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Article

Using Markov Chain to Forecast Stock Price Movement in The Iraq Stock Exchange

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Abstract: The purpose of this paper is to apply "Markov chain" modeling to the Iraq Stock Exchange Index (ISX60) over a period of 231 trading days, from January 02, 2024, to December 30, 2024. The prediction was made by identifying three cases of stock price movement: height, low, and stability. The transition matrix and probability vector for the Markov chain were created, and the results showed that the probability of a decrease in the Iraq Stock Exchange Index prices was the highest, reaching (0.489), the probability of a rise in prices was the lowest, reaching (0.177), and the probability of stock price stability was (0.33). The purpose of this study was to raise local investors' understanding of the Markov chain model's predictive power to aid in investment decision-making.

Keywords: Markov Chain, ISX60, Probability Matrix, Transition Matrix

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1. Introduction

The stock market performs multiple functions, such as financing, capital transfer, and determining stock prices. On the other hand, stock prices are influenced by many factors. For example: political and economic conditions, social and policy, etc. Therefore, stock prices are often referred to as a “barometer” of the broader economy. On the other hand, stock prices greatly influence corporate decision-making and investor behavior, making them closely related to social and economic development and people’s lives [1].

Prices fluctuate in real time based on supply and demand. These stock market fluctuations have a significant impact on businesses, individual investors, and the overall health of the economy. Despite the common perception that stock markets are unpredictable, investors continue to develop forecasting techniques and models. Given the potential for high investment returns, stock market forecasting is actually a worthwhile research topic [2].

The two primary approaches that investors have historically used in the stock market are technical and fundamental analysis. While technical analysis looks for trading opportunities based on trends and statistical patterns, fundamental analysis seeks to quantify the intrinsic worth of stocks. Jordanoski and N. Petrusheva Regression and time series analysis are two statistical techniques used in technical analysis [3]. Modeling the stock market as a Markov chain is another statistical technique that stands out for its simplicity. Since Markov chains don't rely on intricate interactions between variables, they are simple to review.

1.1 Markov Chains

Russian mathematician Andrei Markov lived from 1856 to 1922. He was a low-income kid, and math was the only subject he did not find difficult. Later, he studied mathematics at the University of St. Petersburg, where renowned probability theorist

Pafnuty Chebyshev gave lectures. Markov's initial scientific interests were in approximation theory, convergent series, and number theory. His first work on the topic was published in 1906, and his most well-known research was in Markov chains, hence the name [4].

One essential component of random processes is Markov chains. They are extensively employed in numerous fields. The Markov property, which states that when the present is known, the past and future are independent, is satisfied by a random process that is called a Markov chain.

This implies that one can make the greatest feasible forecast about the process's future if they are aware of its current state and don't need any extra information about its previous states. When examining such a process, the number of parameters can be significantly reduced due to its simplicity. The definition can be stated mathematically as follows:

A stochastic process X = {X_n , n ε N} in a countable space S is a discrete-time Markov chain if:

$$X = \{X_n, n \varepsilon N\}$$
$$for\ all\ \ n \geq 0, X_n \varepsilon\ S$$
$$for\ all\ n \geq 1\ and\ for\ all\ i_0, \ldots .\ i_{n-1}, i_n \varepsilon S\ we\ have\ :$$
$$P\ \{X_n =\ i_n | X_{n-1} = i_{n-1}, \ldots X_0 = i_0\} = P\ \{X_n =\ i_n | X_{n-1} = i_{n-1},\}$$

The probability of occurrences are computed using Markov chains, which treat them as states that change into different states or return to their initial state. Using the weather as an example, the following weather prediction might be made if the probabilities were chosen at random: In the event that it is sunny, there is a 70% likelihood that it will be sunny again the following day, and an 80% chance that it will be rainy the following day.Therefore, it can be described as a sequence of random changes in which the future state Nn+1 is unrelated to the states N1, N2,…….The Markov property is Nn-1 given that the current state is known [5].

1.2 Probability Matrix

The behavior of a Markov chain can be precisely interpreted using the transition probability matrix. The likelihood of moving from one state to the next is represented by each member in the matrix. Transition probabilities are typically analyzed empirically, meaning that they are not based on theory but only on experience and observation. However, they are grounded in real-world experience rather than scientific ideas. The gathered historical data requires conversion into probabilities through which a Markov probability matrix can be built. The following three-state Markov process probability matrix can be constructed as shown below [6].

$$P_{ij} = \begin{bmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{bmatrix} \ldots \ldots \ldots \ldots (1)$$

Where

P11: Probability of price rise when price is high

P12: Probability of price fall when price is high

P13: Probability of price stability when price is high

P21: Probability of price rise when price is low

P22: Probability of price fall when price is low

P23: Probability of price stability when price is low

P31: Probability of price rise when price is stable

P32: Probability of price fall when price is stable

P33: Probability of price stability when price is stable

The transition frequencies between states I and J are represented by Pij in the presented matrix.

1.3 Estimating transition probabilities

The transition probability Pij's maximum likelihood estimate in a first-order Markov chain is

$$p_{ij} = \frac{n_{ij}}{n_i} \quad \dots\dots\dots (2)$$

where ni represents the number of visits in state i and nij represents the number of transitions from state i to state j (Christensen et al., 2004). A second-order Markov chain specifies transition probability pijk through the same criteria as first-order structures.

$$p_{ij} = \frac{n_{ijk}}{n_{ik}} \quad \dots\dots\dots (3)$$

where nij is the number of transitions from state i to state j, and nijk is the number of times the sequence of states i, j, and K has been recorded (Shamshad et al., 2005).

1.4 Stability of the distribution of the Markov chain

A process is stable when the probabilistic transitions remain independent of time difference and statistical properties stay invariant over time with the discrete-time Markov chain being both continuous and temporally homogeneous [7].

$$P = P\,\{X_{n+1} = j | X_n = i\}$$

By multiplying the transitional probabilities matrix by itself (n) times, the application allows one to acquire the transitional probabilities during (n) movements. As a result, the Markov chain matrix has the following form:

$$p^{\wedge} = \begin{bmatrix} p_0 & p_1 & p_2 \\ p_0 & p_1 & p_2 \\ p_0 & p_1 & p_2 \end{bmatrix} \dots\dots\dots\dots (4)$$

1.5 Literature Reviews

Stock index and return predictions become challenging because of unpredictable value patterns. Time series modeling applies as the main methodology for most such investigations. Zhang and Zhang (2009) adopted the Markov model as their basis to research stock price prediction techniques. A stochastic Markov chain model was developed by the researchers to forecast Chinese stock market patterns. The Markov model proved suitable for diverse stock market price forecasting requirements but lacks the aftereffect characteristic. Utilized a Markov process to analyze five renowned Indian petroleum-based stock performances [8]. The research established Indian Oil Corporation (IOC) and Oil India present stable organizational conditions but Bharat Petroleum and Reliance and Hindustan Petroleum demonstrate appreciation potential.

The authors employed a Markov chain forecasting model combination to predict China Railway Corporation stock prices in the Chinese stock market and calculated its expected value [9]. The composite expected value proves to be more accurate by comparison with individual methods' expected values. Based on the research findings the researchers conclude that the composite forecasting method leads other Markov forecasting methods with superior performance while expanding Markov chain forecasting theory and demonstrating robust applicability between both approaches. The study (Aronsson & Folkesson, 2023) investigated how to apply Markov chain modeling to the Swedish stock index OMXS30, and the results showed that the six-state Markov model had slightly higher prediction accuracy than the random chance performance. Furthermore, the prediction accuracy of models with first- and second-order Markov chains did not differ significantly. Looked at the issue of long-term stock price forecasting in Chinese markets and suggested a Markov chain-based approach to stock price forecasting [10]. The foundation of this approach is the idea of state transitions in Markov chains, which transform stock index data into state data. A transition probability matrix is created, and matrix multiplication is used to make predictions. The findings demonstrate the excellent accuracy and stability of the stock price prediction model put out in this study.

2. Materials and Methods

It's challenging to forecast the stock market's performance with any degree of accuracy. In order to forecast future stock prices, particularly in the "Iraq Stock Exchange," several scholars have explored a variety of techniques. Some approaches, like the Markov chain model for predicting future stock market prices, rely on modeling and appear to be more significant. Thus, the study's challenge is if the "Iraq Stock Exchange Index (ISX60)" can be predicted to move using a Markov chain.

This paper aims to test the possibility of using the Markov chain to predict the movement of the "Iraq Stock Exchange Index (ISX60)" to understand the behavior of this index to help investors improve their investment decisions in the Iraqi market. In addition to evaluating the predictive ability of the Markov chain.

The premise of this research is that the Markov chain model can be used to forecast the movement of the Iraq Stock Exchange Index (ISX60). Using the daily closing prices of the Iraq Stock Exchange Index (ISX60) extracted from the daily reports released for the period of January 02, 2024, to December 30th, 2024 (231) trading days, the Iraq Stock Exchange was chosen.

Since the first column of the matrix represents the probabilities of rise, the second column represents the probabilities of decline, and the third column represents the probabilities of stability, the prediction is made by creating a matrix for the frequencies of the transition of the index prices. As shown in Table (1) Transition Matrix, this matrix typically consists of three possibilities (3 * 3) (height, low, stability), provided that the sum of the matrix values equals the number of trading days.

In light of the Iraq Stock Exchange Index's constant price movement, a price increase of more than 1% of the previous day's price is seen as a rising state; a price reduction is regarded as a falling state; and a price increase of less than 1% is regarded as a stable state.

3. Results and Discussion

We are trying to test the Markov chain model on the movement of the "Iraq Stock Exchange (ISX60)" index for (231) trading days by creating a transition matrix and extracting the number of repetitions of transitions for the index movement that include (price increase of more than 1% from the previous day, price decrease, price stability when it increases by less than 1%) so that the matrix becomes as follows:

$$p = \begin{bmatrix} 12 & 19 & 10 \\ 10 & 60 & 36 \\ 15 & 28 & 41 \end{bmatrix}$$

We notice through the price movement matrix of the "Iraq Stock Exchange Index (ISX60)" that the frequency of price increases of more than (1%) when the price was high was (12) times, while the frequency of price decrease when the price was high was (19) times, while the number of repetitions of price stability (price increase less than 1%) when the price was high was (10), while we notice that the number of repetitions of price increases of more than 1% when the price was low was (10) times, which is the least in the matrix, in conjunction with price stability when the price was high, while the number of repetitions of price decrease when the price was low was (60) times, which is the most frequent in this matrix, while the frequency of price stability when the price was low was (36) times, while we find that the number of repetitions of price increases of more than 1% when the price was stable was (15) times, and the number of repetitions of price decrease when the price was stable was (28) times, while the number of repetitions of price stability (price increase less than 1%) when the price was stable was (41) times. To estimate the probability of price transitions using a first-order Markov chain, we obtain the following matrix:

$$p = \begin{bmatrix} 0.29 & 0.46 & 0.24 \\ 0.1 & 0.57 & 0.34 \\ 0.18 & 0.33 & 0.49 \end{bmatrix}$$

To obtain the stable and consistent distribution of the movement of the Iraqi market index prices by applying Markov operations to the transition probability matrix using the Excel program as follows:

$$p^2 = \begin{bmatrix} 0.17 & 0.47 & 0.36 \\ 0.17 & 0.51 & 0.32 \\ 0.21 & 0.47 & 0.32 \end{bmatrix}$$

$$p^3 = \begin{bmatrix} 0.1768 & 0.4888 & 0.3344 \\ 0.1768 & 0.4902 & 0.3328 \\ 0.1784 & 0.4888 & 0.3328 \end{bmatrix}$$

$$p^4 = \begin{bmatrix} 0.17708 & 0.48958 & 0.33333 \\ 0.17708 & 0.48958 & 0.33333 \\ 0.17708 & 0.48958 & 0.33333 \end{bmatrix}$$

From the stable matrix P4 it is clear that the only Markov probability distribution vector is as follows:

$$U_j = [0.17708 \quad 0.48958 \quad 0.33333]$$

Through the Markov stability matrix, it is clear that the probability of prices rising by more than (1%) for the "Iraq Stock Exchange Index" is (0.177), which is the lowest among the possibilities, and the probability of its decline is (0.489), which is the highest among the possibilities, while the probability of stability in the movement of prices for the "Iraq Stock Exchange Index" is (0.33).

4. Conclusion

This study attempted to use the Markov chain model to predict the movement of the "Iraq Stock Exchange (ISX60)" index. This study provides insight into the probabilities of the movement of the "Iraq Stock Exchange index" prices by relying on data of (231) trading days. The results showed that the probability of a price decline for the coming period is the most likely, reaching (0.489), while the probability of a price rise for the Iraq Stock Exchange index is the least likely, reaching (0.177), while the probability of price stability reached (0.33). Therefore, investors and traders in the Iraqi market can take these results into consideration when making their investment decisions.

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