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# Forecasting the exchange rate of the Iraqi dinar against the US dollar using Markov chains

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**ABSTRACT**

The development of trade between worldwide countries is a result of development of economic relations and great openness between these countries. So, there is need to resolve problems of national and foreign currency to maintain global relations among nations. In this research, the exchange rate of the Iraqi dinar against the US dollar using Markov chains and predicting the exchange rate in the future have been investigated. It allows decision makers to take appropriate decisions in times of crisis using matrix of transition probabilities through statistical bulletins derived from the Iraqi Central Bank monthly data from 2015 to 2018. The results of the analysis showed an important conclusion that the exchange rate will remain stable for the upcoming period and then begin to rise as a result of the impact of the global crisis in Iraq.

**Keywords**: Markov chains, random processes, the greatest possible method, exchange rate.

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## 1. Introduction

The exchange rate stands for the price of the currency of a specific country with respect to another country, or the ratio of the exchange between two operations. Namely, it is the number of units of the local currency paid for obtaining one unit of foreign currency. The exchange rate is an imperative and critical role in determining the nature of internal and external economic activities. Within the country, the exchange rate can be used as a tool for monetary policy in the country in order to reduce the rate of inflation in a manner consistent with the ultimate objective of monetary policy. As for foreign economic relations, the significance of the exchange rate is determined by the fact that it represents the costs of production and prices, whether at home or abroad. Consequently, it can be used as an indication of a country's competitiveness for the balance of payments. As in the case of an increase in the local currency exchange rate, this indicates an intensification in the value of locally produced goods and services with a negative impact on exports. Nevertheless, in the case of a lessening in the local currency exchange rate, the situation will be precisely the opposite [1].

Every country prefers a stable exchange rate to ease foreign trade and reduce the degree of risk and uncertainty in the economy. Infrequently, the country may prefer a weaker exchange rate to stimulate aggregate demand and reduce recession or a stronger exchange rate in order to combat inflation. It should be noted that rapid movements from the weak exchange rate to the strong exchange rate may halt export industries. Swift

movements from the strong exchange rate to the weak exchange rate can halt the work of the banking sector. Namely, each exchange rate option implies trade-off between possible cases [2].

Trade exchange between countries of the world is one of the fundamentals that have a significant impact on the economies of these countries because of the development of economic relations and as a result of this development, it emerged a problem between national and foreign currencies [3-4]. Iraq is a country with a good economy. Nevertheless, at the present time, it depends on imports more than export. So, the change in the exchange rate of the Iraqi dinar against the US dollar will affect commodity in terms of the rise, fall and stability of their prices.

Stochastic processes occur as a result of random incidents, and time series are random operations of historical data collected over time. Markov processes are random coincidental processes that change with time and affect it. Its chains are a special case of the coincidence process and as a statistical method to study random phenomena and represent a series of random variables in which the future state is independent of its past conditions provided that its present condition is known [5-7]. Markov chains also have used in the study of queues and the prediction of the price of a particular commodity as well as to compare the brands used in the local and international markets and other. The exchange rate is important in the balance of payments of any country, including Iraq, and is defined as the rate on which foreign exchange takes place in local currency [8].

The periodic monitoring of the accomplished plans contributes to the success of any institution, and here the importance of this research emerges. The goal of the research is to predict the exchange rate of the Iraqi dinar against the US dollar through the use of Markov chains. It allows decision makers to take proper decisions in times of economic crisis using matrix of transition probabilities through monthly statistical bulletins from Iraqi Central Bank data from 2015 to 2018.

## 2. Transition probability matrix

This matrix of transition probabilities as square matrix whose elements are not negative and the sum of the row is equal to one and written as follows [5]:

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1n} \\ . & . & . & . \\ . & . & . & . \\ p_{n1} & p_{n2} & . & p_{nn} \end{bmatrix} \qquad (1)$$

$p_{ik}$ represents the probability of the phenomenon moving from the state (i) to the situation (k). In one period of time until (N) of situations and when you repeat the steps for m times, the symbol for it will be $p_{hk}^{m}$, while the symbol of the transitional probability matrix of the Markov chain is after (n + m). The steps are based on:

$$p^{n+m} = p^{n} * p^{m} \qquad (2)$$

When multiplying the transition probability matrix itself to n times, we can get a matrix with all its identical rows and called a state of stability (Steady State). From this stable distribution, the coincident process is obtained under condition of $(0 \le u_k \le 1)$ in which $(U = u_1, u_2, ..., u_n)$ is the only probability vector and its sum are equal to one [9].

## 3. The greatest possible method

The greatest possible method is used to estimate transitional probabilities by moving from the case (i) in time (t) to the case (k) in time (t + 1). The Markov process in the stability state would be as follows [4]:

$$\Pr(X_0, X_1, ..., X_l) = \Pr(X_0) \prod \prod \Pr(X_t / X_{t-1}) \qquad (3)$$

Proportionally this formula will be [1]:

$$\Pr(X_0, X_1, \ldots, X_l / n) = \Pr(X_0) \prod \prod P_{ik}^{nik} \quad (4)$$

Using the Lagrange multiplication in condition of $\left(\sum P_{ik} = 1\right)$, a Lagrange function is obtained [6]:

$$Log \Pr(X_1, X_2, \ldots, X_l / n) = \sum_i \lambda_i \left( \sum_k P_{ik} - 1 \right) \quad (5)$$

Taking the partial derivative for $(P_{ik})$ and $(\lambda_i)$, resulting from some simple operations, we get the following estimations [3]:

$$\hat{\lambda}_i = \sum_k n_{ik} \quad (6)$$

$$\hat{P}_{ik} = n_{ik} \Big/ \sum_k n_{ik} \quad (7)$$

**4. Data analysis**

The data are obtained from the statistical bulletin of the Central Bank of Iraq during the period (2015 – 2018) and on a monthly time series representing the Iraqi dinar exchange rate against the US dollar, which can be represented by Figure 1.

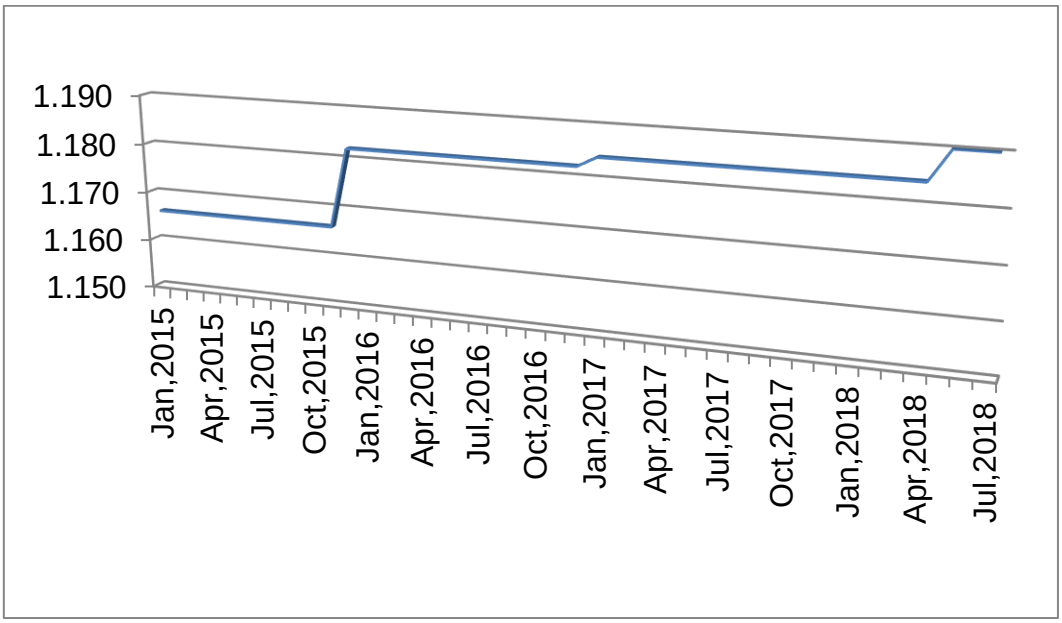


Figure 1. The exchange rate of the Iraqi dinar against the US dollar from 2015 to 2018

The data were divided into three states (height, stability, and decline) to form a transitional probability matrix (Markov matrix) ,which is denoted by the symbol (*p*):

$$p = \begin{array}{c} \\ S1 \\ S2 \\ S3 \end{array} \begin{array}{c} \begin{array}{ccc} S1 & S2 & S3 \end{array} \\ \begin{bmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{bmatrix} \end{array}$$

Where,

S1: The case of high exchange rate, S2: The case of the stability of the exchange rate, S3: The case of high exchange rate

$p_{11}$: Price probability is high after it was high.

$p_{12}$: Price probability is high after it was stable.

$p_{13}$: Price probability is high after it was low.

$p_{21}$: Price probability is stable after it was high.

$p_{22}$: Price probability is stable after it was stable.

$p_{23}$: Price probability is stable after it was low.

$p_{31}$: Price probability is low after it was high.

$p_{32}$: Price probability is low after it was stable.

$p_{33}$: Price probability is low after it was low.

The transition matrix of the Iraqi dinar exchange rate against the US dollar has been as follows:

$$p = \begin{bmatrix} 0 & 3 & 0 \\ 3 & 37 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{matrix} 3 \\ 40 \\ 0 \end{matrix}$$

Since the third row and the third column contain zeros as a result of the lack of transfers in the cases of depreciation of the exchange rate of the Iraqi dinar, so we will have a square matrix of class (2x2) as follows:

$$p = \begin{bmatrix} 0 & 3 \\ 3 & 37 \end{bmatrix}$$

The transitional probability matrix of the Iraqi dinar exchange rate against the US dollar is as follows:

$$p = \begin{bmatrix} 0 & 1 \\ 0.075 & 0.925 \end{bmatrix}$$

By using MATLAB simulator, we find that the matrix has stabilized in the previous step and became as follows:

$$p = \begin{bmatrix} 0.0698 & 0.9302 \\ 0.0698 & 0.9302 \end{bmatrix}$$

Thus, the distribution of Markov process is stable and the distribution vector is as follows:

$$U_k = \begin{bmatrix} 0.0698 & 0.9302 \end{bmatrix}$$

From the stable distribution, we note that the probability of rise is 0.0698, the probability of stability is 0.9302, and the value of the probability of decline is zero. Consequently, the probability of stability of the exchange rate of the Iraqi dinar against the dollar is the highest, followed by the probability of the rise and then the probability of decline as explained by Figure 2.

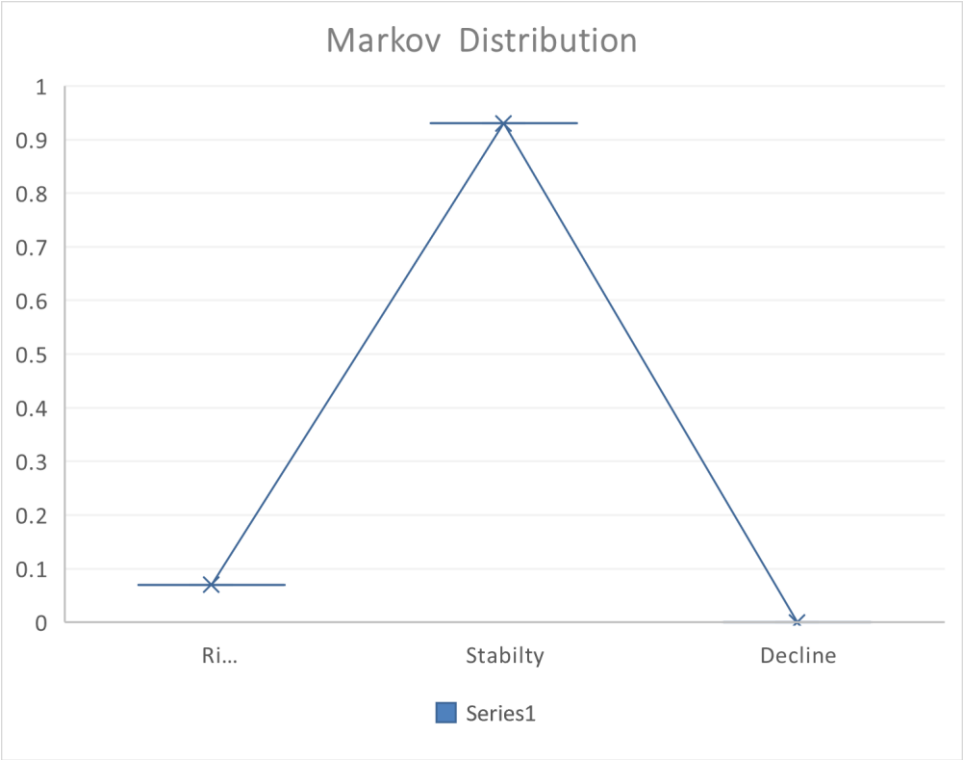


Figure 2. Markov distribution of exchange rate of the Iraqi dinar against the dollar

## 5. Conclusions

This study investigates the exchange rate of the Iraqi dinar against the US dollar using Markov chains and forecasts the exchange rate in the future. Statistical bulletins have been derived from the Iraqi Central Bank data from 2015 to 2018. It was found through the stable distribution of the Iraqi dinar exchange rate against the US dollar that prices will remain stable for a certain period and then will rise as a result of the impact of global crises in Iraq. The rise probability is 0.0698, the stability probability is 0.9302, and the value of decline probability is zero. So, we recommend that decision-makers maintain a unified policy towards the stability of the exchange rate, monitor changes that could destabilize it, and try to avoid them .

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