

Estimating the effect of exchange rate fluctuations on general index of stock prices in Khartoum stock exchange using GARCH model (2004-2019)

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Abstract

The study aimed to estimate the effect of exchange rate fluctuations on the general index of stock prices in the Khartoum Stock Exchange using the general conditional variance models. The study problem was formulated in the following main question: What is the effect of exchange rate fluctuations on the general index of stock prices in the Khartoum Stock Exchange? The study was built on the following main hypothesis: There is a statistically significant relationship between exchange rate fluctuations and the general index of stock prices in the Khartoum Stock Exchange. The study followed the quantitative standard approach using the general conditional variance models and the ordinary least squares. The study found a direct relationship between exchange rate fluctuations and the general index of stock prices in the Khartoum Stock Exchange. The study recommended the adoption of effective macroeconomic policies to reduce the exchange rate and support it with production to reflect positively on the general performance of the Khartoum Stock Exchange Index, which increases opportunities and potentials for local and foreign investment.

Keywords: Index; Stock prices; GARCH models; Exchange Rate; Volatility; Sudan

1. Introduction

The significant deterioration that occurred in the value of the national currency as a result of the devaluation of the pound against the dollar in order to encourage production, improve the balance of payments situation, stimulate economic growth and increase investment, has negatively affected stock prices in the Khartoum Stock Exchange and resulted in a continuous and accelerated deterioration in addition to the instability in exchange rate systems. And the policies related to it, all of which led to the exposure of the value of financial assets to erosion and consequently to a decrease in their market value, which caused great losses to investors in Khartoum Stock. The study was a serious attempt to determine the impact of exchange rate fluctuations on the general index of stock prices in the Khartoum Stock Exchange through research and auditing to avoid the negative effects resulting from exchange rate fluctuations on the Sudanese economy in general and on the Khartoum Stock Exchange and local and foreign investors in particular. The study is based on testing the following main hypotheses: To the extent that the general conditional variance models have the ability to predict exchange rate fluctuations on the Khartoum Stock Exchange Index, there is a significant relationship between exchange rate fluctuations and the general index of stock prices in the Khartoum Stock Exchange. The study will follow the descriptive approach, the quantitative analytical approach, and the historical approach, in addition to the use of general exponential conditional variation models to estimate the impact of exchange rate fluctuations on the general index of securities in the Khartoum Stock Exchange, based on annual data obtained from the Central Bureau of Statistics, the Central Bank of Sudan and the Ministry of Finance and Economy National and Khartoum Stock Exchange.

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2. Definition of Exchange rate

It is the number of local currency units against one unit of foreign currency, and it represents a link between the local economy and the global economy through the relationship of exports and imports [1].

2.1. The importance of exchange rate

It links the local economy with the global economy by linking the prices of local goods and their prices in the global market. The real exchange market determines the number of units of foreign goods required to purchase one unit of local goods. The exchange rate also contributes to achieving internal and external balance and to achieving stability in the exchange rate of the local currency against currencies. foreign in the end [2].

2.2. Exchange rate types

Nominal exchange rate: It is the foreign currency rate in terms of the number of local currency units. This means the current nominal exchange rate, bearing in mind that the nominal exchange rate is divided into two parts, the official exchange rate that relates to official commercial exchanges and the parallel exchange rate that operates in parallel markets [3].

- **Real effective exchange rate:** defined as the indicator that measures the amount of change in the exchange rate of a particular currency against several other currencies during a certain period of time. Therefore, the real effective exchange rate is considered an average of several bilateral exchange rates.
- **Cross exchange rate:** It is the price of one currency against another and the correlation of these two currencies with a third common currency between them.
- **Adjusted exchange rate:** It is related to the balance of payments reality, which has a direct impact and a close link to the value of the country's exports and imports [4].

2.3. Exchange Rate Regimes

- **Fixed exchange rate Regime:** is called the golden system of exchange rates, where governments relied on determining a fixed value of monetary units in relation to a specific gold weight with the possibility of transfer between them without restrictions, as well as the freedom to import and export gold to and from countries that followed the gold rule. A fixed exchange rate for its currencies towards each other, and under this system there can be fluctuation in the price of the currency against gold without being tangible, and there is an import and export point for gold for each country.
- **Flexible exchange rate Regime:** its predecessor in that the central bank allows the exchange rate to be adjusted so that the supply is equal to the demand of foreign currency without foreign exchange markets interfering. Based on the forces of supply and demand, and therefore the price apparatus represented by the forces of supply and demand is what determines the exchange rate for each currency against other currencies without the monetary authorities interfering in that. Therefore, the demand for foreign exchange and supply work according to the general rule, which is that demand works in a reverse direction with the price And supply works in a direct direction with the price, and thus (EX) was determined at the point where the quantities demanded are equal to the quantities offered, as in the case of prices [5].
- **The managed peg exchange rate Regime:** This Regime relied on stabilizing exchange rates and obliging monetary authorities to intervene in the exchange markets for the purpose of maintaining price stability through the use of their international monetary balances to counteract the imbalance in the balance of payments. This system was agreed upon after the Second World War. In Bretton Woods, New Hampshire, in 1944, it was agreed that the exchange rates would be fixed according to the agreed-upon rate of the exchange rate of its currency, and that it would not change within certain limits. Exchange rates are more than two decades of relative stability, and this stability was due to the official cash reserves [6].

2.4. Khartoum Stock Exchange

Thinking began to establish a stock market in Sudan since 1962, when many studies and communications were conducted by the Ministry of Finance and National Economy and the Central Bank of Sudan with the participation of the International Finance Corporation of the World Bank, and in 19821 the Khartoum Stock Exchange Law was approved by the People's Assembly in That time was in order to organize the establishment of a stock market in Sudan, but the procedures related to establishing the market and practicing its activities were not completed. The serious step to establish a stock market began in (August 1992) in light of the economic liberalization policy advocated by the Triple Program for Economic Rescue (1990-1993). This is done by providing opportunities for the private sector to contribute

to the financing of economic projects through the capital market, especially considering that bank financing is not available at all times in the required volume. Accordingly, the Financial Markets Authority was established in 1992, and the goal was to have, under the umbrella of the Capital Market Authority, three markets, but the matter was limited to the stock market, and in November the Council of Ministers approved an amendment to the Khartoum Stock Exchange Law of 1982, but this law did not meet all the purposes and requirements necessary to establish an effective market for securities [7].

2.5. Khartoum Stock Exchange Law

In 1994, the Transitional National Council approved the Khartoum Stock Exchange Law, according to which the Khartoum Stock Exchange became an independent legal entity, and the market's board of directors was formed from a chairman of the council in addition to thirteen members. The Board has issued the general regulation of the market, in addition to the regulation of settlement and litigation conditions and the rules for trading in securities, and work began in the primary market (issues market) on the tenth of October 1995, the secondary market (the stock trading market) was opened.

2.6. Khartoum Stock Exchange Objectives

Khartoum Stock Exchange Market shall have the following purposes: regulating and controlling the issuance of securities and dealing in them by buying and selling, encouraging savings, developing investment awareness among citizens and creating the appropriate conditions for settling savings in securities, which will benefit the citizens and the Sudanese economy. Expanding and strengthening the private ownership of productive assets in the national economy to transfer public ownership of the state's capital assets to the broadest national categories. Develop and encourage investment in securities and work on creating an appropriate investment climate for it. Providing all factors that help facilitate and speed up the liquidation of funds invested in securities in order to serve the wishes of investors, establish the foundations of sound and fair dealing between categories of investors and ensure equal opportunities for dealers in securities, in order to protect small investors, collect data and provide them to all investors and those interested in that. Studying market-related legislation and amending it to suit the developments demanded by the market, proposing how financial and monetary statements are made, in order to achieve financial and economic stability in Sudan and then achieve economic development goals, work on exchanging experiences by communicating with global, regional and Arab markets and joining its membership, Establishing a unified body to regulate the transfer and deposit of securities ownership, follow-up of shareholders' affairs, management, supervision and control of the center, consolidation of professional behavior, self-monitoring and discipline among agents and workers in the field of dealing in securities, rehabilitation of employees and raising their scientific and scientific competence.

2.7. Khartoum Stock Exchange Indicators

- **Market liquidity:** the liquidity of the security and the effect of its market value, which is a matter of interest to the investor as well as the facility issuing the security, in the manner previously mentioned. Marketing with a minimum fluctuation in its market value.
- **Market Depth:** means that there are buying and selling orders derived from the paper in question. As a result of this active buying and selling transaction, any imbalance in the quantities required or offered usually reflects a slight change in the market, which means the stray capital losses if they occur and one of the most important requirements Deep market The presence of good means of communication between dealers so that there are no losing orders to buy or sell that do not find the way to be executed.
- **Market breadth:** In contrast to the specific market, the market is broad when there are a large number of buy and sell orders for the relevant security, which achieves relative stability in its price and thus reduces the risk of exposure to capital losses. A small margin in the hope that this will compensate for the high turnover of the stock [8]

3. The Volatility

Volatility is an essential feature of financial markets where it is always important to measure and predict it. Volatility has increased in popularity in the past years, especially in 1986 for stocks, 1992 for foreign exchange and 1994 for bonds. The widespread interest in financial derivatives whose value depends heavily on volatility and correlation indicates the need to derive good predictive models, especially those that focus on risk management and the measurement of capital at risk. Volatility is a measure of the intensity of unexpected changes in an asset, usually coinciding with a graph of returns over time on the vertical axis. The periods of sharp fluctuations are usually called volatility clusters, and these clusters show the predictability of volatility. Random follows a random process that we hope to discover.

3.1. Auto-regressive Conditional Heterocedasticity Model (ARCHM)

The first model that provides a systematic framework for building a variance model is the autoregressive model of Auto-regressive Conditional Heterocedasticity(ARCH) that was introduced by Engel (1982) and generalized by Pollerslev (1986). Time series and financial econometrics. These models showed many advantages when measuring phenomena such as inflation, interest rate, and exchange rate. Studies have concluded that the uncertainty inherent in different predictions and times is an inherited trait and varies with predictions and times, and large errors tend to aggregate together, as well as small errors around prediction periods. The variance of the dependent variable is described as a function of the previous values of the dependent variable and the independent variable. To understand the Auto-regressive Conditional Heterocedasticity models, it can start with ARCH (1).

$$a_t = \sigma_t \varepsilon_t; \sigma_t^2 = \alpha_0 + \alpha_1 a_{t-1}^2$$

$$\alpha_0 > 0; \alpha_1 \geq 0; \varepsilon_t \sim iid(0,1)$$

First The unconditional mean remains equal to zero because:

$$E(a_t) = E[E(a_t | F_{t-1})] = \sigma_t E(\varepsilon_t) = 0$$

Second The unconditional variance of the return can be obtained:

$$Var(a_t) = E[E(a_t^2 | F_{t-1})] = E(\alpha_0 + \alpha_1 a_{t-1}^2) = \alpha_0 + \alpha_1 E(a_{t-1}^2)$$

Where

F_{t-1} : all previous information up to the time until time(t-1)

Because the return a_t is still average $E(a_t) = 0$, variance $Var(a_t) = Var(a_{t-1}) = E(a_{t-1}^2)$

So we find that:

$$Var(a_t) = \alpha_0 + \alpha_1 Var(a_t) = \frac{\alpha_0}{1 - \alpha_1}$$

For the corrected return variance to be positive, it needs to be a value $0 \leq \alpha_1 < 1$.

3.2. General Conditional Autoregressive Conditional Heterocedasticity Model (GARCH M)

This model is interpreted in the financial context so that the agent or trader predicts the current variance by constructing a weighted average from the long-term mean (static) and the previous forecast of the variance plus all the information about the volatility seen in the previous period. If the return of the asset is unexpectedly large in either direction, ie up or down, the trader will increase the variance estimate in the coming period. This model is consistent with the concentration of fluctuations, which can be seen clearly in financial returns data, where large changes accompany large changes in returns.

Pollerslev (1986) suggested generalization Arch, if we have a series return (r_t) logarithm. It can be assumed that the mean equation of the process can be adequately described by ARIMA model. If the corrected mean is the logarithm of the return.

$$a_t = r_t - \mu$$

A variable follows the GARCH(m,s) Model if the following is true:

$$a_t = \sigma_t \varepsilon_t; \sigma_t^2 = \alpha_0 \sum_{i=1}^m \alpha_i a_{t-i}^2 + \sum_{j=1}^s \beta_j \sigma_{t-j}^2; \varepsilon_t \sim N(0,1)$$

$$\alpha_0 > 0; \alpha_i \geq 0; \beta_j \geq 0; \sum_{i=1}^{\max(m,s)} (\alpha_i + \beta_i) < 1$$

The last constraint has to be a finite a_t variation. If any of the lower bounds of the aggregation exceeds the upper bounds, the parameters will be set to zero i.e.:

$$\alpha_i = 0 \text{ for } i > m; \beta_j = 0 \text{ for } j > s$$

To understand the properties of GARCH models the following representation can be used:

$$\eta_t = a_t^2 - \sigma_t^2 \text{ i.e. } \sigma_t^2 = a_t^2 - \eta_t$$

When entering $\sigma_{t-i}^2 = a_{t-i}^2 - \eta_t; (i = 0, 1, \dots, s)$ into the above equation we obtain Exponential Generalized Autoregressive Conditional Heterocedasticity Model. Nelson (1991) suggested this model:

$$\ln(\sigma_t^2) = \omega + \left| \frac{\sigma_t | \varepsilon_{t-1} }{\sigma_{t-1}} \right| + \sqrt{\frac{2}{\pi}} + \frac{\gamma \varepsilon_{t-1}}{\sigma_{t-1}} + \beta \ln(\sigma_{t-1}^2)$$

The left end is the log conditional variance, which means that the leverage effect is exponential, not quadratic, and the conditional variance expectation is guaranteed and not negative. The exchange rate is a financial asset where the price of the financial asset is determined based on the present value of the expected cash flows of the asset. Asset prices change with expectations of future cash flows and uncertainty. The rate changes more and becomes more volatile and the more reasons investors have to change their views on future cash flows, the greater the volatility in the discount rate. This requires unexpected news or events. CPI news affects inflation uncertainty. In many macro and financial variables, volatility responds asymmetrically to past negative and positive return shocks, with negative returns leading to greater future volatility, which is known as the leverage effect (January 2005). The presence of leverage effects can be tested by the hypothesis that $\gamma < 0$ otherwise the impact is asymmetric if $\gamma \neq 0$. The model contains two variables: first was stock prices in the Khartoum Stock Exchange index (dependent variable), the second was the exchange rate (independent variable). A monthly data series was used. The volume of observations was (181), the study used the Exponential General Auto-regression Conditional Heterocedasticity (EGARCH) to estimate the model [9].

4. Empirical Evidence

Table (1) shows the descriptive statistics of stock prices in the Khartoum Stock Exchange index (INDEX) and exchange rate (EX). Table (2) also shows the results of unit roots for root tests based on the ADF and PP Test where stock prices in the Khartoum Stock Exchange index and exchange rate are stationary with an intercept in 1st difference and 2nd difference. Table (3) shows Johansson Co Integration Test, Trace test indicates 5 cointegrating eqn (s) at the 0.05 level, indicates the presence of four equations among these variables at a 5% significance level i.e. Stock prices in the Khartoum Stock Exchange index (INDEX), exchange rate (EX). Table (4) EGARCH Output and Table (5) shows the ARCH test indicates variance fixed.

4.1. EGARCH Estimation Output

4.1.1. First: the mean equation

$$INDEX = 1616.80 + 274.07EX + 0.73[AR(1)]$$

$$Z\text{-Stat}(81.04)(27.96)(31.12)$$

4.1.2. Second: The Variance Equation

$$\ln(\hat{\sigma}_t^2) = 7.85 + 2.81 \left| \frac{\sigma_t | \varepsilon_{t-1}}{\sigma_{t-1}} \right| - 0.84 + \frac{\gamma \varepsilon_{t-1}}{\sigma_{t-1}} + 0.21 \ln(\sigma_{t-1}^2)$$

Z -Stat(15.53) (21.68)-(5.41)(5.77)

$R^2 = .95$

$\bar{R}^2 = 0.95$

$DW = 1.80$

The estimated coefficients of the mean equation are statistically significant. Parameter stock prices in the Khartoum Stock Exchange index (INDEX) and Exchange Rate (EX) as expected. Incrementing in (INDEX) causes incrementing (EX). The decline in foreign commodity prices is caused by the outflow of capital and the rise in the price of foreign currency. The role of news appears through the variance equation. The leverage effect term (5.77), denoted by RES/SQR [GARCH] (1) in the output is positive and statistically different from zero, indicating a leverage effect (positive correlation between (INDEX) and (EX) in the future: as The past few years have proven that a decline in the general index of the Khartoum Stock Exchange results in financial crises.

Table 1 Jarque-Bera

	INDEX	EX
Jarque-Bera	211.4319	7.162652
Probability	0.345677	0.278390

Table (1) shows the dependence of the data on the normal distribution through the Jarque-Bera test, which indicates that the probability value of the test was greater than (0.05), so the null hypothesis was accepted, that meaning the study data follow the normal distribution.

4.2. Stability Test

The following are the results of the practical application of the stability test by application on the monthly study data (exchange rate and stock price index).

Table 2 Results of unit roots for root tests based on the ADF and PP Test

Test	Augmented Dickey-Fuller (ADF) Prob			Phillips- Peron (PP) Prob		
	Level	1st difference	2nt difference	Level	1st difference	2nt difference
EX	0.02	0.00	0.01	0.02	0.00	0.01
INDEX	0.01	0.00	0.01	0.01	0.00	0.01

Table (2) shows the results of unit root tests based on the ADF and PP Test where the economic stability (EX), Exchange Rate (INDEX) stationary with an intercept in level, 1st difference and 2nt difference.

Table 3 Johansson Co Integration Test

Date: 03/29/22 Time: 20:10				
Sample (adjusted): 2004M06 2019M12				
Included observations: 187 after adjustments				
Trend assumption: Linear deterministic trend				
Series: EX INDEX				
Lags interval (in first differences): 1 to 4				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.126646	25.89005	15.49471	0.0010
At most 1	0.003030	0.567527	3.841466	0.4512

Table (3) shows Johansson Co Integration Test, Trace test indicates 1 co integrating eqn (s) at the 0.05 level.

Table 4 EGARCH Model Output

Dependent Variable: INDEX				
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)				
Date: 03/29/22 Time: 20:15				
Sample (adjusted): 2004M02 2019M12				
Included observations: 191 after adjustments				
Failure to improve likelihood (non-zero gradients) after 210 iterations				
Coefficient covariance computed using outer product of gradients				
Presample variance: backcast (parameter = 0.7)				
$\text{LOG(GARCH)} = C(4) + C(5) * \text{ABS(RESID(-1)} / \text{@SQRT(GARCH(-1))} + C(6) * \text{RESID(-1)} / \text{@SQRT(GARCH(-1))} + C(7) * \text{LOG(GARCH(-1))}$				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
EX	274.0706	3.381586	81.04794	0.0000
C	1616.796	57.82455	27.96037	0.0000
AR(1)	0.725941	0.023326	31.12106	0.0000
Variance Equation				
C(4)	7.852395	0.505610	15.53054	0.0000
C(5)	2.810062	0.129600	21.68265	0.0000
C(6)	-0.837754	0.154543	-5.420837	0.0000
C(7)	0.213265	0.036907	5.778434	0.0000
R-squared	0.950826	Mean dependent var	3786.122	
Adjusted R-squared	0.950303	S.D. dependent var	3360.985	
S.E. of regression	749.2603	Akaike info criterion	14.78870	
Sum squared resid	1.06E+08	Schwarz criterion	14.90790	
Log likelihood	-1405.321	Hannan-Quinn criter.	14.83698	
Durbin-Watson stat	1.806521			
Inverted AR Roots	0.73			

Table 5 Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.7481	Prob. F(2,18)	0.064321
Obs*R-squared	0.8213	Prob. Chi-Square(2)	0.212345

Table (5) shows that the probability value of the Breusch-Godfrey test was greater than (0.05), which means that the null hypothesis is accepted, that is, the variance is constant.

5. Model Estimation

Monthly data were used for the study variables for the period (2004M02 2019M12) and due to the nature of the dependent variable (qualitative), the linear probability model was used in the estimate by relying on the Logit model through the Eviews-10 computer package, so the following estimated economic stability model was reached (see Appendix (1)):

- **Economic criterion:** The model fulfilled the economic criterion of the signal and magnitude of the estimated parameters.

5.1. Statistical Criterion

Individual significance (T-test): We find that the probability value of the model parameters (0.00, 0.00, 0.04, 0.00), respectively, is less than (0.05), and this indicates that all independent variables are important in explaining economic stability in Sudan.

- **Total significance (LR test):** We note that the probability value of LR (0.00) is less than (0.05), and this indicates that the model is significant and that the variables of GDP, unemployment and inflation are important variables in explaining economic stability in Sudan and that the estimated model can be applied.
- **(R-square):** We find that the probability value of the coefficient of determination is (0.80) and this indicates that (80%) of the independent variables that explain economic stability in Sudan are present and included in the model, and that only (20%) are independent variables that explain economic stability, but they are not inline in the model and inline in the random variable.

6. Results and Discussion

The descriptive statistics in table (1) and (2) show a sharp increase in the means and standard deviation of (INDEX) and the exchange rate (EX). There was possibility of a simultaneous feedback relationship between (INDEX) and (EX). And also There was a statistical significant relationship between (INDEX) and (EX) in Sudan. The exchange rate is of great importance in improving the level of (INDEX) if the reduction of the exchange rate was supported by production for export and the improvement of the balance of payments.

Recommendations

The need to improve the exchange rate of the local currency in order to improve the level of the general index of the Khartoum Stock Exchange. The need to support the reduction of the exchange rate through production in order to increase the rate of economic growth, improve the general level of the Khartoum Stock Exchange and move the economy.

7. Conclusion

There is an inverse statistically significant relationship between (INDEX) and (EX) in Sudan. The study recommends reducing the exchange rate, striving towards production, increasing the rate of economic growth, and improving the general level of the Khartoum Stock Exchange.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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