Co-integration and Causal Relationship between Energy Commodities and Energy Stock Index: Empirical Evidence from India

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Abstract
This article’s primary objective is to evaluate, within the Indian setting, the degree to which energy commodities and energy stock prices correlate and are causally related. Weekly spot price data has been sourced from the Multi Commodity Exchange and the National Stock Exchange, which spans from January 2007 to December 2021. This study employs Auto-regressive Distributive (ARDL) Bound test along with Johansen co-integration approach to understand the co-integration between the series under study. The findings support the idea that the energy stock index listed on the National Stock Exchange (NSE) and the energy commodities traded on the Multi Commodity Exchange (MCX) do not exhibit any co-integration. Furthermore, to investigate the cause-and-effect connection between the energy stock index and energy commodities, Granger Causality test has been utilised, which was introduced by Toda and Yamamoto. The results demonstrate that there is no causal relationship between MCX energy commodities and the NSE energy stock index. Thus, the nonexistence of cointegration and causality between NSE energy index and energy commodities provides portfolio diversification opportunities for the investors to hedge their risk by investing in both energy commodities and energy stock index. Policymakers need to promote deeper integration among these markets by making more regulatory and accounting changes.

Keywords: Energy commodities, ARDL bound, Causal relationship, Energy, Johansen Co-integration, Stock index, Toda and Yamamoto test

1 Introduction

Crude oil and natural gas together account for well over half of the world’s primary energy consumption in 2014 (Liu et al., 2017). Since the mid-1950s, crude oil has been the most significant source of energy in the world due to its high energy density, transportability, and relative abundance. According to Herodotus and Diodorus Siculus, there were oil mines in the vicinity of Babylon more than 4,000 years ago. Ignacy Lukasiewicz discovered the method for distilling kerosene from seep oil (petroleum seeps) in the 1850s, which provided an affordable alternative to whale oil. Lukasiewicz constructed the world’s first commercial oil well in Poland in 1854, in response to the rapidly increasing demand for petroleum as a fuel. Lukasiewicz is also credited with inventing the kerosene lamp in 1853 and introducing the first street lanterns to Europe in the same year (Alimi & Oyedeji, 2015).

Natural gas, a flammable blend of hydrocarbon gases, is widely recognised for its environmentally friendly and secure energy provision. The Chinese were cognizant of the possibilities of natural gas seepage through the earth’s surface as early as approximately 500 BC. The utilisation of this method involved the application of heat to sea water, resulting in the separation of salt from the liquid, so rendering it suitable for consumption. In around 1785, the United Kingdom emerged as the pioneering nation in the commercialization of natural gas, namely derived from coal, which was employed for illuminating residential dwellings and street lamps (Etiope, 2015).

Energy market is the largest commodity market in the international market. India is the 3rd largest oil and energy consumer in the world after US and China. The Energy commodities market is now going through a variety of changes and problems that are influencing its present condition. These developments and challenges are taking place on a worldwide basis. Alterations in energy costs, which are caused by changes in certain types of energy resources, are among the recent advancements that have taken place. To provide just one example, the cost of energy dropped...
by 8.2% in November 2023, with coal and oil being the primary contributors to this loss. There are also important strategic choices being made by big companies in the energy sector. One example of this is the decision made by an oil major to decrease its worldwide refining portfolio in order to concentrate on large facilities that are integrated with chemical and trading enterprise operations. In addition, a monitoring authority on energy has indicated that demand growth is 'drastically' decreasing during the first quarter of this year. In addition, there is an increasing focus on issues pertaining to environmental obligations and the possibility of changes in behaviour. For instance, a number of major fossil fuel companies are now campaigning for a phaseout, and there are demands to shift away from fossil fuels, despite the fact that there are no clear dates to phase them out. These insights into the global energy commodity market demonstrate that it is a dynamic terrain that is characterised by price swings, strategic adjustments by important participants, and changing environmental issues. It is imperative that stakeholders in the energy industry keep a close eye on this intricate terrain and demonstrate the ability to successfully traverse it.

There is an increase in India’s reliance on imported crude oil for the first time in 2005 and further increased by 80% in 2016 (Li and Wang, 2019). In FY22, India produced 29.7 million metric tonnes of crude oil, compared to 30.5 million metric tonnes in FY21. India has 600 million tonnes of proven crude oil reserves in 2020. India’s oil consumption increased at a CAGR of 3.54 percent between 2005 and 2022. The consumption of petroleum products increased from 194 Million tonnes in FY21 to 204 Million tonnes in FY22. During FY22, the value of petroleum oil imports was Rs. 8,99,312 Crores, while the value of product exports was Rs. 3,31,615 Crores and the value of product imports was Rs. 1,82,970 Crores. Rapid economic expansion is increasing the demand for oil in production and transportation. Consequently, India’s reliance on energy imports is likely to increase. It is anticipated that as income levels rise, the demand for automobiles will increase, resulting in an increase in the demand for oil and gas.

Crude oil production process is one of the major inputs in an economy (refer Fig. 1).

It appears that the world has seen a time of more crude oil price volatility based on past tendencies (Ghosh, 2011). The increased dependence of India on energy commodities includes natural gas and crude oil make it susceptible to some factors include supply interruption and variations in oil prices globally. These variances will have an impact on the equilibrium of domestic crude oil supply and demand, resulting in changes in crude oil price (Li and Wang, 2019). These differences cause the price of these commodities to become more volatile, endangering price stabilization efforts and making it more difficult for investors to predict the future price of oil (Bouri et al., 2017).
The global production of natural gas had a growth of 4.5% in the year 2021, resulting in a total production volume of 4,036.9 billion cubic metres. The United States experienced a 2% rise in natural gas production in comparison to the preceding year. In the year 2021, there was a decline of 4.9% in global natural gas consumption. However, it is noteworthy that China had a notable increase of 12.5% in its natural gas consumption, resulting in a total consumption of 378.7 billion cubic metres.

Figure 3 depicts that the net production of natural gas in India for the fiscal year 2021-2022 amounted to 33,131 MMSCM, representing a significant increase of 19% compared to the previous fiscal year. In contrast, the import of liquefied natural gas (LNG) reached 30,776 MMSCM, indicating a decrease of 7% compared to the previous fiscal year. The total consumption of natural gas in India during the fiscal year 2021-2022 was recorded at 63,907 MMSCM, indicating a 5% increase compared to the previous fiscal year. Figure 4 illustrates the distribution of consumption across several industries throughout the fiscal year 2021-2022.
The escalating interconnectedness of financial markets around the world, in conjunction with the expanding financialization of commodities, has sparked significant scholarly attention towards examining the transmission of risk between prominent securities and commodity markets under certain conditions. Academic interest in studying the distribution of volatility and return correlations across different financial markets has grown substantially in the last few years (Tang and Xiong, 2010; Aboura and Chevallies, 2015; Baldi et al., 2016). During periods of market turmoil, it is imperative for portfolio managers and professionals to execute remedial measures in order to minimise the potential propagation of risk within financial markets.

Empirical investigations examining the magnitude of spillovers or dynamic interrelationships among markets yield crucial insights that facilitate precise estimations of both return and volatility. The presence of correlation and volatility between energy commodities and financial markets poses significant issues, particularly for policymakers. The observed interconnectivity within these marketplaces carries substantial consequences not just for the costs of production, revenues of corporations, and rates of employment growth, but also for macroeconomic policy (Kaur and Dhiman, 2019; Yadav et al., 2023). The effect of energy commodity price swings on the return and risk characteristics of investment portfolios are, hence, something that investors must fully grasp.

Vivian and Wohar (2012) have observed that a significant number of contemporary research studies are integrating raw materials as a crucial element within investing portfolios alongside other categories of equities. Traders are trying to deduce the prevailing trend and linkages between the stock and commodities markets by applying the findings of this research to the examination of price movements in these markets (Choi and Hammoudeh, 2010).

According to the efficient market hypothesis, the incorporation of news into the market has the capacity to immediately influence investor perception, resulting in the modification of their portfolios or investments. According to Tursoy and Faisal (2017), financial markets swiftly respond to these alterations. Prior studies have shown a significant lack of correlation between commodities and stock prices. Commodities are classified as an asset class since they are not closely linked to other financial assets such as bonds and equities (Elder et al., 2012). Consequently, include commodities in a portfolio has the potential to increase total investment returns. The disparity in the influence of news on commodities and equities prices is a fundamental factor that leads to a weak connection between these two types of assets. The reciprocal effect between people may be attributed to the negative influence they exert on one other (Hammoudeh & Aleisa, 2004; Reddy & Sebastin, 2009). This research aims to evaluate the correlation between commodity and stock markets by focusing on the NSE energy stock index and energy commodities. The researchers used the autoregressive distributive lag (ARDL) bound test and the Granger Causality Test, as described by Toda and Yamamoto, to determine the existence of lead-lag relationships and cointegration among the variables.

2 Literature Review

Fig 4: Industry wise consumption of Natural Gas in India (Source: www.mcxindia.com)
As the price of oil has risen, so has the cost of importing goods into the Indian market. Oil price volatility, and the correlation between crude oil prices and stock prices was the focus of Ghosh and Kanjilal's (2016) study of the Indian setting. Nevertheless, this subject is very significant in the academic community. The responsiveness of the commodity market to investor sentiment in recent times. The rise in trading volume of commodity futures suggests a heightened level of investor interest in these markets. The influence of demand and supply conditions on commodity prices has increased, and investigations in the Indian setting have shown that the correlation between these two sectors has increased.

Investigations have shown that the relationship between oil prices and the stock market has undergone a major shift after the financial crisis of 2008. There has been a significant increase in the relationship between these two sectors. According to Soucek (2013), the relationship between crude prices and the stock market has become more pronounced in times of financial crises. This heightened connection has been observed in the case of the GCC countries, where there has been a positive correlation between the oil market and the stock market since the financial crisis occurred.

The phenomenon of financialization in the commodities market is a crucial factor contributing to the increased correlation observed between the stock market and commodity market in recent times. The influence of demand and supply conditions on commodity prices has increased, and investigations in the Indian setting have shown that the correlation between these two sectors has increased. The rise in trading volume of commodity futures suggests a heightened level of investor interest in these markets. The influence of demand and supply conditions on commodity prices has increased, and investigations in the Indian setting have shown that the correlation between these two sectors has increased.

In a study conducted by Magheyereh and Kendari (2007), the research also used the DCC GARCH Model to examine how changes in oil prices affect Chinese energy equities. The study found that there is a significant positive correlation between oil prices and Chinese energy equities.

The correlation between commodities and stock prices has gained significant attention worldwide during the financial crisis of 2007. Many elements that influence this connection when analysing and making choices about energy investments. The intricacies of energy markets and making informed investment choices. Stakeholders must acknowledge the influence of energy commodities on energy stock prices is an essential field of research for comprehending the characteristics of energy firms, resulting in volatility in stock prices. In conclusion, understanding the relationship between energy commodities and energy stock prices is impacted by variables such as market risk preferences, general uncertainty, and risk aversion.

In summary, to summarise, understanding the relationship between energy commodities and energy stock prices is impacted by variables such as market risk preferences, general uncertainty, and risk aversion. The correlation between commodities and stock prices has gained significant attention worldwide during the financial crisis of 2007. Many elements that influence this connection when analysing and making choices about energy investments. The intricacies of energy markets and making informed investment choices. Stakeholders must acknowledge the influence of energy commodities on energy stock prices is an essential field of research for comprehending the characteristics of energy firms, resulting in volatility in stock prices.
become more substantial because of this. The outcome is that the rate of inflation inside the country has increased. The wealth effect, claims Girardi (2015), is to blame for the decline in stock market investment. In addition, Bouri et al. (2017) put out the idea of co-integrating the energy commodities market with the stock market. There is a one-way causal relationship between crude oil and the stock market. Based on the statistics, crude oil is one of India’s main imports, and the country’s financial markets are quite sensitive to changes in oil prices. Dutta (2017) used the implied volatility index to find a fascinating correlation between oil prices and the US energy stock market. There was a strong correlation and causal relationship between the two variables, according to the research. There is a causal link between oil and US stock performance; that is, oil affects US stock performance. This is primarily because crude oil is an essential component in the operations of US energy businesses, which are significant players in the stock market. The stock performance of these firms is similarly affected by the unpredictable fluctuations in crude oil prices. After a thorough review of the pertinent scholarly sources, it can be inferred that the level of interconnection across these markets has experienced a notable upsurge in recent times. The commodity market has witnessed a notable surge in investor participation, leading to the recognition of commodities as financial assets that can be compared to equities and bonds. Because of commodities’ increased reliance on financial markets, the interdependence of the stock and commodity markets has changed. Because commodity prices include useful information about expected economic circumstances, the correlation between commodity prices and the stock market may be used as a tool for prediction. When commodity prices rise, it may indicate that global economic demand is also on the rise, which in turn affects stock prices (Black et al., 2014). There exists a divergence of opinions among scholars about the precise conceptualization of co-integration between commodity and equities markets. The escalation of commodity prices has been widely recognised as a prominent factor contributing to elevated levels of inflation and interest rates within the economy. Consequently, this phenomenon has exerted an adverse influence on stock prices. Consequently, the establishment of a position in the commodity market can function as a risk management strategy to mitigate unforeseen price swings in the stock market (Conover et al., 2010). Hence, a lack of unanimity exists among scholars with regards to elucidating the concept of connectivity between these two marketplaces. The link between stock and commodities markets has been extensively studied in the literature. However, understanding this phenomena in the Indian context remains puzzling. Considerable study has been conducted in developed economies to investigate this subject, however, there is a noticeable lack of literature on emerging economies like India. Developing countries’ financial markets vary from developed economies in terms of their volatility and speculative activity (Ping et al., 2017). The lack of empirical research is a major factor that adds to the confusion around this concept in the Indian context. Taking into account all of these features and limitations provides a theoretical framework for future inquiries. This research addresses the lack of information about the co-integration of the stock and commodity markets in India by examining energy commodities and the energy stock index. The recent developments made by the Security and Exchange Board of India (SEBI) have increased the level of exposure of individual investors in India to commodities. India’s Securities and Exchange Board of India (SEBI) has recently taken steps to integrate the country’s stock and commodities markets. This involves bringing together investors, intermediaries, and the operational framework. The Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE), the two main stock exchanges in India, have recently submitted applications seeking authorization to commence trading in commodities derivatives. This is a fascinating move towards the consolidation of financial markets and enhancing investor trust. SEBI has just approved the use of option contracts for commodities that are not related to agriculture. Consequently, there has been an increase in the involvement of investors in the commodities market. This study investigates the co-integration between the stock and commodity markets to gain a better understanding of how effective commodities are as a hedge against unexpected fluctuations in the stock market. It takes into account recent developments and amendments in commodity trading that aim to boost investor confidence and participation. Furthermore, the relationship between the prices of raw materials and their respective stock indices will provide valuable insights into possible replacement tactics between commodities and equities (Creti et al., 2013). As a result, they will have a greater ability to predict and be ready for unforeseen changes in the prices of commodities and stocks.

3 Research Methodology
The current investigation used a weekly monitoring of crude oil, natural gas, and the NSE energy index from January 2007 to December 2021. The data on energy commodities and the energy stock index is obtained from the official websites of MCX and NSE, respectively.

The ARDL Bound test, created by Pesaran, Shin, and Smith (2001), was used to examine the cointegration between energy commodities and the NSE energy index. This approach is preferred above other approaches for examining long-run relationships due to its versatility and effectiveness.

3.1 Unit Root Testing

A unit root test is a statistical method used to ascertain the presence of a unit root in a time series variable. A unit root indicates that the series has a random walk or a random process, and it is characterized by a large and persistent change in the level of the variable. The Augmented Dickey-Fuller (ADF) test is a more sophisticated iteration of the Dickey-Fuller test, which is used to test for the presence of a unit root. The null hypothesis of the ADF test is that there is a unit root, whereas the alternative hypothesis is that the series is stationary.

\[ y_t = \alpha + \beta_t + \gamma y_{t-1} + \sum_{i=1}^{n} \delta_i \Delta y_{t-i} + \epsilon_t \]  

Where \( \Delta \) denotes the first differenced operator, \( y_t \) is an energy commodity price series, \( \epsilon_t \) is assumed to be white noise, and \( \gamma \) is the coefficient on the lagged level of \( y_t \). The ADF test aims to reject the null hypothesis of a unit root.

3.2 Co-integration Testing

The co-integration between two or more series is a statistical property that indicates a long-run equilibrium relationship. The relationship is not strict, as the variables can still have different stochastic trends. To examine co-integration, the Dickey-Fuller test is employed on the residuals of the regression equation, which is called the Engle-Granger two-step method.

\[
\Delta\text{NSE Energy} = \omega_1 + \sum_{i=1}^{n} \alpha_{1i} \Delta\text{NSE Energy}_{t-i} + \sum_{i=1}^{n} \beta_{1i} \Delta\text{Com}_{t-i} + a_1\text{NSE Energy}_{t-1} + b_1\text{Com}_{t-1} + \epsilon_{1t}
\]

\[
\Delta\text{Energy Com} = \omega_2 + \sum_{i=1}^{n} \alpha_{2i} \Delta\text{NSE Energy}_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta\text{Com}_{t-i} + a_2\text{NSE Energy}_{t-1} + b_2\text{Com}_{t-1} + \epsilon_{2t}
\]

Where \( \Delta \) denotes the first differenced operator, \( \epsilon_{1t} \) and \( \epsilon_{2t} \) are error terms.

Based on the estimated values, the co-integration between energy commodities and the NSE energy index is shown below.
The estimated value fell between the upper and lower bounds. In such a scenario, the term error correction characterises the long-run co-integration of the variables. The negative and statistically significant error correction term indicates that the series have a long-run association. If the calculated F-statistic falls below the lower limit value, the absence of co-integration between the series is indicated by the null hypothesis.

### 3.3 Toda and Yamamoto Testing

The Toda-Yamamoto (1995) causality model is a statistical technique employed for the purpose of examining causal relationships among time series data. The Granger causality test is expanded by incorporating the potential existence of non-linear causal associations. This measure demonstrates a higher level of effectiveness compared to other standard approaches in determining the lead-lag connection.

First, this approach's accuracy is not contingent on the order of integration. This test is applicable regardless of the order of integration. Second, examining co-integration prior to employing the causality model is unnecessary. This method has reduced the bias associated with unit root testing and the co-integrating properties of variables (Siami-Namini, 2017).

The Toda-Yamamoto causality model can be expressed in the following general form:

\[
y_t = \alpha + \sum (\beta_i * y_{t-i}) + \sum (\Gamma_j * x_{t-j}) + \epsilon_t
\]

Where:
- \(y_t\) represents the time series of the dependent variable at time \(t\)
- \(x_t\) represents the time series of the independent variable at time \(t\)
- \(\alpha\) represents the intercept term in the context of the given equation.
- \(\beta_i\) denotes the coefficients associated with the lagged values of the dependent variable.
- \(\Gamma_i\) denotes the coefficients associated with the lagged values of the independent variable.
- \(\epsilon_t\) represents the error term at time \(t\).

### 4 Results and Discussion

The ADF test is utilised to determine whether the series under consideration contains a unit root. The examination is conducted using both the level and first difference methods. The findings presented in Table 1 indicate the presence of unit root at the level for all the series pertaining to natural gas, petroleum oil, and the NSE energy index. Following this, each series is differenced and subsequently retested to ensure stationarity. The findings suggest that the series attain stationarity at the first difference. The ARDL Bound test operates under the assumption that every series can be integrated at order zero or one. The series should not exceed I(2).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Level t-Statistics</th>
<th>Probability</th>
<th>First Difference t-Statistics</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil</td>
<td>-3.238846</td>
<td>0.2901</td>
<td>-22.26091</td>
<td>0.0000</td>
</tr>
<tr>
<td>Natural gas</td>
<td>-1.880784</td>
<td>0.1232</td>
<td>-24.46685</td>
<td>0.0000</td>
</tr>
<tr>
<td>NSE Energy</td>
<td>-2.428424</td>
<td>0.7572</td>
<td>-23.59602</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Additionally, the AIC criteria implemented within the VAR system were utilised to ascertain the most advantageous lag length for the pairings of energy commodities and energy stock index. The optimal latency length for the crude oil-NSE energy and natural gas-NSE energy couples, as indicated in Table 2, is 1.

<table>
<thead>
<tr>
<th>Pairs of Variables</th>
<th>Lag Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil-NSE Energy</td>
<td>1</td>
</tr>
<tr>
<td>Natural Gas-NSE Energy</td>
<td>1</td>
</tr>
</tbody>
</table>

The Authors
ARDL Bound Test is employed to empirically analyze the long-run co-integration between energy commodities and energy stock index and results shown in Table 3 depicts the nonexistent of co-integration between energy commodities and the NSE energy index, because $F$-statistics is less than the lower bound critical value. As it is evident that there is no co-integration between energy commodities and the NSE energy index, it is suggested that investors can use crude oil, natural gas, and NSE energy index as diversification tools in portfolio allocation.

**Table 3. Results of ARDL Bound Test for Energy Index and Energy Commodities**

<table>
<thead>
<tr>
<th>Variables</th>
<th>$F$-statistics</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Serial Correlation</th>
<th>RESET Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil – NSE Energy</td>
<td>1.31</td>
<td>3.62</td>
<td>4.16</td>
<td>0.011 (0.9159)</td>
<td>0.254 (0.6138)</td>
</tr>
<tr>
<td>Natural Gas – NSE Energy</td>
<td>2.52</td>
<td>3.62</td>
<td>4.16</td>
<td>0.255 (0.6131)</td>
<td>0.021 (0.9826)</td>
</tr>
</tbody>
</table>

The Authors

Moreover, to check the robustness of the ARDL Bound Test, Johansen Co-integration Test (Johansen, 1988) is applied. This method is comparatively convenient for researchers than other models as it allows more than one co-integrating equation between the variables. This test can be employed to the variables with the same integration order (Tursoy & Faisal, 2017). Johansen Co-integration test results are shown in Table 4. These results reconfirm the findings of the ARDL bound test. It means crude oil–NSE energy index, as well as natural gas–NSE energy index pairs, do not follow common trends in the long run. Ghosh and Kanjilal (2016) draw similar findings by examining the co-integration amongst the stock and crude oil prices by using Rank Co-integration Method. The results are similar to the studies suggesting the absence of co-integration between energy commodities and the stock market (Hammoudeh and Aliesa, 2004; Maghyereh and Kandhari, 2007 and Apergis and Miller, 2009). The results indicate that, in the Indian context, energy commodities do not offer substantial insights that can be utilised to forecast stock prices over an extended period of time. A sustained reversal in the trajectory of two markets occurs when stochastic distress increases in one of the markets. The lack of a direct correlation between energy commodities and the stock market implies that energy commodities do not possess the capacity to forecast returns on the stock market.

The absence of co-integration between two financial markets implies that investors may enhance the diversification of their portfolio by include both energy commodities and the energy stock index. The research done...
by Narsimuhulu et al. (2016) establishes that the Efficient Market Hypothesis states that stock prices reflect all publicly accessible information. Consequently, it is not feasible to estimate these values using the aforementioned information or the price indices of other financial markets. When two markets are not co-integrated, it indicates a breach of the efficient market hypothesis, suggesting that one market has sufficient information to predict the behaviour of other financial markets.

It is important to clarify that the limited connection between commodities and stocks stems from the different factors that affect the value of both assets. The absence of correlation between equities and commodities holds significance in the assessment of risk management strategies for constructing an optimal portfolio. The use of commodities into a portfolio mitigates the potential for incurring losses while yet maintaining a satisfactory level of return.

### Table 5

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>Chi-square</th>
<th>Df</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSE Energy index</td>
<td>Crude Oil</td>
<td>2.00E-05</td>
<td>1</td>
<td>0.9964</td>
</tr>
<tr>
<td>Crude Oil</td>
<td>NSE Energy index</td>
<td>0.469554</td>
<td>1</td>
<td>0.4932</td>
</tr>
<tr>
<td>NSE Energy index</td>
<td>Natural Gas</td>
<td>0.030634</td>
<td>1</td>
<td>0.8611</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>NSE Energy index</td>
<td>0.814119</td>
<td>1</td>
<td>0.3669</td>
</tr>
</tbody>
</table>

Utilising the Toda and Yamamoto method for analysing Granger causality, the causal relationship between the NSE Energy index and energy commodities (crude oil and natural gas) is ascertained. The outcomes derived from the execution of this model are presented in Table 5.

The examination of the Toda and Yamamoto methodology begins by estimating the Vector Autoregressive (VAR) model, using the weekly closing price data of energy commodities and the NSE energy stock index. The Akaike information criterion, as shown in Table 2, is used to determine the lag duration. Subsequently, the augmented Vector Autoregressive (VAR) model is used to ascertain the order, with $d_{max}$ representing the maximum integration order of the variables and $p$ denoting the combined lag length. Given the absence of evidence to substantiate the existence of Granger causality, the null hypothesis is deemed valid in this statistical examination. The failure of the null hypothesis implies a probable existence of Granger causation between the series under study.

The study specifically concluded that there is no statistically significant relationship between the NSE energy index and energy commodities such as crude oil and natural gas. This supports the null hypothesis. This discovery implies that there is no meaningful correlation between energy commodities and the indices of the businesses they are associated with. This result is notable since previous research have shown evidence of the Granger causality connection between oil prices and the stock market (e.g., Huang et al., 1996; Sadorsky, 1999; Nwala, 2007). The results of this analysis align with other research that has questioned the existence of a cause-and-effect connection between energy commodities and the energy index (Gormus, 2012; Johnson & Soenon, 2014). Investors may mitigate portfolio risk by diversifying across both markets due to the absence of any causal feedback in either direction, suggesting that the two markets are mutually independent (Reddy and Sebastin, 2009; Yamori, 2010; Gormus, 2012).

Since there is no direct correlation between the commodities and stock markets, it is recommended to think about diversifying one's investment portfolio by containing both commodities and stocks. According to Ping et al. (2018), there has been a noticeable increase in the link between the stock market and commodities. However, it must be noted that different nations show different outcomes in this regard. The main rationale for these findings is because different countries' stock markets are fundamentally different. Differences in financial market volatility patterns and levels of speculation are two distinguishing features of stock markets in developing countries like China and India.

### 5 Conclusion

The recent advancements in the Indian commodity market, facilitated by the Security and Exchange Board of India (SEBI), have expanded the accessibility of commodities to private investors.
6 References


The findings of this study indicate that energy commodities had the potential to serve as instruments for achieving portfolio diversification and hedging objectives over an extended period, hence reducing the level of risk exposure. This is due to the lack of co-integration and the causal link between the energy index and commodities. Utilising ARDL bound and Toda and Yamamoto tests, respectively, this research looked at weekly data from 2007-2014, with an emphasis on India, to empirically assess the connection between the energy index and commodities. The integration and the causal link between the energy index and commodities. This development holds considerable importance for the financialization of commodity market. Moreover, India exhibits a significant reliance on imports of its energy demands, with over 85 percent of its crude oil needs being sourced from external suppliers. The introduction of futures contracts for WTI Crude Oil and Natural Gas. The introduction presents a novel investment possibility for Indian investors, aiming to enhance portfolio diversification and mitigate exposure to commodity price volatility. Additionally, it reduces dependence on international exchanges and enhances market liquidity within India, hence leading to improved pricing efficiency of essential commodities within the nation. This development holds considerable importance for the financialization of commodity market. Moreover, India exhibits a significant reliance on imports of its energy demands, with over 85 percent of its crude oil needs being sourced from external suppliers. The introduction of futures contracts for WTI Crude Oil and Natural Gas. The introduction presents a novel investment possibility for Indian investors, aiming to enhance portfolio diversification and mitigate exposure to commodity price volatility. Additionally, it reduces dependence on international exchanges and enhances market liquidity within India, hence leading to improved pricing efficiency of essential commodities within the nation.


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