Threshold Effects in the Relationship between Inflation and Economic Growth: Evidence from Rwanda

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1. Introduction

Background

It is now widely accepted among economists, policy makers and central bankers that the main objective of macroeconomic policy is to achieve a high and sustained economic growth rate while maintaining a low inflation rate. It is also generally believed that high inflation is detrimental to medium and long-run economic growth. Not surprisingly, the existence and the nature of the relationship between inflation and economic growth have become the subject of an extensive body of theoretical and empirical studies (Temple, 2000). The debate revolves around the following questions: first, is the relationship between inflation and growth positive, negative or non-significant; second, how low should the inflation rate be not to have an adverse effect on economic growth?

Recent studies have uncovered that the relationship between inflation and growth may be non-linear. There was shown to be a positive relationship between low inflation and high output growth, while higher inflation was associated with lower economic growth. According to these studies, the hypothesis of non-linearity suggested 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.

Research problem and motivation

Since the early 1990s, Rwanda has been implementing comprehensive economic stabilization and structural adjustment programmes with the financial and technical assistance of the International Monetary Fund (IMF) and other development partners. As is well known, in such IMF-supported programmes low inflation is a key element of the policy package,with the objective to achieve macroeconomic stability and a sustained high economic growth rate.

During the implementation of successive economic programmes, an inflation rate of around 5% was used as a policy target. This target was met most of the time, but was sometimes missed, notably due to external and internal supply shocks. Bearing in mind the growth-harming effects of very high as well as very low inflation rates (Ghosh and Phillips, 1998), the following question may be posed in the context of the Rwandan economy: was the inflation target chosen for policy purposes appropriate? In other words, was it higher or lower than an optimal or threshold level consistent with

economic growth? Results from some empirical studies like Khan and Senhadji (2001) have suggested that the inflation threshold range is 1–3% for industrial countries and 11–12% for developing countries, while in a similar study by Kremer, Bick and Nautz. (2009) it was shown that the estimated inflation threshold is about 2.5% for industrial countries and 17% for developing countries. Moreover, these studies support the idea that when the existence of the threshold, and consequently the non-linearity in the relationship between inflation and growth, is neglected, substantial biases could affect the estimation of that relationship. Other estimates for specific developing and emerging countries suggested a wide range of inflation threshold levels: 10% for Lesotho (Seleteng, 2005); 9% for Pakistan (Mubarik, 2005); 6% for Bangladesh (Ahmed and Mortaza, 2005); 15% for Egypt (Kheir El-Din and Abou-Ali, 2008); 9% for Mexico (Risso and Carrera, 2009); 22.2% for Ghana (Quartey, 2010); 6% for India (Singh, 2010); 8% for Nigeria (Salami and Kelikume, 2010); and 4% for South Africa (Leshoro, 2012).

Moreover, the management of the National Bank of Rwanda has been envisaging a shift from a monetary-targeting to an inflation-targeting regime for conducting monetary policy. If the latter regime is adopted, a single level or a range of inflation target values must be determined. In this context, the present research may be helpful in the determination of such targets. The last impetus for this research was the availability of data on Rwanda spanning the period 1968–2010, which is more than four decades. This allows for a meaningful time series investigation and valid statistical inference.

Most studies that have been conducted on the inflation threshold effects on economic growth employed cross-sectional and panel data covering large samples from countries. These studies were justified by their ability to generalize empirical findings and their policy implications appeal. However, as suggested by Lin and Ye (2009) and Espinosa ,Leon and Prasad, (2010), due to the heterogeneous factors prevalent in different countries, it is important to carry out country-specific studies in order to relate empirical findings to policy designs in specific cases. Inflation threshold effects should then be estimated for each country separately, allowing the incorporation of country specific characteristics. In particular, this would provide useful information about the appropriate location and width of an inflation-targeting band. In line with these suggestions, this research is a contribution to the literature of developing country case studies on the existence of threshold effects in the relationship between inflation and economic growth.

As far as could be ascertained, no such research has been conducted to date using time series data for Rwanda. However, in two empirical studies[1] based on a panel data set comprising industrial and developing countries, including Rwanda, Kremer, Bick and Nautz (2009) showed that inflation is detrimental to economic growth in developing countries if it exceeds 17%, and that below that threshold the impact of inflation on growth is insignificant, while Pollin and Zhu (2005) estimated a threshold inflation range of 15–23% for low-income countries.

Objective of the study

The purpose of the study is to investigate the relationship between inflation and growth in the case of Rwanda and to determine whether there is a turning point or a threshold level of inflation, above which the inflation effect on economic growth

switches from positive or insignificant to negative. The investigation has been carried out by means of a quadratic regression model which is estimated as a second-degree polynomial. This widely used technique for estimating non-linear relationships allowed the identification of the turning point in the inflation-growth nexus. This approach has been used by Devarajan, Swaroop and Zou (1996), Hermes and Lensink (2001), Pattillo, Poirson and Ricci (2002), Clements, Bhattacharya and Nguyen. (2005),and Pollin and Zhu (2005). Annual data sets spanning the period 1968–2010 have been used for the empirical analysis in this research.

The remainder of this paper is organized as follows: section 2 presents a brief review of both theoretical and empirical literature on the relationship between inflation and growth; section 3 provides an overview of inflation and growth trends in Rwanda during the period covered by the study; section 4 discusses the methodological framework of this research , while section 5 describes the data used; section 6 presents the estimation results ,while section 7 concludes and summarizes the policy implications of the study.

2. Literature review

An extensive body of theoretical and empirical studies investigated the relationship between inflation and growth both in the context of developed and developing countries. This section presents a brief review of the literature.

Theoretical literature

In the Keynesian model framework, comprising Aggregate Demand (AD) and Aggregate Supply (AS) curves, the AS curve is upward-sloping rather than vertical in the short-run. The implication is that changes on the demand side of the economy resulting from expectations, labour force and policy actions such as discretionary monetary or fiscal policies, affect both prices and output in the short run, as predicted by the Phillips Curve (Blanchard and Kitoyaki,1987; Dornbusch, Fischer and Kearney, 1996; Romer, 2001). Therefore, the Keynesian model advocates the existence of a positive relationship between inflation and output. However, in this Keynesian framework it is not the case that inflation is itself a growth-enhancing force, rather, the point is that if rising aggregate demand leads to increased growth, then some inflation pressures are likely to emerge as a relatively benign by-product. The positive relationship between inflation and growth evident in short-run dynamics is unsustainable in the longer term and turns negative with a higher inflation rate.

Mundell (1965) and Tobin (1965) predict a positive relationship between inflation and capital accumulation, which in turn implies a positive impact on growth. The so-called Mundell-Tobin effect states that since money and capital are substitutable, an increase in the inflation rate erodes the purchasing power of money balances, which causes substitution between resources and leads to a shift in the portfolio allocation away from money balances to real assets. This will raise capital accumulation and thereby stimulate the economic growth rate (De Gregorio, 1996; Choi, Smith and Boyd, 1996).

It has been asserted that inflation may be positively correlated with growth since it can be considered a necessary grease or lubricant for the wheels of the economy. From this perspective, it is argued that under wage and price rigidities, a certain level of inflation can help to realign the relative prices in response to structural changes in production during fast modernization periods of the economy (Lucas, 1973; Akerlof, Dickens and Parry, 1996; Kiley, 2000). In this scenario, inflation is rather important for economic growth.

Focusing on the economies of developing countries, some economists pointed out that inflation contributes positively to economic growth as it induces savings and

investment through a number of channels (Baer, 1967; Georgescu-Roegen, 1970; Taylor, 1983). Governments of developing countries, faced with inadequate public revenues, often resort to borrowing from central banks to finance their budget deficits. This seigniorage, or inflation tax resources, may be used by governments to increase capital formation by financing real investment. As long as this financing mechanism does not crowd out private-sector investment, inflationary finance would contribute to economic growth (the Kalecki effect).Nominal wages lag behind prices, due to slowly adjusting expectations,sluggish wage bargaining or Government repression. Consequently, it follows that inflation may boost economic growth by shifting income distribution from individuals to higher saving capitalist firms and hence increasing savings , investment and growth (the Kaldor effect).

Literature on the adverse effects of inflation on economic growth in the long-run is based on the idea that high inflation increases economic inefficiencies and reduces growth through the decrease of the level of investment as well as the rate of productivity growth (Fischer, 1993).

High and volatile inflation interferes with the price signalling mechanism, resulting in confusing information for economic agents on relative prices, which in turn induces distortions in investment decisions and hence impedes the efficient allocation of resources (Fischer,1993; Huybens and Smith, 1998; Khan and Sendhadji, 2000, 2001). Inflation creates uncertainty in financial markets and increases the risk associated with investment. Financial intermediaries are not eager to provide long-term financing for capital formation and tend to maintain liquid portfolios, which translates into a reduction of economic activity (Boyd, Levine and Smith, 1996; Hellerstein, 1997; Romer, 2001). High inflation also causes "shoe leather costs", which are associated with additional efforts that people make to reduce their holding of cash, and "menu costs" that arise from the necessity to change prices more often.

Inflation inhibits financial development; an inflationary environment is often associated with financial repression, as governments take actions, such as implementing interest rate ceilings and credit allocation to protect some priority sectors of the economy. Such controls lead to inefficient resource allocation and hamper economic growth (Boyd, Levine and Smith,1996; Haslag and Koo, 1999; Rousseau and Wachtel, 2002).

In endogenous growth theory, the economic growth rate depends on the rate of return on capital. Since inflation acts as a tax, it decreases the real rate of return, and it follows that inflation impedes capital accumulation and hence decreases the growth rate (Fama and Schwert, 1977; Boyd, Levine and Smith, 1996).

Inflation causes a real appreciation of the domestic currency and reduces international competitiveness by making exports more expensive. In a country with a fixed exchange rate, inflation could lead to the deterioration of the trade balance and capital outflows and impact negatively on the long-term economic growth (Dollar, 1992; Easterly, 1999). Moreover, inflation can interact with the tax system to distort borrowing and lending decisions, thereby raising the cost of capital and reducing the real rate of return that discourages investment,ultimately reducing economic growth (Feldstein, 1982; Jones and Manuelli, 1993).

Empirical evidence

A look at the empirical evidence on the inflation-growth nexus reveals that results vary across time depending on data periods, country experiences and research methodology.

Earlier works (Bhatia, 1960; Dorrance, 1966; Johanson, 1967) found the relationship between inflation and growth to be either non-significant or positive. Based on data from the 1950s and the 1960s, these findings were in line with the prevailing view that inflation was not an important issue. As pointed out by many authors (Sarel, 1996; Cuaresma and Silgoner, 2003), during this period high inflation was basically unknown in most countries and the growth costs of inflation were not considered a serious problem. This is why empirical studies failed to establish any meaningful relationship between inflation and economic growth.

However, after the two oil price shocks (in 1973 and 1979) and the emergence of severe periods of high and persistent inflation rates in many countries during the 1970s and 1980s, the traditional point of view changed radically. As more data became available for these periods, several empirical studies repeatedly confirmed that inflation has a significant and negative effect on economic growth.

In a cross-country study conducted by Kormendi and Meguire (1985) using data of 47 sample countries for the period 1950–1977, it was found that an increase of inflation by 1% reduces economic growth by 0.57%. Fischer (1993) showed that there is a negative relationship between economic growth and some macroeconomic indicators, notably inflation and budget deficits. He further pointed out that the causality runs from these macroeconomic indicators to economic growth.

Barro (1995) explored the inflation-growth nexus using panel data for 100 countries over the period 1960–1990. His empirical finding was that there exists a statistically significant negative relationship between the two variables. He estimated that an average increase in inflation of 10% reduces output growth by 0.2% to 0.3%. In a cross-country study with a data set covering the same period, Motely (1998) detected a similar relationship and his finding was that an increase in inflation of 5% results in a decrease of economic growth of 0.1% to 0.5%.

Regional empirical studies confirmed the existence of a negative relationship between inflation and economic growth: De Gregorio (1992) for Latin America; Fischer, Sahay and Vegh (1996) for transition economies; Gillman, Harris and Matyas (2004) for OECD and APEC countries . The main finding of these studies was that inflation impedes efficient resource allocation by distorting the signalling role of price changes and by producing a variety of output-reducing inefficiencies.

It emerged from the above studies that the effect of inflation on economic growth is positive or non-significant at low rates, but this effect becomes significantly negative at higher rates. It follows from these findings that policy makers should aim for low rates of inflation to foster economic growth. But how low should the inflation be? In other words, at what level does inflation become detrimental to output growth? The answer to the latter question obviously depends on the structure and level of development of the economy and will vary from one country to another.

Several empirical studies conducted since the mid-1990s have examined this issue, focussing specifically on whether the relationship between inflation and economic growth is non-linear. It was hypothesized that if such a relationship exists, it should be possible to estimate the threshold or the structural breakpoint at which the sign of the relationship between the two variables switches from positive to negative.

Fischer (1993) was the first to investigate the possibility of non-linearities in the relationship between inflation and output growth using both cross-sectional and panel data of 93 countries, including developing and industrial countries. He found a positive relationship between inflation and economic growth at low inflation rates, but the relationship became negative as inflation rose. Moreover, using two structural breakpoints, 15% and 40%, Fischer showed not only the presence of non-linearity in the relationship between the two variables, but also that the strength of the relationship weakens for inflation rates above 40%.

Following the results of Fischer (1993) there has been an expanding body of empirical evidence that shows the relationship between inflation and long-run growth was characterized by non-linearities and the existence of threshold effects.

Sarel (1996) used panel data from 87 countries covering the period 1970–1990 and tested for the existence of a threshold effect between inflation and growth. He found evidence of a structural breakpoint at an annual inflation rate of 8%. Below that rate, inflation does not have a significant effect on economic growth, or it may even show a marginally positive impact. Above that level, the effect is negative, statistically significant and very strong. Ignoring the existence of the threshold would substantially bias the impact of inflation on growth.

Ghosh and Phillips (1998) found that although inflation and growth are positively related at very low inflation rates (about 2% to 3% a year), the relationship is reversed at higher rates. Furthermore, the relationship is convex, so that a decline in the growth rate associated with an increase in inflation from 10% to 20% is greater than the fall in growth following a move in inflation from 40% to 50%.This finding confirmed Fischer's (1993) results. They also found that inflation is one of the most important statistical determinants of growth.

Bruno and Easterly (1998) examined the determinants of economic growth using cross-sectional data from 26 countries for the period 1961-1992. They argued that the negative relationship between inflation and growth exists only in high frequency data and with extreme inflation observations. In their empirical analysis, they detected a threshold level of 40%, above which the relationship between inflation and growth was negative. In addition, they found an inconclusive relationship between inflation and economic growth below this threshold level when countries with high inflation crises were excluded from the sample.

Khan and Senhadji (2000, 2001) investigated the inflation-growth interaction for both developing and industrial countries separately, applying the threshold panel data estimation technique originally developed by Hansen (1996,2000). They used a panel data set from 140 countries covering the period 1960–1998. Their findings strongly suggested the existence of a threshold level beyond which inflation exerts a negative effect on output growth. The threshold level was 1–3% for industrial countries and 11–12% for developing countries, respectively. The negative and significant relationship

between inflation and growth above the threshold level was quite robust with respect to the estimation method and different specifications. The results clearly suggested that the threshold level is lower for industrialized countries than for developing countries.

Sepehri and Moshiri (2004) also tested also the non-linearities in the inflation-growth nexus for industrial and developing countries. Using a non-linear specification and data from four groups of countries at various stages of development, they found that the turning points varied widely, from as high as 15% for lower-middle-income countries to 11% for low-income countries, and 5% for upper-middle-income countries. No statistically significant long-run relationship between inflation and growth was detected for OECD countries. Their findings also pointed out the potential bias in the estimation of the inflation-growth nexus that may result from combining various countries at different levels of development. In a similar study on different categories of countries, Pollin and Zhu (2005) found threshold inflation ranges of 14–16% for middle-income countries and 15–23% for low-income countries.

Working with data of a panel from 124 industrial and developing countries, Kremer, Bick and Nautz (2009) investigated the presence of threshold effects of inflation on long-term economic growth. Their empirical results showed that the estimated inflation threshold level was about 2.5% for industrial countries and 17% for developing countries. Above these critical levels, the inflation rate leads to a 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. By contrast, there was no significant impact on economic growth in developing countries when inflation was below 17%.

In a recent study using panel data for the period 1980–2008, Seleteng, Bittencourt and van Eyden (2011) examined the growth-inflation nexus for the SADC[2] countries and provided new evidence on the existence of threshold effects of inflation on growth in African economies. By applying a panel smooth transition regression model, the findings of the study revealed a threshold level of 18.9% above which inflation is detrimental to economic growth in the SADC region. The model also estimated the smoothness of the transition from a low to a high inflation regime.

It is evident from the above empirical literature review that most studies on the threshold effects of inflation on economic growth used cross-sectional or panel data covering a large number of countries. However, a few studies on emerging and developing countries applying the methodology developed by Khan and Senhadji (2000, 2001) used time series data to estimate the threshold level of inflation for country-specific cases. These include, among others: Mubarik (2005) for Pakistan; Seleteng (2005) for Lesotho; Ahmed and Mortaza (2005) for Bangladesh; Kheir El-Din and Abou-Ali (2008) for Egypt; Risso and Carrera for Mexico (2009); Salami and Kelikume (2010) for Nigeria; Quartey (2010) for Ghana; Singh for India (2010); and Leshoro (2012) for South Africa. These studies confirmed the existence of an inflation threshold effect on economic growth in the different country-specific cases.

3. Inflation[3] and growth trends in Rwanda

During the period covered by this research, the Rwandan economy experienced a mixed performance: economic growth and inflation have been characterized by notable fluctuations, resulting from the combined effects of domestic and external factors. The domestic factors included, in particular, supply shocks due to recurrent climate conditions, the breakdown of Rwanda's system of production and distribution during the war in 1990–1994, and the demand shocks reflecting the effects of monetary and fiscal policies. Regarding external factors, the period under consideration has been marked by two oil price shocks, in 1973–1974 and 1979–1980, and the more recent combined increase in prices of oil and food products in 2003–2008.

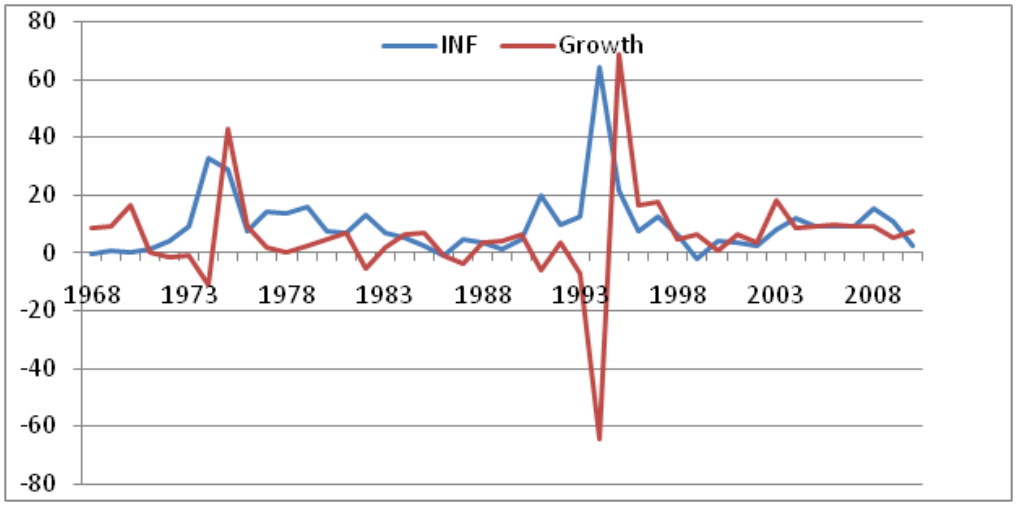
As a first step in exploring the bivariate relationship between growth and inflation, Figure 1 illustrates the historical trends of the two macroeconomic variables. The annual average real economic growth rate for the whole sample period was 5.4%, while the average inflation rate was 9.5%. As can be seen from the graph in Figure 1, the Rwandan economy witnessed two severe recessions and the highest inflation rates in 1974 and 1994 reflecting, respectively, the oil price shock in 1973–1974 and the collapse of the national economy at the end of the war in 1994. As a consequence of these shocks, the real GDP contracted by 11.3% in 1974 and 64.5% in 1994, while inflation was as high as 32.6% and 64% in the same periods. In both cases, the slowdown of overall economic activity was followed by a strong and sustained recovery in subsequent years. However, the recovery was accompanied by higher inflation rates reflecting expansionary macroeconomic policies implemented by the government to stimulate economic growth.

Comparing the economic growth performance during the two sub-periods 1968–1989 and 1990–2010, it appears that the first sub-period witnessed a lower average growth rate of 4.5% against 6.4% observed in the second sub-period. The performance would have been even better in the sub-period 1990–2010 if a severe economic recession due to the genocide in 1994 was not accounted for. The significant difference in economic growth and the behaviour of other economic indicators observed in the two sub-periods can be explained to a large extent by the drastic changes in economic management that occurred in Rwanda between the 1990s and 2000s.

During the 1970s and 1980s, the Rwandan economy was characterized by heavy government intervention and regulation. Not only did the government own and manage an important economic portfolio, but it also determined the prices of goods and services. The financial system functioned according to the McKinnon-Shaw repression paradigm, which is characterized by government interference in the operations of the financial system through interest rate ceilings and direct credit control. In this context, the negative effects of inefficient resource allocation were aggravated by the shocks from the increase

in oil prices and the fall in prices of Rwanda's main export products (coffee and tea), and resulted in lower growth and unsustainable macroeconomic imbalances in the late 1980s.

Figure 1: Inflation trends and real GDP growth



"INF" = inflation; "Growth" = economic growth.

The period between 1990 and 2010 was deeply marked by the genocide and the collapse of the Rwandan economy. However, it also witnessed important economic reforms, which allowed Rwanda not only to restore financial stability and recover economic activity, but also to gradually transition from a state-controlled to a market-oriented economy relying on the private sector. These reforms were implemented through successive economic stabilization and adjustment programmes – Structural Adjustment Program (1990), Enhanced Structural Adjustment Facility (1998), Poverty Reduction and Growth Facility (2000) and Policy Support Instrument (2010) – which focused on domestic revenue mobilization, strengthening public finance management, enhancing the effectiveness of monetary policy, relaxing exchange restrictions and removing impediments to private-sector development. Along with these reforms, priority spending aimed at promoting high economic growth and reducing poverty were channelled to investment in economic sectors such as infrastructure and agriculture, as well as to social sectors like health and education. It is worth mentioning that these reforms were supported by large inflows of foreign aid and international technical assistance.

As shown in Table 1, investment and government expenditure as a share of GDP recorded a steady increase, interrupted by the period of war, while the removal of exchange rate restrictions improved the openness of the economy and boosted the external sector. As can be seen in Table 1, the implementation of sound economic policies resulted in all economic indicators performing better, on average, in the second sub-period 1990–2010 than in the first sub-period 1968–1989, even though higher inflation was experienced in the second sub-period reflecting expansionary macroeconomic policies implemented by the government to stimulate economic growth and reduce poverty.

Table 1: Economic indicator trends

Indicators	1968–1979	1980–1989	1990–1999	2000–2010
Real GDP growth rate	6.4	2.5	4.6	8.1
Inflation rate	10.3	4.7	15.4	7.6
Investment/GDP	11	15.3	14.5	20
M3/GDP	13.5	14.5	15.9	18.1
Government[4]	12.4	13.2	11.3	17.5
Openness	29.8	31.2	32.1	36.5

Source: Original data on different variables are from World Bank Development Indicators (2011) and National Bank of Rwanda (various issues of Annual Reports and Monetary Surveys); ratios and rates are author's calculations.

Regarding the nature of the relationship between inflation and growth, no obvious conclusion can be drawn on the basis of a visual inspection of the historical trends between the two variables depicted in Figure 1. For example, there is no evidence that higher inflation correlates systematically with lower economic growth or the reverse. It emerges instead that the correlation looks either positive or negative in the sense that the two variables are moving in the same or in the opposite direction, depending on the sub-periods of the sample.

This ambiguous relationship between inflation and growth is confirmed by the data presented in Table 2. Following the approach used by Mubarik (2005) and Ghosh and Phillips (1998), sub-ranges of inflation rates have been computed and categorized in ascending order. Average inflation and growth rates corresponding to each inflation range have also been estimated.

No clear pattern emerges from the distribution of the average inflation and growth rates. It is worth recalling that, on average for the whole sample period, as indicated in Table 1, the inflation rate varied between 4.7% and 15.4%, while the economic growth rate ranged between 2.5% and 8.1%.

Table 2: Inflation ranges and economic growth

Inflation ranges	Number of observations	Average inflation	Average growth rate
1) $-2.5 < \pi_t < 2$	9	0.23	6.3
2) $2 < \pi_t < 4$	7	3.52	2.7
3) $4 < \pi_t < 6$	4	6.11	4.9
4) $6 < \pi_t < 8$	4	7.35	11.0
5) $8 < \pi_t < 10$	6	9.28	7.1
6) $10 < \pi_t < 12$	2	11.86	12.0
7) $12 < \pi_t < 14$	4	12.96	-2.5
8) $14 < \pi_t < \infty$	7	28.14	5.9

Source: Author's calculations

It can be observed that from the first to the third inflation ranges, a higher average inflation rate leads to lower economic growth, suggesting a negative relationship. However, the higher average inflation rates corresponding to the fourth,fifth and sixth inflation ranges coexist with impressive average economic growth rates varying between 7% and 12%.These observations provide some preliminary evidence that there may be a non-linear relationship between growth and inflation, and raises the question regarding the sign of the relationship between the two variables and the level of the inflation threshold.

4. Methodological framework

This section discusses the methodological framework adopted for the empirical analysis of this research, specifies the model, and highlights the econometric approach.

General growth model

The starting point of the investigation into the threshold effects on the inflation-growth nexus in Rwanda is a general model describing the link between economic growth and its determinants. This model takes the form of a growth regression equation augmented with inflation:

$$\Delta \ln y_t = \beta_0 + \beta_1 \pi_t + \beta_2 X_t + \varepsilon_t \quad (1)$$

where $\Delta \ln y_t$ is the annual real GDP growth, computed as the log first difference of the annual real GDP and Δ is the first difference operator; π_t represents inflation; X_t is the vector of explanatory variables, selected among the most commonly used in the growth literature; β_2 is the matrix of parameters of the explanatory variables; β_0 is a constant;and ε_t is the error term.

A common problem in growth theory is the determination of the main sources of growth or the choice of the set of explanatory variables to be included in Equation 1. Neoclassical growth theory focuses on capital stock, labour force and technological progress as the main driving forces of growth (Solow, 1956; Swan, 1956), while in the endogenous growth theory, a crucial role is given to human capital, knowledge and new technologies (Romer, 1990; Grossman and Helpman, 1991). This research draws upon the neoclassical model to justify the choice of basic explanatory variables. The power of the Solow model to explain growth in both developed and developing countries has been widely documented in the literature dealing with the empirics of economic growth (Mankiw, Romer and Weil ,1992). However, due to data constraints, this analysis will substitute investment and population for capital stock and labour force, respectively, in the empirical model.

In the empirical literature, Levine and Renelt (1992) and Sala-i-Martin (1997) argue that despite the existence of a large set of explanatory regressors that can potentially be used in the growth regression , only a few of them may be significant. They further proposed checking the robust regressors econometrically.

As a result of Sala-i-Martin's test for robustness, the following explanatory regressors have been identified as among the most important determinants of growth: investment, population growth, inflation rate, government expenditure, trade openness and the growth rate of terms of trade. These variables have in common that they are systematically correlated with growth. Financial development is another important variable that has been emphasized by empirical studies in the growth process (King and Levine, 1993; Levine and Zervos, 1998), hence this variable has also been considered in this study. Therefore, apart from inflation, the empirical analysis of this research into Rwanda will rely on the above results and will use the following basic model:

$$\Delta \ln y_t = \beta_0 + \beta_1 \pi_t + \beta_2 INV_t + \beta_3 \Delta \ln POP_t + \beta_4 OPEN_t + \beta_5 FD_t + \varepsilon_t \quad (2)$$

where $\Delta \ln y_t$ is as defined in Equation 1; π_t representing inflation is defined as the annual percentage change of the Consumer Price Index (CPI_t); INV_t stands for investment proxied by gross fixed capital formation as a share of nominal GDP; $\Delta \ln POP_t$ is the annual population growth rate calculated as the first log difference of population; $OPEN_t$ represents trade openness calculated as the ratio of the sum of exports and imports to nominal GDP, and FD_t is a measure of the financial development indicator computed as the ratio of liquid liabilities of the financial system (broad money represented by the M3 monetary aggregate) to nominal GDP, and β_0 and ε_t have the same definition as in Equation 1. Two dummy variables (Dummy1 and Dummy2) and a trend term have been added to the list of regressors. The dummy variable, Dummy1, takes on the value 1 in 1992–2005 and zero otherwise; it is designed to account for the influence on growth of the comprehensive economic reforms implemented in Rwanda during the 1990s and 2000s. The dummy variable, Dummy2, is set to 1 in 1991–1994 and zero otherwise; it is meant to capture the destabilizing effect of the war period and genocide that led to the collapse of the Rwandan economy. A trend term has also been added to the model to reflect the impact of other shocks which may have affected economic growth in the sample period.

The set of growth determinants adopted in this research has also been used in some influential empirical works investigating the relationship between inflation and growth (Sarel, 1996; Khan and Senhadji, 2001; Mubarik, 2005 and Kremer, Bick and Nautz, 2009) as well as in recent works on developing economies (Risso and Carrera, 2009; Frimpong and Oten-Abayie, 2010; Seleteng, Bittencourt and van Eyden, 2011; Ghazouani, 2012; Ayisi, 2013; Ahortor, Adenekan and Ohemeng, 2012).

Theoretically, the expected effects of the different explanatory variables on growth in Equation 2 are as follows: Investment has been identified by both neoclassical and endogenous growth models as the most fundamental determinant of economic growth, hence the marginal impact of investment or physical capital (INV_t) is expected to be positive, since a change in the investment-to-GDP ratio (I/Y) will lead to an increase in growth according to the accelerator principle. The Harrod-Domar model also argues that the growth rate of output depends on the level of savings and the share of investment spending in GDP.

The growth rate of the population ($\Delta lnPOP_t$) may have either a positive or a negative effect on output growth. According to Todaro (1996), larger populations provide the required aggregate demand ("size" effect) to generate favourable economies of scale in production, lower production costs and provide sufficient labour to achieve higher output levels. Moreover, positive effects of population growth also stem from the human capital contribution. However, as Kelley (1988) pointed out, population growth could have a negative impact on economic growth if the dependency of the young population lowers investment ("age dependency" effect) as a result of diverting resources from more productive activities to basic needs, or if the average productivity of physical capital is lowered via diminishing returns ("capital-shallowing" effect).

It is now widely agreed that financial sector development (FD_t) contributes to economic development as it promotes economic growth through the following functions performed by the financial system: mobilization of savings, efficient allocation of resources, management and pooling of risks, liquidity provision, and reduction of information and transaction costs (Levine, 1997). King and Levine (1993) provide empirical evidence that higher financial development is associated with faster growth. Levine, Loayza and Beck (2000), and Rousseau and Wachtel (2002) came to the same conclusion: that financial development has a positive impact on growth. In growth literature, the ratio of broad money to GDP, representing the size of financial depth, is one of the most used measures of financial development (Hussain, 2005; Frimpong and Oteng-Abayie, 2010).

Regarding openness ($OPEN_t$), theory and empirical studies have shown that trade does not have a simple and straightforward relationship with economic growth. Some economists have contended that trade can act as "an engine" of growth and highlighted the beneficial effects that promoting exports has on overall economic activity (Sachs and Warner, 1995; Edwards, 1998). By contrast, others have emphasized the monetary and balance-of-payments consequences of trade. They pointed out the loss of output that would result from a restrictive adjustment policy to adjust the disequilibrium of balance of payments that is not self-correcting through relative prices movements, i.e., the real exchange rate (Thirlwall, 2000).It follows from these contrasting views that the final effect of openness on growth is an empirical issue.

Modelling inflation threshold effects on growth

To investigate the existence of a non-linear relationship between inflation and economic growth, most empirical studies use the threshold endogenous model developed by Sarel (1996) and Khan and Senhadji (2001).However, this model requires a large set of data to make valid statistical inferences. Therefore, given the relatively small size of the sample in the present study (43 observations), and following Pollin and Zhu (2005) and Quartey (2010), the quadratic function has been adopted to estimate the threshold level or the turning point above which inflation exerts a negative effect on economic growth in the case of Rwanda. The quadratic function approach has also been used in other areas of empirical growth literature. For example, Pattillo, Poirson and Ricci. (2002) and Clements, Bhattacharya and Nguyen . (2005) employed the quadratic function to estimate the non-linear relationship between external debt and growth, while Devarajan, Swaroop and Zou. (1996) and Hermes and Lensink (2001) relied on the

same approach to determine the optimal size of government, i.e., the share of overall government spending that maximizes economic growth. In line with these works, the following quadratic function has been used in the present study to examine the non-linear relationship between inflation and growth:

$$\Delta \ln y_t = \beta_0 + \beta_1 \pi_t + \beta_2 \pi_t^2 + \beta_3 INV_t + \beta_4 \Delta \ln POP_t + \beta_5 OPEN_t + \beta_6 FD_t + \varepsilon_t \quad (3)$$

in which the squared term of inflation, π_t^2, has been added, while all other variables are as defined in Equation 2. As this research focuses on the relationship between inflation and growth, investment as a share of GDP, population growth, openness, and financial development indicators are used as control variables.

In this model, it is expected that the linear term of inflation, π_t, would have a positive sign and is designed to reflect the beneficial effects of low inflation on output, while the squared term of inflation, π_t^2, is expected to have a negative sign and should measure the adverse impact associated with higher inflation. Since the squared term increases in value faster than the linear term, it implies that the presence of negative effects of inflation will eventually outweigh the positive effects. Moreover, the combination of a positive and significant linear term with a negative and significant squared term suggests that the impact of inflation on output can be described as an inverted U-shaped curve. This supports the view that the positive effects of inflation switches to negative when inflation exceeds a 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.

In order to find whether the hypothesis of non-linear effect of inflation on growth is confirmed, Equation 3 is estimated and the significance of the coefficients of the linear and squared terms is assessed. 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 4 is computed with respect to inflation, π_t and is set to zero:

$$\delta \Delta \ln y_t / \delta \pi_t = \beta_1 + 2 \beta_2 \pi_t = 0 \quad (4)$$

Solving the above equation for π_t, the critical point of inflation beyond which the marginal impact of inflation becomes negative is obtained:

$$\pi_t^* = -\beta_1 / 2 \beta_2 \quad (5)$$

5. Data, empirical results and discussion

This section presents the variables used in this research and their time series properties, explains the sources of the data and includes discussions on the estimation results of the study.

Data used

The basic data used in this study include time series on GDP, population, the CPI, gross fixed capital formation (as a proxy for investment or physical capital), imports and exports, broad money aggregate, and M3 (measure of liquid liabilities of the financial system). The set of data spanning 1968–2010 was collected from the World Bank Development Indicators and from various documents published by the National Bank of Rwanda and the National Institute of Statistics of Rwanda (Statistical Bulletins and Annual Reports). The nominal gross domestic product valued in domestic currency (Rwandan francs) has been deflated by the consumer price index to obtain the real GDP and the base year for the CPI is 1990 = 100.

Time series properties of variables

As the Ordinary Least Squares estimation technique has been adopted, it has to be ensured that all the variables included in the different models are stationary in order to have consistent results and to avoid spurious regressions. To this end, the time series properties of the variables have been investigated and the order of integration of each variable has been determined by applying the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests with "constant" and "constant and trend". These tests are complementary, as the PP generalizes the ADF test and provides robust estimates in the presence of serial correlation, time dependent heteroskedasticity and structural breaks in the time series. It is important to recall that some variables are defined as percentage annual changes or growth rates (Δlny_t, π_t and $\Delta lnPOP_t$), while others are defined as ratios (INV_t, $OPEN_t$ and FD_t).The results of both unit root tests are presented in Table 3.

According to the results in Table 3 of both unit root tests, ADF and PP, for all the variables used in this paper, the null hypothesis of non-stationarity has been rejected at a 5% significance level, meaning that these variables are stationary, i.e. I (0). Therefore, the relationship established between economic growth rate and the other variables would not be spurious.

Table 3: Unit root tests

Variables	ADF test		PP test	
	Constant	Constant and trend	Constant	Constant and trend
Δlny_t	-7.359**	-8.741**	-8.131**	-8.115**
INV_t	-10.40**	-10.83**	-3.778**	-6.296**
π_t	-4.888**	-6.092**	-4.029**	-3.959**
π_t^2	-4.888**	-6.092**	-5.379**	-5.314**
$\Delta lnPOP_t$	-5.064**	-4.750**	-3.511**	-3.698**
$OPEN_t$	-3.263**	-5.087**	-4.812**	-5.236**
FD_t	-2.997**	-4.842**	-3.188**	-4.572**
Critical values:				
5% significance level	-2.94	-3.53	-2.935	-3.524

Note: ** indicates that the null hypothesis of non-stationarity is rejected at 5% significance level.

Causality test

Before estimating the quadratic regression model and following a common practice in the literature exploring the relationship between inflation and growth, the Granger Causality test has been performed to investigate the linear causation between inflation and economic growth in Rwanda. This test is used because inflation may not be an exogenous variable in the growth-inflation regression and, consequently, the inflation coefficient may be biased. As pointed out by Khan and Senhadji (2001), the seriousness of this problem will depend, to a large extent, on whether the causality runs mainly from inflation to growth, in which case the endogeneity problem may be benign, or the other way around, in which case the problem may be more severe. However, as suggested by Fischer (1993), the causality is more likely to run predominantly from inflation to economic growth, implying that the bias will not be important and the inflation coefficient will not seriously be affected. This assumption has been explicitly tested through the Granger Causality test and the estimation results are presented in Table 4. It is important to point out that causality does not necessarily imply exogeneity. However, the absence of a feedback effect from growth to inflation helps in the choice of dependent and independent variable for the model specification (Mubarik, 2005; Risso and Carrera, 2009; Hussain and Malik, 2011). It also provides a good indication that inflation does indeed have an impact on growth (Chimobi, 2010).

Table 4: Causality tests

Pairwise Granger Causality Tests
Sample: 1968–2010
Lags: 1

Null Hypothesis:	Obs.	F-Statistic	Prob.
Inflation does not Granger Cause Growth	41	3.16621	0.0832
Growth does not Granger Cause Inflation	0.31409	0.5785	

The test statistic indicates that the null hypothesis that inflation does not cause economic growth is rejected at the 5–10% significance level, as shown by the p-value of 0.0832. This implies that inflation causes economic growth. Conversely, the null hypothesis that growth does not cause inflation is not rejected, meaning that economic growth does not cause inflation. It may then be concluded from these results that there is no feedback from output growth to inflation to suggest that there is a unidirectional causality running from inflation to growth.

Quadratic regression model results

Following the conclusions of extant literature, it was hypothesized that in Rwanda inflation exerts a negative effect on economic growth when it exceeds a certain threshold. To this end, a quadratic regression model was estimated to determine the level of the threshold.

Given the relatively small sample size (43 observations) and the use of annual data in this research, the number of lags was restricted to two in the estimation of the quadratic regression model in order to preserve the degrees of freedom. Hendry's (1995) dynamic general-to-specific approach was then adopted to derive a satisfactory model, which involves testing down the general model by successively eliminating statistically insignificant regressors to obtain the final parsimonious equation. In this process, population growth was not statistically significant, and therefore it was dropped.

The regression is estimated by means of an ordinary least squares technique. According to the results reported in Table 5, the goodness of fit of the model as reflected by the R^2 coefficient of determination is satisfactory. The quadratic regression model explains more than 97.2% of the variation in growth, and the t-values indicate that the main explanatory variables are statistically significant. The estimated Durbin Watson (DW) statistic rejects the hypothesis of serially correlated errors. Moreover, the F-statistic shows that the explanatory variables are jointly significant at the 5% significance level and the model successfully passes the conventional battery of diagnostic tests for serial correlation, normality, autoregressive conditional heteroskedasticity (ARCH), heteroskedasticity, and functional form, implying that the model is well specified and the results are valid for reliable interpretation.

In line with theoretical predictions and empirical evidence, both investment as a share of GDP (INV_t) and the financial development indicator (FD_t) are statistically significant in the model and have a positive impact on growth, while the openness variable ($OPEN_t$) is inversely related to growth. A change of 1% in investment as a share of GDP leads to an increase in the real output growth of 1.59%, while a change of 1% in openness reduces the output growth by 0.47%. It is worth noting that the positive impact of financial development on output growth appears with a one-period lag in the model, while the contemporaneous effect is negative. However, the cumulative effect of this variable on growth is positive.

The two dummy variables, Dummy1 and Dummy2, that are added to the model are both significant and have expected signs .The effect of the first dummy, Dummy1, is positive, capturing the growth-enhancing impact of the economic reforms implemented

in Rwanda during the 1990s and 2000s, while the effect of the second dummy, Dummy2, is negative, reflecting the destabilizing effect of the period of war and genocide in 1990–1994. Finally, the trend term, which attempts to account for other shocks that may have affected growth, is also significant.

Table 5: Results of the quadratic regression model

Modelling Δlny_t by OLS
The estimation sample is: 1971–2010

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	-0.0940325	0.09816	-0.958	0.346	0.0307
INV_t	1.59015	0.3857	4.12	0.000	0.3696
FD_t	-0.906142	0.5258	-1.72	0.095	0.0929
FD_{t-1}	1.45356	0.6835	2.13	0.042	0.1349
$OPEN_t$	-0.468994	0.1575	-2.98	0.006	0.2341
π_t	0.447460	0.2395	1.87	0.072	0.1074
π_t^2	-3.19526	0.5657	-5.65	0.000	0.5238
π^2_{t-1}	1.43867	0.3303	4.36	0.000	0.3955
Dummy1-2	0.0682334	0.02262	3.02	0.005	0.2388
Dummy2	-0.0937167	0.03853	-2.43	0.021	0.1694
Trend	-0.00428949	0.002031	-2.11	0.043	0.1333

R^2	0.971899
F (10, 29)	100.3 [0.000]**
log-likelihood	78.7526
DW	2.04
no. of observations	40
no. of parameters	11

Diagnostic tests			
AR 1- 4 test:	F (4, 25)	=	1.6093 [0.2031]
ARCH 1-1 test:	F (1, 27)	=	0.019707 [0.8894]
Normality test:	Chi^2(2)	=	0.0094802 [0.9953]
Hetero test:	F (17, 11)	=	0.39764 [0.9573]
RESET test:	F(1,28)	=	1.9589 [0.1726]

Regarding inflation, the coefficient of the linear term, π_t, has a positive sign, while the coefficient of the squared term, π_t^2, has a negative sign, as expected in this model. Moreover, both coefficients are statistically significant. These results suggest that low levels of inflation are growth-enhancing, while higher levels reduce growth,which implies that in this research, the relationship between inflation and economic growth is non-linear and may be described by an inverted U-shaped curve. In other words, these findings confirm the hypothesis that there does exist a turning point or threshold level of inflation above which inflation is detrimental to economic growth in Rwanda.

On the basis of the estimation results presented in Table 5, the threshold level of inflation was obtained in two steps: first, the partial derivative of the quadratic regression model was computed with respect to inflation, π_t; second, the partial derivative was set equal to zero and then solved for π_t to find the turning point, π_t^*. In solving for π_t, the steady state values were used, whereby current and lagged values

of inflation and squared inflation are taken into account. The calculation yielded the following results:

$$\delta\Delta lny_t/\delta \pi_t = 0.44746 - 2(3.19526-1.43867) \pi_t = 0 \quad (6)$$

$$\pi t^* = 0.44746-2(1.75659) \pi_t = 0 \quad (7)$$

It follows that the threshold level of inflation is:

$$\pi_t^* = 0.44746/3.51318 = 12.7\% \quad (8)$$

The above result suggests that economic growth peaks when inflation reaches the threshold level of 12.7%, corresponding to the growth maximizing inflation rate. It follows that in the context of Rwanda, inflation is growth-enhancing when it is below 12.7%, while its impact on economic growth becomes negative when it is higher than the threshold level.

This finding is consistent with the results of similar empirical studies on developing countries (Khan and Senhadji, 2001; Mubarik, 2005; Ahmed and Mortaza, 2005; Pollin and Zhu, 2005; Risso and Carrera, 2009; Singh, 2010), but more interestingly, the inflation threshold level in Rwanda falls within the ranges of the estimated thresholds in some specific country and panel studies for African countries.[5] For country-specific studies, the lowest threshold found was for South Africa (4%), while the highest was for Ghana (22.2%).

When comparing the level of the inflation target used for monetary policy purposes in Rwanda – around 5% – with average inflation rates and the corresponding output growth rates in the different sub-periods as shown in Table 2, it appears that the Rwandan economy performed better, in terms of economic growth, when the actual inflation rate was higher than the inflation target level.

The estimated threshold level of inflation, which is obviously higher than the policy inflation target, suggests that in the case of Rwanda there was still a wide range of higher inflation rates that were likely to be associated positively with economic growth. Therefore, it could be inferred that the adopted policy inflation target of 5% was too low,[6] which resulted in the implementation of unduly restrictive fiscal and monetary policies during the economic stabilization and structural adjustment programmes.

Some studies have pointed out that the adoption of such low policy inflation targets, especially in low-income countries where production capacity is not fully utilized and in which supply shocks are predominant, results in high opportunity costs in terms of foregone output growth and employment creation (Pollin and Zhu, 2005; Anwar and Islam, 2011).

6. Conclusion and policy implications

The main objective of this paper was to empirically examine the relationship between inflation and economic growth in Rwanda, and to investigate the existence of possible threshold effects between the two variables. To this end, a quadratic regression model using annual time series spanning 1968–2010 has been employed to estimate the threshold level of inflation. The result estimates of the quadratic regression model provided evidence supporting the hypothesis of a non-linear relationship in the inflation-growth nexus in Rwanda, and the existence of a threshold level of inflation above which inflation is detrimental to economic growth. The estimated threshold level is 12.7%. Moreover, the Granger causality test was performed to investigate the linear causation between inflation and growth in the regression model; the results of the test estimates revealed a unidirectional causality running from inflation to growth and no feedback effect from growth to inflation was detected, implying that the simultaneity bias would not seriously affect the coefficient of inflation in the regression model (Fischer, 1993; Khan and Senhadji, 2001).

This paper is the first attempt to address the threshold effect in the inflation-growth nexus in Rwanda. It is therefore crucial, as it provides a baseline study in search of the optimal inflation for growth in Rwanda. In addition, the findings of this research are consistent with the results of other recent similar empirical studies carried out on developing countries (Risso and Carrera, 2009; Singh, 2010), and in particular with results obtained in panel and specific country studies for African economies (Combey and Nubukpo, 2010; Frimpong and Oteng-Abayie, 2010; Quartey, 2010; Salami and Kelikume, 2010; Seleteng, Bittencourt and van Eyden, 2011; Leshoro, 2012; Ghazouani, 2012).

The analysis of this paper has important policy implications. First, the findings of the study revealed a significant difference between the inflation target used for policy purposes in Rwanda and the estimated inflation threshold. Since the monetary authorities have been targeting an inflation level of around 5% in the implementation of economic stabilization and structural adjustment programmes, one could infer in light of this research that monetary and fiscal policies applied in these programmes were tighter than necessary and that there was room for higher economic growth with a higher inflation rate without pushing the economy into an inflationary spiral.

It follows that, while the primary objective of monetary policy implemented by the National Bank of Rwanda is the achievement and maintenance of price stability, the monetary authorities should also be mindful of the trade-off between inflation, growth and employment in a developing country such as Rwanda in which the production capacity is not fully utilized and where supply shocks are predominant. Second, on the

basis of empirical evidence, this study suggests that the upper limit of the inflation target for policy purposes in Rwanda should be 12.7%, rather than 5%.This implies that more relaxed monetary policy should be pursued when inflation is lower than the threshold level, while a tighter stance should be adopted if inflation approaches that level.

Finally, although the objective of this research was to shed light on the relationship between inflation and growth in Rwanda, some important related issues have not been addressed, such as the channels through which inflation exerts a negative effect on economic growth and the impact of inflation variability on output growth. These are crucial issues that deserve substantial additional attention and should be investigated in future studies.

Notes

1. Other empirical studies using cross-sectional or panel data may have included Rwanda in their sample, but unfortunately the full list of countries was not provided.

2. Members of SADC are: Angola, Botswana, Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

3. The definition of inflation used in this paper is the headline inflation calculated on the basis of the Consumer Price Index (CPI), regularly published by the National Bank of Rwanda and the National Institute of Statistics of Rwanda. This definition was adopted for two main reasons: it is the most frequently used in empirical studies and it is available for the entire period covered by this research. The core inflation is also estimated by the National Bank of Rwanda for monetary policy purposes, however, it was first published only in 2004.

4. Government is defined as the ratio between Government expenditure and nominal GDP.

5. These studies dealt with the specific cases of Egypt (Kheir-El-Din and Abou-Ali, 2008); Ghana (Frimpong and Oteng-Abayie, 2010; Quartey, 2010); Lesotho (Seleteng, 2005); Nigeria (Salami and Kelikume, 2010) and South Africa (Leshoro, 2012). They also include panel studies: WAEMU countries (Combey and Nubukpo, 2010), SADC region (Seleteng et al., 2011) and MENA region (Ghazouani, 2012).

6. Even IMF economists recognized in a recent study that a wider range of inflation targets of 5–10% would be supportive of economic growth in low-income countries.

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Abstract

It is now widely agreed among economists, policy makers and central bankers that the main objective of macroeconomic policy is to achieve a high and sustained economic growth rate while maintaining a low inflation rate. It is also believed that high inflation has an adverse effect on economic growth. But how low should the inflation rate be not to impact negatively on economic growth?

Monetary authorities in Rwanda have been targeting an inflation level of around 5% for economic policy purposes. Was this inflation target the most appropriate for economic growth? Recent studies have demonstrated that, depending on the structure and level of development of the economy, inflation becomes detrimental to economic growth when it exceeds a certain threshold. Below this threshold the impact of inflation on growth is non-significant or even positive.

Against this backdrop, this paper assumes a non-linear relationship between inflation and economic growth and attempts to identify the existence of threshold effects between these variables in the case of Rwanda using a data set spanning the sample period 1968–2010. The existence of a threshold level above which inflation has an adverse effect on economic growth in Rwanda has been investigated by means of a quadratic regression model and the ordinary least squares technique. The results showed that at low levels inflation does not hurt economic growth, while at higher levels inflation reduces economic growth. The estimated inflation threshold level is 12.7%.

As the findings of this study have unveiled the estimated threshold inflation rate consistent with economic growth in Rwanda, they would provide some useful guidance to economic decision makers in designing a more appropriate macroeconomic policy framework.

JEL: *E31; C13; 040*
Key words: *Inflation; Economic growth; Threshold effects*

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