
Munich Personal RePEc Archive

Revisiting the Phillips curve trade-off: evidence from Tanzania using nonlinear ARDL approach

Nkoba, Malik Abdulrahman and Masih, Mansur

INCEIF, Malaysia, INCEIF, Malaysia

29 December 2018

Online at https://mpra.ub.uni-muenchen.de/91631/
MPRA Paper No. 91631, posted 22 Jan 2019 10:50 UTC

Revisiting the Phillips curve trade-off: evidence from Tanzania using nonlinear ARDL approach

Malik Abdulrahman Nkoba[1] and Mansur Masih[2]

Abstract

The spotlight of this study is to re-examine the presence and nature of the long run relationship between inflation and unemployment. The topic has been of much interest to researchers and policy makers as it has significant implications on macroeconomic stabilization policies. Using expected inflation rates and expected unemployment rates generated by Autoregressive integrated moving average (ARIMA), the study tests whether the relationship between the variables is symmetrical or asymmetrical in both short run and long run. Applying the autoregressive distributed lags model (ARDL) and Nonlinear ARDL approaches proposed by Pesaran et al. (2001) and Shin et al. (2014), we confirm the presence of long run equilibrium relationship between expected inflation and expected unemployment. Findings tend to indicate that the long run relationship is symmetrical whereas evidence is in support of asymmetrical short-run trade-off between the variables. CUSUM and CUSUMSQ tests confirm the stability of the coefficients. The study contributes to the literature in three ways. First it uses expected as opposed to actual variables, second it employs recent methodology of Nonlinear ARDL and third it presents new evidence from a Highly indebted poor country-HIPC (Tanzania) using data from 1991 to 2017.

Keywords*:* Phillips curve, unemployment, inflation, nonlinear ARDL

[1]Graduate student in Islamic finance at INCEIF, Lorong Universiti A, 59100 Kuala Lumpur, Malaysia.

[2] **Corresponding author**, Professor of Finance and Econometrics, INCEIF, Lorong Universiti A, 59100 Kuala Lumpur, Malaysia. Email: mansurmasih@inceif.org

1. INTRODUCTION

The relationship between inflation and unemployment is one of the most debated subjects among different schools of economics. Perhaps this is because it has significant implications on macroeconomic stabilization policies. It was first examined by William Phillips in 1958 using unemployment rates and the rate of change in money wage in the United Kingdom (UK) from 1861 to 1957. Phillips found that there is an inverse relationship between Inflation and unemployment. In recognition of his contribution, this trade off was referred to as "Phillips curve" in economics theory. Contrary to the theory, the oil crises in the 1970s led many countries to experience increase in both inflation and unemployment. This positive correlation sparked severe criticisms from Friedman (1968) who argued that the trade-off between inflation and unemployment is only evident in the short run and no trade-off exist in the long run. He introduced the concept of natural rate of unemployment which led to a pre-dominant view in economic theory that in the long run the Philips curve is vertical (i.e. unemployment rate is independent of inflation). In 1977, Milton Friedman also argued that because of the effect of inflation tax, the two variables may be positively correlated in the long run. While the debate in economic theory is on whether there exists a relationship between inflation and unemployment in both short run and long run, and the nature of the slope such relationship (i.e positive negative or vertical), theories have little to say on the functional form of the trade-off in terms of linearity/non-linearity and symmetry/asymmetry.

The focus of most empirical studies has been in line with the theoretical propositions as well. Recent studies like Dixon (1988); Lockwood and Manning (1989); Nickell (1998); Lockwood et al. (1998); Caballero and Hammour (1994); Pissarides (2000); Berentsen et al. (2011); Alfred & King (2014) and Bhattarai K (2016) have re-examined the trade-off between unemployment and inflation in different countries and regions. Using US data from 1955-2005, Berentsen et al (2011) found that in the long run inflation and unemployment are positively correlated. On the other hand, Phillips curve was found to be evident 28 out of 35 OECD countries (Bhattarai K, 2016). Given the mixed evidence of the nature of the slope, the debate is far from being settled. However, as promising evidence continue to grow, it appears that the slope of the Phillips curve manifests itself differently in different countries. Conversely, empirical evidence on the functional form of the curve whether linear or nonlinear and symmetric or asymmetric is limited. Few studies have attempted to examine the nature of the relationship in terms of linearity and symmetry and the results of the existing literature are also mixed. A linear Phillip's curve implies that the trade-off between inflation and unemployment is directly

proportional whereas a symmetrical relationship suggests that rise and fall in inflation has an equal opposite impact on unemployment.

In examining the relationship between inflation and unemployment, Chaido and Melina (2012); Vijay and Maria (2018) and David and Anyiwe (2013) have applied methodologies that assume linearity and symmetry. On the other hand, Kitov (2007) tested for linearity and found a linear relationship between unemployment and inflation. There has been a trend by researchers and policy makers to explore the possibility that Philips curve may be nonlinear. Empirical evidence on non-linearity was initially based on Quadratic form Philips curve where some studies found it to be concave and others convex. At first there was a weak consensus that Philips curve was indeed convex (Green wood, Shin and Van 2012). Stiglitz (1997) and Coen, Eisner, Tepper Marlin and Shah (1999) reports a concave nature of Phillips curve while Laxton, Rose and Tambakis (1999); Maria-Dolores and Naveira (2005) suggest that Phillips curve is convex. More recently, using threshold vector autoregression, Luiggi (2018) confirms the non-linearity of the Philips curve. Using Non-linear autoregressive distributive lag (NARDL) and Wald test, Olumuyiwa, (2017) found a non-linear relationship between inflation and unemployment in Nigeria but the trade-off between them is symmetric. Conversely, using the same methodology (NARDL), evidence from Melike & Fulya (2016) suggest a non-linear but asymmetric relationship between the variables in Canada.

The fact that economic theory does not provide a conclusive answer on the functional nature of the trade-off between unemployment and inflation, and results from empirical evidence are mixed, open up more research needs in this body of knowledge. Three key issues still need to be addressed. ***First*** is whether there exists a long run relationship between inflation and unemployment. ***Second*** is whether such relationship (if any) is linear or non-linear and symmetric or asymmetric. The above two issues have significant policy implications as they will guide economic policy makers in dealing with inflation and unemployment. This is because if the two variables are related in the long run, one can be used to predict the other. However, what is even more important is knowing which variable to hit to achieve a desired outcome in the other. Hence the ***third*** issue is knowing which of the two leads and which follows i.e. which can be used to influence the other.

This study re-examines the presence and nature of long run relationship between inflation and unemployment presenting evidence from Tanzania from 1991 to 2017. It contributes to the existing literature by employing standard time series techniques and more recent techniques of

autoregressive distributed lags model (ARDL) and Nonlinear ARDL approaches proposed by Pesaran et al. (2001) and Shin et al. (2014) respectively. Since decisions in finance theory are predominantly made on the basis of expected financial variables such as expected inflation, unlike most studies, we use Autoregressive integrated moving average (ARIMA) also known as Box-Jenkins to derive expected inflation and unemployment rates. To the best of our knowledge, it is also the first study to present evidence on the presence and nature (i.e. linearity and symmetry) of long run equilibrium relationship between inflation and unemployment using data from one of the heavily indebted poor countries (HIPC) - Tanzania. Having a good knowledge of the nature of the trade-off between inflation and unemployment is crucial for these countries as evidence suggests that that an increase in the inflation rate leads to a decrease in the stock of foreign debt (Mark & Mohammed, 2014). Although this is good for these countries, (Mark & Mohammed, 2014) points out that this reduces employment and output in the long run. In summary, the objective of this study is to re-examine the presence, nature and direction of the long run equilibrium relationship between inflation and unemployment. Our research questions are threefold.

1. Is there a long run relationship between inflation and unemployment (i.e. are they cointegrated)?
2. What is the nature of the relationship between inflation and unemployment? Is it symmetric or asymmetric?
3. Which of the two variables leads and which follows i.e. which can be used to influence the other.

This study confirms the long run equilibrium relationship between inflation and unemployment. In other words, we find that the variables are cointegrated. This is parallel to results found by quite several existing literature such Maria-Dolores and Naveira, (2005); Melike & Fulya, (2016); and Olumuyiwa, (2017). It implies that there is a theoretical relationship between the variables in the long run and one can be used to predict the other. Using NARDL approach, the study finds that the trade-off between inflation and unemployment is symmetrical in the long run but asymmetrical in the short run. Applying Vector error correction model (VECM) and Variance decomposition (VDC), we found that unemployment leads inflation.

Our results are robust to the use of different cointegration methods and coefficient stability tests. They pose significant policy implications to governments around the world as well as central banks especially in developing and heavily indebted countries. These policies are with respect to government's spending via fiscal policies and central bank's implementation of monetary policies. In summary, proper caution needs to be taken in usage of these policies as they do have negative effects to the economy if not used well.

The rest of the paper is organized as follows. The next section provides the theoretical underpinnings and Section 3 reviews relevant literature related to Phillips curve. Section 4 presents the methodology used and econometric specifications. Results from the analysis are discussed in section 5. Section 6 offers policy implications, conclusion and the direction for further research.

2. THEORETICAL UNDERPINNINGS

In 1958, William Phillips, a New Zealand economist examined the relationship between inflation and unemployment in the UK from 1861 to 1957. His main proposition was centred upon what is described as the Phillips curve **(Figure 1).** Phillips curve illustrates an inverse relationship between inflation and unemployment. He argued that to curb inflation the government has to reduce aggregate demand by cutting down spending. However, low spending reduces money supply and inflation at a cost of higher unemployment since workers who were involved in activities covered by the slashed government spending will have to be retrenched. This is to say the lower the inflation in the economy, the higher the unemployment and vice versa. 12 years later (1970s), there was an oil crisis that caused a significant decrease in the supply of oil and rise in its price. Since oil is an input in most production processes, cost of production rose, and economies experienced inflation. At the same time, businesses had to retrench workers given the increased production cost which led to massive unemployment. This was against the inverse trade-off proposed by Phillips. Economist criticized the notion of Phillips curve and argued that the trade-off only holds in the short run. Milton Friedman contended that in the long run there is no trade-off between inflation and unemployment. He stressed that in the long run only a single rate of unemployment referred to as the "natural rate of unemployment (NAIRU)" exist. Therefore, the Phillips curve is vertical in the long run (Figure 2).

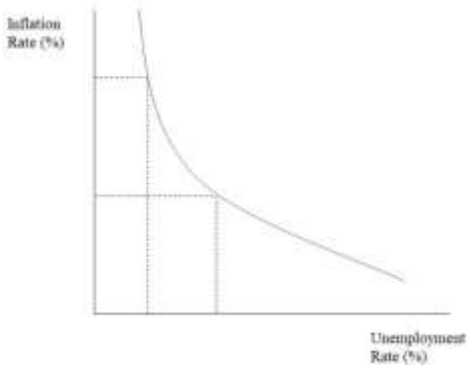


Figure 1

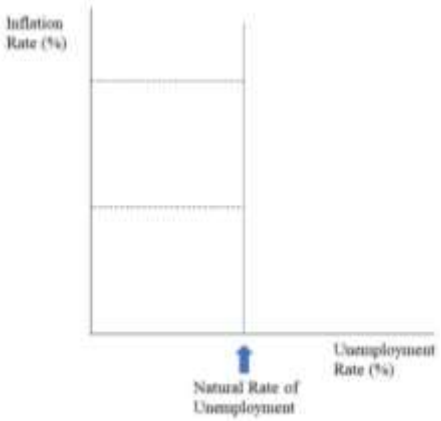


Figure 2

The Philips curve in the short run can be derived from the Lucas aggregate supply function. The Lucus supply function states that aggregate supply is the function of natural level of output ***(Y_{No})*** and the difference between actual prices ***(P_A)*** and expected prices level accounting for past information ***(Ω_{t-1})*** times a coefficient based on an economy sensitivity to price surprises ***($\grave{\alpha}$).***

$$Y_S = Y_{No} + \grave{\alpha}[P_A - E(P_A \mid \Omega_{t-1})] \qquad \textit{Equation 1}$$

This can be simplified as shown in equation 2, where Y_S is the log value of actual output, Y_N is the log value of the natural level of output, $\grave{\alpha}$ is a positive constant, P_A is the log value of actual price level and P_E is the log value of expected price level.

$$Y_S = Y_N + \grave{\alpha}[P_A - P_E] \qquad \textit{Equation 2}$$

Equation 2 can then be rearranged to arrive at equation 3

$$P_A = P_E + \frac{Y - Y_N}{\grave{\alpha}}$$

Equation 3

We then add unexpected exogenous shocks to the world supply ***(k)***

$$P_A = P_E + \frac{Y - Y_N}{\grave{\alpha}} + k$$

Equation 4

By subtracting previous year's price level ***(P-1),*** we will arrive at inflation rates. In equations below, **β** and β_e denotes inflation and expected inflation respectively.

$$P_A - P_{-1} \approx \beta$$

$$P_E - P_{-1} \approx \beta_e$$

Drawing from Okun's law which states there is an inverse relationship between output and unemployment:

$$\frac{Y - Y_N}{\grave{\alpha}} = -\delta(U_N - U_{NN}) \qquad \textit{Equation 5}$$

Where **δ** is a positive constant term, $\mathbf{U_N}$ is the actual rate of unemployment and $\mathbf{U_{NN}}$ is the natural rate of unemployment. Substituting the right-hand side of equation 5 in equation 4, we arrive at the short run Phillips curve represented by equation 6.

$$B = \beta_e - \delta(U_N - U_{NN}) + k \qquad \textit{Equation 6}$$

3. REVIEW OF LITERATURE

The literature on Phillips curve in terms of the presence and nature of the long run relationship between inflation and unemployment can be broadly divided into four main categories. The first category examines the said relationship using methods that assumes the relationship is linear and symmetric. These studies include Chaido and Melina (2012); David and Anyiwe (2013) and Vijay and Maria (2018). The second cluster of literature such as Kitov (2007) tests for the linearity of the trade-off and confirms that the relationship is in fact linear. This implies that there is a direct proportional relationship between inflation and unemployment. The third tests for non-linearity of the relationship by examining whether the curve is convex or concave. These include Stiglitz (1997) and Coen, Eisner, Tepper Marlin and Shah (1999); Laxton, Rose Tambakis (1999); and Maria-Dolores and Naveira (2005). Finally, studies which applied recent techniques to test for both linearity and symmetry such as Melike & Fulya (2016); and Olumuyiwa, (2017).

Chaido and Melina (2012) investigated the impact of unemployment on inflation in the case of Greece within the Phillips Curve (1958) context. Using the data from 1980 to 2010 and applying cointegration tests and vector error correction model, their results showed that there is a long run and causal relationship between inflation and unemployment. Similarly, Vijay & Maria (2018) applied a structured cointegration and vector error correction model to a time series data of inflation and unemployment rates for Hungary from 1999 to 2017. Their cointegration t results confirmed the existence of a long run dynamics between these variables and the vector error correction model depicted that the variables would adjust to long run equilibrium path quickly in case of short run disturbances to the model. The methods used by these researchers have a shortcoming of assuming linearity and symmetry.

Kitov (2007) tested the linearity of the trade-off between inflation and unemployment in Austria and France. The study demonstrated that the countries are characterized by linear relationship between inflation and unemployment. His results were parallel to other similar studies that were conducted in USA and Japan (Kitov 2006a, 2006b & 2006c).

Maria-Dolores and Naveira (2005) assessed the nature of the relationship between inflation and unemployment in European countries. Using data from three European countries (Germany, France and Spain) and the US, their sample periods were 1980(8)–l997(12) for Germany, 1988(7)–1997(12) for France, 1989(5)–1997(12) for Spain and 1984(1)–2001(9) for US. Applying two econometric strategies, ordered probit approach and Euler equation approach, they found a significant evidence of non-linearity in the policy rules of the central banks when inflation moves above their target. They presented evidence in favour of convex Phillips curve arguing a considerably steeper Phillips curve when the output gap is positive than when it is negative. Some studies have presented evidence in favour of concave form. They used the approach of splitting the sample into two distinct regimes, one of which unemployment is above the natural rate of unemployment and the other when it is below. Their results indicate that low level of unemployment have not been associated with high inflation (Stiglitz, 1997; Coen, Eisner, Tepper Marlin & Shah, 1999)

Olumuyiwa, (2017) examined the long- run asymmetry effects of monetary policy shocks on output in Nigeria between 1986 and 2015. Using two – stage nonlinear error correction model under the Non- Linear Auto Regressive Distributed Lag and Wald test his results showed that the positive component of money supply has positive long-run effect on output in Nigeria. He also found that the long run relationship between output and money supply in Nigeria is

symmetric. Likewise, Melike & Fulya (2016) analysed the Post-Keynesian Phillips Curve by using non-linear ARDL approach and non-linear Granger causality method for the period from 1957 to 2015 in Canada. They found that Canada has a bi-directional causal relationship between inflation-unemployment. Contrast to Olumuyiwa, (2017), their study found that there is an asymmetric long run relationship between inflation and unemployment.

Given the above mixed results in the previous empirical studies, my study re-examines the presence and nature of the long run equilibrium relationship between inflation and unemployment in Tanzania. The study will contribute to the literature by providing new evidence from one of the highly indebted poor country (HIPC).

4. DATA AND METHODOLOGY

4.1 Data and Variables

This study has used data on Inflation and unemployment of Tanzania from 1991 to 2017. We have used 27 years data due to data limitation. Unemployment data for Tanzania is only available from 1991. **Table A** shows descriptive statistics of the sample and variables used.

Table A: Descriptive Statistics

Variable	Observation	Mean	Std. Dev	Min	Max
LGDP	27	3.187749	.1646401	2.985009	3.469215
LEXCH	27	2.977892	.2565948	2.340756	3.348082
LINF	27	.9956816	.241251	.7043996	1.459864
LUNE	27	.5520979	.0955076	.3489645	.684319

My focus variables are expected Inflation and expected Unemployment. I intend to examine whether the variables have long term equilibrium relationship i.e. cointegrated and the nature of the relationship whether linear or non-linear and symmetric or asymmetric. However, we have included two control variables that are theoretically related with inflation and unemployment. These are the Gross domestic product (GDP) per capita and real exchange rates. Summary of the variables used, and their sources are presented in **Table B.**

Table B: Summary of the Variables

VARIABLE	Measure	SOURCE	SYMBOL
Gross Domestic Product Per capita	Gross domestic product divided by total population.	World development indicators	LGDP*/DGDP**
Expected Inflation	Consumer price index reflecting the annual percentage change in the cost of living to the average consumer	World development indicators	LINF/DINF
Expected Unemployment	The share of the labour force that is without work but available for and seeking employment.	World development indicators	LUNE/DUNE
Official exchange rates	Exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. (Tanzanian Shilling relative to USD)	World development indicators	LEXCH/DEXCH

**L = Log form **D = Differenced form*

4.2 Econometric Model specifications

I have employed standard time series techniques and more recent techniques of autoregressive distributed lags (ARDL) and Nonlinear ARDL approaches proposed by Pesaran et al. (2001) and Shin et al. (2014) respectively. However, before applying the above techniques, I have used the Autoregressive integrated moving average (ARIMA) also known as Box-Jenkins to derive expected inflation and unemployment rates. The rationale for this is the fact that most economic decisions are done based on expected variables and not actual ones.

4.3 Autoregressive integrated moving average (ARIMA)

To estimate the expected inflation and unemployment rate, I use a time series forecasting model introduced by Box and Jenkins (1976), the ARIMA model. The ARIMA (p,d,q) can be depicted as:

$$\beta(L)\Delta^{d} Y_t = \delta + \grave{\alpha}(L)\varepsilon_t$$

Where $\beta(L) = 1- \beta_1 L – \beta_2 L - ….- \beta_p L^p$ is the operator of the autocorrelation and $\grave{\alpha}(L)= 1 - \grave{\alpha}_1 L - \grave{\alpha}_2 L - ….- \grave{\alpha}_p L^p$ is the operator of moving average.

4.4 Unit root test

Before testing for the existence of long run equilibrium relationship i.e. cointegration, it is necessary that unit root test is performed. The objective of doing a unit root test at level and differenced form is to test for stationarity. Variables are stationary if their mean, variance and covariance are constant whereas a non-stationary series has an infinite variance, permanent shocks and its autocorrelations tend to be unity. This study will use Augmented Dickey-Fuler - ADF (Dickey and Fuller, 1979), Phillips-Perron - PP (Phillips and Perron, 1988) and KPSS (Kwiatkowski et al., 1992) tests to test for stationarity. While the ADF test accounts for only autocorrelation, the PP test accounts for both autocorrelation and heteroskedasticity. It is necessary to perform stationarity test since some cointegration methods like Johansen test are sensitive to the stationarity of the variables. Johansen is only applicable if the variables are non-stationary.

4.5 Determination of the order (lags) of VAR model

In performing the Johansen test (Johansen, 1991), one has to specify the number of lags in the VAR model. This entails determination of the order or lags of the model. Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC) is used. The AIC focus is on predicting the best order of lags, favors large value of likelihood and hence it is less concerned of overparameterization. The SBC on the other hand tends to lower the number of lags trying to avoid over-parameter.

4.6 Cointegration

Co integration is the test of presence or absence of long run equilibrium relationship between the variables. If the variables are cointegrated, it can be concluded that the relationship between them is truly theoretical and not spurious. It also means that variables contain information to predict one another. A number of cointegration tests are applied. First, we use the Engle Granger (Engle and Granger, 1987). Due to the limitations of Engle Granger approach, we also use Johansen cointegration test since our ADF and PP results found all variables to be non-stationary at level form. The contradiction in unit root results of KPSS and the other two tests especially at the level form coupled with the small sample of our study makes ARDL a more appropriate cointegration test to be performed. Therefore, we use ARDL and Nonlinear ARDL approaches proposed by Pesaran et al. (2001) and Shin et al. (2014). NARDL will allow us to see if the trade-off between inflation and unemployment is linear or non-linear and symmetric or non-symmetric. This is for both short run and long run relationship.

4.7 Coefficient stability

The study uses CUSUM and CUSUM square test to check for the stability of coefficients. The CUSUM test is based on a plot of the sum of the recursive residuals. If this sum goes outside of a critical bound, one concludes that there exists a structural break at the point at which the sum began its movement toward the bound. The recursive residuals are standardized one step in front of prediction errors. CUSUM Square test is like the CUSUM test but plots the sum of the squared recursive residuals.

5. RESULTS AND DISCUSSIONS

5.1 Autoregressive integrated moving average (ARIMA)

After testing for stationarity, the variables were found to be stationary at level form[3]. This means the mean, variance and covariance was constant. I then observed the Autocorrelation function (ACF) and the Partial autocorrelation function (PACF) for each of the series to identify the ARIMA model. I have used ARIMA (1,0,1) and ARIMA (1,0,0) to estimate the expected inflation rates and unemployment rates respectively. The coefficients for autoregressive (AR) and moving average (MA) for these models are significant at 1%. Diagnostic tests for the figure for autocorrelation coefficient had P-values more than 5% which disallows us from rejecting the null hypothesis that there is no autocorrelation. Results for ARIMA (1,0,1) and ARIMA (1,0,0) for expected inflation and expected unemployment are shown in **Table 1** and **Table 2**

Table 1: Inflation ARIMA (1,0,1)

	(1)	(2)	(3)
VARIABLES	Inflation	ARMA	sigma
Autoregressive (AR) 1		0.689***	
		(0.245)	
Moving Average (MA)1		0.683***	
		(0.183)	
Constant	1.014***		0.134***
	(0.162)		(0.0279)
Observations	27	27	27

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2: Unemployment ARIMA (1,0,0)

	(1)	(2)	(3)
VARIABLES	Unemployment	ARMA	sigma
Autoregressive (AR) 1		0.879***	
		(0.103)	
Constant	0.516***		0.0573***
	(0.150)		(0.0107)
Observations	27	27	27

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[3] Using KPSS (Kwiatkowski et al., 1992)

5.2 Unit root tests

The three tests present different results on stationarity of the variables. The ADF test shows all variable are non-stationary at level form while GDP per capita and exchange rates still appear to be stationary even at differenced form. The PP test provides similar result with ADF for variables at level form. However, when the test is performed to the variables at first differenced form only GDP per capita maintains the non-stationarity. KPSS test presents results that are in contrast to ADF and PP tests. At level form, expected inflation and expected unemployment are found to be stationary whereas at differenced form all variables are stationary. The results for the three tests, ADF, PP and KPSS are presented in **Table 3, Table 4 and Table 5** respectively.

Table 3: ADF test (Log form)

	VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT
LOG FORM	LGLP	ADF(5)=SBC	73.6855	- 3.440	- 3.654	Non-Stationary
		ADF(3)=AIC	78.8802	- 3.580	- 3.685	Non-Stationary
	LEXCH	ADF(5)=SBC	43.6222	- 1.793	- 3.654	Non-Stationary
		ADF(1)=AIC	50.6804	- 2.532	- 3.688	Non-Stationary
	LINF	ADF(4)=SBC	1.8751	- 2.667	- 2.992	Non-Stationary
		ADF(3)=AIC	5.5405	- 2.570	- 3.1153	Non-Stationary
	LUNE	ADF(3)=SBC	27.4367	- 1.573	- 3.685	Non-Stationary
		ADF(4)=AIC	33.9935	- 1.306	- 3.607	Non-Stationary

Table 3: ADF test (Differenced form)

	VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT
1ST DIFF. FORM	DGDP	ADF(5)=SBC	64.2323	- 1.365	- 3.852	Non-Stationary
		ADF(1)=AIC	70.2225	- 2.167	- 3.674	Non-Stationary
	DEXCH	ADF(5)=SBC	38.4853	- 1.917	- 3.852	Non-Stationary
		ADF(2)=AIC	45.3082	- 3.444	- 3.671	Non-Stationary
	DINF	ADF(1)=SBC	0.1263	- 5.020	- 3.674	Stationary
		ADF(1)=AIC	2.1177	- 5.020	- 3.674	Stationary
	DUNE	ADF(1)=SBC	24.0966	- 3.806	- 3.674	Stationary
		ADF(1)=AIC	31.8911	- 3.919	- 3.852	Stationary

Table 4: PP test (Log form)

	VARIABLE	VALUE	C.V.	RESULT
LOG FORM	LGLP	1.6578	- 2.910	Non-Stationary
	LEXCH	- 2.8725	- 2.910	Non-Stationary
	LINF	- 2.2391	- 2.910	Non-Stationary
	LUNE	- 1.7583	- 3.689	Non-Stationary

Table 4: PP test (Differenced form)

	VARIABLE	VALUE	C.V.	RESULT
1ST DIFF. FORM	DGDP	- 2.6859	- 3.584	Non-Stationary
	DEXCH	- 3.9693	- 2.998	Stationary
	DINF	- 10.0266	- 2.998	Stationary
	DUNE	- 7.2311	- 3.584	Stationary

Table 5: KPSS test (Log form)

	VARIABLE	VALUE	C.V.	RESULT
LOG FORM	LGLP	0.3893	0.381	Non-Stationary
	LEXCH	0.4170	0.381	Non-Stationary
	LINF	0.1389	0.248	Stationary
	LUNE	0.2935	0.381	Stationary

Table 5: PP test (Differenced form)

	VARIABLE	VALUE	C.V.	RESULT
1ST DIFF. FORM	DGDP	0.3133	0.381	Stationary
	DEXCH	0.3384	0.381	Stationary
	DINF	0.1585	0.248	Stationary
	DUNE	0.3546	0.381	Stationary

5.3 Determination of the order (lags) of VAR model

Using the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC), the preferred lag is three (3). **Table 6** presents the results of the order of lag determination.

Table 6: Order of lag

SELECTION CRITERIA	LAG ORDER	VALUE
Akaike Information Criterion (AIC)	3	181.0442
Schwarz Bayesian Criterion (SBC)	3	152.6771

5.4 Cointegration

5.4.1 Engle-Granger cointegration test

In testing for cointegration using Engle-Granger test the null hypothesis is that there is no cointegration. If the C-value is more than the T-statistics, we fail to reject the null hypothesis of no cointegration and hence we conclude the variables are cointegrated. In **Table 7** below, the critical value of **-4.6606** is more than the T-statistics hence we fail to reject the null hypothesis. We conclude that there is no relationship between inflation and unemployment in the long run. However, this method has a limitation of not being able to identify the number of cointegrating vector. It can only show presence and absence of cointegration. Therefore, we proceed to Johansen test.

Table 7: Engle-Granger cointegration test

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.2774	42.1439	41.1439	40.6217	41.0306
ADF (1)	-2.7774	43.3757	41.3757	40.3312	41.1490
ADF (2)	-2.1499	43.4659	40.4659	38.8991	40.1259
ADF (3)	-1.4894	44.1903	40.1903	38.1013	39.7369
ADF (4)	-1.0965	44.6297	39.6297	37.0184	39.0630
ADF (5)	-1.4278	45.6161	39.6161	36.4825	38.9360

95% critical value for the Dickey-Fuller statistic = **-4.6606**

LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

5.4.2 Johansen cointegration test

Like Engle Granger, the null hypothesis is that there is no cointegration. If the C-value is more than the T-statistics, we fail to reject the null hypothesis of no cointegration and hence we conclude the variables are cointegrated. In **Table 8** below, the critical value of for r=1 and r =2 are less than the T-statistics hence we reject the null hypothesis. We conclude that there is a relationship between inflation and unemployment in the long run. However, this method has a limitation being sensitive to the number of lag. It also requires only non-stationary variables and suffers from pre-test bias towards failing to reject the null hypothesis. At 5% significant level, we fail to reject the null 95% of the time. Therefore, the study proceeds to ARDL.

Table 8: Johansen's cointegration test

Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value	Results
r = 0	r = 1	218.0641	31.0000	28.3200	**2 Cointegrations**
r<= 1	r = 2	79.3579	24.3500	22.2600	
r<= 2	r = 3	13.8844	18.3300	16.2800	

Cointegration LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value	Results
r = 0	r>= 1	313.8312	58.9300	55.0100	**2 Cointegrations**
r<= 1	r>= 2	95.7671	39.3300	36.2800	
r<= 2	r>= 3	16.4093	23.8300	21.2300	

5.4.3 Autoregressive distributed lags (ARDL)

Unlike Johansen, ARDL does not suffer from pre-test bias, accommodates both stationary and non-stationary variables, and can be used for small sample size. Since our sample is from 1991 to 2017, this makes it more suitable for our analysis. The null hypothesis for our test for cointegration is absence of cointegration. If the F-statistic is above the upper bound of the critical values we reject the null and conclude presence of cointegration. While the F-statistics is more than the upper critical bound for Inflation, it is below the critical bound for GDP per capita and exchange rate and within the boundaries for unemployment. As long as at least one variable is adjusting to bring about long run equilibrium, the variables are said to be cointegrated. It also makes economic sense because as proposed by William Phillips, increase in inflation causes lower unemployment. Also, GDP is very related to the level of unemployment and inflation. Raise in spending increases the GDP but adds to the money supply which leads to inflation. On the other hand, fall in spending reduces inflation but leads to unemployment as businesses may have to retrench workers due to low demand. **Table 9** shows the results of ARDL cointegration test.

Table 9: ARDL Cointegration

Variable	F-statistics	P-value	Critical Lower Bound	Critical Upper Bound	Conclusion
DGDP	2.8322	[.077]	4	11	No cointegration
DEXCH	0.39940	[.805]	4	11	No cointegration
DINF	14.0955	[.000]	4	11	Cointegration
DUNE	5.1203	[.014]	4	11	Inconclusive

After affirming that the variables are cointegrated, we present the ARDL long run coefficients. Using the Akaike Information Criterion (AIC), expected inflation and GDP per capita are found to be significant at 5% level. Results shows that 1% increase in GDP will increase exchange rate (depreciate) by 0.86%. This may be due to the fact that most of the spending are associated with borrowing that comes with condition to devalue the currency. Similarity, 1% increase in inflation rate will decrease the exchange rate (appreciate) by 0.41%. When inflation goes up, the real purchasing power of domestic consumers fall and hence they can demand less of imports. Fall in the demand for import reduces the supply of domestic currency (i.e. less people sell the currency) which leads to appreciation. **Table 10** shows the results of ARDL long run coefficients.

Table 10: Long run coefficients - LEXCH

Regressor	Coefficient	Standard Error	P-value
LINF	-.40768	.14023	[.010]
LGDP	.86032	.16808	[.000]
LUNE	-.27942	.22015	[.221]

5.4.4 Non-linear ARDL

ARDL have the weakness of assuming linearity and symmetry. To test the nature of the relationship between inflation and unemployment, we use Non-linear ARDL technique. Similar to ARDL, the null hypothesis for our test for cointegration is absence of cointegration. If the F-statistic is above the upper bound of the critical values we reject the null and conclude presence of cointegration. We use the critical values by Persaran et al (2001) and Narayan (2005). Given our small sample size, Narayan critical values are more preferred. **Table 11** shows the results for NARDL cointegration test. At 5% significance level for Persaran critical values and 10% significance level for Narayan critical values, the F-statistics is above the upper bounds of the critical values. This implies presence of long run equilibrium relationship between inflation and unemployment.

Table 11: Non-Linear ARDL

Variable	F-statistics	Critical Value Source	Critical Value (%)	Critical Lower Bound	Critical Upper Bound	Conclusion
LINF	4.6266	Pesaran et al. (2001)	5%	2.695	3.837	Cointegration
LINF	4.6266	Narayan (2005).	10%	3.437	4.470	Cointegration

The results of short run and long run asymmetry from the Wald test shows presence of long run symmetry and short run asymmetry. **Table 12** shows that the P-value is significant only in the short run. This is to say, in the short run the trade-off between inflation and unemployment is not the same in upward and downward scenarios. **Figure 3** shows cumulative effect of expected inflation and expected unemployment. As it can be observed, due to short run asymmetry, some of the lines fall outside the symmetry area highlighted in blue.

Table 12: Wald test for long run and short run symmetry

Independent Variable: Expected Inflation rate	F-Statistics	P-value	Conclusion
Long run	1.589	0.227	Symmetry
Short run	7.658	0.014	Asymmetry

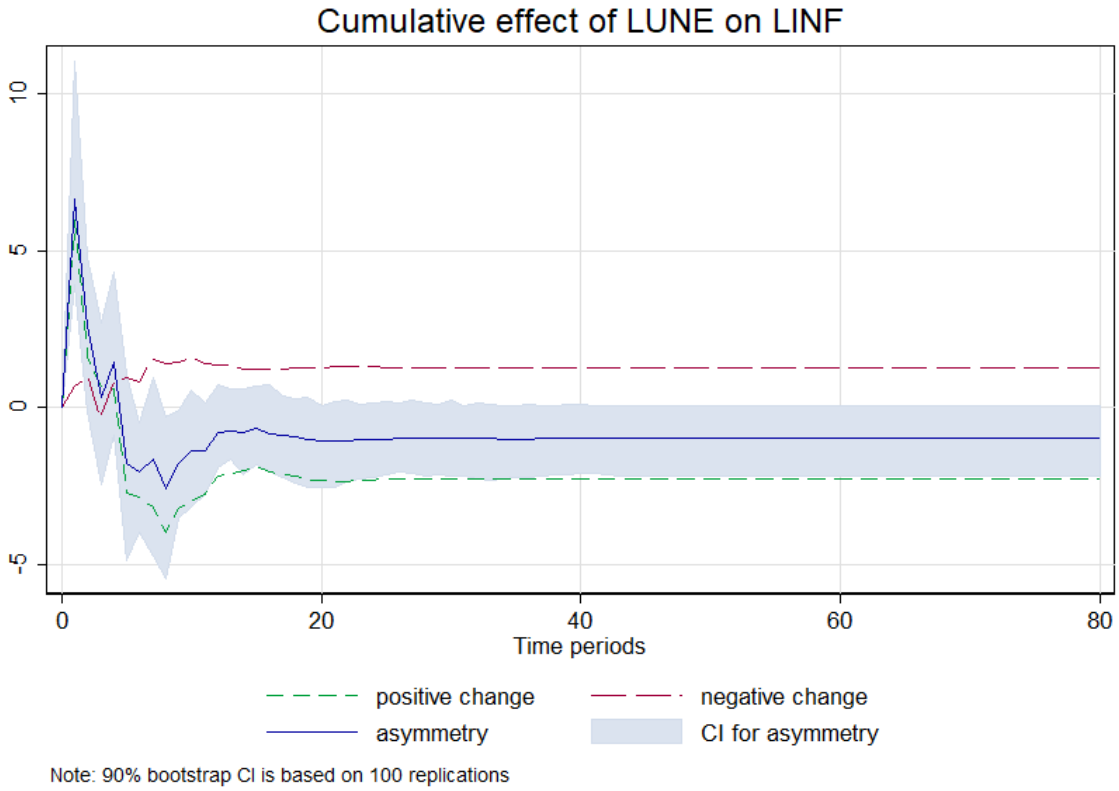


Figure 3

Cointegration does not indicate the direction of causality. To determine which variable leads in the long run relationship and which follows, we performed VECM for the ARDL model.

5.4.4.1 Vector error correction model for ARDL

The VECM test for absolute endogeneity and exogeneity. A p-value of less than 5% would means that the variable is endogenous since the null hypothesis of exogenous variable is rejected. **Table 13** shows results from VECM where inflation is endogenous while Unemployment and Exchange rate are exogenous. This makes economic sense since for most governments, inflation can be controlled by the use of monetary policies, but exchange rates are determined globally. VECM does not show the relative endogeneity and exogeneity of the variables. To know which is the most exogeneous we performed Variance decompositions.

Table 13: Dependent Variable: LGDP

Regressor	Coefficient	Standard Error	P-value	Conclusion
LUNE	.0085584	.017856	[.637]	EXOGENOUS
LINF	-.015469	.0059167	[.017]	ENDOGENOUS
LEXCH	-.019611	.052678	[.714]	EXOGENOUS

5.4.4.2 Variance decomposition (VDC)

In variance decomposition, we decompose the variance of the forecast error of a particular variable into proportions attributable to either shocks or innovations in each variable in the system including its own. The variable which is can be explained most by its own shocks is deemed to be the most exogenous. We have performed both generalized and orthogonalized variance decomposition which yield similar results. However, generalized approach is deemed to be better since it is not affected by the order of variables and doesn't assume that when one variable is shocked others are switched off. Results of variance decomposition are presented in **Table 14 - 15.** Expected unemployment is the most exogeneous followed by GDP per capita, then exchange rates and finally inflation. This is consistent with the results obtained in VECM.

Table 14: Generalized Variance Decomposition

Horizon 10	DGDP	DEXCH	DINF	DUNE
DGDP	65.26%	3.81%	21.61%	9.32%
DEXCH	11.05%	59.84%	11.62%	17.49%
DINF	28.54%	6.03%	53.04%	12.39%
DUNE	6.81%	9.42%	3.37%	80.40%
Exogeneity	65.26%	59.84%	53.04%	80.40%
Ranking	2	3	4	1

Table 15: Orthogonalized Variance Decomposition

Horizon 10	DGDP	DEXCH	DINF	DUNE
DGDP	81.79%	3.77%	1.91%	12.52%
DEXCH	12.64%	65.99%	9.43%	11.94%
DINF	33.30%	10.89%	33.81%	21.99%
DUNE	7.77%	8.52%	1.80%	81.90%
Exogeneity	81.79%	65.99%	33.81%	81.90%
Ranking	2	3	4	1

The fact that the problem of massive unemployment has been persistent in Tanzania shows that unemployment is really most exogenous variable since the government cannot control it. Lack of control can be attributed to the nature of unemployment problem which is more towards the supply side for these countries. Increase in spending to rise employment has a trade-off of increasing foreign debt which has serious consequences. Therefore, the government is reluctant to increase spending and boost employment but relies on factors especially from the supply side like productivity, innovation and technology transfer to boost employment. Most of these factors like technology are exogeneous which makes unemployment exogenous as well. Inflation is found to be endogenous as it can be significantly influenced by the central bank[4] and government using monetary and fiscal policies. For example, to reduce inflation the central bank can simply rise the discount rate or reserve requirement which will curb inflation via reduction in money supply. Exchange rate and GDP per capita are in the middle since changes in unemployment affect both of them. When there is a decrease in unemployment, more people can produce and hence the GDP per capital goes up. Similarly, more production entails more export which raises the demand for domestic currency (Tanzanian Shilling) and hence leads to currency appreciation.

5.4.4.3 Impulse response function (IRF)

To have a clear representation of the VDC, the IRF is used to map out the dynamic response path of a variable owing to a one-period standard deviation shock to another variable. **Figure 4** shows the IRF when unemployment, the most exogenous variable is shocked. As expected,

[4] Bank of Tanzania (BOT)

there is a significant response from the rest of the variables. **Figure 5** shows the IRF when inflation, the most endogenous variable is shocked. Being dependent, it has limited effect to the rest of the variables. In both cases, it will take roughly 8 years for variables to return to equilibrium.

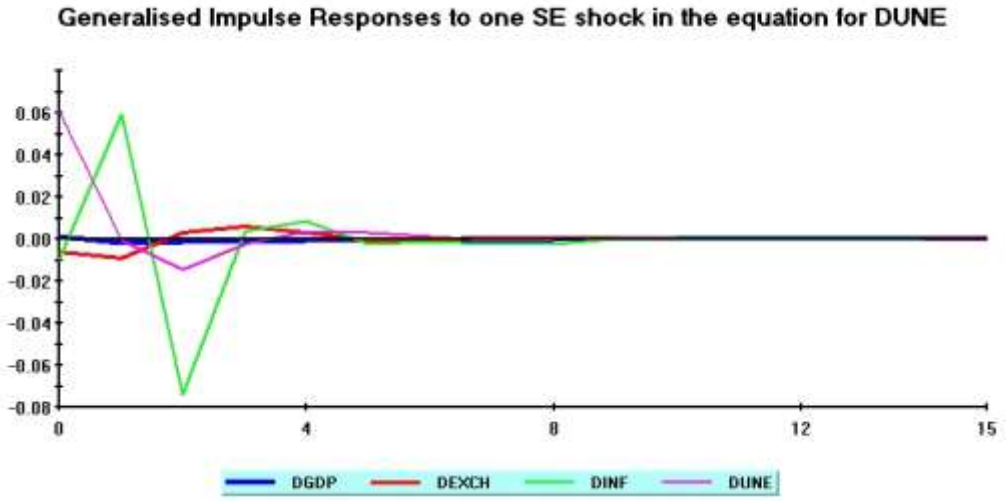


Figure 4

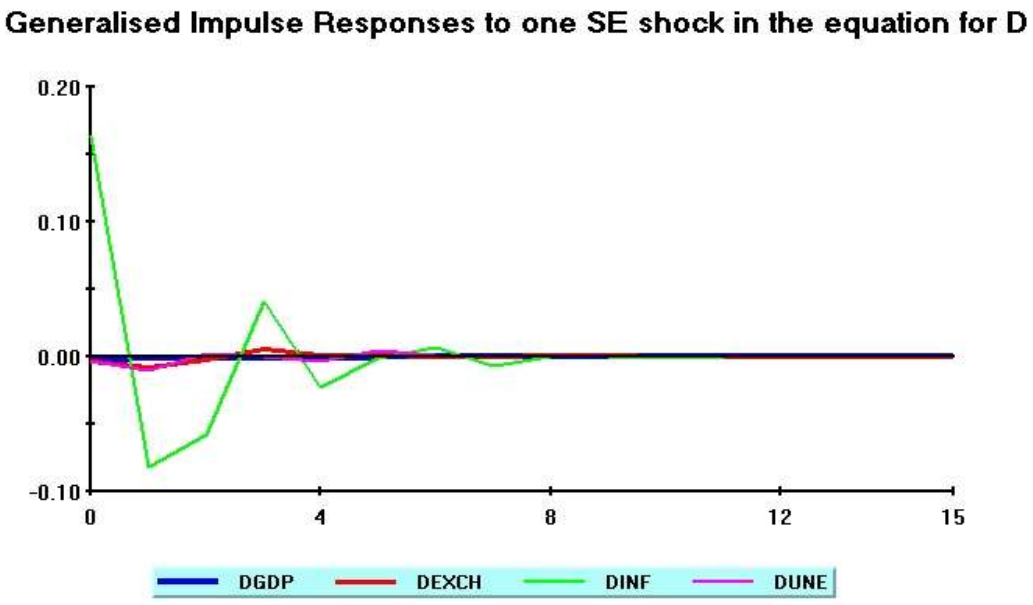


Figure 5

5.5. Test for Stability of the coefficients

Results of the CUSUM and CUSUM squared tests are depicted in **Figure 6 – 9.** The first two figures show the results of CUSUM and CUSUMSQ tests with gross domestic product as the

dependent variable followed by expected inflation rate, expected unemployment rates and exchange rates. **Figure 8 and 9** shows the CUSUM and CUSUMSQ test results with expected unemployment as the dependent variable followed by expected inflation rate, gross domestic product and exchange rates. At 5% significance level all the coefficients are within the critical boundaries and we can conclude that they are stable.

Figure 6: CUSUM test with gross domestic product as the dependent variable followed by expected inflation rate, expected unemployment rates and exchange rates

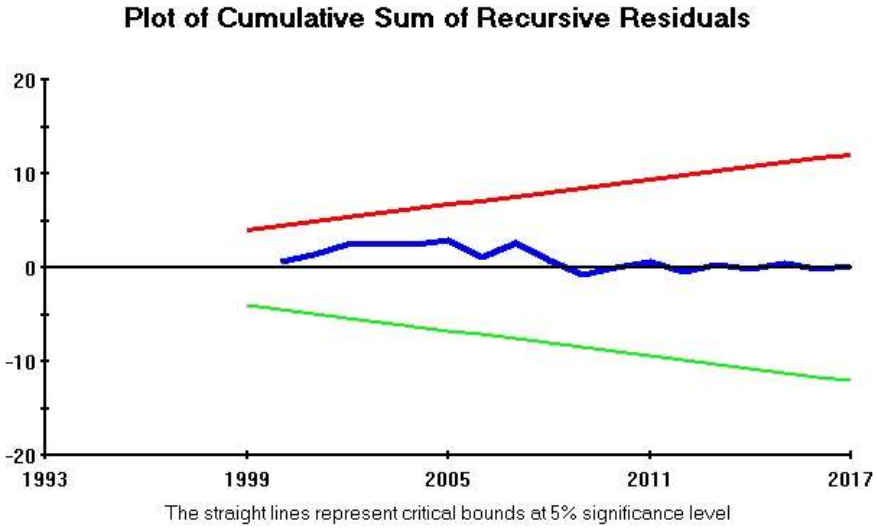


Figure 7: CUSUM Square test with gross domestic product as the dependent variable followed by expected inflation rate, expected unemployment rates and exchange rates

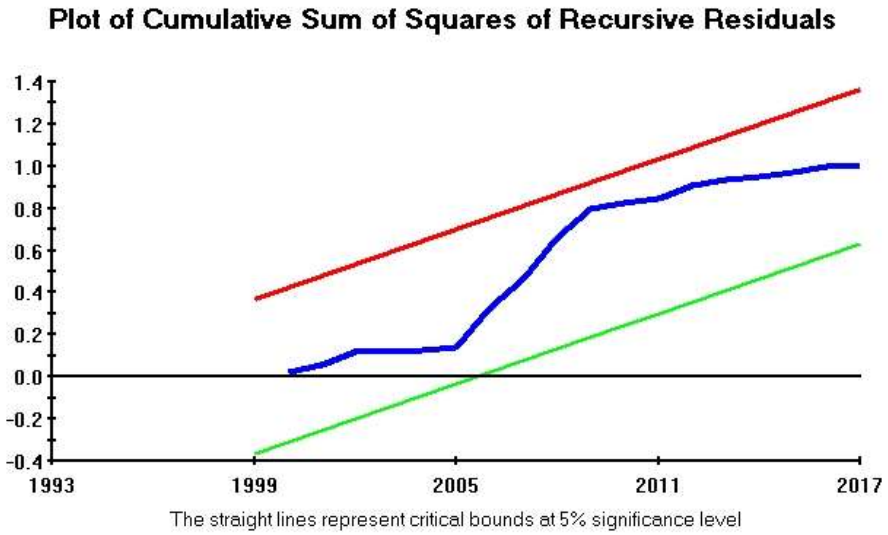


Figure 8: CUSUM test with expected unemployment as the dependent variable followed by expected inflation rate, gross domestic product and exchange rates

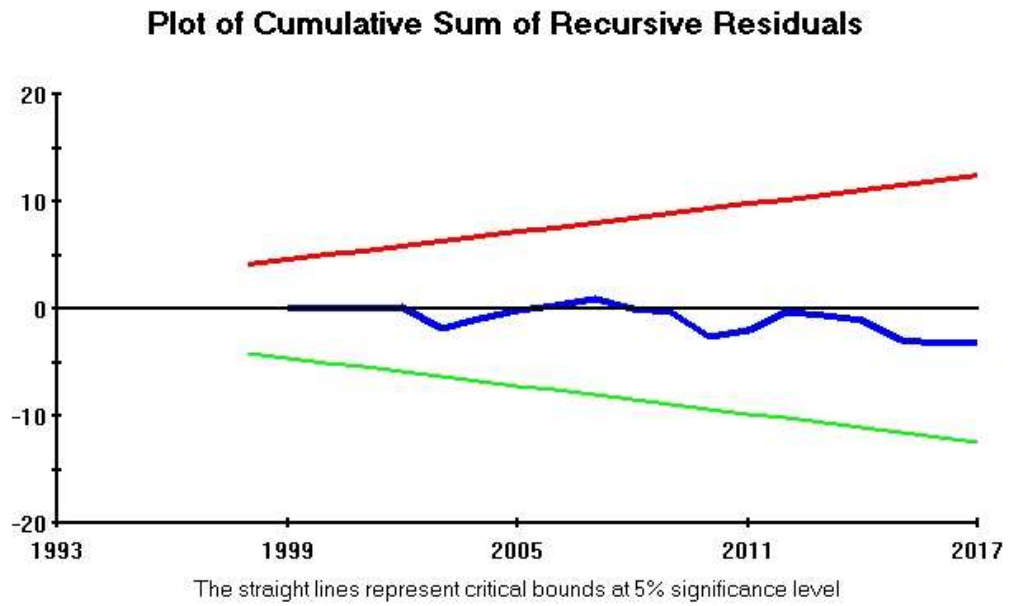
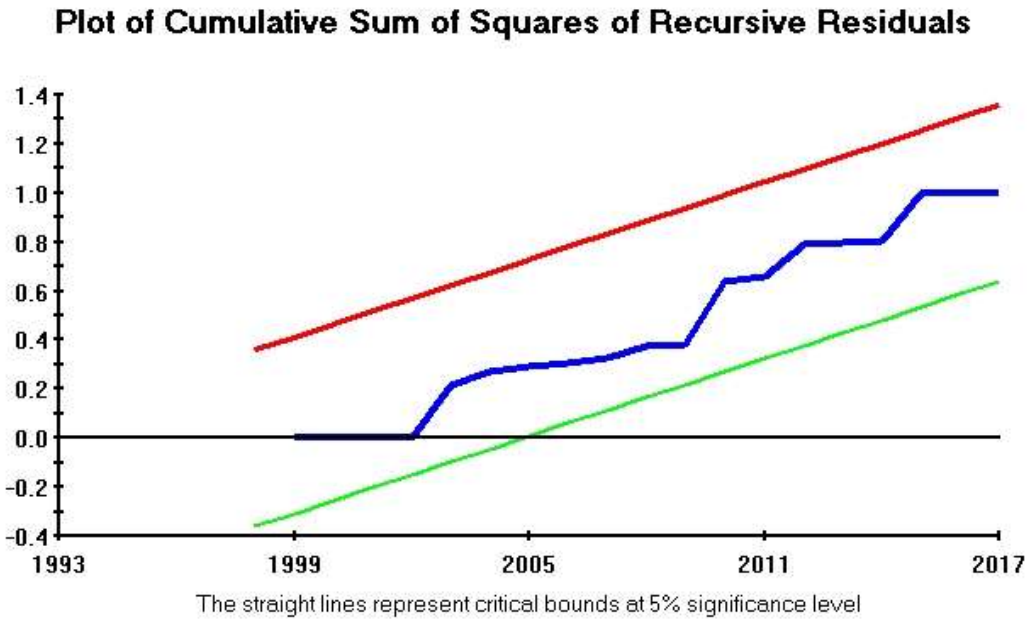


Figure 8: CUSUM Square test with expected unemployment as the dependent variable followed by expected inflation rate, gross domestic product and exchange rates



6. CONCLUSION AND POLICY RECOMMENDATION

This study re-examines the presence and nature of the long run equilibrium relationship between inflation and unemployment using evidence from Tanzania. It applies standard time series techniques and more recent techniques of autoregressive distributed lags model (ARDL) and Nonlinear ARDL approaches proposed by Pesaran et al. (2001) and Shin et al. (2014) respectively. We use the Autoregressive integrated moving average (ARIMA) also known as Box-Jenkins to derive expected inflation and unemployment rates. This is because most economic decisions are made based on expected variables. Apart from contributing to the literature by employing recent technique, to the best of my knowledge, it is also the first study to present such evidence from one of the heavily indebted poor countries (HPIC).

In line with the objectives of the study, three key findings have been reported.

1. Using Johansen test, ARDL and NARDL tests, there is a long run equilibrium relationship between inflation and unemployment. In other words, the variables are cointegrated. This parallel to results found by several existing literatures (Stiglitz, 1997; Coen, Eisner, Tepper Marlin and Shah,1999; Laxton, Rose Tambakis, 1999; Maria-Dolores and Naveira, 2005; Melike & Fulya, 2016); and Olumuyiwa, 2017).
2. Using NARDL approach, the study finds that the trade-off between inflation and unemployment is symmetrical in the long run but asymmetrical in the short run. This confirms the results found by Olumuyiwa (2017) but contradicts those of Melike & Fulya (2016)
3. Applying Vector error correction model (VECM) and Variance decomposition (VDC), we found that unemployment leads inflation. This contradicts the results found by Alfred and Ian (2014).

Our results are robust to the use of different cointegration methods and coefficient stability tests. They pose significant policy implications to governments around the world as well as central banks especially in developing and heavily indebted countries. These policies include; **(1)** Spending should only be used for productive purposes. As a matter of fact, most of these countries suffer from high level of corruption. Governments should be cautious in increasing their spending via fiscal policies as it has a negative relationship to the exchange rate. This is because for these countries most of the spending are associated with borrowing that comes with condition to devalue the currency. This study reveals that 1% increase in GDP will increase exchange rate (depreciate) by 0.86%. **(2)** Central banks should beware of this trade-off as well

in their implementation of monetary policies. **(3)** Equally important is the trade-off between inflation and unemployment. Our study reveals an asymmetric nature of the short run relationship between the variables. This is to say, in the short run the extent of monetary policy used to stimulate the economy by 1% should not equate the one that are used to contract the economy by 1%. The study fails to report the exact percentages as the coefficients are found to be insignificant.

We acknowledge the fact that the use of a small sample period from 1991 to 2017 is among the limitations of this study. Perhaps results may have been different had the sample period been extended. Also, the interpretation of the results could be subjective depending on the basis of economic theory that one is using. Future studies should consider providing more evidence on the magnitude of the asymmetries in both short run and long run. This will be of much use to governments around the world and central banks as they can reduce the negative effects associated with over application and under application of policies for price stabilization i.e. monetary and fiscal policies.

REFERENCES

Alfred. A, King. I, (2014) In the long run, US unemployment follows inflation like a faithful dog, Journal of Macroeconomics, 41, 42-52

Berentsen, A., Menzio, G., Wright, R., 2011. Inflation and unemployment in the long run. American Economic Review, 101, 371–398.

Bhattarai. K, (2016), Unemployment-Inflation trade-off in OECD countries, Economic Modelling, 58, 93 -103

Box, G.E.P., Jenkins, G.M. (1976), Time Series Analysis. Forecasting and Control. San Francisco: Holden-Day.

Caballero, R.J., Hammour, M.L., 1994. The cleansing effect of recession. American Economic Review, 84, 1350–1368.

Chaido. D, Melina. D, (2012) Inflation, Unemployment and the NAIRU in Greece, Procedia Economics and Finance 1,118 – 127

Coen, R.M., Eisner, R., Tepper Marlin, J. and Shah, S.N., 1999. The "Natural Rate" and the NAIRU after Four Years of Low Inflation. American Economic Review Papers and Proceedings, 89(2), 52-57.

David. U, Anyiwe. M A, (2013) Dynamics of Inflation and Unemployment in a Vector Error Correction Model, Research on Humanities and Social Sciences, 3(3), 20 -29.

Dickey, D. A., and W. A. Fuller. 1979. Distribution of the estimators for autoregressive time series with a unit root, Journal of the American Statistical Association, 74: 427–431.

Dixon, H., 1988. Controversy: the macroeconomics of unemployment in the OECD. Economic Journal, 108, 779–781.

Engle, R. and Granger, C. (1987) Co-integration and error correction: representation, estimation and testing, Econometrica, 55, 251-276.

Friedman, M., 1968. The role of monetary policy. American economic Review, 58, 1–17.

Friedman, M., 1977. Nobel lecture: inflation and unemployment. Journal of Political Economy, 85, 451–472.

Greenwood-Nimmo MJ, Shin Y, Van Treeck T (2012) The nonlinear ARDL model with multiple unknown threshold decompositions: An application to the Phillips curve in Canada. University of Melbourne, Mimeo.

Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. Econometrica, 59, 1551-1580.

Kitov, I., (2006a). "Inflation, Unemployment, Labor Force Change in the USA". Working Papers 28, ECINEQ, Society for the Study of Economic Inequality.

Kitov, I., (2006c). "GDP growth rate and population". Working Papers 42, ECINEQ, Society for the Study of Economic Inequality.

Kitov, Ivan. (2007). Inflation, unemployment, labor force change in European countries. University Library of Munich, Germany, MPRA Paper.

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P. and Y. Shin (1992) "Testing the null hypothesis of stationary against the alternative of a unit root: how sure are we that economic time series have a unit root?" Journal of Econometrics, 54, 159-178.

Laxton, D., Rose, D. and Tambakis, D., 1999. The US Phillips Curve: The Case for Asymmetry. Journal of Economic Dynamics and Control, 23, 1459-85.

Lockwood, B., Manning, A., 1989. Dynamic wage–employment bargaining with employment adjustment costs. Economic Journal, 21, 1145-1158.

Lockwood, B., Miller, M., Zhang, L., 1998. Designing monetary policy when unemployment persists. Economica, 65, 327–345.

Luiggi. D, Irina. P, (2018), Wage growth and nonlinearities: The roles of inflation and unemployment, Economic modelling, 68, 273-292

Mark. A Mohammed. M, (2014)The real effects of inflation in a developing economy with external debt and sovereign risk, The North American Journal of Economics and Finance, 30, 40-55

Melike. B, Fulya. O, (2016), Non-Linear Analysis of Post Keynesian Phillips Curve in Canada Labor Market, Procedia Economics and Finance, 38, 368 – 377

Narayan, P. K. (2005), 'The Saving and Investment Nexus for China: Evidence from Cointegration Tests', Applied Economics, 37(17), 1979 - 90.

Neugart, U. and Hassler, M., 2003. Inflation-unemployment tradeoff and regional labor market data. Empirical Economics, 28, 312-324.

Nickell, S., 1998. Unemployment: questions and some answers. Economic Journal, 108, 803–816.

Olumuyiwa, A, (2017) Asymmetry Effects of Monetary Policy shocks on Output in Nigeria: A Non-Linear Autoregressive Distributed Lag (NARDL) Approach. Mimeo, Department of Economics, Faculty of Social Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria.

Pesaran, M. H., Shin, Y. and Smith, R. J. (2001) Bounds testing approaches to the analysis of level relationships, Journal of Applied Econometrics, 16, 289 – 326.

Phillips, A.W., 1958. The relationship between unemployment and the rate of change of money wages in the United Kingdom 1861–1957. Economica 25, 283–299.

Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. Biometrika, 75(2), 335-346.

Shin, Y., B. C. Yu, and M. Greenwood-Nimmo (2014), “Modelling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework”, Festschrift in Honor of Peter Schmidt: Econometric Methods and Applications, eds. By R. Sickels and W. Horrace: Springer, 281-314.

Stiglitz, Joseph. 1997. "Reflections on the Natural Rate Hypothesis." Journal of Economic Perspectives, 11 (1), 3-10.

Vijay. V, Maria. F, Florence. J, (2018), Inflation unemployment dynamics in Hungary – A structured cointegration and vector error correction model approach , Theoretical and Applied Economics, 25(2),195-204