

RELATIONSHIP BETWEEN INFLATION AND EXCHANGE RATE IN TANZANIA: THE VECTOR ERROR CORRECTION MODEL

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Abstract

The study aims at analyzing the relationship that exists between the inflation rate and the exchange rate in Tanzania. The study uses annual time series data from 1981 up to 2018 and employed Vector Error Correction Model to examine long-run and short-run relationships. The results indicated that both a short-term and a long-term relationship was found. Therefore, the government of Tanzania is required to control the inflation rate through the proper use of fiscal and monetary policy effectively to control the inflation rate in Tanzania. This will affect the exchange rate in Tanzania. Granger causality test also shows that the inflation rate influences the exchange rate in Tanzania and through the use of a CUSUM square test it shows that the model lies within a 5 per cent level. Based on the findings, it is recommended that the Tanzanian government should implement stringent fiscal and monetary policies to maintain low inflation rates. By stabilizing the inflation rate, the government can positively influence the exchange rate, thus ensuring economic stability. Future research should explore additional macroeconomic variables that may affect this relationship to provide a more comprehensive understanding. Moreover, continuous monitoring and adjustment of these policies are essential to adapt to the dynamic economic environment. Overall, maintaining a stable inflation rate is crucial for the favorable management of the exchange rate, which in turn supports sustainable economic growth in Tanzania.

Keywords: Exchange Rate, Inflation Rate, Tanzania, Time Series Analysis, Vector Error Correction Model.

Doi: <https://dx.doi.org/10.4314/ijdmr.v19i1.3>

Introduction

Tanzania has experienced a long period of dynamic exchange rates. Depreciation of a currency typically improves a country's balance of trade by encouraging higher export rates. This is achieved by increasing demand for domestically produced goods and services in other nations, while making the importation of the same goods from other countries into the home country more expensive and less profitable (Sadeghi, Feshari, Marvasti, Ghanbari, 2015). Understanding the relationship between inflation and the exchange rate in Tanzania is crucial because exchange rate fluctuations significantly impact the economy, influencing the country's level of trade. This dynamic role of exchange rates is particularly pronounced in a free market economy (Proti, 2013; Dimoso & Andrew, 2021).

Consumer spending in Tanzania, especially in the agribusiness sector, is highly affected by the money supply in the economy. When a country's currency appreciates, its value rises relative to other currencies (Gopinath & Neiman, 2014; Fumbwe, Lihawa, Andrew, Kinyanjui, & Mkuna, 2021). This appreciation makes exports more expensive and imports cheaper, leading to an unfavorable balance of trade if domestic prices remain constant in both countries (Kitole, Lihawa, Sesabo, & Shitima, 2023). Depending on whether a country adopts domestic pricing or foreign pricing, this can disrupt agricultural economies in developing countries (Kitole, 2023; Kitole, Tibamanya, & Sesabo, 2024).

Several factors affect exchange rates, including the balance of payments in the current account, direct foreign investment, government debt, interest on loans, inflation rate, imports, exports, and central bank reserves (Sadeghi et al., 2015). These factors are influenced by the foreign exchange market. The Central Bank of Tanzania (BoT) must control these factors and maintain strict oversight of foreign exchange currency and other financial activities, as Tanzania is a small economy engaged in international trade (Kitole & Sesabo, 2024; Kitole & Sesabo, 2022). Increases in these financial challenges affect the general welfare of developing countries like Tanzania, hindering their ability to provide basic services (Theodory & Kitole, 2024).

Tanzania's currency has depreciated significantly since 1990. Recognizing the importance of fostering a conducive environment for private sector growth, Tanzania has enacted several investment-related laws and policies. These include the Banking and Financial Institutions Acts of 1991 (No. 12 of 1991) and the Customs Tariffs Amendments Act No. 1 of 1976, which aimed to create attractive investment packages and promote private sector development (Kitole & Genda, 2024).

Exchange rate issues persist even in developed countries. No economist can guarantee establishing a perfectly valued currency, which underscores the need to investigate the factors affecting exchange rates in Tanzania, particularly the relationship between inflation and exchange rates. Other factors influencing Tanzania's exchange rate include economic and political factors, both short- and long-term (Kitole et al., 2024). Analyzing macroeconomic variables provides better insights into the behavior of inflation and exchange rates.

International studies have explored the relationship between inflation and exchange rates. For example, Uddin, Quaasar and Nandi (2013) examined the factors causing exchange rate fluctuations in Bangladesh and found strong correlations between exchange rates, inflation rates, and nominal money ratios. Increasing relative debt was identified as another significant factor affecting nominal exchange rates (Reinhurt, Rogoff, & Savastano, 2014). Government borrowing from domestic and foreign sources has been a major cause of the depreciation of the Bangladesh Taka against the US Dollar.

Oduola and Akinlo's (2001) study on Nigeria examined the link between inflation and exchange rates, identifying fiscal, monetary, and balance of payments factors as causes of inflation. Monetary inflation is driven by an increase in the money supply, while fiscal inflation results from budget deficits (Schmitt-Grohe & Uribe, 2018; Ghanbari, 2015). Using several econometric approaches, including the vector autoregression (VAR) model, the study found both short- and long-run relationships between inflation and exchange rates in Nigeria.

The primary aim of this study is to examine the relationship between the inflation rate and the exchange rate in Tanzania, addressing a research gap. Through time series analysis, the study investigated whether there is cointegration between inflation and exchange rates in Tanzania and examined Granger causality to understand the direction and causality of the variables. The null hypothesis tested included no cointegration among the variables and no causality between the exchange rate and inflation rate in Tanzania.

This study contributes to the understanding of the relationship between exchange rates and inflation in Tanzania, providing valuable information for government officials, investors, multinational companies, foreign exchange market players, policy planners, and both private and public sector companies. It offers relevant insights for exporters and importers and suggests several economic policies to manage these macroeconomic variables in Tanzania. Additionally, the findings assist policymakers in formulating effective monetary and fiscal policies tailored to Tanzania's current economic situation.

Literature Review

Theoretical Literature Review

This study is informed by two key theories that focus on global trade as a factor influencing exchange rates: the Purchasing Power Parity (PPP) theory and the Balance of Payment theory. While there are numerous theories on exchange rate determination, no single theory can fully explain past exchange rate behavior or accurately forecast future trends.

The Balance of Payment (BOP) theory, propounded by David Hume in the 18th century, emphasizes the significance of the balance of payments in economic growth and development (Schmitt-Grohe & Uribe, 2018). The theory posits that the balance of payments, which encompasses all economic transactions between residents of a country and the rest of the world, is a crucial measure of a country's economic interactions. Given

its importance, the government plays a vital role in controlling the exchange rate and inflation rate to maintain a balanced economy.

Purchasing Power Parity (PPP) theory, developed by Gustav Cassel in 1918, is another critical framework for understanding exchange rate dynamics (Mayer, Melitz, & Ottaviano, 2014). The PPP theory suggests that in the long run, exchange rates should adjust to equalize the price levels of identical goods and services in different countries. This theory is based on the law of one price, which states that in the absence of transportation costs and other barriers, identical goods should have the same price when expressed in a common currency.

Understanding the determinants of supply and demand for foreign currency is essential for grasping the factors influencing exchange rates. For instance, in a trading relationship between Tanzania (TZ) and the USA, the factors that increase demand for TZ Shillings are also the factors that control the supply of US Dollars (US\$). Conversely, the factors affecting the supply of TZ Shillings also influence the demand for US\$. Therefore, the balance of payments systematically collects all the factors that determine the foreign exchange rate, highlighting the interconnected nature of global trade and currency values (Garcia & Restrepo, 2001; Mayer et al., 2014).

This intricate relationship underscores the importance of a balanced approach to managing both exchange rates and inflation rates to ensure stable economic growth and development. By integrating the insights from both the PPP and BOP theories, this study aims to provide a comprehensive understanding of the factors influencing exchange rates in the context of global trade.

Empirical Literature Review

Quadry et al. (2017) conducted a comprehensive study on the factors affecting the exchange rate of Pakistan between 1979 and 2008. The study employed multiple linear regression, where the exchange rate was the dependent variable, and inflation, interest rate, foreign exchange reserves, trade balance, money supply, and gross domestic product (GDP) were the independent variables (Kabundi & Mbelu, 2018). The findings revealed that inflation, interest rate, and foreign exchange reserves significantly influenced the exchange rate, remaining significant at the 1% level. In contrast, GDP, money supply, and trade deficit were found to be insignificant.

Similarly, Uddin et al. (2013) examined the factors affecting exchange rate fluctuations in Bangladesh. The study demonstrated that the exchange rate is strongly associated with the nominal money stock ratio of respective currencies. An increase in relative debt was identified as another significant factor affecting the nominal exchange rate. Government borrowing from domestic and foreign sources was one of the major causes of the depreciation of the Bangladesh Taka against the US Dollar (Ha, Stocker & Yilmakuday, 2019).

Raza and Afshan (2017) analyzed the determinants of exchange rate in Pakistan. They found that inflation, by increasing the money supply, leads to a depreciation of the local currency, thereby causing exchange rate changes and increased variability. Additionally, oil prices were identified as the second most influential factor affecting exchange rate variability. Government intervention also played a role in this dynamic.

A study by Ahn, Adji, and Willett (1998) explored the effects of changes in inflation and exchange rate policy on investment in developing nations. They found that in developing countries, inflation negatively affects exchange rates both in the short and long term. Although different exchange rate policies can reduce these effects, they cannot completely eliminate them, particularly those that discourage extensive currency overvaluation.

Jaradat and Al-Hhosban (2014) examined the relationship and causality between Interest rate and Inflation rate in Jordan. The study employed a vector error correction model and Granger causality test. The results indicated a long-term relationship between the inflation rate and exchange rate in Jordan. Additionally, Granger causality showed a bi-directional relationship between the variables. The study recommended various strategies to control inflation and rapid exchange rate fluctuations, such as reducing public sector expenditure and the efficient use of both fiscal and monetary policies (Gopinath & Neiman, 2014).

In Nigeria, Obamuyi and Olorunfemi, (2011) examined the financial reforms, interest rate behaviour and economic growth. Using a Vector Error Correction Model approach, the study found that the inflation rate impacts the interest rate, as indicated by Granger causality tests. Subsequently, the interest rate influences the exchange rate. Over the long term, interest rates move positively while inflation negatively impacts exchange rate volatility, suggesting that increasing interest rates can reduce exchange rate volatility (Gopinath, Boz, Casas, 2016).

Mwase (2006) investigated the effects of exchange rates on consumer prices in Tanzania using a vector autoregression model with data from 1990 to 2005. The study showed that fluctuations in the inflation rate cause persistent changes in the exchange rate, leading to the depreciation of the Tanzanian Shilling. The results also indicated that government ministries responsible for controlling exchange rates and inflation should manage the importation of goods and services to prevent unfavorable balances of payments and budget deficits. This insight can help ensure a favorable balance of payments through appropriate adjustments to inflation and exchange rates.

Mahdi and Masood (2011) analyzed the long run relationship between interest rates and inflation in Iran by revisiting Fisher's hypothesis. Their findings showed that in the long run, the currency exchange rate is highly dependent on oil prices and price differences in Iran and other countries. Short-term influences include international financial turbulence and interest rate differentials. Since January 1997, global financial turbulence has

significantly impacted the exchange rate, with effects from international foreign exchange markets being as significant as oil prices on monthly exchange rate movements.

Sabina, Manyo, and Ugochukwu (2017) studied exchange rate volatility and economic growth in Nigeria, finding that the accumulation of external debt has contributed to exchange rate overshooting. Another empirical study in large cities found mixed results, raising debates on how inflation can affect growth and whether it has a direct effect (Kitole et al., 2024; Gopinath & Neiman, 2014). Kitole and Utouh (2023) explored exchange rate fluctuations in Tanzania, suggesting that national debt, political tension, and economic growth are significant factors affecting exchange rate movements.

Despite these extensive studies, research specifically focused on the factors affecting exchange rate dynamics in Tanzania remains limited. This study aims to address this gap by examining economic variables from 1981 to 2018 to assess their impact on the exchange rate in Tanzania.

Conceptual Framework

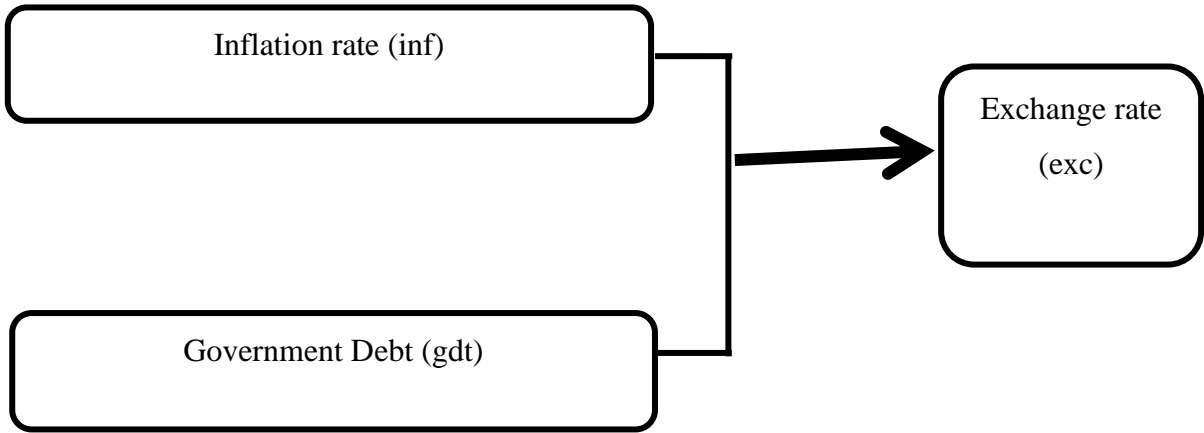
The conceptual framework of this study is designed to delineate the independent and dependent variables as discussed in both the theoretical and empirical literature reviews. The framework provides a structured approach to understanding the dynamic relationships among these variables. The primary dependent variable in this study is the exchange rate, which is analyzed in comparison to other significant macroeconomic indicators, namely the inflation rate and government debt. The exchange rate is a critical economic indicator that reflects the value of a country's currency in relation to foreign currencies. It is influenced by various factors including but not limited to inflation and government debt.

The exchange rate serves as the dependent variable and is the main focus of this study. It is crucial to understand how fluctuations in the exchange rate impact the overall economy, especially in a country like Tanzania, where the exchange rate plays a significant role in international trade and economic stability. Moreover, inflation, measured as the rate at which the general level of prices for goods and services rises, eroding purchasing power, is a key independent variable. It has a direct impact on the exchange rate as changes in inflation can alter a country's competitive position, affecting exports and imports. Government debt, encompassing both domestic and foreign borrowing, is another independent variable (Kitole, Msoma, & Sesabo, 2024). High levels of government debt can lead to higher interest rates and inflation, which in turn can affect the exchange rate. The sustainability of government debt levels is crucial for maintaining economic stability and investor confidence.

The independent variables in this framework are the inflation rate and government debt, both of which have been identified through extensive theoretical and empirical research as significant influencers of the exchange rate. Moreover, inflation rate as an independent variable, the inflation rate is expected to have a direct impact on the exchange rate. Higher inflation typically leads to currency depreciation as the purchasing power of

the currency diminishes relative to foreign currencies. Also, Government debt levels, both domestic and foreign, influence investor confidence and economic stability. High debt levels can lead to concerns about a country's fiscal sustainability, potentially resulting in currency depreciation.

Figure 2.1: Conceptual Framework



Methodology

Data

The data used in this paper are time series data of two macroeconomic variables, the inflation rate and the exchange rate in Tanzania. The study spans a period of 49 years, from 1969 to 2018, to provide a comprehensive analysis of the long-term trends and relationships between these variables. To ensure the accuracy and reliability of the findings, the data were sourced from reputable institutions, including the Bank of Tanzania (BoT), the National Bureau of Statistics (NBS), and international databases such as the World Bank and the International Monetary Fund (IMF). The inflation rate data were collected as annual percentage changes in the Consumer Price Index (CPI), which reflects the cost of a typical basket of goods and services consumed by households. The exchange rate data were obtained as annual average exchange rates of the Tanzanian Shilling (TZS) against the US Dollar (USD), which is the most commonly used foreign currency in Tanzania's international transactions.

The Model

The exchange rate is a function of government expenditures and can be expressed mathematically as follows:

$$exc_t = f(inf_t) \dots \dots \dots (1)$$

Therefore, an econometric model can be specified as follows;

$$exc_t = \beta_0 + inf_t + \varepsilon_t \dots \dots \dots (2)$$

The variable is normalized by using natural logarithm to reduce time series data variation; also, an econometric model will change and be as follows;

$$\ln exc_t = \beta_0 + \beta_1 \ln inf_t + \varepsilon_t \dots \dots \dots (3)$$

Whereby; *exc* = exchange rate, *inf* = inflation rate, *t* = time, ε = error term, β_0 = constant coefficient and β_1 = slope coefficient. Therefore Equation 3 become;

$$\varepsilon_t = -[\beta_0 - \ln exc_t + \beta_1 \ln inf_t] \dots \dots \dots (4)$$

Vector Error Correction Models examines the relationship between inflation and exchange rate in Tanzania. And since a cointegrating association is recognized in the model through a Johansen test, VECM are used to model both the long run and the short run effects of the variable.

When a log of exchange rate is used as a dependent variable, the VEC model is specified as follows:

$$\Delta \ln exc_t = \beta_{01} + \sum_{i=1}^{k-1} \beta_i \Delta \ln exc_{t-i} + \sum_{j=1}^{k-1} \lambda_j \Delta \ln inf_{t-j} + \alpha_{i1} ECT_{t-1} + \varepsilon_{1t} \dots \dots \dots (5)$$

And when a log of inflation rate variable as a dependent variable VEC model is specified as;

$$\Delta \ln inf_t = \beta_{02} + \sum_{i=1}^{k-1} \beta_i \Delta \ln exc_{t-i} + \sum_{j=1}^{k-1} \lambda_j \Delta \ln inf_{t-j} + \alpha_{i2} ECT_{t-1} + \varepsilon_{2t} \dots \dots \dots (6)$$

Hence the cointegrating equation and a long run model specified as;

$$ECT_{t-1} = [\ln exc_{t-1} - \lambda_j \ln inf_{t-1} + \beta_{01}] \dots \dots \dots (7)$$

In the above equation (vi) ECT_{t-1} the error correction term is the lagged value of the residuals obtained from the cointegrating regression of the dependent variable on the regressors. Contain a long run information derived from the long-run cointegrating relationship, ε_t is the residuals (stochastic error terms often called impulses or shocks), α_{i1} speed of adjustment while the short run dynamic coefficients of the model are β_i and β_j . Based in this study a VECM is used to estimate both short run and long run effect among the two variables and some diagnostic test was performed to check if the model and data are correctly specified.

Augmented Dickey Fuller test (ADF) test for stationarity

The Augmented Dickey Fuller (ADF) test is estimated in several steps, First when a time series variable has no constant and no trend ADF test for stationarity is specified

$$\Delta X_t = \alpha_2 X_{t-1} + \sum_{i=1}^k \beta_i \Delta X_{t-1} + \varepsilon_t \dots \dots \dots (8)$$

When a time series variable has constant and no trend ADF test for stationarity specified as;

$$\Delta X_t = \alpha_0 + \alpha_2 X_{t-1} + \sum_{i=1}^k \beta_i \Delta X_{t-1} + \varepsilon_t \dots \dots \dots (9)$$

And when time series variable includes constant, trend and drift the ADF test for stationarity as specified as;

$$\Delta X_t = \alpha_0 + \alpha_1 t + \beta_0 X_{t-1} + \sum_{i=1}^k \beta_i \Delta X_{t-1} + \varepsilon_t \dots \dots \dots (10)$$

Whereby; Δ = difference operator, t time trend, k = number of lags that will be used, ε = error term, α_s and β_s are those parameters to be estimated.

The study tests the null hypothesis against alternative hypothesis. The decision rule is that if the computed t-statistic value is greater than a critical value at 5 per cent level then a null hypothesis of no unit root test will be rejected and an alternative hypothesis will be accepted implying that the variable is stationary. The decision criterion determines whether the variable is stationary after the first difference or at level after the second difference.

Phillips-Perron (PP) test for stationarity

PP-test has been used since 1988 by Phillips Perron as a more robust test for stationarity of time series data. It modifies ADF-test by making a nonparametric modification that corrects the problem of heteroscedasticity and serial correlation in error terms.

PP-test demonstrated as follows:

$$\Delta X_{t-1} = \alpha_0 + \beta X_{t-1} + \varepsilon_t \dots \dots \dots (3.12)$$

A null hypothesis of the presence of a unit root is tested against an alternative hypothesis of no unit root, and PP-test series are also stationary only when the null hypothesis is rejected and alternative hypothesis is accepted at 5% significance level.

Also, after ensuring that all variables in the model become stationary, the next procedure conducted was to test some diagnostic tests like test for serial correlation, heteroscedasticity and other procedure was followed like the selection of lag length, Johansen and Juselius cointegration tests, model stability through a CUSUM square and Granger causality test are among the tests conducted in this study used to in order to ensure the relationship between variables is examined effectively.

Results and Discussions

The time series data set have been checked by graphical and a normal regression to determine if the result is meaningful or useless. The results show that Tanzania's at level inflation rate is not stationary. This implies the data have no constant mean, variance and covariance among the variables. Also, the data have been regressed to check if the results are superius by using the rule of thumb, since the condition is that if the R square are greater than Durbin Watson then the results are superius regression; this means the R square values are equal to 0.2482 which are greater than Durbin Watson values hence the regression results are meaningless then the need to make the data stationary follows;

Results for Unit root test at level form

The results of the unit root tests conducted using the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test at the level for the variables log of the exchange rate (Lnexc) and log of the inflation rate (Lninf) are presented in Table 1. These tests are crucial for determining the stationarity of the time series data, which is a prerequisite for reliable econometric analysis.

Table 1: Unit root test results by ADF-test and Phillips Perron (PP) at level.

Variable	ADF Test statistics at level	At 1% critical value	At 5% critical value	At 10% critical value	PP Test statistics at level	At 1% critical value	At 5% critical value	At 10% critical value
Lnexc	-2.951***	-2.644	-1.950	-1.604	-3.744	-3.675	-2.969	-2.617
Lninf	-1.189	-3.675	-2.969	-2.617	-1.531	-3.668	-2.966	-2.616

Where by: ***, **, * indicates statistically significance at 1%, 5% and 10% respectively.

The unit root test results reveal that the log of the exchange rate (Lnexc) is stationary at the level, as evidenced by the statistically significant ADF and PP test statistics at the 1%, 5%, and 10% critical values. This implies that Lnexc does not have a unit root and its statistical properties, such as mean and variance, do not change over time. Therefore, it is appropriate to use Lnexc in further time series analysis without differencing.

On the other hand, the log of the inflation rate (Lninf) is not stationary at the level, as the ADF and PP test statistics do not exceed the critical values at any significance level. This indicates the presence of a unit root in Lninf, suggesting that its mean and variance are time-dependent and that it exhibits trends or persistence over time. To achieve stationarity, Lninf would likely require differencing or other transformations before it can be included in further econometric modeling.

These findings have important implications for the analysis of the relationship between inflation and exchange rates in Tanzania. The stationarity of Lnexc suggests that exchange rates can be reliably modeled and forecasted without transformation. However, the non-stationarity of Lninf indicates that additional steps are necessary to stabilize the inflation data before it can be accurately analyzed in conjunction with exchange rates.

Table 2: Unit root test results by ADF- test and Phillips-Perron (PP) test at first difference.

Variable	ADF Test statistics at level	At 1% critical value	At 5% critical value	At 10% critical value	PP test statistics at level	At 1% critical value	At 5% critical value	At 10% critical value
$\Delta lninf$	-5.581***	-3.689	-2.975	-2.619	-5.727	-3.675	-2.969	-2.617

Where by: *** indicates significance at 1% level

The unit root test results at the first difference indicate that the log of the inflation rate ($\Delta \ln inf$) becomes stationary after differencing, as evidenced by the statistically significant ADF and PP test statistics at the 1%, 5%, and 10% critical values. This implies that the differenced series does not have a unit root, and its statistical properties, such as mean and variance, are stable over time. The initial non-stationarity of $\ln inf$ (log of the inflation rate) at the level suggested that the series exhibited trends or persistence over time. However, by differencing the series, these trends are removed, and the resulting series ($\Delta \ln inf$) is now suitable for further time series analysis. The stationarity of $\Delta \ln inf$ at the first difference allows for accurate modeling and forecasting, providing reliable insights into the behavior of inflation over time.

Estimation of optimal Lag Length Selection Criterion.

After ensuring that the time series data sets are stationary, the next crucial step is selecting the optimal lag length for model analysis. This process is essential in multivariate cointegration analysis to accurately capture the dynamics between variables. The selection of the optimal lag length is presented in Table 3.

The first test in multivariate cointegration analysis is to determine the optimal lag. This is achieved by considering various information criteria, including the Final Prediction Error (FPE), Akaike Information Criterion (AIC), Hannan-Quinn Information Criterion (HQIC), and Schwarz Bayesian Information Criterion (SBIC). The optimal lag length is determined by the criterion that provides the lowest value. Based on the results of the varsoc testing, the optimal lag length is chosen by evaluating the majority of criteria that indicate the lowest values among FPE, AIC, HQIC, and SBIC. In this study, a lag length of 5.64318 was selected as the optimal lag based on the majority of these criteria.

In summary, the lag length with the lowest value is typically chosen as the optimal lag for the model. For this study, the optimal lag length was determined to be 35.2442. This careful selection process ensures that the model accurately reflects the underlying data dynamics, providing reliable and robust results for the subsequent analysis.

Table 3: Results for a Lag Length Selection Criterion Results.

Lag	LL	LR	Df	P	FPE	AIC	HQIC	SBIC
0	-54.8625				0.107581	3.44621	3.47673	3.53691
1	35.2442	180.21	4	0.000	0.000583*	-1.772327*	-1.68082*	-1.50028*
2	36.5687	0.2.649	4	0.618	0.000688	-1.61022	-1.45764	-1.15674
3	42.1096	11.082*	4	0.026	0.000632	-1.70361	-1.40999	-1.06073
4	44.3502	4.4813	4	0.345	0.000714	-1.59698	-1.32233	-0.780706

Johansen Cointegration Tests Results

Results in Table 4 present the findings of Johansen’s cointegration test. The test reveals that both the maximum rank in trace statistics and max statistics values for the null hypothesis at rank zero fail to be ruled out, implying no cointegration within the model. When the trace value and maximum value statistics exceed the 5 percent critical value, the null hypothesis is rejected, indicating cointegration between the exchange rate and inflation rate. Consequently, the acceptance of the alternative hypothesis signifies cointegration among the variables.

Table 4: Johansen’s Cointegration Tests

Maximum rank	Parms	LL	Eigenvalue	Trace Statistics	5%critical value
0	2	-9.6161143	-	53.0922	15.41
1	5	4.9218992	0.52863	26.0162	3.76
2	6	17.930005	0.51455		
Maximum rank	Parms	LL	Eigenvalue	Max Statistics	5%critical value
0	2	-8.6161143	-	27.0760	14.07
1	5	4.9218992	0.52863	26.0162	3.76
2	6	17.930005	0.51455		

In this study, based on Table 4, the results show that at rank zero, the trace and max statistics values are greater than the 5 percent critical value. For example, the trace statistics value of 53.09 exceeds the 5 percent critical value of 15.41. Similarly, the max statistics value of 27.08 at rank zero is greater than the 5 percent critical value of 14.07. Therefore, the null hypothesis of no cointegration is rejected, while the alternative hypothesis of the existence of cointegration between the variables is accepted. This finding indicates that the

exchange rate and inflation rate are cointegrated, implying a long-run relationship between these two variables.

Vector Error Correction Model Results

The results of the Vector Error Correction Model (VECM) presented in Table 5 provide crucial insights into the short-term dynamics and long-term relationships between the exchange rate (\ln_{exch}) and the inflation rate (\ln_{inf}) in Tanzania. Each coefficient and its corresponding statistics—standard error, z-value, p-value, and confidence intervals—offer a detailed understanding of the influence and significance of the variables in the model.

The coefficient for the long-run equilibrium term ($_ce1, L1$) is 0.0002485 with a standard error of 0.0024639, resulting in a z-value of 0.10 and a p-value of 0.920. This indicates that the term is not statistically significant at any conventional level, suggesting that the adjustment to the long-term equilibrium for the exchange rate is negligible in the short run. This implies that deviations from the long-run equilibrium are not quickly corrected within the current period.

In contrast, the lagged exchange rate ($\ln_{exch}, LD.$) has a coefficient of 0.7292309, a standard error of 0.1255639, and a z-value of 5.81, which is highly significant (p-value < 0.001). This strong significance indicates that past values of the exchange rate have a substantial impact on its current values, highlighting a high degree of persistence in the exchange rate series. This suggests that the exchange rate in Tanzania is influenced significantly by its own historical values, making it a strong predictor of future exchange rate movements.

The first lag of inflation ($\ln_{inf}, LD.$) has a coefficient of 0.0729645 with a standard error of 0.0637316 and a z-value of 1.14, with a p-value of 0.252. This result indicates that the first lag of inflation is not statistically significant in influencing the current exchange rate. Similarly, the second lag of inflation ($\ln_{inf}, LD2.$) has a coefficient of 0.0391857, a standard error of 0.0284858, a z-value of 1.38, and a p-value of 0.169. Like the first lag, this term is not statistically significant, indicating that past inflation rates do not have a considerable short-term impact on the exchange rate.

Additionally, the coefficient for the long-run equilibrium term ($_ce1, L1$) is -0.0344922 with a standard error of 0.0060005, resulting in a z-value of -5.75 and a highly significant p-value (p-value < 0.001). This strong significance indicates a substantial adjustment of the inflation rate towards the long-run equilibrium, implying that inflation rapidly corrects deviations from the equilibrium. This suggests that the inflation rate in Tanzania is responsive to long-term economic forces and quickly adjusts when there are deviations from its long-term path.

The lagged exchange rate ($\ln_{exch}, LD.$) has a coefficient of -0.0514092 with a standard error of 0.305793 and a z-value of -0.17, with a p-value of 0.866. This indicates that the past values of the exchange rate do not have a significant impact on the current

inflation rate. This lack of significance suggests that the exchange rate's historical values do not directly influence the inflation rate in the short run.

The first lag of inflation (lninf, LD.) has a coefficient of 0.1716749, a standard error of 0.1552093, a z-value of 1.11, and a p-value of 0.269. This term is not statistically significant in influencing the current inflation rate, indicating that the immediate past inflation rate does not have a strong effect on current inflation. Similarly, the second lag of inflation (lninf, LD2.) has a coefficient of 0.0002824, a standard error of 0.0693731, a z-value of 0.00, and a p-value of 0.997, further indicating no significant short-term influence of past inflation rates on the current inflation rate.

The results from the VECM indicate that the exchange rate (lnexch) is highly persistent over time, as evidenced by the significant coefficient of its lagged term. This persistence suggests that past values of the exchange rate are strong predictors of its future values. However, the inflation rate (lninf) does not significantly influence the exchange rate in the short run, as both lagged terms of inflation are statistically insignificant.

In contrast, the inflation rate (lninf) shows a significant adjustment towards the long-run equilibrium, as indicated by the highly significant coefficient for the long-run equilibrium term (_ce1, L1). This suggests that any short-term deviations from the long-term equilibrium in inflation are quickly corrected. However, the exchange rate and its lagged terms do not significantly influence the current inflation rate. These findings imply that while the exchange rate exhibits strong short-term persistence, the inflation rate rapidly adjusts to its long-term equilibrium. The lack of significant short-term interactions between the exchange rate and inflation rate suggests that other factors might be driving these variables, necessitating further investigation into additional macroeconomic variables or external shocks that could impact this relationship.

Table 5: Results for Vector error correction Model.

	Coef.	Std. Err	z	P> z	[95% Conf. Interval]
D2_lnexch					
_ce1					
L1.	0.0002485	0.0024639	0.10	0.920	-
lnexch	0.0045806	0.0050777			
LD.					
lninf	0.7292309	0.1255639	5.81	0.000	0.4831303
LD2.	0.9753315				
_cons	0.0729645	0.0637316	1.14	0.252	-0.0519471
	0.1978762				
	0.0391857	0.0284858	1.38	0.169	-0.0166454
	0.0950168				

D2_lning _cel L1.	-0.0344922	0.0060005	-5.75	0.000	-0.046253
lnexch LD.	-0.0227315				
lninf LD2.	-0.0514092	0.305793	-0.17	0.866	-
	0.6507525	0.5479341			
_cons	0.1716749	0.1552093	1.11	0.269	-
	0.1325297	0.4758796			
	0.0002824	0.069373	0.00	0.997	-
	0.1356864	0.1362512			

Granger Causality Test

Granger causality tests are designed to examine if one variable can influence, cause or predict another variable. As an example, the past value of the exchange rate affects the present value of inflation. However, the results in Table 6 indicate that the log of inflation rate influences exchange rates since it is statistically significant at 5% significance level while considering probability values less than 5%. As shown in the following table (4.9).

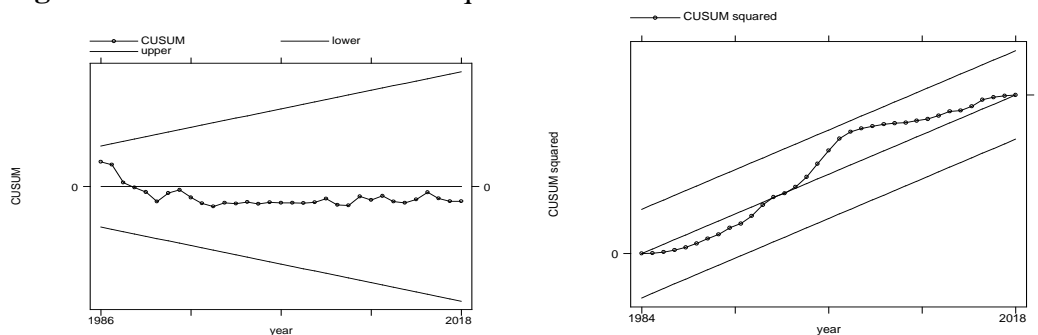
Table 6: Results for Granger causality

Equation	Excluded	Chi2	df	prob > chi2
Lnexc	D_lning	6.154	2	0.046
Lnexc	lninf	6.154	2	0.046
D_lning	lnexc	1.1662	2	0.558
D_lning	lnexc	1.1662	2	0.558

Model Stability Test

The result show that the model is stable since both the CUSUM and a CUSUM squared since a CUSUM and CUSUM square line lies within a range of 5 per cent level of significance as shown clearly in Figure 2.

Figure 4.2: CUSUM and CUSM Square



Conclusion and Policy Recommendations

Since the main objective of this study is to study the existing relationship between the inflation rate and exchange rate in Tanzania, the application of time series analysis was employed in this study and the annual data set of inflation and exchange rate for Tanzania from 1981 to 2018 was used. The model used for analysis based on the nature of the study is the Vector Error Correction Model. The outcomes show both short run and long run relationships between the inflation rate and the exchange rate within the model. Inflation has a negative impact on exchange rate and is statistically significant at 5% level.

Unit root test was also examined based on this study by using the Augmented Dickey full test. The result at level shows that only exchange rate is stable while inflation rate is not stationary at level. Nevertheless, after the first difference, the I(1) inflation rate variable becomes stationary. The Johansen test for a cointegration aims to examine if the long run relationship between the variable in the model exist. And the result shows that both a short run and a long run relationship exists between inflation rate and exchange rate in Tanzania. As a result of the findings, the study shows that the increase in inflation in Tanzania negatively affects the exchange rate in the long run. Hence in order to avoid the problem of inflation in Tanzania the government is required to use both fiscal and monetary policy effectively to control inflation and achieve a stable exchange rate in Tanzania as one of the important factors to have a stable economy and to attract investors to invest both domestic and foreign investors.

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