

A STUDY ON THE EFFECT OF OIL PRICE ON STOCK RETURNS OF THE RENEWABLE ENERGY FIRMS IN INDIA

Thesis

Submitted in partial fulfilment of the requirements for the degree of
DOCTOR OF PHILOSOPHY

by

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November, 2023

DECLARATION

(By the PhD Research Scholar)

I hereby declare that the Research Thesis entitled "**A STUDY ON THE EFFECT OF OIL PRICE ON STOCK RETURNS OF THE RENEWABLE ENERGY FIRMS IN INDIA**" which is being submitted to the National Institute of Technology Karnataka, Surathkal, in partial fulfillment of the requirements for the award of the **Degree of Doctor of Philosophy in Finance**, is *a bonafide report of the research work carried out by me*. The material contained in this Research Thesis has not been submitted to any University or Institution for the award of any degree.



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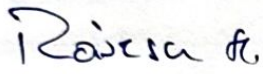
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ACKNOWLEDGEMENT

The last few years of my life, which I have devoted to the Doctoral programme in Management, have been very challenging. Now that I stand here on the verge of completing it, I feel a sense of accomplishment and worthiness. This journey would not have been possible without the assistance and encouragement of many people around me and I wish to express my gratitude to each one of them who have stood by me through thick and thin. I sincerely thank my guide and mentor, Dr. Rajesh Acharya H, Associate Professor in the School of Humanities, Social Science and Management, for his earnest support and motivation, without which this work would not have happened. His mentorship is admirable and has created a positive impact on my life and work throughout the tenure of the research. In his guidance, all the challenges encountered in the work were easily conquered, enabling me to proceed with better focus and clarity. Freedom is happiness. My research journey has been the happiest of my life due to the freedom he has given me during my stay at NITK. I appreciate his efforts and comments, which helped to mold this work efficiently and in due time.

I am filled with immense pride and gratitude for my institution, NITK Surathkal, which allowed me to pursue this course by granting me a scholarship and providing all the necessary infrastructure facilities for this research work. I take this opportunity to thank the Director, Deans, the faculty fraternity of NITK, and the non-teaching staff. I thank Dr. Sheena, the HOD of School of Humanities, Social Science and Management, for supporting me in this endeavor. I also thank the faculties and staff of the department for helping me with the administrative requirements related to the research.

I am grateful to have Dr. Rashmi Uchil and Dr. Nagendrappa H. as my Research Progress Assessment Committee members, as they have always found time to understand and appreciate the work, along with constructive suggestions. This study was possible only because of the proactive support and cooperation the school authorities and staff rendered to me. I take this moment to sincerely thank them for accommodating my requests.

I thank my family for their unwavering belief in me and for standing by me throughout the course of this study and in life. My father, (Late) Ajay Mishra, is an ideologue of our family values. He prioritized the interest of the poor and downtrodden rather than his own. Even during the last breath of his life, he urged me and my brother to help for the betterment of the people in their

sufferings. His good deeds and blessing have always helps me to overcome obstacles of life. My mother, Binapani Mishra, is a symbol of sacrifice in my family and is alone at my native family home. Despite her physical ailment, she never demands my presence at home for my better career. My words and deeds are nothing before her sacrifice. My elder brother, Dr. Nachiketa Mishra, takes responsibility for the family so that I can accomplish my research work on time and is also a source of my strength and motivation. I also express my gratitude to my friends at NITK and outside for the strength and hope they have showered upon me. Finally, I thank God, the Supreme Power, for lighting my way and for the valuable lessons I have learned throughout this journey.

We all come to this world. However, our work speaks for us. I am nothing before thousands of crores of human beings. What I am today or will be in the future is more due to the situation and surrounding than my hard work. I am nothing more than a character in a play of life.

Thank you, everyone!

Lalatendu Mishra

ABSTRACT

The renewable energy share is increasing the total energy consumption. A substantial growth in the renewable energy generation is seen in India which is going to be one of the most renewable energy producer in the world. Like other sector, renewable energy sector's stock return reaction to crude oil price is studied which is growing due to the increasing importance of renewable energy sector. This is an incremental study at firm level and in the context of India. The study period was from January 2009 to March 2022. All renewable energy firm listed in the National stock Exchange of India are considered for the study. The renewable energy sector or industry can be divided into sub-sectors such as solar, wind, etc. But, most Indian renewable energy firms deal in different business activities. Thus, all renewable energy firms are categorized into four sub-group, such as firms dealing in renewable energy products and services, standalone firms dealing in renewable energy production, firms dealing in both renewable and non-renewable energy production, firms dealing in renewable energy and other businesses. For crude oil price, the Indian basket oil price is considered.

In first objective, the effect of oil price change has a direct relationship with stock return in all market conditions in the whole sample of Indian renewable energy firms. The direct effect of oil price change on stock return sees a declining trend in the case of firms dealing in renewable energy and other business activities. In remaining sub groups of renewable energy firms, the direct effect of oil price is seen without any particular trend. And this effect is found in all market conditions.

In the second objective, oil price uncertainty has an indirect effect in bearish market conditions and a direct effect on stock returns of Indian renewable energy firm in the extreme bullish market conditions. In the sub groups, oil price uncertainty has an indirect effect in bearish market conditions and a direct effect during normal and bullish market conditions on stock returns. No asymmetric effect of oil price uncertainty on stock return is observed.

In third objective, the oil price asymmetric effect only on stock returns of the standalone renewable energy production firms is seen in the short run. In the long run, the asymmetric effect is found in the whole sample and other sub-groups of renewable energy firms, except firms dealing in production of renewable and non-renewable energy firms.

In fourth objective, oil supply shock has a direct relationship with stock return only in bullish market condition in the whole sample of renewable energy firms. This pattern is seen in the sub-group of firms. In normal market condition, demand specific to oil price shock has a direct effect on stock return. This interaction is seen in bearish market conditions also. In the case of standalone renewable energy firms, this relationship has a strong presence. In the remaining market conditions, the structural oil shocks have an inverse relationship with stock return.

The result of the study will also be helpful to the investors and portfolio managers to maximize the investment return by observing the possible movement in stock prices of the renewable energy sector firms. The government and the regulatory authorities can understand the behavior of the renewable energy sector stocks in response to oil price. They could frame appropriate policies to ensure investment growth in this sector.

Key words: Renewable energy firms, Oil price, Stock return, Oil price uncertainty, Asymmetric effect, Structural oil shocks

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ABBREVIATION

ARDL	Autoregressive Distributed Lag
UNFCCC	United Nations Framework Convention on Climate Change
ECO	WilderHill Clean Energy Index
FCFE	Free Cash Flow to Equity
GARCH	Generalized AutoRegressive Conditional Heteroskedasticity
GCC	Gulf Cooperation Council
GREI	The S&P Global Renewable Energy Index
MAC	MAC Global Solar Energy Index
MGARCH	Multivariate Generalized Autoregressive Conditional Heteroscedasticity
MS-VAR	Markov switching vector autoregressive
NARDL	Non-linear Autoregressive Distributed Lag
NYSE	New York Stock Exchange
OLS	Ordinary least squares
OVX	Oil price volatility Index
QARDL	Quantile Autoregressive Distributed Lag
RV	Realized Volatility
REI	The S&P Global Renewable Energy Index
SADF	Supremum Augmented Dickey-Fuller
SPGCE	S&P Global Clean Energy Index
SVAR	Structural Vector Autoregression
TDIC	Time-dependent intrinsic correlation
US	United States
UK	United Kingdom

VAR–	Vector Autoregressive-Generalized Autoregressive Conditional
GARCH:	Heteroscedasticity model
VAT	Value Added Tax
VECM	Vector Error Correction Models
WTI	West Texas Intermediate

CHAPTER 1

INTRODUCTION

1.1. INTRODUCTION:

Industrial activities and per capita income in India have been steadily increasing which has led to an increase the energy consumption on industrial and domestic fronts. Traditionally, India is dependent on fossil fuel (oil and coal) for its energy needs. Due to the concern of pollution and limited fossil fuel reserves, there has been a shift toward non-fossil energy which is also known as clean, green, or renewable energy. One of the reasons for replacing fossil fuel with renewable energy is to reduce the emission of greenhouse gases. Renewable energy firms don't assure zero-emission and also responsible for the emission of greenhouse gases. So the question is whether renewable energy helps to reduce the overall emission of these gases. Researchers find that renewable energy firms are responsible for reducing overall greenhouse gases (Squalli, 2017 and Qi et al., 2014). The renewable energy investment not only reduces in greenhouse gases, but also leads to growth in GDP and energy consumption (Lyeonov et al., 2019). Renewable energy is estimated to be the largest source of primary energy consumption worldwide by 2025 (The IEA, 2019). Its share in the power sector would increase from 25% in 2017 to 85% by 2050 (The IRENA, 2018). In this massive growth of the renewable energy sector in the world, the following discussion highlights how India has become a major player in this sector. The International Renewable Energy Agency (IRENA, 2017) released a working paper on renewable energy sector prospects in India, which claims that the energy requirement of India is expected to be doubled by 2030. The increase in the share of renewable energy in overall consumption will reduce the dependence on the import of fossil oil. Renewable energy in India could achieve 40% of power generation and 60% of the power capacity by 2030. Now, India ranks fourth in the world in total installed renewable power generation capacity after China, US and Brazil (REN21, 2022). On August 2022, India achieved 40 per cent installed renewable energy capacity before 2030 (Economic Survey of India, 2022-

23) which was intended at the United Nations Framework Convention on Climate Change (UNFCCC) secretariat in October 2015. Now, India aims to achieve 50 per cent by 2030. In the 26th UN *Climate change conference, 2021 (COP26)*, India is committed to achieving a net zero emission goal by 2070. As per IRENA 2023, India has seen a per capita growth in the renewable energy sector investment by 34 per cent from 2015 to 2021. It is second to China in terms of per capita investment. In contrast, there is a 26 per cent decline in per capita investment in South Asia. Excluding India, the decline is 76 per cent.

Traditionally, fossil fuel or crude oil has dominated the energy requirement. This is also reflected in academic research in the area of energy finance, as well. Mork (1994) finds that oil price influence macroeconomic activities, but the effect is asymmetric. Jones and Kaul (1996) argue that oil price changes the expectation of future real cash flow which ultimately affects stock return. Oil price change destabilizes the expected dividend growth and the expected return associated with a time varying risk premium. This fluctuation in expectations lead to a change in the stock return. Crude oil price is one of the most volatile or uncertain commodities. Oil price uncertainty also affects the economy and investment, ultimately affecting stock return (Park and Ratti, 2008; Elyasiani et al., 2011; Arouri et al., 2012). Oil price change can be positive or negative and both changes need not have the same effect on stock return. If both these changes impact stock return differently, it is a case of asymmetric effect on stock return which has been observed in the extant literature (Arouri and Nguyen, 2010; Ramos and Veiga, 2013; Salisu and Isah, 2017). Oil price change or shock arises due to the different reasons i.e., the sources of oil price shocks or structural oil shocks. These shocks are namely, supply shock, aggregate demand shock and specific demand shock (Kilian, 2009). Structural oil shocks have heterogeneous effects on the capital market (Kilian and Park, 2009; Hamilton, 2009).

There is enough literature which has proved the existence of relation between oil price and stock return. There are two possible arguments available for this relationship. First, oil price has an impact on the input cost. This poses a challenge to maintain the profitability of the firms and affects stock return. Second, the inflationary pressure is triggered by the rise in oil prices. The increased inflation causes increase in the interest rate or the discount

rate, which investors use to discount to know the value of the share. But, the dependency levels of different sectors on oil are not the same. The researches have looked into this aspect and examined the impact of oil price on stock return of various sectors. The impact is heterogeneous (Arouri and Nguyen, 2010). The majority of the studies have not given much attention to renewable energy as a separate sector. Few studies have focused on the impact of oil price on the stock return of renewable energy sector (Uddin et al., 2019; Pham, 2019; Reboredo and Ugolini, 2018). These studies are based on the developed economies. Empirical results of these studies confirm the existence of relationship between oil price and stock return of the renewable energy sector.

The oil pricing is different in India. India is following the dynamic pricing mechanism. In this mechanism, the oil marketing companies are free to make changes in the prices of oil. Due to political compulsion, the government maintains control over the price of oil through public sector companies which are dominating the oil marketing business. The government also uses taxes and subsidies to influence the oil price. During the upward price trend period, the government keeps the taxes low and vice versa. Thus, the domestic oil price in India may not always reflect the changes in the international crude oil price. The oil price in India depends on excise duty, VAT, exchange rate, and demand in the market. The study on the relationship between oil price and stock return of the renewable sector in the context of India is unique given its distinct oil pricing scenario.

1.2. THEORETICAL BACKGROUND

The relationship between oil price and stock return is built upon the discounted cash flow theory. An investor invests in a stock with the expectation of future cash flow from it. Thus, the value of the stock is a function of the discounted value of the future cash flow of the stock. In a simple explanation, the value of the stock would be high in case of predictable and high cash flow and a low value, in case of unpredictable and low cash flow. The risk also affects the discounted cash flow. Higher risk leads to a higher discounting rate of return and lesser value of stock.

Several authors have propounded models of equity valuation based on the discounted cash flow. John Burr Williams (1938), Gordon (1962), Fuller and Hsia (1984) argued the

equity value can be determined by discounting the future dividend flow. These models developed on the dividend flow are called as dividend discounting model. In reality, the firms prefer to hold back profit rather than distributing the entire profit as dividend. This practice is because of two reasons. First, firms prefer to keep the profit for future investment opportunities rather than depending on the market for finance. Second, firms want to maintain a stable dividend distribution to keep the confidence of the investors intact. Free Cash Flow to Equity (FCFE) Model came to the picture to address the shortcomings of the dividend discount model.

FCFE = Net income + Depreciation – Capital expenditures – Change in non-cash working capital – (New debt issued – Debt repayments).

The value of equity can be determined by the FCFE model in the following formula.

$$P_0 = \frac{\text{EXPECTED FCFE}_1}{\text{COST OF EQUITY} - \text{STABLE GROWTH RATE}}$$

The increase in oil price causes an increase in the input costs of the firms. This reduces the profit margin of the firms and ultimately, stock prices fall. The rise in oil price increases the price of different goods and services in the economy. This creates inflationary pressure in the economy. To contain inflation, countries try to manipulate the monetary policy with an increase in the interest rate. The spike in the interest rate increases the discounting rate. The higher is the discount rate, the lower is the intrinsic value of the share (Huang et al., 1996; Miller and Ratti, 2009). This is reflected in the capital market with a fall in stock price. This negative relation between oil prices is not universal across the market condition. In a boom market condition, firms' production are at high to meet the demand of the market. Investors perceive the better performance of the firm. So, they are ready to pay a higher price. Here, the positive oil-stock relationship is replaced with the negative one (Narayan and Narayan, 2010; Kollias et al., 2013; Zhu et al., 2014)

1.3 MOTIVATION

The motivation for this study is derived from the studies, which are explained in the following four discussions. First, the main motivations of the first objective which evaluates the oil price effect on renewable energy firm stock return, are the findings of Zhu et al. (2016), Zhu et al. (2019) and Dawar et al. (2021). Zhu et al. (2016) find that the stock returns sensitivity to oil price fluctuation is not the same in different quantiles in China. They apply panel quantile regression in their study. Recent studies find that oil price affects stock returns of the renewable energy sector. Zhu et al. (2019) find that the oil price effect is heterogenous on stock returns of new energy firms in China. They use time series regression models. Dawar et al. (2021) argue that the effect of oil price on the stock returns of the renewable energy sector is not the same under different market conditions. They use time series quantile regression model. Their study concludes that the effect of oil price on stock returns in the renewable energy sector is heterogenous under different market conditions. These studies give the motivation to examine this relationship across market conditions and at the firm level in India.

Second, Researchers find that the Oil Volatility Index (OVX) has a stronger effect on stock return (Luo and Qin, 2017) and the renewable energy stock return (Dutta, 2017) than the realized volatility. Xiao et al. (2018) find the asymmetric effect of oil price uncertainty (OVX) on China's capital market under different market conditions. These literature motivate to extend the study on the oil price uncertainty effect across market conditions in India. Thus, the second objective explores the oil price uncertainty effect in the Indian renewable energy sector across market conditions and at the firm level.

Third, the researchers provide the evidence of oil price asymmetric effect on renewable energy stock return. Kocaarslan and Soytas (2019) find this effect in the long run by using the Non-linear Autoregressive Distributed Lag (NARDL) model. In the new energy firms of China, oil price interacts asymmetrically with stock return and this interaction is more robust in the case of state-owned firms (Zhu et al. 2019). On the other hand, Salisu and

Isah (2017) and Hatemi-J et al. (2017) deduce that the oil price asymmetric effect on stock return is heterogeneous across countries. The third objective derives motivation from these studies to explore the asymmetric effect of oil price on stock return of renewable energy firms in India across time horizons.

Fourth, extant studies on the linkage between structural oil shocks and stock return in the renewable energy sector are based on sectoral or index level, which consists of the top-performing renewable energy companies in the world (Zhang et al., 2020; Maghyereh and Abdoh, 2021). It is found that the heterogeneous effect of oil shocks across time horizons and market conditions. The effect of oil shock is heterogeneous across countries also (Koh, 2017). These studies motivate to explore the oil shock effect at the firm level in the Indian context. Thus, the fourth objective examines the structural oil shock effect on renewable energy India firms' stock returns across market conditions.

1.4 RESEARCH GAP, RESEARCH QUESTIONS AND RESEARCH OBJECTIVES

1.4.1 Research gap and research questions

Available literature has established that oil price has an impact on stock return. But, this relationship varies across countries (Sadorsky, 2008), industries (Nandha and Faff, 2008; Phan et al., 2015) and firms (Narayan and Sharma, 2011). In the past few years, renewable energy has gotten the attention of researchers. It is due to its emerging role in fulfilling energy demand and as a solution to the climate change problem. The renewable energy literature finds that oil price impacts stock returns of the renewable energy sector (Zhang, and Du, 2017; Reboredo and Ugolini, 2018; Kocaarslan and Soytas, 2019; Dawar et al., 2021; He et al., 2021). The effect of oil price varies across sub-sectors of the renewable energy sector (Pham, 2019). Most studies are done in developed economies and on stock market indices except China (Zhou et al., 2019). So, there is a need to examine the effect of oil price on stock returns of renewable energy at the firm level in India. This research gap leads to the first question of the study.

Research question 1: What is the effect of oil price on stock returns of Indian renewable energy firms across market conditions?

The existing studies show that oil price uncertainty (oil price volatility) can explain stock return. But, the oil price volatility effect on stock return varies across countries (Park and Ratti, 2008; Ramos and Veiga, 2013; Alqahtani et al., 2019) and sectors (Elyasiani et al., 2011; Arouri et al., 2012). In this strand of literature, stock return of the renewable energy sector is also influenced by oil price uncertainty as per recent studies (Dutta, 2017). In the Indian capital market, the oil price uncertainty has a stronger effect in bearish market conditions (Sreenu, 2022). So, there is a need to examine the effect of oil price uncertainty on stock return of the renewable energy sector in India and at the firm level. This research gap leads to the second question of the study.

Research question 2: What is the effect of oil price uncertainty on stock returns of Indian renewable energy firms across market conditions?

As per existing studies, oil price has an asymmetric effect on stock return (Lee and Zeng, 2011). This asymmetric effect varies across countries (Lee and Zeng, 2011; Salisu and Isah, 2017) and sectors (Arouri and Nguyen, 2010; Tsai, 2015). This effect is observed in the renewable energy sector (Kocaarslan and Soytas, 2019) and is heterogeneous in the new energy industry at firm-level analysis (Zhou et al., 2019). Researchers have not given attention to the asymmetric effect of oil price on the stock return of the renewable energy sector in India. This research gap leads to the third question of the study.

Research question 3: Is there any asymmetric effect of oil price on stock returns of Indian renewable energy firms?

The oil price shock effect on stock return has been studied in the existing literature with regard to different countries (Apergis & Miller, 2009; Cunado & Gracia, 2014; Koh, 2017; Maghyereh & Abdoh, 202), different sectors (Degiannakis et al., 2013), and different time regime (Hu et al., 2018; Kang et al., 2015; Broadstock & Filis, 2014). The oil price effect is heterogeneous at the firm level (Narayan and Sharma, 2011; Aggarwal et al., 2012).

Zhang et al. (2020) and Maghyereh and Abdoh (2021) find the heterogeneous effect of structural oil shocks at various quantiles and time horizons. The oil shocks and renewable stock return interactions have not been observed in an emerging economy context. Thus, this study explores the following research question.

Research question 4: What is the structural oil shock effect on stock returns of the renewable energy firms across market conditions in India?

1.4.3 Research objectives

1. To measure the oil price effect on stock returns of renewable energy firms in India under different market conditions.
2. To estimate the oil price uncertainty effect on stock returns of the Indian renewable energy firms under different market conditions.
3. To investigate the asymmetric relationship between oil price change and stock returns of renewable energy firms in India.
4. To evaluate the effect of structural oil shocks on stock returns of Indian renewable energy firms across market conditions.

1.5 METHODOLOGY

In the following points, objective wise methodology is explained. In all the objectives, control variables are the asset pricing factors.

1. To measure the oil price effect on asset pricing of renewable energy firms in India under different market conditions.

For this objective, panel quantile regression is applied with asset pricing factors as control variables.

2. To estimate the oil price uncertainty effect on stock returns of the Indian renewable energy firms under different market conditions.

For this objective, panel quantile regression is applied with asset pricing factors.

3. To investigate the asymmetric relationship between oil price change and stock returns of the renewable energy firms in India.

For this objective, panel nonlinear ARDL (Autoregressive Distributed Lag) model is applied to estimate asymmetric effect across horizons (both in the long run and short run).

4. To evaluate the effect of structural oil shocks on stock returns of Indian renewable energy firms across market conditions.

A two-step approach is applied here. The first step is the estimation of different sources of oil shocks using the structural vector autoregressive (SVAR) model. The second step is the estimation of the oil shocks effect on stock return across market conditions by applying panel quantile regression in the asset pricing framework.

1.6 RESEARCH HYPOTHESES

The followings are the hypothesis of the four objectives of the study.

First objective hypothesis

H0 Oil price has no significant effect on stock returns of the renewable energy firms.

H1 Oil price has a significant effect on stock returns of the renewable energy firms.

Second objective hypothesis

H0 Oil price uncertainty has no significant effect on stock returns of the renewable energy firms.

H1 Oil price uncertainty has a significant effect on stock returns of the renewable energy firms.

Third objective hypothesis

H0 Oil price has a symmetric effect on stock returns of the renewable energy firms.

H1 Oil price has an asymmetric effect on stock returns of the renewable energy firms.

Fourth objective hypothesis

H0 Oil price shocks have no significant effect on stock returns of the renewable energy firms.

H1 Oil price shocks have a significant effect on stock returns of the renewable energy firms.

1.7 DATA

The monthly data from January 2009 to March 2022 is analyzed in this study. Stock prices of renewable energy firms are collected from the CMIE Prowess database. 94 renewable energy firms listed in the National Stock Exchange of India are considered for this study. In the existing literature, the sub-group or sectors are based on energy types such as solar, wind, etc. But in India, most firms deal in more than one energy type. Thus, all renewable energy firms (whole sample) are categorized into the following four subgroups such as; firms dealing in renewable energy products and services, standalone firms dealing in renewable energy production, firms dealing in both renewable and non-renewable energy production, firms dealing in renewable energy and other businesses. Indian Basket crude oil price from Petroleum Planning and Analysis Cell's web page, Ministry of Petroleum, the Government of India is considered for the oil price. The Oil Volatility Index (OVX) data have been accessed from the Chicago Board Options Exchange' website as proxy of oil price uncertainty. Total global oil production from the U.S. Energy Information Administration (EIA) webpage is considered for oil supply driven shock, the index of global real economic activity from the Federal Reserve Bank of Dallas webpage which is calculated as per Kilian (2009) for aggregate demand driven shock and Indian Basket crude oil price from Petroleum Planning and Analysis Cell's web page, Ministry of Petroleum, the government of India for oil price specific demand driven shock. Indian Basket crude oil price is derived from two international oil prices such as Brent oil price and Oman & Dubai oil price. To deflate oil price, the consumer price index as a proxy of inflation is used, which is available on the website of the Federal Reserve Bank of St. Louis. Fama-French factors (Fama and French, 1993) and momentum factor (Carhart, 1997) are collected from Data Library for Indian Market of Indian Institute of Management Ahmedabad.

1.8 CONTRIBUTION AND IMPLICATION

The outcome of this study will be an incremental contribution to the existing body of knowledge in the area of oil price and its effect on the stock return of the renewable energy sector. This study focuses on the relationship of different oil price dynamics such as oil price, oil price shock, oil price volatility, and oil price asymmetric effect with the stock return of the renewable energy sector at the firm level in India. Thus, it will help the investors in their investment decision in various renewable energy firms. The result of the study will also be helpful to the portfolio managers in the management of their portfolios by observing the possible movement in stock prices of the renewable energy sector firms. The government and the regulatory authorities can understand the behavior of the renewable energy sector stocks in response to oil price. They could frame appropriate policies to ensure investment growth in this sector.

1.10 OUTLINE OF THE THESIS

The remaining part of this thesis follows the following structure.

Chapter 2: Literature review

This chapter critically explains the literature under four broad headings such as the effect of oil price, the effect of oil price uncertainty, the asymmetries of oil price and the effect of structural oil shocks on stock returns of Indian renewable energy firms.

Chapter 3: Measuring the oil price effect on stock returns of renewable energy firms in India under different market conditions

This chapter measures the effect of oil price change on stock returns of renewable energy firms in India under different market conditions.

Chapter 4: Estimating the oil price uncertainty effect on stock returns of the Indian renewable energy firms under different market conditions

This chapter evaluates the effect of oil price uncertainty on stock returns of Indian renewable energy firms across market conditions. It also discusses the asymmetric effect of oil price uncertainty.

Chapter 5: Investigating the asymmetric relationship between oil price change and stock returns of the renewable energy firms in India

This chapter discusses the asymmetric effect of oil price on stock returns of Indian renewable energy firms in different time horizons.

Chapter 6: Evaluating the effect of structural oil shocks on stock returns of Indian renewable energy firms across market conditions

This chapter evaluates the effects of different sources of oil shock on stock returns of Indian renewable energy firms across market conditions. It also contains the estimation of oil shocks asymmetries.

Chapter 7: Conclusion

The final chapter contains the findings, contribution and limitations of this study

CHAPTER 2

LITERATURE REVIEW

Researchers have explored different dynamics in the relationship between oil price change and stock return for over three decades. Due to the increasing importance and demand for renewable energy to meet energy requirements, researchers explored the effect of crude oil price on renewable energy stock return. In this chapter, extant literature are critically explained in four aspects: the effect of oil price, oil price uncertainty effect, oil price asymmetric effect and structural oil price shock effect on renewable energy stock price.

2.1. THE OIL PRICE EFFECT ON RENEWABLE ENERGY STOCK RETURN

In a seminal work on oil-stock interaction, Jones and Kaul (1996) explored the effect of oil price on stock market reactions due to the real or future cash flow. The quarterly data from 1947-1991 were analyzed for four countries: the US, Canada, the United Kingdom and Japan. They deduced that stock price reactions to oil price shocks in the US and Canada were due to changes in the real cash flow. Evidence suggested that these markets are rational. But the oil-stock linkage was not supported by the real cash flow change argument in Japan and the United Kingdom. The effect of oil prices and their lag on stock return was negative in these countries.

In a sectoral study, Nandha and Faff (2008) examined the effect of oil price on stock return using time series regression. From April 1983 to September 2005 was the sample period duration for 35 global sectoral indices. Monthly data were analyzed for the study. The oil price negatively affected all sectoral stock returns except mining, oil and gas. They also find the asymmetric effect of oil price on stock return. Thus, the oil price effect on sectoral stock return was heterogeneous.

Sadorsky (2008) examined the linkage between oil price movement and stock return using a panel multi-factor market model. Annual data from 1990–2006 were analyzed for this study. The oil price increase effect was stronger than the oil price decrease on stock

return. This study deduced that the changes in oil prices had an asymmetric effect on stock return. The oil price effect on stock return varied depending upon the size of the firms. Medium-size firms' stock returns were more adversely affected by oil price.

In a firm-level study, Narayan and Sharma (2011) examined the effect of oil prices on firm return. The daily data of 540 firms from 1950 to 2004 were analyzed using GARCH (1, 1) models. They found that the oil price effects on firm returns were heterogeneous. Firm size played a major role in this. In sectoral analysis, energy and transportation saw an increase in return due to an increase in oil prices. But, firms of other sectors experienced a fall in return due to increased oil prices. The oil price lag affected negatively in 10 out of 14 sectors. Large-size firms were positively affected by oil prices. In contrast, small and medium size firms' returns reacted negatively to oil prices. Similarly, turnover affects the reaction pattern of firm returns to oil prices.

Phan et al. (2015) explored the stock returns interactions of firms with oil price movements. They categorized firms into two sets such as oil producers and oil consumers. The daily data were analyzed for the period from 02.01.1986 to 31.12.2010, using time series regression. Stock returns of oil producers reacted positively to oil prices. But, oil prices are affected stock returns heterogeneously to different sectors. The oil price effect on both sets of firms' stock returns was asymmetric. The oil price asymmetries were seen in the sub-sectors. Oil price had a stronger effect on the larger size firms. Oil price affected the consumer firms' stock return in the higher lags while this happened in the maximum two lags producer firms' stock returns.

To explore the long-run interaction between oil price index and stock return index, Silvapulle et. al. (2017) applied a data-driven local linear method. Monthly data of ten large net oil importing countries from September 1999 to June 2015 were considered for the analysis. Here, they explained how oil-stock interaction over a period of time. The interaction was positive among oil price and stock indices, which was higher before the global financial crisis and decreased after the global financial crisis. The oil price index had a negative effect for a brief period in 2005.

In the renewable energy literature, Kumar et al. (2012) investigated the relationship between oil price and clean energy stock returns using the vector autoregression (VAR) model. The Standard and Poors' (S&P) Global Clean Energy Index, representing 30 companies worldwide and the Arca Tech 100 index, representing 100 listed companies in the New York Stock Exchange (NYSE) from 15 different industries, was used for the study. The weekly data from January, 2005 to December 2010 were analyzed for this study. Past movements in oil price, technology stock price and interest rates could explain the stock returns of clean energy sector. The oil price had a significant and positive effect on clean energy stock return. Carbon price influenced the stock return of clean energy and high technology firms.

In a carbon efficient sectoral comparative study, Managi and Okimoto (2013) studied the relationship between oil price, clean energy and technology stock returns in the US, applying Markov switching vector autoregressive models. The weekly data of the clean energy stock index, technology stock index, interest rate and oil price were considered for the study from January 3, 2001, to February 24, 2010. They discovered a positive relationship between oil price and renewable energy stock returns after a structural break in 2007. Clean energy and technology stock returns behavior were similar toward oil price movement.

In a comparative study, Reboredo and Ugolini (2016) examined the impact of quantile price movements in oil, gas, coal and electricity on the quantiles of clean energy stock returns in the US and the EU. They used a multivariate quantile dependence approach (vine copula models) for the study. Their study used daily data from 2nd January 2009 to 1st September 2016. They deduced that the electricity price in the EU and, in the case of large fluctuations, oil prices in the US significantly affected stock returns of the renewable energy sector. Other energy prices played a minor role in influencing renewable stock returns. They also found that energy prices had a symmetric effect on stock returns of the renewable energy sector.

To explore the causal impact and co-movement between alternative energy stock return and crude oil price, Reboredo et al. (2017) used continuous wavelets and cross-wavelet

transformations. The daily data on different global renewable stock indices and sectoral renewable energy indices from 01.01.2006 to 16.03.2016 were used for this study. They provided the evidence of dynamic interaction between oil price and stock return in long run was stronger. A non-linear causal relationship existed between these variables. In high frequencies, the authors identified a unidirectional causality, but in low frequencies, they discovered a bidirectional causality.

In the U.S., Ferrer et al. (2018) explored the connectedness between oil price and clean energy stock price and other financial variables such as stock prices of technology and conventional energy firms, U.S. Treasury bond yields, the U.S. default spread and the volatility of the U.S. stock and government bond markets. The daily data from January 2, 2003 to September 29, 2017 were analyzed. Their study used connectedness methodology and Supremum Augmented Dickey-Fuller (SADF) tests. The Wilder Hill Clean Energy Index (ECO) was used for clean energy stock price. They found that oil price was not explaining the clean energy stock returns in the short or long-run. They argued that the clean energy stock price were more related to geography, capital investment, technology, and legislation, etc. Pairwise volatility connectedness was between clean energy and technology stock.

Uddin et al. (2019) studied the cross-quantile dependence of renewable energy stock returns dependence on the oil price, gold price, exchange rate, and aggregate stock returns by applying cross quantile correlation technique. The daily data of REI (The S&P Global Renewable Energy Index) from 21 November 2003 to 29 December 2017 were analyzed. REI consists of 30 companies in renewable energy in the world. They observed a positive dependence of renewable energy stock returns on oil prices across the quantile. They also found an asymmetric relationship between oil price and renewable energy stock returns. This asymmetric effect was higher in the higher lags. The exchange rate and the gold price positively affected renewable energy stock returns.

In a renewable energy sub-sector study, Pham (2019) investigated the relationship between stock returns and oil price in the US context. The author applied MGARCH (Multivariate Generalized Autoregressive Conditional Heteroscedasticity) model. The

daily data of the respective aggregate renewable energy index and its sub-sector indices were analyzed from 13 October 2010 to 21 August 2018. They found the heterogeneous effect of oil price on renewable energy sub-sectors' stock returns. The author found that wind, geothermal, and fuel cell oil were the least affected. On the other hand, the oil price effect was stronger on biofuel and energy management stock returns.

The linkage between oil price and renewable stock return across market conditions was examined by Dawar et al. (2021) using quantile regression. From 31 March 2005 to 21 June 2019 was the sample period. Weekly data of WTI oil price and three renewable energy indices such as SPGCE (the S&P Global Clean Energy Index), MAC (the MAC Global Solar Energy Index) and the ECO (WilderHill Clean Energy Index) were analyzed. They found a positive effect of oil price and this effect was comparatively weaker in bullish market conditions. The asymmetric effect was found in normal and bullish market conditions. The lag effect of oil price change was also significant on renewable energy stock return.

The dynamic connectedness was examined between oil price and stock return of clean energy and technology firms by Nasreen et al. (2020). They applied wavelet coherence and spillover analysis. The sample period was from December 29, 2000 to June 26, 2017 and the analysis was on aggregate stock. They found the connection between oil price and stock return of clean energy and technology firms after 2008 financial crisis. The connectedness was stronger in low frequency data. Other market shocks affected stock return of the clean energy sector.

In Europe, Geng et al. (2021) investigated the oil price dynamic effect on clean energy companies' stock return using a connectedness network approach. This was an aggregate level stock analysis on weekly data and the sample period from September 1, 2009 to June 7, 2019. They deduced that oil price and clean energy stock price move in the same direction. The relationship was positive. The asymmetric information connectedness existed between oil price and clean energy stock. An increase in oil price had a greater impact on clean energy stocks than a decrease in oil price. Oil price was the net receiver of the information spillover.

Niu (2021) examined the dynamic relationship between oil price, stock return of renewable energy and technology companies by applying time-dependent intrinsic correlation (TDIC) method. The daily data series was from January 3, 2006 to December 31, 2018 on the aggregate stock. They concluded that dependence between pairs was stronger in the long term (more than one year) than in the short (within one week) and medium terms (from one week to one quarter). The dependence of renewable energy stock on oil price decreased after the European debt crisis 2008. They found a stronger effect of negative oil return than positive oil return.

In Europe and US, He et al. (2021) examined the effect of oil price, gold price and financial stress on clean energy stock return using the quantile autoregressive distributed lag (QARDL) approach. Their study considered monthly data sets from November 21, 2003 to January 30, 2020 at the aggregate stock level. They found a positive effect of oil price on clean energy stock return in higher and extreme quantiles of Europe and in almost all the quantiles of US. In the long run, the positive effect on the renewable energy stock return was during the bullish market condition. Gold price had a negative effect on clean energy stock in higher and extreme quantiles in Europe and across quantiles in the USA. Financial stress had a negative association in higher quantiles of Europe and lower and extreme quantiles of the US.

The above discussion shows that oil price influenced stock return (Jones and Kaul, 1996). This effect was heterogeneous across industries (Nandha and Faff, 2008; Phan et al., 2015), countries and firms (Narayan and Sharma, 2011 Sadorsky, 2008). The time-varying effect of oil price was also seen on stock return (Silvapulle et al., 2017). But, oil price affected renewable energy stock return positively (Kumar et al. 2012; Managi and Okimoto, 2013 Reboredo and Ugolini, 2016). At the same time, certain studies did not find a linkage between oil price and renewable energy stock return (Ferrer et al., 2018). The positive impact of oil price on renewable energy stock return was seen across quantiles and the asymmetric effect of oil price was higher in the higher lags (Uddin et al., 2019). But, global crude oil price had a heterogeneous effect on stock return of sub-sectors of renewable energy (Pham, 2019). This positive effect became stronger in bullish market

conditions (Dawar et al., 2021; He et al., 2021). This interaction was stronger in low-frequency data (Nasreen et al., 2020) and in the long run (Reboredo et al., 2017). An increase in oil price had a greater impact on renewable energy stocks than a decrease in oil price (Geng et al., 2021).

2.2. THE EFFECT OF OIL PRICE UNCERTAINTY ON RENEWABLE ENERGY STOCK RETURN

Globally, crude oil meets a significant portion of energy requirements. Uncertainty in oil price causes a reduction in production and investment in the economy (Bernanke, 1983; Bloom, 2009). Park and Ratti (2008) investigated the effect of oil price shock and oil price volatility on the stock markets of the US and European countries. Monthly data from 1986:1–2005:12 were analyzed applying a VAR model. In Norway, an oil exporting country, oil price positively correlated with stock return. The oil price negatively affected stock returns in the remaining countries. Oil price volatility did not adversely affect stock return in the US.

In various industries in the US, Elyasiani et al. (2011) examined the effect of oil price return and oil volatility on stock return and stock return volatility using the GARCH (1,1) technique. December 11, 1998, to December 2006 was the sample period for daily data. Oil price affected stock return than oil price volatility in more industries, especially those related to oil and substitute of oil. The opposite effect is seen for other industries using oil. The financial sector was affected by both oil price and oil price volatility.

To discover the volatility spillover between oil price and stock market in Europe, Arouri et al. (2012) applied a vector autoregressive-generalized autoregressive conditional heteroscedasticity model (VAR–GARCH). Weekly data from January 1st, 1998 to December 31st, 2009 were collected for the sample period. There was more volatility transmission effect from oil price to the stock market. The intensity of transmission varied across sectors.

After cross-sector studies, Ramos and Veiga (2013) investigated oil price volatility linkage with the stock market across countries. Monthly data from 18 countries from

December 1988 to June 2009 were analyzed using GARCH and time series regression. Oil price volatility had a negative effect on oil-importing countries and a positive effect on oil-exporting countries. Whereas the asymmetries of oil price volatility on stock market were seen only in oil-importing countries. Oil price rise depressed stock markets of oil importing countries and raised stock prices of oil exporting countries. The oil price fall negatively affected stock markets of oil importing countries. This negative effect was more severe in oil export countries.

To check whether the effect of oil price uncertainty on stock return across time horizons, Caporale et al. (2015) applied a bivariate VAR-GARCH-in-mean model. January 1, 1997–February 24, 2014, was the sample duration for weekly data. Ten sectoral indices of China: Healthcare, Telecommunications, Basic Materials, Consumer Services, Consumer Goods, Financials, Industrials, Oil and Gas, Utilities, and Technology were considered for the analysis. Oil price uncertainty during demand-side shocks positively affected all sectors except the Consumer Services, Financials, and Oil and Gas sectors. Oil price uncertainty during supply-side shocks negatively impacted the Financials and Oil and Gas sectors.

G 7 countries dominate the world economy. Thus, Diaz et al. (2016) examined the linkage between oil price volatility and stock return in G 7 countries using a [VAR](#) model. GARCH (1, 1) model was used to estimate oil price volatility. They used a monthly dataset of range between January 1970 and December 2014. They deduced that world oil price volatility had more relevance than local oil price volatility. Oil price volatility had a stronger effect than inflation in the country. The oil price volatility impact is stronger on stock return across G 7 economies. Post 1986, the effect of oil price volatility is higher on stock return.

Luo and Qin (2017) examine the oil price volatility and oil volatility index shock on the Chinese aggregate index and sectoral index by applying an unrestricted VAR. Daily data from 10.05.2007 to 31.12.2015 were analyzed for this study. They found that oil price volatility had a negative effect on stock return. However, realized volatility had a weaker effect on stock return, especially after the financial crisis.

To see the oil price and stock return interaction in different market conditions, Xiao et al. (2018) examined the oil price uncertainty effect on the Chinese stock market using quantile regression. The daily data were analyzed for the sample duration from May 10, 2007 to September 20, 2017. The oil volatility index was used for oil price volatility. One composite index and ten sectoral indices were considered. The effect of oil uncertainty on aggregate stock and sectoral stock returns was negative. These negative effects were due to the positive changes in oil price uncertainty than the negative change in oil price uncertainty. The negative effect is asymmetric in bearish market conditions. After 2013, the reforms in oil pricing reduced this negative linkage in bearish market conditions.

Bašta and Molnár (2018) investigated the effect of oil price volatility on stock market volatility using the wavelet methodology. Both implied and realized volatilities were considered for the study. From May 10, 2007, till July 28, 2016 is the period for the daily time series data. There is a strong relationship between oil price volatility and stock market volatility. This linkage is time varying for implied and realized volatility both. The effect of oil price was stronger in the yearly time range and weaker in the daily time range. The implied volatility of stock market led to implied oil market volatility. This pattern was not seen in realized volatility.

In the Gulf Cooperation Council (GCC) countries, Hamdi et al. (2019) examined the influence of oil price volatility on sectoral stock returns by applying quantile regression. Monthly data of 12 sectors from 1st January 2006 to 1st August 2017 were analyzed by the authors. In higher quantile, oil price volatility had a positive coefficient for energy, industrial finance and basic materials sectors. It had a negative coefficient for the banking, oil & gas and transportation sectors. While insurance, minerals, utilities and telecommunications remained unaffected by oil price volatility in normal market condition. In bearish market conditions, industrial and insurance sector were positively affected by oil price volatility. Whereas, Utilities, minerals and telecommunications sectors remained unaffected. In a normal market condition, oil price volatility could not influence minerals, utilities and telecommunications.

The oil volatility index is an implied volatility that was used in many studies as a proxy of oil price uncertainty or volatility. Xiao et al. (2019) investigated the effect of oil implied volatility on stock implied volatility in China using quantile regression. The sample period for daily data was from March 16, 2011 to May 9, 2018. The positive interaction between the two variables became stronger in the bearish market. Oil price volatility affected stock market volatility asymmetrically. In the bearish market condition, the positive change of oil price volatility had a stronger effect. But, the negative change in oil price volatility had a stronger effect in a bullish market. The impact of oil price volatility was weak and insignificant in lags of more than one.

To observe time varying effect, Alqahtani et al. (2019) investigated the oil price volatility on the GCC stock market using an ARMA-DCC-EGARCH and time-varying Student-t copula models. The weekly data range from May 2007 to February 2018 was analyzed for this study. They found that oil volatility depressed stock returns for the entire time duration. These countries' stock markets reacted to the oil price volatility with varying magnitude. There were high (Kuwait and Qatar), medium (Saudi Arabia and UAE) and low (Oman and Bahrain) dependency levels.

In different market conditions and across countries, Joo and Park (2021) discovered the oil price and its volatility effect on different oil and stock market conditions in ten major oil-importing countries such as China, France, Germany, India, Italy, Japan, Korea, the Netherlands, Spain, and the U.S. They applied quantile on quantile approach for a monthly dataset for the sample period from May 2007 to December 2019. In most quantiles, the effect of oil volatility on stock return was negative. However, this effect was stronger in lower quantiles. The positive effect of oil price volatility was observed in bullish market conditions. The effect of oil price volatility was strong during the weaker stock and oil markets. India, Japan, Korea, and the U.S. were strongly affected by the oil price volatility.

In the Indian stock market, Sreenu (2022) explored the linkage between oil price uncertainty and the stock market by applying quantile regression. The oil price volatility index was considered a proxy of oil price uncertainty. The sample period from the daily data of 10 sectoral indices was from March 2008 to March 2020. It was found that the

increase in oil price uncertainty depressed the returns of the indices. In sluggish market conditions, it negatively affects the stock return more. The asymmetries of oil price uncertainty were also seen. The positive change affected negatively more than the negative changes. This study deduced that the effect of oil price uncertainty on stock return reduced after the 2012 reform in oil pricing.

Liu et al. (2023) examined the effect of oil volatility index on stock return of different economies using quantile-quantile model. From 2000 to 2020 was the time range of monthly data for analysis. The countries included in the study are China, Japan, USA, France, and Germany. The impact of crude oil price volatility on stock return was negative. This impact is heterogeneous across quantiles. The effect of oil price volatility is stronger in lower quantiles than in medium and higher quantiles.

The following literature consist of causality and volatility aspect in crude oil price and renewable energy stock return. Using the directional spillover approach, Ahmad (2017) evaluated the direction of spillover between crude oil price and its volatility on stock returns of the clean energy and high technology sectors. Daily data from 2005 to 2015 were analyzed. Clean energy and technology indices were taken into account. Clean energy and high-tech companies were net transmitters of return and volatility spillover to crude oil price volatility.

In a comparative study on the effect of oil price volatility index and realized volatility, Dutta (2017) investigated the impact of crude oil price volatility on the clean energy stock market. The daily data were considered for the period ranging from 10.05.2007 to 30.06.2016. Three realized volatility models were used for the analysis. The author found that the effect of OVX on stock return was substantial compared to the realized variance. The clean energy stock market was more sensitive to the OVX shocks.

The extant literature showed that the oil price uncertainty positively and negatively affected stock return in oil exporting and importing countries, respectively (Park and Ratti, 2008; Ramos and Veiga, 2013; Alqahtani et al., 2019). The effect of oil price volatility was seen influencing stock returns heterogeneously across industries (Elyasiani et al., 2011; Arouri et al., 2012). The asymmetries of oil price uncertainty were seen in oil-importing

countries as per Ramos and Veiga (2013). The oil price uncertainty had a heterogeneous effect on stock return across industries (Caporale et al., 2015). This linkage was also time-varying (Diaz et al., 2016; Luo and Qin, 2017). The asymmetric effect of oil price uncertainty was seen in the bearish market condition (Xiao et al., 2018). On the other hand, the oil price uncertainty had heterogeneous effects across the sectors and market conditions (Hamdi et al., 2019). It was discovered that implied volatility (oil volatility index) had a stronger interaction with stock return (Bašta and Molnár, 2018). The implied volatility effect on stock return was stronger in bullish market conditions (Xiao et al., 2019). The oil price uncertainty effect was stronger in bearish market conditions (Joo and Park, 2021). In the Indian capital market, the oil price uncertainty had a stronger effect in bearish market conditions (Sreenu, 2022). The renewable energy stock return as a new volatility transmitter to crude oil price (Ahmad, 2017) was found. The implied oil price volatility strongly affected renewable energy stock return in higher quantiles (Dutta, 2017).

2.3. THE ASYMMETRIC EFFECT OF OIL PRICE ON RENEWABLE ENERGY STOCK RETURN

Oil price change can be positive or negative and both changes need not have the same effect on the variables. If both these changes impact dependent variable differently, it is a case of asymmetric effect. In a seminal work, Sadorsky (1999) examined the effect of oil price and oil price volatility on stock return using vector autoregression. From 1947:01 to 1996-04 was the sample period for monthly data of the study. The author found that the effect of oil price and oil price volatility on stock return was negative. The positive impact of oil price was found on interest rate and industrial production. The changes in economic activity had the least effect on oil price. Oil price volatility had an asymmetric effect on the economy.

In G7 countries, Lee and Zeng (2011) investigated the impact of oil price on stock returns. Monthly data were analyzed using a quantile regression model for the sample period from 01: 1968 to 12:2009. The asymmetries of oil price were seen on the stock market. Investors were more pessimistic during the bad performance of the market.

Similarly, investors reacted more optimistically to the stock market during good market conditions. The structural break impact on the oil-stock nexus was seen in countries except Canada, an oil exporting country.

Keeping in view of global financial crisis, Tsai (2015) examined how oil price impacted stock return prior to, during and after the financial crisis in the US. The author considered the daily data from January 1990 to December 2012 using OLS with panel-corrected standard errors. The study deduced that the asymmetric effect of oil price was seen during and after the crisis. The asymmetries linked to oil price varied across industries. The negative impact of oil price change were stronger on stock returns of energy-intensive industries. The negative impact of oil price shock was stronger on large size firms during pre-crisis period and on the medium size firms in the post-crisis period.

Hatemi-J et al. (2017) investigated the causal impact of oil price on stock price of the G7 countries. The weekly data from January 1975 to October 2013 were analyzed for the study using the causal test model of Hatemi-J (2012). They did not find a symmetric causal effect of oil price. Using an asymmetric causal test, they found that the investor considered the increase in oil price as an indication of good economic growth that led to the increasing stock price in the US and Japan. German stock market was sensitive to the decrease in oil price, which caused the decrease in stock price.

Salisu and Isah (2017) re-investigated the relationship between oil price and stock price in oil-import and oil-exporting countries. They applied the panel nonlinear ARDL (Autoregressive Distributed Lag) model to examine the asymmetries and predictability using Campbell and Thompson (2008) test. The stock price data from 2000M1 to 2015M12 of eight net oil importing countries and five net oil exporting countries were analyzed. The asymmetric effect was stronger on stock prices of oil net importing countries than net oil exporting countries. Stock price prediction using oil price was effective for net oil importing countries than net oil exporting countries.

In a Chinese study, Huang et al. (2017) explored the effect of oil price on stock return across multiple time horizons using the wavelet transform and VAR model. Daily sample data from October 2006 to December 2014 were analyzed. They found no asymmetric

effect of oil price change on stock returns in different time horizons. Both oil price increase and oil price decrease affected stock return. The oil price change had a stronger effect on stock return in the long run. The stock return response to oil price was higher than the exchange rate.

In an Islamic sectoral study, Badeeb and Lean (2018) examined the asymmetric effect of oil price on stock return using a non-linear Autoregressive Distributed Lag cointegration model. The monthly data from January 1996 until June 2016 were analyzed. They found that oil price had a weaker impact on the Islamic composite index. But, oil price had a varying effect on sectoral Islamic indices. In the long run, the response of different Islamic sector stock was non-linear to oil price changes. Stock return reactions to the oil price negative changes were higher than positive changes. The real sector stock return was resistant to oil price changes. Islamic stock provided gain in a declining oil price. During the uncertain market condition, there was a reduction in the gain. Healthcare, consumer services, financial services, and telecommunications sectors are neutral to the oil price changes in all horizons.

Chang (2020) investigated the extremely small to extremely large changes in oil prices on stock prices by applying multiple threshold non-linear Autoregressive Distributed Lag model. The daily data from 23.09.1997 to 06.02.2020 was analyzed for the study. In the short run, the oil price asymmetries were seen in India, Indonesia and Russia. The asymmetric effect was stronger in the short run. In the long run, oil price had no significant effect on stock price.

In different time horizons and quantiles, Hashmi et al. (2021) explored the effect of oil price on stock return by applying the quantile ARDL model. Daily data of oil exporting and oil importing countries were collected from 25.09.1997 to 20.03.2020. In this study, oil-exporting countries included Russia, Mexico, Venezuela, and Norway and oil-importing countries included India, China, Japan and Norway. The asymmetric effect was found in all countries except Norway. Oil price impacted stock return asymmetrically in both the short and long run. No cointegration existed in the long run for both oil-exporting and oil-importing countries. In the short run, the oil price asymmetric effect were seen at 5

% significance level in Mexico, Venezuela, China, and South Korea. In other countries, the asymmetric effect was seen at a 10% significance level.

In the Islamic stock market, Chang et al. (2020) investigated the oil price effect on Islamic aggregate stock return and sectoral stock return using quantile-on-quantile regression. Daily data from January 1996 to April 2019 was the sample period. Upper(lower) quantiles of oil price depressed lower (upper) quantiles stock returns. The financial sector, healthcare sector, consumer goods, consumer services, oil & gas sector, utility sector, and industrial sector show similar results like the Islamic stock index. A positive interaction between the oil price-stock return was seen in basic material, technology and telecommunication sectors across quantiles.

In GCC countries, Cheikh et al. (2021) investigated the linkage between oil price movements and the stock market. Monthly data spanning the period of January 2005–December 2019 were analyzed using nonlinear vector smooth transition regression models. Kuwait, Oman, Qatar, and Saudi Arabia responded to the large oil price changes than the small ones. Some GCC countries had oil price asymmetries on stock return. Bahrain did not show an asymmetric reaction to oil price movements. Oman, Qatar, and Saudi Arabia were sensitive to the negative oil price change. Kuwait's stock market did not respond to any direction of oil price change.

In the US, Rahman (2022) examined the relationship between oil price and stock return. Monthly data from 1973:01 to 2015:08 were analyzed using nonlinear bivariate structural VAR. The author found that stock returns of different industries affect asymmetrically. Oil price volatility and oil price depressed the US stock return. The effect of positive changes in oil price affected highly than that of negative ones. This study deduced that oil price had an asymmetric effect on aggregate stock return. Similar results were also seen for oil price volatility. The increase in volatility caused the transmission of asymmetric effects from oil price to aggregate stock return.

In different time horizons and countries, Saha (2022) investigated the oil price symmetric and asymmetric effect on stock price using the linear and non-linear Autoregressive Distributed Lag (ARDL) approach to cointegration and error-correction

modeling. Monthly data from 1986 to 2019 for Brazil, Canada, Chile, Japan, S. Korea, Malaysia, Mexico, the U.K. and the U.S. were used. The most asymmetries of oil price changes are seen in the short run. An increase in oil price increases stock prices in Brazil, Chile, Japan, Mexico and S. Korea. However, with an increase in oil price, stock returns decreased in Malaysia and the U.S. A decrease in oil price changes affected the industrial, transportation, bank, computer, and insurance sectors. However, both the biotechnology and semiconductor sectors were affected by an increase in oil price only. The utility sector is affected by both increases and decreases in oil prices.

In a cross-country study, Sadeghi and Roudari (2022) explored the interaction between structural oil shock and stock markets of oil importing (China and Japan) and exporting (Norway and Canada) countries at different time regimes. From 1990:1 to 2020:4 was the sample duration for the monthly data of the study. Stock market reacts negatively to oil price shocks in oil-importing countries. Oil supply shock positively interacted with stock return in oil-exporting countries, while it was the opposite in oil-importing countries. The global oil price shocks affected the stock market in the short run. The developed countries' stock markets were resilient to oil shocks. The regime changes influenced the stock market response to oil shocks.

One strand of literature is dedicated to how oil price has an asymmetric impact on stock return of the renewable energy sector, are explained in this paragraph. Kocaarslan and Soytaş (2019) applied the time series NARDL model to unearth the asymmetric relation between oil price and interest rate with renewable energy and high technology stock return. The daily data from 2004 to 2014 were considered. They deduced the presence of an asymmetric relationship between oil price and renewable stock. The impact of oil price was positive in the long run.

Uddin et al. (2019) examined the cross-quantile dependence between variables using the cross-quantile correlation technique. The dependent variable was the renewable energy stock return and the independent variables were oil price, exchange rate, gold price and the aggregate stock return. The daily data of the S&P Global Renewable Energy Index (REI) from 2003 to 2017 were analyzed. REI consists of 30 companies in renewable energy in

the world. They observed a positive dependence of renewable energy stock return on the oil prices across the quantiles. The renewable energy stock return responded asymmetrically to oil price and was more sensitive in the higher lags.

In a Chinese new energy industry study, Zhu et al. (2019) studied how stock return reacted to oil price at the firm level by using the capital asset pricing model with Fama-French specification and GARCH. The daily data of the new energy companies from 2011 to 2018 were analyzed for the study. The authors noticed that the stock return of the new energy industry reacted asymmetrically. The asymmetric reaction of stock return was stronger in the state-owned firms. Oil price change had a stronger lag effect on stock return in the short term. At the firm level, the effect of the oil price was heterogeneous on stock return.

The above literature showed that the crude oil price had an asymmetric effect on the economy (Sadorsky, 1999). The asymmetries of crude oil price on stock return were also found (Lee and Zeng, 2011). These asymmetries varied across industries (Tsai, 2015). The crude oil price asymmetric effect was stronger in oil-importing countries (Salisu and Isah, 2017). In China, there was no asymmetric effect of oil price change on stock return in different time horizons (Huang et al., 2017). The asymmetric effect of oil prices varied across countries and time horizons (Chang, 2020). But, the asymmetric oil price on stock return was found in both the short and long run (Hashmi et al., 2021). A positive interaction between oil price and stock return was seen in basic material, technology and telecommunication sectors across quantiles among the Islamic stock indices (Chang et al., 2020). The asymmetric effect of oil price in all GCC countries existed except Bahrain (Cheikh et al., 2021). The increase in volatility caused the transmission of asymmetric effects from oil price to aggregate stock returns (Rahman, 2022). The oil price increase and decrease affected heterogeneously across countries and sectors (Sadeghi and Roudari, 2022; Saha, 2022). There was an asymmetric relationship between oil price and renewable stock return (Kocaarslan and Soytaş, 2019). The impact of oil prices was positive in the long run. The renewable energy stock return responded asymmetrically to oil price and was

more sensitive in the higher lags (Uddin et al., 2019). The asymmetric reaction was stronger in state-owned renewable energy firms (Zhu et al., 2019).

2.4. THE EFFECT OF SHOCKS ON RENEWABLE ENERGY STOCK RETURN

In a seminal work, Killian (2009) advocated that different sources of oil price change had varying effects on the economy of a country. By using these sources of oil price change or shocks, Kilian and Park (2009) investigated US stock return reactions to oil shocks. The monthly data from 1973:01 to 2006:012 were considered. They applied structural VAR to decompose all oil market shocks (supply shock, demand shock, oil price specific shock). They concluded that oil market-specific demand had a negative effect, aggregate demand shock had a positive effect and oil supply shock had no significant effect on stock return.

In a cross-country study, Apergis and Miller (2009) investigated the impact of oil shocks on stock returns in different countries (Australia, Canada, France, Germany, Italy, Japan, the United Kingdom and the United States). A vector autoregressive model was applied for the decomposition of oil shock sources. The sample period span was from 1981 to 2007 for monthly data for analysis. The global oil supply and aggregate-demand shock did not affect stock returns in Australia. In Canada, the oil market-specific demand shock effect was weaker. The oil shock effect had less magnitude on stock returns.

On Europe's sectoral stock index return, Degiannakis et al. (2013) investigated the impact of oil price on the basis of origin of the oil shock. Monthly data from January 1992 to December 2010 of 10 sectoral indexes were analyzed using the multivariate autoregressive conditionally heteroskedastic framework. The oil price and stock return linkage was influenced by oil price specific shock. They found a low to moderate correlation level of oil supply shock, zero correlation level of oil demand shock and change (upward or downward) in the correlation level of oil price-specific shocks. Health, Technology, Telecommunications and Utilities provided some portfolio diversification opportunities.

In South Africa, Gupta and Modise (2013) explored the effect of oil price on the stock market using the structural VAR approach. The monthly data sample range was from

1973:01 to 2011:07 for the estimation. Aggregate demand shock had a positive impact on the stock return. Oil supply and speculative demand shocks influenced stock returns negatively.

Wang et al (2013) explored the oil price shocks impact on the stock market of net-oil importing countries and net-oil exporting countries. January 1999 to December 2011 was the sample period range for the monthly data for the estimation. Stock market of countries depended on oil price irrespective of oil importer or oil exporter status. The oil shock effects' magnitude relied on the extent of the economy's oil dependence. The global demand-based oil shock were strong and persistent in oil-exporting countries. The positive coefficient of aggregate demand and precautionary shock affect oil exporting countries and in a few importing countries.

In a cross-oil-importing-countries study, Cunado and Gracia (2014) examined the effect of oil shocks on the stock market of 12 oil-importing countries. VAR and Vector Error Correction Models (VECM) were used to analyze the data for the sample period from 1973:02 to 2011:12. They proposed oil price-specific demand shock. Stock returns were influenced by oil supply-driven shock. Oil price-specific shock negatively affected stock return in most countries. The negative effect of oil supply shock was stronger than demand and oil shock. Oil demand shock had a negative effect in Germany, Italy, Luxembourg, Portugal and the UK) and a positive effect on stock returns in France and Denmark.

In time-varying and sectoral study, Broadstock and Filis (2014) explored the effect of oil price shock on stock markets in the US and China by applying time-varying structural VAR. The sample period for monthly data was from 1995 to 2013. Industrial sectors, namely metals and mining, oil and gas retail, technology and banking, were considered for this study. Different shocks had a substantial varying effect on stock returns. Across the industries, these linkage were heterogeneous. Chinese stock market showed more resilience to different oil shocks than the US stock market. The interaction between oil shock and stock return is time-varying. The aggregate demand shock showed a positive linkage in the US which was not the case in China.

In another time-varying effect study, Kang et al. (2015) explored the oil price effect on the US stock market by applying the time-varying parameter VAR model. The sample duration for the monthly data was from 1968:01 to 2012:12 for the analysis. During global financial crisis, the effect of oil price was the highest on the US stock market. In the post global financial crisis, the effect of oil price was higher than the pre-global financial crisis period. The global oil supply shock impact was higher in the pre-global financial crisis than the pre-global financial crisis period.

In another time-varying effect study, Kang et al. (2015) explored the oil price effect on the US stock market by applying the time-varying parameter VAR model. The sample duration for the monthly data was from 1968:01 to 2012:12 for the analysis. During the global financial crisis, the effect of oil price was the highest on the US stock market. In the post-global financial crisis, the effect of oil price was higher than in the pre-global financial crisis period. The global oil supply shock impact was higher in the pre-global financial crisis than in the pre-global financial crisis period.

In different time horizons, Hu et al. (2018) examined the asymmetric impact of structural oil shocks on stock return in China. They applied a two-step approach: SVAR and NARDL (Nonlinear ARDL). Oil price movement is driven by aggregate demand shock and oil market specific demand shock. Oil supply shocks have the least effect on oil price. In the long run, oil supply shock and aggregate demand shock do not affect the Chinese stock index return. In the short run, the effect of cumulative oil market-specific demand is the greatest. Aggregate demand shock had an asymmetric effect on the stock market in the short run. The aggregate demand shock and supply shock had no asymmetric effect on Chinese stock market.

In emerging economies, Das and Kannadhasan (2020) examined the impact of oil shocks and policy uncertainty on the stock market by applying quantile SVAR. The range of the study period was from 30.12.1994 to November 23.11.2018 for daily data for the study. Demand (Supply and policy uncertainty) shocks impacted positively (negatively) stock returns. In bearish market conditions, sectoral indices were highly influenced by oil shocks. Low demand shock caused the higher return of stocks. On the hand, higher supply,

risk and policy shocks impacted stock return highly. The direction and magnitude of policy uncertainty were heterogeneous across sectors and quantiles. The least affected sectors were materials and energy by supply shock. The highest positive effect of demand shock was on the consumer discretionary and energy sectors. Telecommunications and health care were least affected by risk shocks.

To examine the asymmetric effect of oil price on the stock market of oil importing and exporting countries under different market conditions, Mokin (2020) used the time-varying asymmetric QR (TV-AQR) model. Weekly data of stock market indices of oil importing (China, USA and Japan) and exporting (Russia, Norway and Canada) countries from January 1, 2010 to December 31, 2018 were analyzed. Oil importing countries' stocks reacted more to the negative oil price shock than the positive one. Normal market condition saw a mix of both positive and negative interactions. These interactions during the financial crisis were stronger during the global financial crisis, after which the interaction was stable.

Sadeghi and Roudari (2022) explored the interaction between stock price, structural oil shocks and regime changes. The regime was divided into two, such as the bull and bear market. The sources of oil shock are categorized as global supply shock, global aggregate demand shock and oil market specific demand shock. Threshold Structural Vector Autoregression (TSVAR) was used to explore the above mentioned interaction in two importing countries (China and Japan) and two exporting countries (Norway and Canada). 1990:1–2020:4 was the sample period. Oil shock got a response from stock prices in the short term in both oil importing and oil exporting countries. However, there was a neutral effect of oil shocks in the medium and long term. In the medium term, stock return was more resilient to all oil shocks. The reactions of stock price to all oil shocks were different across regimes such as bull and bear.

Maghyereh and Abdoh (2022) investigated the interaction between oil price shock and the GCC region stock market across market conditions and time frequencies. They applied Ready's (2018) method to decompose oil shock and the quantile cross-spectral dependence approach to estimate the oil shock effect. The study period of monthly data was from June 1, 2006, to February 28, 2020. Global oil supply-driven shock negatively affected stock

return in all GCC stock markets. While, global oil demand-driven shock positively affected stock return, increasing with higher quantile in all GCC markets. The risk shocks' positive (negative) effects were at high (low) quantiles, except for Saudi Arabia and the UAE. The dependence between supply and demand oil shocks and stock market returns was stronger than that of risk shocks and stock market returns.

In China, Ge (2023) examined the asymmetric effect of oil price shocks on the stock market. Daily data from January 1991 to April 2022 are analyzed using quantile-to-quantile regression. Ready's (2018) decomposition method was used for segregating oil shocks such as oil supply shock, demand shock and risk shock. The effect of oil shocks on stock return was asymmetric and heterogeneous in different market conditions. Supply shock did not affect the stock market in bearish market conditions. Demand shocks impact is stronger positive in the bearish market than in the bullish market. The positive supply and demand shock had a stronger effect than the negative shocks. Negative risk shocks were not significant in bullish market conditions. Positive risk shock had a higher negative effect on bullish conditions than that on bearish.

Regarding the oil shock effect on energy stock price, Broadstock et al. (2012) explored the linkage of oil price with energy related stock in China. The weekly data from January 7, 2000, to May 27, 2011, were analyzed using conditional correlation and asset pricing model. They deduced that the energy stocks in China were more sensitive to oil price shocks. The linkage between oil price and energy stocks became stronger after the financial crisis. New energy stocks were less affected by the oil price movements.

In a comparative study, Kassouri and Altıntaş (2022) explored the influence of oil price shocks on stock returns of clean and dirty firms using the quantile regression model. Monthly time series data from January 2004 to December 2017 were used for estimation. Global oil demand and supply shocks negatively affected energy sector stocks. The global demand-driven shock was helpful in the prediction of clean energy and technology stock return. Global oil supply shock had low predictive power for clean energy stock return. Clean and technology stock show more resilience to global oil demand shocks in the long run. Oil supply shock had predictive power for technology stocks during normal and bullish

market conditions. In the short run, the oil demand shock destabilized the returns of these stocks. The asymmetric effect of oil demand shock was seen in the long run.

Zhang et al. (2020) investigated the effect of structural oil shocks on the stock return of the renewable energy sector by applying the wavelet-based quantile-on-quantile and Granger causality-in-quantiles methods. Monthly data were used for the sample period from January 2006 to December 2018. They found that the oil shocks affected the renewable stocks across quantiles. The oil supply shock effect was stronger in the long and short run. Aggregate demand shock had a positive effect on stock return in the bullish and bearish market conditions. On the other hand, the oil specific demand shock effect was positive in the long run.

In their time frequency and tail dependence study, Maghyereh and Abdoh (2021) examined the dependence between oil price and stock price of clean energy and energy companies for the sample period from January 2004 to June 2019. Monthly data were analyzed using the quantile cross-spectral dependence approach and SVAR model. They found the effect of oil supply shock on renewable stock return in the short run than the long run, especially in higher quantiles. In normal market condition, aggregate demand had the highest dependence on clean energy stocks in the medium term. The asymmetric effect of different structural oil shocks was stronger in higher quantiles.

The above literature showed that sources of oil price affected stock return heterogeneously (Kilian & Park, 2009; Gupta & Modise, 2013). Structural oil shocks impacted stock returns heterogeneously across sectors (Degiannakis et al., 2013) and countries (Apergis & Miller, 2009; Cunado & Gracia, 2014; Koh, 2017; Maghyereh & Abdoh, 2022). Oil shocks also had a time-varying effect on stock returns (Hu et al., 2018; Kang et al., 2015; Broadstock & Filis, 2014). Under different market conditions, oil shocks also affected stock returns heterogeneously (Das & Kannadhasan, 2020; Mokin, 2020; Sadeghi & Roudari, 2022; Ge, 2023). Oil shocks had heterogeneous effects on renewable and non-renewable energy stock returns (Kassouri & Altıntaş, 2022). Oil shocks impacted heterogeneously renewable stock returns across market conditions and time horizons (Zhang et al., 2020; Maghyereh & Abdoh, 2021)

2.5 Concluding Remarks

There are a few studies at the firm level in the renewable energy sector except Zhu et al. (2019) in China and Pham (2019) in the USA context. The existing literature has not given enough attention to the Indian market, which is a significant player in the world renewable energy sector. The first objective of the study addresses this gap to explore the oil-renewable energy stock nexus at the firm level in India under different market conditions. Literature show the effect of oil price uncertainty effect on stock return. In renewable energy literature, the effect of oil price uncertainty on stock returns at index or aggregate stock level. The second objective is an extension of existing works to examine the effect of oil price uncertainty on Indian renewable energy firms' stock return across market conditions. The existing literate were based on aggregate stock and mostly in developed countries to examine the oil price asymmetric effect in the renewable energy sector. The third objective is aimed to investigate this effect at the firm level and in the context of India. Available studies on the oil shocks and renewable energy stock linkage are based on aggregate stocks, where these indices consisted of a fixed number of the largest clean energy companies across the globe. Till now, the structural oil shocks' effect was not examined in the emerging economy (e.g., India) context and at the firm level. The fourth objective of the study addresses this gap across market conditions.

CHAPTER 3

MEASURING THE OIL PRICE EFFECT ON STOCK RETURNS OF RENEWABLE ENERGY FIRMS IN INDIA UNDER DIFFERENT MARKET CONDITIONS

3.1 INTRODUCTION

Greenhouse gas emissions and limited fossil fuel reserves are major reasons for a transition towards non-fossil energy, which is also known as clean energy, green energy or renewable energy. Intergovernmental bodies are putting efforts to reduce greenhouse gas emissions through policy interventions. Renewable energy firms play an important role in this direction. Though, these firms do not assure zero emissions. So the question is whether renewable energy helps to reduce the overall emission of greenhouse gases. Researchers find that renewable energy firms are the reason for the reduction of overall greenhouse gases on the earth's surface (Qi et al., 2014; Squalli, 2017; Ghosh, 2022). In order to ensure the growth of the renewable energy sector, this sector requires investment. The study by Lyeonov et al. (2019) concludes that renewable energy investment leads to growth in GDP, energy consumption and reduction in greenhouse gases. Thus, investment in renewable energy has multidimensional benefits. Renewable energy is expected to be the largest source of energy (EIA, 2019). India is one of the largest renewable energy-producing countries (IRENA, 2017). Considering the growing importance of the Indian renewable sector, this study investigates the relationship between oil price change and stock returns of renewable energy firms in India.

The dependency of firms on oil varies across industries. Thus, the effect of oil price on stock returns varies across industries (Elyasiani et al., 2011; Arouri et al., 2012; Das and Kannadhasan, 2020). On the other hand, the oil price increase causes inflationary pressure in the economy and vice versa. This affects the demand for products and services of different industries, irrespective of their dependency on oil. Due to climate change and oil price fluctuation, countries are consciously trying to shift their dependence on crude oil to

renewable energy. Thus, the renewable energy sector is rapidly expanding to fulfill the energy demand.

Literature is also emerging to investigate the relationship between oil price and stock returns of the renewable energy sector. The existing studies are more focused on the developed market (Reboredo and Ugolini, 2018; Pham, 2019) and at aggregate stock level (Uddin et al., 2019; Dawar, 2021). Few studies are available in the context of developing countries, for example China (Zhu et al., 2019). The renewable energy sector growth is exponential in developing countries like India. This objective aims to examine the effect of oil price on stock returns of renewable energy firms in India.

The main motivations for this objective are the findings of Zhu et al. (2016), Zhu et al. (2019) and Dawar et al. (2021). Zhu et al. (2016) find that the stock returns sensitivity to oil price fluctuation is not the same in different quantiles in China. They apply panel quantile regression in their study. Recent studies find that oil price affects stock returns of the renewable energy sector. Zhu et al. (2019) find that the oil price effect is heterogenous on stock returns of new energy firms in China. They use a time series regression model. Dawar et al. (2021) argue that the effect of oil price on the stock returns of the renewable industry is not the same under different market conditions. They use a time series quantile regression model. Their study concludes that the effect of oil price on stock returns in the renewable sector is heterogenous under different market conditions. These studies motivate examining the effect of oil price on renewable stock return at the firm level in India.

In this objective, the relationship between oil price and stock returns of the renewable energy sector at the firm level is investigated using panel quantile regression in the capital asset pricing model (CAPM) framework. The contribution of the objective is explained as follows. First, this objective helps to explore the relationship between oil and stock returns of the renewable energy sector in the different market conditions in addition to the normal market condition in Indian context. Second, existing studies explore the effect of oil price on stock returns of the renewable energy sector at industry level and most of the studies are made in the developed economies. This study is the first of its kind in the renewable

sector of India. Third, this objective is a firm-level study. This study finds that the relationship between oil price and stock returns of the renewable energy sector firms is significant and positive. This relationship is stronger in the bearish market condition.

3.2 LITERATURE REVIEW

In this part, this study summarizes the previous studies on the oil and stock of the renewable energy sector. Henriques and Sadorsky (2008) found a weaker positive oil prices effect on renewable energy stock prices. Similarly, Managi and Okimoto (2013) deduced that after the structural break, oil price interacts positively with renewable energy stocks. The prices of oil affected both technology stocks and renewable energy stocks similarly. Reboredo and Ugolini (2018) discovered that among different energy prices, oil price in the United States (US) and electricity price in the European Union affected renewable energy stock return. In contradiction to these findings, Ferrer et al. (2018) did not find the US renewable energy stock price dependence on oil price. Nasreen et al. (2020) found evidence of the connectedness of oil price with the clean energy stocks after the late 2007 global financial crisis. Oil price correlation was positive with renewable energy stock return and this correlation was weaker in bullish market conditions (Dawar et al., 2021). As per He et al. (2021) its positive effect on the renewable energy stock return was during the bullish market condition in Europe and the US during the long run. The same effect was also seen in the short run during all market conditions in the US. However, a heterogeneous interaction of oil price existed with stocks of the renewable energy sub-sector (Pham, 2019). There is no enough study at firm level in the renewable energy sector except Zhu et al. (2019) in China and Pham (2019) in USA context. The existing literature has not given enough attention to the Indian market, which is a significant player in the world renewable energy sector. This chapter explores this research gap under different market conditions at firm level.

3.3 DATA AND METHODOLOGY

3.3.1 Data

The monthly stock returns of the renewable energy firms are collected from the CMIE Prowess database. 94 renewable energy firms listed in the National Stock Exchange are considered for this objective. In the existing literature, the sub-group or sectors are based on energy types such as solar, wind, etc. However, in India, most of the firms deal in more than one energy type. Thus, all renewable energy firms (whole sample) are categorized into four subgroups such as; firms dealing in renewable energy products and services, standalone firms dealing in renewable energy production, firms dealing in both renewable and non-renewable energy production, firms dealing in renewable energy and other businesses. Indian Basket crude oil price from Petroleum Planning and Analysis Cell's web page, Ministry of Petroleum, the government of India is considered for oil price. Monthly data are considered for this objective. Fama-French factors (Fama and French, 1993) and momentum factor (Carhart, 1997) are collected from Data Library for Indian Market of Indian Institute of Management Ahmedabad (Agarwalla et al., 2013). The period of the study is from January 2009 to March 2022.

3.3.2: Model specification:

$$R_{it} = \alpha_i + \beta_1 Oil_t + \beta_2 R_{mt} + \bar{\varepsilon}_{it} \quad (3.1)$$

Where, $R_{i,t} = \ln \frac{P_{i,t}}{P_{i,t-1}}$ denotes the monthly stock returns. $Oil_{i,t} = \ln \frac{Oil_t}{Oil_{t-1}}$ denotes the monthly crude oil change or return. Ln denotes natural log. $R_{mt} = \ln \frac{P_{i,t}}{P_{i,t-1}}$ denotes monthly return. α_i denotes constant. $\bar{\varepsilon}_{it}$ denotes error term.

$$R_{it} - R_{ft} = \alpha_i + \beta_1 (R_{mt} - R_{ft}) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 WML_t + \bar{\varepsilon}_{it} \quad (3.2)$$

The above Fama-French-Carhart (1997) model measures multi factors' effect on CAPM factors of stocks. Where, $R_m - R_f$ denotes the excess stock returns of a renewable energy firm than that of risk free interest. The Fama French (1993) proposed factors are considered to analyze the firm level effect of oil price on stock returns of the renewable energy firms along with momentum factor of Carhart (1997). The factors are market ($R_m - R_f$), size (SMB), value(HML) and momentum effect (WML).

The following model is derived from model 3.1 and 3.2 to find the effect of oil price in stock return of the renewable energy firms. This panel model is based on ordinary least square assumption.

$$R_{it} - R_{ft} = \alpha_i + \beta_1 Oil_t + \beta_2 (R_{mt} - R_{ft}) + \beta_3 SMB_t + \beta_4 HML_t + \beta_5 WML_t + \bar{\epsilon}_{it} \quad (3.3)$$

The existing literature has shown that the relation between oil price and stock returns is not same under different market conditions using quantile regression models. This objective aims to investigate the relation between oil price and stock returns of the renewable energy sector firms across market conditions. So, this objective has adopted the panel quantile regression with non-additive fixed effect proposed by Powell (2022). Finance (Bruna et al., 2020) and economics literature (Jiang, 2019) apply this regression model. This method addresses the problems of reverse causality and dynamic endogeneity factors and sample heterogeneity. It also captures the covariance between the variables in both the tails including in the median. The panel quantile regression model of this objective is mentioned bellow.

$$R_{it} - R_{ft} = \sum_{j=1}^4 D'_{it} \beta_j (U_{it}^*) \quad (3.4)$$

Where, $R_{it} - R_{ft}$ is the excess stock returns of firms a time t. β is the parameter. D'_{it} is a set of independent of variables in the regression such as oil return (Oil) and CAPM factors namely, market ($R_m - R_f$), size (SMB), value(HML) and momentum (WML). U_{it}^* is the

error term. This error term is a function of several disturbance term, some fixed and some-time varying. The model is linear in terms of parameters and $D'_{it}\beta_j(\tau)$ is strictly increasing in τ . In general for the τ th quantile of $R_{it} - R_{ft}$, the quantile regression relies on the conditional restriction:

$$P(R_m - R_f) \leq D'_{it}\beta_j(\tau) | D'_{it} = \tau \quad (3.5)$$

Equation (3.5) shows that the probability of the outcome variable is smaller than the quantile function, which is the same for all D'_{it} and equal to τ . Powell's (2022) QRPD (Quantile Regression for Panel Data) estimator gives this probability to vary by individual and even within individuals as long as such variation is orthogonal to the instruments. Thus, QRPD counts on a conditional restriction and an unconditional restriction, letting $D_{it} = (D_{i1}, \dots, D_{iT})$.

$$\begin{aligned} P(R_m - R_f \leq D'_{it}\beta_j(\tau) | D_{it}) &= P(R_m - R_f \leq D'_{is}\beta_j(\tau) | D_{it}) \\ P(R_m - R_f) \leq D'_{it}\beta_j(\tau) | D_{it} &= \tau \end{aligned} \quad (3.6)$$

Powell (2022) proposes the estimator in an instrumental variable context given instruments ($Z_{it} = Z_{i1} \dots \dots Z_{iT}$). His estimation uses a generalized method of moments. Sample moments are defined as follows:

$$\hat{g}(b) = \frac{1}{N} \sum_{i=1}^N g_i(b) \text{ with } g_i(b) = \frac{1}{T} \left\{ \sum_{t=1}^T (Z_{it} - \bar{Z}_i) [1(R_m - R_f \leq D'_{it}b)] \right\} \quad (3.7)$$

Where, $\bar{Z}_i = \frac{1}{T} \sum_{t=1}^T Z_{it}$, Using equation (3.6), the parameter set is defined as. $B = \left\{ b | \tau - \frac{1}{N} - \frac{1}{N} \sum_{i=1}^N 1(R_m - R_f \leq D'_{it}b) \right\}$ for all t . Then, the parameter of interest is estimated as follows. $\hat{\beta}(t) = \min_{b \in \beta} \hat{g}_t(b) \hat{A}(b) \hat{A}' \hat{g}_t(b)$ for some weighting matrix \hat{A} . The above model is estimated using the Markov Chain Monte Carlo (MCMC) optimization method.

The study considers seven quantiles (0.05, 0.10, 0.25, 0.50, 0.75, 0.90 and 0.95) for this objective. Lower quantiles such as 0.05, 0.10, and 0.25 are indicators of bearish market

condition. Upper quantile such as 0.75, 0.90 and 0.95 are indicators of bullish market condition. Quantile 0.50 represents a normal market condition. Thus, this study analyzes the output in these quantiles to know the effect of oil price on stock returns of the renewable energy firm under different market conditions.

3.4 RESULTS AND ANALYSIS

The data is normally distributed if skewness is 0 and kurtosis is less than 3. In Shapiro-Wilk test, the probability value of all the variables (Table 1) is less than 0.05. So, the null hypothesis is rejected and variables are not normally distributed. This objective has been conducted with different panel data for analysis such as a) all firms dealing in renewable energy business (the whole sample), b) firms dealing in renewable energy products and services, c) standalone firms dealing in renewable energy production, d) firms dealing in both renewable and non-renewable energy production, e) firms dealing in renewable energy and other businesses. All results for different panels are shown under headings such as A, B, C, D and E. Though, the variables are not in the normal distribution, panel quantile regression is appropriate for this data set. This study runs the panel regression fixed effect model to capture the heterogeneity. Table 3.1 report estimators of quantile regression and also OLS panel regression (for comparison purpose which is adopted in the exiting literature). Oil price fluctuation has a positive and significant effect on the stock returns of standalone renewable energy firms.

To capture the heterogeneity in the relationship between oil price and stock returns under different market conditions, the data is analyzed using panel quantile regression in Table.3.1. Image 3.1 shows the relationship between oil price change and stock return for the whole sample and its sub-groups. Panel A shows the output for all firms that are dealing in renewable energy business, i.e., the whole sample. Oil price has a significant positive effect on stock returns in extreme market conditions except quantile 0.95. In the lower quantiles or bearish market condition, this effect is stronger. In the same market conditions, market ($R_m - R_f$), size (SML), value (HML) and momentum (WML) factors have a significant positive effect on stock returns of these firms. But, this effect is weak.

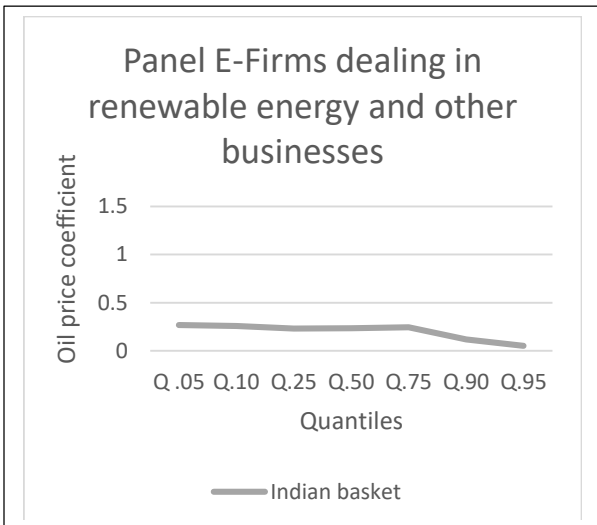
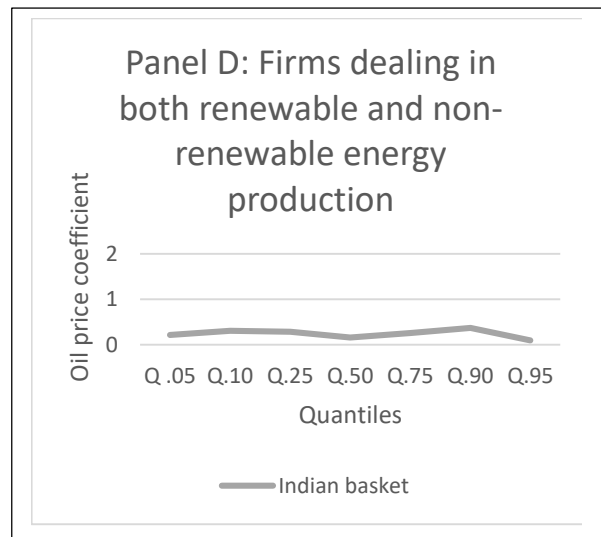
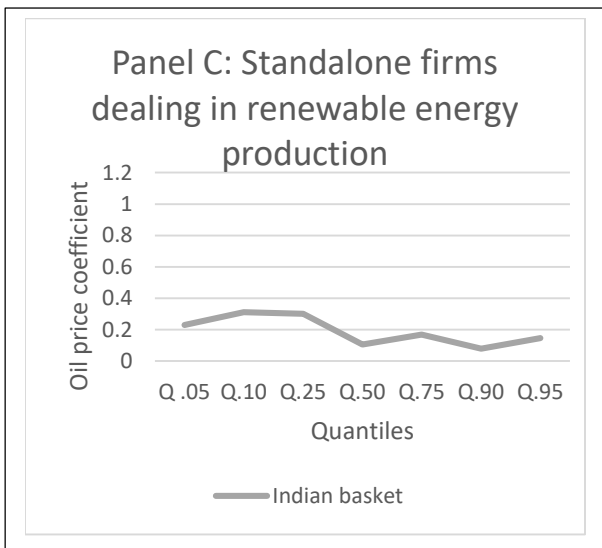
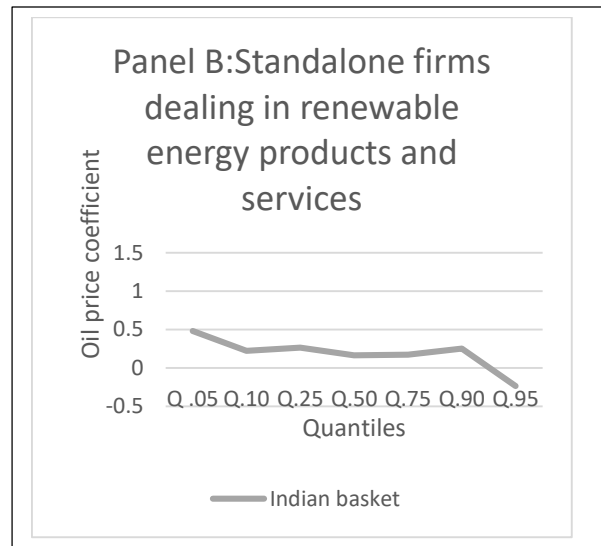
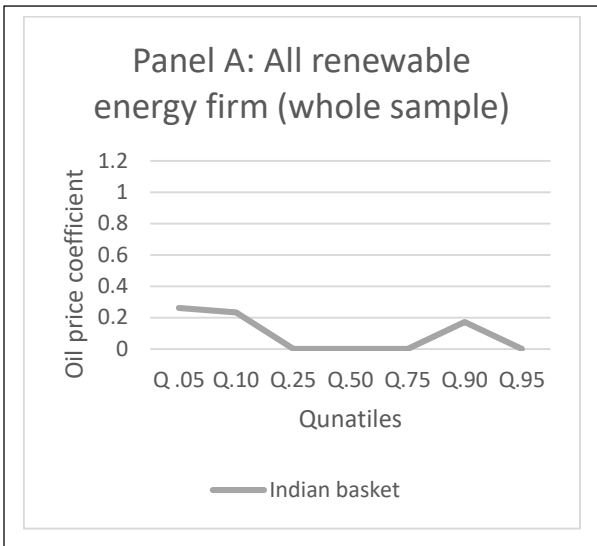


Image 3.1: Relationship between oil price change and stock return

In the standalone firms dealing in renewable energy products and services (Panel B), the oil price and stock returns relationship is significant and positive except $Q_{.95}$ where the relationship is negative. In bearish market conditions, this study observes that the relationship is stronger. All asset pricing factors have positive coefficients in most quantiles. Momentum (WML) has a weaker effect than size (SML), value (HML) and market ($R_m - R_f$) factors.

Oil price positively affects stock returns of the standalone renewable energy production firms (Panel C). Indian basket oil price positively affects stock returns. This effect is stronger in lower quantiles. Market ($R_m - R_f$), size (SML), value (HML) and momentum (WML) factors positively affect the stock returns of these firms in most of the quantiles. Size and momentum have weaker coefficients.

The relationship between oil price and stock returns of the firms dealing in renewable and non-renewable energy production (Panel D) is positive and significant in most quantiles. However, there is no particular pattern in this relationship. In this sub-group, all asset pricing factors show similar effects as there are in panel C.

There is a significant and positive relation between oil price and stock returns of firms dealing in renewable energy and other businesses (Panel E) in most quantiles. These firms' stock returns respond positively to fluctuations in oil prices under different market conditions. But in extreme bullish market conditions, the relationship is weaker. All asset pricing factors show a weak and positive relationship. Among these factors, value and momentum factors show a weaker effect. The null hypothesis is that oil price has a significant effect on stock returns of renewable energy firms. Alternative hypothesis is that oil price has no significant effect on the stock return of renewable energy firms. Null hypothesis is rejected in most of the quantiles.

3.5 SUMMARY

Renewable energy is emerging as a dominant player in the energy market. The increasing funding for renewable energy from different sovereign governments causes exponential growth. India is a dominant player in this sector. Keeping in view of ample literature on the oil and stock nexus across industries and countries, this study investigates the relationship between oil price and stock return of renewable energy firms in India. This objective uses panel quantile regression to capture this relationship under different market conditions. The renewable energy firms are divided into four sub-groups to find any possible heterogeneity in this oil-stock nexus.

The findings of this objective deduce that stock returns of the renewable sector react positively to fluctuations in oil prices only in extreme market conditions. Among sub-groups, oil price and stock returns relationships are positive in most quantiles and stronger in the lower quantiles or bearish market conditions. On the other hand, market ($R_m - R_f$), size (SML), value (HML) and momentum (WML) have a positive relationship with stock returns of the renewable energy firms in most of the quantiles. Though, this relationship is weak.

This objective contributes to the body of knowledge in the relationship between oil price and stock returns of the renewable sector firms. These contributions can be explained in two ways at firm level and under different market conditions. The findings would be immensely useful to the portfolio managers and investors in managing investments and portfolios. They can change their strategies as per oil price fluctuation and market conditions to increase their investment return. On the other hand, the government is changing policies many times to ensure a sound growth of renewable energy sector to solve the dependency on fossil fuel. Thus, the findings will be useful to the policy makers in framing policies to ensure growth of this sector through policy interventions as per oil price changes. A well-developed renewable energy market would save an economy from oil price crisis.

Table 3.1: Summary statistics

Variables	Mean	SD	Min	Max	Variance	Skewness	Kurtosis	SW Test
Stock								
return	0.190	6.066	-3.777012	260.2	36.805	35.066	1269.062	23.546
Oil return	0.005	0.106	-.5165154	0.430	0.007	-0.406	3.720	18.350

S-W: Shapiro-Wilk test with Z-statistics. *** indicates significance at the 5% level. Stock is the stock return of renewable firms and Indian Basket oil return

Table 3.2 Quantile regression estimators for paneldata (QRPD) from Indian basket oil price

Panel A: QRPD analysis on firms dealing in renewable energy business (whole sample)								
Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
Oil	0.263*** (0.000)	0.233*** (0.000)	1.860 (2.386)	0.0587 (0.525)	-0.518 (1.763)	0.173*** (0.000)	-0.003 (0)	0.809* (0.480)
SMB	0.006*** (0.000)	0.004*** (0.000)	0.016 (0.024)	-0.004 (0.016)	-0.008 (0.055)	0.009*** (0.000)	0.009 (0)	0.008 (0.013)
HML	0.007*** (0.000)	0.008*** (0.000)	-0.006 (0.022)	0.008* (0.004)	0.049 (0.057)	0.006*** (0.000)	0.012 (0)	0.032*** (0.012)
WML	0.001*** (0.000)	0.002*** (0.000)	0.017 (0.019)	0.004 (0.006)	0.033 (0.047)	0.000*** (0.000)	0.002 (0)	0.023** (0.011)
R _m -R _f	0.013*** (0.000)	0.013*** (0.000)	-0.027 (0.045)	0.005 (0.030)	-0.122 (0.192)	0.014*** (0.000)	0.013 (0)	0.024* (0.012)
Observations	13,180	13,180	13,180	13,180	13,180	13,180	13,180	13,180
Number of firms	94	94	94	94	94	94	94	94

Panel B: QRPD analysis on standalone firms dealing in renewable energy products and services

Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
Oil	0.484*** (0.000)	0.223*** (0.000)	0.264*** (0.001)	0.165*** (0.000)	0.174*** (0.000)	0.252*** (0.002)	-0.233*** (0.001)	0.087 (0.059)
SMB	0.007*** (0.000)	0.004*** (0.000)	0.003*** (0.000)	0.004*** (0.000)	0.007*** (0.000)	0.013*** (0.000)	0.011*** (0.000)	0.007*** (0.001)
HML	0.002*** (0.000)	0.013*** (0.000)	0.006*** (0.000)	0.009*** (0.000)	0.010*** (0.000)	0.008*** (0.000)	0.020*** (0.000)	0.010*** (0.001)
WML	0.000*** (0.000)	0.003*** (0.000)	0.003*** (0.000)	0.000*** (0.000)	0.003*** (0.000)	-0.001*** (0.000)	0.003*** (0.000)	0.001 (0.001)
R _m -R _f	0.011*** (0.000)	0.009*** (0.000)	0.015*** (0.000)	0.013*** (0.000)	0.017*** (0.000)	0.010*** (0.000)	0.006*** (0.000)	0.014*** (0.001)
Observations	1,214	1,214	1,214	1,214	1,214	1,214	1,214	1,214
Number of firms	9	9	9	9	9	9	9	9

Panel C: QRPD analysis on standalone firms dealing in renewable energy production

Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
Oil	0.230*** (0.000)	0.312*** (0.000)	0.302*** (0.004)	0.106*** (0.000)	0.169*** (0.002)	0.0792*** (0.000)	0.087*** (0.002)	0.147** (0.068)
SMB	0.003*** (0.000)	0.004*** (0.000)	0.005*** (0.000)	0.003*** (0.000)	0.009*** (0.000)	0.009*** (0.000)	0.018*** (0.000)	0.008*** (0.001)
HML	0.014*** (0.000)	0.014*** (0.000)	0.009*** (0.000)	0.010*** (0.000)	0.005*** (0.000)	0.012*** (0.000)	0.026*** (0.000)	0.013*** (0.001)
WML	0.007*** (0.000)	0.003*** (0.000)	0.002*** (0.000)	0.000*** (0.000)	-0.003*** (0.000)	0.004*** (0.000)	0.012*** (0.000)	0.002 (0.001)
R _m -R _f	0.019*** (0.000)	0.017*** (0.000)	0.017*** (0.000)	0.019*** (0.000)	0.018*** (0.000)	0.019*** (0.000)	0.018*** (0.000)	0.018*** (0.001)

Observations	1,131	1,131	1,131	1,131	1,131	1,131	1,131	1,131
Number of firms	10	10	10	10	10	10	10	10

Panel D: QRPD analysis on firms dealing in both renewable and non-renewable energy production

Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
Oil	0.218*** (0.000)	0.310*** (0.001)	0.287*** (0.000)	0.159*** (0.000)	0.260*** (0.002)	0.370*** (0.001)	0.100*** (0.002)	0.227*** (0.051)
SMB	0.002*** (0.000)	0.003*** (0.000)	0.000* (0.000)	0.000*** (0.000)	0.005*** (0.000)	0.008*** (0.000)	0.007*** (0.000)	0.003** (0.001)
HML	0.009*** (0.000)	0.011*** (0.000)	0.005*** (0.000)	0.008*** (0.000)	0.003*** (0.000)	0.000*** (0.000)	0.010*** (0.000)	0.009*** (0.001)
WML	0.000*** (0.000)	0.005*** (0.000)	0.000*** (0.000)	-0.001*** (0.000)	0.000* (0.000)	0.000*** (0.000)	0.001*** (0.000)	0.000 (0.001)
R _m -R _f	0.009*** (0.000)	0.007*** (0.000)	0.016*** (0.000)	0.016*** (0.000)	0.019*** (0.000)	0.017*** (0.000)	0.015*** (0.000)	0.016*** (0.001)
Observations	1,694	1,694	1,694	1,694	1,694	1,694	1,694	1,694
Number of firms	11	11	11	11	11	11	11	11

Panel E : QRPD analysis on firms dealing in renewable energy and other business activity

Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
Oil	0.267*** (0.000)	0.259*** (0.000)	0.231*** (0.030)	0.236*** (0.000)	0.245*** (0.070)	0.117*** (0.000)	0.051*** (0.000)	1.113 (0.696)
SMB	0.008*** (0.000)	0.005*** (0.000)	0.005*** (0.000)	0.004*** (0.000)	0.008*** (0.000)	0.008*** (0.000)	0.009*** (0.000)	0.010 (0.019)
HML	0.003*** (0.000)	0.005*** (0.000)	0.008*** (0.000)	0.005*** (0.000)	0.006*** (0.000)	0.007*** (0.000)	0.010*** (0.000)	0.042** (0.017)

WML	0.002*** (0.000)	0.003*** (0.000)	0.002*** (0.000)	0.000*** (0.000)	0.002*** (0.000)	0.000*** (0.000)	0.001*** (0.000)	0.032** (0.016)
$R_m - R_f$	0.013*** (0.000)	0.013*** (0.000)	0.013*** (0.000)	0.017*** (0.000)	0.016*** (0.002)	0.013*** (0.000)	0.013*** (0.000)	0.027 (0.017)
Observations	9,141	9,141	9,141	9,141	9,141	9,141	9,141	9,141
Number of firms	64	64	64	64	64	64	64	64

Note: Statistical level significance at 1, 5 and 10% are represented by ***, ** and * respectively. Adjacent parentheses contain standard errors. Panel A- all renewable energy firms; Panel B- standalone firms dealing in renewable energy products and services; Panel C- standalone firms dealing in renewable energy power generation, Panel D- firms dealing in both renewable and non-renewable energy power generation and Panel E-firms in renewable energy business and other business activities.

CHAPTER 4

ESTIMATING THE OIL PRICE UNCERTAINTY EFFECT ON STOCK RETURNS OF THE INDIAN RENEWABLE ENERGY FIRMS UNDER DIFFERENT MARKET CONDITIONS

4.1 INTRODUCTION

For economic development and industrial growth, countries depend on different energy sources. Crude oil is the major source to the need of energy requirement. It is a natural resource which is available in few countries. Thus, oil importing countries have no control over international crude oil price. The oil price goes through a lot of fluctuation due to demand, supply disruption, war, pandemic and changes in US oil reserves. Net oil import countries' economy like India is very sensitive to the oil price uncertainties due to the heavy dependence on crude oil. On the other hand, crude oil consumption is a major contributor to greenhouse gas emissions. Due to climate change, there is an effort to reduce reliance on crude oil and switch towards renewable energy sources worldwide. Renewable energy firms would play a greater role in achieving this renewable energy dependency. To ensure the growth of renewable energy firms, researchers need to understand how these firms' stock returns react to oil price uncertainties. Thus, this study examines the relationship between oil price uncertainties and stock returns of Indian renewable energy firms across market conditions.

Many industries need crude oil at different stages. Thus, the crude oil price fluctuation affects the output cost and the extent of this effect depends on how much one industry relies on oil as an input. Though oil price affects the cost of inputs, companies' cash flow also fluctuates due to oil price changes. As per oil price fluctuations, the companies' cash flow changes and it is reflected in stock prices. Based on this logic, literature shows vidence of the oil price effect on stock return (Jones and Kaul, 1996; Kilian and Park, 2009). Instability in oil price also affects the inflationary condition in the economy of different countries. The changes in inflation affect the interest rate which investors use to discount the future

cash flow of the companies (Huang et al., 1996; Miller and Ratti, 2009) and have an ultimate effect on the stock prices. Another set of studies argues that the boom economic condition is instrumental to cause a positive interaction between oil price with stock price (Kollias et al., 2013; Zhu et al., 2014). In a booming economy, the industrial demand for oil is more to meet the consumer demand. Here, the increased oil demand causes oil price rise instead of an oil supply constraint. The increase in oil price is interpreted as an indication of a boom in economic condition by the investors. This positive sentiment of investors leads to an increase in share prices in the market.

Globally, crude oil meets a significant portion of energy requirements. Uncertainty in oil price causes a reduction in production and investment in the economy (Bernanke, 1983; Bloom, 2009). Consequently, Oil price volatility creates turmoil in stock markets (Arouri et al., 2012). Oil price volatility impacts capital market of most countries as per Park and Ratti (2008). It also impacts stock returns of most industries in the US (United States) (Elyasiani et al., 2011). Joo and Park (2021) find that stock returns in oil importing countries and oil exporting countries respond to oil price volatility negatively and positively, respectively. India, Japan, Korea and the US are the crude oil importing countries where this study finds that the oil price volatility effect on stock return is stronger. Hamdi et al. (2019) observe the heterogeneous effect of crude oil price volatility across Gulf Cooperation Council countries' industries under various market scenarios.

Due to greenhouse gas emission concerns and limited crude oil deposits, countries are promoting the generation and use of renewable energy (the IEA, 2019). Till now, renewable energy has not replaced crude oil. Like other sectors, researchers try to understand the renewable energy sector stocks' interaction with oil price movements. Contemporary research shows the oil-stock nexus in the renewable energy sector (Managi and Okimoto, 2013; Dutta, 2017; Pham, 2020 and Dawar et al., 2021). The spike in crude oil prices changes a country's inflationary level. Even though oil is not a direct input in the renewable energy business, stock return of this sector could be influenced due to inflationary condition. Renewable energy is a viable alternative to crude oil. As a result, the renewable energy stock return responds positively to oil price. (Managi and Okimoto,

2013; Dawar et al., 2021). In China, this interaction is also positive, as per Broadstock et al. (2012). In another Chinese renewable energy study, Zhu et al. (2019) identified that crude oil price has a weaker negative effect and a heterogeneous effect on stock return at the industry and firm levels, respectively. On the global stage, India is emerging as a dominant player in the renewable energy sector (IRENA, 2017). India ranks third after the US and China in the Renewable Energy Country Attractiveness Index, 2021 (Warren and Giovanni, 2021). This study evaluates the interaction of crude oil price uncertainty with India's renewable energy companies' stock returns under various market conditions.

As a common practice, oil price volatility estimation considers historical oil price data by using GARCH or realized volatility model. Historical oil price data do not contain future oil price movement information. The OVX of the CBOE contains past information and investor's belief on the future oil price. Thus, researchers use OVX for oil price volatility in different contexts, such as stock market (Luo and Qin, 2017; Xiao et al., 2018; Xiao et al., 2019), renewable energy stock return (Ahmad et al., 2017; Dutta, 2017), commodity market (Jin and Zhu, 2021), metal market (Dutta, 2018 and Dutta et al., 2019) and Bitcoin market (Al-Yahyaee et al., 2019; Das et al., 2020). Researchers find that the OVX has a stronger effect on stock return (Luo and Qin, 2017) and on the renewable energy stock return (Dutta, 2017) than the realized volatility. The panel quantile approach is very effective to capture the interaction between variables across market conditions. Thus, this study investigates the interaction of the OVX shock with India's renewable energy companies' stock returns under various market conditions using panel quantile regression. According to the studies, there is an asymmetric association between oil price volatility and stock return (Xiao et al., 2018; Kocaarslan and Soytas, 2019). Investors should be aware of how oil price uncertainty or volatility affects stock returns to devise methods for maximizing profits. Thus, this study also examines OVX shock asymmetric interaction with stock returns of the Indian renewable energy firms across market conditions.

The following are this research objective's contributions. Existing studies on the impact of oil price uncertainty on renewable energy stock returns have been conducted using aggregate stock or index returns and time series models with the ordinary least square

assumption. This study analyzes firm-level data to investigate the effect of crude oil price uncertainty across market conditions using panel quantile regression. This is the first study to delve into the oil-renewable energy stock nexus in India. This is also the first study at firm level in the renewable energy sector. This study also incorporates the CAPM factors in the panel quantile regression model. They discover an indirect relationship between crude oil price uncertainty and stock return in bearish market conditions. But, the oil price uncertainty coefficient is positive in the standalone renewable energy firms in most quantiles or market conditions. The asymmetries of oil price uncertainty with stock returns do not exist.

4.2 LITERATURE REVIEW

In the volatility and spillover strand of literature, Dutta (2017) found that the interaction of renewable energy stock return is stronger with oil price volatility index than that of realized volatility of crude oil price in the US. As per Reboredo et al. (2017), unidirectional and bidirectional causality among the price of oil price and renewable stocks were in high frequency and low frequency data, respectively. A nonlinear causality from renewable energy stock price and a mixed causality from oil price were seen across the time horizon. There was a bidirectional spillover between the Chinese renewable energy sub-sector stock return and oil price (Lv et al., 2021). New energy vehicle stock prices are influenced the most by oil price. In developing countries, research on the interaction between oil price volatility and renewable energy sector stock returns is lacking. This study investigates this relationship in the context of India and at the firm level under different market conditions.

4.3 DATA AND METHODOLOGY

4.3.1 Data

This objective considers all renewable energy companies listed on the National Stock Exchange of India. The CMIE prowest database is the source of stock prices for these companies. It is difficult to categorize the Indian renewable energy firms on the basis of sub-sectors such as solar, wind, etc. Because, renewable energy firms in India are dealing

in more than one renewable energy sub-sector and other business activities. Thus, all renewable energy firms (94 firms) are categorized into four sub-group, such as firms dealing in renewable energy products and services, standalone firms dealing in renewable energy production, firms dealing in both renewable and non-renewable energy production, firms dealing in renewable energy and other businesses. The Oil Volatility Index data have been accessed from the Chicago Board Options Exchange' website. The Data Library for Indian Market webpage of Indian Institute of Management Ahmadabad was the source for Fama-French (1992) and Carhart (1997) factors. These factors are used as the control variables in the regression model of this objective. January 2009 to March 2022 is the study period for analysis. Data frequency is monthly.

4.3.1 Model specification

To examine the relationship between oil price volatility and stock returns of the renewable energy firms, the base model can be specified as follows

$$R_{it} = \alpha_i + \beta_1 OVX_t + \beta_2 R_{mt} + \bar{\varepsilon}_{it} \quad (4.1)$$

Where, $R_{i,t} = \ln \frac{P_{i,t}}{P_{i,t-1}}$ is the monthly stock returns of the renewable energy firms. $OVX_t = \ln \frac{OVX_t}{OVX_{t-1}}$ is the monthly change in oil price volatility index. Ln denotes natural log. R_{mt} is the market return at the time t. Fama-French (1992) and Carhart (1997) have prescribed factors affecting CAPM. The following model specification is framed after including asset pricing factors in model 4.1.

$$R_{it} - R_{ft} = \alpha_i + \beta_1 (R_{mt} - R_{ft}) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 WML_t + \bar{\varepsilon}_{it} \quad (4.2)$$

Where, $(R_{it} - R_{ft})$ represents the excess stock return of the renewable energy firms. $R_m - R_f$ represents the excess stock returns of market or market premium is the market factor. Remaining factors are size, value and momentum factor are symbolically mentioned as SMB, HML and WML respectively. To estimate the impact of oil price volatility shock on stock return, the following panel regression model based on ordinary least square assumption is derived from equations 4.1 and 4.2.

$$R_{it} - R_{ft} = \alpha_i + \beta_1 OVX_t + \beta_2 (R_{mt} - R_{ft}) + \beta_3 SMB_t + \beta_4 HML_t + \beta_5 WML_t + \bar{\varepsilon}_{it} \quad (4.3)$$

To check the asymmetric effect of the OVX shock, the changes in OVX shock are decomposed into the positive changes and negative changes. The ordinary least square panel regression model for estimating asymmetric effect is specified in equation 4.4.

$$R_{it} - R_{ft} = \alpha_i + \beta_1 OVX_t^+ + \beta_2 OVX_t^- + \beta_3 (R_{mt} - R_{ft}) + \beta_4 SMB_t + \beta_5 HML_t + \beta_6 WML_t + \bar{\varepsilon}_{it} \quad (4.4)$$

Quantile regression is used in new literature to evaluate the effect of oil prices under diverse market scenarios. (Reboredo and Ugolini, 2018; Dawar et al., 2021; He et al., 2021; Maghyreh and Abdoh, 2021). Keeping in view of this objective's data type, this study applies panel quantile regression with non-additive fixed effect model (Powell, 2022). This model is being used widely in finance (Bruna et al., 2020; Anilov and Ivashkovskaya, 2020) and economics (Behera and Dash, 2019; Jiang, 2019; Sarkodie and Strezov, 2019) literature. Reverse causality and dynamic endogeneity factors and sample heterogeneity don't arise in this model. It also captures the covariance between the variables in both the tails including in the median.

$$R_{it} - R_{ft} = \sum_{j=1}^4 D'_{it} \beta_j (U_{it}^*) \quad (4.5)$$

Where, $R_{it} - R_{ft}$ signifies the excess stock returns of firms a time t. β represents the parameter. D'_{it} is a set of independent of variables used in the regression, oil price volatility (OVX) and Fama-French-Carhart (1997) factors. The factors are market ($R_m - R_f$), size (SMB), value (HML) and momentum (WML). In case of asymmetric effect, oil price volatility change would be replaced by positive (OVX_t^+) and negative (OVX_t^-) change in the oil price volatility index. U_{it}^* denotes the error term. It is a function of several disturbance term, some fixed and some-time varying. The model is linear in terms of

parameters and $D'_{it}\beta_j$ (τ) is increasing in τ i.e., quantile. Markov Chain Monte Carlo (MCMC) optimization method is used in framing the above model.

This objective estimates for seven quantiles, including median quantile 0.50, representing normal market condition. The bearish market condition is represented by 0.05, 0.10 and 0.25 quantiles. On the other hand, the boom market condition represented by 0.75, 0.90 and 0.95 quantiles. In this paper, all these quantiles are mentioned as $Q_{.05}, Q_{.10}, Q_{.25}, Q_{.50}, Q_{.75}, Q_{.90}$ and $Q_{.95}$. This study investigates the effect of the OVX shock on renewable energy companies' stock returns across market conditions using panel quantile regression model outlined above.

4.4 RESULT AND ANALYSIS

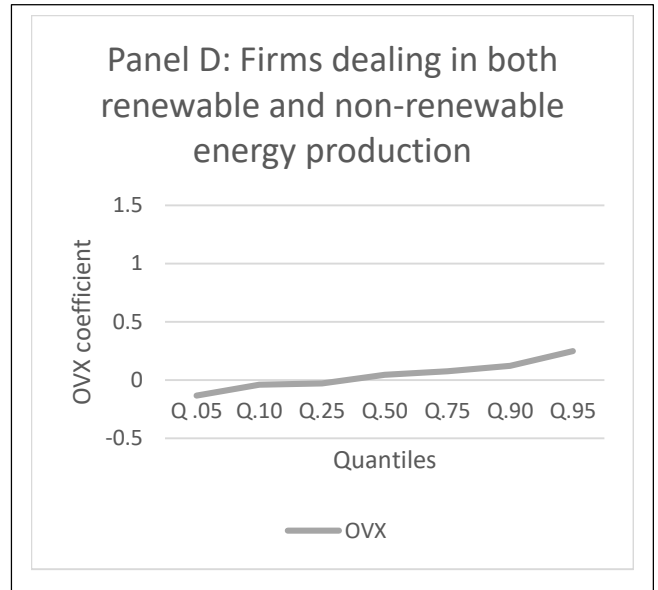
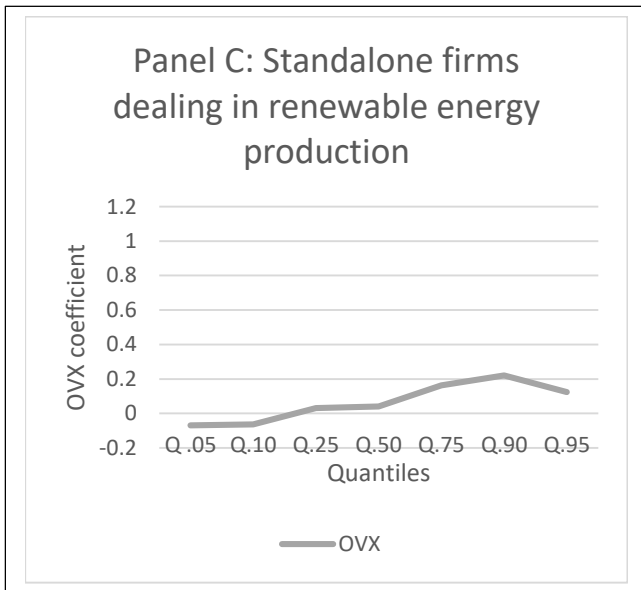
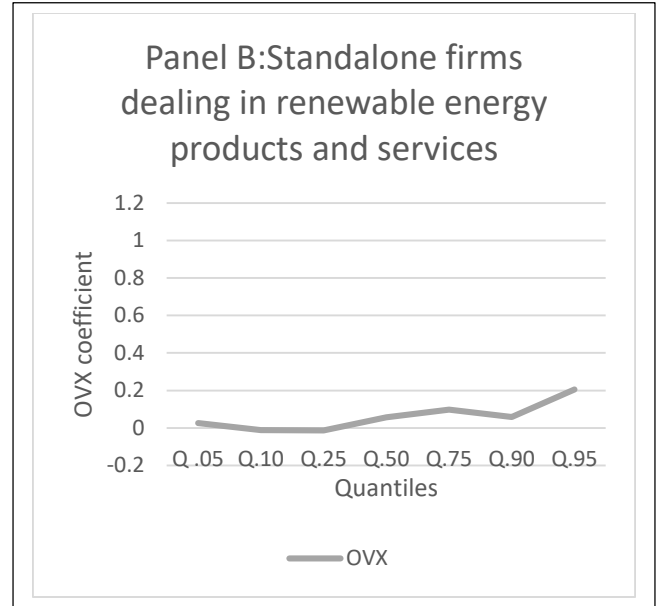
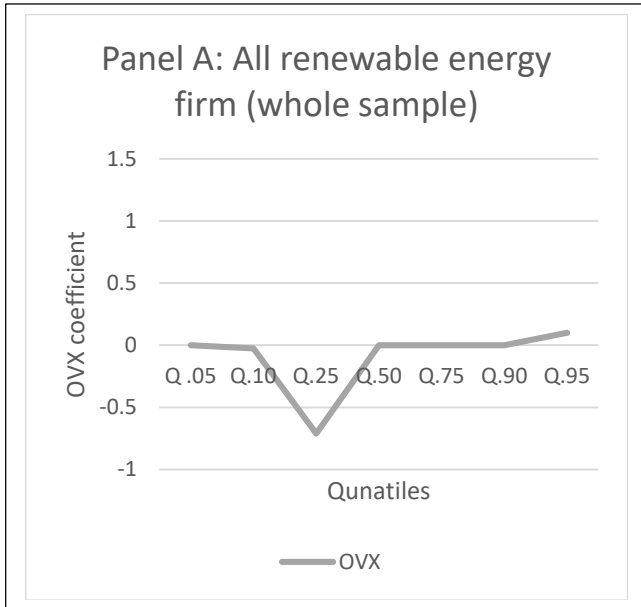
4.4.1 The OVX effect on stock return of the renewable energy sector firms

Summary statistics in table 4.1 show that OVX shock is more volatile in comparison to stock return. Shapiro-Wilk test shows that variables are not normally distributed. In this case, OLS regression estimation might produce an over or under-estimated coefficient of independent variables. Thus, Panel quantile regression is the most suited for this data set. But for reporting purpose, this study includes OLS estimations in different tables along with panel quantile estimations. To avoid pseudo-regression model, this study tests stationarity of the variables. Here, this study uses Im–Pesaran–Shin (2003) unit root test for the stationarity of variables. It rejects the null hypothesis of non-stationarity.

Table 4.2 exhibits panel quantile regression estimation on the impact of OVX changes (OVX shock) on India's renewable energy companies' stock returns. These estimations are also shown in graphical form in image 4.1. In the whole sample of the renewable energy sector firms (Panel A), the OVX shock affects negatively only in the bearish conditions ($Q_{.05}, Q_{.10}$ and $Q_{.25}$). The OVX shock positive effect is seen in quantile $Q_{.95}$. In quantile $Q_{.25}$, only size factor has a positive and significant effect. All asset price factors affect stock return positively in the remaining respective quantiles ($Q_{.05}$ and $Q_{.10}$).

In the case of panel B (standalone renewable energy products and services firms), stock returns positively interact with the OVX shock except for 0.10 and 0.25 quantiles. It is stronger in higher quantiles. All asset pricing factors have positive coefficients in most

quantiles. Market and value factors have a stronger positive interaction with stock return than the remaining factors.



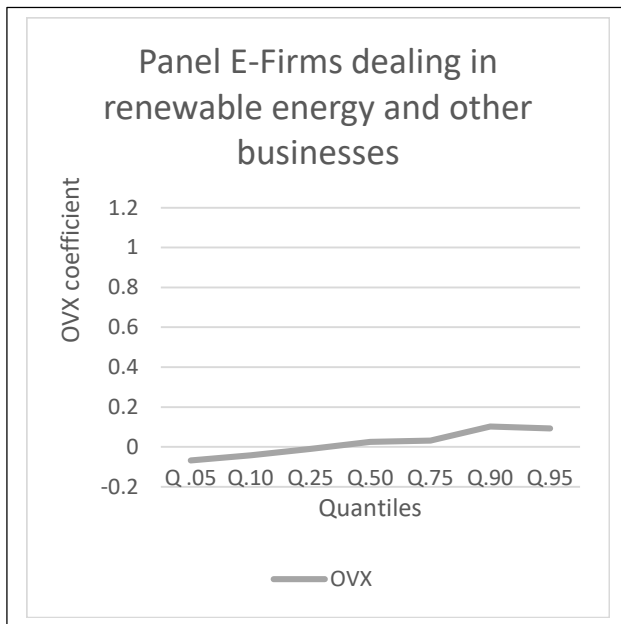


Image 4.1: Relationship between OVX shock and stock return

Panel C shows the estimation for standalone renewable energy production firms. The OVX shock effect is positive in most quantiles except 0.05 and 0.10. This positive effect is stronger in the higher quantiles. Among asset pricing factors, market and value factors have a stronger positive interaction with stock return in all the quantiles. Size and momentum factors have weak positive effects with few exceptions where it is negative.

In lower quantiles (bearish market condition), the OVX shock negatively affects stock returns of the renewable and non-renewable energy production firms in Panel D. The positive OVX shock effect on stock return is seen in bullish (upper quantile) and normal market (Q_{.50}) conditions. In this panel, market and value factors have a direct effect on stock return. Size and momentum factors have a mixed relationship with stock return.

In panel E, firms dealing in renewable energy and other business activities are analyzed. The OVX shock affects stock return negatively in lower quantiles (bearish market condition). In normal (median quantile) and bullish market (upper quantiles) conditions, the OVX shock effect is positive. All asset pricing factors have positive coefficients across quantiles. The intensity of these factors is in the following order, market, size, value and momentum. The null hypothesis is that oil price uncertainty has a significant effect on stock returns of renewable energy firms. Alternative hypothesis is that oil price uncertainty has

no significant effect on the stock return of renewable energy firms. Null hypothesis is rejected in most of the quintiles.

4.4.2 The OVX asymmetric effect of on stock return of the renewable energy sector firms

To test the asymmetric effect, the OVX changes are decomposed into the positive OVX changes and the negative OVX changes. The positive OVX changes signify the increase in oil price uncertainty change. On the other hand, the negative OVX changes signify the decrease in oil price uncertainty change. When both the changes affect stock return similarly (positively or negatively), it is an asymmetric effect. Table 4.3 exhibits the asymmetric interaction of the OVX change on stock return of the renewable energy sector firm in India. Based on existing literature, the null hypothesis is that the oil price volatility index change has a symmetric effect on stock returns of renewable energy firms. The null hypothesis is not rejected for the whole sample and sub-groups of renewable energy firms. In panel A (all renewable energy firms in India), this study does not find the asymmetric impact of OVX shock. The positive OVX change affects stock return positively in all quintiles. On the other hand, the negative change in OVX shock affects stock return negatively in most quintiles. Market, size, value and momentum factors have a positive relationship with stock return in all quintiles. The market factor effect is the strongest among these.

This study finds the absence of OVX asymmetric influence on stock return in panel B, i.e., standalone renewable energy products and services firms. The positive OVX change affects stock return positively in all quintiles. On the other hand, the negative change in OVX shock affects stock return negatively in most quintiles. This study observes that market, size and value factors have positive coefficients. But, momentum factor has negative coefficients in the extreme bullish market conditions ($Q_{.90}$ and $Q_{.95}$).

In the case of standalone renewable energy production firms (Panel C), the OVX shock asymmetric effect does not exist. The positive OVX change has a positive relationship with stock return in all the quintiles. However, the negative OVX change has a negative effect

in all quantiles. The OVX change effect is stronger in higher quantiles, in general. Market, size and value factors positively correlate with stock return in all market conditions. On the other hand, the momentum factor has a mix of positive and negative coefficients.

In panel D, this study observes no the OVX change asymmetric effect on stock return of renewable and non-renewable energy production firms. The positive OVX change has a significant and positive interaction. It goes stronger with a higher quantile. Whereas, the negative OVX change has a negative effect without any pattern. Market, size and value factors have positive coefficients in most quantiles. The momentum factor affects stock return negatively except $Q_{.95}$.

Panel E shows the estimations of firms dealing in renewable energy and other business activities. Here, the study also finds no asymmetric effect of the OVX changes. The positive OVX change positively affects stock return. It shows an increasing trend. The negative OVX change has negative coefficients. These coefficients show a stable trend in the lower quantiles. Market, size, value and momentum factors positively affect stock returns. The only exception is the momentum factor which has negative coefficients in $Q_{.95}$.

4.5 SUMMARY

This objective looks at how stock returns of the Indian renewable energy firms respond to oil price uncertainty in this objective. This objective applies panel quantile regression model to examine the effect of crude oil price uncertainty under various market scenarios. The oil volatility index is used as a proxy of oil price uncertainty due to its better explaining ability. To assess the oil price uncertainty asymmetric effect, the OVX changes are segregated into positive and negative changes. This study finds that the OVX shock effect on India's renewable energy companies' stock returns is negative only in bearish market conditions. In sub-group firms, the effect of OVX shock is positive on stock returns in most quantiles. In standalone renewable energy firms, the positive interaction between the OVX shock and stock returns is more dominating. In the remaining subgroups, the relationship between two variables is negative in most quantiles. In the whole sample of all renewable

energy firms, the OVX asymmetric effect does not exist. Similarly, this study also found no asymmetric effects in the sub-groups of renewable energy firms.

The observations of this objective provide very useful insights on the interaction between crude oil price volatility index and India's renewable energy companies' stock returns. The present study also provides evidence for different market conditions. Investors and portfolio managers need to be vigilant during bearish and bullish market conditions to use the oil price volatility index movements to maximize their investment return. In the future, developing countries like India would depend heavily on the renewable energy sector to keep their economic growth at a good pace. So, policymakers can use these findings to stimulate the growth of the renewable energy business in India by incorporating appropriate policy intervention in different market conditions. Renewable energy industry practitioners can use these findings to enable renewable energy firms to maximize their wealth. They can formulate strategies for different market conditions also. As this objective study is at a firm level, strategic planners of the respective renewable energy companies could use the corresponding findings for the company's growth. This objective will encourage the academicians to do future research on Indian renewable energy firms for the contributions to above mentioned matters.

Table 4.1 Summary statistics

Variables	Mean	SD	Min	Max	Variance	Skewness	Kurtosis	SW Test
Stock								
return	0.190	6.066	-3.777012	260.2	36.805	35.066	1269.062	23.546
OVX	-.001	0.215	-0.568	1.202	0.046	-0.406	1.290	17.318

S-W: Shapiro-Wilk test with Z-statistics. *** indicates significance at the 1% level.

Table 4.2: The oil volatility index effect on stock returns of the renewable energy firms in India**Panel A: QRPD analysis on firms dealing renewable energy business (whole sample)**

Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
OVX	-0.040*** (0.000)	-0.025*** (0.000)	-0.711* (0.430)	0.339 (1.021)	0.471 (0.667)	0.087 (0)	0.099*** (0.000)	0.304 (0.254)
$R_m - R_f$	0.014*** (0.000)	0.014*** (0.000)	-0.0159 (0.017)	0.010 (0.041)	-0.019 (0.087)	0.016 (0)	0.016*** (0.000)	0.029** (0.013)
SMB	0.004*** (0.000)	0.002*** (0.000)	0.029* (0.015)	0.0371 (0.119)	-0.058 (0.100)	0.006 (0)	0.009*** (0.000)	0.009 (0.013)
HML	0.009*** (0.000)	0.009*** (0.000)	-0.045 (0.030)	-0.135 (0.458)	0.025 (0.036)	0.010 (0)	0.012*** (0.000)	0.036*** (0.012)
WML	0.001*** (0.000)	0.002*** (0.000)	-0.015 (0.011)	-0.065 (0.212)	0.009 (0.000)	0.000 (0)	0.001*** (0.000)	0.021* (0.000)
Observations	12,173	12,173	12,173	12,173	12,173	12,173	12,173	12,173
Number of firms	94	94	94	94	94	94	94	94

Panel B: QRPD analysis on standalone firms dealing in renewable energy products and services

Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
OVX	0.026*** (0.000)	-0.011*** (0.000)	-0.014*** (0.000)	0.057*** (0.001)	0.097*** (0.000)	0.059*** (0.000)	0.205*** (0.000)	0.028 (0.031)
R _m - R _f	0.010*** (0.000)	0.013*** (0.000)	0.015*** (0.000)	0.018*** (0.000)	0.018*** (0.000)	0.013*** (0.000)	0.018*** (0.000)	0.014*** (0.000)
SMB	0.002*** (0.000)	0.004*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.007*** (0.000)	0.010*** (0.000)	-0.002*** (0.000)	0.007*** (0.001)
HML	0.009*** (0.000)	0.011*** (0.000)	0.012*** (0.000)	0.011*** (0.000)	0.009*** (0.000)	0.012*** (0.000)	0.018*** (0.000)	0.011*** (0.001)
WML	0.002*** (0.000)	0.003*** (0.000)	0.005*** (0.000)	0.002*** (0.000)	0.000*** (0.000)	-0.003*** (0.000)	0.000*** (0.000)	0.001 (0.001)
Observations	1,214	1,214	1,214	1,214	1,214	1,214	1,214	1,214
Number of firms	9	9	9	9	9	9	9	9

Panel C: QRPD analysis on standalone firms dealing in renewable energy production

Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
OVX	-0.068*** (0.000)	-0.063*** (0.000)	0.031*** (0.000)	0.041*** (0.000)	0.164*** (0.000)	0.221*** (0.002)	0.124*** (0.000)	0.019 (0.036)
R _m - R _f	0.017*** (0.000)	0.024*** (0.000)	0.019*** (0.000)	0.019*** (0.000)	0.022*** (0.000)	0.022*** (0.000)	0.021*** (0.000)	0.018*** (0.001)
SMB	0.002*** (0.000)	0.001*** (0.000)	0.000*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	-0.001*** (0.000)	0.017*** (0.000)	0.009*** (0.001)
HML	0.012*** (0.000)	0.020*** (0.000)	0.011*** (0.000)	0.011*** (0.000)	0.009*** (0.000)	0.013*** (0.000)	0.020*** (0.000)	0.013*** (0.001)
WML	0.003*** (0.000)	0.005*** (0.000)	0.002*** (0.000)	0.000*** (0.000)	-0.002*** (0.000)	0.004*** (0.000)	0.010*** (0.000)	0.002 (0.001)
Observations	1,131	1,131	1,131	1,131	1,131	1,131	1,131	1,131
Number of firms	10	10	10	10	10	10	10	10

firms

Panel D: QRPD analysis on firms dealing in both renewable and non-renewable energy production

Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
OVX	-0.134*** (0.000)	-0.040*** (0.000)	-0.028*** (0.000)	0.045*** (0.000)	0.076*** (0.000)	0.121*** (0.000)	0.249*** (0.000)	0.019 (0.027)
R _m - R _f	0.007*** (0.000)	0.013*** (0.000)	0.014*** (0.000)	0.017*** (0.000)	0.019*** (0.000)	0.018*** (0.000)	0.021*** (0.000)	0.016*** (0.001)
SMB	-0.002*** (0.000)	0.000*** (0.000)	-0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.002*** (0.000)	0.017*** (0.000)	0.003*** (0.001)
HML	0.009*** (0.000)	0.009*** (0.000)	0.008*** (0.000)	0.008*** (0.000)	0.009*** (0.000)	0.011*** (0.000)	0.010*** (0.000)	0.009*** (0.001)
WML	-0.002*** (0.000)	-0.001*** (0.000)	0.000*** (0.000)	-0.001*** (0.000)	0.000*** (0.000)	0.003*** (0.000)	-0.002*** (0.000)	0.000 (0.001)
Observations	1,694	1,694	1,694	1,694	1,694	1,694	1,694	1,694
Number of firms	11	11	11	11	11	11	11	11

firms

Panel E : QRPD analysis on firms dealing in renewable energy and other business activities

Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
OVX	-0.068*** (0.000)	-0.042*** (0.000)	-0.0100** (0.004)	0.026*** (0.000)	0.031*** (0.001)	0.102*** (0.001)	0.093*** (0.0001)	0.433 (0.368)
R _m - R _f	0.013*** (0.000)	0.014*** (0.000)	0.015*** (0.000)	0.018*** (0.000)	0.017*** (0.000)	0.016*** (0.000)	0.015*** (0.000)	0.035* (0.018)
SMB	0.007*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.002*** (0.000)	0.008*** (0.000)	0.007*** (0.000)	0.010*** (0.000)	0.011 (0.019)
HML	0.005*** (0.000)	0.006*** (0.000)	0.007*** (0.000)	0.006*** (0.000)	0.008*** (0.000)	0.008*** (0.000)	0.010*** (0.000)	0.047*** (0.017)
WML	0.001*** (0.000)	0.002*** (0.000)	0.001*** (0.000)	0.000*** (0.000)	0.001*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.030* (0.016)
Observations	9,141	9,141	9,141	9,141	9,141	9,141	9,141	9,141

Number of firms 64 64 64 64 64 64 64

Note: ***, ** and * represent significant level at 1, 5 and 10% respectively and adjacent parentheses contain standard errors. Panel A-all renewable energy firms; Panel B- standalone firms dealing in renewable energy products and services; Panel C- standalone firms dealing in renewable energy power generation, Panel D- firms dealing in both renewable and non-renewable energy power generation and Panel E-firms in renewable energy business and other business activities. QRPD: Quantile Regression for Panel Data.

Table 4.3: The oil volatility index asymmetric effect on stock returns of the renewable energy firms in India

Panel A: QRPD analysis on firms dealing renewable energy business (whole sample)								
Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
OVX ⁺	0.123*** (0.000)	0.126*** (0.002)	0.128*** (0.000)	0.214*** (0.006)	0.265*** (0.023)	0.236*** (0.000)	0.326*** (0.000)	0.638* (0.364)
OVX ⁻	-0.252*** (0.0003)	-0.204*** (0.000)	-0.249*** (0.000)	-0.187*** (0.013)	-0.141*** (0.010)	-0.134*** (0.000)	-0.208*** (0.000)	-0.238 (0.493)
R _m - R _f	0.012*** (0.000)	0.011*** (0.000)	0.015*** (0.000)	0.015*** (0.000)	0.018*** (0.000)	0.016*** (0.000)	0.017*** (0.000)	0.029** (0.013)
SMB	0.004*** (0.000)	0.006*** (0.000)	0.006*** (0.000)	0.005*** (0.000)	0.005*** (0.000)	0.009*** (0.000)	0.010*** (0.000)	0.011 (0.013)
HML	0.007*** (0.000)	0.008*** (0.000)	0.008*** (0.000)	0.008*** (0.000)	0.010*** (0.000)	0.009*** (0.000)	0.011*** (0.000)	0.037*** (0.012)
WML	0.000*** (0.000)	0.000*** (0.000)	0.002*** (0.000)	0.000* (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.023** (0.011)
Observations	13,180	13,180	13,180	13,180	13,180	13,180	13,180	13,180
Number of firms	94	94	94	94	94	94	94	94
Panel B: QRPD analysis on standalone firms dealing in renewable energy products and services								
Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
OVX ⁺	0.202***	0.263***	0.256***	0.284***	0.355***	0.389***	0.437***	0.303***

	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.043)
OVX ⁻	-0.237***	-0.330***	-0.397***	-0.300***	-0.279***	-0.447***	-0.242***	-0.418***
	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.001)	(0.000)	(0.058)
R _m - R _f	0.011***	0.012***	0.014***	0.012***	0.013***	0.013***	0.014***	0.014***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
SMB	0.003***	0.001***	0.004***	0.006***	0.010***	0.012***	0.011***	0.008***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
HML	0.010***	0.012***	0.012***	0.012***	0.013***	0.012***	0.011***	0.011***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
WML	0.002***	0.002***	0.003***	0.000***	0.000***	-0.001***	-0.001***	0.002*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Observations	1,214	1,214	1,214	1,214	1,214	1,214	1,214	1,214
Number of firms	9	9	9	9	9	9	9	9

Panel C: QRPD analysis on standalone firms dealing in renewable energy production

Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
OVX ⁺	0.030***	0.167	0.242***	0.252***	0.363***	0.415***	0.310***	0.199***
	(0.000)	(0)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.050)
OVX ⁻	-0.198***	-0.258	-0.167***	-0.180***	-0.244***	-0.320***	-0.328***	-0.278***
	(0.000)	(0)	(0.000)	(0.000)	(0.000)	(0.002)	(0.002)	(0.069)
R _m - R _f	0.019***	0.012***	0.017***	0.0162***	0.0130***	0.0240***	0.0224***	0.0187***
	(0.000)	(0)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
SMB	0.003***	0.007	0.003***	0.005***	0.014***	0.005***	0.020***	0.009***
	(0.000)	(0)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
HML	0.012***	0.014	0.013***	0.012***	0.015***	0.008***	0.023***	0.014***
	(0.000)	(0)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
WML	0.004***	0.000	0.000***	-0.002***	-0.004***	0.000***	0.006***	0.003**

	(0.000)	(0)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Observations	1,131	1,131	1,131	1,131	1,131	1,131	1,131	1,131
Number of firms	10	10	10	10	10	10	10	10

Panel D: QRPD analysis on firms dealing in both renewable and non-renewable energy production

Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
OVX ⁺	0.020*** (0.000)	0.032*** (0.000)	0.096*** (0.003)	0.233*** (0.000)	0.227*** (0.001)	0.186*** (0.000)	0.293*** (0.000)	0.159*** (0.039)
OVX ⁻	-0.164*** (0.000)	-0.149*** (0.000)	-0.223*** (0.002)	-0.233*** (0.000)	-0.150*** (0.002)	-0.009*** (0.000)	-0.273*** (0.000)	-0.204*** (0.052)
R _m - R _f	0.009*** (0.000)	0.012*** (0.000)	0.011*** (0.000)	0.015*** (0.000)	0.014*** (0.000)	0.014*** (0.000)	0.019*** (0.000)	0.016*** (0.001)
SMB	0.000 (0.000)	0.000*** (0.000)	0.003*** (0.000)	0.001*** (0.000)	0.005*** (0.000)	0.009*** (0.000)	0.012*** (0.000)	0.004*** (0.001)
HML	0.009*** (0.000)	0.008*** (0.000)	0.010*** (0.000)	0.008*** (0.000)	0.010*** (0.000)	0.009*** (0.000)	0.009*** (0.000)	0.010*** (0.001)
WML	-0.002*** (0.000)	-0.001*** (0.000)	-0.003*** (0.000)	0.000*** (0.000)	-0.002*** (0.000)	-0.001*** (0.000)	0.001*** (0.000)	0.001 (0.001)
Observations	1,694	1,694	1,694	1,694	1,694	1,694	1,694	1,694
Number of firms	11	11	11	11	11	11	11	11

Panel E : QRPD analysis on firms dealing in renewable energy and other business activities

Variables	Q _{.05}	Q _{.10}	Q _{.25}	Q _{.50}	Q _{.75}	Q _{.90}	Q _{.95}	OLS
OVX ⁺	0.100*** (0.000)	0.066 (0)	0.137*** (0.000)	0.183*** (0.000)	0.198*** (0.002)	0.299*** (0.001)	0.291*** (0.000)	0.835 (0.529)
OVX ⁻	-0.262*** (0.000)	-0.212 (0)	-0.261*** (0.000)	-0.214*** (0.000)	-0.124*** (0.001)	-0.046*** (0.000)	-0.140*** (0.000)	-0.217 (0.715)
R _m - R _f	0.012*** (0.000)	0.012*** (0)	0.015*** (0.000)	0.017*** (0.000)	0.017*** (0.000)	0.012*** (0.000)	0.015*** (0.000)	0.034* (0.018)
SMB	0.007***	0.006	0.006***	0.005***	0.007***	0.009***	0.011***	0.013

	(0.000)	(0)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.019)
HML	0.006***	0.006	0.007***	0.006***	0.008***	0.011***	0.010***	0.048***
	(0.000)	(0)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.017)
WML	0.000***	0.001	0.002***	0.000***	0.001***	-0.002***	0.000***	0.032**
	(0.000)	(0)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.016)
Observations	9,141	9,141	9,141	9,141	9,141	9,141	9,141	9,141
Number of firms	64	64	64	64	64	64	64	64

Note: ***, ** and * represent significant level at 1, 5 and 10% respectively and adjacent parentheses contain standard errors. Panel A-all renewable energy firms; Panel B- standalone firms dealing in renewable energy products and services; Panel C- standalone firms dealing in renewable energy power generation, Panel D- firms dealing in both renewable and non-renewable energy power generation and Panel E-firms in renewable energy business and other business activities. QRPD: Quantile Regression for Panel Data.

CHAPTER 5

INVESTIGATING THE ASYMMETRIC RELATIONSHIP BETWEEN OIL PRICE CHANGE AND STOCK RETURNS OF THE RENEWABLE ENERGY FIRMS IN INDIA

5.1 INTRODUCTION

Fossil oil is a very common element in industrial production as oil is an input in various industries. Thus, fluctuations in oil price could affect the cost of production, which has the ultimate effect on industrial and economic growth. Oil price change can be positive or negative. If both these changes impact dependent variables differently, it is a case of asymmetric effect. Mork (1994) and Sadorsky (1999) find that oil price affects the economy (macroeconomic variables) asymmetrically. Researchers find this effect also on stocks (Xu, 2015; Zhu et al., 2017). Oil price affects stock prices asymmetrically across countries as per Salisu and Isah (2017). But, the oil price asymmetric effect is stronger in oil-importing countries. Cross-industry studies find that the oil price asymmetric effect is heterogeneous across industries (Arouri and Nguyen, 2010; Ramos and Veiga, 2013). This is because the dependency on oil is not the same in different industries. The asymmetric effect is heterogeneous on firms' stock prices within a particular industry (Tsai, 2015). This heterogeneous asymmetric effect depends on the characteristic of firms in an industry. In renewable energy literature, the researchers also find that stock return responds to oil price asymmetrically (Zhu et al., 2019; Kocaarslan and Soytaş, 2019). This objective investigates the asymmetric interaction between oil price on stock returns of the Indian renewable energy firms.

The researchers provide evidence of the oil price asymmetric effect on renewable energy stock price. Kocaarslan and Soytaş (2019) find this effect in the long run by using the panel non-linear ARDL (NARDL) model. In the new energy firms of China, oil price interacts asymmetrically with stock return and this interaction is more robust in the case of state owned firms (Zhu et al. 2019). On the other hand, Salisu and Isah (2017) and Hatemi-

J et al. (2017) deduce that the oil price asymmetric effect on stock price is heterogeneous across countries. Due to the predominant role of India in the global renewable energy sector (IRENA, 2017), these studies motivate to investigate the asymmetric impact of oil price in the renewable energy sector at the firm level in India. Since 2002, India has moved away from Administered Price Mechanism. But, oil price in India is not in sync with the international oil price due to taxation and political compulsions. So, it is interesting to see the asymmetric relationship of domestic and international oil prices with stock returns of the renewable energy firms in India.

This objective adopts NARDL approach of Salisu and Isah (2017). This model detects the possible asymmetric effect of an independent variable. Here in panel NARDL, the independent variable i.e. oil price change, is decomposed into positive and negative changes to evaluate non-linearity in the oil-stock relationship. The existing studies are based on aggregate stock or stock indices of the renewable energy sector and in the context of China and different developed countries using time series analysis. The novelty is that this objective is the first study that has used panel NARDL in the renewable energy sector, specifically in India. Wherein this objective examine oil price asymmetric interaction with stock returns of the renewable energy sector firms and the subgroups of these firms in India. The proposed panel NARDL approach captures the asymmetric effect of oil price in different time horizons at the firm level. This study finds that the oil price asymmetric effect only on stock returns of the standalone renewable energy production firms in the short run. In the long run, the asymmetric effect is found in the whole sample and other sub-groups of renewable energy firms, except firms dealing in producing renewable and non-renewable energy firms.

The contributions of this objective are explained in the following ways. In the renewable energy sector, the existing studies are on aggregate stock level and concentrated more in developed countries. This objective investigates the asymmetric effect of oil price in India and at the firm level. This also incorporates Fama–French and momentum factors of the asset pricing model in panel NARDL regression.

5.2 LITERATURE REVIEW

Extant literature is dedicated on how oil price has the asymmetric implication on stock return of the renewable energy sector are explained in this paragraph. Oil price changes can be disentangled into two changes such as positive changes and negative changes. If both the changes affect a dependent variable similarly, it is a case of oil price asymmetric effect. Applying NARDL model, Kocaarslan and Soytas (2019) observed that the asymmetric interaction was seen only in the long run. The positive and negative impacts of oil price were seen on clean energy stock price in the long and short run, respectively. Uddin et al. (2019) examined the dependency between renewable energy stock return and the price of crude oil using cross-quantilogram model. They concluded that the renewable energy stock return responded positively to oil price and this dependency became weaker and asymmetry was higher in the longer lags. Zhu et al. (2019) conducted a study in China context. They deduced that the price of crude oil influenced stock return, which is negative at the sectoral level and heterogeneous at the firm level. A stronger lag effect of oil price in the short run was seen. Oil price also impacted asymmetrically new energy firms in China. And it was more robust among state-owned firms. The existing literature is based on aggregate stock return and mostly in developed countries to examine oil price asymmetric effect in the renewable energy sector. Thus, this objective aims to investigate this effect at the firm level and in the context of India.

5.3 DATA AND METHODOLOGY

5.3.1 Data: The dataset is same as in the first objective of the study

5.3.2 Model specification

This objective uses panel NARDL model. This technique applies two estimators. The pooled mean group (PMG) and the mean group (MG) are the estimators. To determine the appropriate one, the Hausman test is used. The null hypothesis is that PMG is the efficient estimator. The alternate hypothesis implies that the MG is the efficient estimator. All firms in the sample are divided into four subgroups to examine heterogeneity in the oil-stock nexus. These sub-groups firms are, a) standalone firms dealing in renewable energy

products and services, d) standalone firms dealing in renewable energy power generation, c) firms dealing in both renewable and non-renewable energy power generation, and d) firms dealing in renewable energy and other business activities.

5.3.2.1 Panel ARDL

To begin the study of the objective, this study examines the symmetric relation between oil price and stock price. In the panel ARDL framework, the following model specification is to study these symmetric effects in the long run and short run.

$$\Delta y_{it} = \sum_{j=1}^p \beta_{ij} y_{t-j} + \sum_{j=0}^q \lambda_{ij} x_{t-j} + \mu_i + \bar{\varepsilon}_{it} \quad (5.1)$$

Where, Y_{it} is the dependent variable, $X_{i,t=j}$ ($k \times 1$) is the vector of independent variable, ε_{it} is the error term, μ_i is the group-specific effect, β_{ij} is the coefficient of lagged value of dependent variable. λ_{ij} ($k \times 1$) is the vector of independent variable. i implies the number of cross-section. t implies the number of time.

The following panel ARDL model is specified for this objective.

$$\begin{aligned} \Delta(R_{it} - R_{f,i,t}) = & \beta_{0i} + \beta_{1i} Oil_{t-1} + \beta_{2i}(R_{mt-1} - R_{ft-1} + \beta_{4i}SMB_{t-1} \\ & + \beta_{3i}HML_{t-1} + \beta_{6i}WML_{t-1} + \sum_{j=1}^{M-1} \lambda_{ij} \Delta(R_{i,t-1} - R_{ft-1}) \\ & + \sum_{j=0}^N \lambda_{ij} \Delta Oil_{t-1} + \sum_{j=0}^O \lambda_{ij} \Delta(R_{mt-1} - R_{ft-1}) \\ & + \sum_{j=0}^P \lambda_{ij} \Delta SMB_{t-1} + \sum_{j=0}^Q \lambda_{ij} \Delta HML_{t-1} + \sum_{j=0}^R \lambda_{ij} \Delta WML_{t-1} \\ & + \mu_i + \bar{\varepsilon}_{it} \end{aligned} \quad (5.2)$$

Where, $R_{i,t}$ ($R_{i,t} = \ln \frac{P_{i,t}}{P_{i,t-1}}$), represents monthly stock return of renewable energy firms Oil_t ($Oil_t = \ln \frac{Oil_t}{Oil_{t-1}}$) represents monthly oil price change, and $(R_{mt} - R_{ft})$ denotes market factor which is the excess stock return of a renewable energy firm than that of risk

free interest or market premium. Fama-French (Fama and French, 1993) and momentum (Carhart, 1997) factors such as market ($R_m - R_f$ i.e., market return minus risk free interest or market risk premium), size (SMB related to firm size), value (HML related to market capitalization) and momentum (WML related to value stock) are used as controlling variables.

The assumptions in the long run are $\Delta(R_{i,t-j} - R_{ft-j}) = 0$ and $\Delta Oil_{t-j} = 0$. Thus, the slope coefficient in long run is measured by $\frac{\beta_{2i}}{\beta_{1i}}$. The short run slope coefficient is measured by λ_{ij} . Based on above model, the following is the error correction term.

$$\begin{aligned} \Delta(R_{it} - R_{ft}) = & \delta_i v_{i,t-1} + \sum_{j=1}^{M-1} \lambda_{ij} \Delta(R_{i,t-1} - R_{ft-1}) + \sum_{j=0}^N \lambda_{ij} \Delta Oil_{t-1} \\ & + \sum_{j=0}^O \lambda_{ij} \Delta(R_{mt-1} - R_{ft-1}) + \sum_{j=0}^P \lambda_{ij} \Delta SMB_{t-1} \\ & + \sum_{j=0}^Q \lambda_{ij} \Delta HML_{t-1} + \sum_{j=0}^R \lambda_{ij} \Delta WML_{t-1} + \mu_i + \bar{\varepsilon}_{it} \end{aligned} \quad (5.3)$$

Here, the error correction term $v_{i,t-1}$ ensures speed of adjustment to reach equilibrium in long run. The long run slope coefficient δ_i explains how much duration is required due to the shock in the independent variables. One can observe in equations 5.2 and 5.3, there is no decomposition of oil price changes in to positive and negative changes. Thus, panel ARDL is based on assumption of symmetric effect.

5.3.2.2 Panel NARDL

In panel nonlinear ARDL, the asymmetric effect of the independent variable is studied. In the asymmetric effect, the dependent variable respond in a similar manner to the explanatory variable's positive and negative movements. The explanatory variable oil shock is decomposed into two shocks, such as positive shocks (increasing change) and negative shocks (decreasing change) to investigate the oil price asymmetric. The model specification as per panel ARDL framework is specified bellow.

$$\begin{aligned}
\Delta(R_{i,t} - R_{f,t}) = & \beta_{0i} + \beta_{1i}(R_{i,t-1} - R_{f,t-1}) + \beta_{2i}^- Oil_{t-1}^- + \beta_{3i}^+ Oil_{t-1}^+ \\
& + \beta_{4i}(R_{mt-1} - R_{ft-1}) + \beta_{5i}SMB_{t-1} + \beta_{6i}HML_{t-1} \\
& + \beta_{7i}WML_{t-1} + \sum_{j=1}^{M-1} \lambda_{ij}\Delta(R_{i,t-1} - R_{f,t-1}) \\
& + \sum_{j=0}^N \gamma_{ij}^- \Delta Oil_{t-1}^- + \gamma_{ij}^+ \Delta Oil_{t-1}^+ + \sum_{j=0}^O \lambda_{ij}\Delta(R_{mt-1} - R_{ft-1}) \\
& + \sum_{j=0}^P \lambda_{ij}\Delta SMB_{t-1} + \sum_{j=0}^Q \lambda_{ij}\Delta HML_{t-1} + \sum_{j=0}^R \lambda_{ij}\Delta WML_{t-1} \\
& + \mu_i + \bar{\varepsilon}_{it}
\end{aligned} \tag{5.4}$$

Where, positive and negative shocks are represented as Oil_t^+ and Oil_t^- respectively. Coefficients of Oil_t^+ and Oil_t^- in the long run elasticity are calculated as $\frac{\beta_{2i}^+}{\beta_{1i}}$ and $\frac{\beta_{2i}^-}{\beta_{1i}}$. In the same order, these shock are estimated as partial sum decomposition for oil price as follows

$$Oil_t^+ = \sum_{k=1}^t \gamma_{ij}^+ \Delta Oil_{ik}^+ = \sum_{k=1}^t \max(\Delta Oil_{ik}, 0) \tag{5.5}$$

$$Oil_t^- = \sum_{k=1}^t \gamma_{ij}^- \Delta Oil_{ik}^- = \sum_{k=1}^t \min(\Delta Oil_{ik}, 0) \tag{5.6}$$

The error correction term for equation (5.4) is given bellow

$$\begin{aligned}
\Delta(R_{it} - R_{ft}) = & \tau_i \xi_{i,t-1} + \sum_{j=1}^{M-1} \lambda_{ij}\Delta(R_{i,t-1} - R_{f,t-1}) \\
& + \sum_{j=0}^N \gamma_{ij}^- \Delta Oil_{t-1}^- + \gamma_{ij}^+ \Delta Oil_{t-1}^+ + \sum_{j=0}^O \lambda_{ij}\Delta(R_{mt-1} - R_{ft-1}) \\
& + \sum_{j=0}^P \lambda_{ij}\Delta SMB_{t-1} + \sum_{j=0}^Q \lambda_{ij}\Delta HML_{t-1} + \sum_{j=0}^R \lambda_{ij}\Delta WML_{t-1} \\
& + \mu_i + \bar{\varepsilon}_{it}
\end{aligned} \tag{5.7}$$

Where, the error correction term is $\xi_{i,t-1}$ and the long run slope coefficient is τ_i . The error term in equation (5.7) explains speed adjustment to equilibrium in panel NARDL model. And corresponding coefficients explain how long it takes to arrive the long run equilibrium due to shocks in explanatory variables in the short run.

5.4 RESULTS AND DISCUSSION

In this objective, this study use three different oil prices. Table 5.1 shows that stock price change (stock return) is more volatile than oil price change (oil return). On the other hand, market return is more volatile than stock returns of the renewable energy firms. As a common practice, it is required to conduct the panel unit root test where T is larger than N. The data set is stationary as the null hypothesis is rejected using Im–Pesaran–Shin (2003) unit root test. Thus, panel ARDL and panel NARDL frameworks are applied in this objective.

Table 5.2 contains the output of panel ARDL and panel NARDL, where Indian basket oil price is the independent variable. This study estimates the MG and PMG estimators for all panel data. After that, the Hausman test is conducted to know which estimator is the efficient. Here, the null hypothesis is that the PMG is a better estimator. The null hypothesis in the Hausman test is rejected in panel A only in both types of regressions. If Hausman test statistics fails in the rejection of the null hypothesis, there is no distinction between the MG and PMG estimators. In that scenario, this objective uses the PMG estimator. Thus, the analysis generates the PMG estimates for all panels in panel ARDL and panel NARDL regression.

Panel ARDL assumes that independent variable change has symmetric interaction with dependent variables. Table 5.2 displays estimation results for Indian basket oil price. The upper and lower sections of the table show estimations for the short run and long run, respectively. Oil price change and stock returns of the renewable energy firms have no significant association both in the short run and long run. Among the sub-groups, this relationship exists only in standalone renewable energy products and services firms (Panel B) in the short run has a direct association. In the long run, this study finds stock returns of

firms dealing in renewable energy and other business (Panel E) has a positive association with oil price. In the short run, market factor ($R_m - R_f$) has no significant interaction in with stock return in panel C. On the other hand, the value (HML) factor has a positive relationship with stock return in all panels except D. Size (SMB) and momentum (WML) factors also have positive and negative associations, respectively, in A, B and E panels. In the long run, market ($R_m - R_f$), size (SMB) and value (HML) factors have a positive and significant effect on stock return in all the panels. On the other hand, the momentum (WML) factor has a positive association with stock return in panel A and E.

In panel NARDL estimations using Indian basket oil price (Table 5.2), this study observes the oil price effect on stock return in the following sentences. In the short run, the oil price increase has that oil price change influences stock return of the renewable energy firms positively in all panels except panel E. The negative oil price changes negatively affect stock returns in A, D and E panels. But, the asymmetric effect of oil price change is not seen. In the short run, the size (SBM) factor has a positive association with stock return in panel A, B and D. Except for panel C, there is a positive impact of the value (HML) factor. The market ($R_m - R_f$) factor has a negative coefficient except in panel B.

In the long run, both positive and negative oil price changes have a negative effect on stock return. But, the oil price asymmetric effect is seen in panel B only. In the long run, Market ($R_m - R_f$), size (SMB) and value (HML) factors interact positively with stock return. On the contrary, the momentum (WML) factor has a negative relationship in all panels except A and D. The null hypothesis is that oil price has a symmetric effect on stock returns of renewable energy firms. The alternative hypothesis is that oil price has an asymmetric effect on stock return of renewable energy firms. In the short run, the null hypothesis is not rejected. In the long run, the null hypothesis is rejected for the whole sample and other sub-groups of renewable energy firms except firms dealing in the production of renewable and non-renewable energy firms.

5.5 SUMMARY

In this objective, this study investigates whether stock returns of the renewable energy companies in India respond to oil price asymmetrically. Panel ARDL with symmetric assumption and Panel Nonlinear ARDL with asymmetric assumption explore the oil-stock nexus. Under the symmetric assumption, oil price has a positive significant effect on stock returns of all renewable energy firms across time horizons. A positive effect of oil price is seen on stock returns of standalone renewable energy products and services firms in the short run and firms dealing in renewable energy business and other business activities in the long run. However, the oil price asymmetric effect is not seen in the short run. In the long run, the asymmetric effect is found in firms dealing in renewable and non-renewable energy production. Furthermore, asset pricing factors have a heterogeneous and weak relationship with stock return across different sub-groups and the whole sample.

To the body of knowledge in oil-stock nexus in the renewable energy sector, this objective contributes in the following levels. First, it is a study on firm-level by using the panel NARDL model in the renewable energy sector. Second, the study uses the CAPM framework for the analysis of asymmetric effect. Third, the study in Indian capital market is the first of its kind. Corporate managers could use the observations of this objective in the strategy formulation to ensure the good performance of their company stocks in the capital market. Portfolio managers and investors could use the outcomes of this study to maximize the investment returns. The policymakers may use the observations in framing the policy to boost the growth of the renewable energy sector.

Table 5.1: Summary statistics

Variables	Mean	SD	Min	Max	Variance	Skewness	Kurtosis	SW Test
Stock								
return	0.190	6.066	-3.777012	260.2	36.805	35.066	1269.062	23.546
Oil return	0.005	0.106	-.5165154	0.430	0.007	-0.406	3.720	18.350

S-W: Shapiro-Wilk test with Z-statistics. *** indicates significance at the 5% level. Stock is the stock return of renewable firms and Indian Basket S-W: Shapiro-Wilk test with Z-statistics. *** indicates significance at the 1% level. Stock is the stock return of renewable firms. Oil return represents crude oil Indian Basket Oil price.

Table 5.2 Panel regression estimation using Indian basket crude price

Panel ARDL: symmetric assumption

Variables	Panel A	Panel B	Panel C	Panel D	Panel E
Δ Oil	0.036** (0.016)	0.154** (0.067)	0.085 (0.069)	-0.000 (0.043)	0.020 (0.019)
Δ SMB	0.002*** (0.000)	0.003*** (0.001)	0.000 (0.004)	0.000 (0.001)	0.003*** (0.000)
Δ HML	0.003*** (0.000)	0.004*** (0.001)	0.002 (0.001)	0.004*** (0.000)	0.003*** (0.000)
Δ WML	-0.001*** (0.000)	0.001 (0.000)	0.000 (0.001)	-0.002*** (0.000)	-0.001*** (0.000)
$\Delta R_m - R_f$	-0.000 (0.000)	0.001 (0.001)	-0.005** (0.002)	0.000 (0.000)	0.000 (0.000)
Oil	0.078* (0.043)	-0.142 (0.131)	-0.153 (0.131)	0.033 (0.129)	0.161*** (0.052)
SMB	0.004*** (0.001)	0.002 (0.003)	-0.000 (0.003)	0.001 (0.003)	0.006*** (0.001)
HML	-0.002*** (0.000)	-0.000 (0.002)	0.002 (0.002)	-0.004* (0.002)	-0.003*** (0.000)
WML	0.001** (0.000)	-0.002 (0.002)	-0.001 (0.002)	-0.001 (0.002)	0.003*** (0.000)
$R_m - R_f$	0.024*** (0.000)	0.016*** (0.003)	0.027*** (0.002)	0.024*** (0.002)	0.025*** (0.001)
Constant	-0.326*** (0.011)	-0.396*** (0.046)	-0.424*** (0.040)	-0.277*** (0.028)	-0.311*** (0.012)
\hat{v}_{t-1}	-0.571*** (0.020)	-0.678*** (0.075)	-0.749*** (0.069)	-0.479*** (0.048)	-0.547*** (0.022)
Hausman test	-47.99	-1.32	3.94	0.74	2.09
P value χ_k	(-)	(-)	(0.558)	(0.980)	(0.836)
Observations	10,744	1,037	851	1,386	7,470
No. of firms	94	9	11	10	64

Panel NARDL: asymmetric assumption

Variables	Panel A	Panel B	Panel C	Panel D	Panel E
Δ Oil ⁺	0.229***	0.393***	0.187	0.293***	0.252***

	(0.043)	(0.108)	(0.188)	(0.054)	(0.039)
ΔOil^-	-0.120**	0.115	0.019	-0.138***	-0.099***
	(0.050)	(0.104)	(0.182)	(0.045)	(0.033)
ΔSMB	-0.001	0.000	-0.001	-0.001	0.000*
	(0.001)	(0.000)	(0.004)	(0.000)	(0.000)
ΔHML	0.002***	0.002**	0.001	0.003***	0.002***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
ΔWML	-0.000	0.002***	0.001	-0.001**	-0.001***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
$\Delta R_m - R_f$	-0.002***	-0.000	-0.007***	-0.002***	-0.002***
	(0.000)	(0.001)	(0.002)	(0.000)	(0.000)
Oil^+	0.085	-0.223**	-0.140	-0.0916	0.053
	(0.067)	(0.103)	(0.117)	(0.087)	(0.039)
Oil^-	-0.301***	-0.543***	-0.397***	-0.498***	-0.302***
	(0.044)	(0.115)	(0.131)	(0.097)	(0.044)
SMB	0.012***	0.009***	0.006**	0.007***	0.011***
	(0.001)	(0.002)	(0.003)	(0.002)	(0.001)
HML	0.001*	0.003*	0.004**	0.000	-0.000
	(0.000)	(0.001)	(0.002)	(0.001)	(0.000)
WML	0.000	-0.003*	-0.002	-0.003**	0.001**
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
$R_m - R_f$	0.019***	0.014***	0.025***	0.022***	0.024***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.000)
Constant	-0.475***	-0.490***	-0.640***	-0.377***	-0.383***
	(0.042)	(0.053)	(0.080)	(0.029)	(0.018)
$\xi_{i,t-1}$	-0.775***	-0.813***	-0.817***	-0.671***	-0.678***
	(0.023)	(0.072)	(0.071)	(0.057)	(0.018)
Hausman test	16.59**	-1.40	2.35	3.89	2.09
P value χ_k	(0.010)	(-)	(0.885)	(0.691)	(0.836)
Observations	10,744	1,037	851	1,386	7,470
No. of firms	94	9	11	10	64

Note: ***, ** and * refer to significance at 1, 5 and 10% levels respectively, corresponding parenthesis contains standard errors. Panel A-all renewable energy firms; Panel B- standalone firms dealing in renewable energy products and services; Panel C- standalone firms dealing in renewable energy power generation, Panel D- firms dealing in both renewable and non-renewable energy power generation and Panel E-firms dealing in renewable energy business and other business activities.

CHAPTER 6

EVALUATING THE EFFECT OF STRUCTURAL OIL SHOCKS ON STOCK RETURNS OF INDIAN RENEWABLE ENERGY FIRMS ACROSS MARKET CONDITIONS

6.1 INTRODUCTION

Limited fossil fuel deposits and carbon emission concerns have led the world towards renewable energy. Renewable energy not only meets energy requirements but also helps in preventing climate change. Thus, renewable energy use in the world is increasing rapidly. Researchers find that the increase in renewable energy presence reduces the overall carbon emission to the environment (Qi et al., 2014; Squalli, 2017) and increases overall economic growth (Lyeonov et al., 2019). In the power sector, renewable energy will likely to increase its share from 15% to 85% by 2050 globally (EIA, 2019). Due to these developments, the literature has emerged to analyze the interaction of crude oil price with renewable energy stock price. In the global arena, the role of India is pivotal in the renewable energy sector. In the Renewable Energy Country Attractiveness Index, it holds 3rd position after the US and China (Warren and Giovanni, 2021). The growth of the renewable energy sector in India has been exponential at present. By 2030, India would emerge as the fourth largest renewable energy market in the world after China, the US and the European Union (IRENA, 2017). In this objective, the study investigates the response of Indian renewable energy firms' stock returns to oil shocks across market conditions.

The first argument on the oil and stock nexus is based on the discounted cash flow theory. Oil price hike inflates operating costs and this causes a decrease in the firms' earnings. As a result, the firms' stock prices fall (Kling, 1985; Jones and Kaul, 1996). Second, high oil prices cause inflation in the economy and the central bank increases the interest rate to combat inflation. Investors use this high-interest rate to discount stock price and stock prices fall as a response to the oil price increase. Third, in a booming economy, consumer demand and industrial production remain high. Here, oil prices increase due to the increase in the oil consumption by industries rather than a supply crunch and firms earn

profit due to high consumer demand. Thus, the price of crude oil has a direct interaction with stock market in a booming economy (Park and Ratti, 2008; Cong et al., 2008). The last argument focuses on how significant is the change in production cost due to the oil price movement. Insignificant change does not establish any relationship between oil price and stock price (Chen et al., 1986; Huang et al., 1996; Henriques and Sadorsky, 2008).

Kilian (2009) explains that the sources or reasons for oil price shocks are essential for understanding the effect of oil price shocks. This study untwines the shocks of oil price into three shocks such as oil supply driven shock, aggregate demand driven shock and oil price demand driven shock. These sources of oil shocks affect stock return with varied intensity (Kilian and Park, 2009 and Mokin 2020). Studies show the heterogenous effect of different oil shocks across countries (Cunado and Gracia, 2014; Bastianin et al., 2016 and Koh, 2017) and sectors (Degiannakis et al., 2013 and Das and Kannadhasan, 2020). In the renewable energy sector, the heterogeneous oil shock effect is observed on stock returns across quantiles and time horizons (Maghyereh and Abdoh, 2021; Zhang et al., 2020). Due to political pressure in India, oil marketing companies do not change oil prices in tandem with the changes in international oil prices. This objective derives the motivation from the above discussed literature, India's position in the global renewable energy sector and the oil pricing scenario in India.

Studies on the linkage between structural oil shocks and stock return in the renewable energy sector are based on sectoral or index level which consists of the top performing renewable energy companies in the world (Maghyereh and Abdoh, 2021 and Zhang et al., 2020). It is also known that the effect of oil shock is heterogenous across countries (Koh, 2017). Therefore, this objective is in the context of India and at the firm level. The Indian renewable energy firms are into different renewable energy business and also other business activities. Thus, instead of sub-sector basis classification, this study classifies them on their business dealings basis. The following sentences elaborate on the contributions of this study. First, this objective investigates the structural oil shocks effect on stock return of the renewable energy sector at firm level. Second, this type of study is the first in a developing country context, India. Third, the study investigates these effects

across market conditions using the panel quantile regression model along with the CAPM framework. The control variables are asset pricing factors are used in the model. The study finds the structural oil shocks' negative effect on stock return in most quantiles. The asymmetric effects of oil supply driven shock and oil price specific demand driven shock are seen in the study.

6.2 LITERATURE REVIEW

In the renewable energy sector, Zhang et al. (2020) and Maghyereh & Abdoh (2021) studied the role of structural oil shocks at various quantiles and time horizons. Their data set and methodologies were different. According to Zhang et al. (2020) oil supply shock affected stock return in the short and long run. In extreme quantiles, there was a positive impact of aggregate demand shock. Furthermore, oil price specific demand shock had an asymmetric interaction with stock returns in the long run. Maghyereh and Abdoh (2021) showed a bigger oil supply shock in the short term, as well as higher quantiles. Aggregate demand shock had a stronger relationship with stock return in normal market condition and the medium term. Oil specific demand shock effect was stronger than aggregate demand shock. The asymmetric effect of these shocks in higher quantiles was stronger. Zhao (2020) reported the reaction of stock return is heterogeneous to different oil specific shock during the COVID-19 pandemic time. This study observed the negative effect of oil specific shock and policy uncertainty shock negatively affect renewable energy stock return. In the case of demand and supply shocks, the effect is positive. Till now, the effect of structural oil shocks is not examined in the developing country context and at the firm level. This objective addresses these research gaps in this study.

6.3 DATA AND METHODOLOGY

6.3.1 Data

This objective uses the data on total global oil production from the U.S. Energy Information Administration (EIA) webpage for oil supply driven shock, the index of global real economic activity from the Federal Reserve Bank of Dallas webpage which is

calculated as per Kilian (2009) for aggregate demand driven shock and Indian Basket crude oil price from Petroleum Planning and Analysis Cell's web page, Ministry of Petroleum, the Government of India for oil price specific demand driven shock. Indian Basket crude oil price is derived from two international oil prices such as Brent oil price and Oman & Dubai oil price. To deflate oil price, the consumer price index as a proxy of inflation is used, which is available at the website of the Federal Reserve Bank of St. Louis.

6.3.2 Model specification

In this study, a two-stage approach is applied. First, this study generates three oil shocks by applying SVAR regression. Then, this study estimates the effect of these shocks on stock return across market conditions using panel quantile regression. The following is the specification for SVAR model.

$$B_0 y_t = \alpha \sum_{i=1}^{24} B_i(L) y_{t-i} + \varepsilon_t \quad (6.1)$$

Where y_t represents Δop_t , ea_t and Δcop_t . It is a vector (3×1) of three endogenous variables. Δop_t is the global oil production change in percentage and is computed as first difference of log total global production. ea_t is the percentage deviation in the global economic activity index. Δcop_t is the real oil price change in percentage and is computed as first difference of log real oil price. B_i denotes the autoregressive coefficients for $i = 1$ to lag 24 (as per Kilian, 2009, 24th lag estimation captures better dynamics of monthly data). ε_t is the serially and mutually uncorrelated matrix for all shocks, calculated as $e_t = B_0^{-1} \varepsilon_t$.

After imposing block recursive on B_0^{-1} , curtailed form innovation and structural shocks can be specified as follows.

$$e_t = \begin{pmatrix} e_t^{\Delta op_t} \\ e_t^{ea_t} \\ e_t^{\Delta cop_t} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} e_t^{ss} \\ e_t^{ds} \\ e_t^{sds} \end{pmatrix} \quad (6.2)$$

The above equation (6.2) shows three oil shocks such as supply, demand and oil specific demand shocks symbolically as e_t^{ss} , e_t^{ds} and e_t^{sds} , respectively. The OLS (ordinary least square) panel regression model to estimate the linkage between oil shocks and stock return can be framed as follows.

$$R_{it} = \alpha_i + \beta_1 ss_t + \beta_2 ds_t + \beta_3 sds_t + \bar{\varepsilon}_{it} \quad (6.3)$$

Where, $R_{i,t} = \ln \frac{P_{i,t}}{P_{i,t-1}}$ refers the monthly stock returns. ss_t , ds_t and sds_t refer oil supply driven shock, aggregate demand driven shock and oil price specific demand driven shock, respectively.

$$R_{it} - R_{ft} = \alpha_i + \beta_1 R_{mt} - R_{ft} + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 WML_t + \bar{\varepsilon}_{it} \quad (6.4)$$

Where, $R_i - R_f$ i.e., the excess stock returns of a renewable energy firm than the risk free interest rate. The Fama French (1993) proposed factors are considered to analyze at the firm level along with momentum factor of Carhart (1997). These factors are market ($R_m - R_f$ i.e. excess market return to risk free interest rate), size (SMB represents small minus big where size of the firm is the base), value (HML represents high minus low where book to market ratio value of the firm is the base) and momentum effect (WML represents winners minus losers where past performance of the firm is the base).

The following model is derived from equation 6.3 and 6.4 to estimate the effect of oil price shocks on stock returns of the renewable energy firms.

$$R_{it} - R_{ft} = \alpha_i + \beta_1 ss_t + \beta_2 ds_t + \beta_3 sds_t + \beta_4 R_{mt} - R_{ft} + \beta_5 SMB_t + \beta_6 HML_t + \beta_7 WML_t + \bar{\varepsilon}_{it} \quad (6.5)$$

The model specification for checking asymmetric effect of oil shocks is given bellow

$$R_{it} - R_{ft} = \alpha_i + \beta_1 ss_t^+ + \beta_2 ss_t^- + \beta_3 ds_t^+ + \beta_4 ds_t^- + \beta_5 sds_t^+ + \beta_6 sds_t^- + \beta_7 R_{mt} - R_{ft} + \beta_8 SMB_t + \beta_9 HML_t + \beta_{10} WML_t + \bar{\varepsilon}_{it} \quad (6.5)$$

Existing literature shows that stock return reacts heterogeneously to the structural oil shock across market condition (Das and Kannadhasan, 2020). So, panel quantile regression

with non-additive fixed effect model (Powell, 2022) is used for the analysis. This method addresses the problems of reverse causality and dynamic endogeneity factors and sample heterogeneity. The panel quantile regression model used for this objective is mentioned below.

$$R_{it} - R_{ft} = \sum_{j=1}^4 D'_{it} \beta_j(U_{it}^*) \quad (6.6)$$

Where, $R_{it} - R_{ft}$ is the excess stock returns of firms a time t . β is the parameter. D'_{it} is a set of independent variables in the regression such as structural oil shocks and asset pricing model factors. U_{it}^* is the error term. In general for the τ th quantile of $R_{it} - R_{ft}$, the quantile regression depends on the conditional restriction. The Markov Chain Monte Carlo (MCMC) optimization method is used in the above model. In this study, panel quantile estimation is done for the following quantiles 0.05, 0.10, 0.25, 0.50, 0.75, 0.90 and 0.95. Quantile 0.50 represents normal market condition. Lower quantiles (below 0.50 quantile) and upper quantiles (above 0.50 quantile) represent bearish and bullish market conditions, respectively. Q is used for the term quantile in this paper.

6.4 RESULTS AND ANALYSIS

Table 6.1 shows summary statistics of all three shocks which are estimated by applying SVAR. All three sources of oil shocks are more volatile than stock return. Therein, the interaction estimates between these variables may cause interest among the stakeholders. The results of skewness, kurtosis and Shapiro-Wilk tests show that the data don't follow a normal distribution. Thus, panel quantile regression model is suitable for this data set. Variables are proved to be stationary after rejecting the null hypothesis of non-stationarity in Im–Pesaran–Shin (2003) unit root test. Figure 6.1 shows that aggregate demand is more volatile till 2016 and oil price specific demand shock has been more volatile from 2016 to 2019. Oil supply shock follows a less volatile trend in comparison to other shocks. Figure 6.2 shows the impulse response of all shocks on aggregate demand, oil price and oil supply. Crude oil price specific demand driven shock negative influence exists on aggregate demand and oil supply. At the same time, oil supply positive influence exists on aggregate

demand and oil price in the early phase only. Aggregate demand driven shocks have the

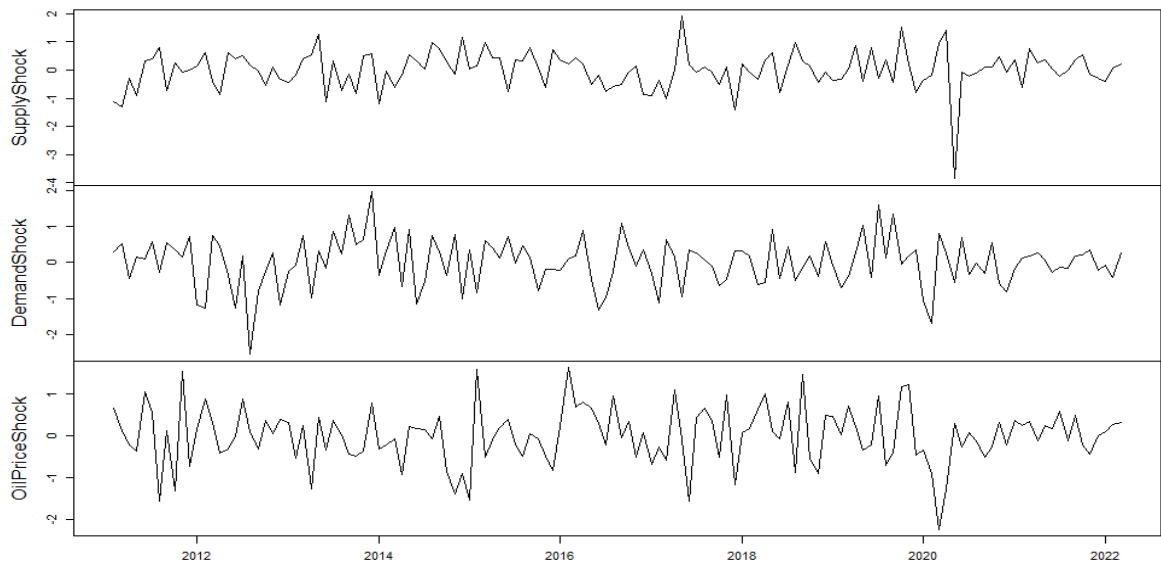


Figure 6.1 : Oil shocks' trend

weakest impact on oil price and oil supply. But, its impact on its own source i.e. aggregate demand is the strongest.

6.4.1 The structural oil shocks effect

Table 6.2 shows the estimations of oil shocks' effect on stock return across market scenarios. Figure 6.3 displays all these estimations graphically. Table 6.2 also displays panel regression with fixed effect estimation for reporting purpose. In panel A, there is no

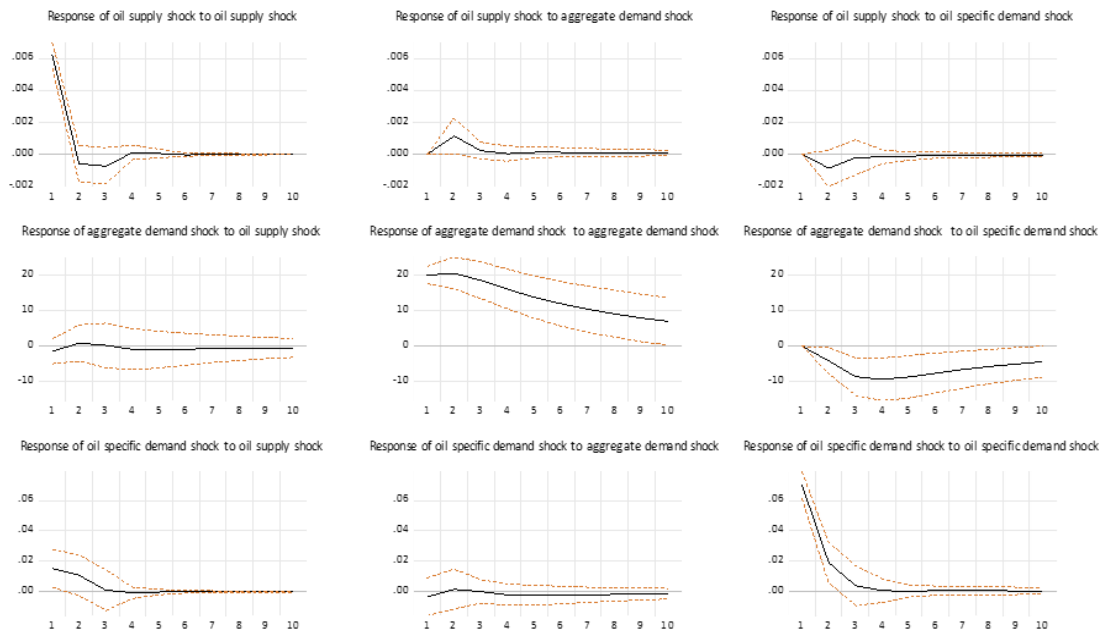
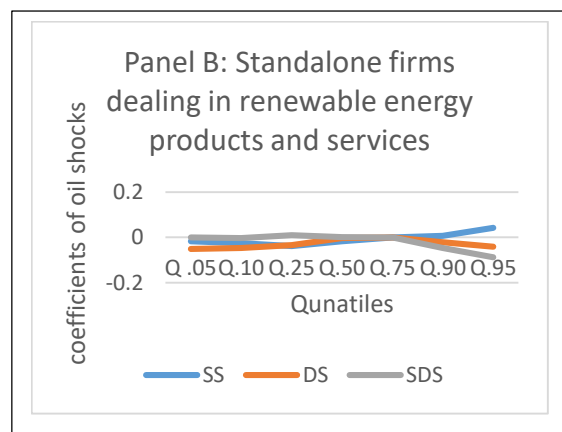
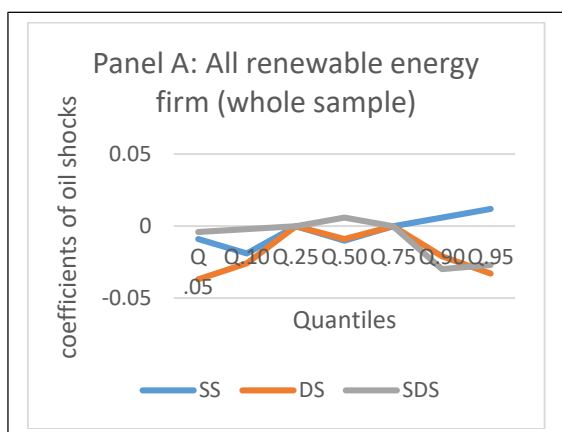


Figure 2: Response to Cholesky One S.D. (d.f adjusted) Innovations = 2 S.E.

Figure 6. 2: Impulse response

significant effect of oil shocks in $Q_{.25}$ and $Q_{7.5}$. Oil supply shocks negatively affect in extreme bullish market conditions ($Q_{.10}$ and $Q_{.25}$) and normal market (median quantile) condition stock return. But, it has positive coefficients in $Q_{.95}$. Oil demand shock coefficients are negative. Here, stock return reacts strongly to oil demand driven shocks than other shocks. Oil price specific demand shock has negative coefficients except for median quantile.



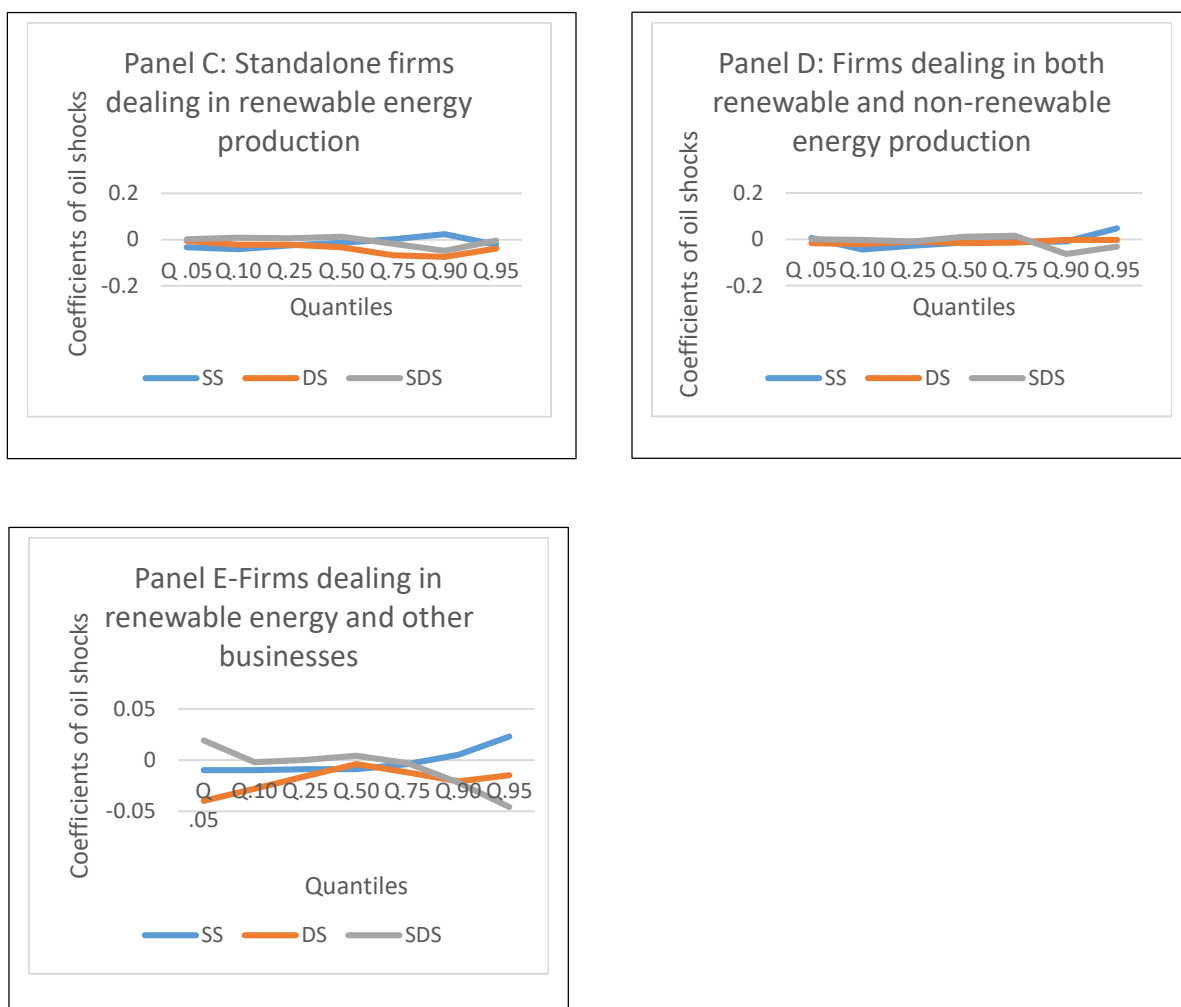


Figure 6.3: Structural oil shocks effect on stock returns of renewable energy firms
 All asset pricing factors have positive coefficients. Size and momentum factors have no significant coefficients in Q_{.25}.

In panel B, supply driven shock affects negatively in bearish market condition and normal market conditions. In extreme bullish market conditions (Q_{.90} and Q_{.95}), it has positive effect. Demand driven shock has negative coefficients. Oil demand driven shocks have negative coefficients except for Q_{.25}. Q_{.75} does not show any significant effect of oil shocks. All asset pricing factors have positive coefficients in most quantiles. Market and value factors have stronger coefficients.

In panel C, there is no significant coefficients in Q_{.05}. Supply shocks affect negatively stock return in bearish and normal market conditions. But it has positive coefficients in Q_{.75} and Q_{.90}. In Q_{.95}, supply shock has negative coefficients. In contrast, oil specific

demand shock has the positive coefficients in bearish market condition, negative coefficient in normal and bullish market conditions. Demand shock has negative coefficients across quantiles. All asset pricing factors have positive coefficients in most quantiles. Market and value factors have stronger coefficients.

In panel D, supply shock has positive quantiles in extreme conditions ($Q_{.05}$ and $Q_{.95}$). In remaining market conditions, it has negative coefficients. Demand shocks had negative coefficients in all market conditions. Oil specific demand shock has negative coefficients except $Q_{.50}$ and $Q_{.75}$. The market factors have the positive coefficients in all quantiles. Remaining factors also have positive coefficients with few exceptions.

In the last sub-group panel E, negative coefficients in most quantiles are found for aggregate demand shock. Supply driven shock coefficients are negative except in extreme bullish market condition ($Q_{.90}$ and $Q_{.95}$) where a positive interaction is found. Oil price specific demand driven shock has positive coefficients in $Q_{.05}$ and $Q_{.50}$ and negative coefficients in the remaining quantiles. All asset pricing factors have positive coefficients in most quantiles. The null hypothesis is that oil price shocks significantly affect renewable energy firms' stock returns. And, the alternative hypothesis is that oil price shocks have no significant effect on the stock return of renewable energy firms. The null hypothesis is rejected in most of the quintiles.

6.4.2 The oil shocks' asymmetric effect

The exogenous structural oil shocks changes are segregated into positive and negative changes to check the asymmetric effect. Table 6.3 exhibits the asymmetries of sources of oil shocks on Indian renewable energy firms' stock returns in different quantiles. It also displays panel regression (under ordinary least square assumption) with fixed effect estimation for reporting purpose. In panel A, this study sees the influence of the structural shocks on of the renewable energy firms' stock returns. Here, all firms are considered. Stock returns react asymmetrically to supply shocks in $Q_{.05}$, $Q_{.10}$ and $Q_{.75}$. Here asymmetries of aggregate demand driven shocks does not exist. The shocks emanating from oil price specific demand interact asymmetrically with stock returns in $Q_{.95}$ quantiles. Positive coefficients are seen for asset pricing factors in most quantiles.

In Panel B, oil supply shock affects asymmetrically in quantile $Q_{.05}$, $Q_{.10}$ and $Q_{.90}$. Aggregate demand driven shock does not affect stock return asymmetrically. Positive and negative changes in aggregate demand shock have negative and positive coefficients, respectively. Oil price specific demand shock interacts asymmetrically in normal (median quantile) and bullish market conditions (upper quantile). Positive coefficients are seen for asset pricing factors in most quantiles.

Panel C displays the estimation for standalone renewable energy production firms. Oil supply shock strike stock return asymmetrically in extreme market conditions (both bullish and bearish). Therein, supply shock changes affect negatively and positively in bearish and bullish markets, respectively. In the case of aggregate demand shock, the asymmetric effect is not seen. Aggregate demand shock has negative and positive correlation for positive and negative changes, respectively. The oil specific demand driven shock asymmetric effect exists only in $Q_{.95}$. But, the heterogeneous impact of oil specific demand driven shock is seen across quantiles. Positive coefficients for market, size and volume factors are seen in most quantiles. The momentum factor effect is positive except for the extreme bullish market conditions.

In the case of renewable and non-renewable energy production firms (Panel D), the asymmetric effect of supply driven shock is seen in bearish market condition ($Q_{.10}$ and $Q_{.25}$). Demand and oil specific demand shocks do not show asymmetries. Market and volume factors have positive coefficients. In contradiction, size and momentum factors have a mix of positive and negative coefficients.

In the last panel E, the oil supply driven shock asymmetric effect is seen in most quantiles except $Q_{.10}$ and $Q_{.75}$. On the other hand, the asymmetries of shocks emanating from economic demand are not seen in this panel. Oil price specific demand shock affects stock return asymmetrically only in $Q_{.25}$. In most quantiles, positive coefficients are observed for all asset pricing factors. The null hypothesis is that oil price shocks have a symmetric effect on stock returns of renewable energy firms. The alternative hypothesis is that oil price shocks have an asymmetric effect on stock return of renewable energy firms. In the whole sample, the null hypothesis is rejected in few quantiles or market conditions

for oil supply shock. In standalone renewable energy firms' stock returns, the null hypothesis is rejected for oil shocks in most quantiles.

6.5 SUMMARY

This objective investigates the oil shocks effect on stock returns of the Indian renewable energy firms. This study uses SVAR model to disentangle oil shocks on the basis of three sources such as: oil supply, economic demand and demand specific to oil price. Then, this study applies panel quantile regression to estimate the effect of these shocks across market conditions. In the whole sample analysis, the negative effects of oil shock sources on stock returns are seen in most market conditions except oil supply shock. In sub-groups, oil shocks negatively affect stock returns in most market conditions. The positive interaction of oil price specific shock conditions and oil supply shock in a few quantiles. In standalone renewable energy production firms, the positive interaction of oil price specific shock in bullish market conditions and oil supply shock in bearish market conditions are seen. In the whole sample, the asymmetric effects of shocks arising from oil supply and oil-specific demand are seen in few quantiles or market conditions. In contrast, demand shock does not affect asymmetrically. In the sub-group analysis, standalone renewable energy firms' stock returns are most asymmetrically affected by these shocks. The oil supply shock asymmetric effect is found in the majority of these asymmetries.

This is the first study at the firm level that looks at the oil shocks and renewable energy stock returns interactions across market scenarios. Most of the existing studies on the renewable energy sector are at the sectoral level, but this objective focuses at the firm level and in India context. In these ways, this objective contributes towards energy finance literature. These results give a better understanding to different stakeholders on how stock returns of the renewable energy firms responds to different shocks of oil price. Policymakers would be able to change the policies as per structural oil shocks' movement to maintain bullish stock return trends and stimulate growth in the renewable energy sector. The outcome of this objective will be useful to investors and portfolio managers to

maximize the return with the appropriate strategy as per the movements in different oil price shocks.

Table 6.1: Summary statistics

Variables	Stock return	Supply Shock	Demand Shock	Oil Specific Demand Shock
Min	-3.777	-1.244	-1.382	-1.363
Max	2.605	1.443	1.152	1.505
Mean	0	0	0	0
SD	0.156	0.566	0.566	0.566
Variance	0.024	0.320	0.320	0.320
Skewness	-0.23	0.230	-0.102	0.111
Kurtosis	51.72	-0.389	-0.418	0.026
SW Test	0.205	0.110	-0.480	-1.131

S-W: Shapiro-Wilk test with Z-statistics. *** indicates significance at the 1% level

Table 6.2. Estimation of oil price shocks effect on stock returns of renewable firms in India using panel quantile regression

Panel A: QRPD analysis on firms dealing in renewable energy business (whole sample)								
Quantiles	0.05	0.10	0.25	0.50	0.75	0.90	0.95	OLS
Variables								
SS	-0.009*** (0.000)	-0.019*** (0.000)	0.066 (0.0766)	-0.010*** (0.000)	0.026 (0.0554)	0.006*** (0.000)	0.012*** (0.000)	0.015 (0.085)
DS	-0.037*** (0.000)	-0.026*** (0.000)	0.001 (0.019)	-0.009*** (0.000)	-0.044 (0.037)	-0.021*** (0.000)	-0.033*** (0.000)	-0.025 (0.0873)

SDS	-0.004*** (0.000)	-0.002*** (0.000)	-0.120 (0.113)	0.006*** (0.000)	-0.014 (0.010)	-0.030*** (0.000)	-0.027*** (0.000)	0.076 (0.086)
$R_m - R_f$	0.0129*** (0.000)	0.0128*** (0.000)	0.0110*** (0.002)	0.0157*** (0.000)	0.0136*** (0.004)	0.018*** (0.000)	0.0152*** (0.000)	0.0232 (0.016)
SMB	0.004*** (0.000)	0.003*** (0.000)	-0.016 (0.018)	0.001*** (0.000)	0.006* (0.003)	0.004*** (0.000)	0.007*** (0.000)	0.010 (0.015)
HML	0.009*** (0.000)	0.009*** (0.000)	0.015** (0.006)	0.009*** (0.000)	0.015*** (0.002)	0.010*** (0.000)	0.014*** (0.000)	0.042*** (0.014)
WML	0.0031*** (0.000)	0.003*** (0.000)	0.028 (0.024)	0.000*** (0.000)	0.004*** (0.001)	0.003*** (0.000)	0.003*** (0.000)	0.029** (0.013)
Observations	11,573	11,573	11,573	11,573	11,573	11,573	11,573	11,573
No. of firms	94	94	94	94	94	94	94	94

Panel B: QRPD analysis on standalone renewable energy products and services firms

Quantiles	0.05	0.10	0.25	0.50	0.75	0.90	0.95	OLS
Variables								
SS	-0.017*** (0.000)	-0.026*** (0.000)	-0.0391*** (0.000)	-0.0181*** (0.000)	0.00476 (0)	0.00794*** (0.000)	0.0420*** (0.000)	-0.00994 (0.009)
DS	-0.051*** (0.000)	-0.047*** (0.000)	-0.0356*** (0.000)	-0.003*** (0.000)	-0.027 (0)	-0.022*** (0.000)	-0.041*** (0.000)	-0.013 (0.010)
SDS	0.000*** (0.000)	-0.003*** (0.000)	0.00968*** (0.000)	0.00119*** (0.000)	-0.0474 (0)	-0.0476*** (0.000)	-0.0885*** (0.000)	-0.00884 (0.0100)
$R_m - R_f$	0.009*** (0.000)	0.010*** (0.000)	0.010*** (0.000)	0.015*** (0.000)	0.016 (0)	0.014*** (0.000)	0.008*** (0.000)	0.013*** (0.000)
SMB	0.001*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.000*** (0.000)	0.005 (0)	0.004*** (0.000)	0.012*** (0.000)	0.006*** (0.001)
HML	0.011*** (0.000)	0.013*** (0.000)	0.014*** (0.000)	0.009*** (0.000)	0.013 (0)	0.013*** (0.000)	0.016*** (0.000)	0.012*** (0.001)
WML	0.002*** (0.000)	0.005*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	-0.001 (0)	0.000*** (0.000)	0.000*** (0.000)	0.002 (0.001)

Observations	1,123	1,123	1,123	1,123	1,123	1,123	1,123	1,123
No. of firms	9	9	9	9	9	9	9	9

Panel C: QRPD analysis on standalone renewable energy production firms

Quantiles	0.05	0.10	0.25	0.50	0.75	0.90	0.95	OLS
Variables								
SS	-0.033 (0)	-0.042*** (0.000)	-0.025*** (0.000)	-0.014*** (0.000)	0.002*** (0.000)	0.024*** (0.000)	-0.022*** (0.000)	-0.036*** (0.000)
DS	-0.005 (0)	-0.022*** (0.000)	-0.022*** (0.000)	-0.033*** (0.000)	-0.068*** (0.000)	-0.074*** (0.000)	-0.038*** (0.000)	-0.004*** (0.000)
SDS	0.001 (0)	0.008*** (0.000)	0.005*** (0.000)	0.013*** (0.000)	-0.018*** (0.000)	-0.048*** (0.000)	-0.004*** (0.000)	-0.019*** (0.000)
R _m - R _f	0.018 (0)	0.017*** (0.000)	0.015*** (0.000)	0.015*** (0.000)	0.019*** (0.000)	0.018*** (0.000)	0.0147*** (0.000)	0.020*** (0.000)
SMB	0.000 (0)	0.003*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.008*** (0.000)	0.012*** (0.000)	0.019*** (0.000)	0.002*** (0.000)
HML	0.017 (0)	0.016*** (0.000)	0.013*** (0.000)	0.014*** (0.000)	0.011*** (0.000)	0.019*** (0.000)	0.042*** (0.000)	0.0182*** (0.000)
WML	0.006 (0)	0.003*** (0.000)	0.003*** (0.000)	0.001*** (0.000)	0.002*** (0.000)	0.014*** (0.000)	0.020*** (0.000)	0.006*** (0.000)
Observations	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031
No. of firms	10	10	10	10	10	10	10	10

Panel D: QRPD analysis on renewable and non-renewable energy production firms

Quantiles	0.05	0.10	0.25	0.50	0.75	0.90	0.95	OLS
Variables								
SS	0.006*** (0.000)	-0.044*** (0.000)	-0.027*** (0.000)	-0.014*** (0.000)	-0.012*** (0.000)	-0.009*** (0.000)	0.047*** (0.000)	-0.008 (0.008)
DS	-0.016*** (0.000)	-0.020*** (0.000)	-0.010*** (0.000)	-0.016*** (0.000)	-0.013*** (0.000)	-0.002*** (0.000)	-0.003*** (0.000)	-0.018** (0.008)

SDS	0.001*** (0.000)	-0.003*** (0.000)	-0.009*** (0.000)	0.011*** (0.000)	0.015*** (0.000)	-0.063*** (0.000)	-0.032*** (0.000)	0.008 (0.008)
R _m -R _f	0.006*** (0.000)	0.018*** (0.000)	0.013*** (0.000)	0.014*** (0.000)	0.019*** (0.000)	0.017*** (0.000)	0.016*** (0.000)	0.015*** (0.001)
SMB	0.000*** (0.000)	0.004*** (0.000)	-0.001*** (0.000)	-0.002*** (0.000)	0.000*** (0.000)	0.006*** (0.000)	0.009*** (0.000)	0.001 (0.001)
HML	0.012*** (0.000)	0.014*** (0.000)	0.010*** (0.000)	0.012*** (0.000)	0.012*** (0.000)	0.011*** (0.000)	0.014*** (0.000)	0.012*** (0.001)
WML	-0.002*** (0.000)	0.006*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.003*** (0.000)	0.001*** (0.000)	0.002*** (0.000)	0.001 (0.001)
Observations	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474
No. of firms	11	11	11	11	11	11	11	11

Panel E : QRPD analysis on firms dealing renewable energy and other business activity

Quantiles	0.05	0.10	0.25	0.50	0.75	0.90	0.95	OLS
Variables								
SS	-0.010*** (0.000)	-0.010*** (0.000)	-0.009*** (0.000)	-0.009*** (0.000)	-0.004*** (0.000)	0.005*** (0.000)	0.023*** (0.000)	0.026 (0.124)
DS	-0.040*** (0.000)	-0.028*** (0.000)	-0.016*** (0.000)	-0.004*** (0.000)	-0.012*** (0.000)	-0.021*** (0.000)	-0.015*** (0.000)	-0.026 (0.127)
SDS	0.019*** (0.000)	-0.002*** (0.000)	0.000*** (0.000)	0.004*** (0.000)	-0.003*** (0.000)	-0.022*** (0.000)	-0.046*** (0.000)	0.111 (0.125)
R _m -R _f	0.0118*** (0.000)	0.013*** (0.000)	0.013*** (0.000)	0.016*** (0.000)	0.020*** (0.000)	0.017*** (0.000)	0.015*** (0.000)	0.0266 (0.0234)
SMB	0.004*** (0.000)	0.003*** (0.000)	0.003*** (0.000)	0.001*** (0.000)	0.002*** (0.000)	0.004*** (0.000)	0.006*** (0.000)	0.0134 (0.022)
HML	0.008*** (0.000)	0.007*** (0.000)	0.007*** (0.000)	0.008*** (0.000)	0.009*** (0.000)	0.011*** (0.000)	0.014*** (0.000)	0.055*** (0.020)
WML	0.000*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.001*** (0.000)	0.004*** (0.000)	0.003*** (0.000)	0.005*** (0.000)	0.042** (0.019)

Observations	7,945	7,945	7,945	7,945	7,945	7,945	7,945	7,945
No. of firms	64	64	64	64	64	64	64	64

Note: Statistical level significance at 1, 5 and 10% are represented by ***, ** and * respectively. Adjacent parentheses contain standard errors. Panel A- all renewable energy firms; Panel B- standalone firms dealing in renewable energy products and services; Panel C- standalone firms dealing in renewable energy power generation, Panel D- firms dealing in both renewable and non-renewable energy power generation and Panel E-firms in renewable energy business and other business activities.

Table 6.3. Estimation of oil price shock asymmetry on stock returns of renewable firms in India using panel quantile regression

Panel A: QRPD analysis on firms dealing in renewable energy business (whole sample)								
Quantiles	0.05	0.10	0.25	0.50	0.75	0.90	0.95	OLS
Variables								
SS ⁺	-0.013*** (0.000)	-0.014*** (0.000)	-0.022*** (0.000)	-0.030*** (0.000)	-0.025*** (0.000)	-0.016*** (0.000)	-0.033*** (0.000)	-0.235 (0.179)
SS ⁻	-0.014*** (0.000)	-0.008*** (0.000)	0.004*** (0.000)	0.018*** (0.000)	-0.001*** (0.000)	0.005*** (0.000)	0.022*** (0.000)	0.254* (0.137)
DS ⁺	-0.144*** (0.000)	-0.145*** (0.000)	-0.133*** (0.000)	-0.112*** (0.000)	-0.122*** (0.000)	-0.122*** (0.000)	-0.143*** (0.000)	-0.521*** (0.175)
DS ⁻	0.041*** (0.000)	0.049*** (0.000)	0.056*** (0.000)	0.072*** (0.000)	0.086*** (0.000)	0.080*** (0.000)	0.085*** (0.000)	0.411*** (0.155)
SDS ⁺	0.035*** (0.000)	0.019*** (0.000)	-0.003** (0.000)	-0.021*** (0.000)	-0.041*** (0.000)	-0.065*** (0.000)	-0.082*** (0.000)	-0.337* (0.176)
SDS ⁻	-0.031*** (0.000)	-0.013*** (0.000)	0.015*** (0.000)	0.038*** (0.000)	0.016*** (0.000)	0.003*** (0.000)	-0.016*** (0.000)	0.353** (0.161)
R _m -R _f	0.017*** (0.000)	0.014*** (0.000)	0.014*** (0.000)	0.017*** (0.000)	0.017*** (0.000)	0.014*** (0.000)	0.013*** (0.000)	0.023 (0.000)
SMB	0.003***	0.005***	0.003***	0.002***	0.002***	0.003***	0.005***	0.001

	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.015)
HML	0.008***	0.009***	0.009***	0.008***	0.009***	0.011***	0.014***	0.039***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.014)
WML	0.001***	0.002***	0.001***	0.002***	0.002***	0.003***	0.006***	0.031**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.013)
Observations	11,573	11,573	11,573	11,573	11,573	11,573	11,573	11,573
No. of firms	94	94	94	94	94	94	94	94

Panel B: QRPD analysis on standalone renewable energy products and services firms

Quantiles	0.05	0.10	0.25	0.50	0.75	0.90	0.95	OLS
Variables								
SS ⁺	0.008***	-0.021***	-0.061***	-0.023***	-0.008***	-0.009***	-0.033***	-0.031
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.020)
SS ⁻	0.031***	-0.001***	0.017***	0.018***	0.001***	-0.014***	0.001***	0.004
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.015)
DS ⁺	-0.149***	-0.155***	-0.129***	-0.134***	-0.153***	-0.146***	-0.207***	-0.145***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.019)
DS ⁻	0.062***	0.031***	0.064***	0.078***	0.114***	0.091***	0.152***	0.097***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.017)
SDS ⁺	0.029***	0.030***	0.010***	-0.001***	-0.004***	-0.092***	-0.063***	-0.012
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.019)
SDS ⁻	-0.066***	-0.032***	-0.013***	-0.001***	-0.048***	-0.036***	-0.061***	-0.022
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.018)
R _m -R _f	0.017***	0.015***	0.013***	0.015***	0.017***	0.012***	0.007***	0.014***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
SMB	0.000***	0.002***	0.004***	0.001***	0.003***	0.003***	0.012***	0.006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
HML	0.011***	0.012***	0.011***	0.009***	0.011***	0.012***	0.018***	0.011***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
WML	0.001***	0.004***	0.002***	0.000***	0.001***	0.000***	0.009***	0.001

	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Observations	1,123	1,123	1,123	1,123	1,123	1,123	1,123	1,123
No. of firms	9	9	9	9	9	9	9	9

Panel C: QRPD analysis on standalone renewable energy production firms

Quantiles	0.05	0.10	0.25	0.50	0.75	0.90	0.95	OLS
Variables								
SS ⁺	-0.033*** (0.000)	-0.023*** (0.000)	-0.039*** (0.000)	-0.015*** (0.000)	0.024*** (0.000)	0.003*** (0.000)	0.023*** (0.000)	-0.022 (0.024)
SS ⁻	-0.014*** (0.000)	-0.038*** (0.000)	-0.008*** (0.000)	0.009*** (0.000)	-0.011*** (0.000)	0.020*** (0.000)	0.084*** (0.000)	0.017 (0.018)
DS ⁺	-0.195*** (0.000)	-0.145*** (0.000)	-0.144*** (0.000)	-0.139*** (0.000)	-0.153*** (0.000)	-0.231*** (0.000)	-0.437*** (0.001)	-0.171*** (0.024)
DS ⁻	0.061*** (0.000)	0.045*** (0.000)	0.070*** (0.000)	0.080*** (0.000)	0.068*** (0.000)	0.064*** (0.000)	0.190*** (0.000)	0.075*** (0.022)
SDS ⁺	0.032*** (0.000)	0.018*** (0.000)	-0.008*** (0.000)	-0.019*** (0.000)	-0.031*** (0.000)	-0.082*** (0.000)	-0.113*** (0.000)	-0.044* (0.024)
SDS ⁻	0.008*** (0.000)	0.007*** (0.000)	0.005*** (0.000)	0.017*** (0.000)	-0.013*** (0.000)	-0.006*** (0.000)	0.000*** (0.000)	0.025 (0.022)
R _m -R _f	0.022*** (0.000)	0.019*** (0.000)	0.017*** (0.000)	0.017*** (0.000)	0.018*** (0.000)	0.012*** (0.000)	0.024*** (0.000)	0.017*** (0.002)
SMB	0.000*** (0.000)	0.004*** (0.000)	0.003*** (0.000)	0.005*** (0.000)	0.006*** (0.000)	0.010*** (0.000)	0.006*** (0.000)	0.007*** (0.002)
HML	0.015*** (0.000)	0.015*** (0.000)	0.011*** (0.000)	0.011*** (0.000)	0.009*** (0.000)	0.022*** (0.000)	0.033*** (0.000)	0.015*** (0.001)
WML	0.005*** (0.000)	0.003*** (0.000)	0.001*** (0.000)	0.002*** (0.000)	0.000*** (0.000)	0.010*** (0.000)	0.027*** (0.000)	0.004** (0.001)

Observations	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031
No. of firms	10	10	10	10	10	10	10	10
Panel D: QRPD analysis on renewable and non-renewable energy production firms								
Quantiles	0.05	0.10	0.25	0.50	0.75	0.90	0.95	OLS
Variables								
SS ⁺	-0.018*** (0.000)	-0.021*** (0.000)	-0.026*** (0.000)	-0.041*** (0.000)	-0.037*** (0.000)	-0.027*** (0.000)	-0.040*** (0.001)	-0.043** (0.017)
SS ⁻	0.000*** (0.000)	-0.022*** (0.000)	-0.011*** (0.000)	0.033*** (0.000)	0.000*** (0.000)	0.003*** (0.000)	0.004*** (0.001)	0.0203 (0.013)
DS ⁺	-0.134*** (0.000)	-0.096*** (0.000)	-0.133*** (0.000)	-0.135*** (0.000)	-0.163*** (0.000)	-0.155*** (0.000)	-0.315*** (0.001)	-0.151*** (0.017)
DS ⁻	0.069*** (0.000)	0.045*** (0.000)	0.061*** (0.000)	0.082*** (0.000)	0.115*** (0.000)	0.123*** (0.000)	0.219*** (0.000)	0.094*** (0.015)
SDS ⁺	0.076*** (0.000)	0.058*** (0.000)	0.010*** (0.000)	-0.040*** (0.000)	-0.040*** (0.000)	-0.064*** (0.000)	0.010*** (0.001)	-0.019 (0.017)
SDS ⁻	-0.058*** (0.000)	-0.041*** (0.000)	-0.007*** (0.000)	0.040*** (0.000)	0.041*** (0.000)	0.031*** (0.000)	-0.005*** (0.000)	0.016 (0.015)
R _m -R _f	0.017*** (0.000)	0.014*** (0.000)	0.015*** (0.000)	0.017*** (0.000)	0.019*** (0.000)	0.011*** (0.000)	0.018*** (0.000)	0.016*** (0.001)
SMB	0.001*** (0.000)	0.001*** (0.000)	0.000*** (0.000)	-0.001*** (0.000)	-0.000*** (0.000)	0.001*** (0.000)	0.004*** (0.000)	0.001 (0.001)
HML	0.008*** (0.000)	0.010*** (0.000)	0.010*** (0.000)	0.009*** (0.000)	0.008*** (0.000)	0.010*** (0.000)	0.012*** (0.000)	0.011*** (0.001)
WML	-0.001*** (0.000)	0.000*** (0.000)	-0.001*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.002*** (0.000)	0.007*** (0.000)	0.001 (0.001)
Observations	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474
No. of firms	11	11	11	11	11	11	11	11
Panel E : QRPD analysis on firms dealing in renewable energy and other business activity								
Quantiles	0.05	0.10	0.25	0.50	0.75	0.90	0.95	OLS

Variables								
SS ⁺	-0.019*** (0.000)	-0.013*** (0.000)	-0.020*** (0.000)	-0.023*** (0.000)	-0.025*** (0.000)	-0.031*** (0.000)	-0.069*** (0.000)	-0.327 (0.260)
SS ⁻	0.007*** (0.000)	-0.002*** (0.000)	0.004*** (0.000)	0.010*** (0.000)	-0.003*** (0.000)	0.017*** (0.000)	0.022*** (0.000)	0.366* (0.199)
DS ⁺	-0.140*** (0.000)	-0.153*** (0.000)	-0.119*** (0.000)	-0.115*** (0.000)	-0.121*** (0.000)	-0.122*** (0.000)	-0.160*** (0.000)	-0.693*** (0.255)
DS ⁻	0.031*** (0.000)	0.048*** (0.000)	0.041*** (0.000)	0.078*** (0.000)	0.079*** (0.000)	0.083*** (0.000)	0.077*** (0.000)	0.561** (0.226)
SDS ⁺	0.020*** (0.000)	0.007*** (0.000)	0.006*** (0.000)	-0.026*** (0.000)	-0.040*** (0.000)	-0.051*** (0.000)	-0.076*** (0.000)	-0.483* (0.255)
SDS ⁻	-0.023*** (0.000)	-0.008*** (0.000)	0.019*** (0.000)	0.039*** (0.000)	0.020*** (0.000)	0.008*** (0.000)	0.010*** (0.000)	0.516** (0.235)
R _m - R _f	0.015*** (0.000)	0.014*** (0.000)	0.014*** (0.000)	0.017*** (0.000)	0.017*** (0.000)	0.016*** (0.000)	0.013*** (0.000)	0.026 (0.023)
SMB	0.003*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.001*** (0.000)	0.002*** (0.000)	0.000 (0.022)
HML	0.006*** (0.000)	0.008*** (0.000)	0.009*** (0.000)	0.007*** (0.000)	0.009*** (0.000)	0.011*** (0.000)	0.013*** (0.000)	0.051** (0.021)
WML	0.000*** (0.000)	0.001*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.004*** (0.000)	0.003*** (0.000)	0.007*** (0.000)	0.044** (0.019)

Observations	7,945	7,945	7,945	7,945	7,945	7,945	7,945	7,945
No. of firms	64	64	64	64	64	64	64	64

Note: Statistical level significance at 1, 5 and 10% are represented by ***, ** and * respectively. Adjacent parentheses contain standard errors. Panel A- all renewable energy firms; Panel B- standalone firms dealing in renewable energy products and services; Panel C- standalone firms dealing in renewable energy power generation, Panel D- firms dealing in both renewable and non-renewable energy power generation and Panel E-firms in renewable energy business and other business activities.

CHAPTER 7

CONCLUSION

7.1 INTRODUCTION

The energy requirement of developing countries is immense to catch up with the standard of living of developed countries. However, the Covid-19 pandemic and Ukraine-Russia crisis brought a slowdown in global economic growth. Thus, world is looking at developing countries as there is a stagnation of economic growth in developed countries. To ensure good economic growth, industries need vast amounts of energy to increase industrial production. Crude oil is a major source of energy. Crude fuel deposit is limited and its price is also uncertain. In addition to this, there is a growing awareness of climate change issues. Thus, there is a lot of effort to shift energy dependency on renewable energy sources globally. In this direction, governments are funding and making policies favoring renewable energy efficient economy. The renewable energy share is increasing the total energy consumption. Substantial growth in renewable energy generation is seen in India which is going to be one of the largest renewable energy producer in the world (IRENA 2023). Like other sectors, the renewable energy sector's stock return reaction to crude oil price is studied, which is growing due to the increasing importance of the renewable energy sector. But, these studies are lacking at firm level and in the context of India. The present study addresses this research gap.

The researchers find that oil price impacts stock return (Jones and Kaul, 1996; Sadorsky, 1999). The oil price effect on stock return varies across sectors (Nandha and Faff, 2008; Elyasiani et al., 2011; Phan et al., 2015), countries (Ramos and Veiga, 2013; Sadeghi and Roudari, 2022) and firms (Narayan and Sharma, 2011; Zhu et al., 2019). The interaction between oil price and stock return varies over time also (Alqahtani et al., 2019; Caporale et al., 2015). The renewable energy sector is an alternative to crude oil. Thus, the oil price change has a positive effect on stock return (Managi and Okimoto, 2013; Dutta, 2017; Pham, 2020 and Dawar et al., 2021). In certain studies, this effect is weaker (Zhu et

al., 2019). The oil volatility index has a stronger effect on renewable energy stock return than the realized volatility (Dutta, 2017). And structural oil shocks have a heterogeneous effect across time and market conditions (Zhang et al., 2020 and Maghyereh & Abdoh, 2021).

This study aims to explore Indian renewable energy firms' stock return reaction to oil price changes. Firms listed in the National Stock Exchange of India are considered in the study. The renewable energy sector or industry can be divided into sub-sectors such as solar, wind, etc. But, most Indian renewable energy firms deal in different business activities. Thus, all renewable energy firms are categorized into four sub-group, such as firms dealing in renewable energy products and services, standalone firms dealing in renewable energy production, firms dealing in both renewable and non-renewable energy production, firms dealing in renewable energy and other businesses. For crude oil price, the Indian basket oil price is considered. There are four objectives of this study. The first objective examines the effect of oil price change on stock return of renewable energy firms across different market conditions using panel quantile regression model. The second objective estimates the oil price uncertainty effect on stock returns of renewable energy firms across different market conditions by applying panel quantile regression. The third objective evaluates the oil price asymmetric effect on stock returns of renewable energy firms in different time horizons using panel NARDL model. The fourth objective evaluates the structural oil shock effect on stock returns of renewable energy firms across market conditions using panel quantile structural VAR.

7.2 FINDINGS OF THE STUDY

Existing studies find that the oil price effect on stock returns across sectors, countries and firms. And in the renewable energy sector, oil price affects stock return positively. The first objective evaluates the effect on stock returns of renewable energy Indian firms under different market conditions using panel quantile regression. In the whole sample of Indian renewable energy firms, the effect of oil price change has a direct relationship with stock

returns in extreme market conditions. In the sub-groups of renewable energy firms, the direct effect of oil price is observed, which is stronger in the bearish market conditions.

Oil price uncertainty affects industrial and economic growth. Similarly, oil price uncertainty affects stock return across countries, sectors and firms. In the renewable energy sector, the oil price volatility Index has a stronger effect on stock return than the realized volatility. The second objective estimates the oil price uncertainty (the oil price volatility Index) effect on stock returns of Indian renewable energy firms under different market conditions using panel quantile regression. Oil price uncertainty has an indirect effect in bearish market conditions and a direct effect in extreme bullish market conditions. In the sub-groups, oil price uncertainty has an indirect effect in bearish market conditions and a direct effect during normal and bullish market conditions on stock returns of standalone renewable energy firms. In the remaining subgroups, the relationship between two variables is negative in most quantiles. No asymmetric effect of oil price uncertainty on stock return is observed.

Researchers find that the effect of oil price on stock return is asymmetric. This means if an increase in oil prices depresses stock return, a decrease in oil price also depresses stock return instead of an increase in stock return. The asymmetries of price are heterogeneous across countries, industries and firms. The third objective evaluates the oil price asymmetric effect on stock returns of renewable energy firms in different time horizons using the panel NARDL model. The oil price asymmetric effect is not seen in the short run. In the long run, the asymmetric effect is found in firms dealing in both renewable and non-renewable energy production.

The cause or sources of oil price change are oil supply shock, demand shock and oil price specific demand shock. Researchers find the heterogeneous effects of oil shock across countries, sectors and firms. In the renewable energy sector, structural oil shocks have a heterogeneous effect across time horizons and market conditions. The fourth objective measures the structural oil shocks effect on stock returns of Indian renewable energy firms under different market conditions using panel quantile structural VAR. In the whole sample of renewable energy firms, oil supply shock has a direct relationship with stock return only

in extreme bullish market conditions. This pattern is seen in the sub-group of firms. In normal market condition, demand specific to oil price shock has a direct effect on stock return. This interaction is seen in bearish market conditions also. In the case of standalone renewable energy firms, this relationship has a strong presence. In the remaining subgroups, the positive interaction of oil price specific shock conditions and oil supply shock in a few lower quantiles. In standalone renewable energy production firms, there is a positive coefficient of oil price specific shock in bullish market conditions and oil supply shock in bearish market conditions. In the whole sample, the asymmetric effects of oil supply and oil-specific demand shocks are seen in few quantiles or market conditions. In contrast, demand shock does not affect stock return asymmetrically. In the sub-group analysis, standalone renewable energy firms' stock returns are most asymmetrically affected by these shocks. The oil supply shock asymmetric effect is found in the majority of these asymmetries.

7.3 CONTRIBUTION TO THE BODY OF KNOWLEDGE

This study's contribution to the body of knowledge on the oil price and stock return interaction in the renewable energy sector are explained as per different objectives in the following sentences. The first objective estimates the oil price effect on stock returns of renewable energy Indian firms under different market conditions. This objective contribution is at a firm level and under different market conditions. The second objective estimates the oil price uncertainty effect on stock returns of renewable energy Indian firms under different market conditions. Existing studies on the impact of oil price volatility on renewable energy stock returns have been conducted using aggregate stock or index returns and time series models with the ordinary least square assumption. This objective analyzes firm level data to investigate the effect of crude oil price volatility across market conditions using panel quantile regression. This is the first study to delve into the oil-renewable energy stock nexus in India. This is also the first study at firm level in the renewable energy sector. In the renewable energy sector, the existing studies on oil price asymmetries are on aggregate stock level and concentrated more in developed countries. The third objective

evaluates the oil price asymmetric effect on stock returns of renewable energy firms in the short and long run. This objective investigates the asymmetric effect of oil price in the context of India and at the firm level at different time horizons at the firm level. The fourth objective measures the structural oil shocks effect on stock returns of renewable energy Indian firms under different market conditions. This objective is the first study at the firm level that looks at the oil shocks and renewable energy stock returns interactions across market scenarios. Studies on the renewable energy sector are at the sectoral level in most of the existing, but this objective focuses on the firm level and in the context of India. In these ways, this study contributes to energy finance literature.

7.4 LIMITATION

The renewable energy firms considered for the study are listed on the National Stock Exchange of India. In 2019, these firms were identified and categorized. Most of the existing renewable energy firms deal with more than one renewable energy sub-sector. Thus renewable energy sub-sector-level study could not be conducted. The firm's revenue share on the basis of business type is not available. So, it is not possible to estimate the effect of oil price as per share of sub-sectors and renewable energy business contribution.

7.5 CONCLUSION

This study examines the interaction between oil price changes and stock returns of Indian renewable energy firms through four different objectives. The first objective measures the effect of oil price change on renewable energy firms' stock return across market conditions using panel quantile regression. The second objective evaluates the oil price uncertainty effect on renewable stock return using renewable energy firms' stock return using panel quantile regression. The third objective investigates the asymmetric effect of oil prices on renewable energy firms' stock return using the panel NARDL model. The fourth objective estimates the structural oil shocks' effect on renewable energy firms' stock return using panel quantile SVAR. Positive interaction is found in extreme market conditions. Among sub-groups, standalone renewable energy firms see the most positive

impacts of oil price on stock return. The increasing presence of renewable energy in our lives will give extra mileage to this study's usefulness. The growth of renewable energy depends on active investors and favorable policies. The understanding of renewable energy stock return movement helps to make investment decisions easy. Investors and portfolio managers can resort to renewable energy stock trading while other firms stocks are affected negatively due to oil price changes. Policymakers can frame policies as per oil price movements to ensure the growth of renewable energy firms. Renewable energy industry practitioners can use the findings to enable renewable energy firms to maximize their wealth. They can formulate strategies for different market conditions also. As this study is a firm level one, strategic planners of the respective renewable energy firms could use the corresponding findings.

REFERENCES

- Agarwalla, S. K., Jacob, J. and Varma, J. R. (2013), Four factor model in Indian equities market, Working Paper W.P. No. 2013-09-05, Indian Institute of Management, Ahmedabad. <https://faculty.iima.ac.in/~iffm/Indian-Fama-French-Momentum/four-factors-India-90s-onwards-IIM-WP-Version.pdf>
- Ahmad, W. (2017). On the dynamic dependence and investment performance of crude oil and clean energy stocks. *Research in International Business and Finance*, 42, 376-389. <https://doi.org/10.1016/j.ribaf.2017.07.140>
- Alqahtani, A., Klein, T., & Khalid, A. (2019). The impact of oil price uncertainty on GCC stock markets. *Resources Policy*, 64, 101526. <https://doi.org/10.1016/j.resourpol.2019.101526>
- Al-Yahyaee, K. H., Mensi, W., Al-Jarrah, I. M. W., Hamdi, A., & Kang, S. H. (2019). Volatility forecasting, downside risk, and diversification benefits of Bitcoin and oil and international commodity markets: A comparative analysis with yellow metal. *The North American Journal of Economics and Finance*, 49, 104-120. <https://doi.org/10.1016/j.najef.2019.04.001>
- Anilov, A. E., & Ivashkovskaya, I. V. (2020). Do boards of directors affect CEO behavior? Evidence from payout decisions. *Journal of Management and Governance*, 24(4), 989-1017.). <https://doi.org/10.1007/s10997-019-09491->
- Anton Mork, K. (1994). Business Cycles and the Oil Market. *The Energy Journal*, 15(01). <https://doi.org/10.5547/issn0195-6574-ej-vol15-nosi-3>
- Apergis, N., & Miller, S. M. (2009). Do structural oil-market shocks affect stock prices?. *Energy economics*, 31(4), 569-575. <https://doi.org/10.1016/j.eneco.2009.03.001>
- Apergis, N., & Miller, S. M. (2009). Do structural oil-market shocks affect stock prices?. *Energy economics*, 31(4), 569-575.
- Arouri, M. E. H., & Nguyen, D. K. (2010). Oil prices, stock markets and portfolio investment: Evidence from sector analysis in Europe over the last decade. *Energy*

- policy*, 38(8), 4528-4539. <https://doi.org/10.1016/j.enpol.2010.04.007>
- Arouri, M. E. H., Jouini, J., & Nguyen, D. K. (2012). On the impacts of oil price fluctuations on European equity markets: Volatility spillover and hedging effectiveness. *Energy Economics*, 34(2), 611–617. <https://doi.org/10.1016/j.eneco.2011.08.009>
- Badeeb, R. A., & Lean, H. H. (2018). Asymmetric impact of oil price on Islamic sectoral stocks. *Energy Economics*, 71, 128-139.
- Bašta, M., & Molnár, P. (2018). Oil market volatility and stock market volatility. *Finance Research Letters*, 26, 204-214. <https://doi.org/10.1016/j.frl.2018.02.001>
- Bastianin, A., Conti, F., & Manera, M. (2016). The impacts of oil price shocks on stock market volatility: Evidence from the G7 countries. *Energy Policy*, 98, 160-169. <https://doi.org/10.1016/j.enpol.2016.08.020>
- Behera, D. K., & Dash, U. (2019). Prioritization of government expenditure on health in India: A fiscal space perspective. *Socio-Economic Planning Sciences*, 68, 100667. <https://doi.org/10.1016/j.seps.2018.11.004>
- Bernanke, B. S. (1983). Irreversibility, uncertainty, and cyclical investment. *The quarterly journal of economics*, 98(1), 85-106. <https://doi.org/10.2307/1885568>
- Bloom, N. (2009). The impact of uncertainty shocks. *econometrica*, 77(3), 623-685. <https://doi.org/10.3982/ECTA6248>
- Broadstock, D. C., & Filis, G. (2014). Oil price shocks and stock market returns: New evidence from the United States and China. *Journal of International Financial Markets, Institutions and Money*, 33, 417-433.
- Broadstock, D. C., Cao, H., & Zhang, D. (2012). Oil shocks and their impact on energy related stocks in China. *Energy Economics*, 34(6), 1888–1895. <https://doi.org/10.1016/j.eneco.2012.08.008>
- Bruna, M. G., Đăng, R., Ammari, A., & Houanti, L. H. (2020). The effect of board gender diversity on corporate social performance: An instrumental variable quantile regression approach. *Finance Research Letters*, (January), 101734. <https://doi.org/10.1016/j.frl.2020.10173>

- Caporale, G. M., Ali, F. M., & Spagnolo, N. (2015). Oil price uncertainty and sectoral stock returns in China: A time-varying approach. *China Economic Review*, 34, 311-321. <https://doi.org/10.1016/j.chieco.2014.09.008>
- Carhart, M. M. (1997). On persistence in mutual fund performance. *Journal of Finance*, Vol. 52, pp. 57–82. <https://doi.org/10.1111/j.1540-6261.1997.tb03808>.
- Chang, B. H. (2020). Oil prices and E7 stock prices: an asymmetric evidence using multiple threshold nonlinear ARDL model. *Environmental Science and Pollution Research*, 27(35), 44183-44194. <https://doi.org/10.1007/s11356-020-10277-2>
- Chang, B. H., Sharif, A., Aman, A., Suki, N. M., Salman, A., & Khan, S. A. R. (2020). The asymmetric effects of oil price on sectoral Islamic stocks: new evidence from quantile-on-quantile regression approach. *Resources Policy*, 65, 101571. <https://doi.org/10.1016/j.resourpol.2019.101571>
- Cheikh, N. B., Naceur, S. B., Kanaan, O., & Rault, C. (2021). Investigating the asymmetric impact of oil prices on GCC stock markets. *Economic Modelling*, 102, 105589. <https://doi.org/10.1016/j.econmod.2021.105589>
- Chen, N. F., Roll, R., & Ross, S. A. (1986). Economic forces and the stock market. *Journal of business*, 383-403.
- Cong, R. G., Wei, Y. M., Jiao, J. L., & Fan, Y. (2008). Relationships between oil price shocks and stock market: An empirical analysis from China. *Energy Policy*, 36(9), 3544-3553. <https://doi.org/10.1016/j.enpol.2008.06.006>
- Cong, R. G., Wei, Y. M., Jiao, J. L., & Fan, Y. (2008). Relationships between oil price shocks and stock market: An empirical analysis from China. *Energy Policy*, 36(9), 3544-3553. <https://doi.org/10.1016/j.enpol.2008.06.006>
- Cunado, J., & de Gracia, F. P. (2014). Oil price shocks and stock market returns: Evidence for some European countries. *Energy Economics*, 42, 365-377. <https://doi.org/10.1016/j.eneco.2013.10.017>
- Das, D., & Kannadhasan, M. (2020). The asymmetric oil price and policy uncertainty shock exposure of emerging market sectoral equity returns: A quantile regression approach.

- International Review of Economics and Finance*, 69, 563–581.
<https://doi.org/10.1016/j.iref.2020.06.013>
- Das, D., Le Roux, C. L., Jana, R. K., & Dutta, A. (2020). Does Bitcoin hedge crude oil implied volatility and structural shocks? A comparison with gold, commodity and the US Dollar. *Finance Research Letters*, 36, 101335. <https://doi.org/10.1016/j.frl.2019.101335>
- Dawar, I., Dutta, A., Bouri, E., & Saeed, T. (2021). Crude oil prices and clean energy stock indices: Lagged and asymmetric effects with quantile regression. *Renewable Energy*, 163, 288–299. <https://doi.org/10.1016/j.renene.2020.08.162>
- Degiannakis, S., Filis, G., & Floros, C. (2013). Oil and stock returns: Evidence from European industrial sector indices in a time-varying environment. *Journal of International Financial Markets, Institutions and Money*, 26, 175–191. <https://doi.org/10.1016/j.intfin.2013.05.007>
- Diaz, E. M., Molero, J. C., & de Gracia, F. P. (2016). Oil price volatility and stock returns in the G7 economies. *Energy Economics*, 54, 417–430. <https://doi.org/10.1016/j.eneco.2016.01.002>
- Dutta, A. (2017). Oil price uncertainty and clean energy stock returns: New evidence from crude oil volatility index. *Journal of Cleaner Production*, 164, 1157–1166. <https://doi.org/10.1016/j.jclepro.2017.07.050>
- Dutta, A. (2018). Modeling and forecasting the volatility of carbon emission market: The role of outliers, time-varying jumps and oil price risk. *Journal of Cleaner Production*, 172, 2773–2781. <https://doi.org/10.1016/j.eneco.2018.07.026>
- Dutta, A., Bouri, E., & Roubaud, D. (2019). Nonlinear relationships amongst the implied volatilities of crude oil and precious metals. *Resources Policy*, 61, 473–478. <https://doi.org/10.1016/j.resourpol.2018.04.009>
- Economic Survey of India, Ministry of Finance, Economic Division, Government of India, New Delhi (2022–2023)
- EIA. (2019). International Energy Outlook 2019. *U.S. Energy Information Administration*, September(09), 25–150

- Elyasiani, E., Mansur, I., & Odusami, B. (2011). Oil price shocks and industry stock returns. *Energy Economics*, 33(5), 966–974. <https://doi.org/10.1016/j.eneco.2011.03.013>
- Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics*, 33(1), 3–56. [https://doi.org/10.1016/0304-405X\(93\)90023-5](https://doi.org/10.1016/0304-405X(93)90023-5)
- Fang, C. R., & You, S. Y. (2014). The impact of oil price shocks on the large emerging countries' stock prices: Evidence from China, India and Russia. *International Review of Economics & Finance*, 29, 330-338.
- Ferrer, R., Shahzad, S. J. H., López, R., & Jareño, F. (2018). Time and frequency dynamics of connectedness between renewable energy stocks and crude oil prices. *Energy Economics*, 76, 1–20. <https://doi.org/10.1016/j.eneco.2018.09.022>
- Ge, Z. (2023). The asymmetric impact of oil price shocks on China stock market: Evidence from quantile-on-quantile regression. *The Quarterly Review of Economics and Finance*, 89, 120-125. <https://doi.org/10.1016/j.qref.2023.03.009>
- Geng, J., Liu, C., Ji, Q., & Zhang, D. (2021). Do oil price changes really matter for clean energy returns? *Renewable and Sustainable Energy Reviews*, 150(May), 111429. <https://doi.org/10.1016/j.rser.2021.111429>
- Ghabri, Y., Ayadi, A., & Guesmi, K. (2021). Fossil energy and clean energy stock markets under COVID-19 pandemic. *Applied Economics*, 53(43), 4962-4974. <https://doi.org/10.1080/00036846.2021.1912284>
- Gupta, R., & Modise, M. P. (2013). Does the source of oil price shocks matter for South African stock returns? A structural VAR approach. *Energy Economics*, 40, 825-831. <https://doi.org/10.1016/j.eneco.2013.10.005>
- Hamdi, B., Aloui, M., Alqahtani, F., & Tiwari, A. (2019). Relationship between the oil price volatility and sectoral stock markets in oil-exporting economies: Evidence from wavelet nonlinear denoised based quantile and Granger-causality analysis. *Energy Economics*, 80, 536-552. <https://doi.org/10.1016/j.eneco.2018.12.021>
- Hashmi, S. M., Chang, B. H., & Bhutto, N. A. (2021). Asymmetric effect of oil prices on

- stock market prices: New evidence from oil-exporting and oil-importing countries. *Resources Policy*, 70, 101946. <https://doi.org/10.1016/j.resourpol.2020.101946>
- Hashmi, S. M., Chang, B. H., & Bhutto, N. A. (2021). Asymmetric effect of oil prices on stock market prices: New evidence from oil-exporting and oil-importing countries. *Resources Policy*, 70, 101946. <https://doi.org/10.1016/j.resourpol.2020.101946>
- Hatemi-j, A. (2012). Asymmetric causality tests with an application. *Empirical economics*, 43, 447-456. <https://doi.org/10.1007/s00181-011-0484-x>
- Hatemi-J, A., Al Shayeb, A., & Roca, E. (2017). The effect of oil prices on stock prices: fresh evidence from asymmetric causality tests. *Applied Economics*, 49(16), 1584–1592. <https://doi.org/10.1080/00036846.2016.1221045>
- He, X., Mishra, S., Aman, A., Shahbaz, M., Razzaq, A., & Sharif, A. (2021). The linkage between clean energy stocks and the fluctuations in oil price and financial stress in the US and Europe? Evidence from QARDL approach. *Resources Policy*, 72(September 2020), 102021. <https://doi.org/10.1016/j.resourpol.2021.102021>
- Henriques, I., & Sadorsky, P. (2008). *Oil prices and the stock prices of alternative energy companies*. 30, 998–1010. <https://doi.org/10.1016/j.eneco.2007.11.001>
- Hu, C., Liu, X., Pan, B., Chen, B., & Xia, X. (2018). Asymmetric impact of oil price shock on stock market in China: A combination analysis based on SVAR model and NARDL model. *Emerging Markets Finance and Trade*, 54(8), 1693-1705. <https://doi.org/10.1080/1540496X.2017.1412303>
- Huang, R. D., Masulis, R. W., & Stoll, H. R. (1996). Energy shocks and financial markets. *Journal of Futures markets*, 16(1), 1-27. [https://doi.org/10.1002/\(SICI\)1096-9934\(199602\)16:1%3C1::AID-FUT1%3E3.0.CO;2-Q](https://doi.org/10.1002/(SICI)1096-9934(199602)16:1%3C1::AID-FUT1%3E3.0.CO;2-Q)
- Huang, S., An, H., Gao, X., & Sun, X. (2017). Do oil price asymmetric effects on the stock market persist in multiple time horizons?. *Applied energy*, 185, 1799-1808. <https://doi.org/10.1016/j.apenergy.2015.11.094>
- Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, 115(1), 53–74. <https://doi.org/10.1016/S0304->

[4076\(03\)00092-7](#)

- IEA, 2019, World Energy Outlook, <https://iea.blob.core.windows.net/assets/98909c1b-aabc-4797-9926-35307b418cdb/WEO2019-free.pdf>
- IRENA (2017), Renewable Energy Prospects for India, a working paper based on REmap. The International Renewable Energy Agency (IRENA), Abu Dhabi. www.irena.org/remap
- IRENA (2018), Global Energy Transformation: A roadmap to 2050, International Renewable Energy Agency, Abu Dhabi.
- IRENA (2023), World Energy Transitions Outlook 2023: 1.5°C Pathway, Volume 1, International Renewable Energy Agency, Abu Dhabi
- Jiang, Y., Zhou, Z., & Liu, C. (2019). The impact of public transportation on carbon emissions: a panel quantile analysis based on Chinese provincial data. *Environmental Science and Pollution Research*, 26(4), 4000–4012. <https://doi.org/10.1007/s11356-018-3921-y>
- Jin, X., & Zhu, F. (2021). Global oil shocks and China’s commodity markets: the role of OVX. *Emerging Markets Finance and Trade*, 57(3), 914-929. <https://doi.org/10.1080/1540496X.2019.1658075>
- Jones, C. M., & Kaul, G. (1996). Oil and the stock markets. *The journal of Finance*, 51(2), 463-491. <https://doi.org/10.1111/j.1540-6261.1996.tb02691.x>
- Joo, Y. C., & Park, S. Y. (2021). The impact of oil price volatility on stock markets: Evidences from oil-importing countries. *Energy Economics*, 101, 105413. <https://doi.org/10.1016/j.eneco.2021.105413>
- Kang, W., Ratti, R. A., & Yoon, K. H. (2015). Time-varying effect of oil market shocks on the stock market. *Journal of Banking & Finance*, 61, S150-S163. <https://doi.org/10.1016/j.jbankfin.2015.08.027>
- Kassouri, Y., & Altıntaş, H. (2022). The quantile dependence of the stock returns of “clean” and “dirty” firms on oil demand and supply shocks. *Journal of Commodity Markets*, 28, 100238. <https://doi.org/10.1016/j.jcomm.2021.100238>

- Kilian, L. (2009). Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market. *American Economic Review*, 99(3), 1053-69.
- Kilian, L., & Park, C. (2009). The impact of oil price shocks on the US stock market. *International Economic Review*, 50(4), 1267-1287. <https://doi.org/10.1111/j.1468-2354.2009.00568.x>
- Kling, J. L. (1985). Oil price shocks and stock market behavior. *The Journal of Portfolio Management*, 12(1), 34-39. <https://doi.org/10.3905/jpm.1985.409034>
- Kocaarslan, B., & Soytaş, U. (2019). Asymmetric pass-through between oil prices and the stock prices of clean energy firms: New evidence from a nonlinear analysis. *Energy Reports*, 5, 117–125. <https://doi.org/10.1016/j.egyr.2019.01.002>
- Koh, W. C. (2017). How do oil supply and demand shocks affect Asian stock markets? *Macroeconomics and Finance in Emerging Market Economies*, 10(1), 1-18. <https://doi.org/10.1080/17520843.2015.1135819>
- Kollias, C., Kyrtou, C., & Papadamou, S. (2013). The effects of terrorism and war on the oil price–stock index relationship. *Energy Economics*, 40, 743-752. <https://doi.org/10.1016/j.eneco.2013.09.006>
- Kumar, S., Managi, S., & Matsuda, A. (2012). Stock prices of clean energy firms, oil and carbon markets: A vector autoregressive analysis. *Energy Economics*, 34(1), 215–226. <https://doi.org/10.1016/j.eneco.2011.03.002>
- Lee, C. C., & Zeng, J. H. (2011). The impact of oil price shocks on stock market activities: Asymmetric effect with quantile regression. *Mathematics and Computers in Simulation*, 81(9), 1910-1920. <https://doi.org/10.1016/j.matcom.2011.03.004>
- Liu, F., Umair, M., & Gao, J. (2023). Assessing oil price volatility co-movement with stock market volatility through quantile regression approach. *Resources Policy*, 81, 103375. <https://doi.org/10.1016/j.resourpol.2023.103375>
- Luo, X., & Qin, S. (2017). Oil price uncertainty and Chinese stock returns: New evidence from the oil volatility index. *Finance Research Letters*, 20, 29-34. <https://doi.org/10.1016/j.frl.2016.08.005>
- Luo, X., & Qin, S. (2017). Oil price uncertainty and Chinese stock returns: New evidence

- from the oil volatility index. *Finance Research Letters*, 20, 29-34.
<https://doi.org/10.1016/j.frl.2016.08.005>
- Lv, X., Dong, X., & Dong, W. (2021). Oil Prices and Stock Prices of Clean Energy: New Evidence from Chinese Subsectoral Data. *Emerging Markets Finance and Trade*, 57(4), 1088–1102. <https://doi.org/10.1080/1540496X.2019.1689810>
- Lyeonov, S., Pimonenko, T., Bilan, Y., Štreimikiene, D., & Mentel, G. (2019). Assessment of green investments' impact on sustainable development: Linking gross domestic product per capita, greenhouse gas emissions and renewable energy. *Energies*, 12(20).
<https://doi.org/10.3390/en12203891>
- Maghyereh, A., & Abdoh, H. (2021). The impact of extreme structural oil-price shocks on clean energy and oil stocks. *Energy*, 225, 120209.
<https://doi.org/10.1016/j.energy.2021.120209>
- Maghyereh, A., & Abdoh, H. (2022). Extreme dependence between structural oil shocks and stock markets in GCC countries. *Resources Policy*, 76, 102626.
- Managi, S., & Okimoto, T. (2013). Does the price of oil interact with clean energy prices in the stock market? *Japan and the World Economy*, 27, 1–9.
<https://doi.org/10.1016/j.japwor.2013.03.003>
- Miller, J. I., & Ratti, R. A. (2009). Crude oil and stock markets: Stability, instability, and bubbles. *Energy economics*, 31(4), 559-568.
<https://doi.org/10.1016/j.eneco.2009.01.009>
- Mokni, K. (2020). A dynamic quantile regression model for the relationship between oil price and stock markets in oil-importing and oil-exporting countries. *Energy*, 213, 118639. <https://doi.org/10.1016/j.energy.2020.118639>
- Nandha, M., & Faff, R. (2008). Does oil move equity prices? A global view. *Energy economics*, 30(3), 986-997. <https://doi.org/10.1016/j.eneco.2007.09.003>
- Narayan, P. K., & Sharma, S. S. (2011). New evidence on oil price and firm returns. *Journal of Banking & Finance*, 35(12), 3253-3262.
<https://doi.org/10.1016/j.jbankfin.2011.05.010>

- Nasreen, S., Tiwari, A. K., Eizaguirre, J. C., & Wohar, M. E. (2020). Dynamic connectedness between oil prices and stock returns of clean energy and technology companies. *Journal of Cleaner Production*, 260(March 2016). <https://doi.org/10.1016/j.jclepro.2020.121015>
- Niu, H. (2021). Correlations between crude oil and stocks prices of renewable energy and technology companies: A multiscale time-dependent analysis. *Energy*, 221, 119800. <https://doi.org/10.1016/j.energy.2021.119800>
- Park, J., & Ratti, R. A. (2008). Oil price shocks and stock markets in the US and 13 European countries. *Energy economics*, 30(5), 2587-2608. <https://doi.org/10.1016/j.eneco.2008.04.003>
- Pham, L. (2019). Do all clean energy stocks respond homogeneously to oil price? *Energy Economics*, 81, 355–379. <https://doi.org/10.1016/j.eneco.2019.04.010>
- Phan, D. H. B., Sharma, S. S., & Narayan, P. K. (2015). Oil price and stock returns of consumers and producers of crude oil. *Journal of International Financial Markets, Institutions and Money*, 34, 245-262. <https://doi.org/10.1016/j.intfin.2014.11.010>
- Powell, D. (2016). Quantile regression with nonadditive fixed effects. *Quantile Treatment Effects*, 1–28. Retrieved from http://works.bepress.com/david_powell/1/
- Qi, T., Zhang, X., & Karplus, V. J. (2014). The energy and CO2 emissions impact of renewable energy development in China. *Energy Policy*, 68(May), 60–69. <https://doi.org/10.1016/j.enpol.2013.12.035>
- Rahman, S. (2022). The asymmetric effects of oil price shocks on the US stock market. *Energy Economics*, 105, 105694. <https://doi.org/10.1016/j.eneco.2021.105694>
- Ramos, S. B., & Veiga, H. (2013). Oil price asymmetric effects: Answering the puzzle in international stock markets. *Energy Economics*, 38, 136–145. <https://doi.org/10.1016/j.eneco.2013.03.011>
- Ready, R. C. (2018). Oil prices and the stock market. *Review of Finance*, 22(1), 155-176. <https://doi.org/10.1093/rof/rfw071>
- Reboredo, J. C., & Ugolini, A. (2018). The impact of energy prices on clean energy stock

- prices. A multivariate quantile dependence approach. *Energy Economics*, 76, 136–152. <https://doi.org/10.1016/j.eneco.2018.10.012>.
- Reboredo, J. C., Rivera-Castro, M. A., & Ugolini, A. (2017). Wavelet-based test of co-movement and causality between oil and renewable energy stock prices. *Energy Economics*, 61, 241–252. <https://doi.org/10.1016/j.eneco.2016.10.015>
- REN21. 2022. Renewables 2023 Global Status Report.
- Sadeghi, A., & Roudari, S. (2022). Heterogeneous effects of oil structure and oil shocks on stock prices in different regimes: Evidence from oil-exporting and oil-importing countries. *Resources Policy*, 76, 102596. <https://doi.org/10.1016/j.resourpol.2022.102596>
- Sadeghi, A., & Roudari, S. (2022). Heterogeneous effects of oil structure and oil shocks on stock prices in different regimes: Evidence from oil-exporting and oil-importing countries. *Resources Policy*, 76, 102596. <https://doi.org/10.1016/j.resourpol.2022.102596>
- Sadorsky, P. (1999). Oil price shocks and stock market activity. *Energy Economics*, 21(5), 449–469. [https://doi.org/10.1016/S0140-9883\(99\)00020-1](https://doi.org/10.1016/S0140-9883(99)00020-1)
- [Sadorsky, P. \(2008\). Assessing the impact of oil prices on firms of different sizes: Its tough being in the middle. *Energy Policy*, 36\(10\), 3854-3861. https://doi.org/10.1016/j.enpol.2008.07.019](https://doi.org/10.1016/j.enpol.2008.07.019)
- Saha, S. (2022). Asymmetric Impact of Oil Price Changes on Stock Prices: Evidence from Country and Sectoral Level Data. *Journal of Economics and Finance*, 46(2), 237-282. <https://doi.org/10.1007/s12197-021-09559-3>
- Saha, S. (2022). Asymmetric Impact of Oil Price Changes on Stock Prices: Evidence from Country and Sectoral Level Data. *Journal of Economics and Finance*, 46(2), 237-282. <https://doi.org/10.1007/s12197-021-09559-3>
- Salisu, A. A., & Isah, K. O. (2017). Revisiting the oil price and stock market nexus: A nonlinear Panel ARDL approach. *Economic Modelling*, 66(July), 258–271. <https://doi.org/10.1016/j.econmod.2017.07.010>

- Sarkodie, S. A., & Strezov, V. (2019). Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. *Science of the Total Environment*, *646*, 862-871. <https://doi.org/10.1016/j.scitotenv.2018.07.365>
- Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2012). Modelling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.1807745>
- Silvapulle, P., Smyth, R., Zhang, X., & Fenech, J. P. (2017). Nonparametric panel data model for crude oil and stock market prices in net oil importing countries. *Energy economics*, *67*, 255-267. <https://doi.org/10.1016/j.eneco.2017.08.017>
- Squalli, J. (2017). Renewable energy, coal as a baseload power source, and greenhouse gas emissions: Evidence from U.S. state-level data. *Energy*, *127*, 479-488. <https://doi.org/10.1016/j.energy.2017.03.156>
- Sreenu, N. (2022). Impact of crude oil price uncertainty on Indian stock market returns: Evidence from oil price volatility index. *Energy Strategy Reviews*, *44*, 101002. <https://doi.org/10.1016/j.esr.2022.101002>
- Tsai, C. L. (2015). How do U.S. stock returns respond differently to oil price shocks pre-crisis, within the financial crisis, and post-crisis? *Energy Economics*, *50*, 47-62. <https://doi.org/10.1016/j.eneco.2015.04.012>
- Uddin, G. S., Rahman, M. L., Hedström, A., & Ahmed, A. (2019). Cross-quantilogram-based correlation and dependence between renewable energy stock and other asset classes. *Energy Economics*, *80*, 743-759. <https://doi.org/10.1016/j.eneco.2019.02.014>
- Wang, Y., Wu, C., & Yang, L. (2013). Oil price shocks and stock market activities: Evidence from oil-importing and oil-exporting countries. *Journal of Comparative economics*, *41*(4), 1220-1239. <https://doi.org/10.1016/j.jce.2012.12.004>
- Warren, B., & de Giovanni, A. (2021). Renewable energy country attractiveness index. *EY RECAI*, *58*.

- Xiao, J., Hu, C., Ouyang, G., & Wen, F. (2019). Impacts of oil implied volatility shocks on stock implied volatility in China: Empirical evidence from a quantile regression approach. *Energy Economics*, 80, 297-309. <https://doi.org/10.1016/j.eneco.2019.01.016>
- Xiao, J., Zhou, M., Wen, F., & Wen, F. (2018). Asymmetric impacts of oil price uncertainty on Chinese stock returns under different market conditions: Evidence from oil volatility index. *Energy Economics*, 74, 777-786. <https://doi.org/10.1016/j.eneco.2018.07.026>
- Xu, B. (2015). Oil prices and UK industry-level stock returns. *Applied Economics*, 47(25), 2608–2627. <https://doi.org/10.1080/00036846.2015.1008760>
- Yahya, M., Kanjilal, K., Dutta, A., Uddin, G. S., & Ghosh, S. (2021). Can clean energy stock price rule oil price? New evidences from a regime-switching model at first and second moments. *Energy Economics*, 95, 105116. <https://doi.org/10.1016/j.eneco.2021.105116>
- Yu-Ling Hsiao, C., Lin, W., Wei, X., Yan, G., Li, S., & Sheng, N. (2019). The impact of international oil prices on the stock price fluctuations of China's renewable energy enterprises. *Energies*, 12(24). <https://doi.org/10.3390/en12244630>
- Zhang, H., Cai, G., & Yang, D. (2020). The impact of oil price shocks on clean energy stocks: Fresh evidence from multi-scale perspective. *Energy*, 196, 117099. <https://doi.org/10.1016/j.energy.2020.117099>
- Zhao, X. (2020). Do the stock returns of clean energy corporations respond to oil price shocks and policy uncertainty? *Journal of Economic Structures*, 9(1), 1-16.
- Zhu, F., Jin, F., Wu, H., & Wen, F. (2019). The impact of oil price changes on stock returns of new energy industry in China: A firm-level analysis. *Physica A: Statistical Mechanics and Its Applications*, 532. <https://doi.org/10.1016/j.physa.2019.121878>
- Zhu, H. M., Li, R., & Li, S. (2014). Modelling dynamic dependence between crude oil prices and Asia-Pacific stock market returns. *International Review of Economics & Finance*, 29, 208-223. <https://doi.org/10.1016/j.iref.2013.05.015>
- Zhu, H., Su, X., You, W., & Ren, Y. (2017). Asymmetric effects of oil price shocks on

stock returns: evidence from a two-stage Markov regime-switching approach. *Applied Economics*, 49(25), 2491–2507. <https://doi.org/10.1080/00036846.2016.1240351>

APPENDIX I: LIST OF RENEWABLE ENERGY FIRMS

SL. NO.	NAME
RENEWABLE ENERGY PRODUCTS AND SERVICES FIRMS	
1	ENERGY DEVELOPMENT CO. LTD.
2	INOX WIND LTD.
3	KARMA ENERGY LTD.
4	N H P C LTD.
5	ORIENT GREEN POWER CO. LTD.
6	S E POWER LTD.
7	SURANA TELECOM & POWER LTD.
8	TATA POWER CO. LTD.
9	UJAAS ENERGY LTD.
RENEWABLE ENERGY PRODUCTION FIRMS	
1	BRIGHT SOLAR LTD.
2	INDOSOLAR LTD.
3	INOX WIND LTD.
4	SOLEX ENERGY LTD.
5	SURANA SOLAR LTD.
6	SUZLON ENERGY LTD.
7	SWELECT ENERGY SYSTEMS LTD.
8	WEBSOL ENERGY SYSTEM LTD.
9	X L ENERGY LTD.
10	ZODIAC ENERGY LTD.
RENEWABLE AND NON-RENEWABLE ENERGY PRODUCTION FIRMS	
1	J S W ENERGY LTD.
2	JINDAL STEEL & POWER LTD.
3	ADANI POWER LTD.
4	TORRENT POWER LTD.
5	JAIPRAKASH POWER VENTURES LTD.
6	INDIA POWER CORPN. LTD.
7	R E C LTD.
8	RELIANCE POWER LTD.
9	RATTANINDIA POWER LTD.
10	S J V N LTD.
11	N T P C Ltd.
FIRMS DEALING IN RENEWABLE ENERGY AND OTHER BUSINESS ACTIVITY	
1	AMARA RAJA BATTERIES LTD.
2	CORDS CABLE INDS. LTD.

3	CYIENT LTD.
4	DALMIA BHARAT LTD. [MERGED]
5	DE NORA INDIA LTD.
6	EMKAY TAPS & CUTTING TOOLS LTD.
7	EMPEE SUGARS & CHEMICALS LTD.
8	EVEREST INDUSTRIES LTD.
9	EXIDE INDUSTRIES LTD.
10	G V K POWER & INFRASTRUCTURE LTD.
11	GEECEE VENTURES LTD.
12	GENUS POWER INFRASTRUCTURES LTD.
13	GODAWARI POWER & ISPAT LTD.
14	GOLDSTAR POWER LTD.
15	GUJARAT AMBUJA EXPORTS LTD.
16	GUJARAT INDUSTRIES POWER CO. LTD.
17	H B L POWER SYSTEMS LTD.
18	I M P POWERS LTD.
19	J B M AUTO LTD.
20	K C P LTD.
21	K P R MILL LTD.
22	K S B LTD.
23	K S K ENERGY VENTURES LTD.
24	KANORIA CHEMICALS & INDS. LTD.
25	KEI INDUSTRIES LTD.
26	KIRLOSKAR INDUSTRIES LTD.
27	LAMBODHARA TEXTILES LTD.
28	LANCO INFRATECH LTD.
29	MAGADH SUGAR & ENERGY LTD.
30	MOSER BAER INDIA LTD.
31	N C L INDUSTRIES LTD.
32	N L C INDIA LTD.
33	NATIONAL ALUMINIUM CO. LTD.
34	NELCO LTD.
35	OIL INDIA LTD.
36	OLECTRA GREENTECH LTD.
37	OMAX AUTOS LTD.
38	P A E LTD.
39	P T C INDIA LTD.
40	PARAMOUNT COMMUNICATIONS LTD.
41	POWER GRID CORPN. OF INDIA LTD.
42	PRAKASH INDUSTRIES LTD.
43	S P M L INFRA LTD.
44	SALONA COTSPIN LTD.

45	SALORA INTERNATIONAL LTD.
46	SARDA ENERGY & MINERALS LTD.
47	SATIN CREDITCARE NETWORK LTD.
48	SAVITA OIL TECHNOLOGIES LTD.
49	SERVOTECH POWER SYSTEMS LTD.
50	SHAKTI PUMPS (INDIA) LTD.
51	SHILPI CABLE TECHNOLOGIES LTD.
52	SHRIRAM E P C LTD.
53	SIEMENS LTD.
54	SIMPLEX CASTINGS LTD.
55	SMARTLINK HOLDINGS LTD.
56	SUPER SALES INDIA LTD.
57	SWELECT ENERGY SYSTEMS LTD.
58	T D POWER SYSTEMS LTD.
59	TATA STEEL LTD.
60	TECH MAHINDRA LTD.
61	THERMAX LTD.
62	URJA GLOBAL LTD.
63	V-GUARD INDUSTRIES LTD.
64	VINDHYA TELELINKS LTD.

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List of publications:

1. Mishra, L., & Acharya, R. H. (2022). The oil price uncertainty effect on stock returns of the Indian renewable energy firms under different market conditions. *OPEC Energy Review*, 46(4), 437-448. <https://doi.org/10.1111/opec.12267>
2. Mishra, L., & Acharya, R. H. (2023). Oil price effect on asset pricing of renewable energy firms in India: a panel quantile regression approach. *International Journal of Energy Sector Management*, 17(5), 904-924. <https://doi.org/10.1108/IJESM-11-2021-0017>