**A Matrix Approach in Predicting Stock Market Prices with Regularly Varying Perturbations**

**Abstract**

The behavior of a stock exchange marketcan be analysed through the temporal changes in volatile market variables in time so as to predict stock price fluctuations. However, a matrix application to Dangote stock market prices is considered where an illustrative case is provided in different forms. The systems of linear Equations were perturbed and there were no significant changes in the original systems which makes our model robust and stable. The statistical variables such as mean, kurtosis and skewness gave clear insight to investors about investment plans. Nevertheless, we developed, proved propositions and theorems. Finally, the results of propositions were simulated and graphical solutions obtained according to the value of each investment of different periods. This is informative to Dangote and other corporate investors develop strategies to achieve their investment goals and their daily decision making.

**Keywords: Stock prices, Investors, Matrix, Dangote and Perturbation.**

**MSC: 15A24;62P05;81Q15.**

* 1. **Introduction**

A stock in a stock market or in an investment signifies a share in the ownership of an incorporated company. Stocks are indication of ownership. Investors buy stocks in the hope that it will yield income from dividends and increase in value, or grow in value. Thus, market price is the current price at which an asset or service can be bought or sold. Economic theory contends that the market prices converge at a point where the forces of supply and demand meet. Market price of stock is the most recent price at which the stock was traded. It is the result of traders, investors and dealers interacting with each other in a market. However, Matrix plays a vital role in mathematics and several other sciences due to its numerous applications. The topic of matrix has a lot of great content for discussion and research. It offers countless beautiful theorems that are straight forward and yet striking on their formulation, uncomplicated and yet ingenious in their proof, and diverge as well as powerful in their application,[1] .

Nevertheless, lots of authors has written extensively on stock prices,[2] investigated different method for estimation of parameter of Weibull distribution using stock prices. In another dimension, [3] examined the applications of Markov Chain and the impact of time delay in assessing Nigeria Current Account (NCA) net movement. [4] Studied empirically the dynamics of asset value function only on periodic events of market prices. In the same vain, [5] examined stochastic system with changes to measure the value of wealth for each corporate investor through linear and quadratic returns. Also, [6] Investigated system of stochastic differential equations with prominence on disparities of drift parameter for stock market. More so, [7] presented solution of SDE and Fourier series expansion with delay parameter in the model. The empirical studies which show increase in delay parameter decreases the value of assets in time varying investment. [8] Considered stochastic differential equations with some imposed parameters in the model. The problem was solved by adopting Ito’s theorem to obtain an analytical solution which was used to generate various discrepancies on various asset prices. [9] studied the stochastic analysis of variation of critical stock prices was successfully analyzed through additive effect with influence of time. [10] Considered stochastic analysis of discrepancies of initial stock prices through multiplicative effects with the impact of time delay parameter in the model. In [11] study, the stochastic analysis of two asset values was successfully analysis through its close from analytical solution. [12]. Considered stability and controllability for stock exchange market were obtained; first by developing a vector valued stochastic differential system with control. [13] studied an empirical result of Stochastic Delay Differential Equation (SDE) was effectively exploited for the analysis of asset value through multiplicative effects with influence of time delay parameter. [14] Presents a reinsurer’s portfolio which is a combination of surplus and risky assets for both stochastic and deterministic cases. [15] Examined asset value and its return rates for economic investment plans. [16] Considered system of stochastic differential equation with emphasis on variations of drift parameter as it affects financial market. Many authors have extensively addressed the issues of stock prices such as [21 – 28].

In all, the assessment of stock market prices in the economy as a whole is more complicated due to the inherent stochastic behavior of stock market which brought a lot of dynamical changes, the rise and fall pattern of prices where investors are primarily affected in their decision by the expected returns, these decisions can be made realistic if a matrix application with perturbation changes are used. We are motivated due to the empirical application of matrix models on Dangote stock market prices and other considerable factors in the stock exchange market. To this end, we developed and proved propositions to show financial processes such as the expected profit of the investments in the future. The advantage of this present study over previous efforts is applying a matrix approach in predicting stock market prices of Dangote with regularly varying perturbations.

The plan of this paper is set as follows: Section 2.1 is Methodology, Section 3.1 presents Results and Discussion, Section 4.1 concludes the paper.

**2.1. Methodology**

We consider matrices imposed with the dynamics of stock quantities which is said to have a complete probability space such that a finite time investment horizon. Also considering an investment where dividends will not have been declared and no new assets have been purchased then stock return follows particular processes,[4] and [17].

Here, we use the form of matrix to present initial stock prices of Dangote Cement, PLC in order to note different uses of matrix algebra in analyzing stock market prices such as: to presents the quantity of Dangote stock prices during each period of trading, obtaining the solution of the systems which could be used for some demand specifications, the sum total of independent stocks according to sales, the relative amount of each cement according to sales, getting the total cost of cement to four key marketers to different locations.

Mathematically, Let  be the initial stock prices of Dangote chosen quarterly for independent years covering four months,(time is counted for trading days in multiples of fundamental unit, say quarter) . Also, let an  stock price data matrix associated with  be  We consider  stock prices over  months’ time horizon. For define the vector  by taken mean of each column data matrix such that  will be:

 (2.1)

The following are dynamics in illustrative cases.

**Case 1:** Let us assume this is a fair market and according to historical data where stock prices are represented in  matrix as follows:

 (2.2)

**Case 2 :** Let  represents disparities of order made from other companies to Dangote Cement PLC. Also let the initial stock prices of Dangote cement form system of linear equations, hence we have:

 (2.3)

and representing the solution of the systems by means of a row matrix which is:

 (2.4)

**Case 3:** Considering trading investments periods where new dividends will not have been declared, [20], the sum total of independent stocks according to sales is given as  matrix, [18]

 (2.5)

**Case 4**: Let  represents the relative amount of each Cement according to sales for Dangote in short trading period, [19]. we have the following:  .

 (2.6)

**Case 5**: Let  represents the Cost function in naira of getting raw material for production of cement is as follows:

 (2.7)

what will be the total cost . The total cost dynamics is defined as : , hence we have as follows



 (2.8)

**2.2 Regularly Varying Perturbation on System of Equations**

Here, by introducing perturbations into a system one gain insight into a system, which can help Dangote Cement to identify potential weakness or vulnerability. Suppose we now perturb the system of equations in (2.2) by adding a small random amount to each equation which gives as follows:

 (2.9)

where  are constants of customers demand stock market quantities and are random perturbation.

2.3 Statistical Metrics

However, when considering future investments, understanding the mean, kurtosis, and skewness of predicted stock prices can help investors or Dangote Cement make informed decisions. Hence, the following metrics are defined thus:

 (2.10)

 (2.11)

 (2.12)

where  is individual predicted stock prices, is the mean of the predicted stock prices and  is the number of predicted stock prices.

**2.4. Data Description**

The data set for this study were obtained from Nigerian Stock Exchange (NSE): Dangote Cement on the first quarter of four initial stock prices for different years (2021-2024).The right hand side on the system of linear equations above were obtained by calculating the mean of each of the data set row-wise.

**Theorem 2.1** : Let the Dangote stock price  is a nonnegative, integrable random variable with strictly increasing, continuous cumulative density function (cdf) is given as;



*Proof.*

Let be the cdf of  . Then

So to establish the claim we need to show that



Since the mapping

 is differentiable, with strickly increasing , continuous derivative



it reaches its unique minimum at 

**3.1 Results and Discussion**

Section presents analyzed results whose methods are stated in Section 2.1-2.2. which were implemented using Matlab programming software:

**Representation of Dangote Stock Market Prices:**



Case 1 presents the quantity of Dangote stock prices during each period of trading. The stock prices are full of uncertainties displaying stochastic formation of the trading pattern. Rising stock prices generally indicate that investors are optimistic about the company’s prospects, while falling prices indicates investor concerns or dissatisfactions. Dangote stock prices provides management with valuable information about the performances of the company’s stock and its standing in the market.

**Case II: System of Linear Equations using Dangote Stock Market Prices**







The systems of equations were solved using Matlab programming software and above solutions were obtained. This results shows  demand from major marketers of Dangote Cement .The less demand is due to high cost of cement across the country. When demand for a product like Cement is low, it can indicate several things about the market: low demand may reflect a weak economy or a decrease in construction activity, which can affect Dangote’s sales and profitability. If the market for Cement is saturated, with many suppliers offering similar products, low demand can indicate that there are more suppliers than buyers

**Case III: The sum total of independent stocks according to sales**



The relative amount of each cement according to sales are as follows: This provides investors with a way to gauge the size and potential value of a company. This scenario will help Dangote stocks with high market capitalizations (ie a large number of shares outstanding) tend to be more stable and less volatile than those with low market capitalizations. This makes them more appealing to risk-averse investors.

**Case IV: The Relative amount of each cement according to sales:**





This scenario provides Dangote with valuable information about its sales pattern and customer demand. Here , knowing the number of Cement bags sold to key marketers can help Dangote predict future sales and adjust production levels accordingly, which can help the company maximize profitability and avoid over-or under producing Cement

**Case V: Getting the total cost Cements to four key marketers to different locations :**



This can be valuable information for Dangote . Here are some ways this scenario can help:

Dangote can use this information to adjust pricing based on locations and market conditions, allowing them to maximize profits while remaining competitive in each market.

**Table 1: Predicted Dangote Stock Prices and other Statistical Variables**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
| 0.2535 | 0.2535 | 0.2535 | 0.2534 | 0.2535 | 0.2535 | 3.2500 | -1.500 |
| 0.2623 | 0.2623 | 0.2623 | 0.2623 | 0.2623 | 0.2623 | NAN | NAN |
| 0.2373 | 0.2372 | 0.2372 | 0.2372 | 0.2372 | 0.2372 | 3.2500 | 1.500 |
| 0.2379 | 0.2379 | 0.2378 | 0.2378 | 0.2379 | 0.2379 | 1.1667 | 0.4082 |

It is clear in Table 1, that the model is perturbed and the resulting predictions are not significantly different from the original predictions, this suggests that the model is robust or stable in the face of small changes. In other words, the model is able to withstand small changes in inputs or assumptions without significantly changing its predictions. This is generally a good thing for investors or Dangote’s company as it suggests that the model is less likely to be influenced by minor fluctuations or variations in the underlying stock data or assumptions. In all, this can provide a greater degree of confidence in the model’s predictions, which can help Dangote make informed investment decisions.

The values provides a more conservative estimate of stocks which can help investors manage risk and make more informed investment decisions, see column 6. The kurtosis is a measure of the ‘’flatness’’ or peakedness of a distribution, where there are more extreme values on one side of the distribution than the other. If the distribution is right skewed, it means that there are more high values in the predicted prices, see column 7. In the vain, the skewness is related measure of distribution, indicating the degree to which a distribution is asymmetric. A positive skewness with high values than the low values. This indicates that investors are bullish on Dangote Cement stock and expected prices to rise over time see column 8.

**3.2. Analysis of Dangote stock price changes**

In real life situation, the value of stocks grows significantly according to different forms over time. The curves of growth may vary due to some environmental hazards. The shapes of this curve will be realistic if integration is carried out for its appropriate approximations as this will provide management with valuable information about the performance of the Dangote stock and its standing in the market. Therefore, we state and prove proposition as follows:

**Proposition 3.1:** Considering an aspect of random variability of a stock, [20]. Let represents the aggregate intrinsic value of stock. Also let represents changes on interest rate or inflation that impact the value of an investment over time and  is the nature and capacity of asset both at time,  . Suppose the dividend is declared at time, , the shape of the curve grows to a process where  is the number of trading days. Hence the dynamics governing the entire process is:



***Proof***

To show the future value of Dangote Cement based on the growth pattern of the investments as a result of changes on interest rates or inflation.

Using Nedu’s method of integration by parts gives the following



 (3.1)

(3.1) shows a compounding growth , where the rate of growth itself changes over time. This informs an investor to take vital decisions.

**Proposition 3**.**2:** Considering periodic fluctuations in the investment returns which is a seasonal cycle such as sales of Dangote Cement that peak in the spring and trough in the fall. Let represent intrinsic value of the stock. Then, let  be the unit price of the stock, is the capacity and nature of the asset all at time. Assuming the shape of the curve grows to a process and hence the future value dynamics follows:



***Proof***

To show the future value of Dangote Cement based on the growth pattern of seasonal fluctuations of the investment.

Using Nedu’s method of integration by parts gives the following



 (3.2)

**Proposition 3**.**3:** Assuming we have another periodic fluctuations which represents seasonal cycles such as sales that increases in the winter whose unit price of the stock, capacity and nature of the asset is and  respectively all at time . The entire function becomes. If sales of Dangote Cement increases to a curve of a fundamental processes known as  . Therefore the process is defined as:



***Proof***

To show the future value of Dangote Cement based on the growth pattern of seasonal fluctuations of the investment.

Using Nedu’s method of integration by parts gives the following

  (3.3)

More so, considering different periods of investing and trading respectively where investors find it difficult to take some informed decisions, now we state as follows:

**Theorem 3.2:** By propositions 3.2 and 3.3. Let  

Then are mutually independent random variables having Normal distribution

*Proof:*

Let  be arbitrary. adopting method of  we have 

we can see that the second and third term on the right hand side are continuous martingales; thus ,taking expectations on both sides and denoting  we get

 Using Fubini’s Theorem gives as follows



Therefore , gives the solution of the differential equation

 

so we have



This implies that



considering the above we have



so after evaluating the integrals



The argument for the case  is identical in every ramifications.

The solutions of (3.2) and (3.3) shows more complex or multi-periodic cycles in the investments returns such as annually or quarterly fluctuations that are combined with longer-term trends. It also indicates that the cyclical pattern is occurring at different phase or is offset relative to the pattern modeled.

However, since Dangote investment is time-dependent in nature and can reflect changes in interest rates over time, as the interest rates can impact the value of the investment. Therefore using (3.1),(3.2) and (3.3) gives:

 (3.4)

 (3.5)

 (3.6)

The simulation of the above equations gives:



**Figure 1: The future growth changes of Dangote Cement when is positive exponential**

Figure .1 shows Dangote investment is growing at a rate that compounds over time, leading to faster and faster growth. The investment may be benefiting from technological innovations or other breakthroughs that are driving its growth. The projected revenue growth indicates a positive linear trend, with a consistent increase in revenue over the years. This growth is driven by the company’s strategic investments, expansion plans, and increasing demand for cement in Africa.

2

**Figure 2: The future growth changes of Dangote Cement when is periodic but negative trends**

Here, the investment is losing value over time due to factors such as poor performance, market conditions or inflation see Figure 2.Weakening demand for cement in key markets ,such as Nigeria or other African countries, could lead to negative linear growth. This decline might be driven by factors like reduced infrastructure spending, increased competition, or economic downturns.



**Figure 3: The future growth changes of Dangote Cement when is periodic but positive trends**

Figure 3 represents a situation where the investment is performing well and generating positive returns. The investment is increasing in value over time due to factors such as good performance, favorable market condition or inflation. The company’s growth may be affected by economic cycles, with periods of rapid growth followed by slower growth or consolidation.

**4.1 Conclusion**

In finance generally, investments are ventures associated with risk which cannot be avoided.

Our human daily lives and day-to-day activities are associated with risk; thus, risk is a factor to effectively accomplish investment portfolios, because it is contributory to the ascertainment of fluctuation or variations of returns on the stock and portfolio, which provides the investor a mathematical framework for investment decisions. This paper considered application of matrix to Dangote stock market prices for prediction with illustrative case is provided in different forms such as to presents the quantity of Dangote stock prices during each period of trading, obtaining the solution of the systems which could be used for some demand specifications, the sum total of independent stocks according to sales, the relative amount of each cement according to sales, getting the total cost of cement to four key marketers to different locations. The systems of linear Equations were perturbed and there were no significant changes from the original systems which makes our model robust and stable. The statistical variables such as mean, kurtosis and skewness gave clear insight to investors about investment plans. Finally, we developed and proved propositions and theorems to show financial processes such as the expected profit of the investments in the future, and the results of propositions were simulated, graphical solutions obtained according to the value of each investment. This informs Dangote and other corporate investors in their daily decision making. We shall combine stochastic matrices together with this noble idea in the next paper.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

**Reference**

[1] Dao, L.K.O, Le, D.H, Do,P.T, Shin-Huny, P.(2022) .Review of Matrix with Application in Economics and Finance. *Advances in Decision Sciences* (ADS) ,54-70.

[2] Amadi,I.U**,** Ahana,U and Anyamele,B. A. (2022). Analytical Solution of two Model Equations for the variation of Capital Market Prices, *International Journal of Mathematics and Statistics Studies,*10,12-27.

[3] Okoro, J.C,Amadi, I.Uand Howard, C.C (2024) **.** A Markov Chain in Finite State and the Impact of time Delay on Nigeria Current Account Net for Capital Market. *World Science News: an international journal*. WSN 197,88-98.

[4] Loko,O.P , Davies,I and Amadi,I.U. (2023).A Generalized Solution of Asset Value Function for Capital Market Prices. *Asian Journal of Economics, Finance and Management,* 5(1) 208-218.

[5] Amadi, I.U, Ogbogbo, C.P.N, Davies,I and Katsekpor, T.(2024). A Stochastic Model for the Variation of Furier Series Expansion with Time Delay Arising in Financial Market Price Changes , *International Journal of Mathematical Sciences and Optimization theory and Applications*, 10(3),140-153

[6] Amadi**,I**.U**,** Nnoka,L.C and Amadi,C. P. (2024). Application of Non-Linear Evolution Stochastic Equations with Asymptotic Null Controllability Analysis, *International Journal of Mathematics and Statistics Studies,*12(2),9-24.

[7] Amadi, I.U. and Jachi, J. (2024). Existence of Weak Solution for Black-Scholes Partial Differential Equation and Application of Energy Estimate Theorem in Sobolev Space. *LOKA: Journal of Environmental Sciences*, 113-127.,E-ISSN- 2986- 3023(ONLINE).

[8] Azor,P.A. Okpara,M.O and Amadi, I.U(2023). Application of Non-linear Stochastic Systems on Asset pricing Returns for Stock Market prices. *Asian Journal of pure and applied mathematics,*7(1),277-290.

[9] Uchechukwu, C.F, Amadi,I.U and Azor,P. A. (2023) Solution of Stochastic Delay Differential Equation on Asset Value Changes for Capital Market Price, *International Journal of Mathematical Analysis and Modeling*, 6(2), 275- 288.

[10] Amadi**,I**.U,Ebakpa,L.E and Azor,P. A. (2023). A Stochastic Model of Asset Pricing Function with Additive Effects Series For Capital Market Prices. *International Journal of Mathematical Analysis and Modeling,* 6(2), 253-254

[11] Azor,P.A., Ogbuka,J.C and Amadi,I.U (2023).System of Non-Linear Stochastic Differential Equations with Financial Quantities, *International Journal of Mathematics and Statistics Studies,*11(2),48-61.

[12] Davies,I, Amadi,I.U, Amadi C.P, Ateke,R.C and Owhorndah,N. S. (2023). Stability and Controllability Analysis of Stochastic Model for Stock Market Prices, *International Journal of Statistics and Applied Mathematics*, 8(4), 55-62.

[13] Amadi**,I**.U,Tamunotonye,R and Azor,PA. (2023) Stochastic Model on the Assessment of Asset Values for Economic Investments, *Asian Journal of Economic, Finance and Management,*5(1), 245-254.

[14] Azor,P.A, Annorzie,M.N and Amadi,I.U (2024).Approximate Solutions for Non- Linear Evolution Stochastic Equations with Variations of Drift Parameters, *Asian Journal of Mathematics,* 20(5),38-49.

[15] Azor, P.A ,and Amadi, U.C.(2024). Mathematical modeling of an Investor’s Wealth with different Stochastic Volatility Models. *Communication in Physical Sciences*, 11 (2), 355- 372.

[16] Azor,P.A and Amadi,I.U (2024).Pricing European Call Option and Sobolev Space Energy Estimate Theorem on Access Bank Share Prices. *International Journal of Computer Science and Mathematical theory,*10 (2),2695-1924.

[17] Osu, B.O. (2010). A stochastic model of the variation of the capital market price*. International Journal of Trade, Economics and Finance,* Vol.1,No3),pp.297-302*.*

[18] Gilbert,S. (2016) *Introduction* *to* *Linear Algebra* .5th edition, Cambridge.

[19] Osu, B. O, Okoroafor, A. C. (2007). On the Measurement of Random behaviour of Stock Price changes. *Journal of Mathematical Science Dattapukur*; 18(2): 131-141.

[20] Osu,B.O, Okoroafor, A.C and Olunkwe, C.(2009). Stability Analysis of Stochastic Model of Stock Market price.African .*Journal of Mathematics and Computer Science Research* 2(6), 98-102.

[21] Osu,B.OandAmadi,I.Uand Azor,P.A. (2022).Analytical Solution of Time-Varying Investment Returns with Random Parameters. *Sebha University journal of Pure and Applied Sciences* vol. 21, NO.2. Doi:10.51984/JOPAS.v2112.1857

[22] Amadi,I.Uand Wobo,O. G. (2022)A Mathematical Model Analysis For Estimating Stock Market price Changes, *International journal of Applied Sciences and Mathematical theory,*5, 51-67.

[23] Azor,P.A, Nwobi,F.N and Amadi,I.U (2024). Solutions of Linear Stochastic Differential Equations for Economic Investments, *American Journal of Applied Mathematics and Statistics,* 12(2),28-34.

[24] Adeosun, M. E., Edeki, S. O., Ugbebor, O. O. (2015). Stochastic Analysis of stock market price models: A case study of Nigerian stock Exchange (NSE). *WSEAS Transactions on Mathematics*.14:353-363.

[25] Ofomata, A. I. O., Inyama, S. C., Umana, R. A. and Omane, A. O. (2017). A stochastic model of the dynamics of stock price for forecasting*. Journal of Advance in Mathematics and Computer Science.* 25(6):1-24.

[26] Agbam, S.A and Azubuike,J.T.(2021). Stochastic Forecasting of Stock Prices in Nigeria. Applications of Geometric Brownian Motion Model. *International Journal of Finance*, 3(1), 46-53.

[27] Amadi, I. U., Ogbogbo, C. P. and Osu, B. O. (2022). Stochastic Analysis of stock price

Changes as Markov Chain in Finite State. Global Journal of Pure and Applied Science

Vol. 28, pp. 91-98

[28] Amadi, I. U. and Okpoye, O. T*. (2022). Application of Stochastic Models in Estimation of*

*Stock Return rates in Capital Market Investments. International Journal of*

*Mathematical Analysis and Modelling. Vol.5, issue 1, pp. 108-120*

.