University of Tartu

School of Economics and Business Administration

Michael Mosisa Gurmessa

Can inflation affect economic growth? Evidence from East African countries

Master's thesis

Supervisor: Senior Research Fellow Jaan Masso (PhD)

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Name and signature of supervisor ....

Allowed for defence on ....
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I have written this master's thesis independently. All viewpoints of other authors, literary sources and data from elsewhere used for writing this paper have been referenced.

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Abstract

The relationship between inflation and economic growth remains one of the key fundamental questions in macroeconomics. This paper tries to show this relationship in the case of East African countries. The result shows that there is bi-directional Granger causality between CPI inflation and GDP growth. Furthermore, there is a negative relationship between CPI inflation and GDP growth in the short run but there is no significant relationship in long run. The existence of nonlinear relationship between the two shows that annual CPI inflation beyond 8.7% has a negative effect on GDP growth. Thus, both governments and central banks should use alternative policies to achieve stable inflation.

1 Introduction

Achieving sustainable economic growth is among the main objectives of any country. This can be triggered by the stability of other macroeconomic variables including inflation which plays a significant role in determining the good performance of economic growth because any deviation from this can cause serious macroeconomic distortions. According to Aydın et al. (2016), macroeconomic stability, including a low and predictable rate of inflation, is a pre-condition for stable economic growth. Up to date, economic growth and inflation still remains one of the most important macroeconomic performance measures of a given economy. Thus, there is extensive literature dealing with the relationship between inflation and economic growth for different countries, yet the relationship between the two still remains unclear. This ambiguous relationship between inflation and economic growth has drawn the attention of many authors. For example, Fischer (1993) shows that there is a negative relationship between inflation and economic growth. However, Mallik and Chowdhury (2001) found a positive relationship.

The lesson from Latin American countries show that high inflation (above 50%) had an adverse effect on economic growth especially in the 1970s and the same result applies for East European countries during 1970s (De Gregorio (1992)). Drummond et al. (2015) conduct a research on convergence criteria in the East African region in which each country should achieve a set of goals in a certain time bound. One of the preconditions is setting inflation up to 8% and achieving economic growth up to 7% until 2012 and sustain thereafter. Since then government policy focuses more on price stability than economic growth because recently growth in this region has been relatively better than other African regions (see Gigineishvili et al. (2014)). However, until recent time, the rate of inflation in this region has kept increasing (creeping inflation[1]) and this persistent increase of inflation brings many distortions like uncertainty about future investment projects particularly when there is high inflation volatility (Gokal and Hanif (2004)) and problems in financial sector. In the latter case, high inflation diminishes lending activities and stock market development (Boyd et al. (2001) and BenNaceur and Ghazouani (2005)).

In East African countries, where there has been substantially high inflation, the marginal cost of additional unit of inflation is clearly very high. For example, in the past decades the annual

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[1]It is a moderate and gradual increase of inflation rate over time. See Holzman (1959)

inflation rate in Kenya reaches up to 45% and in Burundi up to 36% but this doesn't mean that inflation is always harmful. In the case of very low inflation rate, the economy can be in the recession and obviously increasing inflation can boost economic growth. Conversely, a very high inflation can be dangerous for economic growth because it can reduce saving and investment which in turn reduce the level of employment. This further implies that the return from investment and capital accumulation become very low which may lead to a low output (Yabu and Kessy (2015)). In East Africa, the large share of populations lives below poverty line. According to Chen and Ravallion (2010) in Sub-Saharan countries, 50.9% of the population lives below the poverty line (people who get below $1.25 per day in 2005). Therefore, many East African countries implement inflation targeting policy[2] just to maintain the monetary policy. This means that it has been perceived by local policymakers that inflation can hurt the poor by redistributing resources from poor people to relatively rich people.

In this paper, I showed how inflation can affect economic growth particularly in East African countries. This region comprises many countries (around 20) which include members of East African Community (EAC[3]) like Tanzania, Kenya, Uganda, Rwanda, Burundi and South Sudan. Despite the strategic location of these countries, the socioeconomic relationship among these countries is much stronger than with other continents especially in international trade (Goto (2012)). Even though there are many studies that deal with the relationship between inflation and economic growth, there are considerably fewer studies available for developing countries, especially for East African countries. Most of the previous studies on East African countries are restricted to three founding members of EAC like Kenya, Tanzania and Uganda (Yabu and Kessy (2015), Goto (2012)). Therefore, in this study, I include more countries including founding members of EAC and use most recent data to shed a light on the subject matter. Then the important question that needs to be answered in this regard will be, what is the direction of causation between inflation and economic growth and what is the optimal level of inflation? This kind of questions are very debatable in different literature and this paper tries to answer these questions.

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[2]This policy is implemented by the central bank to control inflation by using different mechanisms. The central bank also project or "target" level of inflation and aims to make actual inflation to be equal with this projected inflation.

[3]It is intergovernmental relationship founded in 1917 and aiming political, economic and social co-operation among member countries.

The rest of this paper is organized as follow, section 2 deals with literature review, section 3 introduces the data used in this study, section 4 explain about model and methodology, section 5 presents empirical results and section 6 brings conclusions and remarks.

2 Literature Review

2.1 Theoretical evidence

Different economic theories come to different conclusions about the relationship between economic growth and inflation. Keynesian models show that a persistent increase in inflation makes firms to adjust their prices more often. This means that volatile price is adjusted to nominal shocks very fast which implies that shocks have smaller real effects (Ball et al. (1988)).

However, the birth of neoclassical and endogenous growth theories postulates that the effect of inflation on growth comes through its impact on investment. This means that high inflation reduces the purchasing power of money which is followed by reduction of saving and finally this will bring down investment. On the other hand, there is a debate between structuralists and monetarists on the importance of inflation for economic growth. Mallik and Chowdhury (2001) show the two aspects of the debate between structuralists and monetarists. The former consider that moderate inflation is important for greasing the wheels of the economy while the latter argue that inflation is not good for economic growth because it can also affect the value of domestic currency against other currencies.

According to Bain and Howells (2009), as cited in the article of Munyeka (2014), monetarist also argue that inflation is all about a monetary phenomenon and closely related to money supply. Sidrauski (1967) shows the relationship between inflation and economic growth based on the assumption that there is an infinitely lived representative household. By merging this into growth model he suggests that long run capital stock is not dependent on the rate of monetary expansion but high monetary expansion will cause an increase in the general price level of commodities and reduce the stock of cash but it doesn't affect the level of consumption. Regardless of this conclusion, Stockman (1981) develop a model which shows that high inflation will reduce the steady state of output and capital stock. In this model, he showed that inflation

erodes the purchasing power of money and this makes people to spend less on both goods and services, and capital assets in the period of high inflation.

According to Rowthorn (1977), inflation can redistribute income from workers to capital owners. Therefore, poor people become poorer and poorer while richer people get richer and richer. This implies that during high inflation period the majority of people spend more and save less. Furthermore, high unemployment will be followed by investment decline and finally, the economy will produce less output than expected. The following figure also shows this mechanism.
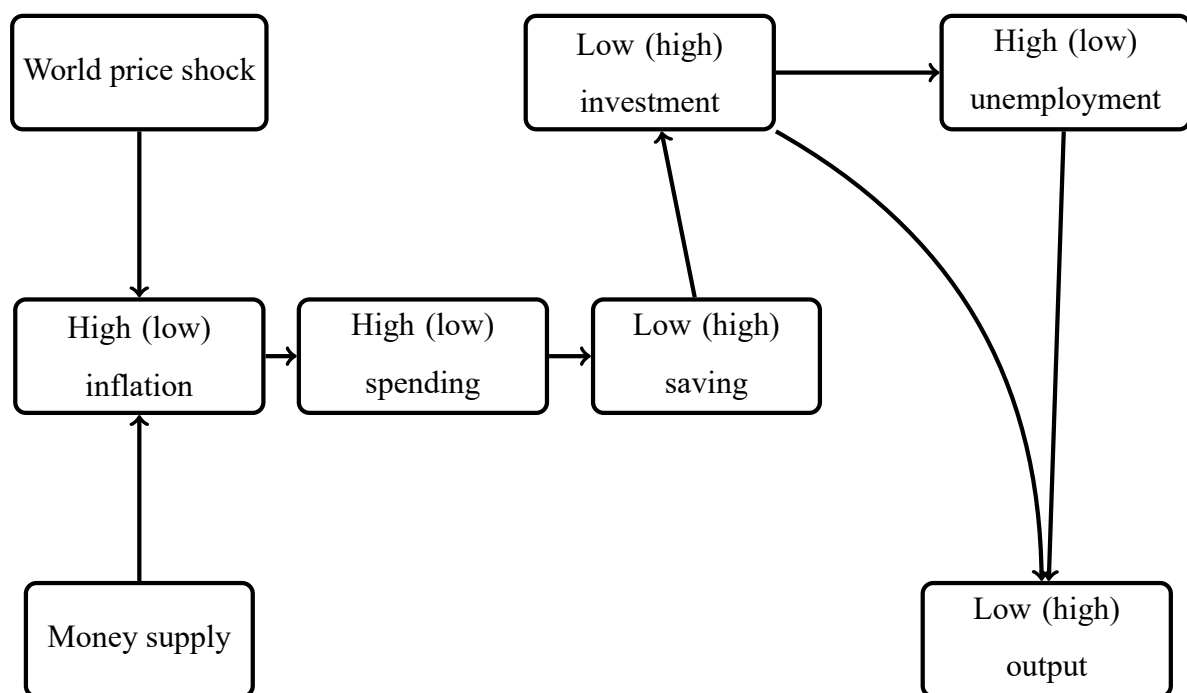

Figure 1: Mechanism through which inflation and economic growth are affected.

Source: compiled by author based on based on quantity theory of money and neoclassical theory.

Economic theories describe the relationship between inflation and economic growth from different perspectives and end up in diverse conclusions. Therefore, this relationship still remains among the most debatable and ambiguous macroeconomic questions. Apart from this many authors demonstrate the relationship between inflation and economic growth and contribute to the literature and this part discussed in the following section.

2.2 Empirical evidence

There is a substantial number of studies that show the linear relationship between inflation and economic growth. In the 1960s the relationship between inflation and economic growth has been considered as positive both in the short run and long run (Bruno and Easterly (1996)). The evidence from Tobin (1965) and Kormendi and Meguire (1985) shows that high inflation increases the level of output permanently. He also argued that in the period of high inflation people tend to substitute money for high interest bearing assets which propagate capital intensity and economic growth (Gokal and Hanif (2004)).

Romer (1993) investigated the relationship between inflation and trade openness. He argued that increasing trade openness will worsen output price inflation via world price shock and this can affect countries general price level by increasing the cost of production and ultimately this leads to low output. Furthermore, Li (2012) study the relationship between inflation and economic growth by including unemployment rate. The result shows that in the long run, there is a positive relationship between inflation and economic growth while there is a negative relationship between unemployment rate and economic growth. However, in the short run, this relationship did not exist. Mallik and Chowdhury (2001) study inflation and economic growth for four South Asian countries (Bangladesh, India, Pakistan and Sri Lanka) by using co-integration and error correction model. Their result shows that firstly, there is a positive relationship between inflation and economic growth, and secondly, the sensitivity of inflation towards to economic growth is higher than the sensitivity of growth towards inflation.

Risso and Edgar (2009) study the long run relationship between inflation and Mexican economic growth using co-integration technique. The result shows that there is a negative relationship between inflation and economic growth. Accordingly, 1 percentage point increase in inflation reduces annual economic growth by 1.5 percentage point during the year between 1970 to 2007. Another very extensive and recent study has been done by Veiga et al. (2016) using 52 African countries for the year 1950-2012. Their finding shows that in Sub-Saharan countries the optimal annual growth rate is found to be 6.39% and optimal inflation is 8.17%. Likewise, focusing on South Africa, Munyeka (2014) analyze the relationship between economic growth and inflation using quarterly data for the years 2002-2011 and regress real GDP growth on inflation. The result shows that there is an inverse relationship between inflation and real GDP in South Africa.

But the model suffers from omitted variable bias because important variables like money supply, trade, and foreign direct investment are missing. Thus, the result might not be reliable.

Bon (2015) investigates the relationship between inflation and economic growth by including public debt and trade openness as additional control variables. In this analysis, the author uses data from 22 Asian countries, 11 Latin American countries and 27 African countries from 1990 to 2014. The findings of this study show that inflation has a positive influence on economic growth in Africa and in Asia. However, inflation has a negative influence on economic growth in Latin America. The impact of inflation on economic growth in Sri Lanka was investigated by M. W. Madurapperuma (2016). By using co-integration and error correction model, the author found that short run changes in consumer price index affect economic growth negatively. However, the result didn't show anything about how inflation adjusts to the long-run equilibrium level. This is very important to show the speed of adjustment to long run equilibrium or disequilibrium. Baltar (2015) study the relationship between inflation and economic growth by using prices of tradeable and non-tradeable goods. This approach is very useful to see whether high inflation comes from tradeable goods or non-tradeable goods. The author also uses cost-based price approach to investigate the relationship between inflation and economic growth. The result shows that there is a positive impact of economic growth on inflation of non-tradeable goods. This shows that inflation in developing countries is higher than in developed countries and there is a negative relationship between economic growth and tradeable goods inflation [4].

Recently there is an extensive literature showing that inflation can be good for economic growth up to some level and beyond that level it has an adverse effect on economic growth (non-linear relationship). According to VANI (2007) inflation can affect economic growth positively up to some threshold point and then the effect could be negative beyond some point. Qaiser Munir et al. (2009) uses this approach to analyze the impact of inflation on economic growth for Malaysia. By using data for the period of 1970–2005, the authors found that there is one threshold value, 3.89%, beyond which inflation can exert a negative effect on economic growth. Aydın et al. (2016) also study the relationship between inflation and economic growth for five Turkish Republics in transition process (Azerbaijan, Kazakhstan, Kyrgyzstan, Uzbekistan,

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[4]According to the author, this is due to the inverse correlation between economic growth and the real exchange rate.

and Turkmenistan). In this study authors show that there is a non-linear relationship between inflation and economic growth in the long term: inflation will affect economic growth negatively if inflation is above 7.97% but positively below that level. However, they didn't show any causal relationship between the two. Kremer et al. (2013) shows that threshold level for industrialized country is 2% and for non-industrialized countries the threshold level is 17%. This is very high level as compared to earlier studies.

Muhammad Ayyoub et al. (2011) also study whether inflation can affect economic growth of Pakistan. The result shows that inflation can reduce economic growth for the threshold of above 7%. This means inflation propagates economic growth if it is below this threshold point. Furthermore, Burdekin et al. (2004) shows non-linearities between inflation-output relationship for both developed and developing countries. Their result shows that there is a higher threshold level of inflation for industrial countries than developing countries, 8% versus 3%. This result is completely the reverse of what Khan and Ssnhadji (2001) found. The whole dataset is converted into the 5-year averages and found 1-3% threshold inflation for industrial countries and 7-11% for developing countries. However, Burdekin et al. (2004) uses annual data without taking the average of observations. Likewise, the study made by López-Villavicencio and Mignon (2011) agrees with the work of Khan and Ssnhadji (2001). They study the impact of different level of inflation on economic growth by including both developed and developing countries. The result shows threshold level of inflation is 14.5% for developing countries and 1.2% for developed countries.

To summarize, there is no clear relationship between inflation and economic growth in the literature. Many authors claim that there is a linear relationship between inflation and economic growth. This view implies that the relation will be always positive or always negative. This notion might not always true because recent studies show that inflation can be vital for economic growth up to some extent but beyond that point, there will be negative consequences for economic growth. This can be possibly investigated further for developing countries, particularly for East African countries where there is high economic growth and relatively high inflation rate. Exploring this relationship is very vital, not only for researchers but also for policy makers.

3 Data

In this study, I use annual time series data for the period between 1985 to 2015 from the World Bank database. The list of variables that I used includes annual GDP growth, inflation (measured by GDP deflator and consumer price index (CPI)), velocity of money, foreign direct investment, broad money, and trade openness (sum of import and export). Except for annual GDP growth, inflation, and velocity of money, the remaining three variables are included as shares of GDP. According to United Nation geographical composition, there are 20 countries confined to the East African region. But based on the availability of data, I use 10 of them only. These are Burundi, Comoros, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Seychelles, Tanzania and Uganda[5]. The rest of countries have frequently missing values, for example, in case of inflation, broad money, and trade.

Based on available data, I took the simple unweighted average for each year observations from all countries in the sample to show the dynamics of East African region's average level of inflation and growth in the data. The result shows that the average inflation rate in the case of consumer price index (CPI) in those countries ranges from 5.2% to 37.8% and the inflation rate in the case of GDP deflator varies between 6.2% and 44.5%, and GDP growth swings between 0% to 6.8%.

The above figure shows that there is downward trend in the rate of inflation for the year between 1986 and 1990. This high inflation (which is greater than 10%) is mainly caused by political and environmental problems in this region. Kimemia (2000) studies the performance of the East African economy since 1985. According to him, the reasons for high inflation between 1985 to 1995 in this region are multidimensional. Among these, excess money supply and oil price shock took a lion share. The environmental reasons are related to remedies for high and severe drought in that region and behind this problem there is also political issues. Starting from 1997 up to 2007, the gap between inflation and GDP growth became narrower. During Great Recession, this gap increased a little bit. The following graph shows the scatter plot of inflation and real GDP growth plot for all countries in our sample.

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[5]Those countries have different income level, for example, Kenya is lower middle income country, Mauritius is upper middle income country and Seychelles is high income country. The rest can be categorized as low income level countries. But all are categorized under developing countries.

Figure 2: Trends of inflation and GDP growth using simple unweighted average over each year for all countries in the sample.

Note that outliers are considered for inflation more than 40%.

Figure 3: Scatter plot for the relation between inflation and GDP growth by countries.

The above figure shows that there are slight variations between two graphs. This means there are periods in which some countries had negative GDP deflator inflation and high GDP growth

rate. However, some countries experience occasionally negative GDP growth rate and high level of inflation. Despite these data issues, in the case of CPI inflation, it is quite clear that fitted values show there is a negative relationship between inflation and GDP growth and this relationship is still maintained after removing outliers. Furthermore, GDP deflator inflation shows a negative relationship between inflation and GDP growth but this relationship changed after removing outliers.
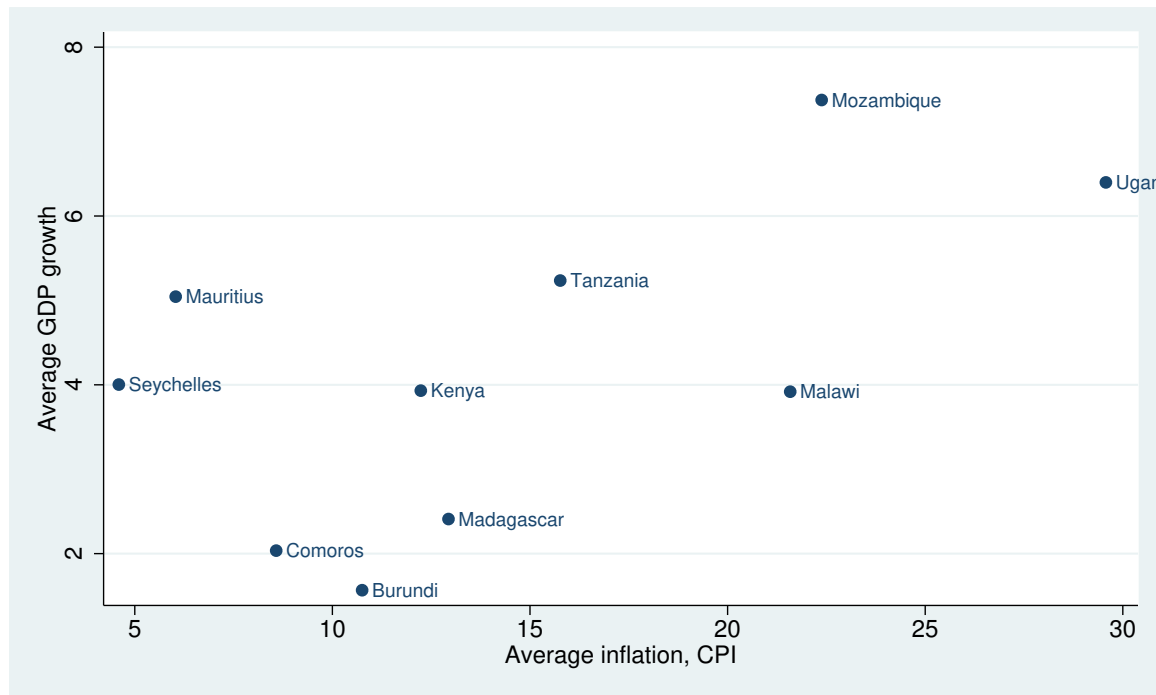
Figure 4: Levels of average inflation and average GDP growth.

Tanzania, Mozambique, Malawi and Uganda had average inflation of about more than 15% with average GDP growth between 4% and 8%. The rest of countries had average CPI inflation of less than 15% and between 1% up to 5% of average GDP growth. Before showing the relationship between inflation and GDP growth in detail, it worth to see the descriptive statistics of the variables used in the analysis.

Table 1: Descriptive statistics

Variables	Observations	Mean	Sta.dev	Min	Max
GDP growth (annual %)	30	4.192	1.451	0.0682	6.873
Inflation, consumer prices (annual %)	30	14.44	8.943	5.299	37.82
Inflation, GDP deflator (annual %)	30	14.80	8.848	6.221	44.55
FDI, net inflow (% of GDP)	30	3.310	2.656	0.390	11.59
Broad money (% of GDP)	30	34.03	5.349	24.78	43.24
Trade openness (% of GDP)	30	67.40	10.64	48.76	85.39
Velocity of money from CPI	30	1.205	1.791	0.0369	6.038
Velocity of money from GDP deflator	30	1.205	1.863	0.0461	7.847

The dynamic correlation between these variables (correlation between a given variable and its one period lag) shows that there is a strong negative correlation between annual GDP growth and inflation (both CPI and GDP deflator). The correlation between the velocity of money (measured separately in case of both CPI inflation and GDP deflator) and annual GDP growth is found to be strong and negative. The correlation between GDP growth and the rest of variables are found to be positive and strong. This is in accordance with works of Edwards (1998) and Yanikkaya (2003). The correlation among one period leads of GDP growth and one period lagged variables also shows the same result[6]. The correlation matrix of HP-filtered variables shows the same pattern with non-filtered data except for broad money which turns to be negative in this case. Comparing between HP-filtered variables and non-filtered variables, the correlation strength in HP-filtered data is weaker than among non-filtered variables [7].

Following the works of Yabu and Kessy (2015), Khan and Ssnhadji (2001) and Qaiser Munir et al. (2009) I categorize inflation level as low, if it is less than or equal to 5%, medium if inflation is between 5% to 15% (inclusive) and high if inflation is greater than 15%. This is very important to see the frequency of inflation in a given category and its relationship with GDP growth. The following scatter plot shows this relationship.

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[6]See Appendix A

[7]See Appendix B, the smoothing value of annual data is $\lambda = 6.25$ see Ravn and Uhlig (2002)
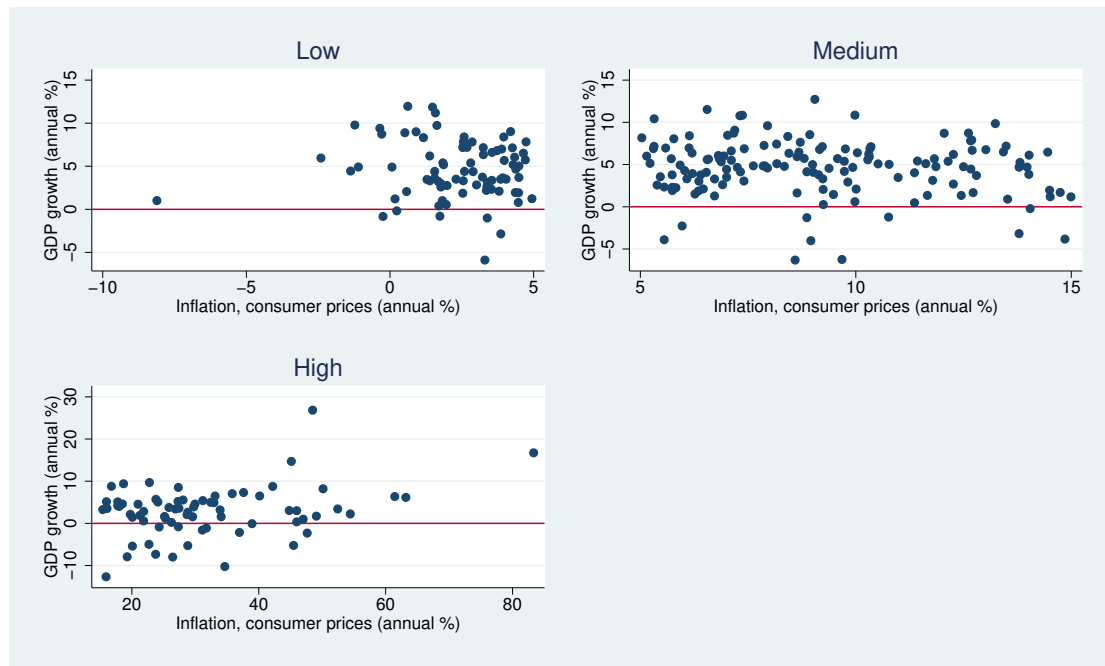
Figure 5: The relationship between CPI inflation and GDP growth by CPI inflation categories.

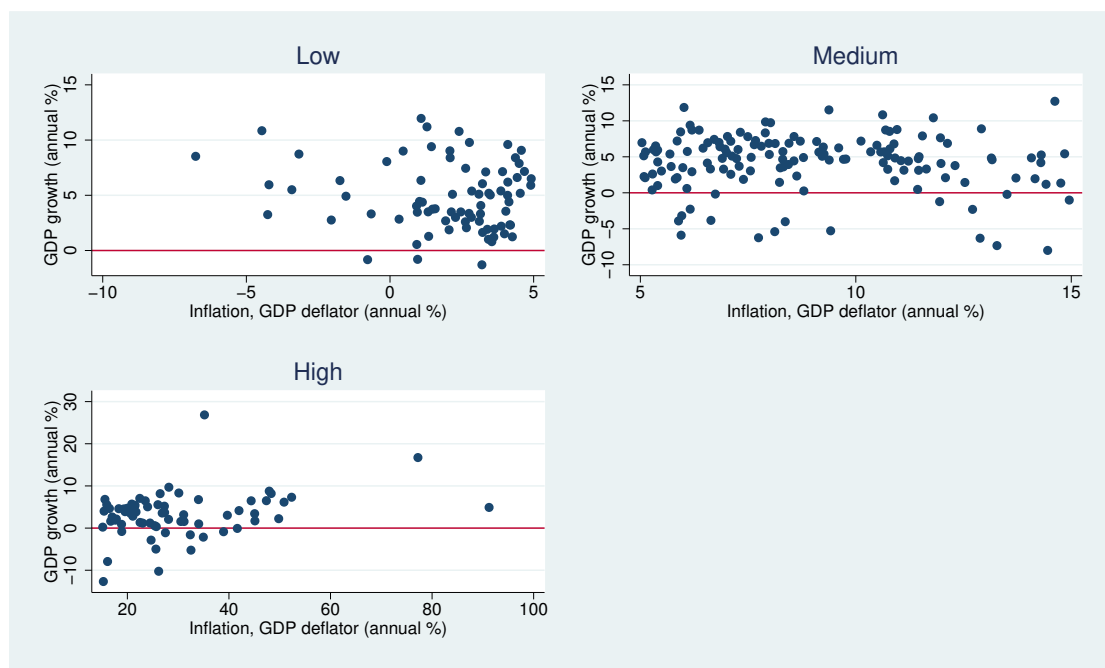Figure 6: The relationship between GDP deflator inflation and GDP growth by GDP deflator inflation categories.

The scatter plot can give us some ideas about the relationship between different levels of inflation categories and GDP growth. In medium category of CPI inflation and GDP deflator, the relationship looks like more of non linear pattern than low and high categories (for both CPI and GDP

deflator inflation). This relationship shows the possibility to predict in which rage can we possibly find threshold level of inflation.

4 Model and methodology

4.1 Relationship between inflation and economic growth

In order to achieve the main aim of the study and address research question, I use quantity theory of money model which is suggested by Paul et al. (1997) within Granger causality framework. This method is very useful to show a short run and a long run relationship between inflation and economic growth. Finally, I calculate optimal inflation and how optimal inflation can affect economic growth. Therefore, the starting point is specifying the equation that shows the relationship between price level and GDP as:

$$MV = PY \tag{1}$$

where, M is money supply, V is velocity of money, P is consumer price index and Y is GDP. By transforming this equation into logarithmic form we will get:

$$m + v = p + y \tag{2}$$

The lowercase letters represents log transformation of respective upper case letters. In order to make this model flexible, I add external factors that can influence inflation. This is very important to describe the relationship between inflation and GDP growth in developing countries, particularly in Africa. Many authors show that external factors such as trade openness and foreign direct investment (FDI) are very important in determining inflation and GDP growth (see Romer (1993), Terra (1998), Geda and Tafere (2008), Yabu and Kessy (2015)). The dynamic relationship between economic growth and inflation can be captured by the vector autoregressive (VAR) model. Many authors use this method because VAR model is very useful tool for forecasting if there is strong causality between variables. (see Paul et al. (1997), Risso and Edgar (2009), Vogel (1974),Geda and Tafere (2008)). The VAR model that we are going to use can be specified as follows;

$$y_t^g = \alpha + \sum_{i=1}^{r} \varphi_i \nu_{t-i} + \sum_{i=1}^{r} \beta_i y_{t-i}^g + \sum_{i=1}^{r} \gamma_i \pi_{t-i} + \sum_{i=1}^{r} \eta_i \tau_{t-i} + \sum_{i=1}^{r} \delta_i m_{t-i} + \sum_{i=1}^{r} \phi_i f_{t-i} + u_t \tag{3}$$

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$$\pi_t = a + \sum_{i=1}^{r} v_i \nu_{t-i} + \sum_{i=1}^{r} b_i y_{t-i}^g + \sum_{i=1}^{r} c_i \pi_{t-i} + \sum_{i=1}^{r} d_i to_{t-i} + \sum_{i=1}^{r} e_i m_{t-i} + \sum_{i=1}^{r} h_i f_{t-i} + v_t \quad (4)$$

where, y^g is annual GDP growth, ν is velocity of money, π is inflation measured by CPI or GDP deflator, m is broad money as a percentage of GDP, τ is foreign trade (sum of import and export) as a percentage of GDP and f is net inflow of foreign direct investment (FDI) as a percentage of GDP. α and a are intercept terms and φ, β,γ, η, δ ϕ, v,b, c, d, e, h are coefficients. r indicates the number of time periods that can be included in the equations (optimal lag length). u_t and v_t are assumed to be white noise. If $\gamma_i = 0$ and $b_i = 0$ $\forall i$, then one can say that there is no Granger causality between inflation and GDP growth but if $\gamma_i \neq 0$ and $b_i = 0$ $\forall i$, then there is only unidirectional relationship between the two, that is from inflation to GDP growth. Likewise, if $\gamma_i = 0$ and $b_i \neq 0$; $\forall i$, the direction is still unidirectional but it is from GDP growth to inflation. If $\gamma_i \neq 0$ and $b_i \neq 0$ $\forall i$, then there is bi-directional relationship between the two. Non-stationary time series are said to be cointegrated if the linear combination of these variables turned to be stationary. This requires that the error term in the long-run relation to be stationary (Behera (2014) and Johansen (1988)). If there are cointegrating equations, then we can run vector error correction model (VECM) to see the long run and short run relationships between inflation and GDP growth.

The relationship between inflation and economic growth doesn't follow the same pattern across different levels of inflation because of non-linear relationship between the two. Therefore, it is important to determine the optimal level of inflation that can boost economic growth and see what happens if inflation exceeds the optimal level. Study made by Hansen (2000) show a new approach in threshold estimation. According to him, threshold variable is exogenously given and this variable is used to split the sample into two regimes based on the threshold value. Consider the following two regimes:

$$y_t^g = \Gamma_1' x_t + \epsilon_{1t} \qquad\qquad \text{if} \quad q \leq \Omega \qquad (5)$$

$$y_t^g = \Gamma_2' x_t + \epsilon_{2t} \qquad\qquad \text{if} \quad q > \Omega \qquad (6)$$

where, y_t^g is dependent variable and x_t is vector of independent variables, Ω is threshold value, q is threshold variable and ϵ_{it} is error term having iid property. Since the value of Ω is not known prior to regression, Hansen (2000) recommend estimating Ω based on ordinary least squares (OLS) method. Following this procedure, threshold model can be formulated as follows:

$$\begin{aligned} y_t^g = [\beta_{11}\pi_t + \beta_{12}m_t + \beta_{13}\tau_t + \beta_{14}f_t + \beta_{15}\nu_t] \, d_1[\pi_t^T \leq \Omega] \\ + [\beta_{21}\pi_t + \beta_{22}m_t + \beta_{23}\tau_t + \beta_{24}f_t + \beta_{25}\nu_t] \, d_2[\pi_t^T > \Omega] + \epsilon_t, \end{aligned} \qquad (7)$$

where y^g is annual GDP growth, π is inflation, m is broad money as percentage of GDP, τ is trade as percentage of GDP, f is net inflow of FDI as a percentage of GDP, ν is velocity of money, d_1 and d_2 are dummy variables, π^T is threshold inflation and ϵ is error term. The existence of threshold level can be tested by using bootstrapped p-value. According to Davidson and MacKinnon (1999) bootstrap testing method is one of popular way of testing non-linearity estimation and it performs more accurate and in some cases exact test than conventional asymptotic theory. In our case, we test null hypothesis i.e. there is no threshold effects $(\beta_{11} = \beta_{21})$ against the alternative hypothesis that there is threshold effects $(\beta_{11} \neq \beta_{21})$. According to Hansen (1996) some measures generated from this bootstrap method follow the first-order asymptotic distribution. Therefore, p-values constructed from this procedures are asymptotically valid.

5 Results

5.1 Granger causality

Following Granger (1988), if the coefficients of inflation in equation (3) and coefficients of real GDP in equation (4) are different from zero, then there is a bi-directional relationship between inflation and real GDP. Granger causality test depends on the lag selection criteria (Guilkey and Salemi (1982)). According to Geweke (1984) and Kang (1985) Granger causality test result also very sensitive to lag selection criteria. In this paper optimal lag length is determined by using Akaike Information Criterion (AIC) and the result suggest that optimal lag length of 2[8]. For robustness check I use lag length of 1 based on Hannan–Quinn information criterion (HQIC) but it is not robust.

Time series variables tend to have the property of non-stationarity. Proceeding by ignoring this property leads to spurious regression. Therefore, before showing Granger causality between inflation and real GDP all variables need to tested for the presence of unit root[9]. There are two popular ways of checking unit root test, these are Augmented Dickey Fuller test which is based on the works of Dickey and Fuller (1981) and KPSS test which is proposed by Kwiatkowski

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[8]See Appendix C

[9]The unit root test is reported on Appendix D and Appendix E

et al. (1992). The test result shows that all variables are non-stationary at level except for GDP deflator inflation and velocity of money. But all variables are stationary at the first difference I(1). By using equation 3 and 4 the result shows that there is bi-directional Granger causality between CPI inflation and GDP growth but in the case of GDP deflator inflation, the causality runs from inflation to GDP growth (unidirectional). According to Granger (1988) if there is bidirectional causality between inflation and GDP growth, then the past values of inflation contain information that helps us to better predict GDP growth than using past values of GDP growth only. Conversely, the past values of GDP growth contain information that helps us to better predict inflation than using its past values only. This test result is in accordance with Paul et al. (1997). According to their results, Mauritius is among African countries that show bidirectional Granger causality between inflation and GDP growth. Ozpence (2016) show that there is one directional causation link between inflation and GDP growth (from GDP deflator inflation to GDP growth) for Turkey and Pradana and Rathnayaka (2013) got the same result for China.

5.2   Cointegration and vector error correction model (VECM)

The number of cointegrating relationships is determined by using Johanson cointegration method. Based on AIC the optimal lag length of 2 is used to carry out this test. By using CPI inflation, the result for cointegration indicates that there is one co-integrating relationship in our model[10]. However, there are 2 cointegrating relationships when GDP deflator inflation is used[11]. Hence, if there is cointegration relationship then one can show short run and long run relationship by using VECM. The result from VECM shows that in the short run a rise in CPI inflation has a power to reduce GDP growth less than proportionally but GDP growth has no significant effect on CPI inflation (not reported here). The speed of adjustment of GDP growth to its own long run equilibrium is very high. That means 30 % of disequilibrium in GDP growth is adjusted every year to its equilibrium.

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[10]See Appendix G

[11]SeeAppendix H

Table 2: Vector error correction model estimation

	With CPI inflation	
	Dependent variable Dy^g	Dependent variable $D\pi$
VEC	-0.299***	0.811***
Dy^g(-1)	-0.547***	1.010
$D\pi$(-1)	-0.921**	2.089*
Df(-1)	-0.098	1.204
Dm(-1)	-0.120	2.186***
$D\tau$(-1)	0.096	-0.466
$D\nu$(-1)	0.156**	-0.360
cons	-1.015**	0.557

*** p<0.01, ** p<0.05, * p<0.1

Note that VEC is vector error correction term in this case.

This result is also in accordance with work of Behera (2014). He shows that the long run speed of adjustment of GDP growth for 5 Asian countries and the result shows that GDP growth adjustment to its long run equilibrium is 1.6% for Bangladesh, 5.1% for Sri Lanka and 11.6% for Nepal. Okechukwu et al. (2016) also show the long run relationship between inflation and GDP growth using VECM. Their result suggest that long run speed of adjustment of annual GDP growth is 70%. Compared to our result this figure is very high. This is because they didn't include strong explanatory variables that better explain GDP growth; they simply used inflation and GDP growth relationships. In the case of GDP deflator inflation, there is no significant relationship between GDP deflator inflation and GDP growth either in the short run or in the long run.

The VECM (using CPI inflation) passed all the diagnostic test[12] (no autocorrelation at lag order, disturbance is normally distributed and VECM is stable).

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[12]See Appendix I

5.3 Threshold analysis

The relationship between inflation and economic growth is not always linear. The main argument in this case is that inflation can boost economic growth until some optimal point and beyond this point it has an adverse effect on economic growth. This non-linearity can be shown by using threshold estimation procedure. Following the works of Hansen (2000) and Hansen (1996), the threshold level of CPI inflation is found to be 8.7% and GDP deflator inflation is 10.1%. In comparison to CPI inflation, the difference is not that much bigger. This means that any moderate inflation (according to inflation classification I made earlier) which is below threshold level can boost economic growth. However, if inflation exceeds this level, then each additional percentage point increase in inflation will bring a negative effect on real GDP[13].

Table 3: Inflation threshold estimation

	CPI inflation	GDP deflator inflation
Number of Bootstrap Replications	2000	2000
Trimming Percentage	.15	.15
Threshold Estimate	8.72***	10.10*
LM-test for no threshold	19.29	10.42

*** $p < 0.01$,** $p < 0.05$, * $p < 0.1$

* indicates rejection of null hypothesis that no threshold exist based on bootstrap p-value.

In many developing countries the threshold level of inflation is found to be between 8% to 15% and my result goes in accordance with findings of many authors (see Yabu and Kessy (2015), Qaiser Munir et al. (2009), Ayyoub et al. (2011), Khan and Senhadji (2001) and Sarel (1996)). The consistency (robustness) of this result is also checked by hypothesis testing of estimated threshold level based on F test. Our null hypothesis is that there is no threshold value and the alternative hypothesis is there is one optimal threshold value. The result shows that F-line is above the line representing the critical value of for CPI inflation which implies that we reject our null hypothesis and accept the alternative one. However, the results in the case of using GDP deflator inflation is not robust in this case because we cannot reject the null hypothesis[14].

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[13]Threshold estimation for each country is found in Appendix L

[14]See Appendix J and Appendix K

The next important question is how much economy can grow at this level of inflation and how economic growth will respond if inflation exceeds that threshold level? These questions can be answered by using equation (7). Before estimating threshold level of inflation, it is advisable to create models of two regimes. In the first regime all inflation below the threshold level is considered and in the second regime all inflation above threshold point is considered.

Table 4: Threshold estimation of the effect of inflation on real GDP

Dependent variable y	With CPI inflation		With GDP deflator inflation	
	Regime 1	Regime 2	Regime 1	Regime 2
π^{BT}	0.00755			
	(0.0345)			
f	0.144***	0.0124	0.0680	0.0185
	(0.0342)	(0.0233)	(0.0387)	(0.0172)
m	1.450*	1.739***	2.147**	1.503***
	(0.700)	(0.316)	(0.608)	(0.302)
to	-0.00401	0.0156**	0.0208	0.0167**
	(0.0108)	(0.00663)	(0.0133)	(0.00631)
π^{AT}		-0.0180***		
		(0.00328)		
π^{BT}			-0.00148	
			(0.0278)	
π^{AT}				-0.0193***
				(0.00363)
Constant	18.13***	16.48***	14.10***	17.23***
	(2.337)	(0.990)	(2.001)	(1.095)
Observations	11	19	10	20
R-squared	0.958	0.969	0.970	0.964

*** p<0.01, ** p<0.05, * p<0.1 (Robust standard errors in parentheses)

Note: π^{BT} is inflation below threshold level and π^{AT} is above threshold level

The estimation result shows that when CPI inflation exceeds its threshold level, then each additional percentage point of CPI inflation will bring down GDP growth by 1.8%. Likewise, if GDP deflator inflation exceeds its threshold value, then each additional percentage point of

GDP deflator inflation reduces GDP growth by 1.9%. This result shows that high inflation is very sensitive to GDP growth because 1 percentage point higher inflation has the power to lower GDP growth by almost a double fold. As we can see the result from GDP deflator estimation is not robust. Estimating what would happen when inflation exceeds its threshold value is something that we find in literature very seldom. Sarel (1996) studied the non-linear effect of inflation on economic growth and he showed that when inflation is below the threshold level, then it has no effect or slightly positive effect but when inflation is above its threshold level, then inflation has a powerful and negative effect on growth. He also suggests to use CPI inflation rather than GDP deflator inflation because by construction changes in GDP deflator inflations are negatively correlated with growth rate.

6   Concluding remarks

The relationship between inflation and economic growth is among core macroeconomic questions which puzzles many authors. In developing countries, sustainable economic growth and low inflation are among the key objectives of macroeconomic policy. This paper tries to investigate the relationship between inflation and economic growth in East African countries. The main objectives of this study are to show the causal relationship between inflation and economic growth, and finding optimal inflation level using threshold estimation. Granger causality test is used to show the direction of causality between inflation and GDP growth. The result suggests that there is bi-directional causality between CPI inflation and GDP growth. In the short run, CPI inflation affects GDP growth negatively but GDP growth has no significant effect on CPI inflation. In the long run, there is no significant relationship between CPI inflation and GDP growth. The threshold estimation suggests that 8.7% of CPI inflation is desirable for economic growth. This means that if inflation goes beyond this level, then each additional percentage point of inflation reduces GDP growth by 1.8 percentage points. Therefore, it is very important to regulate inflation level by using different policy measures.

Given these results, I can recommend central banks to use alternative monetary policies to lower inflation. Thus, inflation targeting policy will be advisable for countries in this region. Central banks of these countries also need to revise their monetary policy based on the needs of their

economies. Financial markets can play a significant role in regulating the level of inflation via exchange rate, transactions with government bonds, and etc. This further influences economic growth via international trade or balance of payment. For example, if the value of the given country's currency depreciates against the others, then the purchasing power of that currency will decline which means imported goods become more expensive in domestic market and thereby causing market prices to increase. Even though currency depreciation promotes export, it has a limited significance on African economy because the majority of African countries economy depends on backward and subsistence agricultural system. The government can also regulate money supply and demand using other mechanisms. For example, when there is an excess supply of currency in the market, then the government can sell bonds and securities to absorb currency that circulates in the market. Generally, macro policy makers or central banks should take alternative methods into consideration while formulating monetary policy. Possibly fiscal policy can also be used to regulate high inflation through government expenditure and tax.

There are also limitations in this study. For example, the approach of using CPI inflation and GDP deflator inflation is not always advisable because they didn't give any information separately about the price of tradable goods (goods that are traded or potentially tradable at a domestic prices) and non-tradable goods. Hence, in addition to domestic price inflation, we can also use exchange rate and world price in our model to see the relationship between world price inflation and GDP growth. Thus, if further research will include these indicators, then the analysis would be more successful in terms of showing the effect of world price both on domestic price and GDP growth.

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Appendix

Appendix A   Correlation matrix of variables used in the analysis

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
GDP growth (1)	1.000															
Inflation, consumer prices (annual %) (2)	-0.716	1.000														
Inflation, GDP deflator (annual %) (3)	-0.717	0.910	1.000													
FDI, net inflows (% of GDP) (4)	0.893	-0.533	-0.533	1.000												
Broad money (% of GDP) (5)	0.883	-0.811	-0.773	0.698	1.000											
Trade (% of GDP) (6)	0.919	-0.650	-0.665	0.868	0.878	1.000										
Velocity of money (CPI) (7)	-0.758	0.988	0.915	-0.578	-0.867	-0.722	1.000									
Velocity of money (GDP deflator) (8)	-0.748	0.909	0.990	-0.565	-0.830	-0.722	0.933	1.000								
Lag real GDP (9)	0.997	-0.697	-0.702	0.875	0.891	0.910	-0.682	-0.647	1.000							
Lag inflation CPI (10)	-0.704	0.847	0.839	-0.546	-0.829	-0.678	0.805	0.776	-0.711	1.000						
Lag inflation GDP deflator (11)	-0.708	0.802	0.734	-0.562	-0.788	-0.674	0.811	0.728	-0.717	0.907	1.000					
Lag FDI (12)	0.909	-0.527	-0.519	0.887	0.697	0.829	-0.481	-0.445	0.905	-0.514	-0.516	1.000				
Lag broad money (13)	0.857	-0.790	-0.756	0.707	0.971	0.875	-0.815	-0.769	0.869	-0.806	-0.769	0.683	1.000			
Lag trade (14)	0.936	-0.679	-0.667	0.853	0.859	0.948	-0.701	-0.666	0.936	-0.636	-0.653	0.863	0.879	1.000		
Lag velocity of money from CPI (15)	-0.699	0.865	0.899	-0.524	-0.844	-0.691	0.913	0.934	-0.710	0.898	0.869	-0.500	-0.840	-0.701	1.000	
Lag velocity of money from GDP deflator (16)	-0.674	0.850	0.827	-0.503	-0.815	-0.657	0.897	0.863	-0.686	0.853	0.922	-0.471	-0.808	-0.676	0.966	1.000

Appendix B Correlation matrix of HP filtered variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDP growth (1)	1.000							
Inflation, consumer prices (annual %) (2)	-0.090	1.000						
Inflation, GDP deflator (annual %) (3)	-0.311	0.634	1.000					
FDI, net inflows (% of GDP) (4)	0.322	0.222	0.164	1.000				
Broad money (% of GDP) (5)	-0.132	0.276	0.174	-0.252	1.000			
Trade (% of GDP) (6)	0.107	0.639	0.311	0.394	0.140	1.000		
Velocity of money (CPI) (7)	-0.080	0.987	0.620	0.200	0.221	0.606	1.000	
Velocity of money from GDP deflator (8)	-0.288	0.567	0.988	0.148	0.119	0.273	0.568	1.000

Appendix C   Optimal lag length based on AIC

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-428.825				1.2e+06	31.0589	31.1462	31.3444
1	-326.385	204.88	36	0.000	11509.2*	26.3132	26.9241*	28.3115*
2	-285.952	80.866*	36	0.000	12469.2	25.9966*	27.1311	29.7077

Appendix D   Unit root test at levels

Variables	Augmented Dickey Fuller test			Kwiatkowski Philips Schmidt Shit (KPSS) test	
	Constant	Trend and constant	Without Trend and constant	Constant	Trend and constant
GDP growth	-2.038	-3.628**	2.406	0.703	0.111
	(-3.689)	(-4.323)	(-2.650)	(0.739)	(0.216)
Inflation, consumer prices (annual %)	-1.716	-2.618	-1.637*	0.610	0.172
	(-3.679)	(-4.309)	(-2.647)	(0.739)	(0.216)
Inflation, GDP deflator (annual %)	-3.669**	-3.662**	-3.300***	0.619	0.219
	(-3.689)	(-4.309)	(-2.650)	(0.739)	(0.216)
FDI, net inflows (% of GDP)	-1.185	-2.633	-0.151	0.585	0.152
	(-3.679)	(-4.309)	(-2.647)	(0.739)	(0.216)
Broad money (% of GDP)	-1.235	-3.42*	2.12	0.682	0.118
	(-3.724)	(-4.339)	(-2.656)	(0.739)	(0.216)
Trade (% of GDP)	-1.497	-2.591	1.353	0.677	0.109
	(-3.679)	(-4.309)	(-2.647)	(0.739)	(0.216)
Velocity of money (CPI)	-1.476	-2.885	-2.432**	0.659	0.146
	(-3.699)	(-4.309)	(-2.653)	(0.739)	(0.216)
Velocity od money from GDP deflator	-4.213***	-3.257*	-4.465***	0.623	0.185
	(-3.689)	(-4.309)	(-2.650)	(0.739)	(0.216)

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Note: test critical values at 1% are in the brackets

Appendix E   Unit root test at first difference

Variables	Augmented Dickey Fuller test			Kwiatkowski Philips Schmidt Shit (KPSS) test	
	Constant	Trend and constant	Without Trend and constant	Constant	Trend and constant
GDP growth	-3.141**	-3.633**	-0.455	0.391	0.122
	(-3.689)	(-4.323)	(-2.656)	(0.739)	(0.216)
Inflation, consumer prices (annual %)	-5.071***	-5.373***	-5.503***	0.500	0.500
	(-3.699)	(-4.339)	(-2.650)	(0.739)	(0.216)
Inflation, GDP deflator (annual %)	-4.688***	-4.723***	-8.744***	0.304	0.302
	(-3.737)	(-4.394)	(-2.650)	(0.739)	(0.216)
FDI, net inflows (% of GDP)	-5.466***	-5.368***	-5.462***	0.275	0.347
	(-3.689)	(-4.323)	(-2.650)	(0.739)	(0.216)
Broad money (% of GDP)	-3.712**	-3.722**	-3.412***	0.072	0.072
	(-3.724)	(-4.374)	(-2.650)	(0.739)	(0.216)
Trade (% of GDP)	-5.111***	-5.058***	-4.865***	0.460	0.368
	(-3.689)	(-4.323)	(-2.650)	(0.739)	(0.216)
Velocity of money (CPI)	-6.016***	-5.535***	-5.664***	0.500	0.392
	(-3.689)	(-4.339)	(-2.650)	(0.739)	(0.216)
Velocity od money from GDP deflator	-10.24***	-4.325**	-9.416***	0.359	0.304
	(-3.689)	(-4.394)	(-2.650)	(0.739)	(0.216)

$^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$

Note: test critical values at 1% are in the brackets

Appendix F   Granger causality test between inflation and GDP growth

	Using CPI inflation					Using GDP deflator inflation			
Equation	Excluded	chi2	df	Prob> chi2	Equation	Excluded	chi2	df	Prob> chi2
y^g	π	8.49	2	0.014	y^g	π	7.74	2	0.021
y^g	f	1.14	2	0.564	y^g	f	0.77	2	0.678
y^g	m	10.85	2	0.004	y^g	m	5.46	2	0.065
y^g	τ	0.58	2	0.748	y^g	τ	0.05	2	0.973
y^g	ν	8.15	2	0.017	y^g	ν	7.52	2	0.023
y^g	All	24.71	10	0.006	y^g	All	28.26	10	0.002
π	y^g	11.48	2	0.003	π	y^g	3.42	2	0.180
π	f	3.27	2	0.194	π	f	1.23	2	0.538
π	m	3.53	2	0.170	π	m	4.96	2	0.084
π	τ	2.20	2	0.332	π	τ	16.10	2	0.000
π	ν	12.96	2	0.002	π	ν	0.15	2	0.928
π	ALL	30.20	10	0.001	π	ALL	40.41	10	0.000

Note that all variables are in first difference.

Appendix G   Johanson co-integration test when CPI inflation used

Maximum Rank	Parms	LL	Eigenvalue	Trace statistic	5% critical value
0	42	-343.18		114.46	94.15
1	53	-318.89	0.82	65.88*	68.52
2	62	-307.17	0.56	42.44	47.21
3	69	-296.38	0.53	20.87	29.68
4	74	-290.02	0.36	8.14	15.41
5	77	-286.50	0.22	1.09	3.76
6	78	-285.95	0.03		

Note that * indicates there are one co-integrating relationship based on trace statistic.

Appendix H   Johanson co-integration test when GDP deflator inflation used

Maximum Rank	Parms	LL	Eigenvalue	Trace statistic	5% critical value
0	42	-350.82		119.17	94.15
1	53	-328.26	0.80	74.05	68.52
2	62	-311.72	0.69	40.97*	47.21
3	69	-301.99	0.5	21.49	29.68
4	74	-295.13	0.38	7.77	15.41
5	77	-291.27	0.24	0.05	3.76
6	78	-291.24	0.00		

Appendix I   Diagnostic test for VECM

Table 5: Lagrange-multiplier test

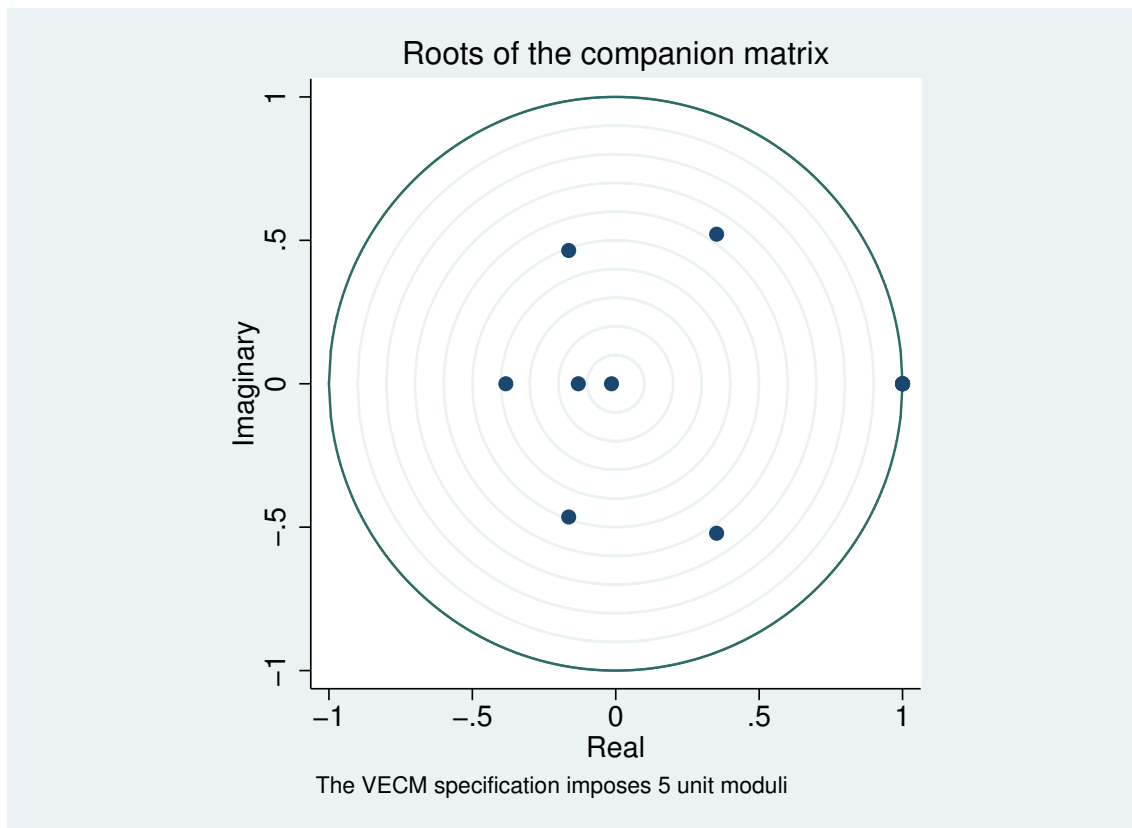| Lag	chi2	df	Prob>chi2
1	24.8493	36	0.91930
2	32.1197	36	0.65375

Note that the null hypothesis is no autocorrelation at lag order.

Table 6: Jarque Bera statistic

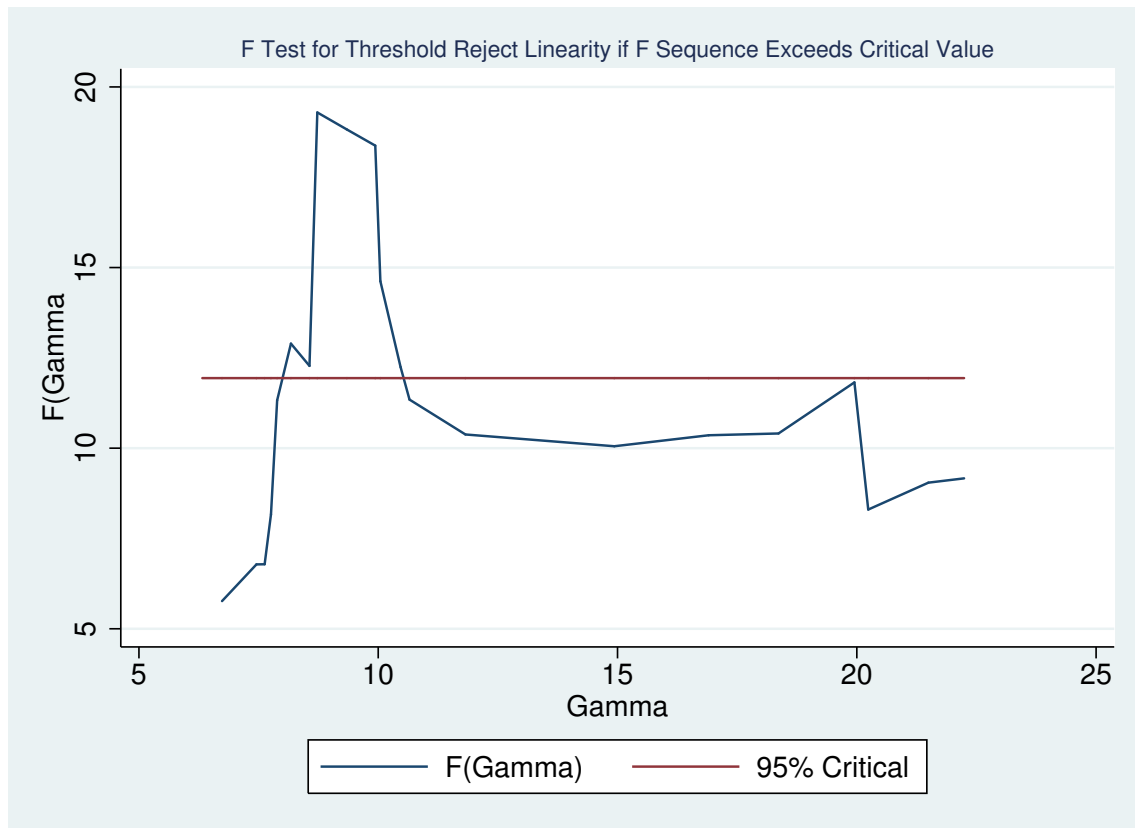| Equation	chi2	df	Prob>2
Dy^g	0.246	2	0.88
$D\pi$	4.396	2	0.11
Df	15.175	2	0.00
Dm	1.199	2	0.54
$D\tau$	0.001	2	0.99
$D\nu$	3.193	2	0.20
All	24.751	12	0.16

Note that null hypothesis is the distribution of disturbance term is normal

Figure 7: Stability of VECM test

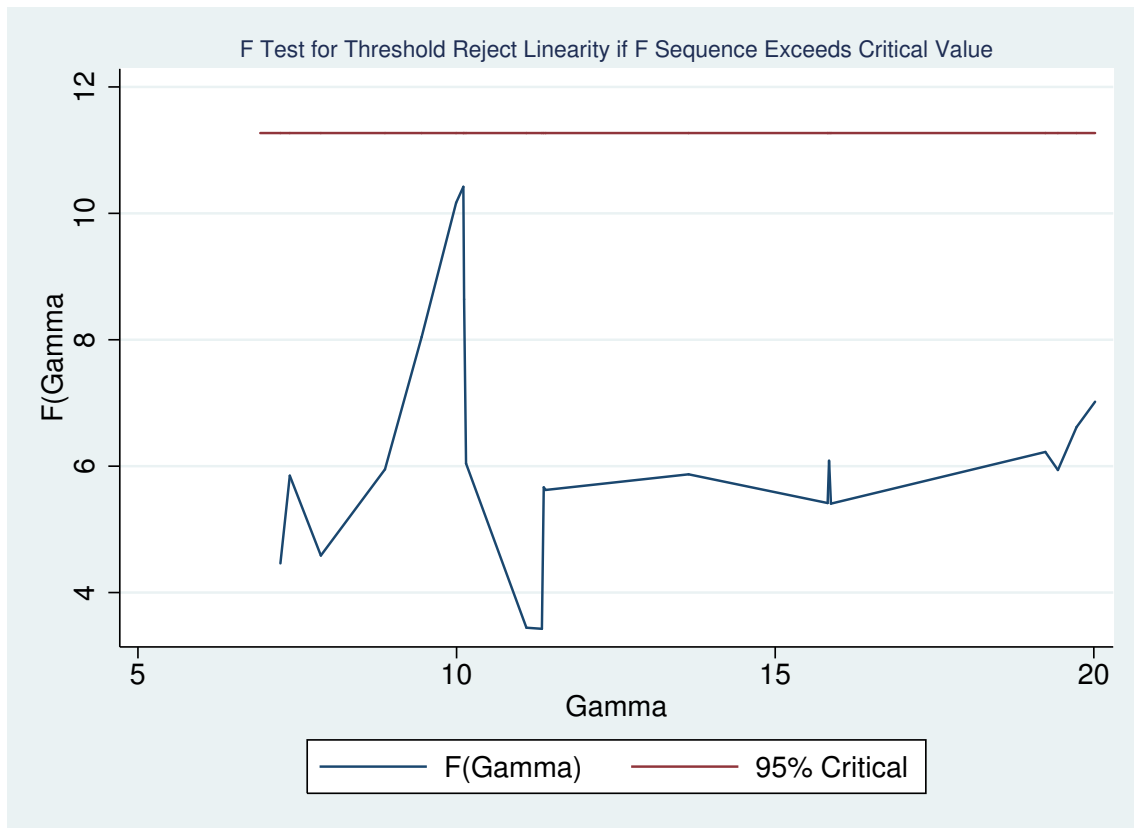# Appendix J　Robustness check for CPI inflation

F Test for Threshold Reject Linearity if F Sequence Exceeds Critical Value

Appendix K   Robustness check for GDP deflator inflation

F Test for Threshold Reject Linearity if F Sequence Exceeds Critical Value

Appendix L CPI inflation threshold estimation for each countries

Burundi

Number of Bootstrap Replications	2000
Trimming Percentage	.15
Threshold Estimate	5.55
LM-test for no threshold	6.45
Bootstrap P-Value	.75

Comoros

Number of Bootstrap Replications	2000
Trimming Percentage	.15
Threshold Estimate	4.47**
LM-test for no threshold	12.26
Bootstrap P-Value	.04

Kenya

Number of Bootstrap Replications	2000
Trimming Percentage	.15
Threshold Estimate	9.75**
LM-test for no threshold	13.64
Bootstrap P-Value	.01

Madagascar

Number of Bootstrap Replications	2000
Trimming Percentage	.15
Threshold Estimate	9.9***
LM-test for no threshold	12.99
Bootstrap P-Value	0

Malawi

Number of Bootstrap Replications	2000
Trimming Percentage	.15
Threshold Estimate	29.74
LM-test for no threshold	8.23
Bootstrap P-Value	.41

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$, Note:* indicates rejection of null hypothesis that no threshold exist.

Mauritius

Number of Bootstrap Replications	2000
Trimming Percentage	.15
Threshold Estimate	4.94
LM-test for no threshold	9.01
Bootstrap P-Value	.22

Mozambique

Number of Bootstrap Replications	2000
Trimming Percentage	.15
Threshold Estimate	13.23**
LM-test for no threshold	12.31
Bootstrap P-Value	.01

Seychelles

Number of Bootstrap Replications	2000
Trimming Percentage	.15
Threshold Estimate	2.59
LM-test for no threshold	7.61
Bootstrap P-Value	.50

Tanzania

Number of Bootstrap Replications	2000
Trimming Percentage	.15
Threshold Estimate	16***
LM-test for no threshold	15.7
Bootstrap P-Value	0

Uganda

Number of Bootstrap Replications	2000
Trimming Percentage	.15
Threshold Estimate	21.4
LM-test for no threshold	12.70
Bootstrap P-Value	.019

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$, Note:* indicates rejection of null hypothesis that no threshold exist.

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