COINTEGRATION ANALYSIS OF CRUDE OIL PRICES IN INDIA AND THE NIFTY AUTO INDEX RETURNS: AN EMPIRICAL INVESTIGATION

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ABSTRACT

The energy source for the manufacturing and industrial activities the crude oil is a very important. This article has studied on Nifty Auto Index returns on crude oil prices. The study has been envisaged on select 15 automobile companies applying Augmented Dickey-Fuller Test on secondary data for 10 years period. The purpose of the study is to understand whether there is an impact of crude oil prices in the long run and as well to study the movements of the price changes with the strength of their relationship. Appropriate statistics are applied for examination.

Keywords:

ADF test: Augmented Dickey-Fuller Test

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Introduction:

The association between crude oil prices and the Nifty Auto Index returns, which represent the performance of the automotive sector in India, has been a subject of interest for researchers and market participants. Understanding this relationship is crucial as crude oil prices can have significant implications for the profitability and performance of the auto industry, which, in turn, can impact the stock market.

Crude oil prices are warped by an array of elements, including global supply and demand dynamics, earth science events, OPEC (Organization of the Petroleum Exporting Countries) decisions, and macroeconomic conditions. Fluctuations in oil prices can have wide-ranging effects on various sectors of the economy, and the automotive sector is particularly sensitive to changes in energy costs.

The Nifty Auto Index, on the other hand, is an indicator that tracks the prosecution of automobile associations registered on the National Stock Exchange of India. It includes companies involved in the manufacturing of vehicles, auto parts, and related services. The performance of the Nifty Auto Index reflects market sentiment towards the automotive sector and can be influenced by factors such as sales figures, consumer demand, regulatory changes, and input costs.

The association between crude oil prices and the Nifty Auto Index returns is often explored using econometric techniques, such as co-integration analysis, vector autoregressive models, and Granger causality tests. Researchers aim to investigate whether there continues a lengthy equilibrium association between these variables and examine the direction and magnitude of their interaction.

By examining this relationship, researchers aim to uncover the dynamics and potential collision of oil price movements on the performance of the automotive sector and the stock market returns of companies within the sector.

Review of Literature:

Garg, A., et al. (2017): This study analyzes the relationship between crude oil prices and sectoral stock returns in India, including the automotive sector. It examines the short-term and long-term dynamics using a vector autoregressive model and finds evidence of significant linkages between oil prices and the Nifty Auto Index returns.

Maitra, D., et al. (2014): This research examines the collision of crude oil prices on the stock market in India, including the Nifty Auto Index. It employs the Granger causality test and volatility analysis and finds an important association between oil prices and the Nifty Auto Index returns, indicating that oil price evolution has a spillover effect on the automotive sector.

Nandha, M., et al. (2012): This study focuses on the association between crude oil prices and stock market indices in China and India. It employs co-integration analysis and vector error correction model and finds proof of a long-term equilibrium association between oil prices and the Nifty Auto Index returns.

Kumar, S., & Singh, P. (2014): This research investigates the collision of oil price fluctuations on the Indian stock market, considering different sectors, including the automobile sector. It uses co-integration analysis and the Granger causality test and finds a significant long-term association between crude oil prices and the Nifty Auto Index returns.

Mohanty, B. P. (2015): This study examines the collision of crude oil prices on the Indian stock market, with a specific focus on the automotive and banking sectors. It employs co-integration analysis and the vector error correction model and finds proof of a long-term association between oil prices and the Nifty Auto Index returns.

Need for the study/ Research Gap: Existing literature might have primarily examined the association between crude oil prices and the overall stock market, neglecting the specific dynamics of the automotive sector. A research gap exists in analyzing the co-integration and long-term association specifically between crude oil exports and the Nifty Auto Index, which represents the auto industry in India.

Statement of the problem: Based on the research gap, the problem statement would be to understand the long-term association between the Indian crude oil prices in India and NIFTY AUTO index daily returns.

Objectives of the study

1. Do crude oil prices in India impact the NIFTY AUTO index returns in the long term?
2. Do they move in the same direction or not?
3. What is the strength of their relationship?

Methodology for the study:

Source of data: The period of the study is 10 years of daily adjusted price returns of the above companies aggregated as the NIFTY AUTO index (dependent variable) and 10 years of daily prices of Crude oil in India are considered as independent variables. Nifty Auto Index data is collected from the official site of MSE and Crude oil prices data has been obtained from the government databases. Sample Size consists of NIFTY AUTO which consists of 15 companies namely.

1. Ashok Leyland
2. Bajaj Auto
3. Bal Krishna Industries
4. Bharat Forge
5. Bosch
6. Eicher Motors
7. Hero MotoCorp
8. M.R.F.
9. Mahindra & Mahindra
10. Maruti Suzuki
11. Samvardhana Motherson International Ltd
12. Sona BLW Precision Forgings
13. TVS Motor Company
14. Tata Motors
15. Tube Invest India

Statistical Tools Used in the Study:

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Linear Regression Model:

The linear regression statistical modeling method is used to investigate the relationship between a dependent variable and one or more independent variables. It assumes that the variables have a linear relationship and that the dependent variable can be predicted using the independent variables.

The general form of a linear regression model can be expressed as:

$Y = \beta0 + \beta1X1 + \beta2X2 + ... + \beta nXn + \varepsilon$

Where:

Y is the dependent variable or the variable to be predicted.
X1, X2, ..., and Xn are the independent variables or predictors.
β0, β1, β2, ..., βn are the coefficients or parameters that determine the relationship between the dependent variable and the independent variables.
ε represents the error term or residual, which captures the variability that is not explained by

Augmented Dickey-Fuller test *(*ADF*)* tests (stationarity test)

The Augmented Dickey-Fuller (ADF) test is a statistical test used to determine whether a time series is stationary or not. The ADF test is an extension of the simpler Dickey-Fuller test, which tests for the presence of a unit root in a time series.

The test is to check the stationarity in the series of data before performing the cointegration test. We should conduct the Augmented Dickey–Fuller test (ADF), by calculating.

The P value should be less than 0.05 then the data be stationary data to proceed with the Johansen cointegration test.

$\Delta Y_t = \phi Y_{t-1} + U_t$

Granger- Causality Test (Cointegration test)

The Granger causality test is a statistical test used to determine if a one-time series variable can predict another time series variable. It helps in assessing the causal relationship between two variables based on their past values. The mathematical formula for the Granger causality test can be represented as follows:

Consider two-time series variables, X and Y, where X is the potential causal variable, and Y is the potentially influenced variable. We want to test if X Granger causes Y.

The null hypothesis (H0) of the Granger causality test states that X does not Granger cause Y. The alternative hypothesis (H1) suggests that X does Granger cause Y.

The general mathematical formula for the Granger causality test is as follows:

Yt = αY + βX + ε1t (Model 1)
Yt = γY + δX + ε2t (Model 2)

where:

Yt represents the value of the dependent variable Y at time t.
Xt represents the value of the potential causal variable X at time t.
α, β, γ, and δ are the coefficients to be estimated.
ε1t and ε2t are the error terms or residuals of the models.

The Granger causality test involves estimating these two models using methods such as Ordinary Least Squares (OLS) regression. The test then examines the statistical significance of the coefficients β and δ to determine if X Granger causes Y.

If the coefficient β is found to be statistically significant while the coefficient δ is not, it suggests that X Granger causes Y. On the other hand, if the coefficient δ is significant while the coefficient β is not, it indicates that Y Granger causes X. If both coefficients are statistically significant, it suggests bidirectional causality between X and Y.

the P value should be less than 0.05 then the data is in stationary data to proceed with the Johansen cointegration test.

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$$\Delta Y_t = \phi Y_{t-1} + U_t$$

Data Analysis and Interpretation

Constructing a Linear Regression model:

We construct a linear regression model that measures the mathematical relation between the independent variable (Crude Oil Prices) and the dependent variable (NIFTY AUTO index returns)

```
> m<-lm(g$adjcl~g$coil)
> summary(m)

Call:
lm(formula = g$adjcl ~ g$coil)

Residuals:
     Min       1Q   Median       3Q      Max
-10547.0   -813.2    214.2   1662.3   3651.1

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 6.932e+03  1.173e+02   59.09   <2e-16 ***
g$coil      6.628e-03  3.456e-04   19.18   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2168 on 2465 degrees of freedom
Multiple R-squared:  0.1298,    Adjusted R-squared:  0.1295
F-statistic: 367.7 on 1 and 2465 DF,  p-value: < 2.2e-16
```

Thus, we have created a regression model for the two variables. Now we proceed to perform the stationarity test.

Augmented Dickey-Fuller test (ADF) tests (stationarity test)

We calculate the stationarity test for the residuals of the linear model. Only non-rationalized data unfolds the possibility for cointegration.

```
> r<-m$residuals
> adf.test(r)

        Augmented Dickey-Fuller Test

data:  r
Dickey-Fuller = -2.1627, Lag order = 13, p-value = 0.5094
alternative hypothesis: stationary

> str(g)
tibble [2,467 × 2] (S3: tbl_df/tbl/data.frame)
 $ adjcl: num [1:2467] 13983 13890 13864 13768 13890 ...
 $ coil : num [1:2467] 519917 520074 519061 518622 517327 ...
```

Null Hypothesis: The data is not stationary. Alternative Hypothesis: The data is stationary. Since p>0.05, we accept the null hypothesis.

Thus, the data is not stationary, and we can proceed to perform a cointegration test.

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Granger Causality Test

We perform the cointegration test to understand the long-term association between our independent variable (Crude Oil Prices) and the dependent variable (NIFTY AUTO index returns).

```
> library(lmtest)
> grangertest(g$adjcl~g$coil,order=1)
Granger causality test

Model 1: g$adjcl ~ Lags(g$adjcl, 1:1) + Lags(g$coil, 1:1)
Model 2: g$adjcl ~ Lags(g$adjcl, 1:1)
  Res.Df Df       F    Pr(>F)
1   2463
2   2464 -1 22.487 2.236e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

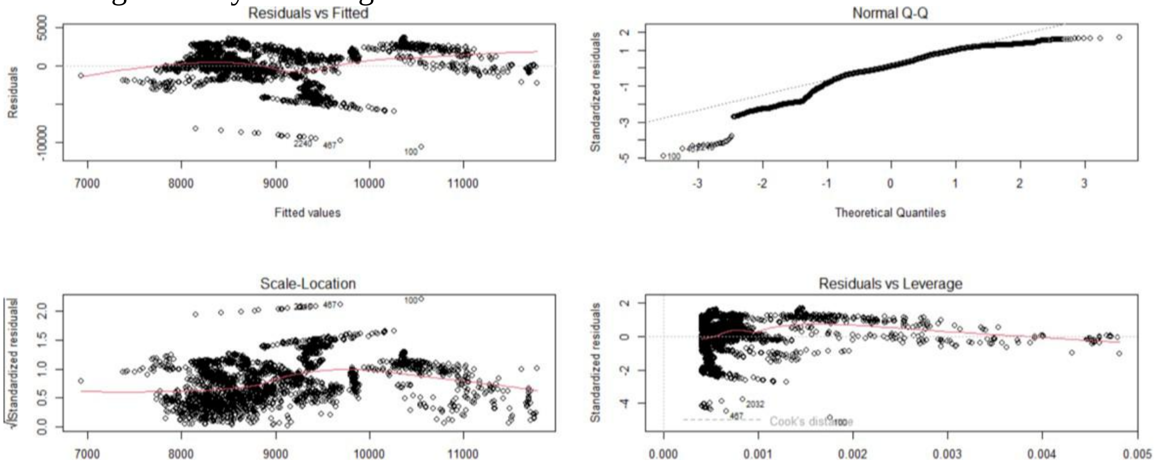
Thus, it is evident that the co-integration between the dependent and the independent variable is significant at Lag 1.

Findings and recommendations

Based on the obtained findings from the stationary test and co-integration analysis, we can draw the following conclusions:

Stationary Test: The findings indicate that the residuals of the linear model are non-stationary, which means they do not exhibit a constant mean and variance over time. This implies that the variables in the model are not stationary individually.

Cointegration Test: The results suggest a significant cointegration between the independent variable (Crude Oil Prices) and the dependent variable (NIFTY AUTO index returns) at Lag 1. Cointegration implies a long-term association or relationship between the variables, indicating that they move together over time.



The plot of the linear model

Based on these findings, we can make the following recommendations:

Explore the direction of causality: Cointegration does not imply causality but suggests a long-term relationship between the variables. To determine the direction of causality between

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Crude Oil Prices and NIFTY AUTO index returns, further analysis such as the Granger causality test or other time series econometric methods can be employed.

Consider a dynamic model: Given the significant co-integration at Lag 1, it may be useful to explore the dynamics and lagged effects between the variables by incorporating lagged terms or dynamic models. This can help capture the short-term adjustments and lead-lag relationships between Crude Oil Prices and NIFTY AUTO index returns.

Monitor and the NIFTYss the relationship over time: Since the co-integration relationship is significant at Lag 1, it is important to monitor and reassess the relationship between Crude Oil Prices and NIFTY AUTO index returns periodically. Changes in market conditions, economic factors, or policies can impact the long-term association between the variables, necessitating regular evaluation of the relationship.

Findings

1. The data is not stationary, and we proceeded to perform a cointegration test. There is a co-integration between the dependent and the independent variable is significant at Lag 1.
2. Assess the direction of causality: Determine the direction of causality between Crude Oil Prices and NIFTY AUTO index prices. This can be done by examining the Granger causality test or employing other econometric techniques. Understanding the causal relationship can provide insights into whether changes in Crude Oil Prices drive movements in the NIFTY AUTO index prices or vice versa.
3. Consider hedging strategies: If there is a significant co-integration relationship between Crude Oil Prices and NIFTY AUTO index prices, it implies that changes in Crude Oil Prices can impact the NIFTY AUTO index. Consider implementing hedging strategies to manage the risks associated with these price movements. For example, hedging positions in the futures market or using options to protect against adverse price fluctuations can be considered.
4. Monitor global oil market dynamics: Keep a close eye on global oil market dynamics and factors that can influence Crude Oil Prices. Factors such as geopolitical events, supply and demand dynamics, production levels, and OPEC decisions can all impact oil prices. By staying informed about these factors, you can anticipate potential changes in Crude Oil Prices and their subsequent impact on the NIFTY AUTO index.
5. Conduct sensitivity analysis: Perform sensitivity analysis to assess the magnitude of the impact of changes in Crude Oil Prices on the NIFTY AUTO index. This analysis can help quantify the relationship and determine the sensitivity of the index to fluctuations in oil prices. It provides valuable insights into the potential risks and opportunities associated with changes in Crude Oil Prices.
6. Explore diversification opportunities: Consider diversifying your investment portfolio by including assets that are inversely correlated with Crude Oil Prices. By incorporating assets that have a negative relationship with oil prices, such as renewable energy stocks or alternative energy investments, you can potentially mitigate the impact of oil price movements on your portfolio.
7. Stay informed about industry-specific developments: Stay updated on developments within the automotive sector, as they can significantly influence the NIFTY AUTO index. Factors such as technological advancements, regulatory changes, consumer preferences, and macroeconomic conditions can impact the performance of the automotive industry and, consequently, the NIFTY AUTO index.
8. Continuously review and update your investment strategy: Given the cointegration between Crude Oil Prices and NIFTY AUTO index prices, regularly review and update your investment strategy. Monitor the changing dynamics of both variables and adjust your investment decisions accordingly. This could involve rebalancing your portfolio, adjusting allocation weights, or adopting a more dynamic investment approach.

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Conclusion

In conclusion, the analysis reveals a significant co-integration between Crude Oil Prices and NIFTY AUTO index returns. This indicates a stable and long-term relationship between these variables, suggesting that changes in Crude Oil Prices have a meaningful impact on the NIFTY AUTO index returns. The co-integration is found to be significant at Lag 1, indicating that the relationship is observed with a one-period time delay.

The findings highlight the importance of considering Crude Oil Prices as a factor when analyzing or forecasting NIFTY AUTO index returns. Monitoring the movements and trends in Crude Oil Prices can provide valuable insights into the potential behavior of the NIFTY AUTO index, aiding in informed investment decisions within the automotive sector.

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