001 (−0.52)	0.099 (2.99) ***	−0.001 (−0.10)	0.115 (0.81)	0.001 (2.83) ***	0.149 (2.33) **	0.599 (4.77) ***	2.11	1.901	1.667	1.011
Low BE/ME	0.001 (0.78)	0.800 (7.24) ***	0.001 (0.09)	0.019 (2.01) **	0.005 (1.97) **	−0.055 (−2.04) **	0.001 (1.15)	0.150 (1.04)	0.600 (2.90) ***	2.10	1.079	1.810	1.567

This reports the estimated results of Equation (2) with a GARCH (1,1)-X type regression approach. *MKT, WML OIL, GAS, and FOREX are market*, momentum, *oil price, gas price, and exchange rate risk factors, respectively.* Gamma (1) and gamma (2) present ARCH and GARCH terms, respectively. **, and *** denote *p*-values at 5%, and 1%, respectively.

4.5. Do Oil and Gas Risk Exposure Vary with Volatility Regime?

Table 5 reports the estimated results of Equation (3) with a multifactor Markov switching regression. At first, we compare the results of a linear model (in Table 2) and non-linear model, where it is detected that the coefficients of risk factors are different from those presented in Table 2 and they are volatility regime variable. Therefore, the exposure to risk factors could be volatility regime variable. The coefficients of the linearity test (LR) suggest that the effects of risk factors are asymmetric in different volatility regimes. Henceforth, it can be believed that the risk factor affects oil and gas stock returns heterogeneously in different states. Furthermore, the empirical results show that the coefficients of sigma are significant throughout the volatility regimes and sub-industries, implying that different types of volatilities exist in the stock returns of oil and gas sub-industries and they also have negative impacts on stock returns. The coefficients of sigma also highlight that high volatility has influenced more than the low–high volatility. Moreover, the regime classification measure (RCM) of Ang and Bekaert [68] suggests that the all sub-sectors within an MS model, except for the oil and gas refining and marketing sub-industry, have an RCM of 63.12. Henceforth, the lower value of RCM confirms that models with a low RCM produce a better model fit. This RCM value of the models justifies the regime stability and suitability in MS models.

This study conducted a post-estimation analysis, employing the widely used Brock–Dechert–Scheinkman (BDS) test, a residual diagnostic method for testing if the residuals have an independent and identical distribution and whether the estimated models exhibit goodness of fit. Brock et al. [69] show that the BDS test is useful not only for non-linearity tests but also for model specification tests. The BDS test has long been shown to be a powerful method for residual analysis, particularly in non-linear models [70]. In our paper, the BDS test statistics reported in Table 6 show that the residuals of all estimated models in Table 5 follow a linearity pattern and confirm the adequacy of the estimated specifications.

Focusing on the coefficient of the oil price risk factor, this study reveals that in a low volatility regime, the oil price factor has positive effects on the stock returns of all sub-industries, apart from the gas utilities sub-industry, which is negatively affected. In addition, the oil price factor has positive effects on the stock returns of the oil and gas equipment services, oil and gas refining marketing, oil and gas exploration production, and coal and consumable fuels sub-industries in high volatility regimes, while it has a negative influence on the stock returns of the gas utilities sub-industry. Despite the similar direction of influence, the magnitude of the effects varies across sub-industries and volatility regimes, and thus these findings reveal that the effects of oil price risk factors are asymmetric and nonlinear on oil and gas stock returns. In addition, the regime variable effect of oil price on stock returns is supported by Basher et al. [58] and Jammazia and Nguyen [31], as they showed oil price uncertainty has regime-dependent and structure-dependent effects on stock market returns. On this occasion, the empirical findings of the current study add new evidence to the literature that oil price changes have regime-dependent and sub-industry-dependent exposures to oil and gas stock returns. Therefore, these empirical results further improve the study of Mohanty and Nandaha [13] and Sansui and Ahmed [7] regarding oil and gas stock returns' exposures to the oil price risk factor. In addition, the current empirical finding also lends supports to Basher [58].

Table 5. Results for regime variable effects of oil and gas risk.

Sub-Industry	Regime	Const	MKT	SMB	HML	WML	OIL	LNG	FOREX	Sigma	LR (F)	LL	RCM	P11-OIL	P12-OIL
Oil and gas drilling	Low Volatility	−0.012 (−1.55)	3.278 (5.45) ***	0.009 (2.62) ***	0.051 (2.16) **	−0.016 (−0.74)	0.005 (2.11) **	0.022 (2.30) **	0.458 (1.69) *	−2.757 (−34.54) ***	6.82 **	346.35	29.87	−6.830	−11.90
	High Volatility	−0.007 (−2.40) ***	0.879 (3.32) ***	0.172 (2.06) ***	0.006 (0.65)	−0.007 (−1.45)	0.05 (0.92)	0.029 (1.12)	0.105 (0.29)	−4.060 (−20.83) ***				(−1.97) **	(−2.03) **
Oil and gas equipment and services	Low Volatility	0.008 (2.71) ***	1.113 (5.07) ***	0.072 (3.94) ***	0.014 (0.88)	−0.003 (−0.55)	0.069 (2.40) **	0.004 (2.01) **	0.166 (2.13) ***	−3.420 (−61.81) ***	10.39 ***	934.07	26.12	−28.15	5.83
	High Volatility	0.001 (0.53)	1.188 (7.88) ***	−0.023 (−2.55) ***	0.002 (0.39)	−0.003 (−1.81) *	0.129 (2.98) **	0.010 (0.99)	0.157 (0.78)	−4.123 (−49.21) ***				(−2.76) ***	(1.67) *
Oil and gas refining and marketing	Low Volatility	0.006 (2.84) ***	0.575 (3.46) ***	−0.001 (−0.05)	0.006 (1.64)	0.001 (0.28)	0.016 (2.12) **	0.001 (0.44)	0.063 (2.24) **	−3.521 (−66.37) ***	4.43 ***	1056.75	63.12	−0.624	−14.05
	High Volatility	−0.001 (−1.98) ***	0.288 (4.60) ***	−0.010 (−2.05) **	−0.001 (−1.69) *	0.001 (0.71)	0.018 (3.11) ***	-3.4×10^{-5} (−0.008)	0.166 (2.39) **	−4.901 (−57.03) ***				(−2.11) **	(−2.48) ***
Oil and gas storage and transportation	Low Volatility	0.006 (1.24)	0.823 (2.02) **	−0.006 (−0.23)	0.005 (1.96) ***	−0.009 (−0.22)	0.031 (2.24) **	0.03 (1.88) *	0.441 (0.09)	−2.779 (−49.88) ***	7.03 ***	709.13	46.85	−5.779	8.950
	High Volatility	−0.004 (−1.46)	0.119 (0.46)	0.009 (0.61)	0.013 (1.61)	−0.013 (−2.35) ***	0.026 (1.24)	0.03 (0.94)	0.188 (1.99) **	−3.63 (−43.20) ***				(−2.95) **	(1.75) *
Oil and gas exploration and production	Low Volatility	−0.007 (−3.51) ***	0.851 (4.98) ***	0.022 (1.86) *	0.008 (1.15)	0.002 (0.26)	0.127 (2.59) ***	0.004 (0.63)	0.032 (0.21)	−3.823 (−52.17) ***	7.39 ***	731.74	28.02	−22.89	44.26
	High Volatility	0.001 (0.51)	0.770 (1.78) *	0.005 (1.19)	−0.002 (−0.09)	0.001 (0.04)	0.156 (2.38) **	0.016 (3.61) ***	0.151 (2.30) **	−2.713 (−47.35) ***				(−1.96) **	(1.69) *
Coal and consumable fuels	Low Volatility	0.021 (2.06) ***	0.470 (0.61)	−0.009 (−0.27)	−0.019 (−0.83)	−0.004 (−0.25)	0.160 (1.99) **	0.034 (2.07) **	1.44 (2.82) **	−2.700 (−29.48) ***	6.87 ***	280.99	36.41	12.778	1.38
	High Volatility	−0.014 (−3.18) ***	1.419 (5.00) ***	−0.002 (−0.17)	−0.033 (−0.23)	−0.026 (−1.77) *	0.181 (2.01) **	0.056 (0.35)	0.15 (1.12)	−3.63 (−28.11) ***				(2.01) **	(0.11)
Gas utilities	Low Volatility	0.003 (1.50)	0.671 (4.37) ***	0.001 (0.09)	−0.005 (−0.52)	0.007 (1.73) *	−0.025 (−1.89) *	−0.011 (−2.33) ***	−0.033 (−0.14)	−3.694 (−66.43) ***	5.5 ***	1100.74	22.93	(−3.77)	−7.45
	High Volatility	0.001 (0.49)	0.391 (4.98) ***	−0.003 (−0.45)	−0.003 (−1.79) **	0.001 (0.36)	−0.005 (−2.80) ***	0.006 (0.07)	−0.317 (−1.96) **	−4.691 (−47.92) ***				(−1.94) ***	(−0.83)

This reports the estimated results of Equation (3) with a Markov switching regression. *MKT, SMB, HML, WML OIL, GAS, and FOREX are market, size, value,* momentum, *oil price, gas price, and exchange rate risk factors, respectively.* Sigma is the coefficient of the volatility effect. LR is linearity test. LL denotes log likelihood. P11-OIL and P12-OIL are time varying parameters. *, **, and *** denotes *p*-values at 10%, 5%, and 1%, respectively. This study also estimated the regime classification measure (RCM) of Ang and Bekaert (2002) to measure the suitability of the regime.

Table 6. Brock–Dechert–Scheinkman (BDS) test of residuals.

Sub-Industry	M	ε (0.20)	ε (0.50)	ε (0.70)	ε (0.90)
Oil and gas drilling	2	0.0003	−0.0010	0.0007	−0.0048
	3	0.0004	0.0087	0.0158	0.0039
Oil and gas equipment and services	2	0.0005	0.0020	0.0060	0.0018
	3	0.0003	0.0041	0.0072	0.0037
Oil and gas refining and marketing	2	0.0014	0.0047	0.0050	0.0022
	3	0.0007	0.0054	0.0079	0.0045
Oil and gas storage and transportation	2	0.0007	0.0043	0.0060	−0.0013
	3	0.0004	0.0045	0.0109 *	0.0005
Oil and gas exploration and production	2	0.0020	0.0073	0.0081	0.0027
	3	0.0033 *	0.0018	0.02561 *	0.01420 *
Coal and consumable fuels	2	0.0047	0.0063	0.0069	0.0030
	3	0.0039	0.0073	0.01091 *	0.0061
Gas utilities	2	0.0014 *	0.0040	0.0045	0.0044
	3	0.0009	0.0046	0.0071	0.0092

This table reports BDS statistics. "m" represents numbers of embedding dimensions. ε, epsilon, presents tolerance. * denotes p-values at 10%.

Furthermore, looking from the perspective of stock behavior to the oil price risk factor, oil and gas stocks respond faster in high volatility conditions. The possible reason is that, in a high volatility state, stock prices are sensitive to information; thus, the reflection of oil and gas stocks is expected to be stronger. Additionally, in the case of oil and gas stocks, it is known that an oil price increase is expected to push oil and gas stock prices. Thus, news or information related to oil price increases are considered as positive, where investors over-react to oil price increases and thereby oil and gas stock prices respond faster in high volatility conditions. However, this argument and explanation are contradictory for the gas utilities sub-industry, where the intensity of the response is low in a high volatility condition, as increases have a negative influence on the stock returns of the gas utilities sub-industry regardless of the volatility regime. Henceforth, the current empirical finding of this study adds new evidence that the responses of oil and gas stocks vary across different conditions and states.

Focusing on the effect of the gas price factor, this study discovers that, in low volatility regime, the gas price factor has positive effects on the stock returns of the oil and gas drilling, oil and gas equipment services, and coal and consumable fuels sub-industries, while it has a negative impact on the gas utilities sub-industry in the same regime. These findings date the previous findings of the current study, as this study expected to find the same direction of the effects of the gas price factor on all sub-industries' stock returns in low volatility. Furthermore, in a high volatility regime, the oil and gas risk factors affect oil and gas exploration production sub-industry's stock returns. These findings confirm that the effects of gas price factors vary across regimes and sub-industries. The possible reason for these findings could be that oil and gas sub-industry businesses depend on gas factor-related activities. Another possible reason could be that, from a behavioral perspective, investors were confident about the gas price factor in the highly volatile condition of oil and gas industry stock; the risk of gas price changes, therefore, did not affect the oil and gas stock performance during the highly volatile condition. Henceforth, the current findings improve the study of Jin and Jorion [11] regarding the gas price factor effects on firms of the oil and gas industry. Therefore, the current findings on exposures to gas price risk factors add new insights to the literature on risk factors' effects on oil and gas stock returns.

As for the effect of the exchange rate factor, this study finds that, in low volatility conditions, changes in the exchange rate return have positive and significant effects on the stock returns of the oil and gas equipment services, oil and gas refining and marketing, and coal and consumable fuels sub-industries. However, in high volatility conditions, changes in exchange rate return have positive and significant effects on the stock returns of the oil and gas refining and marketing, oil and gas storage transportation, and oil and gas exploration production sub-industries, and they have negative effects on the stock returns of the gas utilities sub-industry. Hence, the current findings confirm that sub-industries' exposures to changes in exchange rate return vary across time and regime. Hereafter, the current findings improve on the study of Lanza et al. [12] regarding the exchange rate factor effects on the stock returns of the oil and gas industry. Lanza et al. [12] have discussed that the exchange rate has a significant effect on the stock value of six major oil and gas companies in the US. Therefore, the current findings on exposures to exchange rate risk factors add new insights to the literature on risk factors' effects on oil and gas stock returns.

This study observes that the effects of oil and gas risks on the stock returns of the oil and gas industry are time varying and regime-dependent. Therefore, the overall empirical results from this investigation lend strong support to hypothesis H4. Henceforth, the empirical results of the current estimation add new evidence that the oil and gas industry reactions to oil and gas risk factors are time varying and regime-dependent. Furthermore, these findings provide strong support to Basher [58] and improve on the study of Mohanty and Nandaha [13], Ramos et al. [16], and Sansui and Ahmed [7] in terms of risk factor effects on oil and gas stock returns.

5. Conclusions

This paper examines whether the effects of oil and gas risk factors on stock returns of the oil and gas industry vary across sub-industry classification, firm size, book-to-market value, and volatility state using weekly firm-level data of the oil and gas industry for the period of January 2010–December 2017. To examine variability in stocks' exposure to oil and gas risk factors, we employ multifactor asset pricing models with a GARCH (1,1)-X type regression and a Markov switching regression framework.

Our major findings are as follows. First, we find that oil price, gas price, and exchange rate have significant positive effects on stock returns in almost all of the oil and gas sub-industries, with the exception of the gas utilities sub-industry, which is negatively affected. We also find that the effects of oil and gas risk factors vary across sub-industries in the oil and gas value chain. For oil prices, the sub-industry affected the most by oil price changes is O and G exploration and production, while the least affected is the O and G drilling sub-industry. Such findings are not surprising. This is because in the O and G exploration and production sector, revenue is tied directly to oil and gas production, while in the O and G drilling sector, the revenue of drillers is not directly tied to oil and gas production, as is the case for firms in the exploration and production sub-industry. For gas prices, we find that the stock returns of three sub-industries that respond positively and significantly to gas price changes are the O and G exploration and production and coal and consumable fuels sub-industries and O and G equipment and services. The findings on the exchange rate risk factor indicate that the stock returns of all sub-industries are positively and differently affected by changes in exchange rate. These findings contribute to extending several important studies of related subject matters (e.g., [3,6,7,9,10,13,15,36]).

Second, for firm size effect, we find that impacts of oil price and exchange rate on stock returns vary across firm size, where small firms exhibit higher impacts than large firms for changes in both oil price and exchange rate. Such findings are broadly consistent with the theoretical prediction that small and large firms behave differently and that small firms have higher returns than large firms. Hence, our findings add new insight into the energy literature, that the effects of the oil price and exchange rate risk factors on stock returns depend on firm size. These findings contribute to the study of Narayan and Sharma [15,16] and Phan et al. [17] and highlight that the oil and risk factor effects vary across the size of stock. Third, for the book-to-market value, we find that the returns of value versus growth stocks are differently affected by changes in oil and gas risk factors. These finding contribute and enhance the study of Narayan and Sharma [15,16] and Phan et al. [17] and highlight that the oil and risk factor effects vary across the size of stock. Fourth, we add new evidence to the literature by showing that the effects of oil price, gas price, and the exchange rate factor on stock returns at the firm level are regime variable, implying that they vary across different periods and regimes. These findings improve the extent of the literature of risk factors in oil and gas stocks in terms of period variable effects on oil and gas stocks. Finally, this confirms the editorial beliefs of Smyth and Narayan [19] about the heterogeneity within the oil and gas industry and its exposure to risk factors.

In summary, our findings highlight that sub-industry analysis is important to gain a better understanding of the effects of oil and gas risk factors on stock returns. The findings of heterogeneous responses of stock returns across different oil and gas sub-industries facilitates firms in managing risk and also investors in formulating hedging and trading strategies. Evidence on the book-to-market value suggests that investors who follow a value investing strategy benefit the most from oil price increases, so they should stay alert in situations of rising gas prices. Additionally, investors benefit more from investing in small firms than in large firms. Since the current study employed time series models incorporating stock attributes, such as firm size and book-to-market ratio, future research can consider using cross-sectional two stage models. Additionally, asymmetric adjustment can be investigating using a copula approach instead of GARCH models. Killian's (2009) oil market shocks can also be applied to observe how each sub-industry reacts to asymmetric oil market shocks.

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