

Appropriate Threshold Level of Inflation for Economic Growth: Evidence from the Three Founding EAC Countries

Nicas Yabu¹ & Nicholaus J. Kessy¹

¹Nicas Yabu and Nicholaus J. Kessy, Research Department, Bank of Tanzania, Dar es Salaam, Tanzania.

Correspondence: Nicas Yabu, Bank of Tanzania, 2 Mirambo Street, 11884 Dar es Salaam, Tanzania.

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Abstract

This paper empirically estimated threshold level of inflation, which is conducive for economic growth in the three founding EAC countries, Kenya, Tanzania and Uganda using panel data set for the period 1970 to 2013. The non-linear quadratic model was used to estimate the threshold level or the turning point beyond which inflation exerts a negative impact on economic growth. To examine the inflation-growth relationship other moderating variables were included in the model. It was found that credit to GDP ratio, degree of openness of the economy and foreign direct investment flows to EAC member states have significant and positive impact on growth.

In determining threshold level of inflation for the three EAC member states, regression results of the random effect model establish that the *average* rate of inflation beyond 8.46 percent has negative and significant impact on economic growth. For individual countries, findings from the Seemingly Unrelated Regression (SUR), which treats each country separately, indicate that the optimal levels of inflation for Kenya, Tanzania and Uganda are 6.77 percent, 8.80 percent and 8.41 percent, respectively, beyond which inflation starts exerting cost on economic growth. The implication for monetary policy is that policy makers in the EAC member countries need to continue putting effort in achieving and maintaining single-digit level of inflation to support economic growth.

1. Introduction

1.1 Background

In November 2013, the East African Countries (EAC) signed a protocol for the establishment of a monetary union that will bring in greater monetary integration, stronger trade, investment and growth. The next move is to establish independent regional central bank and single currency which is envisaged to bring forth greater monetary policy credibility in the region. To ensure that economies going for monetary union are sufficiently integrated with somewhat similar economic bases, the member states need to fulfill certain agreed upon requirements - the macroeconomic convergence criteria.

IMF (2012) carried out a study on the convergence criteria and a macroeconomic framework for the EAC in which, each member state is to achieve a set of goals in a prescribed time period. One of the primary convergence criteria is the ceiling on headline inflation of 8 percent for which each partner state is to achieve by 2021 and sustain thereafter. Implicit in the target for inflation is the achievement of high economic growth since the two are fundamental macroeconomic objectives of most economies. One of the secondary convergence criteria in the EAC region is the achievement of 7 percent growth rate of output.

In the economic literature, there has been considerable debate on the nature of inflation and growth relationship. There was an increasing agreement that inflation has distributional effects on long-term economic growth if it gets "too high" and thus industrial countries consensus was inflation of 2 percent until the 2007 financial crisis that challenged the norm. Blanchard, DellAricia and Mauro (2010) argue that the effects of inflation on growth are difficult to discern so long as inflation remains in single digit. They suggest that inflation target of 4 percent for industrial countries might be appropriate because it leaves some room for expansionary monetary policy in a case of adverse shocks.

For each country or group of countries there exists a certain level or a range of inflation (threshold inflation) which is conducive for growth. This study attempts to answer a question whether or not the process of achieving the primary convergence criteria of the ceiling on headline inflation of 8 percent supports economic growth in EAC member states.

It is from that standpoint this paper intends to determine and examine the threshold level of inflation for the economic growth among the EAC partner economies.

1.2 Significance of the Study

The relationship between inflation and economic growth play an important role in the EAC. High or unpredictable inflation rates are regarded as harmful to an overall economy. They add inefficiencies in the market, and make it difficult for companies to budget or plan long-term. High inflation can cause companies or investors to shift resources away from high to low inflation countries as a hedge against losses that might be generated from rising costs of inflation. Estimating the threshold level of inflation will inform the EAC authorities responsible for controlling inflation to ensure that inflation maintained at levels that spur growth. As growing economies, it is important for the EAC to know the appropriate threshold level of inflation, beyond which, may be detrimental for sustainable economic growth.

1.3 Scope of the study

This study covered only three EAC founding member states using macroeconomic statistics for a period from 1970 to 2013. These countries have a long historical relationship. They have some common characteristics which can be generalized for comparison purposes, rather than studying five EAC member countries together, where Burundi and Rwanda joined the community recently. In the past, Kenya, Tanzania and Uganda enjoyed a long history of co-operation under different regional integration arrangements. These have included the Customs Union between Kenya and Uganda in 1917, which the then Tanganyika later joined in 1927; the East African High Commission (1948-1961); the East African Common Services Organization (1961-1967); the East African Community (1967-1977) and the East African Co-operation (1993-2000). Also Tanzania, Kenya and Uganda are the three largest economies in the region.

1.4 Organization of the study

Following this introduction, the rest of the paper is structured as follows: Section two discusses the inflation dynamics and economic growth in the three EAC founding countries. Section three provides both the theoretical and empirical literature on inflation and economic growth. Section four addresses methodological issue, while section five presents the analysis and discussion of the empirical results. The last section provides conclusion and policy recommendations.

2. Inflation Dynamics and Economic Growth

The relationship between inflation and growth in the economies of the EAC founding members is evident in the patterns of historical statistics on inflation and growth.

2.1.1 Inflation Dynamics and Economic Growth in Tanzania

Low inflation has been at the heart of Tanzania's monetary authorities since the country attained independence in the 1960s. In fact, the primary mission of the Bank of Tanzania is to maintain domestic price stability that is conducive to the attainment of macroeconomic stability and the achievement of sustainable growth. The Bank of Tanzania has the responsibility of ensuring that monetary conditions are consistent with low and suitable inflation (SADC, 2011), (BOT ACT, 2006).

With the decline of primary commodity prices and the oil crisis of the 1970s, Tanzania experienced a decline in GDP growth and a sharp increase in the rate of inflation. GDP growth rate declined from an average of 5.7 percent between 1965 and 1975 to an average of 1.8 percent between 1976 and 1979 and then to 1.2 percent between 1980 and 1985; while at the same time inflation increased from 7.3 to 30.6 percent in the same period (Table 2.1).

Table 2.1 Average Annual Real Rates of Growth (%): Tanzania 1965 - 1985

Period	Overall GDP	Real Per Capita GDP	Inflation Rate
1965 - 1975	5.7	2.5	7.3
1970 - 1976	5.1	1.9	11.1
1976 - 1979	1.8	1.0	14.9
1980 - 1985	1.2	-1.6	30.6

Source: Mbelle, et al, (2002).

The country embarked on economic recovery and structural adjustment programmes from which the economy recorded a noticeable improvement. Overall, between 1996 and 2009 real GDP growth averaged 6.2 percent, which was higher than the annual average growth of less than 5 percent in the early 1990s. Over the same period, the rate of inflation was contained to a single digit, averaging 6.8 percent compared with 25 percent recorded in the early 1990s (BoT, 2011).

For the period between 1995 and 2000 inflation declined steadily while growth largely remained constant. Low and stable inflation experienced between 2001 and 2005 was reciprocated by a gently rising growth in GDP. In 2012 the

economic growth rate was 6.9 percent compared to 6.5 percent recorded in 2010. Meanwhile inflation reached at 16.0 percent in 2012 from 7.2 percent in 2010. Figure 1.1 shows the historical trends of inflation rate and real GDP growth rate of Tanzania during the period of 1995 to 2013.

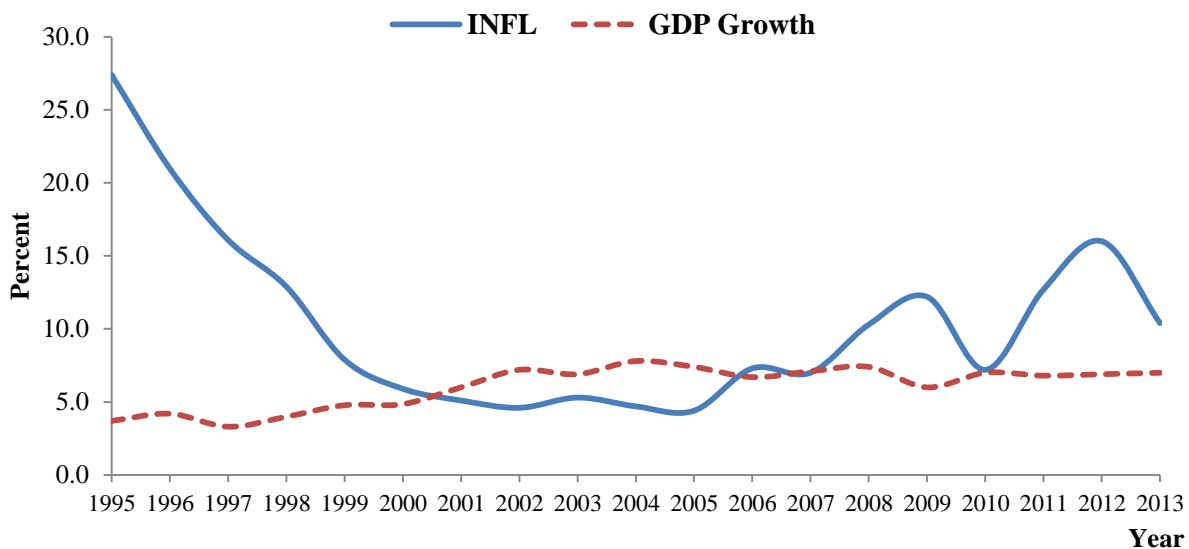


Figure 2.1 Trend of inflation and GDP growth rate in Tanzania

Although it is premature to conclude anything on the basis of a visual inspection of figure 2.1, it however more or less depicts an inverse relationship between rate of inflation and GDP growth rate throughout this period. The relationship between inflation rate and real growth rate of output for Tanzania is further investigated in Table 2.2 in which the entire set of actual observations on inflation and growth from 1967 to 2013 is subdivided into ranges starting from the minimum value of actual rate of inflation in the sample. The second column in the table shows how often (the number of years) incidences of inflation in a particular range occurred. For example, the inflation range between 2 and 5 percent occurred eight times between 1980 and 2013. The inflation band between 10 and 20 percent had the highest incidence of occurrence in the observation period.

Table 2.2 Relationship between Inflation and real GDP growth in Tanzania (1980 – 2013)

Inflation Range / Band	Inflation Frequency	Mean Inflation	Mean GDP Growth
$2 \leq \text{INFL} < 5$	8	4.8	6.7
$5 \leq \text{INFL} < 10$	10	6.8	5.9
$10 \leq \text{INFL} < 20$	13	14.1	3.9
$20 \leq \text{INFL} < 30$	9	25.7	1.8
$\text{INFL} \geq 30$	9	32.8	3.6

Source: Authors computations

Within each range or band of inflation, the mean inflation and real GDP growth rate is calculated. For example, the average real GDP growth rate for inflation less than 5 percent is 6.7 percent; 5.9 percent for inflation between 5 – 10 percent etc. The last column in Table 2.2 reveals that mean real GDP growth rate is high at 6.7 in the inflation range less than 5 percent (mean inflation of 4.8 percent), while the high inflation range is associated with lower GDP growth rates. This observation signifies that economic activity thrives in an environment of characterized by price stability. That is low mean inflation rates are associated with high real growth rates of output.

2.1.2 Inflation Dynamics and Economic Growth in Kenya

The first decade following Kenya’s independence was marked by macroeconomic stability when exchange rate was fixed and inflation averaged 3 percent. In the 1970’s, with the first oil price shocks and balance of payments problems, the rate of inflation began to increase. This increase was accompanied by devaluations and changes in the exchange rate peg.

One particular turn of events in the 1990’s was the slowdown in economic growth, the rapid rise in inflation, money growth and interest rates, and a rapid depreciation of the shilling. Factors behind rapid increase in money supply

included the foreign aid embargo at the time, escalating fiscal deficits that were financed from money printing and the exchange rate regime had changed to a dual system in which there was an official exchange rate and a ‘black market’ rate.

Over the 15-year period from 1995 to 2010, the growth rate of the economy did not show a steady or regular pattern. In the year 1995 and 1996, the rate of economic growth in real GDP was 4.3% and 4.0% respectively. However, in the year 1997, the growth rate decreased substantial to a dismal level of 0.2%. The growth rate rose in following years to 4.6% and 7.0% in 2004 and 2007 respectively (Figure 2.2).

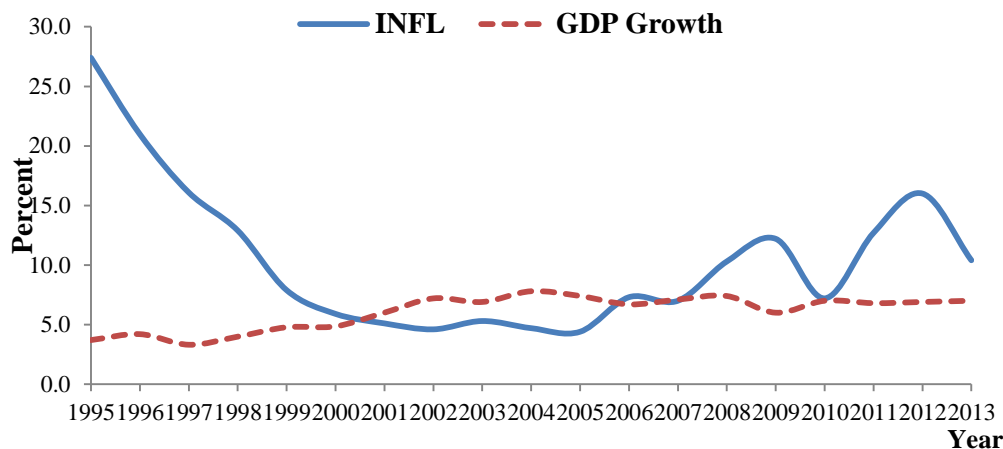


Figure 2.2 Trend of inflation and GDP growth rate in Kenya

Between 1995 and 1996, the government was able to confine underlying inflation within the single digit range. This was mainly due to tight monetary policy implemented by the monetary authorities in Kenya. However, in 1997, inflation increased to 11.9%, associated with general election expenditures. Higher inflation is also seen in the year 2000, 2004, 2009 and 2010 mainly being as a result of increasing commodity prices as influenced by rising world oil prices.

From 1995 to 2001, an increase in the real GDP growth does not correspond to decreases in inflation. However, between the year 2002 and 2004, an increase in real GDP growth rate related to an increase in inflation. At the same time from 2008 to 2010, the relationship between inflation and economic growth seems to be negative, where a decrease in the rate of inflation rate from 15.1% in 2008 to 11.6% in 2009 and further to 4.1% was associated with a rise in the economic growth from 1.5% to 2.6% and further to 5.6% in the same period, respectively. The inflation decreased further from 10.6% in 2009 to 5.7% in 2013, while growth increased from 2.6% to 4.5% in the same period respectively (Figure 2.2). Therefore the trend is mixed; hence on the basis of a visual inspection, no general conclusion can be drawn on the relationship between inflation and economic growth in Kenya.

The historical inflation-growth relationship for Kenya is summarized in Table 2.3 in which average GDP growth is high when inflation rate is low and high inflation rates are detrimental to growth. There exists an inverse relationship between inflation and growth in Kenya with a negative 0.5 correlation coefficient.

Table 2.3 Relationship between Inflation and real GDP growth in Kenya (1980 – 2013)

Inflation Range / Band	Inflation Frequency	Mean Inflation	Mean GDP Growth
2≤INFL<5	4	3.4	4.7
5≤INFL<10	11	7.9	4.0
10≤INFL<20	15	12.8	3.6
20≤INFL<30	3	25.6	1.0
INFL≥30	1	46.0	-0.1

Source: Authors computations

2.1.3 Inflation Dynamics and Economic Growth in Uganda

For most of the 1970s and 1980s, Uganda suffered severe macroeconomic imbalances, including high rates of inflation and balance of payments deficits, because the growth of nominal aggregate demand consistently outstripped the growth of real supply in the economy. The main reason for this was the printing of money to finance public sector deficits, leading to large increases in money supply which fuelled high rates of inflation.

In 1987, Uganda embarked on an Economic Recovery Programme with support from the IMF, the World Bank and other multilateral and bilateral donors. The principal objectives were to revamp the economy and enhance economic growth, to reduce inflation and to minimize the potential for a balance of payments crisis. Because of the consistency

with which these measures were and are being implemented, real GDP growth rates have been positive since then, averaging 6.1% per annum from 1986 to 2004. Inflation has been declining overtime from 143.8% to a single digit of 5.0% in the same period. A substantial increase in inflation from 5.0% in 2004 to 14.2% in 2009 was associated with a significant increase in GDP growth from 6.8% to 7.2% in the same period (**Figure 2.3**). As in Kenya, the inflation and economic growth seems to be negative related in Uganda.

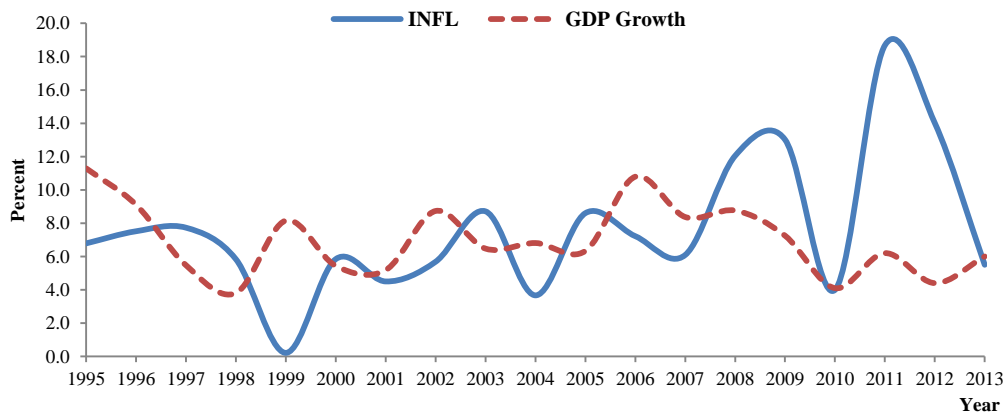


Figure 2.3 Trend of inflation and GDP growth rate in Uganda

Table 2.4 summarizes historical data for inflation and GDP growth for Uganda. Again, the tradeoff between inflation and growth is evident as inflation range from 2 to 10 percent is associated with highest average GDP growth of 7.6 percent.

Table 2.4 Relationship between Inflation and real GDP growth in Uganda (1980 – 2013)

Inflation Range / Band	Inflation Frequency	Mean Inflation	Mean GDP Growth
$2 \leq \text{INFL} < 5$	3	2.4	7.6
$5 \leq \text{INFL} < 10$	12	6.8	7.2
$10 \leq \text{INFL} < 20$	5	15.5	2.1
$20 \leq \text{INFL} < 30$	1	25.4	5.0
$\text{INFL} \geq 30$	12	110.6	-3.6

Source: Authors computations

High inflation rate above 30 percent per annum is detrimental to growth as is associated with a negative growth of output. For Uganda, the correlation coefficient between growth and output is negative at 0.51. On the basis of historical statistics, for the three founding EAC member countries, there is evidence for inflation-output tradeoff. On the basis of the correlation coefficients, the influence of inflation on output seems to be high in Tanzania and Kenya than in Uganda. That is, growth in Tanzania and Kenya is more susceptible to high inflation, while Uganda's growth can withstand relatively higher inflation. Thus, the EAC's across-the-board convergence criteria for inflation (5 percent) and growth (7 percent) may not be simultaneously achieved by the three member states because of the differences of inflation-growth dynamics and economic bases.

3. Literature Review

3.1 Theoretical Literature Review

The theoretical underpinnings of inflation-growth dynamics have roots in the models of economic growth in which Classical economics basing on supply-side theories, emphasize the need for incentives to save and invest if the nation's economy is to grow. Keynesian theory provided the AD-AS framework which is a more comprehensive model for linking inflation to growth. Monetarism re-emphasized the critical role of monetary growth in determining inflation, while Neoclassical and Endogenous Growth theories sought to account for the effects of inflation on growth through its impact on investment and capital accumulation (Brian & Howard, 2005). A detailed account of each of the growth models in relation to inflation – growth relationship is provided hereunder.

Classical theorists laid a foundation for a number of growth theories. Classical economics hinges on the supply-side theories, which emphasize the need for incentives to save and invest if a nation's economy is to grow; linking it to three factors of production i.e. land, capital and labour. Classical theorists argued that growth is self-reinforcing as it exhibited increasing return to scale. Savings were viewed as a source of investment and hence growth. Income

distribution was considered to be the most important determinant of how fast (or slow) a nation would grow; and decline in profits were associated with competition of capitalists for workers which bid up prices rather than declining marginal productivity of labour (Kaldor, 1956; Samuelson, 1959). Although the link between the change in price level and its effects on profit level and output were not explicitly articulated in the classical growth theories; the relationship between the two variables is implicitly suggested to be negative as indicated by the reduction in firm's profit levels through higher wage costs.

The Keynesian models provided a more comprehensive model for linking inflation to growth under the AD-AS framework. In the AD-AS framework, the AS curve is upward sloping in the short run so that the change in the demand side of the economy affects both price and output (Dornbusch, 1996). Dornbusch (1996) also argues that AD and AS yields an adjustment path which shows an initial positive relationship between inflation and economic growth but eventually turns negative towards the latter part of the adjustment path. The initial positive relationship between inflation and economic growth is due to the time inconsistency problem - producers feel that only the prices of their products have increased while the other producers are operating at the same price level. The relationship between inflation and growth is thus positive as the time inconsistency problem lures the producers into more output. Moreover, Blanchard and Kiyotaki (1987) argue that inflation and economic growth are positively related because of the agreement of firms to supply on agreed price with implication that the firm has to produce even at increased price.

Monetarism updated the Quantity Theory, reemphasizing the critical role of monetary growth in determining inflation. In this framework and in the short run, money has a dominant influence on real variables (real GDP, employment and price level); but in the long-run the influence is on price level and other nominal variables. The Philips Curve (inflation-unemployment trade-off) holds in the short run and money is neutral and super-neutral in the long run (Tobin, 1965). Thus Monetarists suggest that in the long-run, prices are mainly affected by the growth rate in the money, while having no real effect on growth.

Neo-classical models introduced technological change to replace investment (or capital) as a primary factor to explain long-term growth (Solow, 1965 and Swan, 1956). Mundell (1963) articulated into the neo-classical a mechanism relating inflation and output growth, which was distinct from the excess demand for commodities in which an increase in inflation or inflation expectations reduced people's wealth. To accumulate the desired wealth, people save more by switching to assets, increasing their price, thus driving down the real interest rate. Greater savings means greater capital accumulation and thus faster output growth. Tobin (1965) developed the Mundell's theory further by introducing money as a store of value that serves as a financial capital asset. Inflation causes productive economic agents to acquire more capital than holding idle cash balances which leads to greater capital intensity that promotes economic growth.

Sidrauski (1967) proposed the next major development in the neo-classical models, with his seminal work on the context of an infinitely-lived representative agent model where money is 'super-neutral'. Superneutrality holds when real variables, including the growth rate of output, are independent of the growth rate in the money supply in the long-run. The main result in the Sidrauski's economy is that an increase in the inflation rate does not affect the steady state capital stock. As such, neither output nor economic growth is affected.

Stockman (1981) developed a neo-classical model in which an increase in the inflation rate results in a lower steady state level of output and people's welfare declines. In Stockman's model, money is a complement to capital, accounting for a negative relationship between the steady-state level of output and the inflation rate. Stockman's insight is prompted by the fact that firms put up some cash in financing their investment projects. Sometimes the cash is directly part of the financing package, whereas other times, banks require compensating balances. Stockman models this cash investment as a cash-in-advance restriction on both consumption and capital purchases. Since inflation erodes the purchasing power of money balances, people reduce their purchases of both cash goods and capital when the inflation rate rises. Correspondingly, the steady-state level of output falls in response to an increase in the inflation rate.

The neo-classical theoretical review demonstrates that the framework can yield very different results with regard to inflation and growth. An increase in inflation can result in higher output (Tobin Effect) or lower output (Stockman Effect) or no change in output (Sidrauski, 1967).

Neo-Keynesian's major development was the introduction of the concept of "potential output" which is the level of output where the economy is at its optimal level of production, given the institutional and natural constraints. This level of output also corresponds to the natural rate of unemployment, or what is also referred to as the non-accelerating inflation rate of unemployment (NAIRU). NAIRU is the unemployment rate at which the inflation rate is neither rising nor falling. In this particular framework, the 'built-in inflation rate' is determined endogenously, that is by the normal workings of the economy. According to this theory, inflation depends on the level of actual output (GDP) and the natural rate of employment (Gordon, 1997; Roberts, 1995).

Endogenous growth theories sought to account for the effects of inflation on growth through its impact on investment

and capital accumulation. In endogenous growth theory, the growth rate has depended on one variable - the rate of return on capital (Gillman, Harris & Matyas, 2002). Variables, like inflation, that decrease the rate of return, which in turn reduces capital accumulation and decreases the growth rate. Some versions of the endogenous growth set within a monetary exchange framework also reported that inflation rate (tax) lowers both the return on all capital and the growth rate (Lucas, 1980; Lucas & Stokey, 1987; McCallum & Goodfriend, 1987)

On the basis of the above brief theoretical review on the inflation -growth relationship, we can discern four major predictions on the relationship between inflation and growth as highlighted in the literature by Drukker et al. (2005). First, some theories find that there are no effects of inflation on economic growth. Related to this category, are those who perceive money as being super neutral (Sidrauski, 1967). Second, are those who subscribes to the fact that money is a substitute for capital, so sees inflation as having positive effects on growth (Tobin 1965).

Third, Stockman (1981) proposes a model in which money is seen as a complement to capital, thus inflation generates negative effects on economic growth and lastly, is a new class of theory that supports that though inflation impacts negatively on economic growth but only when it is above a certain threshold. In these models, high inflation rates exacerbate the frictions on financial markets, thus hampering efficiency and causing reduction on economic growth. This class of models assumes that there is a non-linear relationship between inflation and economic growth.

3.2 Transmission mechanism from Inflation to Growth

The process through which changes in the inflation get transmitted to real GDP growth or vice versa is what is referred to as “inflation – growth transmission mechanism”. The uncertainty associated with high and volatile unanticipated inflation has been found to be one of the main determinants of the rate of return on capital and investment (Bruno, 1993; Pindiky & Solimano 1993). However, fully anticipated inflation may reduce the rate of return of capital and it undermines the confidence of domestic and foreign investors about the future course of monetary policy. Inflation also affects the accumulation of other determinants of growth such as human capital or investment in research and development – this channel of influence is known as the *accumulation or investment effect* of inflation on growth.

Inflation also worsens the long-run macroeconomic performance of market economies by reducing the total factor productivity – this channel is known as the *efficiency channel*. Although in the literature it is documented that the efficiency channel is harder to formalize in a theoretical model (Briault, 1995), its importance in the transmission mechanism from inflation to lower growth cannot be undermined. A high level of inflation induces frequent changes in price that may be costly to firms (menu costs) and reduces the optimal level of cash holdings by consumers (shoe leather costs). It also generates larger forecasting errors by distorting the information content of prices, encouraging economic agents to spend more time and resources in gathering information and protecting themselves against the damage that may be caused by price instability – thus endangering the efficient allocation of resources.

The capital accumulation or investment effects and efficiency transmission channels from inflation to economic growth are shown schematically in (Figure 3.1).

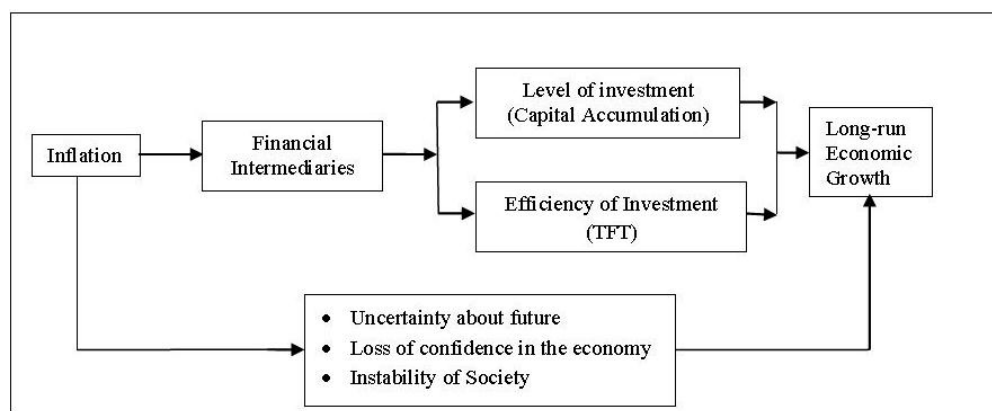


Figure 3.1 Transmission Mechanism from Inflation to Growth

Source: Adapted from Li Min (2006), “Inflation and Economic Growth: Threshold Effects and Transmission Mechanisms

3.3 Theoretical Framework

3.3.1 General Growth Model

In the review of theoretical link between inflation and growth in section 3.1 we have shown the role played by growth models in linking inflation and growth. In line with the work of Barro (1991), Levine and Renelt (1992) and

Sala-i-Martin (1997) the relationship between inflation and economic growth can be analyzed using the growth regression model of the general form:

$$\partial \log Y_t = c + \beta X_t + \varepsilon_t \quad (1)$$

Where $\partial \log Y_t$ is a growth rate in real GDP; X_t is the vector of explanatory variables; β is the matrix of parameters; c is a constant and ε_t is the error term.

There however exists a challenge of employing empirical analysis on models based on endogenous, neoclassical and neo-Keynesian growth theories. The problem with these models is that they do not produce an exact list of explanatory variables. For instance, the theories agree that the level of technology is an important determinant of growth, but there is no single way to measure the technological variable. Sala-i-Martin (1997) listed such potential candidates on the role of “level of technology” as market distortions, distortionary taxes, maintenance of property rights and degree of monopoly. The same is true for growth determinants such as “human capital” or “efficient government”.

The choice of explanatory variables can be based on the macroeconomic theoretical framework (neo-classical growth models would require such variables as investment, openness of the economy and population growth). The second way to choose explanatory variables is on the basis of empirical growth literature. Levine and Renelt (1992) and Sala-i-Martin (1997) argued that despite the existence of a large set of explanatory variables that can be potentially used in the growth regression, only a few of them may be significant. Moreover, some variables may be significant with one set of explanatory variables, but become insignificant with others.

3.3.2 Non-linear Model

Taking into account that inflation and growth are non-linearly related, developments in econometric modeling have enabled authors to make a further step of not only showing the existing positive or negative relationship between inflation and growth but also estimating the threshold level of inflation beyond, which it has a detrimental effect to growth. The main argument here is the existence of non-linearity hypothesis, which suggest that the adverse effect of inflation on economic growth is not universal; it appears only when inflation exceeds some turning-point or threshold level below which inflation has a positive or non-significant impact on economic growth. In this vein, Sarel (1996), Khan and Senhadji (2001) developed a non-linear threshold endogenous model in estimating the turning point rate of inflation after which the inflation is deterrent to economic growth. The non-linear model takes quadratic form of:

$$\partial \log Y_t = c + \alpha_1 \pi + \alpha_2 \pi^2 + \beta X_t + \varepsilon_t \quad (2)$$

Where π and π^2 are linear and nonlinear terms of inflation respectively.

In equation (2) non-linearity is introduced in the model by including squared term of inflation, π^2 as an explanatory variable. Other regressors, X_t , are added in the model as moderating variables. This is a straightforward and mostly used technique for estimating non-linear relationships, through allowing for changes in slopes as a function of changes in the independent variable [Pattillo, Poirson & Ricci (2002); Clements, Bhattacharya & Nguyen (2005); Devarajan, Swaroop & Zou (1996); Hermaes & Lensink (2001)]. In this case, the slope of the estimating equation can vary with changes in the inflation rate. This enables to observe turning points in the relationship between inflation-growth and inflation-equality.

3.4 Empirical Evidence

The findings from empirical evidences on the inflation-growth relationship differ across countries depending on data periods, country experiences and methodology. Among the first authors to analyse the inflation-growth relationship was Bhatia (1960) who applied a linear model for the United Kingdom, Germany, Sweden, Canada, and Japan using different data sets from 1812 to 1912. His findings indicate that the rate of growth was inversely related to the inflation in Germany and Japan. In the United Kingdom, Sweden and Canada, higher rates of growth were accompanied by higher rates of inflation. Also Dorrance (1963, 1966) and Johanson (1967) conducted a study in both developed and developing states, respectively, and found no conclusive empirical evidence for either a positive or a negative association between the two variables. The popular view in the 1960s was that the effect of inflation on growth was not principally very important in both developed and developing countries.

However, change in view came after many countries experienced severe crisis of high and persistent inflation rates associated with a general decline in macroeconomic performance and balance of payment crisis in 1970s and 1980s. Therefore, at this time the impact of inflation to growth was given much attention and several studies were devoted to find this relationship.

Kormendi and Meguire (1985) did a panel data study, using 47 sample countries for the period 1950-1977. They found that an increase of inflation by 1% reduces the economic growth by 0.57%. Fisher (1993) found negative associations

between inflation and growth in a pooled cross-section, time series regressions for a large set of countries. He argued that inflation impedes the efficient allocation of resources by obscuring the signaling role of relative price changes, the most important guide to efficient economic decision-making. Barro (1995) examined the five-year average data of 100 countries over the period of 1960-90 by using the Instrumental Variable (IV) estimation method. Using different instrumental variables, he obtained a robust estimation result showing that an increase in average inflation by 10 percentage points per year would slow the growth rate of the real per capita GDP by 0.2-0.3 percentage points per year.

Many authors including Levine and Renelt (1992), Bullard and Keating (1995), and Bruno and Easterly (1995) provided further facts that the negative relationship between inflation and economic growth emerges only when rates of inflation exceed some threshold. Clark (1997) also questioned whether a uniformly negative relationship exists between inflation and growth regardless the prevailing rate of inflation. Therefore, in the mid-1990s different studies went even far by starting estimating not only the existing relationship between inflation and growth but also identifying the breakpoints (threshold level) after which inflation is harmful to economic growth. They used the new class of models regarding inflation-economic growth linkage by indicating that the relationship between them is non-linear and, therefore, there is a threshold level. However, the empirical evidence differs substantially across the countries in terms of the optimal level after which the inflation is deterrent to economic growth. Below are summary of some empirical facts on the threshold level of inflation for economic growth.

Sarel (1996) used a non-linear model on a panel dataset for 87 countries covering a period of 1970-1990 with variables on population, GDP, consumer price indices, terms of trade, real exchange rates, government expenditures and investment rates. The empirical findings provide evidence of the existence of a structural break that was significant. The break was estimated to occur when the inflation rate is 8%.

Christoffersen and Doyle (1998) investigated the nonlinear relationship between inflation and growth for 22 transitional countries of Central and Eastern Europe as well as of the Post Soviet Union Countries, including Azerbaijan over the period from 1990 to 1997. The authors found that threshold level of 13%.

Nell (2000) examined the issue whether inflation is always harmful to growth or not. The author applied the South African economy's data for the period 1960-1999 and divided it into four periods. Using Vector Auto Regressive (VAR) technique, the empirical results suggested that inflation within the single-digit zone may be beneficial to growth, while inflation in the double digit zone appeared to impose costs in terms of slower growth.

Khan and Senhadji (2001) examined threshold effects of inflation on growth separately for industrial and developing countries. The data set covered 140 countries from both groups and non-linear least squares (NLLS) and conditional least squares methods were used. The empirical results verified the existence of a threshold beyond which inflation exerts a negative effect on growth. The study established statistically significant thresholds at 1-3 percent and 11-12 percent inflation levels for industrialized and developing countries, respectively. The view of low inflation for sustainable growth was strongly supported by this study.

Gillman, Harris and Matyas (2002) presented an econometric model with the feature of the inflation rate reducing the return to capital, by taking two samples of OECD and APEC member countries over the years 1961-1997. Inflation rate was included as central variable and the theory is related with the concept of equilibrium along the balanced growth path that implicitly includes transitional approaches to the balanced growth rate. The results was consistent with Khan and Senhadji (2000) and they showed that the effect is negative and significant at low inflation rates for the OECD. When inflation rate going from 0-10 percent range to a 0-5 percent range, the negative co-efficient nearly doubles in magnitude and remains highly significant.

Sweidan (2004) examined the relationship between inflation and economic growth for economy of Jordan using a non-linear model and found a structural break point at 2 percent level of inflation. Another issue which was covered by the study was to check the effect of inflation uncertainty on the growth and developments in the economy. The result implied that the effects of inflation on growth were stronger as compared to the effects of inflation uncertainty and variability. Gokal and Hanif (2004) reviewed several different economic theories to develop consensus on the inflation and growth relationship for the economy of Fiji. Their results showed that a weak negative correlation exists between inflation and growth, while the change in output gap bears significant bearing. The causality between the two variables ran one-way from GDP growth to inflation.

Hussain (2005) found no definite threshold level of inflation for Pakistan but suggests that a 4 to 6 percent range of inflation is tolerable for economy of Pakistan. This study reported similar results as the one by Singh (2003) which recommended 4 to 7 percent range of inflation for India. Hussain (2005) followed the methodology used by Khan and Senhadji (2001) and Singh (2003) and used the empirical results to advise the monetary authorities to keep the inflation low and stable irrespective of any threshold level.

Ahmed and Mortaza (2005) explored the relationship between real GDP and CPI using a non-linear approach and

established a threshold at 6 percent level of inflation for the economy of Bangladesh. The empirical evidence demonstrates that there exists a statistically significant long-run negative relationship between these two variables.

Pollin and Zhu (2005) presented panel regression estimates from a non-linear model form of quadratic function of the relationship between inflation and economic growth for 80 countries over the period 1961–2000. They found threshold inflation ranges of 14–16% for middle-income countries and 15–23% for low-income countries.

Munir et al. (2009) analyzed the non-linear relationship between inflation level and economic growth rate for the period 1970–2005 in the economy of Malaysia. Using annual data and applying new endogenous threshold autoregressive (TAR) models proposed by Hansen (2000), they found an inflation threshold value existing for Malaysia and verify the view that the relationship between inflation rate and economic growth is nonlinear. The estimated threshold regression model suggested 3.89 percent as the structural break point of inflation above which inflation significantly hurts growth rate of real GDP. In addition, below the threshold level, there is statistical significant positive relationship between inflation rate and growth.

Frimpong and Oteng-Abayie (2010) analyzed the threshold effect of inflation on economic growth in Ghana for the period of 1960–2008 by using threshold regression models. The result indicated inflation threshold level of 11% at which inflation starts to significantly hurt economic growth in Ghana. Below the 11% level, inflation was likely to have a mild effect on economic activities, while above this threshold level, inflation would adversely affect economic growth.

Sergii (2009) investigated the growth-inflation interaction for CIS countries, including Azerbaijan for the period of 2001–2008. He found that this relation was strictly concave with some threshold level of inflation. Inflation threshold level was estimated using a non-linear least squares technique, and inference was made applying a bootstrap approach. The main findings were that when inflation level is higher than 8 % economic growth is slowed down, otherwise, it is promoted.

Espinoza et al. (2010) examined threshold effect of inflation on GDP growth using a panel data of 165 countries including oil exporting countries. A smooth transition model used over the period of 1960–2007 indicates that for all country groups threshold level of inflation for GDP growth is about 10 percent (except for advanced countries where threshold is much lower). They also separated non-oil exporting countries and found that inflation from higher than 13 percent decreases real non-oil GDP by 2.7 percent per year.

Also Rutayisire (2013) estimated a threshold level of inflation in Rwanda using a quadratic regression model with time series data from 1968 to 2010. His findings indicate that the economy of Rwanda can be supported by the rate of inflation which does not exceed 14.97 percent.

Kremer, Bick and Nautz (2013) investigated the presence of threshold effects of inflation on long term economic growth using data of a panel for 124 industrial and developing countries. Their empirical results showed that the estimated inflation threshold level was about 2.5% for industrial countries and 17 percent for developing countries; above these critical levels, inflation rate leads to lower long-term economic growth rate in both cases. In addition, the study indicated that below these thresholds, the effect of inflation on long-term economic growth was significantly positive in developed countries; in contrast, there was no significant impact on economic growth in developing countries when inflation is below 17 percent.

4. Research Methodology

4.1 Econometric Specification

The model used in this paper follows the Pollin and Zhu (2005) model who utilized a non-linear model form of quadratic function to estimate the threshold level or the turning point above which inflation exerts a negative effect on economic growth. The same approach was used by Patillo et al. (2002) and Clements et al. (2005) to estimate the non-linear relationship between external debt and growth. Also Devarajan et al. (1996) and Hermes and Lensink (2001) used the same methodology to determine the optimal size of government; that is the share of overall government spending that maximizes economic growth. In line with these works, the quadratic function of equation (2) has been adopted and modified to add more explanatory variables to examine the non-linear relationship between the rate of inflation and economic growth.

$$d \log Y = \beta_0 + \beta_1 INFL_{it} + \beta_2 INFL_{it}^2 + \beta_3 Pg_{it} + \beta_4 INV_{it} + \beta_5 FD_{it} + \beta_6 OPEN_{it} + \beta_7 FDI + \beta_8 DUM + \varepsilon_{it} \quad (3)$$

Where $d \log Y$ is growth rate of real GDP, $INFL$ is growth rate of CPI and Pg is population growth rate, INV is investment to GDP ratio, FD is credit to GDP ratio, $OPEN$ is degree of openness ((Export + Import)/GDP), FDI is foreign direct investment to GDP ratio, DUM is a dummy variable, which takes zero during price control and one elsewhere and ε is the error term.

From equation (3), the squared term of inflation, $INFL_{it}^2$, was generated to find out the turning point, from which the threshold level of inflation can be obtained. Therefore, combination of linear and squared term, propose that the impact of inflation on economic growth can be described as an inverted U-shaped curve, and supports the view that the positive effects of inflation switches to negative when inflation exceeds some threshold level. The peak of the quadratic function identifies the inflation threshold level or the turning point above which the marginal effect of inflation becomes negative.

The non-linearity effect of inflation on growth is assessed basing on the significance of the coefficients of linear and non-linear estimated terms of inflation in equation (3). If both coefficients are significantly different from zero, we can find out the peak of the quadratic function that identifies the critical point of inflation above which the marginal impact of inflation on growth is negative. To calculate the critical point corresponding to the inflation threshold level, the partial derivative of equation (3) is computed with respect to inflation, π_t . The derivative yields the following equation that is set equal to zero:

$$\frac{d(d \ln \text{GDP})}{dINFL_{it}} = \beta_1 + 2\beta_2 INFL_{it} = 0 \quad (4)$$

Solving equation (4) for the critical point of inflation π^* beyond which the marginal impact of inflation on economic growth becomes negative gives the following equation:

$$INFL^* = -\frac{\beta_1}{2\beta_2} \quad (5)$$

4.2 Choice of sample and Variables

Three founding EAC countries, Tanzania, Kenya and Uganda were used in the study for the purpose of making good comparison. Rwanda and Burundi were not included because of very short time series (data limitation) as the two joined the economic community in 2007. The choice of the explanatory variables in equation (3) is consistent with the choice made in other empirical works (Khan & Senhadji, 2000, 2001; Mubarak, 2005; Risso & Carrera, 2009; Kremer et al. 2013).

4.3 Data and Data Source

The study used annual time series data set on economic growth rates and inflation from three founding EAC countries, Tanzania, Kenya and Uganda from 1970 to 2013. The major sources of data were the Bank of Tanzania, Central Bank of Kenya and Central Bank of Uganda and International Financial Statistics (IFS).

4.4 Unit Root Test

It has often been argued that macroeconomic data are characterized by a stochastic trend and, if unresolved, the statistical behaviour of the estimators will be influenced by such a trend such that results may be spurious. According to Hamilton (1994), there are different methods of overcoming the problem of spurious regression arising from using non-stationary time series. The methods include: using a lagged endogenous variable as an explanatory variable and differencing the non-stationary time series (until they become stationary) before variables are used in a regression. Also another way of resolving the problem is to transform variables into growth rates, which obvious include differencing a variable, and using ratios. For this reason, we used growth rate of real GDP, population growth rates, while the remaining variables are ratios to GDP.

4.5 Estimation and Data Analysis Methods

An equation (3) was estimated using STATA and Gretl econometric packages using data for the three EAC member states. Both fixed and random effect models were estimated using the Hausman specification test; and random effect vs pooled effect models using the Breusch-Pagan test. The idea was to find out, which model is more appropriate for the data.

In order to estimate the threshold level of inflation for each EAC member state, equation (3) was also estimated using the Seemingly Unrelated Regression (SUR). The results for the estimated regression with the threshold values for all three countries and individual country using the random effect and SUR model, respectively, are presented and discussed in the following section.

5. Findings and Discussion of the Results

5.1 Unit Root Test

The findings from a panel unit root based on Levin–Lin–Chu test of Augmented Dicky full indicate that all variables are stationary (Table 5.1).

Table 5.1 Levin–Lin–Chu - Panel Unit Root

Variable	t- values		
	Without Constant and Trend	Time Trend	No-constant
dlogY	-7.1408*	-8.3928*	-3.4274*
INFL	-3.8395***	-4.5570***	-1.8675*
Pg	-2.4406	-4.1370	-0.9705
INV	-1.6328	-5.2774*	0.1543
FD	1.2665	0.3635	2.7699**
OPEN	-3.6760	-4.6760*	-0.5406
FDI	2.1777	-5.5276*	-0.5935

Notes: *, **, and *** indicate rejection of the null hypothesis that panels contain unit roots at 1% , 5% and 10% levels of significance respectively.

Source: Author's regression estimates

5.2 Random Effect Regression

Before estimation and discussion of the regression results of the model, we tested both fixed effect against random effect models using the Hausman specification test, and random effect against pooled effect models using the Breusch-Pagan test. The test in Table 5.2 indicates that the random effect model is preferred to fixed effect model, because the P-value ($p = 0.38753$) is not significant for the Hausman Tests. Meanwhile since the Breusch-Pagan test is significant ($P = 0.00132$) then random effect is better than the pooled model. Therefore, the random effect model is more appropriate for the data.

Table 5.2 Fixed Vs Random Effect and Random Vs Pooled Effect Test

Breusch-Pagan test	Hausman test
Null hypothesis: Variance of the unit-specific error = 0	Null hypothesis: GLS estimates are consistent
Asymptotic test statistic: Chi-square = 7.39185	Asymptotic test statistic: Chi-square = 0.74667
with p-value = 0.00132	with p-value = 0.38753

Source: Regression results

Findings from the estimated random effect model presented in Table 5.3 indicate that inflation has a positive and significant impact on growth, while inflation squared has a negative and significant impact on growth. The coefficient of credit to GDP ratio as a proxy for financial development was found to be positive and statistically significant. Therefore, financially developed countries are more likely to increase growth within the EAC member states. Also findings indicate that degree of openness has positive and significant impact to growth. This implies that trade openness exerts leverage on the economy through increase in the market size and thus allows for increasing returns to scale. Also it improves business competitiveness and promotes a better allocation of resources. At the same time FDI flows to Tanzania, Kenya and Uganda have statistically significant and positive effects on growth. This suggests that most of FDI was allocated in productive sectors, which promote growth in those countries. Dummy variable did not produce robust results, hence was removed during estimation.

Table 5.3 Random Effects GLS Regression Results

xtreg dlogY INFL INFL-1 INFL² NFL²-1 Pg INV FD OPEN FDI, re robust

dlogY	Coefficient	Std. Error	Z-statistics	Prob
INFL	1.269	0.299	4.246	0.000
INFL-1	0.228	0.074	3.10	0.000
INFL ²	-0.075	0.001	-3.07	0.001
NFL ² -1	0.190	0.693	0.274	0.620
Pg	0.550	0.564	0.976	0.301
INV	-0.027	0.048	-0.55	0.580
FD	0.083	0.027	3.03	0.002
OPEN	0.128	0.043	2.98	0.021
FDI	0.607	0.119	5.08	0.000
Cons	-0.321	1.824	-0.176	0.857

sigma_u | 0
 sigma_e | 2.1371770
 rho | 0 (fraction of variance due to u_i)

R-square: Within =
 0.851
 Between = 0.920
 Overall =
 0.897

As it has been stated in the theoretical literature that inclusion of a large set of explanatory regressors in the inflation-growth relationship model can be potential but only few of them may be significant (Renelt, 1992 & Sala-i-Martin, 1997). Also according to Martin (1997) and Levine and Renelt (1992) some variables may be significant with one set of regressors, but become insignificant with others. Findings indicate that the ratio of investment to GDP and population are statistically insignificant.

Calculating threshold level of inflation yields:

$$\frac{d(d \log Y)}{dINFL_{it}} = 1.269 - 2(0.075)INFL_{it} = 0 \tag{6}$$

From equation (6) it follows that the threshold level of inflation is:

$$INFL^* = \frac{1.269}{2(0.75)} = 8.46 \tag{7}$$

The above results establish that the maximum level of inflation, which supports economic growth, is 8.46%. That is, the rate of inflation beyond the threshold of 8.46 percent for Kenya, Tanzania and Uganda has negative and significant impact on economic growth. This is the maximum tolerable cost of inflation to growth.

The regression results of the random effect model discussed above represent the average coefficients for all three EAC member states. The estimated threshold level of inflation of 8.46 percent assumes to support growth for all three EAC member states. However, regression of each country is important because it provides the individual threshold level for each member state basing on its own historical characteristics. The Seemingly Unrelated Regression (SUR) was analysed and presented in order to give out the threshold level of inflation of each country, beyond which it has detrimental impact on growth. The results and discussion of the SUR are presented and discussed in the next sub-section.

5.3 Seemingly Unrelated Regression

Regression for the SUR treats equations for each EAC member country as independent but assuming that error terms are related across member states. In this case, external shocks are assumed to affect all EAC member states the same way. Therefore, there is a link among the cross-section units (EAC member states) but at the same time retaining the coefficients for cross-section units. The results of the SUR are presented in Appendix 1 and calculation and discussion of threshold level of inflation for each member state is presented below.

Kenya

For the case of Kenya calculation of threshold level of inflation becomes:

$$\frac{d(d \log Y_K)}{dINFL_K} = 0.894 - 2(0.066)INFL_K = 0 \quad (8)$$

From equation (6) it follows that the threshold level of inflation is:

$$INFL_K^* = \frac{0.894}{2(0.066)} = 6.77 \quad (9)$$

Tanzania

For the case of Tanzania calculation of threshold level of inflation becomes:

$$\frac{d(d \log Y_T)}{dINFL_T} = 1.444 - 2(0.082)INFL_T = 0 \quad (10)$$

From equation (6) it follows that the threshold level of inflation is:

$$INFL_T^* = \frac{1.444}{2(0.082)} = 8.80 \quad (11)$$

Uganda

For the case of Uganda calculation of threshold level of inflation becomes:

$$\frac{d(d \log Y_U)}{dINFL_U} = 1.06 - 2(0.063)INFL_U = 0 \quad (12)$$

From equation (6) it follows that the threshold level of inflation is:

$$INFL_U^* = \frac{1.06}{2(0.063)} = 8.41 \quad (13)$$

Equations (9), (11) and (13) present the estimated threshold level of inflation for all three EAC member states. The results indicate that the maximum rates of inflation which supports economic growth for Kenya, Tanzania and Uganda are 6.77 percent, 8.80 percent and 8.41 percent, respectively, beyond which inflation starts exerting cost on growth.

6. Conclusion and Policy Recommendation

This paper estimated the threshold level of inflation, which is conducive for economic growth in the three founding EAC countries, Kenya, Tanzania and Uganda using the non-linear threshold model for the period of 1970 to 2013. Based on the growth model that examines inflation-growth relationship other intervening variables such as population growth rate, investment to GDP ratio, credit to GDP ratio, degree of openness and foreign direct investment to GDP ratio were included in the model and their impact on growth were examined.

Findings from the random effect model suggest that inflation has a negative and significant impact on growth, while credit to GDP ratio, degree of openness and FDI flows to EAC member states have significant and positive impact on growth. The average calculated coefficient of optimal level of inflation from the random effect model for all three EAC member states suggests that the rate of inflation beyond the threshold of 8.46 percent has negative and significant impact on economic growth. However, further findings from the Seemingly Unrelated Regression (SUR), which treats each country separately, indicate that the optimal level of inflation for Kenya, Tanzania and Uganda are 6.77 percent, 8.80 percent and 8.41 percent, respectively, beyond which inflation starts exerting cost on economic growth. The implication for monetary policy is that policy makers need to continue putting effort in achieving and maintaining single level of inflation for all EAC member states to support economic growth.

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Appendix 1: Seemingly Unrelated Regression Results with Dependent Variable $dlogY$

No	Country	Cons	INFL	INFL-1	INFL ²	INFL ² -1	Pg	INV	FD	OPEN	FDI	R ²
1	Kenya	-0.472 (-0.15)	0.894 (3.17*)	0.894 (1.16)	-0.066 (-4.06*)	-0.031 (3.01*)	0.634 (0.50)	0.566 (4.23*)	-0.453 (-0.51)	0.205 (5.24*)	0.242 (0.64)	0.78
2	Tanzania	1.522 (0.77)	1.444 (4.05*)	0.282 (-3.00*)	-0.082 (-2.84**)	-0.040 (-3.52*)	-4.267 (-1.99**)	0.044 (0.27)	0.114 (3.64*)	0.738 (2.10**)	0.502 (4.69*)	0.90
3	Uganda	1.320 (0.19)	1.06 (2.88**)	0.966 (-1.98**)	-0.063 (-3.65*)	-0.018 (-3.40*)	-0.299 (-1.27)	0.911 (1.39)	0.449 (2.12**)	0.061 (2.38**)	0.927 (2.10**)	0.81

Note: * and ** means statistically significant at 1% and 5%, respectively.

Source: Authors findings.

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