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A Fisher's equation of exchange analysis of money supply and inflation in Tanzania

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Abstract

Objective*: The current study analyzed how Tanzania's inflation is affected by the money supply. Fisher's equation of exchange was the subject of the current study. Methods: Before estimating the equation, the study tested for unit root problem in the series. Money was differenced stationary, while inflation was trend stationary. This allowed for co-integration test which confirmed long run relationship in two out of five approaches. Vector error correction (VEC) followed by vector auto regressive (VAR) model, paved way for Granger-causality test. Nevertheless, the study also pursued stability test after VEC and VAR estimation. Results: The VEC analysis proved a short run positive effect of money supply on inflation. However, under VAR, the positive relationship lasted for one year and reversed two years later. The Granger-causality test proved a unidirectional causality with broad money causing consumer price index. Originality: This is the only study that employed a pure Fisher's equation of exchange to uncover the effect of broad money on inflation in Tanzania which was verified though not in the long run.*

Keywords*: Inflation, demand for money*

JEL Classification*: E31, E41*

Introduction

Inflation has been a challenge for both developing and emerging countries (Von Braun, 2008). Central banks change regimes to control money supply as a way of containing inflation. In Tanzania (Bank of Tanzania, 2011), the central bank began its role after its establishment in 1966. The government went through different phases to adjust the structure of the economy. The Arusha declaration in 1967 nationalized all institutions including commercial banks.

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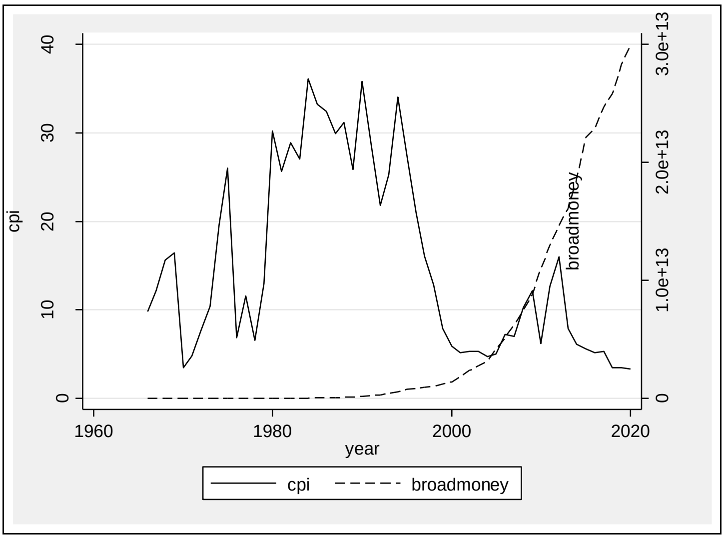
The centralized system proved fruitful for only a decade till early 1980s. But, later the worsening external conditions exposed the system's ineffectiveness. Problems like foreign exchange crisis and sharply reduced economic growth emerged (Laryea & Sumaila, 2001). Inflation in the mid-1970s was due to centralization policy as the central bank lacked the autonomy to control inflation (Bank of Tanzania, 2011).

The government adopted market based policies in the mid-1980s by launching an Economic Recovery Programme (ERP) in 1986. Initial focus of the reform agenda was macroeconomic stabilization and liberalization. But during the early 1990s, the focus was broadened to fiscal performance improvement, civil service restructuring and state enterprises privatization. The reform efforts were fruitful with the average economic growth rate maintained at 3 to 4 percent from 1985 to 1991. International reserves improvement to about 3 months of imports by the end of 1992/1993 was the reform fruits. But, inflation continued to be higher than 30 percent, while fiscal discipline dropped in the mid-1990s with sharp increase of deficits in budget and external current account (Laryea & Sumaila, 2001).

The central bank executed a sound monetary course of action in 2018/2019 to increase liquidity level thereby enabling credit access by the private sector for economic growth, devoid of inflation targeting intolerance. The discount rate was reduced from 9 percent to 7 percent, and banks were provided with liquidity under open market operations, reserve repurchase agreements, facilities for standby credit, and discount window (Bank of Tanzania, 2019).

Figure 1: The trend of CPI and money supply



Source: Own computation, using data from World Bank (2022)

From Figure 1, broad money has been slowly rising for about three decades till early 2000s followed by an exponential growth. On the other hand, inflation had been fluctuating with higher levels above 30 percent from the early 1980s to the mid-1990s, dropping to lower rates than 10 percent in earlier 2000s with slight fluctuations. A graphical analysis shows a negative relationship between money and inflation. But, it is not easy to tell from the causality point of view. Under Fisher's equation, the current study uncovered a broad money-inflation causal relationship. Section two reviewed existing literature, methodology and findings are in section three and four respectively, and section five is the conclusion.

Literature Review

When Fisher (1911) was trying to explain the reasons for the rise in general price level in his book, "purchasing power of money", six variables were the model's ingredients. The equation's left side contained volume of money in circulation, velocity of money in circulation, volume of bank deposits subject to check and its velocity, whilst the general price level and transactions affected by money and deposits on the right hand side. With a broad definition of money, the model comprises (Gardiner, 2006) money supply, money velocity, general price level as well as transactions.

Fisher's equation received numerous criticisms from the choice of words to the set of variables. For instance velocity to be replaced by frequency and transaction volume by gross national product (Gardiner, 2006). This is the quantity hypothesis of money that must assume that, in the long-run, nominal growth in broad money cannot influence real income for the proportionate relationship between broad money and consumer price index to hold. That expanding broad money proportionately expands the consumer price index (Pinter, 2021). Contrary to the exogenous concept, modern interpretation has to do with the concept of endogenous which reveals questions about the starting point of demand for money, its association with supply of money, and the capacity to create a farthest amount of currency (Shvets, 2021). This current study does not refute the critiques, but rather proves the existence of Fisher's equation of exchange in Tanzania.

For most studies, the analysis is not a pure exchange equation but rather a mixture with other variables in the model. Joshi (2021) analyzed the effect of money supply on consumer price index (CPI) in Nepal using vector fault adjustment representation (VECM) and established a protracted positive money supply-inflation affiliation. This study nearly followed the quantity hypothesis of money, but Indian inflation inclusion ruined the theory's purity thereby deviating from origin. Alexandrov, Valinurova, Kostromin, Zenkina, & Egorov (2021) worked on how household income growth and money supply affect inflation in different economies. They found that the influence of quick income growth and high monetization was lesser in developed and rich economies than developing countries. Using Markov-Switching model, Bojanic (2021) found that in a near to the ground regime of inflation, growth in money and velocity were the most important issues behind inflation variance.

Using the vector auto regressive (VAR) model, Antwi, Issah, Patience, & Antwi (2020) investigated the exchange rate determinants in Ghana. They confirmed the quantity hypothesis of money relationship. Their advice to reduce the rate of interest and supply of money in order to reduce inflation is based on the strong relationship hypothesized by the quantity theory of money. However, Duodu, Baidoo, Yusif, & Frimpong (2022), under quarterly data from 1999 to 2019 revealed the opposite relationship. Their analysis also included deficit in the budget, rate of exchange and interest.

Islam (2022) analyzed the influence of foreign exchange rate, broad money supply, and human development index (HDI) on consumer price index (CPI) or inflation. They applied panel dynamic OLS (PDOLS) and fully modified OLS (FMOLS) estimators examining the long run relations and conducted the Toda-Yamamoto Granger-causality test. Their findings confirmed that broad money supply positively influences domestic inflation in a unidirectional causality. Nevertheless, they confirmed an individual effect of broad money, consumer price index, as well as foreign exchange on human development index. However, there was no causality between overseas swap velocity and price rises, and broad money and overseas swap.

Nguyen (2015) applied two approaches namely; pooled mean group (PMG) and panel differenced general method of moment (GMM). Their panel analysis had shown significant influence of money supply on inflation in the PMG approach alone. However, government expenditure, interest rate and fiscal deficit persistently influenced inflation in both approaches. Smauel, Udoh, Prince, Ifeanyi, & Ndu (2019) revealed that, in Nigeria, it is inflation that causes money supply. They suggested that dealing with issues other than money such as political flux, bribery, and underprivileged basic road and rail networks can significantly reduce inflation.

In their novelty study, Long, Hien, & Ngoc (2021) analyzed the liaison amid supply of money, price increases along with output in Vietnam and China. They applied fault adjustment replica, vector auto regression (VAR) model plus canonical co-integration regression (CCR). They uncovered that inflation was strongly influenced by the growth of money and output in China, while strongly influenced by expected inflation and output growth in Vietnam. They contend that the affiliation between broad money, price increases as well as output escalation was still true within the case of transition economies.

Ndanshau (2012) analyzed the effect of disaggregated broad money; M0, M1 plus M2, along with deficit in budget on inflation within Tanzania from 1967 to 2010. Inflation Granger caused a budget deficit and base money (M0). But M1 Granger caused inflation and no causality was established between inflation and M2. Nevertheless, the budget deficit also Granger caused M0. Using these money supply components as separate variables can result in multicollinearity problems because one higher component has the values of another lower component. The empirical analyses were not pure Fisher's equation of exchange which the current study tried to establish.

Methodology and data

The unit root test

Generally, economic period succession statistics have unit derivation problems, that is, being non-stationary (Johansen & Juselius, 1990). With non-stationary data series, the ordinary least square approach is not feasible because of the error term suffering from serial correlation problem. Below, is the unit root model as described in the basic econometrics book of Gujarati & Porter (2009). In the textbook, the starting point is the stochastic process.

$$X_t = \sigma X_{t-1} + e_t \quad -1 \leq \sigma \leq 1 \tag{1}$$

If $\sigma = 1$, a unit root issue, equation (1) becomes a random walk model with no drift, which is a non-stationary stochastic process. We cannot estimate (1) using ordinary least square to test that $\sigma = 1$ using usual t-statistics since the test is biased. Therefore, we transform (1) by subtracting X_{t-1} from both sides to get equation (2)

$$\Delta X_t = \delta X_{t-1} + e_t \tag{2}$$

Where, $\delta = (\sigma - 1)$, and Δ is the operator of differencing once.

The expression $\delta = 0$ was tested against $\delta < 0$. A problem exists if ($\delta = 0$, and $\sigma = 1$). That is, the time series under consideration is non-stationary. In this case, equation (2) becomes as expressed in equation (3) below.

$$\Delta Y_t = e_t \tag{3}$$

Since e_t is a white noise error term, differencing a random walk time series once makes it stationary. With non-stationary, the *t*-test does not have an asymptotic normal distribution. Therefore, Dickey-Fuller (DF) test, which is one-sided as alternative hypothesis states that $\delta < 0$ $(\sigma < 1)$, is applied. We estimate DF test under three different null hypotheses.

X_t is a random walk: $\Delta X_t = \delta X_{t-1} + e_t$ (4)

X_t is a random walk with drift: $\Delta X_t = \beta_1 + \delta X_{t-1} + e_t$ (5)

X_t is a random walk amid drift about a deterministic trend:

$$\Delta X_t = \beta_1 + \beta_2 t + \delta X_{t-1} + e_t \tag{6}$$

The DF test presented above assumes that the error term is uncorrelated. To curb this problem, an augmented DF (ADF) test was developed. With ADF test we estimate equation (7):

$$\Delta X_t = \beta_1 + \beta_2 t + \delta X_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta X_{t-i} + \varepsilon_t \quad (7)$$

The error term in equation (7) is an untainted white noise. The study estimated equation (7) to test whether unit root exist in inflation or broad money. Equation (7) is the adjusted form of equation (6) and can reflect the three equations depending on the assumptions. In this study, equation (7) has been applied for inflation time series with 13 lagged differences. For broad money, the study used assumption two which reflects equation (5). Even though, to become stationary the series was differenced.

Co-integration test

At level, none of the two variables was problem free. CPI was trend stationary, while broad money was differenced stationary. To avoid spurious regression (Gujarati & Porter, 2009), Johansen and Juselius co-integration test (Johansen, 1988; Johansen & Juselius, 1990) which has been applied in many studies including Olorogun (2021), was conducted. The co-integration equation is given as follows.

$$\Delta Y_t = \beta_1 + \beta_2 + \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \phi D_t + \varepsilon_t \quad (8)$$

Wherein $\Pi = \sum_{i=1}^{q} A_i - I$ and $\Gamma_i = -\sum_{j=i+1}^{q} A_j$,

Y_t is $(Y-1)$ dimension vector relative to the variable numbers in the series in which all variables are integrated of order one. Similarly, Π , Γ , and ϕ are estimated parameters. Moreover, D_t is the deterministic elements containing vector (invariable and tendency) and ε_t is the Gaussian white noise error term with zero mean and unvarying variance. When running co-integration, we are interested in Π with long run association as well as adjustment coefficient. $\Pi = 1$ implies one co-integration vector. Alternatively, one stationary linear combination such that the integration of Π can be decayed into $\Pi = \alpha\beta'$ where α stands for the vector of adjustment coefficients and β symbolizes the vector of long term stability. Consequently, Y_t indicates $I(1)$, but the expression $\beta' Y_{t-1}$ signifies $I(0)$. The Johansen process is to establish the matrix of Π based on an unrestricted vector auto-regressive and as well test whether we reject the implied restriction through the reduced Π rank. Normally, two well-liked procedures for estimating the reduced Π rank are trace statistics and maximum Eigen value.

$$\lambda_{trace} = -T\sum_{i=r+1}^{k}\ln(1-\lambda_i^2) \quad (9)$$

$$\lambda_{\max}(r, r+1) = -T\ln(1-\lambda_{r+1}) \quad (10)$$

λ_i is the ordered Eigen value obtained from estimated matrix; T is the observation number after lag correction. The trace test null hypothesis is that the number of distinct co-integration vectors is less or equal to r as opposed to all alternatives. Though, the null hypothesis for maximal Eigen value test states that the number of co-integration vectors is r against the alternative of $r+1$.

Earlier, Engle & Granger, (1987) pointed out that if a co-integration is determined among variables, it is imperative to establish an error correction model (ECM). The vector ECM in equation (11) allows for long-run stability and short-run dynamics.

$$\Delta CPI(t) = \beta_1 \Delta CPI(t-1) + \beta_2 \Delta \ln Money(t-1) + \lambda_i ECT(t-1) + \varepsilon_t \quad (11)$$

Where, $ECT(t-1)$ is the co-integrating equation, which is, the long-run equilibrium association. However, the coefficients of the lagged difference are the short run dynamics. The $ECT(t-1)$ coefficient shows the adjustment speed which leads the variables to a long-run equilibrium.

Research Findings and Comments

Tests before estimation

The ordinary least squares (OLS) is not an ideal approach for time series with unit root problem. But, it is inappropriate to apply alternative approaches without empirically testing for the unit root. From the test, the consumer price index was trend stationary at the 13th lag, but broad money was differenced stationary. The lag provided robust results because lower and higher lags led into less significant Z(t) statistics. For instance, at lag 12 the test was significant but at 5 percent and lower lags was insignificant.

Table 1: Unit Root Test Statistics

	Test Statistics	MacKinnon approximation p-value for Z(t)	Interpolated Dickey-Fuller Critical Value		
			1 %	5%	10%
CPI with trend	-4.544 (13)	.0013	-4.233	-3.536	-3.202
Money at Level	-2.383 (12)	.1465	-3.634	-2.952	-2.610
Money at 1st Difference	-3.937 (0)	.0018	-3.576	-2.928	-2.599

Source: Own computation, using data from World Bank (2022)

From Table 2, the results show that trend and constant are very significant in influencing the change in CPI. Most lagged differences were not statistically significant however their inclusion was based on the significance of the lagged CPI coefficient. The coefficient became statistically significant due to inclusion of lagged differences including insignificant lagged differences. There were only four statistically significant lagged differences. These are lagged difference 4, 5, and 6. They influenced the differenced CPI positively at 5 percent levels of significance. The inclusion of lagged differences of CPI was from the Augmented – Dickey Fuller concept of removing serial correlation.

Table 2: Unit Root Test for Consumer Price Index

$\Delta CPI(t)$	Coefficient	Standard Error	t-Statistic	Probability Value	Confidence Interval	
$CPI(t-1)$	-.7373	.1622	-4.54	.000	-1.071	-.4031
$\Delta CPI(t-1)$	.1178	.1582	.74	.463	-.2080	.4437
$\Delta CPI(t-2)$	.0749	.1500	.50	.622	-.2340	.3839
$\Delta CPI(t-3)$	.1922	.1466	1.31	.202	-.1098	.4942
$\Delta CPI(t-4)$	.3372	.1487	2.27	.032	.0310	.6433
$\Delta CPI(t-5)$	.3358	.1404	2.39	.025	.0467	.6249
$\Delta CPI(t-6)$	.3420	.1347	2.54	.018	.0645	.6194
$\Delta CPI(t-7)$	.2171	.1377	1.58	.128	-.0666	.5007
$\Delta CPI(t-8)$	.1527	.1354	1.13	.270	-.1261	.4315
$\Delta CPI(t-9)$	.1247	.1335	.93	.359	-.1503	.3997
$\Delta CPI(t-10)$	.2209	.1333	1.66	.110	-.0537	.4954
$\Delta CPI(t-11)$	.2130	.1322	1.61	.120	-.0592	.4852
$\Delta CPI(t-12)$	.0227	.1295	.18	.862	-.2441	.2895
$\Delta CPI(t-13)$	.1449	.1254	1.16	.259	-.1133	.4031
$Trend$	-.4953	.1119	-4.43	.000	-.7257	-.2648
$Const$	29.28	6.261	4.68	.000	16.39	42.18

Source: Own computation, using data from World Bank (2022)

The coefficient of the lagged CPI is the difference between another coefficient and unit. With zero coefficient value, we have a perfect unit root problem. On the other hand, the unit root problem is completely absent if the coefficient above is -1. But, extreme cases stated are very rare in real life. However, the magnitude above is much closer to -1 indicating absence of unit root. The difference between the coefficient above and unit is 0.2627 which is far less than unit. From this analysis, it is fair to conclude that CPI is trend stationary.

The results for broad money however differ from those of CPI in many ways. First, for the case of broad money, the trend is not significant and its inclusion results in a positive coefficient. Second, unlike CPI, the coefficients for broad money are all but one insignificant. Therefore, the nature of data for broad money differs from that of CPI.

Broad money was differenced with zero lag. The zero lag was selected for robust results purpose. This was due to the fact that higher lags brought either positive coefficients or negative but lower statistics. For instance, at lag 1, the Z(t) statistic becomes exactly equal to the critical value at 10 percent levels of significance.

Both broad money and CPI were integrated of order one since they became stationary after some adjustments. Therefore, they are likely to have a long-run association. The co-integration discussion is provided in the next section.

Table 3: Broad Money Unit Root Analysis

(a) $\Delta Money(t)$	**Coefficient**	**Std. Err.**	**t-value**	**p-value**	**95% Confidence Interval**	
$Money(t-1)$	-.0144	.0060	-2.38	.024	-.0268	-.0020
$\Delta Money(t-1)$	.2566	.1755	1.46	.155	-.1028	.6160
$\Delta Money(t-2)$	.1618	.1817	.89	.381	-.2105	.5341
$\Delta Money(t-3)$	.0454	.1848	.25	.808	-.3330	.4239
$\Delta Money(t-4)$	.0412	.1848	.22	.825	-.3374	.4198
$\Delta Money(t-5)$	-.1697	.1896	-.90	.378	-.5582	.2187
$\Delta Money(t-6)$	.0319	.1930	.17	.870	-.3633	.4272
$\Delta Money(t-7)$	.0565	.1923	.29	.771	-.3374	.4503
$\Delta Money(t-8)$	-.0673	.1919	-.35	.728	-.4603	.3257
$\Delta Money(t-9)$	-.0828	.1922	-.43	.670	-.4765	.3110
$\Delta Money(t-10)$	-.0972	.1901	-.51	.613	-.4867	.2922
$\Delta Money(t-11)$	.0260	.1904	.14	.893	-.3640	.4159
$\Delta Money(t-12)$	.2040	.1828	1.12	.274	-.1705	.5784
$Const$	.5106	.2012	2.54	.017	.0985	.9227
(b) $\Delta(\Delta Money(t))$						
$\Delta Money(t-1)$	-.4846	.1231	-3.94	.000	-.7316	-.2375
$Const$	.0895	.0253	3.54	.001	.0388	.1402

Source: Own computation, using data from World Bank (2022)

The Johansen Tests for Co-integration

This section discussed the long-run association amid CPI and broad money. The proper test for co-integration is the Johansen co-integration test. Different Johansen co-integration test approaches have been used.

Table 4: CPI and broad money co-integration test

Maximum rank	Trend (none)	Trend (rconstant)	Trend (Constant)	Trend (trend)	Trend (rtrend)
0			14.3303	14.7592	17.2445
1	.8813	5.1954			
Critical value (5%)	3.84	9.42	15.41	18.17	25.32

Source: Own computation, using data from World Bank (2022)

Two of the five approaches proved a long run relationship between CPI and broad money. In these approaches, trace statistics were lower than critical values at 5 percent. The 1 maximum rank void premise was rejected. Other approaches, column 4, 5, and 6, had shown lower trace statistics than 5 percent critical values at the maximum rank of 0. In this case, we failed to decline the zero co-integration void premise. With constant, trend, or rtrend approach, the study failed to reject the null hypothesis of no long-run stability. But, the aim of co-integration test was to find out whether the variables could be subjected into VECM to get both short-run dynamics along with long-run stability.

Using STATA provided maximum lags the range was from 0 to 4 lags. Except the SBIC which was lower at lag 1, the rest of the criteria have lowest statistics at lag 2.

Table 5: Lag selection prior to estimation

Lag	LL	LR	df	P	FPE	AIC	HQIC	SBIC
0	-318.169				972.543	12.5557	12.5846	12.6314
1	-101.284	433.77	4	.000	.230323	4.20721	4.29406	4.43448*
2	-93.938	14.692*	4	.005	.202201*	4.076*	4.22075*	4.45479
3	-92.8312	2.2134	4	.697	.227	4.18946	4.39211	4.71977
4	-91.0824	3.4977	4	.478	.24894	4.27774	4.53829	4.95956

Source: Own computation, using data from World Bank (2022)

From the table, 0.2022 is the lowest among FPE statistics found in the row of lag 2. When using AIC, 4.076 is the lowest statistics of all statistics in that column and it is found in the fourth row corresponding to 2 lags, 4.22 was the lowest statistics among HQIC statistics and corresponds to the fourth row implying selection of lag 2. The study used two lags in vector error correction (VEC) estimation because only one information criterion suggested one lag usage.

Estimation of the Model

From the co-integration test, two approaches confirmed the existence of one co-integration equation. However, only one model resulted in a significant long run relationship.

Table 6: VEC Model Estimation Results

$\Delta CPI(t)$	Trend (none)	Trend (rconstant)
$ECT(t-1)$	-.1852***(.0578)	-.1630***(.0545)
$\Delta CPI(t-1)$	-.1097 (.1276)	-.1154(.1301)
$\Delta Money(t-1)$	30.10***(9.604)	29.24***(9.966)
$CPI(t)$		
$Money(t)$	-.6500***(.2219)	-.2357(.8832)
$Const.$		-14.35(25.22)

Source: Own computation, using data from World Bank (2022)

The adjustment speed was negative as expected showing convergence towards equilibrium. Only 18.52 percent of the disequilibrium is adjusted in one year. It takes about 5 years and 5 months to correct for the discrepancies to reach equilibrium. Broad money affected CPI positively in the short-run, but negatively in the long-run. Duodu, Baidoo, Yusif, & Frimpong (2022) also revealed a negative influence of money supply on inflation in Ghana. Therefore, increasing money supply increases inflation only in the short run. Using tight monetary policy to control inflation is more effective only in the short-run. A mixture of tight and expansionary monetary policies could be more effective with fiscal policy.

Post-estimation tests

Autocorrelation, normality and stability tests have been displayed in Table 7. In panel (a), the study failed to decline the void premise of no autocorrelation at lag order. The estimated residual was also normally distributed because the void premise of normally distributed disturbance could not be discarded. The negative sign of Skewness indicated that the disturbance had a longer tail to the left than the right of distribution to lack symmetry as shown in Figure 2 (a). But, since the statistics were insignificant, the Skewness coefficient was not different from zero indicating that the distribution lied at the center.

Table 7: Tests after VEC estimation

(a) Lagrange-multiplier test			
Lag	Chi2	df	P-value
1	2.4404	4	.65534
2	2.4971	4	.64515
H0: no autocorrelation at lag order			

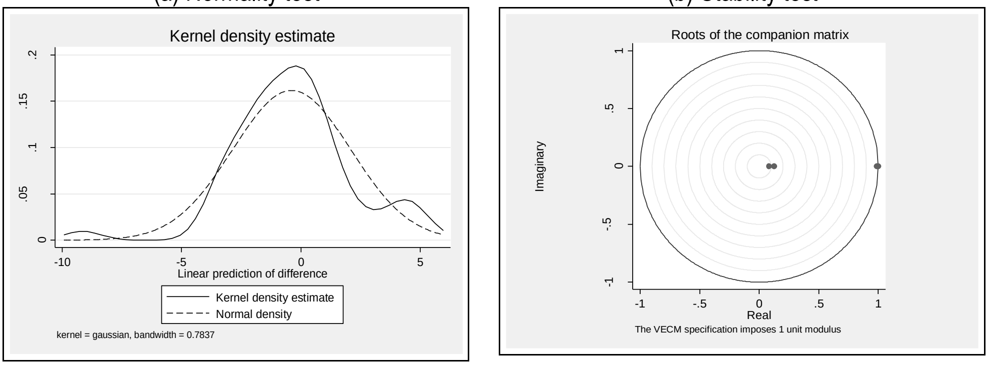
(b) Normality test		Chi2	df	p-value
Jarque-Bera		1.021	2	.60028
Skewness	-.14332	0.181	1	.67014
Kurtosis	3.6165	0.839	1	.35960
H0: disturbances are normally distributed				

(c) Stability test	
Eigen value	Modulus
1	1
.988928	.988928
.1260043	.126004
.08448583	.084486

Source: Own computation, using data from World Bank (2022)

Figure 2: Graphical illustration for normality and stability test

(a) Normality test (b) Stability test



Source: Own computation, using data from World Bank (2022)

All points lied within the circle indicating that VEC estimates were stable. From post-estimation tests, VEC estimates were valid and reliable.

Granger causality between money and inflation

Post-estimation tests proved that Vector Error Correction (VEC) estimates were reliable and valid. But the analysis remained silent on causality direction. To conclude on causality, the Granger-causality test was inevitable. To implement the test for causality, this section analyzed the automatic degeneration vector commonly known as VAR model. The implementation of VAR has also supported the relationship established in VEC analysis. The results under VAR could have been relied on as an alternative model in case co-integration failed to exist. But since co-integration proved to exist, VAR implementation was necessary for testing causality between the two variables. The pre-estimation lag selection information criteria for VAR did not differ from those displayed under VEC analysis. Their statistical similarities informed the study on repetition avoidance.

Inflation (CPI) was positively influenced by one past year values of its own. An increase in inflation by 10 percent increased the expected inflation by 6.5 percent and the impact lasted for one year only. An increase in money supply by 1 percent, increased expected inflation by 25.76 percent, but reduced two years expected inflation by 26.15 percent. Implicitly, the initial impact of money on inflation was positive due to increased demand for goods and services. However, fiscal adjustments thereafter tended to dampen the general price level down. The intercept coefficient was statistically insignificant as for VEC estimation. This was another proof to show that the non intercept VEC model was valid and reliable for the study's statistical inferences.

Table 8: VAR Estimates of CPI equation

$CPI(t)$	Coefficient	Std. Err.	Z(t)	p-value	95% Confidence interval	
$CPI(t-1)$	.6593	.1318	5.00	.000	.4010	.9177
$CPI(t-2)$	.0742	.1265	0.59	.557	-.1738	.3222
$Money(t-1)$	25.76	9.519	2.71	.007	7.098	44.41
$Money(t-2)$	-26.15	9.513	-2.75	.006	-44.79	-7.506
$Const$	9.460	7.032	1.35	.179	-4.323	23.24

Source: Own computation, using data from World Bank (2022)

From Table 9, Granger causality Wald test also confirmed that it was money that caused inflation. From the analysis, it was the CPI equation and not the money equation that was statistically significant.

Table 9: Causality analysis under Wald tests

Null Hypotheses	Equation	Excluded	Chi2	df	p-value
There is no influence of Money on CPI	CPI	Money	10.375	2	0.006
There is no influence of CPI on Money	Money	CPI	2.1786	2	0.336

Source: Own computation, using data from World Bank (2022)

The hypothesis in CPI equation stated that money does not Granger cause inflation, that is, money was excluded in the equation. Since the statistics were significant, the study rejected the null hypothesis. As a result, the study concluded that money Granger caused inflation. On the other hand, inflation did not Granger cause money, since the statistics were insignificant in which the study failed to decline the null hypothesis. From the data set used and the fact that only two variables have been considered, inflation was a monetary phenomenon.

Conclusion

The current study analyzed the consumer price index (CPI) or inflation influence of money supply in Tanzania. The findings revealed both short-run as well as long-run association amid broad money and CPI. However, broad money was effective in reducing inflation in the short-run. In the long-run, in order to reduce inflation, the central bank had to increase money supply. So, while money could be increased, other factors such as fiscal discipline were likely to have a strong influence to reduce inflation. Fisher's equation of exchange did not hold water in the long run. Studies should continue adopting models according to current monetary practices to reflect reality.

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