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The effect of oil price shocks on inflation in Tanzania - an autoregressive distributed lag and vector autoregressive approach *

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Abstract The import for oil in the whole world and particularly in Tanzania is heavily increasing due to the increasing number of cars, motorcycles, industries, and other machines for their operations. However, the imported oil has been going along with the imported inflation in the country. It is well known that a strong and stable inflation influences the economic growth of a country since it inspires investments, and enhances the consumers to afford purchasing of goods and service and therefore it affects the economic growth of a country. With this background, this study is conducted to examine the oil price shocks and inflation in Tanzania by including macro-economic variables such as crude oil price, inflation rate, exchange rate and GDP. The study employs the Auto-Regressive Distributed Lag (ARDL)approach of co-integration to establish a relationship between oil price shocks and inflation. The Vector Auto regression (VAR) approach through the Impulse Response Function (IRF), and Forecast Error Variance Decomposition(FEVD)technique are used to examine the impact of oil price changes on inflation and to determine the degree of responsiveness of the inflation rate to shocks using annual data from 1970–2017.The results show that there exists a significant long run positive relationship between the inflation and the oil price. The results also show a significant long run negative relationship between the inflation and the GDP. In addition, the result from VAR approach reveals that the oil price and the exchange rate has a positive impact on the inflation while the GDP has a negative impact on the inflation. Based on the results of this study it is recommended that the government should find other source of energy to reduce heavily the importation of oil to reduce the inflationary pressure in Tanzania.

Key words Inflation, Economic growth, Co-integration, unit roots, Auto-Regressive Distributed Lag, impulse response functions, Forecast Error Variance Decomposition, macro economy variables, oil price shocks.

2020 Mathematics Subject Classification 62M10, 62M99, 62P99, 91B84.

1 Introduction

The prices of oil and inflation are seen as being connected within a cause and effect framework. As the value of the precious black liquid goes up, inflation follows in the same direction. That is being

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said, if the input cost for oil rises, so will the costs of finished products and services. The reason why this happens, may be that, oil is a major input in the economy - it is used in critical activities such as fueling transportation or goods made with petroleum products - and if the costs of intermediate input rise, so should the cost of end output. For instance, if the price of oil rises, then it will cost more to make plastic, and a plastics company will then pass on some or all of this cost to the consumer, which raises prices and thus the inflation.

Although Tanzania is among the developing countries, blessed with mineral and energy resources, still no oil has been discovered yet (Deloitte [10]). Due to this, the country still imports crude oil and refines it within the country. According to the Bank of Tanzania, the import of oil increased by 14.9% to US$ 3,172.7 million (BOT [5]). Consequently, a change in oil price affects the price of consumable goods and services. The increase in the price of commodities and amenities causes a rise in the inflation. The inflation demoralizes real investment since it affects the stability of the currency. As a result, it deteriorates the country's economy since it reduces the size of employment, investment, and output (Osmond and Ezeji [25]). In the 1990's the country tried several monetary policies to secure macroeconomic stability (Laryea and Ussif [20]). These transformations comprise the endorsement of the Bank of Tanzania (BOT) Act of 1995. The act was established to reinforce the ability of the Central Bank of Tanzania in combating inflation. There was a high increase in inflation from 1970 to 1994 from 2.4% to 35.9%, while it started to decrease from 1995 to 2018 with a minimum inflation rate of 4.4% in 2005 (BOT [4]).Oil is an important raw material for driving economic activities and oil prices provide a direct and indirect impact on inflation. Since the price of petroleum products, energy bills, and other production costs are influenced by the change of oil price, the sudden change of oil price influences the production expenditures, thus resulting in lower output in production and increase in the buying costs of goods and services. A rise in commodities price due to the increase of oil price causes a low purchasing power to consumers which affect investment of companies and a fall in household consumptions (Jiranyakul [16]).

The need to study the inflation rate and oil price shock in Tanzania is sensitive given the fact that the increase in industrial cost influences the rise of goods and services leading to the high cost of living to the consumers. Also, many empirical studies like, Lacheheb and Sirag [19], Rotimi and Ngalawa [29], and Davari and Kamalian [30], etc. confirm the existence of a negative or positive relationship of an oil price change and inflation but failed to state the degree of responsiveness of inflation on the adjusted oil price. Therefore, this study, apart from studying the relationship and impact of the oil price shock and inflation, is also intended to observe the pressure of sudden change of oil price on inflation by considering the degree of responsiveness of change of inflation due to the change of oil price in Tanzania. The study will also enable policymakers to make a plan and come up with a compatible strategy for maintaining a reasonable price of fuel oil so as to minimize the rate of inflation and thus to eradicate the higher cost of goods and services.

2 Review of literature

A large body of empirical research has confirmed that oil price increase has strong and negative influences for the real economy (e.g., Hamilton [12,13], Burbidge and Harrison [31], Gisser and Goodwin [32], and Cunado and Gracia [8]). Several authors therefore re-examined the oil price-macroeconomic relationship, using instead asymmetric or nonlinear methods (Mork [23], Mork et al. [24], Lee et al. [21], Hamilton [12, 13] and Cunado and Gracia [8]). They found that the negative linkage between oil price increases and economic activity still persisted. Consequently, it may be reasonable to partition oil price changes into oil price increases and decreases for the analysis of the related issue.

There are several other studies in the literature analyzing the effects of oil prices on the growth and inflation (Lu et al. [22], Kilian and Vigfusson [17], Gomez-Loscos et al. [11], Jbir [15]).

Yoshino and Taghizadeh-hesary [28] assessed the impact of crude oil price shocks on two macro-variables such as GDP growth rate and inflation rate in developed economies countries (US and Japan) and in an emerging economy (China) by employing the Structural Vector Autoregressive (SVAR) model. Their findings showed that the impact of oil price shocks on developed economies oil importers' GDP growth is much slighter than on the GDP growth of the emerging economy.

Ibrahim [14] analyzed the relations between food and oil prices for Malaysia using Nonlinear Autoregressive Distributive Lag (NARDL) model. The co-integration test of the NARDL model found the presence of long-run relationship among food price, oil price and real GDP. In the long run, they found a significant relationship between oil price increases and food price increases. Also in the short run, they found a positive significant relationship between the oil price and the food price inflation.

Dhaoui and Saidi [1] employed macro-economic variables to study the relationships between oil price shocks and stock market in 11 OECD (UK, USA, Canada, Czech Republic, Denmark, Hungary, Korea, Mexico, Norway, Poland and Sweden) by using a time series data ranging from January 1990 to December 2013. Yusof and Usman [33] employed the ARDL model to examine the relationship between macroeconomic variables in Malaysia. They found that macroeconomic variables have a long-run and short-run influence on Islamic home financing in Malaysia.

Asghar and Naveed [34] used a time series data, which includes the variables such as inflation rate, oil prices in dollars and exchange rate covered over a period from January 2000 to December 2014 to explore the impact of global oil prices on domestic inflation in Pakistan. Their study finding showed that in the long-run oil prices and exchange rate significantly affect inflation in Pakistan.

Al-risheq [3] investigated the impact of oil prices and other key variables on industrial production from 52 developing countries by applying a fixed effects model with instrumental variables. The study shows that an increase in oil prices has a negative and highly significant impact on industrial production. The real exchange rate had an extreme impact on industrial production among other variables included in the model. Also, the study showed that oil price shocks have a negative impact on industrial production and economic growth in developing countries mainly because of heavy importation of oil.

Lacheheb and Sirag [19] examined the relationship between oil price changes and inflation rate in Algeria from 1970–2014 using NARDL. The study found the existence of asymmetries relationship between oil price and inflation. The estimated model discovered the presence of a significant relationship between oil price increases and inflation rate.

Brini et al. [6] analyzed the impact of oil price shocks on inflation and the real exchange rate in a six oil importers and exporters Middle East and North Africa (MENA) countries: Tunisia, Morocco, Algeria, Bahrain, Saudi Arabia and Iran using the SVAR model. In their finding, the impulse response showed that, in the long run, oil price shocks have a great impact on the real exchange rate of oil-importing countries (Tunisia and Morocco). Also, the variance decomposition results exhibited that oil price shocks do not explain the variation in the two considered variables in Algeria and Iran.

Choi et al. [7] explored the impact of global oil prices shocks on domestic inflation using an unbalanced panel of 72 developed and developing countries. Their study showed a positive impact, that is, a 10% increase in global oil price leads to 0.4% increases in domestic inflation, in which the effect disappears after two years. They also found that the asymmetric effect of oil price shock on domestic inflation with positive oil price fluctuations had a bigger effect than negative ones. The study further showed that the impact of oil price shocks has declined over time after implementation of good monetary policy.

Rotimi and Ngalawa [29] employed a Panel Structural Vector Autoregressive (P-SVAR) model to study the relationship between oil price shocks and economic performance in Africa's oil exporting countries by considering macro economic variables such as inflation rate, money supply, bank rate, exchange rate, gross domestic product, unemployment and oil price shock. The study covered the period starting from 1980 to 2015 in which oil price shocks were treated as exogenous while other variables were treated as endogenous variables. Their study findings revealed that there is a significant positive relationship between oil price shocks and GDP in the Africa's oil exporting countries. The results also showed that oil price shocks have a significant role in influencing variations in economic growth.

Umar and Chin [27] assessed asymmetric results of oil price on inflation in African energy producers members' countries in Algeria, Angola, Libya and Nigeria. ARDL was employed to estimate the short and long run impacts. The study found that the impact was significant when oil prices decreased.

Davari and Kamalian [9] used non-linear ARDL to study the relationship between oil price shock and inflation rate in Iran using data ranging from 2003–2015. The method of the study recognized a significant relationship between the reduction in oil price and inflation growth while the significant relationship between the increase in oil price growth and the inflation rate was absent.

3 Research methodology

3.1 Data source

To accomplish the analysis, annual series data were collected for the period 1970 to 2017 from the following sources: Inflation rate, Exchange rate and GDP data from the Bank of Tanzania (BOT), while crude oil price data were obtained from the U.S.Energy Information Administration through the website https://www.eia.gov/outlooks/steo/realprices. The exchange rate and GDP data are expressed in Tanzania Shillings while the oil price and inflation are expressed in USD/barrel and percentages respectively.

3.2 Variables used

To get a better outcome of fitting, four variables were considered for this study, viz., the inflation, the oil price, the exchange rate and the GDP in the same order of magnitude. To remove the outliers and to reduce the variability of the data the logarithm base 10 transformation was applied for the GDP, the exchange rate and the oil prices, while the inflation rate remains the same because its units were in percentages.

Logarithm transformation to GDP variable

$\text{LGDP} = \log(\text{GDP})$, where LGDP is the logarithm base 10 of GDP.

Logarithm transformation to Exchange rate variable

$\text{LEXCH} = \log(\text{EXCH})$, where LEXCH is the logarithm base 10 of the exchange rate EXCH.

Logarithm transformation to Crude Oil Prices

$\text{LOIL\_PRICE} = \log(\text{OIL\_PRICE})$, where LOIL_PRICE is the logarithm base 10 of the oil price OIL_PRICE.

3.3 Steps for analysis

3.3.1 The ARDL approach

- Augmented Dickey-Fuller test and Phillips-Perron test are performed to establish the stationarity of the variables.
- Cointegration test is applied. Note that the ARDL model works for $I(0)$ or $I(1)$ or both.
- An appropriate ARDL model is selected by using the Akaike Information Criterion(AIC) [2].
- The parameters of the long-term in the ARDL model are estimated by the ordinary least squares method.
- The short-term coefficients are estimated from error correlation models (ECM) developed by the ARDL model.
- The model diagnostic testing to check for correlation, normality, and Heteroskedasticity are conducted.
- The model stability is tested.
- Forecasting of the variables under the study to predict the future trends of the inflation, the oil price change, the GDP and the foreign exchange rate is done.

3.3.2 Steps for the VAR approach

- The VAR model is specified.
- Augmented Dickey-Fuller test and Phillips-Perron test are performed to establish the stationarity of the variables.
- Optimal lag length of variables is determined.
- Estimate of the standard VAR is obtained.
- The model diagnostics: normality, autocorrelation heteroskedasticity and model stability are examined.
- Impulse response is performed.
- Forecast error variance decomposition is performed.

3.3.3 The ARDL model specification

$$\begin{aligned}\text{INFL}_t = \alpha_0 + \sum_{i=1}^{p} \beta_1 \text{INFL}_{t-i} + \sum_{i=1}^{q_1} \beta_2 \text{LOILPr}_{t-i} \\ + \sum_{i=1}^{q_2} \beta_3 \text{LEXR}_{t-i} + \sum_{i=1}^{q_3} \beta_4 \text{LGDP}_{t-1} + e_t\end{aligned} \tag{3.1}$$

where α_0 is the constant term, p is the lag of the dependent variable, q_1, q_2 and q_3 are the lags of independent variables, INFL_t is the inflation, LOILPr_t is the logarithm of the oil price, LEXR_t is the logarithm of the exchange rate, LGDP_t is the logarithm of the Gross Domestic Product and e_t is the error term.

3.3.4 The VAR model specification

The term autoregressive stands for the presence of the lagged values of the dependent variable on the right-hand side of an equation and the term vector means that the system contains a vector of two or more variables. The VAR model is constructed only if the variables are integrated of order one. All the variables on the VAR system are endogenous, there are no exogenous variables and the stochastic error terms are called impulses, or shock, or innovation. The dependent variable in the VAR model is a function of its dependent lagged values and the lagged values of the other variables in the model. The variables in the VAR model are presented in equal lag length. The VAR must be specified in levels.The model is given as follows:

$$x_t = a_{10} - a_{11} y_t + b_{11} x_{t-1} + b_{12} y_{t-1} + \varepsilon_{xt} \tag{3.2}$$

$$y_t = a_{20} - a_{21} x_t + b_{21} x_{t-1} + b_{22} y_{t-1} + \varepsilon_{yt} \tag{3.3}$$

with $x_t, y_t \in I(0), \varepsilon_{xt}, \varepsilon_{yt} \in$ white noise with variance ${\sigma^2}_x$ and ${\sigma^2}_y$ and covariance $\text{cov}(\varepsilon_{xt}, \varepsilon_{yt}) = 0$. In structural form VAR(1) of (3.2) and (3.3) can be written as:

$$Az_t = b_0 + B_1 z_{t-1} + \varepsilon_t \tag{3.4}$$

where $A = \begin{pmatrix} 1 & a_{11} \\ a_{21} & 1 \end{pmatrix}, z_t = \begin{pmatrix} x_t \\ y_t \end{pmatrix}, b_0 = \begin{pmatrix} a_{10} \\ a_{20} \end{pmatrix}$, and $B_1 = \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix}, \varepsilon_t = (\varepsilon_{xt},\ \varepsilon_{yt})'$.
Now, the standard or reduced form of VAR(1), given the structural matrix A, can be written as:

$$z_t = c_0 + C_1 z_{t-1} + e_t \tag{3.5}$$

with $c_0 = A^{-1} b_0 = (c_{10}, c_{20})', C_1 = A^{-1} B_1$, and $e_t = A^{-1} \varepsilon_t = (e_{1t}, e_{2t})$. Therefore (3.4) can be written as the following pair of equations:

$$x_t = c_{10} + c_{11} x_{t-1} + c_{12} y_{t-1} + e_{1t} \tag{3.6}$$

$$y_t = c_{20} + c_{21} x_{t-1} + c_{22} y_{t-1} + e_{2t} \tag{3.7}$$

Specifically for this study, the VAR model is given as follows:
Equation 1: When the inflation rate is regarded as dependent, then

$$\text{INFL}_t = \alpha_1 + \sum_{i=1}^{k} \varphi_i \text{INFL}_{t-i} + \sum_{i=1}^{k} \theta_i \text{LOILPr}_{t-i} + \sum_{i=1}^{k} \delta_i \text{LEXR}_{t-i} + \sum_{i=1}^{k} \lambda_i \text{LGDP}_{t-i} + e_{1t} \tag{3.8}$$

Equation 2: When exchange rate is regarded as the dependent variable, then

$$\text{LEXCH}_t = \alpha_2 + \sum_{i=1}^{k} \varphi_i \text{LEXCH}_{t-i} + \sum_{i=1}^{k} \theta_i \text{LOILPr}_{t-i} + \sum_{i=1}^{k} \delta_i \text{INFL}_{t-i} + \sum_{i=1}^{k} \lambda_i \text{LGDP}_{t-i} + e_{2t} \tag{3.9}$$

Equation 3: When oil price is regarded as the dependent variable, then

$$\text{LOILP}_t = \alpha_3 + \sum_{i=1}^{k} \varphi_i \text{LOILP}_{t-i} + \sum_{i=1}^{k} \theta_i \text{INFL}_{t-i} + \sum_{i=1}^{k} \delta_i \text{LEXR}_{t-i} + \sum_{i=1}^{k} \lambda_i \triangle\text{LGDP}_{t-i} + e_{3t} \tag{3.10}$$

Equation 4: When GDP is regarded as the dependent variable, then

$$\text{LGDP}_t = \alpha_4 + \sum_{i=1}^{k} \varphi_i \text{LGDP}_{t-i} + \sum_{i=1}^{k} \theta_i \text{LOILPr}_{t-i} + \sum_{i=1}^{k} \delta_i \text{LEXR}_{t-i} + \sum_{i=1}^{k} \lambda_i \triangle\text{INFL}_{t-i} + e_{4t} \tag{3.11}$$

Table 4.1: Summary of descriptive statistics.

	LOIL_PRICE	LGDP	LEXCH	INFL
Mean	3.953098	30.34560	5.288754	0.163625
Median	3.896399	30.18977	6.216978	0.124000
Maximum	4.757634	31.55349	7.714231	0.361000
Minimum	3.896399	29.50894	1.931521	0.024000
Std. Dev	0.453717	0.584228	2.055994	0.110090
Skewness	0.267746	0.552764	−0.563877	0.435623
Kurtosis	1.746778	2.111435	1.804919	1.640501
Jarque-Bera	3.714634	4.023479	5.400099	5.214617
P-value	0.156091	0.133756	0.067202	0.073733
Observations	48	48	48	48

4 Results and discussion

4.1 Descriptive statistics

Table 4.1 presents the descriptive statistics, which can ensure the normal distribution of the data. The skewness measure of each variable is almost approaching to zero, and the kurtosis values of the Exchange rate, the GDP, the Oil Price and the Inflation rate is less than 3. This indicates that the distribution follows a normal distribution. Also from the Jarque-Bera tests, it is evident that the distribution is normally distributed since the probability values of each variable is higher than 5% level of significance.

4.2 Unit root test

Before introducing the ADF and PP test, it is always better to plot a time series of the variables under the study as it can exhibit the order of integration of the time series variables. It was observed that the variables: Inflation rate, Exchange rate, GDP and Oil Price are non-stationary. The time series variables exhibit an upward or downward trend. Their means and variances are not constant over time. In this case, the differencing was applied to the variables to find if there was any existence of stationarity at the first difference. Fig. 4.1 shows the variables Inflation rate, Exchange rate, GDP, and Oil Price, integrated at the first difference (stationary) as it is seen that the series revolves around the mean. That means the time series data do not display any upward or downward trend or seasonal effects. Its mean and variance are constant over time. However, no statistical fact can be derived numerically from the graphical inspection of the variables. Based on this caveat, ADF unit root test and Phillip-Perron unit root test were used to investigate statistically their integration properties.

4.3 Results for ADF and PP unit root test at first difference

Table 4.2 shows the evidence that the null hypothesis for unit root is rejected. The ADF test and the PP test indicate that the variables under study are stationary at first difference. This order of integration of stationarity satisfies the use of the ARDL model. To test the presence of a long-run relationship between the variables, the co-integration test is applied based on the ARDL model.

4.4 The co-integration test (Bound test)

The co-integration test is established to determine whether there is a long-run relationship among variables.

4.4.1 Lag length selection

Before proceeding with the co-integration test it is necessary to find the optimal lag length for the bound test by using the VAR model. Under the VAR model, all the variables are endogenous. One way is to choose the lowest value from either Akaike Information Criterion (AIC) [2], Schwartz Bayesian Criterion (SBC), or, Hannan-Quinn Criterion (HQ) [35]. That lag length is optimal for which the value of AIC, SBC or HQ is minimum. Tables 4.3 to 4.6 present the optimal lag length for all the four

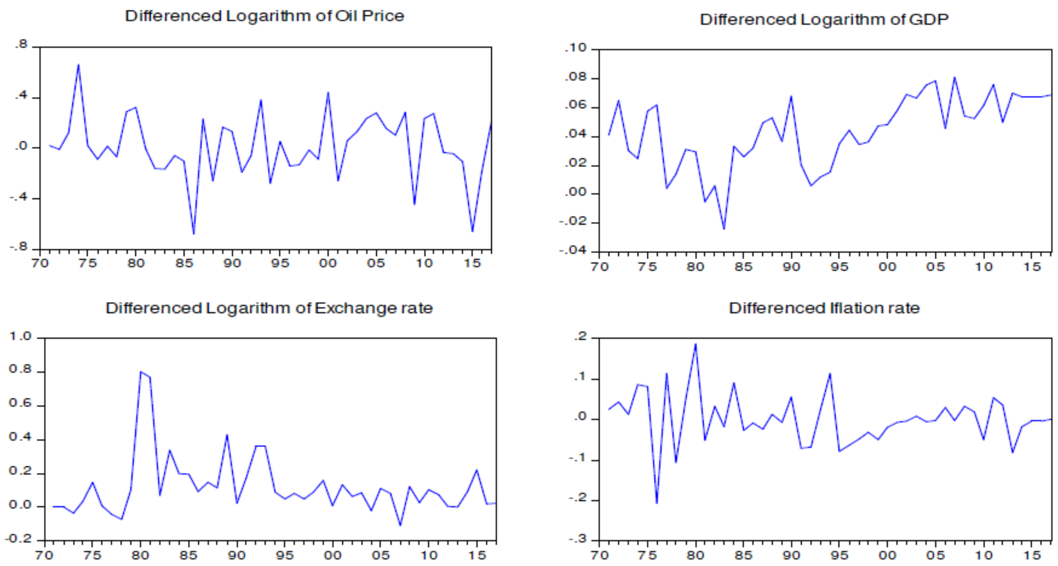

Fig. 4.1: Plots of first difference time series variables.

Table 4.2: Unit root test results -ADF and PP test at first difference.

With constant		Infl		lexch		lgdp		Loil_price	
		ADF	PP	ADF	PP	ADF	PP	ADF	PP
	p-value	0**	0**	0.001**	0.001**	0.026**	1.0313**	0**	0.000**
With constant & trend	*p*-value	0**	0**	0.003**	0.0048*	0.006**	0.0075**	0**	0.000**
No constant & trend	*p*-value	0**	0**	0.001**	0.0010*	0.557**	0.3440**	0**	0.000**

Table 4.3: Optimal lag length of the Inflation rate (INFL).

Lag	AIC	SC	HQ
0	−1.572112	−1.532359	−1.557220
1	−2.644732*	−2.565226	−2.614949
2	−2.641612	−2.522353	−2.596937

Table 4.4: Optimal lag length of the logarithm of exchange rate (LEXCH).

Lag	AIC	SC	HQ
0	4.221087	4.260840	4.235979
1	−0.574504	−0.494998	−0.544721
2	−0.682005*	−0.562746	−0.637330

variables.

Since in Table 4.3 the AIC gives the lowest values compared to the other information criteria, that is AIC=−2.644732, therefore the optimal lag length is chosen from the AIC. Hence the optimal lag length of Inflation rate selected by the AIC is 1.

Further in Table 4.4 the AIC gives the lowest value compared to the other information criteria, that is AIC=−0.682005 which is less than the SC=−0.562746, therefore the optimal lag length is chosen from the AIC. Hence the optimal lag length of Exchange rate selected by AIC is 2.

Also, in Table 4.5 the AIC gives the lowest value compared to other information criteria, that is AIC= −5.044943, which is less than SC= = −4.925684, therefore the optimal lag length is chosen from the AIC. Hence the optimal lag length of LGDP selected by AIC is 2.

It is seen from Table 4.6 that the AIC gives the lowest value compared to other information criteria, that is AIC=0.299022 which is less than SC= = 0.328805, therefore the optimal lag length is chosen from the AIC. Hence the optimal lag length of LOIL_P_PRICE selected by the AIC is 1.

4.4.2 **Co-integration test**

The co-integration test is employed to examine whether there is a long-term relationship among the variables. In the co-integration test, all the variables are assumed to be dependent. In this study, the ARDL model is expressed in four equations given below:

Equation 1: When the Inflation rate is regarded as dependent:

$$\Delta \mathrm{INF}_t = \alpha_0 + \sum_{i=1}^{p} \varphi_i \Delta \mathrm{INF}_{t-i} + \sum_{i=1}^{q} \theta_i \Delta \mathrm{LOILPr}_{t-i} + \sum_{i=1}^{q} \delta_i \Delta \mathrm{LEXR}_{t-i} + \sum_{i=1}^{q} \lambda_i \Delta \mathrm{LGDP}_{t-i} + \beta_1 \mathrm{INF}_{t-1} + \beta_2 \mathrm{LOILPr}_{t-1} + \beta_3 \mathrm{LEXR}_{t-1} + \beta_4 \mathrm{LGDP}_{t-1} + e_t \tag{4.1}$$

Table 4.5: Optimal lag length of logarithm of GDP (LGDP).

Lag	AIC	SC	HQ
0	1.737227	1.776980	1.752119
1	−4.936527	−4.857021	−4.906743
2	−5.044943*	−4.925684	−5.000268

Table 4.6: Optimal lag length of logarithm of oil price (LOIL_P_PRICE).

Lag	AIC	SC	HQ
0	1.513400	1.553153	1.528291
1	0.299022*	0.378528	0.328805
2	0.322454	0.441713	0.367129

Table 4.7: Symbols for F-statistics.

Dependent variable	F-statistics symbol
Inflation	F_{Infl}(Infl\Exch, Oil price, GDP).
Exchange rate	F_{Exch}(Exch \Infl, Oil price, GDP).
Oil price	$F_{\text{Oil Price}}$(Oil Price\Exch, Infl, GDP)
GDP	F_{GDP}(GDP\Exch, Oil price, Infl)

Equation 2: When the Exchange rate is regarded as the dependent variable:

$$\Delta \text{LEXCH}_t = \alpha_0 + \sum_{i=1}^{p} \varphi_i \Delta \text{LEXCH}_{t-i} + \sum_{i=1}^{q} \theta_i \Delta \text{LOILPr}_{t-i} + \sum_{i=1}^{q} \delta_i \Delta \text{INFL}_{t-i} + \sum_{i=1}^{q} \lambda_i \Delta \text{LGDP}_{t-i} + \beta_1 \text{INF}_{t-1} + \beta_2 \text{LOILPr}_{t-1} + \beta_3 \text{LEXR}_{t-1} + \beta_4 \text{LGDP}_{t-1} + e_t \tag{4.2}$$

Equation 3: When the Oil Price is regarded as the dependent variable:

$$\Delta \text{LOILP}_t = \alpha_0 + \sum_{i=1}^{p} \varphi_i \Delta \text{LOILP}_{t-i} + \sum_{i=1}^{q} \theta_i \Delta \text{INFL}_{t-i} + \sum_{i=1}^{q} \delta_i \Delta \text{LEXR}_{t-i} + \sum_{i=1}^{q} \lambda_i \Delta \text{LGDP}_{t-i} + \beta_1 \text{INF}_{t-1} + \beta_2 \text{LOILPr}_{t-1} + \beta_3 \text{LEXR}_{t-1} + \beta_4 \text{LGDP}_{t-1} + e_t \tag{4.3}$$

Equation 4: When the GDP is regarded as the dependent variable:

$$\Delta \text{LGDP}_t = \alpha_0 + \sum_{i=1}^{p} \varphi_i \Delta \text{LGDP}_{t-i} + \sum_{i=1}^{q} \theta_i \Delta \text{LOILPr}_{t-i} + \sum_{i=1}^{q} \delta_i \Delta \text{LEXR}_{t-i} + \sum_{i=1}^{q} \lambda_i \Delta \text{INF}_{t-i} + \beta_1 \text{INF}_{t-1} + \beta_2 \text{LOILPr}_{t-1} + \beta_3 \text{LEXR}_{t-1} + \beta_4 \text{LGDP}_{t-1} + e_t \tag{4.4}$$

The co-integration test is compared with the critical values of F-distribution for either rejecting or accepting the null hypothesis. If the F-statistics (symbols given in Table 4.7) is lower than the $I(0)$ bound, the null hypothesis can't be rejected, otherwise, it is rejected.

4.4.3 Co-integration test results

The results in Table 4.8 show that there is a long-run relationship among the variables when the Inflation rate is the dependent variable because its F-statistic is higher than the upper bound $I(1)$ at 10% level of significance. Also, there is no long-run relationship for variables such as the Exchange rate, the GDP and the Oil price since their F-statistics are less than lower bound $I(0)$ at 1%, 5%, and 10% level of significance. Therefore comparing the F-statistic for each dependent variable with the lower and upper bounds, we conclude that the long-run relationship exists only when the Inflation Rate is the dependent variable.

Table 4.8: Results from the co-integration test.

Dependent variable	Lag length	F-Statistic	Sign level	Lower bound $I(0)$	Upper bound $I(1)$	Decision
F_{Infl}(Infl\Exch,GDP,Oil pr)	1	3.861404	10%	2.72	3.77	Cointegration
			5%	3.23	4.35	No Cointegration
			1%	4.29	5.61	No Cointegration
F_{Exch}(Exch\Infl,GDP,Oil pr)	2	1.555815	10%	2.72	3.77	No Cointegration
			5%	3.23	4.35	No Cointegration
			1%	4.29	5.61	No Cointegration
F_{OilPr}(Oil Pr\Infl,GDP,Exch)	1	2.734128	10%	2.72	3.77	No Cointegration
			5%	3.23	4.35	No Cointegration
			1%	4.29	5.61	No Cointegration
F_{GDP}(GDP\Infl,Exch,Oil pr)	2	1.645522	10%	2.72	3.77	No Cointegration
			5%	3.23	4.35	No Cointegration
			1%	4.29	5.61	No Cointegration

4.5 Long-run and short-run estimation (OLS method of estimation)

4.5.1 ARDL model specification

The specified model, selected by the AIC to estimate the parameters of the model, is given as ARDL$(1,0,0,0)$ indicated in Table 4.9 (Fig. 4.2). ARDL$(1,0,0,0)$, which is equivalent to ARDL(p,q_1,q_2,q_3), represents dependent variable (p) which is LINFL and it contains lag 1, likewise q_1,q_2 and q_3 are independent variables which are LEXCH(q_1), LGDP(q_2) and LOIL_P_WTI(q_3) with lag length 0,0,0 respectively.

Table 4.10 (Fig. 4.3) shows the result of estimated coefficients of the long-run relationship, which indicates that there is a significant positive relationship between the Inflation and the Oil price shock. A 1% increase (decrease) in the Oil price leads to a 0.17% increase (decrease) in the Inflation. Also, there is a negative significant relationship between the GDP and the Inflation. A 1% increase in the GDP leads to a 0.31% decrease in the Inflation. Likewise, the coefficient of long-run estimate indicates that there is an insignificant positive relationship between the Exchange rate and the Inflation, that is a 1% increase(decrease) in the Exchange rate leads to a 0.05% increase(decrease) in the Inflation.

4.5.2 Result for short run estimation by ordinary least square method

The results in Table 4.11 (Fig. 4.4) indicate that the coefficient of ECM$= -0.33$ is highly significant $(p < 5\%)$ and it has the correct sign (negative sign).The error coefficient of -0.33 shows that there is a moderate speed of annual adjustment of the Inflation rate to converge towards the equilibrium aftershock. Approximately 33% of disequilibrium from the previous year shock converges back to the long-run equilibrium in the current year.

4.6 Autocorrelation and heteroscedasticity test

4.6.1 Breusch-Godfrey serial correlation LM test for serial correlation

The results in Table 4.12 (Fig. 4.5) show that the F-statistics for the serial correlation test is higher than 5%. Therefore the null hypothesis of no serial correlation cannot be rejected. This result indicates that the variables are not serially correlated. In this case, the model is stable and ready for analysis.

Fig. 4.2: Table 4.9: ARDL model specification.

Selected Model: ARDL(1, 0, 0, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
INFL(-1)	0.667191	0.101271	6.588189	0.0000
LEXCH	0.016510	0.011689	1.412470	0.1652
LGDP	-0.104384	0.046399	-2.249680	0.0298
LOIL_PRICE	0.055213	0.023480	2.351502	0.0235
C	2.917888	1.310016	2.227367	0.0313

Fig. 4.3: Table 4.10: Long-run estimation by OLS (the dependent variable is the Inflation).

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LEXCH	0.049608	0.030337	1.635210	0.1095
LGDP	-0.313644	0.110874	-2.828823	0.0071
LOIL_PRICE	0.165899	0.075513	2.196946	0.0336

EC = INFL - (0.0496*LEXCH -0.3136*LGDP + 0.1659*LOIL_PRICE)

Fig. 4.4: Table 4.11: The short-run dynamics associated with the long-run relationship.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.917888	0.717168	4.068627	0.0002
CointEq(-1)*	-0.332809	0.081811	-4.068031	0.0002

Fig. 4.5: Table 4.12: The serial autocorrelation test.

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	1.461560	Prob. F(2,40)	0.2440
Obs*R-squared	3.200762	Prob. Chi-Square(2)	0.2018

Fig. 4.6: Table 4.13: Breusch-Pagan-Godfrey test for homoscedasticity.

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	2.232048	Prob. F(4,42)	0.0818
Obs*R-squared	8.239543	Prob. Chi-Square(4)	0.0832
Scaled explained SS	12.62437	Prob. Chi-Square(4)	0.0133

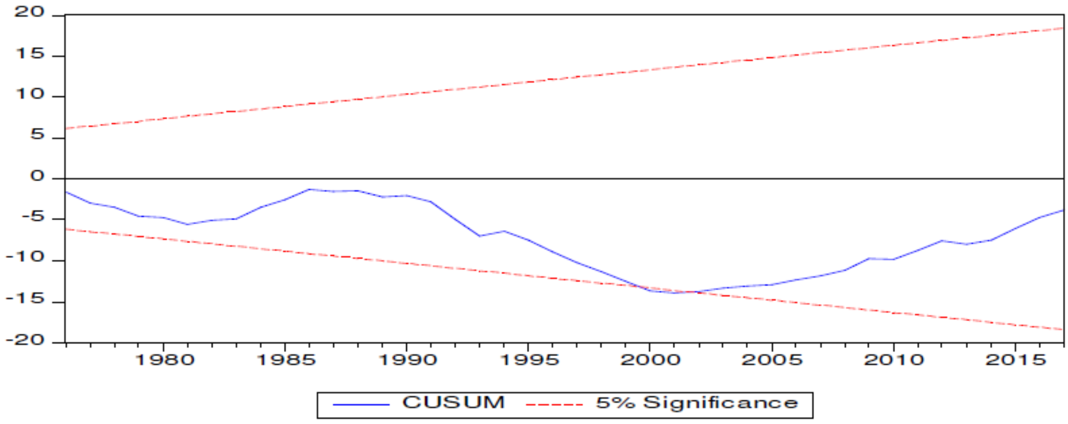

Fig. 4.7: The cumulative sum of recursive (CUSUM) test for model stability.

4.6.2 Breusch-Pagan-Godfrey test for homoscedasticity

The results in Table 4.13 (Fig. 4.6) shows that the F-statistics and the R-squared for homoscedasticity test are higher than 5%. This result indicates that the variables do not suffer from heteroscedasticity.

4.6.3 Testing of model stability

The results in Figs. 4.7 and 4.8, Cumulative Sum of Recursive (CUSUM) and Cumulative Sum of Recursive Residual(CUSUMSQ) tests show that the model is stable at 5% level of significance because the coefficients of both the models are within the boundary of the plot.

4.7 The impact of the Oil price shock on the Inflation

4.7.1 Lag length criteria

Before proceeding with the impulse response test and variance decomposition analysis to find the impact of the Oil price shock on the Inflation, it is necessary to find the optimal lag length of the variables in order to specify the VAR model. Under the VAR model, all the variables are endogenous. One way is to choose the lowest values from either AIC, SC or HQ. The lower criterion value, is the better lag length for co-integration of the model.

4.7.2 Result of lag length selection

The result in Table 4.14 (Fig. 4.9) shows that the optimal lag length of all the variables is 1.This optimal lag length is applicable in estimating the VAR model, impulse response, forecast error variance decomposition and is also used for model diagnostic.

4.8 Model diagnostics

4.8.1 Serial correlation LM test

The results in Table 4.15 (Fig. 4.10) shows that the p-value is higher than 5%. Therefore the null hypothesis of no serial correlation cannot be rejected. This result indicates that the variables are not

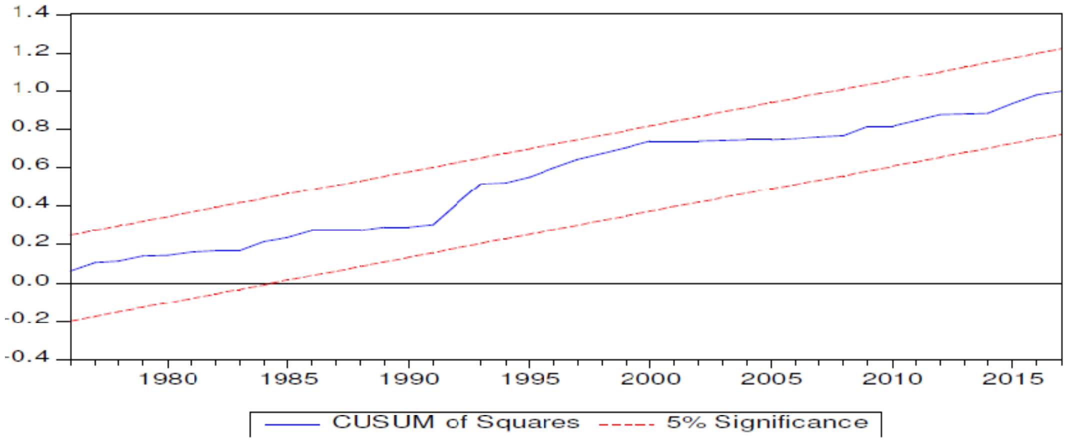

Fig. 4.8: The cumulative sum of squares of recursive residual (CUSUMSQ) test for model stability.

Fig. 4.9: Table 4.14: Lag length selection.

Lag	AIC	SC	HQ
0	3.172476	3.331489	3.232043
1	-8.379773*	-7.584711	-8.081938
2	-8.169061	-6.737950	-7.632958

Fig. 4.10: Table 4.15: Result from serial correlation LM test.

Null hypothesis: No serial correlation at lag h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	25.14534	16	0.0673	1.662416	(16, 92.3)	0.0684

Fig. 4.11: Table 4.16: Result for heteroscedasticity test.

Joint test:

Chi-sq	df	Prob.
161.9318	160	0.4424

serially correlated.

4.8.2 Heteroscedasticity test

The results in Table 4.16 (Fig. 4.11) shows that the joint probability of heteroscedasticity test is higher than 5%. Therefore the null hypothesis of heteroscedasticity is rejected. This result indicates that the variables do not suffer from heteroscedasticity.

4.9 Normality test

The result in Table 4.17 (Fig. 4.12) shows that the probability in the Jarque-Bera test is higher than 5%. This indicates that the variables are normally distributed. Hence from the model diagnostics test above, it is evident that the model is stable and good for analysis.

The study used the impulse-response function to analyze the response of inflation rate to Generalized One S.D. innovation in other variables and the response of crude oil price, exchange rate and GDP to Generalized One S.D inflation rate innovation. The Generalized Impulse Response Function(GIRF) was initially suggested for non-linear multivariate models (Koop et al. [18]). Later in 1997, Pesaran et al. [26] developed the generalized impulse response function(GIRF) for linear models. Applying the generalized impulse response function(GIRF), it is possible to determine the impact of responses of each variable to shocks to any of the other variables. The advantage of the GIRF is that the generalized impulse response does not require orthogonalization of shocks and is invariant under the ordering of the variables in VAR.

4.10 Interpretation of response of inflation rate to Generalized One S.D. innovations $\pm$ SE in other variables

4.10.1 The response of Inflation rate to oil price shock

Fig. 4.13 shows that the positive reaction of inflation rate to oil price shock is very strong with significantly increasing after the shock. The positive response of inflation rate means that, as the oil price increases, the inflation rate also increases and vice versa. The result shows that the effect slowly decreases with small level of significance and approaches to zero at lag 8 after shock. The effect is significant from the first and half period to second and half period after the shock as the confidence interval shows. The result also shows that 1% increase in oil price leads to a positive impact of 3%

Fig. 4.12: Table 4.17: Result for normality test.

Component	Jarque-Bera	df	Prob.
1	2.760695	2	0.2515
2	3.172248	2	0.2047
3	2.396759	2	0.3017
4	2.334841	2	0.3112
Joint	10.66454	8	0.2214

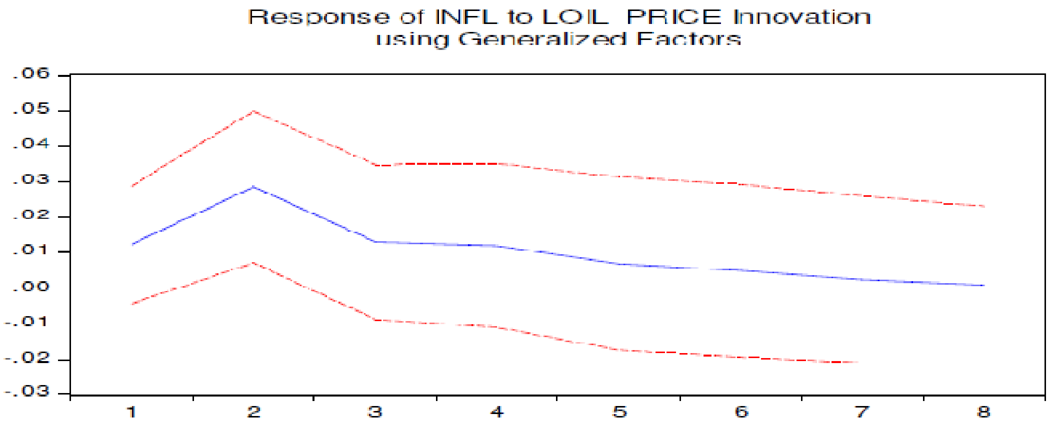

Fig. 4.13: The Impulse response of inflation rate to the oil price shock.

increase in the inflation at lag 1. At lag 3 as the oil price positively decreases by 1%, the rate of inflation also decreases by 1%. The inflation rate continues to decrease positively until lag 8 as the oil price decreases.

The results support the evidence that, a positive increase in oil price provides a profit to the oil exporting countries as it may lead to increase in the revenues of these countries. While on the opposite side, the oil price shock harms the economic development of oil importing countries like Tanzania, since a rise in oil price leads to a rise in the inflation rate as it is shown in Fig. 4.13. Similarly, a fall in the oil price may generate loss to the oil exporting countries and hence it decreases in their revenue while, it creates a profit to the oil importing countries as it may help to decrease the rate of inflation in these countries.

4.10.2 The response of the Inflation rate to the GDP shock

The result of IRF in Fig. 4.14 shows that the inflation rate responds negatively to the GDP shock: as the GDP increases, the inflation rate decreases. In addition, as the GDP decreases, the inflation rate increases. The response of inflation rate is insignificantly rising until lag 2 after the shock. From the 2nd period, it declines insignificantly and converges to zero at lag 8. The effect is insignificant for all

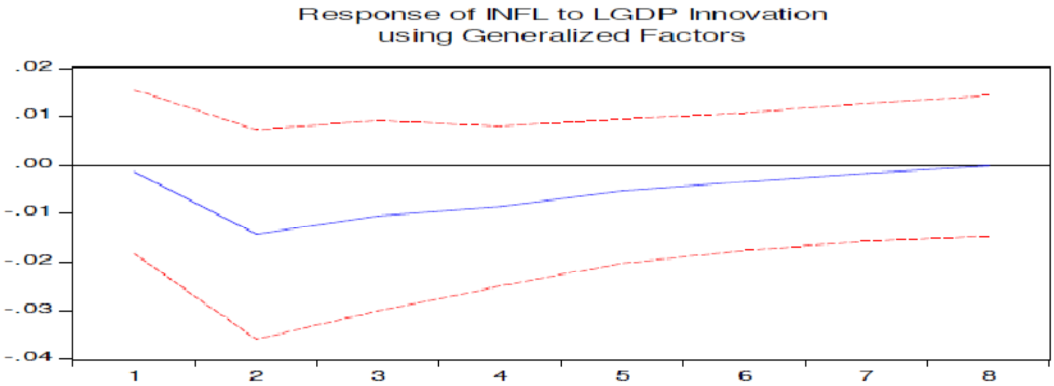

Fig. 4.14: The Impulse response of the inflation rate to the GDP shock.

8 lags after the shock as it is seen in the confidence intervals. The result shows that a 1% increase in GDP leads to a 0.5% decrease in inflation at lag 2. At lag 3, the inflation rate increases by 1% as the GDP decreases by 1%. The rate of increase in inflation continues to lag 8 as the GDP decreases.The results in Fig. 4.14 support the evidence that as the GDP increases in Tanzania, the inflation rate decreases. The decrease in inflation rate may lead to the fall in the price of goods and services and thus consumers may afford to make purchases.

4.10.3 The response of the Inflation to the Exchange rate shock

As shown in Fig. 4.15, the reaction of the inflation rate to the exchange rate shock is positive from the 1st period until the 7th period, then the negative reaction start from the 7th period. As the exchange rate positively increases (decreases) from period 1 to period 7, the inflation rate also increases (decreases). The result also shows that the inflation rate increases strongly positive after the exchange rate shock from the 1st period to the 2nd period. The effect starts to decrease slowly and converges to zero at lag 7 as the exchange rate decreases. The effect is significant only from the middle of the 1st period which lasts till the early stage of the 2nd period. The effect is insignificant from the 2nd period until the period 8. The result also indicates that a 1% increase in the exchange rate leada to a 2% increase in the inflation at lag 2. Also a 1% decrease in the exchange rate leads to a 1% decrease in the inflation at lag 3. The Inflation rate continues to decrease until the period 7 as the exchange rate decreases.
The results support the evidence that an increase in the exchange rate affects the price of goods and services as suggested by the response of the inflation rate. A high level of inflation rate may decrease the purchasing power of the people and thus may lead to a lowering in the living standard of the consumers.

4.11 The response of the oil price, the GDP, and the exchange rate to the Generalized One S.D. Inflation innovation

4.11.1 The response of oil price to inflation rate innovation

The impulse response of the oil price to the inflation rate shock is positive decreasing from the 1stperiod until the middle of the 2nd period, which converges to zero. Then the effect is negative, decreasing from the end of the 2nd period until the period 8. The effect is insignificant for all the 8 periods as shown by the confidence intervals.
The result in Fig. 4.16 shows that a 1% positive decrease in the inflation rate leads to a 1% decrease in the oil price at lag 2. Also a 1% increase in the inflation rate leads to a 4% decrease in the oil price at lag 3. The oil price continues to decrease as the inflation rate increases until lag 8.
The result supports the evidence that a decrease in the level of inflation from lag 1 to the middle of lag 2 influences the decrease in the oil price. Since the inflation rate may be caused by the depreciation of domestic currency, then when the domestic currency is stable against the dollar it will need a less amount of domestic currency to purchase oil which is sold in term of dollars.
Also the result shows the evidence that an increase in the inflation rate influences the decrease in the

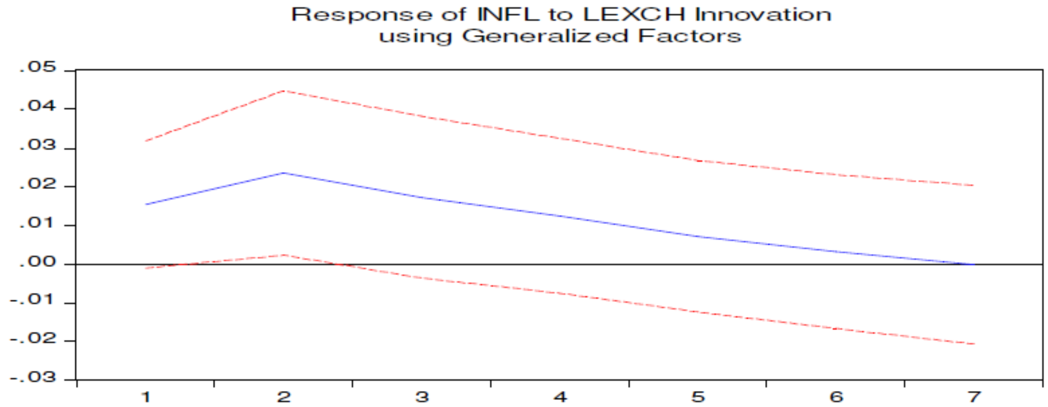

Fig. 4.15: The Impulse response of the inflation rate to the exchange rate shock.

oil price from the middle of lag 2 to lag 8. This may happen because of a decrease in the purchasing power of government and may lead to a lesser demand of oil, which may then lead to the oil exporting countries to reduce the oil price.

4.11.2 The response of GDP to Inflation rate innovation

The impulse response of the GDP to the inflation rate shock is negative, decreasing from the 1st period to the 8th period. The effect is also insignificant for the all the 8 periods as shown by the confidence intervals. The result in Fig. 4.17 shows that a 1% increase in the inflation rate leads to a very low decrease in the GDP at lag 2. The effect continues to decrease slowly to lag 8 as the inflation rate increases by 1%.

The result also shows the fact that an increase in the level of inflation from lag 1 to the middle of lag 2 influences the decrease in the GDP. The higher level of inflation rate may discourage the investments. Low investments in the country may encourage the unemployment. Since there is not enough investment in the country as well as a high rate of unemployment, the government loses a lot of its income which could be obtained from the investment tax as well as income tax from the employed people. So all these effects may lead to a decrease in the economic growth of the country.

4.11.3 The response of exchange rate to inflation rate innovation

The result in Fig. 4.18 shows that the positive reaction of the exchange rate to the inflation rate shock is very strong with significant increase after the shock. The positive response of the exchange rate means that as the inflation rate increases the exchange rate also increases.

From the 2nd period to the 8th period, the result shows that the effect slowly increases with small level of significance after the shock. The effect is significant only from the middle of the 1st period until the end of the 3rd period as the confidence interval shows. The results shows that a 1% increase in the inflation rate leads to a positive impact of 9% increase in the exchange rate at lag 2. At lag 3 as the inflation rate positively increases by 1%, the rate of exchange also increases by 10%. Then the exchange rate continues to increase slowly from lag 2 to lag 8 as the inflation rate increases by 1%.

The result shows the evidence that an increase in the inflation rate influences the rise in the exchange rate. This maybe due to the depreciation of domestic currency against a foreign currency. A fall in the domestic currency value may lead to the government to use large amount of money to buy the foreign currency which may result into a rise in the foreign currency reserves of the country.

4.12 Vector error variance decomposition results

The variance decomposition results are presented in Tables 4.18 (Fig. 4.19) to 4.21 (Fig. 4.22), which explain the importance of the other variables which are contributing to describe the changes of each variable towards the shocks at a different step ahead of the forecast variance.

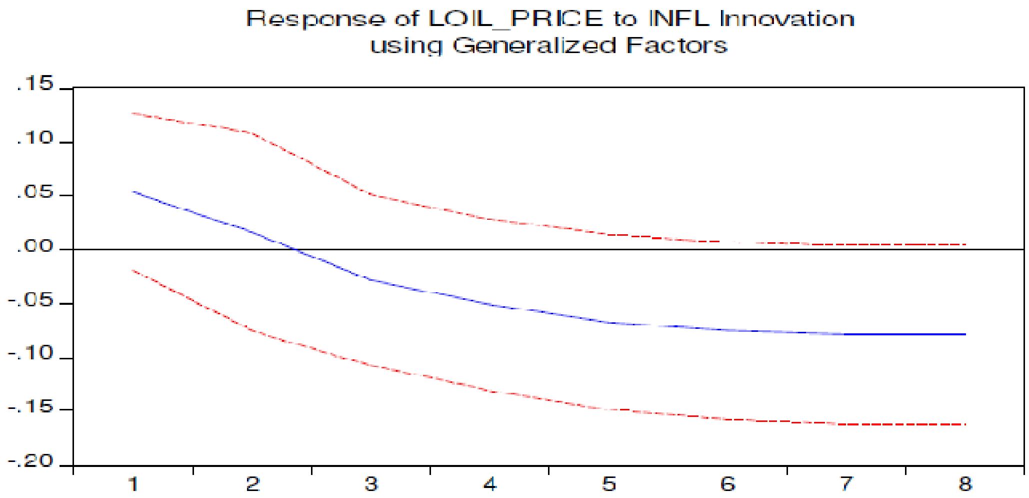

Fig. 4.16: The impulse-response of the oil price to the inflation rate innovation.

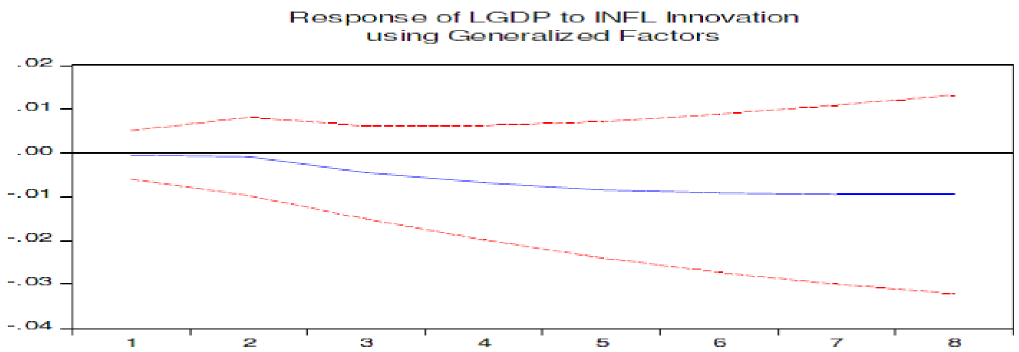

Fig. 4.17: The impulse-response of the GDP to the inflation rate innovation.

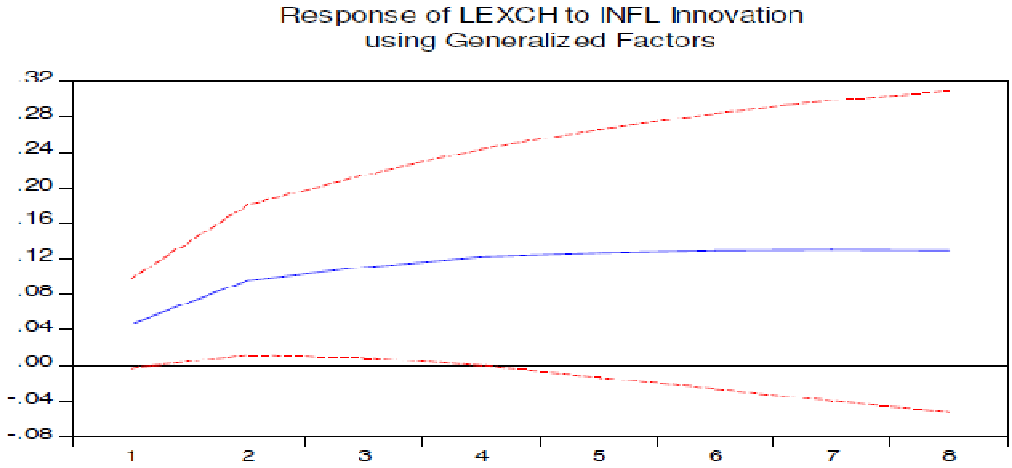

Fig. 4.18: The impulse-response of the exchange rate to the inflation rate innovation.

Fig. 4.19: Table 4.18: The variance decomposition of the inflation rate (INFL).

Period	S.E.	INFL	LEXCH	LGDP	LOIL_PRICE
1	0.056891	100.0000	0.000000	0.000000	0.000000
2	0.071169	85.77435	4.516236	1.576465	8.132954
3	0.079269	86.09372	4.858088	2.077714	6.970476
4	0.083456	85.74563	4.958140	2.414696	6.881537
5	0.086007	86.16089	4.713513	2.552329	6.573266
6	0.087449	86.38365	4.571136	2.634998	6.410217
7	0.088371	86.41275	4.636583	2.669015	6.281648
8	0.088992	86.19076	4.936314	2.678739	6.194187

Cholesky Ordering: INFL LEXCH LGDP LOIL_PRICE

4.12.1 Variance decomposition of inflation rate

From Table 4.18 (Fig. 4.19) it can be noticed that in the short run, the fluctuation in the inflation rate is highly explained by itself at the 1^{st} period with a gently decreasing trend toward the next lags. The results shows 100% of variation in the inflation rate is explained by its own shock, while no variation in the inflation rate is explained by the exchange rate, the GDP(LGDP), and the oil price (LOIL_PRICE). Also in the long run (period 8) the variation in the inflation rate is still influenced by its own shock. The Inflation accounts for 86.19% variation on itself, followed by the oil price(LOIL_PRICE) which accounts for 6.19% fluctuation in the inflation rate. The Exchange rate (LEXCH) and the GDP(LGDP) account for 4.9% and 2.68% respectively in the fluctuation of the inflation rate.

Table 4.19 (Fig. 4.20) shows the evidence that in the short run, the fluctuation in the exchange rate is extremely influenced by itself at the 1^{st} period with slightly decreasing trend afterward. The result shows that 92.65% of variation in the exchange rate is explained by its own shock, while no variation in the exchange rate is explained by the GDP(LGDP) and the oil price (LOIL_PRICE). The Inflation rate accounts for 7.35% fluctuation in the exchange rate in the short run.

In the long run (period 8) the variation in the exhange rate(LEXCH) is still influenced by its own shock. The Exchange rate(LEXCH) contributes 75.93% variation on itself, followed by the inflation rate(INFL) which contributes 23.67% fluctuation in the exchange rate. The Oil price (LOIL_PRICE) and the GDP(LGDP) account for 0.36% and 0.03% respectively in the fluctuation of the exchange rate.

Fig. 4.20: Table 4.19: The variance decomposition of the exchange rate(LEXCH).

Period	S.E.	INFL	LEXCH	LGDP	LOIL_PRICE
1	0.056891	7.348661	92.65134	0.000000	0.000000
2	0.071169	13.45817	86.39268	0.000102	0.149048
3	0.079269	15.90283	83.67873	0.017463	0.400976
4	0.083456	17.92505	81.60363	0.030840	0.440480
5	0.086007	19.57341	79.94688	0.037305	0.442411
6	0.087449	21.07431	78.46901	0.037814	0.418871
7	0.088371	22.43064	77.14504	0.035218	0.389107
8	0.088992	23.67294	75.93770	0.031613	0.357746

Cholesky Ordering: INFL LEXCH LGDP LOIL_PRICE

Fig. 4.21: Table 4.20: The variance decomposition of the LGDP.

Period	S.E.	INFL	LEXCH	LGDP	LOIL_PRICE
1	0.056891	0.059733	11.20683	88.73344	0.000000
2	0.071169	0.093462	14.94923	84.87196	0.085343
3	0.079269	1.321807	16.86008	80.95609	0.862015
4	0.083456	2.790498	18.03295	76.46433	2.712216
5	0.086007	4.118285	18.47783	72.75857	4.645314
6	0.087449	5.071126	18.45353	70.00195	6.473394
7	0.088371	5.704530	18.10728	68.10316	8.085032
8	0.088992	6.069051	17.55811	66.86496	9.507877

Cholesky Ordering: INFL LEXCH LGDP LOIL_PRICE

4.12.2 The variance decomposition of the LGDP

The forecast error variance decomposition proves that the GDP(LGDP) in Tanzania is typically explained by its own shock as it has shown in Table 4.20 (Fig. 4.21). The result shows that 88.73% of changes in the GDP(LGDP) is influenced by its own shock in the short run (period 1) and then tend to decrease as the number of periods increases. Also in the short run (period 1) the oil price (LOIL_PRICE) contributes 0% in the fluctuation of the GDP, that is, change in the GDP is not caused by the oil price. The Exchange rate(LEXCH) and the inflation rate(INFL) contribute 11.21% and 0.059% respectively in the fluctuation of the GDP(LGDP).

In the long run lag 8 the variation in the GDP(LGDP) is still caused by its own shock for 66.86%. The Exchange rate contributes 17.56% change in the GDP(LGDP) followed by the oil price and the inflation rate which account for 9.51% and 6.07% respectively in the fluctuation of the GDP(LGDP).

4.12.3 The variance decomposition of the oil price (LOIL_PRICE)

The forecast error variance decomposition of the oil price(LOIL_PRICE) is described in Table 4.21 (Fig. 4.22). The results indicate that the changes in the oil price (LOIL_PRICE) in Tanzania are extremely caused by its own shock. The result confirmed that 93.12% of changes in the oil price (LOIL_PRICE) are caused by its own shock in the short run (period 1) which then start to decrease.

The Inflation rate(INFL), the exchange rate(LEXCH), and the GDP(LGDP) contribute very low in the fluctuation of the oil price in Tanzania. Each of them contribute 4.63%, 2.09%, and 0.16% respectively.

In the long run lag 8 the rise and fall of the oil price (LOIL_PRICE) in Tanzania is also caused by its own shock. The Oil price accounts for 76.11% to its own fluctuation followed by the inflation rate which accounts for 18.07% in changes of the oil price. The Exchange rate(LEXCH) and the GDP(LGDP) contribute 4.85% and 0.96% respectively in the fluctuation of the oil price(LOIL_PRICE).

Fig. 4.22: Table 4.21: The variance decompositon of the LOIL_PRICE.

Period	S.E.	INFL	LEXCH	LGDP	LOIL_PRICE
1	0.056891	4.629634	2.088710	0.162978	93.11868
2	0.071169	3.286814	2.279061	0.131242	94.30288
3	0.079269	3.475217	2.001437	0.110825	94.41252
4	0.083456	5.286366	1.973694	0.161125	92.57882
5	0.086007	8.276215	2.414689	0.304735	89.00436
6	0.087449	11.68202	3.192252	0.512443	84.61328
7	0.088371	15.04540	4.056808	0.742748	80.15505
8	0.088992	18.06732	4.851956	0.969909	76.11082

Cholesky Ordering: INFL LEXCH LGDP LOIL_PRICE

Fig. 4.23: Table 4.22: The result of the degree of responsiveness of the inflation rate on the oil price, the exchange rate and the GDP.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.549353	1.462116	5.847248	0.0000
LOIL_PRICE	0.105801	0.031971	3.309257	0.0019
LGDP	-0.300664	0.052539	-5.722663	0.0000
LEXCH	0.060476	0.014184	4.263804	0.0001

$$\text{INFL} = -0.300664{*}\text{LGDP} + 0.060476{*}\text{LEXCH} + 0.105801{*}\text{LOIL\_PRICE} + 8.549353$$

4.13 The degree of responsiveness of the Inflation on the Oil price, the Exchange rate and the GDP

To determine the degree of responsiveness of the Inflation on exogenous variables which are the oil price shock, the GDP and the Foreign Exchange rate. The result from the estimated regression equation is presented in Table 4.22 (Fig. 4.23).

The result shows that, in Tanzania the inflation rate is inelastic on GDP because the value of the estimated coefficient β_1(-0.300664) is less than one, that is 1% increase in the GDP leads to a decrease in the inflation rate which is less than 1% . The result is also significant at 5% level of significance. From this result, the degree of responsiveness of change of the inflation rate due to the changes in the GDP is less elastic to the disequilibrium of -0.300664, and a 1 percent increase in the GDP leads to a -0.300664 decrease in the inflation.

The degree of responsiveness of the inflation on the exchange rate is also less elastic because the value of the estimated coefficient of β_2 (0.060476) is less than one, that means a 1% increase in the exchange rate results in a rise in the inflation rate which less than 1%. The Inflation rate adjusts to the equilibrium at the speed of 0.060476. It also explains the fact that a 1% increase in the exchange rate increases the inflation rate by 0.060476.

Likewise, the degree of responsiveness of the inflation rate on the oil price shock under this study is less elastic at the tune of 0.105801, and a 1% increase in the oil price leads to a 0.105801 increase in the inflation rate.

4.14 Forecasting a series of variables under study

4.14.1 Performance criteria

Table 4.23 (Fig. 4.24) shows the performance metrics and their calculations. RMSE, THEIL, and MAE were used to measure the correctness of a prediction in terms of levels and the deviation between the

Fig. 4.24: Table 4.23: The model performance.

	RMSE	THEIL	MAE
VAR(1)	0.069233	0.558453	0.055769
ARDL(1,0,0,0)	0.279525	0.906527	0.214820

Fig. 4.25: Table 4.24: Serial correlation test (LM test).

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	25.1455	16	0.06730
2	29.8826	16	0.01862

H0: no autocorrelation at lag order

actual and the predicted values. The smaller the values, the closer the predicted values were to the actual values.

4.14.2 Comparison of model performances

Employing the accuracy measures (RMSE, THEIL,MAE), we compared the predicted and the observed data for the period of 48 years from the ARDL and VAR models to determine the best-performed model. Table 4.23 (Fig. 4.24) gives the error estimates of both models used in the study for predicting the Inflation rate in Tanzania.

The results from Table 4.23 (Fig. 4.24) show that the VAR model approach can give more reliable predictions of the Inflation rate than the ARDL modeling approach as its error estimates are less than the ARDL for all the three measures. Before proceeding with the forecasting, the VAR model is checked for serial correlation and normality.

4.15 VAR model diagnostic

4.15.1 Serial correlation test (LM test)

The results in Table 4.24 (Fig. 4.25) show that the p-value at lag 1 is higher than 5% level of significance while the p-value at lag 2 is less than 5% level of significance. Since one lag out of two is higher than the 5% level of significance. Therefore the null hypothesis of no serial correlation cannot be rejected. This result indicates that the VAR model is not serially correlated.

The results in Table 4.25 (Fig. 4.26) show that the p-value of the GDP and the Oil price for Jarque-Bera test are higher than 5% level of significance while the p-value of the inflation rate and the exchange rate are less than 5% level of significance. Since the p-values of two variables out of four are higher than 5% level of significance, we can conclude that the VAR model is normally distributed and it is good for forecasting.

4.16 Future estimation (forecasting)

Using the best suitable validated VAR model, which is determined above, the inflation rates are forecasted until 2025 for Tanzania. For scenario, differently forecasted data of GDP, exchange rate, and oil price are considered.

From Fig. 4.27 the forecasting results indicate that in the future the inflation rate is increasing slowly

Fig. 4.26: Table 4.25: Jarque-Bera test for normality.

Jarque-Bera test

Equation	chi2	df	Prob > chi2
INFL	11.172	2	0.00375
LGDP	0.454	2	0.79685
LEXCH	10.009	2	0.00671
LOilprice	4.393	2	0.11117
ALL	26.029	8	0.00104

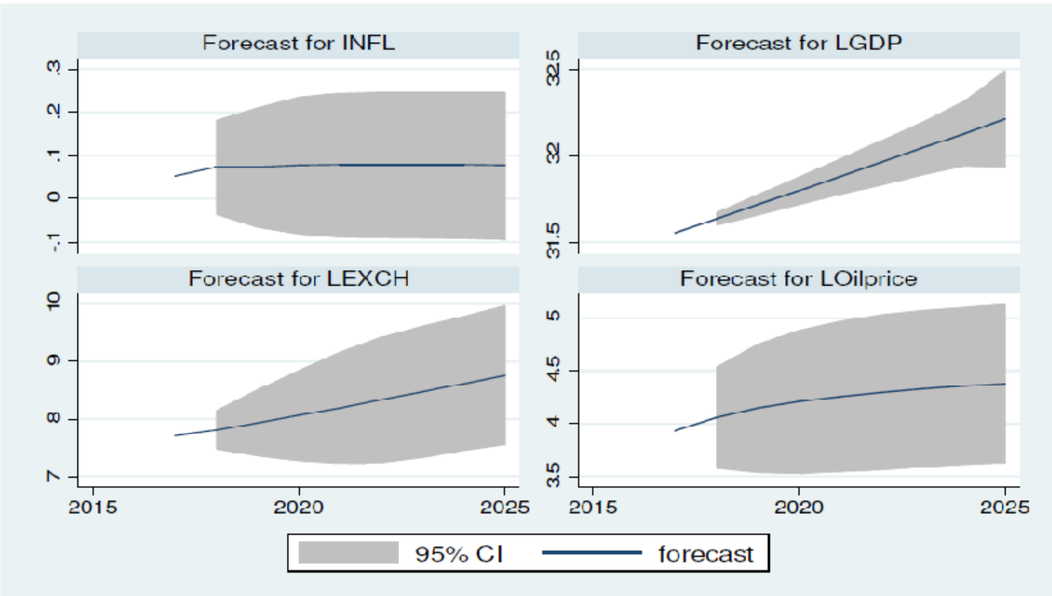

Fig. 4.27: Forecasting results from the VAR model.

till 2025. Also the result shows that there is a rapid increase in the foreign exchange rate, the oil prices, and the GDP till 2025. However, the increase of the inflation rate is influenced by the exchange rate and the oil price, therefore strong policies should be formulated by the government to control the increase in the exchange rate and the oil prices.

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