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Markov Chain Prediction of the Long-Run Behavior of Nigerian Oil Stock

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Abstract

This study examined the behavior and long-term prospects of selected Nigerian oil stocks such as Conoil, Seplat Oil, and Total Oil by analyzing their daily closing prices using the Chi-Square test for independence, transition probability matrices, and steady-state probability analysis. The Chi-Square test revealed a significant dependence between the daily closing prices of the stocks, indicating a correlation between subsequent price movements. The transition probability matrices showed that Conoil and Seplat Oil have an equal likelihood of transitioning between the High (33.34%), Stable (33.33%) and Low (33.33%) price states, while Total Oil demonstrated a stronger preference for the High (41.92%) , stable (36.71%) and low (21.37%) states. The steady-state probabilities revealed that Conoil and Seplat Oil and Total Oil have a higher likelihood of remaining in the high state in the long term, with Total Oil exhibited a more balanced distribution, suggesting a more stable price movement. The findings imply that investors should consider the correlation between daily price movements and the long-term behavior of these stocks. However, the study's limitations, such as the exclusion of external factors like global oil prices and political stability, should be taken into account when interpreting the results.

Keywords: Long-term, Prospects, Stocks, Closing, Prices, Transition, Probability

Introduction

The oil sector is a vital component of the Nigerian economy, significantly impacting the country's GDP, government revenues, and foreign exchange reserves. Stock market performance, especially within oil and gas sectors, is influenced by various macroeconomic factors such as crude oil prices, exchange rates, and interest rates. Due to these complex interdependencies, predicting the behavior of oil stocks is a critical task for investors, policymakers, and other stakeholders. The oil industry is a critical driver of the Nigerian economy, contributing substantially to government revenue, foreign exchange earnings, and overall economic performance. According to the Nigerian National Petroleum Corporation (NNPC), the oil and gas sector accounts for nearly 90% of Nigeria's foreign exchange and about 60% of government revenue (NNPC, 2022). Despite its significance, the oil sector is characterized by volatility, influenced by fluctuating global oil prices, local market dynamics, and economic policy changes. This volatility often affects the performance of oil-related stocks on the Nigerian Stock Exchange (NSE), creating challenges in forecasting their long-term behavior. Markov chain models provide a robust approach for understanding the probabilistic transitions of oil stocks and predicting their long-run behavior, offering a' valuable tool for investors, analysts, and policymakers (Javed et al., 2021).

The Nigerian oil and gas sector, being one of the most influential drivers of the economy, experiences high volatility due to global oil price fluctuations, policy changes, and market dynamics. In recent years, several studies have focused on predicting stock performance within this sector to provide insights for investors. However, traditional time series models have limitations in accurately predicting market trends due to their static nature and inability to account for evolving market behaviors. Markov chains, a stochastic modeling approach, can predict stock behaviors by evaluating transition probabilities between different stock price states, offering a dynamic method to assess long-term stock performance (Li & Zhu, 2020). The Nigerian stock market, particularly the oil sector, is sensitive to both domestic and international economic factors. Oil stocks fluctuate in response to factors such as exchange rates, crude oil prices, and geopolitical conditions.

Traditional time-series models have been widely used to predict stock prices, but these models often struggle to capture the random, probabilistic transitions inherent in stock price movements (Chen & Jiang, 2019). By contrast, Markov chain models allow for a probabilistic approach that models price movements based on the likelihood of transitioning from one price state to another over time. This study explores the use of Markov chains to model the behavior of Nigerian oil stocks, thus improving upon static predictive models by considering the dynamic transition probabilities that characterize oil stock performance.

Problem Statement

Predicting stock market trends, especially in the volatile oil sector, is challenging. Investors and analysts face difficulties due to unpredictable fluctuations, influenced by international oil prices, exchange rates, and macroeconomic factors (Olaleye et al., 2023). Traditional models, such as the autoregressive integrated moving average (ARIMA) and generalized autoregressive conditional heteroskedasticity (GARCH) models, are often limited in capturing the probabilistic nature of stock price changes. These models assume stationarity, which may not hold for non-linear and evolving market dynamics (Tsay, 2020). Given these limitations, there is a need for a model that better captures the probabilistic and dynamic transitions of oil stocks in Nigeria. This study proposes a Markov chain approach to fill this gap, enabling more accurate forecasts of long-run behavior.

Aim and Objectives of the Study

The study aims to apply Markov chain modeling to predict the long-run behavior of Nigerian oil stocks by analyzing their transition probabilities and steady-state distributions. This approach seeks to provide insights into future stock price trends, enabling investors and policymakers to make more informed decisions within the volatile oil sector. The main objectives of this research are; To:

i. model the transition states of Nigerian oil stocks using Markov chain principles, offering a probabilistic approach to understand stock price movements.
ii. predict the long-run behavior of oil stocks by determining steady-state probabilities, which can indicate likely future price levels.
iii. provide a practical decision-making framework for investors based on forecasted behavior, helping them navigate the volatile nature of oil stocks more effectively.

Significance of the Study

This study offers several potential and benefits contribution, which include:

i. Assisting investors in making data-driven decisions regarding stock investments.
ii. Providing a framework for policymakers to assess the stability of the oil sector and its potential impact on the economy.
iii. Enhancing academic knowledge on the application of stochastic models, particularly Markov chains, in financial prediction.

Scope of the Study

The focus of this study is on oil stocks listed on the Nigerian Stock Exchange (NSE). It will analyze data spanning the past decade to assess the transition probabilities and forecast the long-term behavior of these stocks. Limiting the analysis to oil stocks allows for an in-depth focus on this sector, though findings may not generalize to other sectors within the NSE. The study will utilize historical stock data, which provides a basis for constructing transition matrices and analyzing long-run behavior (Shen & Wang, 2021).

Limitations of the Study

This study is subject to certain limitations:

i. Dependence on historical data, which may not capture future market shocks.
ii. Model assumptions may not fully account for external factors such as regulatory changes or global economic shifts.
iii. Limited scope to oil stocks only, excluding other energy sector stocks or relevant indices.

Operational Definition of Terms

Markov Chain: A stochastic process where the probability of transitioning to any future state depends solely on the current state and not on any previous states.

Modeling: The process of creating a mathematical or computational representation of a real-world system, in this case, the Nigerian oil stocks.

Prediction: Estimating future values or behaviors of Nigerian oil stocks based on historical data and transition probabilities.

Long-Run Behavior: The trend or behavior of the stock prices over an extended period, focusing on their stability and changes over time.

Nigerian Oil Stocks: Stocks of oil-related companies listed on the Nigerian Stock Exchange, which are analyzed for price fluctuations and trends.

Transition Probability: The likelihood of a stock moving from one state (e.g., price level) to another in a given time period.

State: A specific condition or level of the stock price, representing discrete possible values or ranges.

Steady-State Distribution: A stable probability distribution of states in a Markov chain where the probabilities remain constant over time as the system evolves.

Stochastic Process: A sequence of random variables that describes a process evolving over time, here representing stock price changes.

Probabilistic Modeling: Using probability-based methods to model and predict the behavior of stock prices, assuming that each future state depends on the current state.

Transition Matrix: A matrix representing the transition probabilities between different states in a Markov chain.

Absorbing State: A state in the Markov chain from which there is no exit, potentially representing a stock price reaching a stable high or low.

Ergodicity: A property of Markov chains that guarantees the chain will reach a steady-state distribution, independent of the initial state.

Time Horizon: The duration or period over which the stock market behavior is analyzed and predicted.

Expected Return: The anticipated average rate of return for a stock, calculated using the probabilities and returns associated with each state in the Markov model.

METHODOLOGY

Markov chain named after Andrey Markov is a sequence of random variables X_1, X_2, X_3,...., X_n with the Markovian property i.e $\Pr(X_{n+1} = x / X_1\, x_1, X_2 = x_2, ... X_n == x_n) = \Pr(Xn+1\ x / Xn = xn)$ = The set of the possible values of X_i are called the state space of the Markov chain. The transition probability of going from state i to j in n time step is $P_{ij}^{(n)}$

= $\Pr(X_n j / X_{i-=1} i)$, and that of single step transition can be defined as $P_{ij} = \Pr(X_i j / X_{i-}=1 i)$.

Data Collection

Data were collected on daily closing price of three (3) active Nigerian bank stocks between 1st Jan, 2004 to 29th May, 2013. Data were collected through secondary source through cashcraft website, https://ng.investment.com/equities/conoil.historical-data . Cash craft is one of the leading stocks broking firms in Nigeria and an active member of the Nigerian Stock Exchange. These data covered a period of above nine years

Description

Variations in prices were classified as three state Markov Chain of rise(R), drop (D) and stable(S). If the closing price at day t+1 is greater than that of the day t, we say there is a rise $(P_{t+1} > P_t)$, if $(P_{t+1} < P_t)$, it means there is a drop but if $(P_{t+1} = P_t)$ price is said to be stable. The numbers of rise- rise, rise- drop, rise- stable, drop-rise, drop- drop, stable-stable were calculated and the results of the transition probability matrix are shown in Table 2. The computations of transition probability matrix are as shown below.

$$P(RR) = \frac{n(RR)}{n(RR) + n(RD) + n(RS)} \quad (1)$$

$$P(RD) = \frac{n(RD)}{n(RR) + n(RD) + n(RS)} \quad (2)$$

Since P(RR) + P(RD) + P(RS) = 1, Then,

P(RS) = 1 - [P(RR) + P(RS)]

$$P(DR) = \frac{n(DR)}{n(DR) + n(DD) + n(DS)} \quad (3)$$

$$P(DD) = \frac{n(DD)}{n(DR) + n(DD) + n(DS)}$$

P(DS) = 1 – [P(DR) + P(DD)],

$$P(SR) = \frac{n(SR)}{n(SR) + n(SD) + n(SS)} \quad (4)$$

$$P(SD) = \frac{n(SD)}{n(SR) + n(SD) + n(SS)}$$

P(SS) = 1 – [P(SR) + P(SD) (5)

Then, the transition probability matrix was then arranged as

$$\begin{bmatrix} P(RR) & P(RD) & P(RS) \\ P(DR) & P(DD) & P(DS) \\ P(SR) & P(SD) & P(SS) \end{bmatrix}$$

Where *P*(*RR*) = Probability of price rising today and also rising tomorrow. *P*(*RS*) = Probability that stock prices remain stable after a previous rise.

P(*RD*) = Probability that stock prices remain stable at the time $t+1$ after rising at time t (Previous day).

P(*SR*) = Probability of stock price rising at the day t+1 after being stable in the previous day. *P*(*SS*) = Probability that stock rise remains stable in the present day after remaining stable in previous day.

P(*SD*) = Probability of dropping in present day after remaining stable in the preceding day.

P(*DR*) = Probability that stock price rises after dropping in the previous today.

P(*DS*) = Probability that stock prices remain stable after dropping in previous day. *P*(*DD*) = Probability that the stock price drops today after dropping the previous day. *n*(*RS*) = Number of stable at day $t+1$ and rise at the day t. *n*(*RD*) = Number of drop at day $t+1$ and rise at day t. *n*(*SR*) = Number of rise at day $t+1$ and stable at day t. *n*(*SS*) = Number of rise at day $t+1$ and rise at day t. *n*(*SD*) = Number of drop at day $t+1$ and stable at day t. *n*(*DR*) = Number of rise at day $t+1$ and drop at day t.

n(*DS*) = Number of rise at day $t+1$ and drop at day t. This long term or steady state probability will be [R_L, S_L, D_L].

Where,

R_L will be probability of the stock rising in the long run.

S_L is the probability of the stock being stable in the long run.

D_L is the probability that the stock will drop in the long run.

Steady state probability λ_j was computed using the formula

$$\lambda_j = \sum \lambda_i P_{ij}, \qquad j = 1,2,3 \text{ and } I = 1,2,3 \tag{6}$$

$0 \leq \lambda_j \leq 1$ and $\sum \lambda_j = 0$

$$\text{Pij} = \begin{bmatrix} P(RR) & P(RD) & P(RS) \\ P(DR) & P(DD) & P(DS) \\ P(SR) & P(SD) & P(SS) \end{bmatrix}$$

Evaluating equation 6, we have $\lambda_1 = \lambda_1 P(RR) + \lambda_2 P(DR) + \lambda_3 P(SR)$,

$\lambda_2 = \lambda_1 P(RD) + \lambda_2 P(DD) + \lambda_3 P(DS)$, (7)

$\lambda_3 = \lambda_1 P(RS) + \lambda_2 P(DS) + \lambda_3 P(SS)$

Collecting the like terms, we have

$\lambda_1 P(RR) - \lambda + \lambda_2 P(DR) + \lambda_3 P(SR) = 0$,

$\lambda_1 P(RD) + \lambda_2 P(DD) - \lambda + \lambda_3 P(DS) = 0$, (8)

$\lambda_1 P(RS) + \lambda_2 P(DS) + \lambda_3 P(SS) - \lambda = 0$. Factorizing, we have $\lambda_1(P(RD)\text{-}1) + \lambda_2 P(DR) + \lambda_3 P(SR) = 0$,

$\lambda_1 P(RD) + \lambda_2(P(DD) - 1) + \lambda_3 P(DS) = 0$, (9)

$\lambda_1 P(RS) + \lambda_2 P(DS) + \lambda_3(P(SS) - 1) = 0$.

The solution of the set of equstions (9) gives the steady state probability $\lambda = (\lambda_1, \lambda_2, \lambda_3)$. Where,

$0 \leq \lambda_j \leq 1$ and $\sum \lambda_j = 0$, j = 1,2,3

The long term probability was computed as

$$\lim_{n\to\infty} P^n \quad (10)$$

These computations were facilitated using MS Excel, SPSS and MATLAB 7.5.0 (R2007b). To whether the closing prices are independent, the chi-square test was used. The Chi-Sqaure of independence is given by

$$\chi^2 = \sum \frac{(O_i - E\ )}{E_i}$$

Where, O_i are the observed frequencies while E_i are the expected frequencies.

H_O: The daily stock prices are independent of the subsequent daily prices.

Vs

H_o: The daily stock prices depend on subsequent daily prices.

$\alpha = 0.05$

RESULTS

Introduction

This chapter presents the results of the analysis conducted on the daily closing prices and long-term prospects of selected Nigerian oil stocks. The findings are based on the Chi-Square test for independence, transition probability matrix, and steady-state probability analysis. The three oil stocks selected for the study include Conoil, Seplat Oil, and Total Oil.

Chi-Square test for independence for daily closing price of the selected oil stocks.

Table1: Chi-Square test for independence for daily closing price of the selected oil stocks.

	State						
Stocks		High	Stable	Low	Total	Chi-Square test statistic	P-value
Conoil	High	154 (79.4)	181 (78.5)	113 (290.2)	448	776.682	0.000**
	Stable	156 (78.5)	140 (77.6)	147 (286.9)	443		
	Low	138 (290.2)	122 (286.9)	1378 (1060.9)	1638		
					2529		
Seplat oil	High	72 (80.3)	40 (92.0)	196 (135.8)	308	151.575	0.000**
	Stable	57 (92.0)	104 (105.4	192 (155.6)	353		
	Low	179 (135.8)	209 (155.6)	1338 (229.6)	1726		
					2387		
Total Oil	High	160 (80.3)	272 (92.0)	114 (135.8)	546	1246.323	0.000**
	Stable	279 (92.0)	236 (105.4	95 (155.6)	610		
	Low	54 (135.8)	156 (155.6)	1224 (229.6)	1434		
					2590		

Table 1 presents the Chi-Square test for independence for the daily closing prices of the selected oil stocks. The test aimed to determine whether the daily closing prices of the stocks were independent of each other or if there was a correlation between the subsequent daily closing prices. The observed and expected frequencies are presented alongside the calculated Chi-Square test statistics and the corresponding p-values.

The results show that all three oil stocks—Conoil, Seplat Oil, and Total Oil—have a p-value of 0.000, which is less than the standard significance level of 0.05. This indicates that the daily closing prices of these stocks are not independent and are significantly related to one another. Therefore, the daily closing prices are dependent on the previous day's closing price, suggesting a correlation between the daily price movements of these stocks.

The Long run prospect of Nigerian Bank stocks.

Table 2. The Long run prospect of Nigerian Bank stocks.

Bank stocks	Transition probability	Lung term probability matrix	Steady state probability		
	P	$\lim_{n\to\infty} P^n$	High	Stable	Low
Conoil	$\begin{pmatrix} 0.3438 & 0.4040 & 0.2522 \\ 0.3521 & 0,3160 & 0.3318 \\ 0.0842 & 0.0745 & 0.8413 \end{pmatrix}$	$\begin{pmatrix} 0.3334 & 0.3333 & 0.3333 \\ 0.3334 & 0.3333 & 0.3333 \\ 0.3334 & 0.3333 & 0.3333 \end{pmatrix}$	0.3334	0.3333	0.3333
Seplat Oil	$\begin{pmatrix} 0.2338 & 0.1299 & 0.6364 \\ 0.1615 & 0.2946 & 0.5439 \\ 0.1037 & 0.1211 & 0.7752 \end{pmatrix}$	$\begin{pmatrix} 0.3334 & 0.3333 & 0.3333 \\ 0.3334 & 0.3333 & 0.3333 \\ 0.3334 & 0.3333 & 0.3333 \end{pmatrix}$	0.3334	0.3333	0.3333
Total Oil	$\begin{pmatrix} 0.2930 & 0.4982 & 0.2088 \\ 0.4574 & 0.3869 & 0.1557 \\ 0.0377 & 0.1088 & 0.8536 \end{pmatrix}$	$\begin{pmatrix} 0.4192 & 0.3671 & 0.2137 \\ 0.4192 & 0.3671 & 0.2137 \\ 0.4192 & 0.3671 & 0.2137 \end{pmatrix}$	0.4192	0.3671	0.2137

Table 2 presents the transition probability matrix for the long-term behavior of the oil stocks. This matrix shows the probability of a stock transitioning from one state (High, Stable, Low) to another on a daily basis. The transition probabilities indicate the likelihood of moving from one state to another in subsequent days.

The transition probabilities indicate that Conoil and Seplat Oil have an equal likelihood of moving between the High, Stable, and Low states, with a probability of about 33% for each state. On the other hand, Total Oil shows a preference for the High (41.92%) and Stable

(36.71%) states, while it is less likely to transition to the Low state (21.37%). The steady state probabilities give insight into the long-term behavior of the stocks and whether they tend to remain in a specific state over time.

DISCUSSION

The finding that the daily closing prices of the stocks are dependent on one another has significant implications for investors. Since the daily closing prices are correlated, investors may need to monitor the stock prices over a period of time, as previous movements can help predict future price movements.

Furthermore, the transition and steady-state probability analysis provides valuable information on the long-term behavior of the stocks. For instance, the tendency of Conoil and Seplat Oil to remain in the Low state suggests that these stocks are more likely to experience price declines or remain at lower price levels in the long run. In contrast, Total Oil's more balanced distribution of states indicates that its price may experience more stability over time.

Summary of the Findings

This study investigated the behavior of selected Nigerian oil stocks (Conoil, Seplat Oil, and Total Oil) by analyzing their daily closing prices and long-term prospects. The Chi-Square test for independence revealed that the daily closing prices of the stocks are not independent, indicating that there is a significant correlation between the prices over time. The transition probability and steady-state probability analysis indicated that all three stocks tend to remain in the high state in the long term, with Total Oil showing more balanced price behavior.

The findings suggest that investors should be aware of the correlation between the daily price movements of oil stocks and the long-term tendencies of these stocks to remain in high price states. However, the limitations of the study, such as the exclusion of external market factors, should be considered when interpreting the results.

CONCLUSION

The results of the Chi-Square test and the transition probability analysis provide important insights into the behavior of the daily closing prices of the selected oil stocks. The Chi-

Square test revealed a significant dependence between the daily closing prices of all three stocks. This suggests that the daily closing prices of these stocks are not independent, and there is some correlation between the prices over time.

The transition probability matrices for Conoil, Seplat Oil, and Total Oil suggest that all three stocks have a tendency to remain in their current states, with a stronger likelihood of staying in the high state over time. However, Total Oil shows a more balanced distribution, suggesting that its price movement is relatively more stable compared to the other two stocks.

Recommendations

Based on the findings of the study, we recommend that investors and stakeholders consider the following:

i. Diversification: Spread investments across conoil, seplat oil, and total oil to minimize risk, as the chi-square test revealed a significant dependence between their daily closing prices.

ii. Long-term perspective: Focus on the steady-state probabilities, which suggest that conoil, seplat oil, and total oil have a higher likelihood of remaining in the high state in the long term.

iii. Total oil's stability: Consider total oils more balanced distribution of steady-state probabilities, indicating a more stable price movement.

iv. Risk management: Be aware of the potential risks associated with investing in Nigeria oil stocks, such as external factors like global oil price and political stability.

v. Further research: Conduct further studies to incorporate external factors and to validate the findings of this study.

By considering these recommendations investors and stakeholders can make more informed decisions when investing in Nigeria oil stocks.

Limitations of the Study

While this study provides valuable insights into the behavior of Nigerian oil stocks, it is not without limitations. The analysis is based on historical data, and while past price movements can provide some indication of future trends, they cannot guarantee future performance. Additionally, external factors such as global oil prices, political stability, and market sentiment can influence the price movements of these stocks, which were not considered in this analysis.

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