DYNAMIC RELATION BETWEEN INFLATION AND ECONOMIC GROWTH IN PAKISTAN: LINEAR VS. NON-LINEAR APPROACH

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بسم الله الرحمن الرحيم

Dedication
To My Teachers, Family and Friends

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ABBREVIATION AND ACRONYMS

2SLS	Two stage least square
3 G	Third generations
4G	Fourth generation
AD	Aggregate Demand
ADF	Augmented dickey fuller test
AIC	Akiek information criteria
AR	Autoregressive
ARDL	Autoregressive distribute lag
AS	Aggregate Supply
BD	Budget deficit
BIC	Basic information criteria
BISP	Benazir income support program
CIS	Common independent states
CNG	Compressed natural gas
CPI	Consumer price index
DUM	Dummy variable
DW	Durban Watson
ECM	Error correction model
ECT	Error correction term
EG	Engle Granger
EU	European Union
FDI	Foreign direct investment
G8	Group eight
GDPt	Gross domestic product at time t
GLS	Generalize least square
GMM	Generalize method of moment
IMF	International Mountry fund
INFt	Inflation rate at time t
INVt	Investment at time t
LSTAR	Logistic Smooth transition autoregressive
MS	Money supply
NAIRU	Non Acceleration Inflation Rate of Unemployment
NATO	North Atlantic treaty organization
NLS	Non-linear least square
OECD	Organization of economic cooperation and development
OLS	Ordinary least square
PML (N)	Pakistan Muslim league(Nawaz)
PP	Philips Perron
PPP	Pakistan people's party
PSTR	Penal smooth transition regression
QTM	Quantity Theory of Money
SBP	State bank of Pakistan
SC	Serial correlation
SSA	Sub-Sahara Africa

STAR	Smooth transition autoregressive
TAR	Threshold autoregressive
UK	United Kingdom
UN	United Nation
US	United States
USSR	United States of soviet Russian
VEM	Vector error matrix
WB	World Bank
WDI	World Development Indicators
Z.A	Zulfiqar Ali

ABSTRACT

This thesis attempts to investigate: i) the linear relationship between inflation and economic growth; ii) the existence of structural break in inflation and growth series and iii) the existence of threshold level of inflation using Smooth Transition Autoregressive Model (STAR) using Time Series data over the period 1972-2013. The analysis indicates the nonlinear relationship between inflation and GDP growth with 9.68 percent threshold level of inflation. There is a positive and significant relation below the threshold level; negative and significant; above the threshold level between inflation and economic growth. Therefore, it is desirable that the central bank and policy makers to keep inflation stable at single digit because it may be helpful for achievement of sustainable economic growth. The findings of this study are also consistent with the study of Khan and Sendji (2000) which suggests 7-11 percent threshold level of inflation for developing countries.

CHAPTER 1

INTRODUCTION

1.1 Background

It is generally believed that macroeconomic stability is prerequisite for sustained and high economic growth. Inflation is considered as a main indicator of macro-stability. To keep inflation stable and low, various policy reforms have been introduced by the policy makers which include on demand side control over money supply, rationalization of discount rate and on supply side efficient provision of infrastructure like energy and maintain good governance. Various efforts have been made to establish the link between inflation and economic growth with the main argument that low and stable inflation has a positive impact on economic growth while high and unstable inflation has adverse effects on the economic growth.

A bulk of literature investigates the relationship between inflation and economic growth of country as well as regional and/or world level. The available literature on the inflation-growth nexus portraits conflicting results on direction and significance. Based on the available literature, there are three competing stance about the relationship between inflation and economic growth.

One strand of literature argues that there is a positive relationship between inflation and economic growth (Bhatia1960, Johansen1967, Lucas1973, Malik and Chowdhury2001). The second strand of literature negates the positive relationship and found the negative relationship between these variables (Mundell 1963, Stockman 1981, Fischer 1993, Barro 1995, Brunno and Easterly 1995, Malla 1997 and Faria 2001). The third strand of literature finds that the relationship between inflation and economic growth neither positive nor negative (Wali1959, Dorrance1963, Levin and Zervos1993).

The prevailing contradictory outcome between the relationship between inflation and economic growth introduces the concept threshold or non-linearity in the inflation-growth nexus. Recent literature is more focused on finding the threshold level of inflation where the direction of relation changes from one domain to other i.e. negative/positive to positive/negative (Khan and Senhadji, 2001; Mubarik, 2005; Hussain, 2005; Iqbal and Nawaz, 2009; Ayyoub *et al.*, 2010; Rehman *et al.*, 2011). The studies conclude that below the threshold level, inflation positively influence the growth while above the threshold level, inflation depresses the growth.

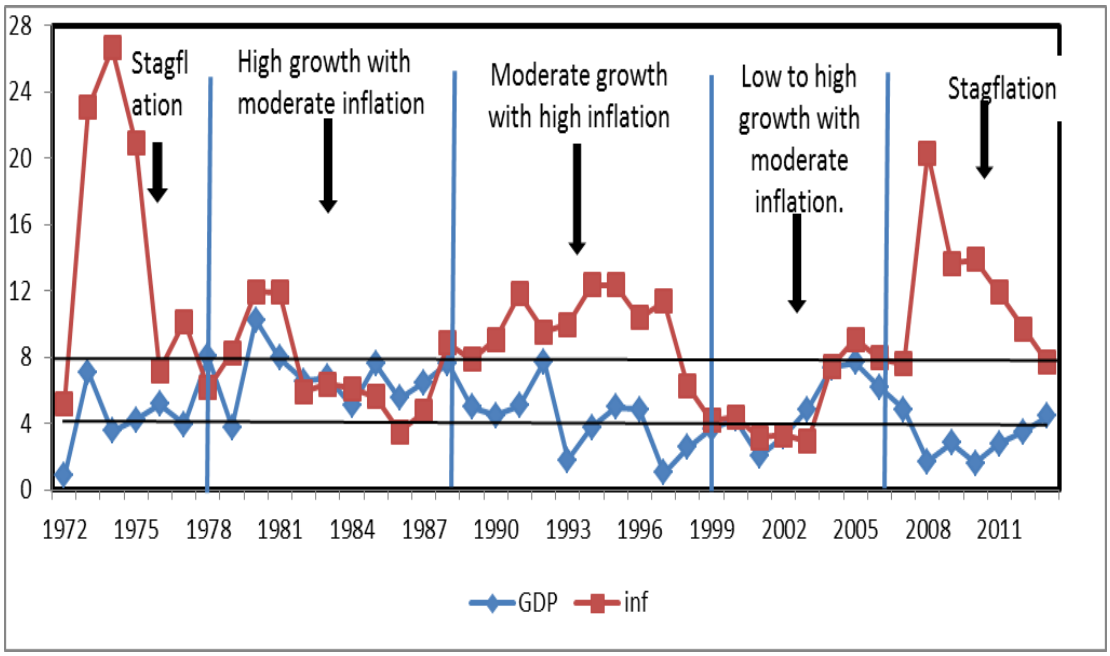
There are different channels through which inflation can effect economic growth in non-linear fashion. Investment may be as an important channel through inflation effect economic growth. The general perception about the relationship between inflation and growth is that low and stable rate of inflation positively accelerates the economic growth. Low level of inflation means prices are likely to be stable and price stability therefore boosts investments in the country. In the long- run anticipated change in inflation are impartial but precise prediction of future inflation is a difficult task. However a considerable body of literature argues that high and volatile rate of inflation creates welfare loss of the society *i.e.,* economic growth in long-run. High inflation is likely to cause uncertainty about the future profitability of investment projects and eventually halted economic growth. In case of high inflation conservative monetary authority increases the interest rate to curb the inflation which deteriorates the investment in the country. In case of developing countries, it is debated that inflation is supply shock phenomenon and volatility in inflation adversely affect the investment and consumption (Singh and Kalirajan 2003). These studies further argue that, in less developed countries, high and volatile inflation puts pressure on government hence invites government interventions in goods and

financial market so prices become inappropriate to judge the macroeconomic policies and action of the economic agents which further creates macroeconomic instability. In this context the nexus between economic growth and inflation has been tested both empirically and theoretically for developing and developed economies and empirical findings were in line with the view of non-linear nexus between real economic activity and inflation.

1.1. Motivation and Problem Statement

Like other developing countries, the prime objective of macroeconomic policies in Pakistan is the price stability along with sustained economic growth. Moreover there is a widespread conflicting and dissimilar literature on the nature of the relationship between inflation and economic growth in Pakistan. The figure 1.1 depicts the relationship between inflation and GDP growth over the period from 1972-2013.

Figure 1.1: Graphical Presentation of Inflation Growth Nexus from 1972-2013



Source: Author's own formulation based on data from World Bank, (2015)

As shown from the figure 1.1 there are two bands, upper band represents 8 percent average inflation rate and lower band 4 percent minimum economic growth. Pakistan has experienced cyclical pattern of economic growth over the last four decades. There are episode of high growth followed by low economic growth. Similar pattern has been observed for inflation. High inflation is linked with low economic growth and vice versa. It is important to note here that high economic growth since 1980 has been observed along with lower level of inflation. After 1988 economy witnessed a new phenomenon moderate growth along with high inflation rate. Between1999 to 2007 observed that the economy moved low to high economic growth with moderate inflation and then economy again shown stagflation. More recently, a low inflation has contributed significantly in stabilizing economic growth especially after financial crisis.

Several studies have analyzed the non-linear relationship between inflation and economic growth in Pakistan including Khan and Senhadji (2001), Mubarik (2005), Hussain (2005), Iqbal and Nawaz (2009) Ayyoub *et al.*, (2010), and Rehman *et al.*, (2011). Finding of these studies vary substantially in term of nature of relation and threshold level. Mubarik (2005) signposted that the threshold level of inflation is 9 percent and inflation above this rate has hostile impact of economic growth in Pakistan. The study of Hussain (2005) marks the findings that inflation rate over and above to 4-6 percent will be constraint for economic growth in Pakistan. The study of Iqbal and Nawaz (2009) supports the existence of nonlinear nexus between inflation and economic growth in Pakistan with two threshold level of inflation. By the same token the studies conducted by Khan and Senhadji (2001) and Budekin (2000) respectively establish 11 % and 3 % of threshold level of inflation for developing countries including Pakistan. However Hussain (2005) argues that inflation is not a

monetary phenomenon in Pakistan. Hussain (2005) further argues that demand and supply forces determined the inflation in Pakistan and there is no threshold level of inflation in Pakistan. The study of Rehman (2011) investigates the presence of Smooth Transition Autoregressive (STAR) nonlinearity in inflation series for Pakistan covering the data interval from July 1992 to February 2011 and find that underlying data generating process support the inflation nonlinearity in Pakistan. These empirical studies for Pakistan draw contradictory results about the nexus between inflation, economic growth and threshold level of inflation. There can be several reasons for contradictory findings of these studies including econometrics methodology, different time period used in these studies. The previous studies do not take into account the structural break presence in the data while analyzing the inflation and GDP growth nexus. Espinoza (2010) argue that the structural breaks occur instantaneously in inflation growth nexus.

The nexus between inflation and output growth is very complex. However literatures support the view that at a low level of inflation, there is positive nexus between output growth and inflation but at high level of inflation this nexus may be inverse (Espinoza 2010). When inflation exceeds the threshold level, there would be a need for policy change to curb the inflation within its limit. There are several aspects of interest attached with this study. First and most important, this study mainly focuses on nonlinear nexus between inflation and output growth in Pakistan. Secondly, economy of Pakistan has been subject to prominent economic instability because of political instability and structural change. The economic instability may lead to complex nexus between inflation and output growth. This study will take into account the structural breaks. Keeping in mind the contradictory results of previous study regarding inflation-output nexus for Pakistan, the prime objective of this study

is to examine the nexus between inflation and output growth for Pakistan by using a Logistic Smooth Transition (LSTAR) model.

1.2. Objectives

The overall objective of this thesis is to investigate the nature of relationship between inflation and economic growth using time series data over the period 1972-2013. More specifically, this thesis has the following objectives:

i. To analyze the linear relationship between inflation and economic growth
ii. To investigate the existence of structural break in inflation and growth series
iii. To find the threshold level of inflation using Smooth Transition Autoregressive Model (STAR)

1.3. Significance of the Study

This study is significantly different from earlier studies in two aspects. First, the modern approach of Logistic Smooth Transition Autoregressive (LSTAR) model has been used in this study. Logistic Smooth Transition (LSTAR) is an appropriate technique to capture the nonlinear effect of inflation on economic growth. Earlier studies capture the nonlinearity of inflation by using the dummy variables or square term of inflation in the estimation models. Second, in this study we use dummy variables to capture the structural break to avoid the biased estimation results.

1.4. Organization of the Thesis

Rest of the study is schematized in four thematic frameworks such as: Chapter 2 provides the brief overview of Pakistan's economy since 1972-2013, and explored the nexus between inflation and economic growth. Chapter 3 consists of review of theoretical and empirical the findings of previous studies that focused on the nexus

between inflation and output growth. Chapter 4 depicts the data and the econometric methodology applied in this research. Chapter 5 presents the empirical results and discussion, and Chapter6 provides a conclusion and policy recommendations.

CHAPTER 2

HISTORICAL TRENDS OF INFLATION AND GDP GROWTH IN PAKISTAN

2.1 Introduction

Before proceeding to formal analysis of relationship between inflation and economic growth, it is essential to look at the historical trend of inflation and economic growth. The trend analysis provides the behavior of these important economic indicators in the light of economic policies adopted during different political regimes. As the core objective of central bank is to keep inflation low and stable while government is trying to maintain high and sustained economic growth. This trend analysis aligns these two objectives using time series data over the period 1972-2013. For deeper analysis the whole data set (1972 to 2013) has been divided into five Regimes

- 1972-1979 (Nationalization and Fiscal Crisis)
- 1980-1989 (Growth and Privatization)
- 1990-1999(Structural Adjustment and Deeping Crises of the Economy)
- 2000-2007 (Growth and Openness)
- 2007-2013 (Debt Burden and Budget Deficit)

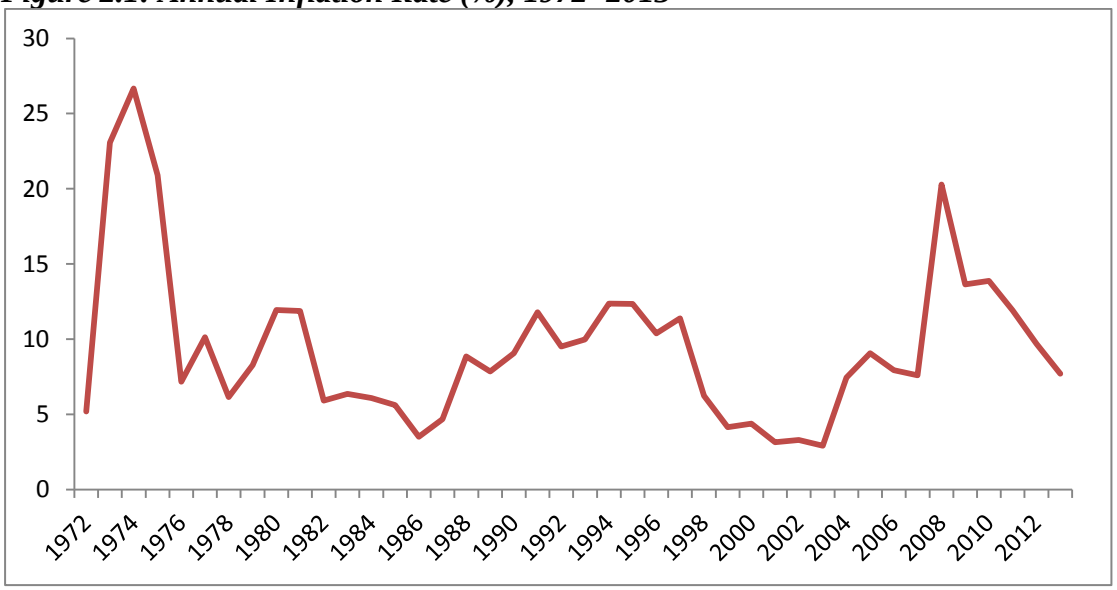
The first part of this chapter 2.2 presents the historical analysis of the inflation and second portion 2.3 focuses on economic growth and final section 2.4 presents the conclusion of the relation between inflation economic growths.

2.2 Historical Analysis of Inflation in Pakistan

The overall average inflation rate 9.52 percent with 5.31 percent standard deviation during the study period (1972 to 2013), 2.91 percent and 26.26 percent is the minimum and maximum inflation rates respectively .Which indicated that there has been major fluctuation in the inflation level of Pakistan. The standard deviation indicates spread of data of its mean. If the value of standard deviation is low it means that the spread of data from its average value is low. If the value of standard deviation is high, it indicates that the data spread is high from its average value.

The decade 1972 to 1979 recorded an average inflation rate 13.44 percent which is higher in all five decades .The main reason of high inflation in this decade is the nationalization, oil price shock, land reforms, decrease in private investment, devaluation of the domestic currency up to 120% and political disturbance.

Figure 2.1: Annual Inflation Rate (%), 1972 -2013



Source: World Bank (2015)

During1980 to 1989 has been reported the average inflation 7.27% which is lower than the earlier decade. Denationalization, assigning more economic role to the

private sector and in this period government offered number of incentives such as low interest credit, duty free imports of machinery and tax holidays were the main reasons of reducing the inflation. 1990 to 1999 observed 9.72% average inflation rate which is more than the previous decade. Political instability, corruption, widening budget deficit, worse balance of payment, devaluation in domestic currency and weak law and order situation were the main reasons of increase in the inflation level during this period.

The period 2000 to 2007 witnessed the average level of inflation 7.97 percent which lower than the previous decade. The main reason of reducing the inflation were the inflow of FDI, aid and low interest credit from international agencies, , rescheduling debt due to the war on terror after 9/11 attacks because Pakistan and US became close ties in Afghan War.

Table2.1: Analysis of Inflation (%) in Different Regimes

Years	Mean	Std.Dev	Min	Mix
1972-1979	13.44	8.63	5.18	26.26
1980-1989	7.27	2.86	3.51	11.94
1990-1999	9.72	2.69	4.14	12.37
2000-2007	5.72	2.53	2.91	9.06
2008-2013	12.85	4.35	7.69	20.28

Source: World Bank (2015)

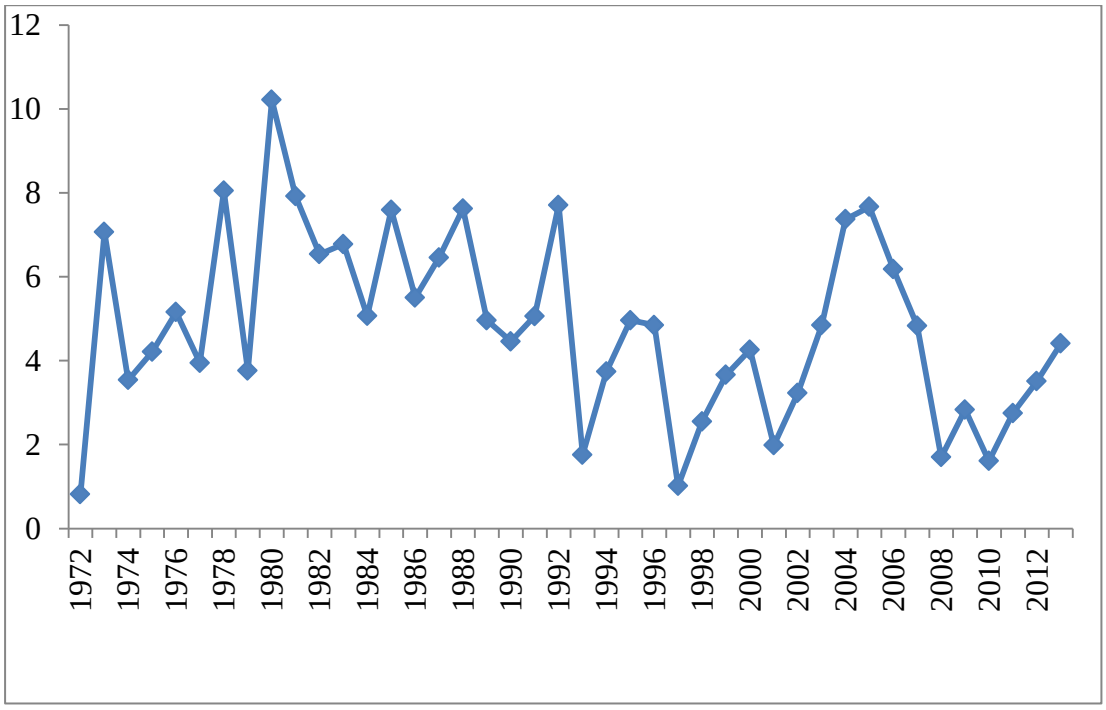
Finally 2008 to 2013 reported the average inflation 12.85% and reasons of increase in this phenomenon were, oil price shock, international financial crises, energy shortage, corruption, cost of war on terrorism, increasing debt burden, higher budget deficit and deficit in balance of payment. Table 2.1 present the useful

information about the inflation during the study period 1972 to 2013 regime wise i,e. mean, standard deviation, minimum and maximum values in percentage.

2.3 Historical Analysis of GDP Growth in Pakistan

Figure 2.2 in following portraits the GDP growth during the study period 1972 to2013.

Figure 2.2: Annual GDP Growth (%), 1972 -2013



Source: World Bank (2015)

In 70s the average GDP growth 4.57 percent was observed .The main reasons of low growth during this period were the political disturbance, war with India and international oil price shock. During this period macroeconomic management shifted towards nationalization. Political disturbance lead to the separation of former East Pakistan. Nationalization of banking sector has broken the link between saving and investment and this affected the growth negatively. The decade of 1980s was market by privatization, deregulation and liberalization policies. The average growth rate

during this period was observed 6.87 percent. During this regime economic indicator was stable with low inflation and high GDP growth.

For the period 1990 to 1999 was observed low GDP growth which averaged 3.98 percent. The reasons of low growth were the political instability, weak law and order situation, inconsistency in economic policies, deficit in budget and balance of payment. Through the period 2000 to 2007 the average GDP growth was 5.04 percent. The main reason of increasing the growth rate during this era were the better macroeconomic management policies, increasing foreign direct investment and aid from US ,good governance and accountability, openness and increasing in remittances.

During the period 2008 to 2013 the average GDP growth was observed 2.80 percent. Oil price shock, bad governance and corruption, worse law and order situation, high food prices, decrease in foreign direct investment, increase in debt burden, deficit in budget and BOP were the main reasons of low growth in this regime.

Table2.2 Analysis of GDP Growth (%) in Different Regimes

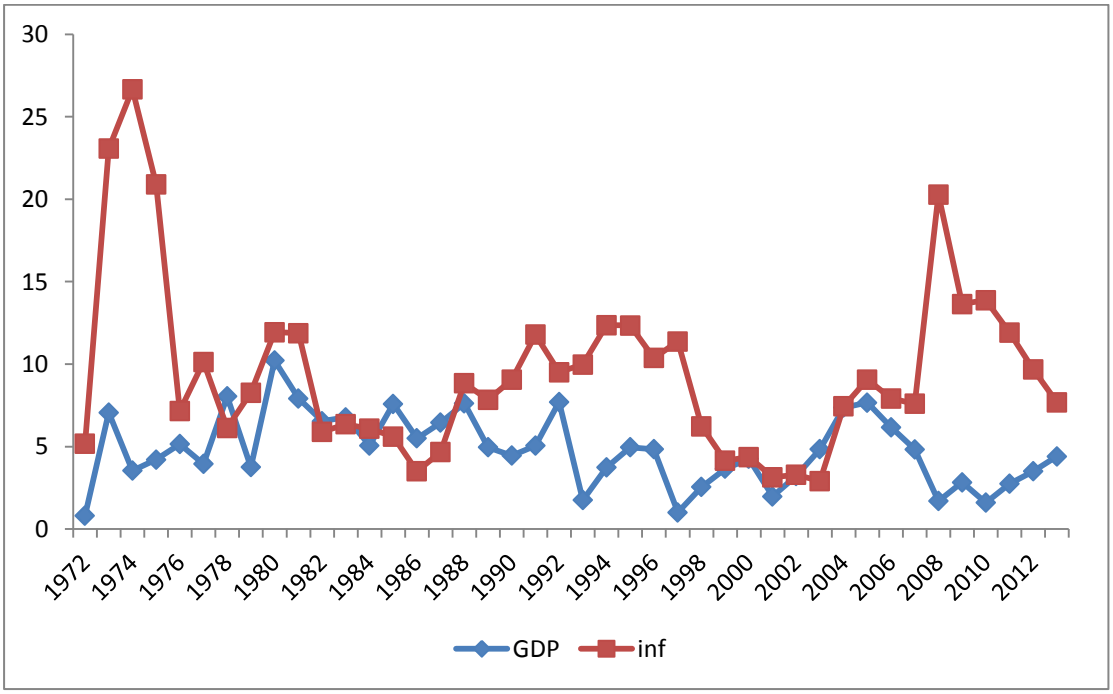
Years	Mean	Std.Dev	Min	Mix
1972-1979	4.57	2.24	0.81	8.05
1980-1989	6.87	1.58	4.96	10.22
1990-1999	3.98	1.91	1.01	7.71
2000-2007	5.04	1.96	1.98	7.67
2008-2013	2.80	0.81	1.61	4.41

Source: World Bank (2015)

2.4 Conclusion

In the light of above discussion in section 2.2 and 2.3 we concluded that there was observed unstable relationship between inflation and GDP growth and the figure 2.3 also confirms that major fluctuations in these variables. During the period 1972 to 1979 and 2008 to 2013 shows high inflation 26.66 percent and 20.28 percent in maximum terms respectively. The maximum GDP growth 10.22 percent in 80s was observed and minimum growth 0.81 percent seen in 70s.

Figure 2.3: Annual Inflation (%) and GDP Growth Rates (%)



Source: World Bank (2015)

The figure 2.3 presents trends of inflation and economic growth in percentage of the study period 1972-2013.Trends of GDP growth looks like same as with trends of inflation. By the visual examination of the above figure 2.3 we understand the inflation growth nexus in better ways.

CHAPTER 3

LITERATURE REVIEW

3.1 Introduction

This chapter consists on conceptual framework and empirical findings of previous studies that focused on the inflation growth nexus. We mainly focused on the studies which deal with linear versus non- linear nexus between inflation and output growth for Pakistan as well as for rest of the world. Section 3.2 of this chapter deals with the conceptual framework and empirical studies are presented in section 3.3.

3.2 Conceptual Frame Work

Each school of thought makes particular contribution to the inflation growth relationship. Classical school of thought believes on supply side and more emphasis on the need for incentives to save and invest in the economy to increasing economic growth. Keynesians and Neo-Keynesians presented the AD-AS frame work for linking inflation and economic growth. Monetarist presented the QTM while Neo-Classical conducted the effects of inflation on economic growth through investment and capital accumulation. We shortly overview the theoretical views of these schools of thoughts about the nature of relationship between inflation and economic growth.

Adam Smith is the founder of the Classicals and he written the book "The Wealth of Nations" in 1776.Classicals believe in market based economy and supply side. They predict that there is negative relationship between inflation and economic growth because rise in prices lead to reduce the firms profit through higher wages.

Keynes in 1936 developed AD-AS model to show the relationship between inflation and economic growth. According to this model AS curve is upward slopping in short run and in long run AS curve is vertical so due to this there is short run

tradeoff between inflation and output growth but there is no permanent trade off in the long run.

Milton Friedman is the head of Monetarists. They focus on the long run supply side properties of the economy. They suggest that prices are mainly affected by the money growth in long run and there is no real effect on output. If money growth rate higher to the output growth rate then inflation will occur.

Neo-Classical economist presents different views about inflation growth relationship. Mundell (1963) developed a model relating to inflation and output growth. This model indicates that people's wealth decreases as inflation increases. Tobin (1965) extended the Mundell model further and concludes that output level rises permanently at higher inflation rate. This predicts the positive relationship between inflation and economic growth (Choi et al 1996). Sidrauski (1967) analyzing that steady state capital does not affected by the increase in inflation rate so there is impact on output and economic growth. Stockman (1981) developed a model, in this model his findings that due to increase in inflation rate both are decline i.e. steady state level of output and people's welfare. In summary an increase in inflation can yield higher output (Tobin Effect) or lower output (Stockman Effect) or no change in output (Sidrauski Effect).

Neo-Keynesian introduce the idea of 'potential output' and this theory reveals that; inflation depends on the level of actual output and the natural rate of employment or (NAIRU) non-acceleration inflation rate of unemployment .NAIRU is the unemployment rate at which the inflation rate is neither rising nor falling. If output above its potential and unemployment is below the NAIRU, all else equal then inflation will accelerate. If output below its potential level and unemployment above

the NAIRU, all else equal then inflation will decrease. If output equal to its potential and the unemployment rate is equal to NAIRU then inflation same neither increasing nor decreasing.

In conclusion, we can say that the inflation growth relationship is controversial and mix in theoretical literature review. Each economic theory makes its particular contribution and these theories do not favor accelerating inflation. According to these theories inflation growth relationship may be positive, negative, neutral or non-linear.

3.3 Empirical Review

The inflation-GDP growth nexus has been extensively studies in the literature, however some influential studies in the regards are Fisher (1993), Bruno and Easterly (1998), Khan and Senhadji (2001), Gylfason and Herbertson (2001), Singh and Kalirajan (2003), Burdekin *et al* (2004), Bick (2010), Bittencourt (2012) among others. The first study which investigated the nonlinear nexus between inflation and GDP growth was Fisher (1993). Fisher (1993) and Bruno and Easterly (1998) found a nonlinear nexus between inflation and GDP growth and concluded that high inflation has negative impact on growth. With the same line of research Khan and Senhadji (2001) investigated the threshold level of inflation for developing countries and estimate 11 percent threshold level of inflation. According to this study inflation rate above 11 percent has significant negative impact for the growth of developing countries while below this rate has no significant impact for the economies of developing countries.

Gylfasoon and Herbertsson (2001) the interaction between inflation and growth by incorporating money and finance in an optimal growth frame work with constant return to scale. They include saving and real interest rate, velocity of money and financial development, government budget deficit and tax revenue in the model

and conclude that inflation rate excess of 10-20 percent per year is generally detrimental to economic growth.

Empirical estimation of Singh and Kalirajan (2003) for India over the period from 1971-1998 suggest that there is no threshold level of inflation for India. Burdekin *et al.*,(2004) argue that nonlinear nexus between inflation and growth are different for developing and develop countries and found that threshold level of inflation falls within the range of single digit. Burdekin *et al.,* (2004) further argue that ignoring the nonlinearity while estimating effect of inflation on growth cause downward biased. Bettencourt (2012) study focuses on nexus between inflation and growth for four Latin American countries for the period of 1970-2007 and conclude that inflation has had a detrimental effect on growth for panel of four Latin American countries.

Some important previous studies for Pakistan include Qayyum (2006), (Qayyum and Bilquees (2006), Khalid (2006), among others. These studies are based on linear nexus between inflation and GDP growth. Qayyum (2006) findings suggest that the money supply growth at first round affects real GDP growth and at the second round it affects inflation in Pakistan. The findings of Khalid (2006) suggest that imported inflation, seigniorage, and openness caused inflation in Pakistan. The result also indicates that imported inflation, deficit-GDP ratio, seigniorage, money depth, exchange rate depreciation and domestic credit may be important determinants of inflation in Pakistan.

Barro (1995) estimate the inflation growth nexus for 100 countries from the data set 1960—1990 by using ordinary least squares (OLS) .He finds the negative nexus between inflation and growth .He also finds an increase in average inflation by

10 percentage points per year a reduction of the growth rate (per capita) of GDP by 0.2—0.3 percentage points per year.

Bruno and Easterly (1996) analyzed and address the issue of inflation growth nexus for the data 1961—1992.The study finds that there is no nexus between inflation and economic growth at annual inflation rate less than 40%.

Anders and Hernando(1999) studies OECD (organization of economic cooperation and development) countries during the period of time 1960—1992 using ordinary least square(OLS).They mentioned that there is a significance negative correlation between inflation and economic growth.

Another study is conducted by Gosh and Phillips (1998) writing a paper "Warning: inflation may be harmful to your growth" In this paper they find that very inflation is bad for economic growth using panel regression. They also find that economically signifying negative nexus between inflation and economic growth.

Mamo and Lin(2012) investigate the nexus between inflation and economic growth using the panel data of 13SSA(Sub Saharan Africa) countries from 1969—2009.Taking GDP growth as dependent variable and inflation, investment ,population, initial GDP as independent variable .They find strongly negative nexus between inflation and economic growth. The causality runs uni-directional from inflation to GDP growth.

Khan and Senhadji (2000) examine the issue of the existence of threshold level effects in the nexus between inflation and economic growth. The data set of 140 countries in which included develop and developing countries covers the period 1960--1998.They use the Generalized Least Square(GLS) method and Two Stage

Least (2SLS) method. The data suggest that the threshold level is 7%—11% for developing countries and 1%—3% for developed countries. The threshold level of inflation of developing countries is higher than the developed countries. The empirical results strongly show that the nexus between inflation and economic growth beyond the threshold level is negative effects on the economic growth.

Li (2005) explore the nexus between inflation and economic performance by using the data of 118 countries in which 90 developing countries and 28 developed countries over the time period 1961--2004 by employing ordinary least square (OLS).He finds that there is nonlinear nexus between inflation economic growths. Furthermore he investigates that developing countries and develop countries show different forms of nonlinearities in the inflation growth nexus .For developing countries there is two threshold level of inflation exist ,the rate of inflation below the first threshold level of inflation, the impact on economic growth is insignificant and even positive, between two threshold levels of inflation the effect is significant and strongly negative, at extremely high rates of inflation the marginal impact of additional inflation on economic growth diminishes. For developed countries only one threshold level is detected and proved significant.

Rousseau and Wachtel (2002) estimated the nexus between inflation threshold and the finance growth about 84 countries from1960—1995 using ordinary least square (OLS) technique. According to this study financial depth has a positive effect on economic growth only when inflation falls below a threshold level that varies between 13% to25%.The effects becomes significantly positive when inflation falls below a threshold level of inflation about 6% to 8%.Inflation has a negative effect on financial depth when the inflation rate is 15% to20%.

Sergii (2009) explored the inflation growth nonlinear nexus evidence from CIS (common independent states) countries for the period 2001—2008.He finds that the nexus between inflation and economic growth is strictly concave with some threshold level of inflation. Inflation threshold is estimated using a non-linear least square (NLS) technique. The main finding is that when inflation level is higher than 8% economic growth is slow down otherwise it is promoted.

Jude and Khan(2013) using a large panel data 1960-2009 of 102 developed and developing economies using PSTR(Panel smooth transitional regression) and dynamic GMM(Generalized method of moments) technique. They verified the fact that inflation growth nexus is nonlinear and there exist certain threshold level of inflation. The inflation above this threshold is harmful below this level enhancing the economic growth. They also find developing economies threshold level of inflation high than developed economies threshold level of inflation.

Kremer,Nautz and Bick(2008) investigate the inflation growth nexus for the data 1960—2004 of 63 industrial and non-industrial countries based on modified panel threshold model. They find 2% and 12% threshold level for industrial and non-industrial countries respectively. The inflation below the threshold significantly positive and above hampers the economic growth.

Raphael, Leon and Prasad (2010) estimating the inflation growth nexus a smooth transition model using a panel of 165 countries for 1960—2007.They find the 10% threshold level of inflation and above threshold level inflation becomes harmful to economic growth .Inflation threshold level is much lower for advanced countries. They find the nonlinear nexus between inflation and economic growth.

Raul,Trupkin,Maxico and Montevideo (2014) analyzed the nexus between inflation and economic growth .They using a panel data of 124 countries for the period 1950—2007 and apply panel smooth transition regression (PSTR) model. They find nonlinear nexus between inflation and economic growth estimate 4.1% and 19.1% threshold level of inflation for industrial and non-industrial countries respectively.

3.3.1 Country Specific Evidence

Faria (2001) investigate the nexus between inflation and economic growth in Brazil for 1980—1997 by applying vector autoregressive (VAR) technique .This study finds that inflation does not impact on real output in long run but in the short run there exist a negative effect .

Gokal and Hanif (2004) studied inflation growth nexus in case of Fiji for time period 1970—2003 by employing Granger causality test. The results show that there is weak negative link between inflation and economic growth while causality in uni-directional runs from economic growth to inflation.

Marbuah (2011) investigate the nexus between inflation and economic growth for Ghana using annual data set 1955—2010 by employing Zivot and Andres test .He finds that the inflation threshold levels 6% and 10%.The inflation below 6% is minimum and between the range 6% to 10% is moderate and above 10% is the harmful for the economy.

A time series analysis has been conducted by Grima (2012) for the economy of Ethiopia 1980—2011 by using vector autoregressive (VAR) model. The study shows that an increase in economic growth decrease inflation but inflation does not have significant effect on economic growth in the short run .It also shows that

economic growth has forecasting power about inflation but not vice versa. The study shows that there is significant negative nexus between inflation and economic growth in the short run but in the long run there is no significant effect of inflation on economic growth.

Kasidi (2013) examined the impact of inflation on economic growth for the economy of Tanzania 1990—2011. This study used reduced form regression equation and indicates that inflation has negative impact on economic growth .It also shows that there is no nexus between inflation and economic growth in the long run.

3.3.2 Summary of Empical Review of Country Specific Evidence:

The following table 3.1 presents the summary of empirical literature review of inflation growth relationship about country specific evidence

Table 3.1 Summary of Empirical Review of Country Specific Evidence

Auther(s)	Methodology/Period	Findings
Faria and Carneiro (2001)	VAR/1980-1997	• Negative nexus between inflation and economic growth in short run while no relationship in long run
Gokal and Hanif (2004)	OLS/1970-2003	• Weak negative nexus between inflation and economic growth
Marbuah(2011)	Z.A test,Engle Granger/1955-2010	• Non-linear nexus between inflation and economic growth at 6% and 10% threshold level of inflation
Grima(2012)	VAR/1980-2011	• Negative nexus between inflation and economic growth in short run while in long run there is no relationship to these variables
Faraji and Kasidi (2013)	ILS/1990-2011	• Negative nexus between inflation and economic growth in short run while in long run there is no relationship to these variables

3.3.3 Asian Experience

Malik and chowdhury (2001) investigate inflation growth nexus for four South Asian countries Bangladesh (1974—1997), India (1961—1997), Pakistan (1957—1997) and Sri Lanka (1966—1997).They finds long run positive nexus between inflation and economic growth by using OLS technique.

Jayathiuke and Ratheneyke (2013) testing the nexus between inflation and economic growth in short run and long run in Asian Economies over the time period 1980—2010 using the methodology of co integration and causality test .The results shows negative significant nexus exist between inflation and economic growth in the long run in Sri Lanka. There is no significant nexus were found in China and India in the long run but in the short run negative significant nexus were found in China. There is unidirectional causality runs from economic growth to inflation in China.

Vineyagathasen (2013) studies the inflation growth threshold level for Asian Economies over the time period 1980—2009 by using Panel Threshold growth regression technique. He finds 5.43% threshold level of inflation, there is no effects below this level of inflation on economic growth.

Thanh (2012) analyzed the threshold effects of inflation in the ASEAN-5 (Association of South East Asian countries) over the period 1980—2011 by using Panel Smooth Transition Regression (PSTR) and Generalized Method of Moments (GMM) technique. The study finds there exist a significant negative nexus between inflation and economic growth above the threshold level 7.84%. The central banks and policy makers should keep inflation below threshold level to promote economic growth.

Ahmed and Mortaza (2005) analyzed the inflation growth nexus in Bangladesh for the time period 1981—2005 using co-integration and error correction model (ECM).There findings shows the significant negative long run nexus between inflation and economic growth . They also estimate 6% threshold level of inflation, the inflation above threshold level adversely affects the economic growth .The central bank and policy makers should keep inflation below the 6% to enhance the economic growth.

Hussain, Ghosh and Islam (2011) investigate the inflation growth nexus in Bangladesh for the time period 1978—2010 by using Augmented Dickey—Fuller (ADF) test, Phillips—Perron (PP) test Co-integration and Vector Autoregressive (VAR) model. The results shows there is no co-integration nexus between inflation and economic growth .They also find the unidirectional causality from inflation to economic growth.

Zia-ur-Rehman (2012) examine the empirical nexus between inflation and economic growth in Bangladesh for the time period 1976—2011.He used vector autoregressive (VAR) methodology .This study shows that inflation and economic growth have a statistically significant negative nexus in the long run for the economy of Bangladesh.

Salian and k (2010) examine the nexus between inflation and GDP growth in India for the annual data set 1972—2008 by employing co integration ,Engle Granger and Error Correction Model(ECM) .The results shows negative nexus between inflation and GDP growth in the long run .

Bhaduria (2013) revisiting the growth inflation nexus in India for the time period 1976—2007 by using wavelet multi resolution analysis. The results show

strong negative nexus between inflation and economic growth in the short run but insignificant in the long run.

Cooray (2013) studied the nexus between inflation and economic growth in Sri Lanka for the period 1972-2001 using vector autoregressive (VAR) model .He find the nonlinear nexus between inflation and economic growth .The study showing a positive nexus up to 11% of inflation after this level of inflation it is negative.

3.3.4 Summary of Empirical Review of Asian Experience

The following table 3.2 presents the summary of empirical literature review of the nature of relationship about inflation and economic growth in case of Asian countries.

Table 3.2 Summary of Empirical Review of Asian Experience.

Auther(s)	Methodology/Period	Findings
Malik and Chowdhury (2001)	OLS/1966-1997	• Positive nexus between inflation and economic growth in the long run
Jayathinke and Ratheneyke(2013)	VEM/1980-2010	• Negative nexus between inflation and economic growth in Sri Lanka and China in the long run
Vineyagathasen (2013)	GMM/1980-2009	• Non-linear nexus between inflation and economic growth at 5.43% threshold level of inflation
Thanh (2012)	GMM/1980-2011	• Non-linear nexus between inflation and economic growth at 7.84% threshold level of inflation
Ahmed and Mortaza (2005)	ECM/1981-2005	• Non-linear nexus between inflation and economic growth at 6% threshold level of inflation
Hussain, Ghosh and Islam (2011)	VAR/1978-2010	• Uni directional causality running from inflation to economic growth • No cointegration between inflation and economic growth
Zia-ur-Rehman (2012)	VAR/1976-2011	• Negative nexus between inflation and economic growth in long run
Salian and K(2010)	ECM/1972-2008	• Negative nexus between inflation and economic growth in long run
Bhaduria (2013)	WMRA/1976-2007	• Negative nexus between inflation and economic growth in short run while no relationship in long run to these variables
N.S.Cooray (2013)	VAR/1960-2010	• Non-linear nexus between inflation and economic growth at 11% threshold level of inflation

3.3.5 Evidence for the Case of Pakistan

Mubarak (2005) discovered the threshold level of inflation for Pakistan by using annual data 1973—2000 by applying Granger Causality test. This test defines causality direction from inflation to economic growth and vice versa .He estimates the 9% threshold level of inflation for Pakistan economy. The inflation below this threshold level is favorable for the economy but the inflation above this threshold level bad for the economy.

Manzoor Husain (2005) find that there is no threshold level of inflation for Pakistan .They study finds that 4%--6% range for inflation threshold using the data set 1973—2005.His estimation is based on ordinary least square(OLS) .On the basis of this study it is desirable to keep inflation 4%--6% in Pakistan to promote economic growth .His findings are contrast to Mubarak(2005) and similar to Singh which suggest4%--7% inflation target for India.

Shahzad Husain (2011) using annual data 1960—2006 and employing co integration and Error Correction Model (ECM) finds that inflation is positive related with economic growth in Pakistan and vice versa. The causality between inflation and economic growth is found to be uni-direction (e.g.) inflation causing growth but growth is not causing inflation .The results justified the Tobin portfolio shift effect .The Granger causality test check the linear causation implies that inflation affects growth at lag three while there is no reverse causation from economic growth to inflation. His empirical findings also demonstrate that there is significant nexus between the two variables in the long run .He also finds that the 9% threshold level above this level lower the economic growth in Pakistan. This result is consistent with Mubarak (2005) .Blow this threshold level of inflation is suitable for economic growth.

Ayyoub (2011) investigates the nexus between inflation and economic growth using annual time series data 1972—2010 for Pakistan by applying ordinary least square (OLS) technique .A negative and significant inflation growth nexus has been found .The results indicates that persistent increase in the general price level hurts the economic growth .This study also finds the feasible threshold level 7% of inflation. Inflation below this level brings positive impact to the economic growth. But above

this threshold level of inflation may hurt economic activity .This study recommended to keep inflation below the level of 7% in the economy.

3.3.6 Summary of Empirical Review in Case of Pakistan

The following table 3.3 presents the summary of the empirical literature review about the relationship between inflation and economic growth in case of Pakistan.

Table 3.3 Summary of Empirical Review In Case of Pakistan

Auther(s)	Methodology/Period	Findings
Mubarak (2005)	OLS,2SLS/1973-2000	• Non-linear nexus between inflation and economic growth at 9% threshold level of inflation
Manzoor Hussain(2005)	OLS,2SLS/1973-2005	• Non-linear nexus between inflation and economic growth at threshold range of inflation 4% to 6%
Iqbal and Nawaz (2009)	OLS/1961-2008	• Non-linear nexus between inflation and economic growth with two threshold level of inflation 6% and11% while single threshold level of inflation is 7%
Shahzad Hussain (2011)	OLS/1961-2006	• Non-linear nexus between inflation and economic growth at 9% threshold level of inflation
Ayyoub(2001)	OLS/1972-2010	• Non-linear nexus between inflation and economic growth at 7% threshold level of inflation

CHAPTER 4

METHODOLOGICAL FRAMEWORK

4.1 Introduction:

Inflation and economic growth itself are only key indicators of any economy and the relationship between these two variables is play critical role in macroeconomic policy formulation. Like many other developing countries, the prime objective of macroeconomic policy in Pakistan is to attain high and viable rates of economic growth with low and stable rates of inflation in the country. A large body of empirical as well as theoretical literature focuses on the relationship between inflation and economic growth for both developing and develops countries. However the relationship between inflation and economic growth is highly debatable topic among the macroeconomist and policy makers. The implicit assumption regarding the nature of relationship between inflation and economic growth is that higher inflation always has a significantly negative effect on economic growth. There are studies which claim that inflation does not always negatively affect economic growth. There is negative relationship between inflation and economic growth after some threshold level. This school of thought argues that there is nonlinear relationship between inflation and economic growth. Keeping in mind these arguments, we empirically test the nature of relationship between inflation and growth for Pakistan. For this analysis ARDL and LSTAR methodology has been used. Both methodologies have been explained in the following section in detail.

The link between inflation and economic growth can be derived using the standard growth equation Barro (1991) and Sala-i-Martin (1997)

$$dlogY = X\beta + \varepsilon \quad \text{.....4.1}$$

Where Y is real output, X is the set of explanatory variables, β slope of coefficients and ε is error term. This growth equation extended to capture the link between inflation and economic growth in the following equation.

$$dlog\ Y = a_0 + a_1(\text{inf}) + X\beta + \varepsilon \quad \text{.....4.2}$$

Where $dlog\ Y$ is the growth rate of real GDP, inf represent inflation rate which is growth rate of consumer price index (CPI) and X is the matrix of other explanatory variables, β is matrix of slope coefficient, ε is the error term. Investment is used in our model because it more influential variable in the inflation growth relationship. So in equation 4.2 investments included as explanatory variable in the following equation.

$$dlog\ Y = a_0 + a_1(inf) + \beta(inv) + \varepsilon \quad \text{.....4.3}$$

Where $dlog\ Y$ growth rate of real GDP, inf is growth rate of CPI, inv is investment to GDP ratio and ε is the error term.

4.2 Methodology

There are two methodologies used for estimation ARDL and LSTAR in section 4.2.1 and section 4.2.2 respectively. The purpose of using two different methodologies is comparing the results for empirical literature and robustness**.**

4.2.1 ARDL Methodology

The autoregressive distributive lag model (ARDL) has been employed to investigate the long-run relationship between inflation and GDP growth by incorporating inflation square as an additional explanatory variable. Inflation square has been included in the ARDL specification to capture the cointegration relationship in the presence of nonlinearity. This

approach has many merits. (1) It can be used irrespective of whether the explanatory variables are I(0) or I(1). (2) It capture both short run and long run dynamics when testing for the presence of co-integration.(3) It offers explicit tests for the existence of a unique co-integration vector rather than assuming that exists.(4) Finally it also preferred for small samples. Various diagnostic tests have been used to ensure that the model is adequately specified. General equation of ARDL model is as follow:

$$\Delta GDP_t = \alpha_0 + \sum_{i=1}^{p} \gamma_{1i} \Delta GDP_{t-i} + \sum_{i=0}^{p} \gamma_{2i} \Delta Inf_{t-i} + \sum_{i=0}^{p} \gamma_{3i} \Delta Inf_{t-i}^2 + \gamma_4 GDP_{t-1} + \gamma_5 Inf_{t-1} + \gamma_6 Inf_{t-1}^2 + \varepsilon_{1t} \quad (4.4)$$

Where GDP_t is gross domestic product, Inf_t represents inflation rate,Inf_t^2 is the inflation square. Inflation is measured as growth rate of consumer price index.

The second equation in which we add investment as additional explanatory variable is as follows

$$\Delta GDP_t = \alpha_0 + \sum_{i=1}^{p} \beta_{1i} \Delta GDP_{t-i} + \sum_{i=0}^{p} \beta_{2i} \Delta Inf_{t-i} + \sum_{i=0}^{p} \beta_{3i} \Delta Inf_{t-1}^2 + \sum_{i=0}^{p} \theta_{1i} \Delta Inv_{t-1} + \beta_4 GDP_{t-1} + \beta_5 Inf_{t-i} + \beta_6 Inf_{t-1}^2 + \beta_7 Inv_{t-1} + \varepsilon_{4t} \quad (4.5)$$

Equation (4.4) and equation (4.5) have been estimated by OLS (ordinary least squares) and for cointegration relationship; F-test is conducted on the joint significance of the lagged-level variables. The null hypothesis of no cointegration in Eq. (4.4) is H_0: $\gamma_4=\gamma_5=\gamma_6=0$ against the alternative that H_1; $\gamma 4 \neq \gamma_5 \neq \gamma_6 \neq \neq 0$. The null hypothesis of no cointegration in Eq. (4.5) is H_0: $\beta_4=\beta_5=\beta_6=\beta_7=0$ against the alternative that H_1; $\beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq 0$.For ARDL cointegration test, Pesaran et al. (2001) provides two asymptotic critical values, one lower critical value in which it is assume that the explanatory variables are stationary in levels that *I(0).* Second an upper critical value by assuming that explanatory variables are non-stationary in level but are stationary in first differences: *I (1).* We reject the null of no cointegration if the value of F-statistic lies above the upper critical values. If the value of F-statistic

lies below the lower critical value, we cannot reject the null hypothesis of long-run relationship. We used general to specific approach for estimation and 2 lags of difference variables are selected on the basis of Schwarz Bayesian Information Criterion (SB). Statistically insignificant variables were deleted from the model when SBC justified. The final ARDL model is selected when the estimated equations satisfy all of the diagnostic tests including the Lagrange multiplier tests of residual serial correlation; the Jarque-Bera test of normality based on a test of skewness and kurtosis of the residual; the heteroskedasticity test based on the regression of squared residuals on squared fitted values; and the Ramsey's RESET test using the square of the fitted values for the functional form.

When we find cointegration relationship among the variables of interest in the first step then in next, the long- run and short-run parameters can be estimated by general form of ARDL specification. Following are the long-run equation of ARDL model:

$$GDP_t = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} GDP_{t-i} + \sum_{i=0}^{p} \beta_{2i} Inf_{t-i} + \sum_{i=0}^{p} \beta_{3i} Inf_{t-i}^2 + \varepsilon_{2t} \quad (4.6)$$

ECM or Short run equation of ARDL model is as follow:

$$\Delta GDP_t = \alpha_2 + \sum_{i=1}^{p} \beta_{1i} \Delta GDP_{t-i} + \sum_{i=0}^{p} \beta_{2i} \Delta Inf_{t-i} + \sum_{i=0}^{p} \beta_{3i} \Delta Inf_{t-i}^2 + \varphi_1 ECT_{t-i} + \varepsilon_{3t} \quad (4.7)$$

Where φ_1 is the co-efficient of the error correction term (ECT), which defined as

$$ECT_{t-1} = GDP_t - \alpha_1 - \sum_{i=1}^{p} \beta_{1i} GDP_{t-i} - \sum_{i=0}^{p} \beta_{2i} Inf_{t-i} - \sum_{i=0}^{p} \beta_{3i} Inf_{t-i}^2 \quad (4.8)$$

The long-run and short-run equations for second model are given as below

$$GDP_t = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} GDP_{t-i} + \sum_{i=0}^{p} \beta_{2i} Inf_{t-i} + \sum_{i=0}^{p} \beta_{3i} Inf_{t-i}^2 + \sum_{i=0}^{p} \beta_{4i} Inv_{t-i} + \varepsilon_{5t} \quad (4.9)$$

$$\Delta GDP_t = \alpha_2 + \sum_{i=1}^{p} \beta_{1i} \Delta GDP_{t-i} + \sum_{i=0}^{p} \beta_{2i} \Delta\, Inf_{t-i} + \sum_{i=0}^{p} \beta_{3i} \Delta Inf_{t-1}^2 + \sum_{i=0}^{p} \beta_{4i}\, Inv_{t-i} + \varphi_2 ECT_{t-i} + \varepsilon_{6t} \quad (4.10)$$

Where φ_i is the co-efficient of the error correction term (ECT),

$$ECT_{t-1} = GDP_t - \alpha_1 \sum_{i=1}^{p} \beta_{1i} GDP_{t-i} - \sum_{i=0}^{p} \beta_{2i}\, Inf_{t-i} - \sum_{i=0}^{p} \beta_{3i} Inf_{t-i}^2 - \sum_{i=0}^{p} \beta_{4i}\, Inv_{t-i} \quad (4.11)$$

4.2.2 Non-Linear Model: LSTAR Methodology

In last few years numbers of new econometrics models have been introduced in economic literatures for analysis of nonlinear nexus among variable. There are two main approaches of econometric modeling which take into account the nonlinearities of the economic variables. These approaches includes, Markov regime switching models (for example Hamilton, 1989) and family of threshold autoregressive models. In Markov regime switching models, switching between regimes is illustrated by probabilistic function while in threshed hold family of nonlinear models, identify the regime switch as a function of past values (Tong 1990; Tsay 1989). Tong (1978) and Tong and Lim (1980) proposed the Threshold Autoregressive (TAR) model. TAR (Threshold Autoregressive) model proposed by Tong (1978) and Tong and Lim (1980) assume that threshold variable s_t determine regimes switch from one regime to another regime.

4.2 .3 Model

They proposed the following specification of TAR model

$$y_t = (\theta_{10} + \sum_{j=1}^{p} \theta_{1j} y_{t-j+1})(1 - I(s_t - c) + (\theta_{20} + \sum_{j=1}^{p} \theta_{2j} y_{t-j+1})(I(s_t - c) + \mu_t \quad (4.12)$$

This equation can fragmented into two parts as follows

$$y_t = \left(\theta_{10} + \sum_{j=1}^{p} \theta_{1j} y_{t-j+1}\right) + \mu_t \qquad s_t < c \qquad (4.13)$$

$$y_t = \left(\theta_{20} + \sum_{j=1}^{p} \theta_{2j} y_{t-j+1}\right) + \mu_t \qquad s_t \geq c \qquad (4.14)$$

Where $I(s_t - c) = 0 \quad if\ s_t < c$ and $I(s_t - c) = 1 \quad if\ s_t \geq c$

s_t that is the threshold variable can be define as a linear function of the lagged values of dependent variable y_t. Therefore we can write s_t as follow

$$s_t = \sum_{j=1}^{p} \omega_j\, y_{t-j} \qquad (4.15)$$

Where ω_j is the co-efficient lag value of y. This specification of TAR model is known as a Self-Exciting Threshold Autoregressive model (SETAR).

However according to Terasvirta (1994) there is discontinuities in likelihood function of these models because of the abrupt switching between regimes that may affect statistical inference. Some studies for example Terasvirta (1994), Granger and Terasvirta (1993), Terasvirta and Anderson (1992) proposed nonlinear model which are based on smooth transition of threshold models. Chan and Tong (1986) proposed a smooth transition between two regimes in TAR models through a transition function to avoid an abrupt switching between regimes.

Nevertheless for estimation of parameters, STAR model needs huge stationary data sets. Ruth (2014) argued that a nonlinear smooth transition autoregressive (STAR) model based on the assumption that data generating process of variables have different regimes with their own dynamics. In one regime, the dynamics of the variables are liner; the non-linearity arises from the possibility of transition from one regime to another (Van Dijk *et al.*,. 2000). In smooth transition autoregressive model, the shift from one regime to another regime is defined by transition function. For smooth transition, Terasvirta (1994) suggest the following specification of Smooth Transition Autoregressive (STAR) model:

$$y_t = (\varphi_{1.0} + \varphi_{1,1}y_{t-1} + \cdots + \varphi_{1,p}y_{t-p}\big(1 - G(s_t;\, \gamma, c)\big) + (\varphi_{2.0} + \varphi_{2,1}y_{t-1} + \cdots + \varphi_{2,p}y_{t-p}\big(1 - G(s_t;\, \gamma, c)\big) + \varepsilon_t \qquad (4.16)$$

Where $G(s_t; \gamma, c)$ is a transition function. s_t is a transitional variable, this can be define as lagged values of exogenous variables. γ is transition rate and c is the threshold value. The extreme limits of transition function are 0 and 1, 0 for regime 1 and 1 for regime 2. The transition function $G(s_t; \gamma, c)$ can be define as a logistic function (LSTAR) as follow (see Van Dijik, 2000)

$$G(s_t;\, \gamma, c) = \frac{1}{1+\exp\{-\gamma(s_t - c)\}} \qquad (4.17)$$

$G(s_t;\, \gamma, c)$ is monotonically increasing transition function form 0 to 1 with the increase in transitional variable s_t.

In this formulation smoothness of the transition function is determined by the constant γ. The transition will be abrupt with the larger value of constant γ. This function has some important properties Chan and Mc Aleer (2002)

$$Limit\ s_t \to -\infty\ G(s_t;\, \gamma, c) \to 0$$

$$Limit\ s_t \to \infty\ \mathrm{G}(s_t;\ \gamma, c) \to 1$$

$$\gamma = 0 \to \infty\ \mathrm{G}(s_t;\ 0, c) = \frac{1}{2}$$

$$Limit\ \gamma \to -\infty\ \mathrm{G}(s_t;\ \gamma, c) \to 0$$

$$Limit\ \gamma \to \infty\ \mathrm{G}(s_t;\ \gamma, c) \to 1$$

When $\gamma \to \infty$, the shape of the model become a TAR model that changes instantly from one regime to the other as s_t=c. So that c acts as a pure transition variable.

One way of interpreting this function as a two regime switching model associated with two extreme values of the transition function Van Dijk (2000). Ruth (2014) follows this interpretation of transition function in their analysis for inflation dynamics in Swedish economy.

For effective use of this model, selection of appropriate transition function and threshold variable is critical. Chan and Mc Aleer (2002) suggest LM test for the appropriate selection of $\mathrm{G}(s_t;\ \gamma, c)$ and $s_{t..}$ This formulation has been used by number of other studies in to analyze the dynamic behavior of economic variables. For example Terasvirta and Anderson (1992) explored that nonlinearity arises from the asymmetry introduced by large negative shocks to the economy. Ocal and Osborn (2000) found two different business cycle regimes in recession and expansion for UK economy.

For estimation purpose, first we have to test the presence of linearity against the LSTAR model. In literature, LM type test has been used for nonlinearity against linearity. Van Dijk *et al.,(*2000), Chan and McLeer (2002), Zhou (2010) and Ruth (2014), explain the following procedure for estimation of LSTAR models.

- By using AIC or BIC criterion, select the optimal lag length of the autoregressive model (AR).
- In the second step, estimate the linear AR model for selected lag order and obtained the residuals and compute sum of squared residuals (SSR_0), where SSR_0 represent the sum of square of residuals for linear AR model.
- In the third step, estimate the Taylor expansion of nonlinear STAR model with same lag length order and obtained residuals to calculate the sum of square of residuals (SSR_1).
- By using SSR0 (the sum of square of residuals for linear AR model) and SRR1 (the sum of square of residuals based on estimation of nonlinear STAR model), compute the LM test.

$$LM = \frac{T(SSR_0 - SRR_1)}{SRR_0}$$

This is the χ2-version of LM test and T is the number of observation. If tests show that there is nonlinearity, then we can go for LSTAR model. Luukkonen *et* al, (1998) argue that for the across the regimes, model is based on the third-order Taylor expansion as follows:

$$y_t = \beta_0 x_t + \beta_1 x_t s_t + \beta_2 x_t s_t^2 + \beta_3 x_3 s_t^3 + e_t \quad (4.18)$$

In this equation, y_t is the GDP, x_t is the vector of explanatory variables and autoregressive lags variable. St is the transition variables. The explanatory variables included are inflation, investment ratio to GDP and GDP growth. The residuals obtained from this estimation are used to test the nonlinearity. Chi Square test is performed with 3(P+1) degree of freedom. Van Dijk (2000) introduce the additional term $\beta_i s_i$ in the above model if s_t is the exogenous variable. So the above equation become

$$y_t = \beta_0 x_t + \beta_1 x_t s_t + \beta_2 s_t + \beta_3 x_t s_t^2 + \beta_4 s_t^2 + \beta_5 x_3 s_t^3 + \beta_6 s_t^3 + e_t \quad (4.19)$$

4.3 Data

The key objective of this study is to analyze the nexus between inflation and GDP growth, therefore, GDP growth rates and inflation rate are targets variables of this study. Annual data have been taken from World Bank, World Development Indicators (2015) on the required variables from 1972 to 2013.

4.3.1 Definition of the Variables

Definitions of the variables used in this study given in the following table 4.1

Table 4.1: Definition of Variables

Variable	Definition
GDP growth rate	Annual percentage growth rate at constant price at 2005.
Investment as % of GDP	Gross fixed capital formation as percentage of GDP.
Inflation	Inflation is measured as percentage growth rate of CPI.

4.3.2 Descriptive Statistics

The table 4.2 descriptive summary of the variables shows that the average value of GDP growth rate is 4.81 percent, investment has average value 16.12 percent and inflation average value is 9.52 percent. In column 3 the standard deviation of the variables are given, the lowest standard deviation is investment which is 1.89 and then GDP growth rate 2.20 while the largest value of standard deviation is associated with inflation which is 5.31.

The minimum GDP growth rate is 0.81 percent and maximum is 10.22 percent. The minimum investment as % of GDP is 12.60 percent while maximum level is 19.24 percent. The minimum inflation rate is 2.91 percent and maximum inflation rate is 26.66 percent. The table 4.2 gives useful information about inflation and GDP growth.

Nonlinearity in both inflation and GDP is seemed to be pronounced and their inter nexus is also be nonlinear. If the behavior of data is nonlinear, the linear estimation of the nexus between inflation and GDP growth may lead to wrong results. Before Appling the linearity test on the variables, time series properties of data has been inspected because estimation technique of LSTAR, required stationary data.

Table 4.2 Descriptive Summary of the Variables

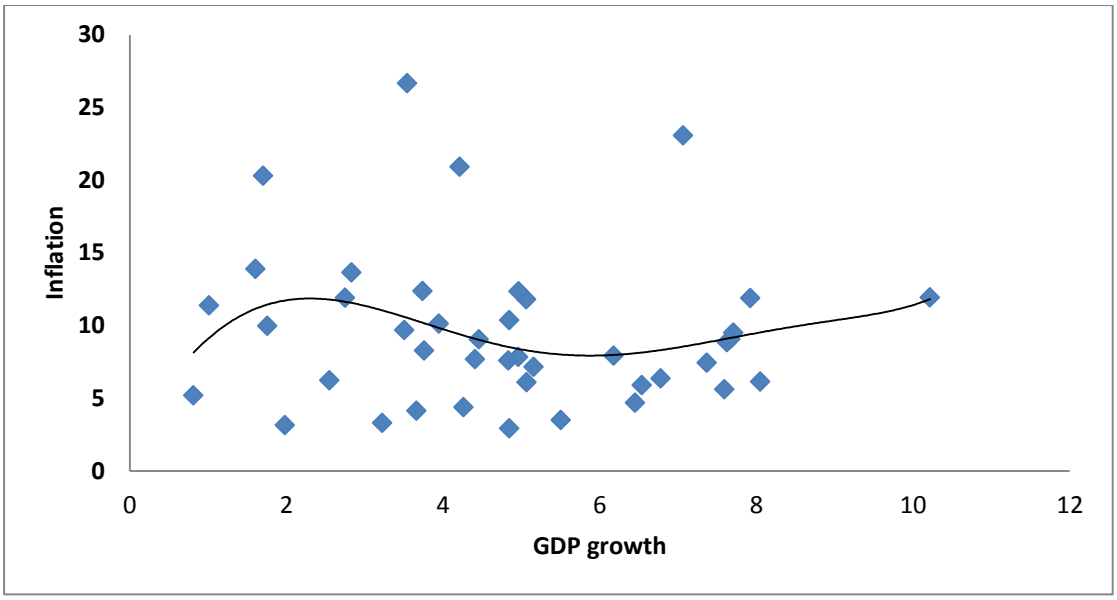
Variable	Observation	Mean	Std.Dev	Min	Max
GDP growth rate	42	4.81	2.19	0.81	10.22
Investment as % of GDP	42	16.12	1.89	12.60	19.24
Inflation	42	9.52	5.31	2.91	26.26

Source; World Bank, (2015)

Before estimation we see the visual relationship between GDP growth and inflation in our sample is portraying in figure 4.1, which suggest that this relationship is non-linear and there exist some threshold level of inflation .The relationship among the variables below this threshold level of inflation observe positive and above that threshold level of inflation this relationship becomes negative.

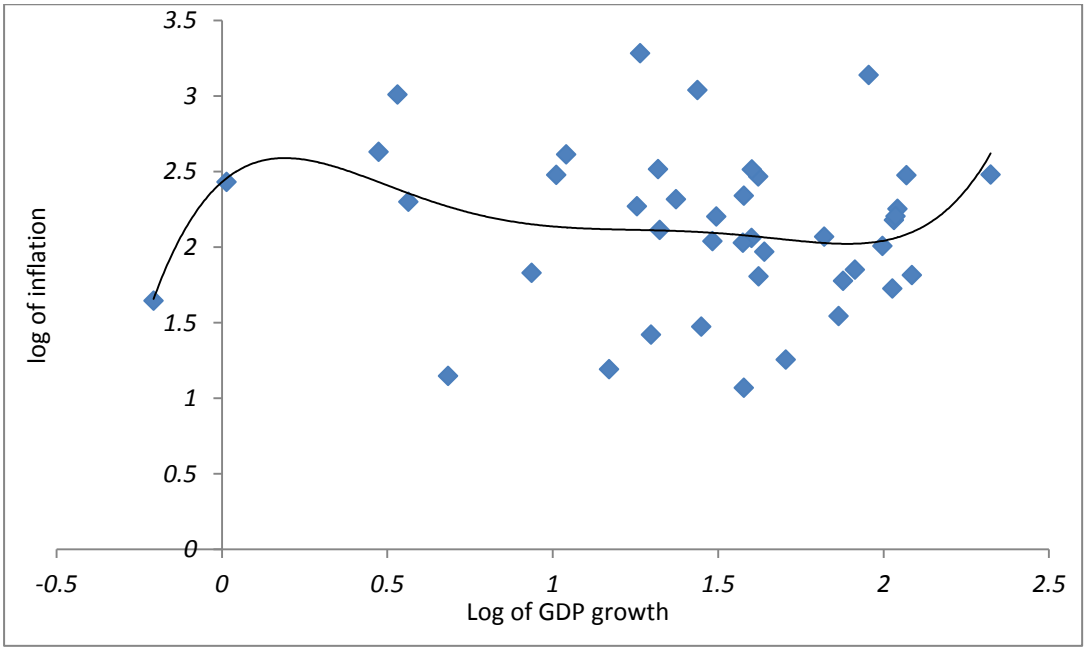
We also observe this relationship between GDP growth and inflation after taking a log of both the variables which is shown in figure4.2.This graph also shows the nonlinear nexus between these variables. Both the graph confirms that relationship between GDP growth and inflation is non-linear. Now this non-linearity estimated by ARDL methodology and STAR methodology.

Figure 4.1: Non-linear Nexus Inflation and GDP Growth, 1972-2013



Source; World Bank, (2015)

Figure 4.2:Non-linear nexus log of GDP growth and log of inflation 1972-2013



Source: World Bank, (2015)

CHAPTER 5

EMPIRICAL RESULTS AND DISCUSSION

5.1 Introduction:

For empirical analysis we used two different methodologies LSTAR and ARDL. The LSTAR methodology was used to capture the nonlinear relationship between GDP growth and inflation. The main purpose of using two different methodologies is to compare the results for robustness. Time series properties of data have been checked through ADF unit root test and Zivot–Andrews (1992) structural break test. Identify structural break test are incorporated in estimation of LSATR and ARDL.

5.2. Unit Root Test

5.2.1 ADF Unit Root Test

Augmented Dickey-Fuller (ADF) statistics has been used to test the time series properties of the data and results of ADF test are reported in Table 5.1. The results indicate that all variable i.e. inflation, square of inflation, and investment percentage of level except GDP are stationary at level i.e. I(0). GDP is non-stationary at level and become stationary at first difference i.e. I(1) .So in this situation ARDL is an appropriate estimation methodology.

Table5.1: Results of the Unit Root Test

Variables Name	Level		First difference	Order of integration
	With Intercept	With trend & Intercept	With Intercept	
GDP	0.327	-2.651	-4.093*	I(1)
INF	-4.434*	-4.542*		I(0)
INF^2	-3.273**	-3.451		I(0)
INV	-2.101	-3.792**		I(0)

Note: The SBC has been used for the lag length. * indicates the rejection of the null hypothesis on the non-stationary of the variable under consideration at a 1 percent level of significance. ** Indicates significant at 5%

Gross fixed capital formation as percentage of GDP has been used as proxy for investment

5.2.2 Zivot and Andrews Structural Break Unit Root Test:

However there are many studies for example Perron (1998) used Zivot and Andrews structural break unit root test. In the presence of structural break, the standard ADF tests are biased towards the non-rejection of null hypothesis. Therefore, these tests provide biased and spurious results. To take into account the problems of structural break we employ structural break unit root test proposed by Zivot and Andrews (1992). Zivot and Andrews (1992) assume that there is unknown break point in data that appear as the deterministic trend function. In their methodology, test for unit root in model (A)—(C) involves the following equations.

$$x_t = \alpha_0 + \alpha_1 DUM_t + \beta t + \rho y_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta y_{t-i} + e_t \qquad \text{Model (A)}$$

$$x_t = \alpha_0 + \gamma DT_t + \beta t + \rho y_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta y_{t-i} + e_t \qquad \text{Model (B)}$$

$$x_t = \alpha_0 + \alpha_1 DUM_t + \gamma DT_t + \beta t + \rho y_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta y_{t-i} + e_t \qquad \text{Model (C)}$$

Where DUM_t is the intercept dummy indicates a one-time shift in the level; DMUt=1 if (t>TB) and zero otherwise; DT_t is the slope dummy represent a change in the slope of the trend function. Results of structural break unit root test are reported in Table 5.2

Table 5.2: Results of the Zivot–Andrews Structural Break Trended Unit Root Test

	Level		1st difference	
Variables	t-statistic	Time break	t-statistic	Time break
GDPg	-3.44	2007		
GDPk	-0.89	1992	-5.43	2007
INF	-4.109	2008		
INF^2	-4.95	2008		
INV	-2.57	2005	7.703	1979

The results of structural break unit root test indicate that inflation and square of inflation are stationary at level, while GDP and investment are non-stationary at level. GDP and investment series are integrated of order one.

5.3 ARDL Estimate and Cointegration Test

ARDL specified equation in chapter 4 Equation (4.4) and equations (4.5) have been estimated by OLS (ordinary least squares) and for cointegration relationship; F-test is conducted on the joint significance of the lagged-level variables. Final equations are selected when all diagnostic tests are satisfied and diagnostic test are reported in Table 5.3. The stability test for estimated parameters is assessed by using the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests. Figures 5.1a, 5.1b and 5.2a and 5.2b present the plot of the CUSUM and CUSUMSQ test statistics for two models. The plot of CUSUM and CUSUMSQ fall within the

critical bounds of the 5% significance level. This finding indicates that the estimated coefficients are stable over the estimation period. Table 5.3 reports the F-statistics for equations (4.4), and (4.5), respectively.

The F-statistic for cointegration test that is the joint null hypothesis of lagged-level variables are zero, are presented in Table 5.3. The calculated F-statistics as reported in Table 5.3 for are higher than the appropriate upper-bound critical value for two estimated models. In both estimated model the value of F-statistic is greater than upper bound critical value. The results show that the null hypothesis of no cointegration is rejected at 1 percent level of significance in both models. We can conclude that long run relationship exists among GDP, inflation, and inflation square in equation one.

The equation (1) shows positive and statistical significant relationship between inflation and economic growth up to certain threshold level of inflation beyond this certain threshold of inflation this relationship becomes statistical significantly negative in the long run and this certain threshold level of inflation is 6.93 percent. This threshold level of inflation is similar to Ayyoub (2011), Nasir and Nawaz (2009) which is also 7 percent and approximately same to Hussain (2005) which is 6 percent in case of Pakistan. This threshold level of inflation approximately same to Marbuah (2010) in case of African country Ghana, Ahmed and Mortaza (2005) in case of Bangladesh) which is 6 percent. The short run relationship between these variables behaves similar pattern as in long run and ECM is statistical significant and negative. The value of ECT is -0.257 means that any deviation in the short run from the long run equilibrium is corrected 25.7 percent each year.

Table 5.3: Estimated Coefficients of ARDL

	Eq1	Eq2	Eq3
Panel A: Long-Estimates			
INF_t	.097(2.31)	.171(2.18)	.182(2.21)
INF_t^2	-.007(-2.08)	-.0109(-2.65)	-.011(-2.63)
INV_t		-1.883(-1.86)	-1.93(-1.97)
DUM			.313(.39)
Constant	6.99(13.07)	11.87(2.81)	11.90(4.42)
Threshold	6.93	7.84	8.27
Panel B: Short-term			
ΔINF_t	.004(1.87)	.007(2.91)	.007(2.66)
ΔINF_{t-1}	.002(3.26)	.0026(4.15)	.003(4.10)
ΔINF_t^2	-.185(-2.54)	-.310(-3.50)	-.345(-2.62)
ΔINV_t		.053(1.33)	.050(1.22)
ΔDUM			.009(.37)
Constant	.179(2.68)	.338(2.51)	.359(2.43)
ECM_{t-1}	-.257(-2.39)	-.285(-2.44)	-.030(-2.38)
Adjusted R^2	0.82	0.89	0.84
F-test for cointegration	7.85	6.47	
DW	1.91	1.86	1.88
Panel C: Diagnostic tests			
$\chi^2_{SC}(1)$	.996(.318)	.008(.929)	.010(.919)
$\chi^2_N(2)$	1.136(.567)	1.998(.368)	1.919(.383)
$\chi^2_H(1)$	.596(.440)	.0897(.756)	.131(.718)
$\chi^2_{FF}(1)$	6.00(.014)	4.444(.035)	4.341(.037)

Note: t-values are given in parentheses, and p-values are given in brackets. $\chi^2_{SC}(1)$ is the Lagrange multiplier tests of residual serial correlation; $\chi^2_N(2)$ is the Jarque-Bera test of normality based on a test of skewness and kurtosis of the residual; $\chi^2_H(1)$ is a heteroskedasticity test based on the regression of squared residuals on squared fitted values; and $\chi^2_{FF}(1)$ is Ramsey's RESET test using the square of the fitted values for the functional form. The critical values for the lower I(0) and upper I(1) bounds are 3.79 and 4.85, respectively, for a 5 percent significance level for CI(iii) Case III: unrestricted intercept and no trend (case ii). The critical values for the lower I(0) and upper I(1) bounds are 2.72 and 3.83, respectively, for a 5 percent significance level for CI(i) Case I: no intercept and no trend [Pesaran et al. (2000)]

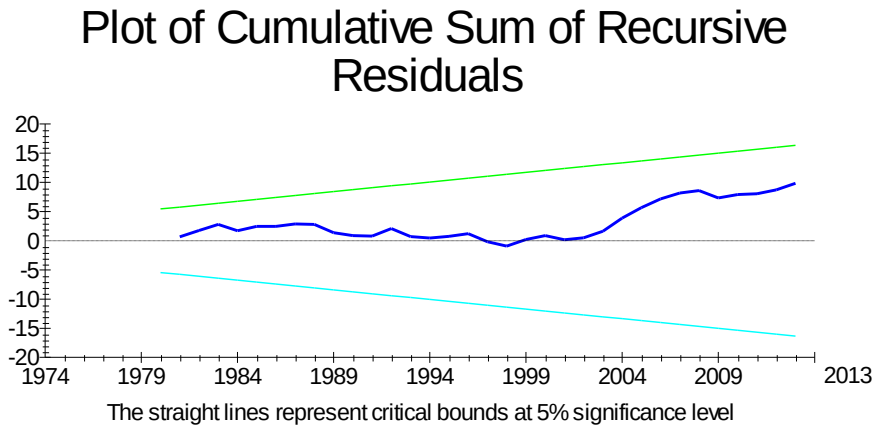
By including investment as explanatory variable in equation (1) then threshold level of inflation increases .The relationship between inflation and economic growth up to certain threshold level of inflation is significantly positive after this threshold level of inflation the relationship between these variables becomes significantly negative and this certain threshold level of inflation is 7.84 percent. This threshold level of inflation is similar to Thanh (2012) which is 7.84 percent in case of ASEAN-5 countries. The short run relationship between these variables behaves similar pattern as in long run and ECM is statistical significant and negative. The value of ECT is -0.285 means that any deviation in the short run from the long run equilibrium corrected 28.5 percent each year.

By including investment and dummy variable in equation (1) then threshold level of inflation again increases. The results show significantly positive relationship between inflation and GDP growth up to certain threshold level of inflation and beyond this level the relationship becomes significantly negative with inflation and this certain threshold level of inflation is 8.3 percent. This threshold level of inflation is approximately similar to Mubarak (2005) which 9 percent and Hussain.S (2011) which also 9 percent in case of Pakistan. This equation also shows statistically insignificant negative relation with investment and statistically insignificant positive with dummy. In the short run relationship between these variables behaves similar pattern and ECM is significant statistically negative. The ECT value is -0.030 suggest that any deviation in the short run from the long run equilibrate 3 percent in each year.

The CUSM and CUSMSQ tests are plotted in figure 5.1(a), 5.1(b) and 5.2 (a), 5.2(b).

Figure5.1: Plot of Cumulative Sum and Cumulative Sum of Squares of Recursive Residuals for Equation (1)

(a)



(b)

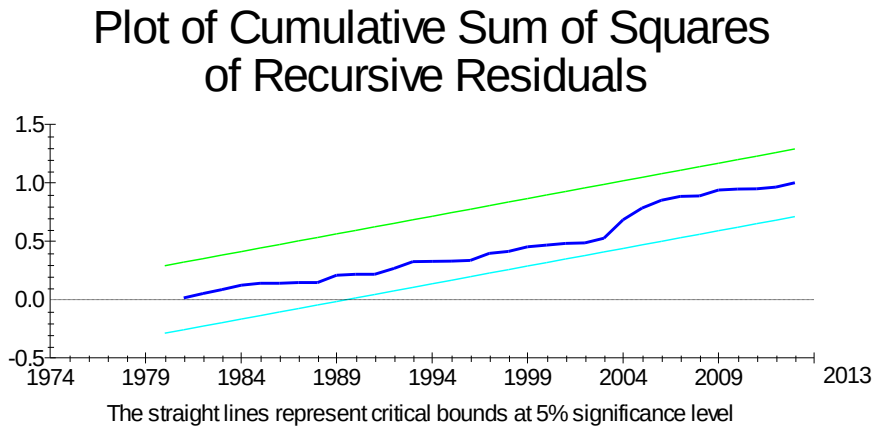
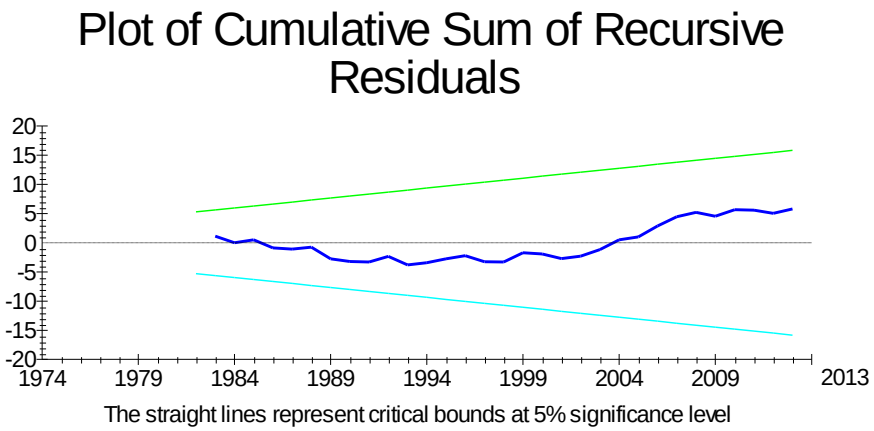
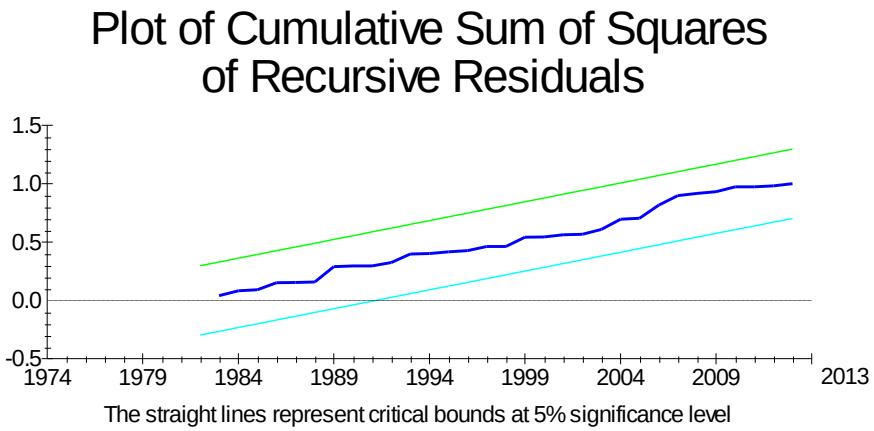


Figure 5.2 Plot of Cumulative Sum and Cumulative Sum of Squares of Recursive Residuals for Equation (2)

(a)



(b)



5.4 Non-linear Model: LSTAR Estimate

In the first step to estimate a STAR model to select an appropriate transition variable .The transition variable should be the highest probability of rejection the null hypothesis of linearity. In this model inflation rate selects as a transition variable and LSTAR is an appropriate model with one of LSTAR1.Inflation rate also select as a threshold variable and LSTAR1 is considered non-linear model for inflation growth dynamic relation in Pakistan.

The estimation results of LSTAR1 model are presented in table (5.4).Diagnostic tests confirms that the model is adequately specified. The normality tests are consistent with requirements. There is no autocorrelation problem and no variance unevenness in the LSTAR1 model. Model results are reliable in the absence of autocorrelation and unevenness in variance of residuals.

There are two equation used to estimate the LSTAR model, in equation one estimate GDP growth and inflation relationship and in second eqation investment include as additional explanatory variable. There are two part of the table (5.4), upper part shows linear relationship between the variables and the lower part shows nonlinear relationship between the variables in both the equations of LSTAR model. The non-linear part shows the smooth transition part of the LSTAR model and it can be categories in regime two and linear part called as regime one. The comparison of both regimes shows that in less persistent regime as well as in high persistent regime. The impact of inflation dynamics on GDP growth is almost similar a very slightly volatility occur such as in regime one to regime two in both the models.

The two regime model indicates that the coefficient of slope parameter γ is 1.46 with inflation threshold extreme c 9.68 percent for equation one and the coefficient of slope parameter γ is 2.39 with inflation threshold extreme c 13.5 percent for equation two. The slope coefficient of equation two more signifies fast transition from one regime to another and the equation one less signifies transition from one regime to another.

Table 5.4: Estimated Coefficients of LSTAR

The Linear Part of the Model					
Variables	Coefficient	t-state	Variables	Coefficients	t-state
GDP_{t-1}	1.04	8.75	GDP_{t-1}	0.98	4.9
Inf_t	0.01	2.53	Inf_t	0.001	1.06
inft-1	0.03	2.27	inft-1	0.001	3.66
inft-2	0.59	2.08	inft-2	0.002	-2.7
			Invt	0.01	2.32
			inv t-1	0.01	0.99
			Inv t-2	0.004	2.49
Constant	7.97	4.78	Constant	0.15	1.45
Selected Model	LSTAR		LSTAR		
The nonlinear Part of the Model					
GDP_{t-1}	0.01	4.17	GDP_{t-1}	0.49	-2.07
Inf_t	0.01	3.19	Inf_t	0.14	0.69
inft-1	0.03	-2.27	inft-1	0.25	-2.07
inft-2	0.59	2.07	inft-2	0.07	2.09
			Invt	0.87	0.08
			inv t-1	1.56	3.07
			Inv t-2	0.07	2.09
Constant	212.8	3.32	Constant	11.8	1.08
Slope Parameter	1.46		2.39		
C Threshold	9.68		13.5		
	Diagnostic Tests				
ARCH-LM TEST 8lags	t-state	p-value(chi^2)	F-state	p-value(F)	
	6.575	0.583	0.9702	0.475	
JARQUE-BERA TEST	3.85	0.146			

NOTE: J multi software has been used for estimation of LSTAR.

The threshold level of inflation of equation two is more than the threshold level of inflation of equation one. The threshold level of inflation of equation one less or more consistent to Khan and Sendji (2000) is 7-11 percent for developing countries. For further explanation results of the model one for regime one, G=0

$$GDP_t=7.97+1.04GDP_{t-1}+0.01Inf_t+0.03Inf_{t-1}+0.58Inf_{t-2}$$

For regime two G=1

$GDP_t=212.8+0.01GDP_{t-1}+0.01Inf_t+0.03Inf_{t-1}+0.59Inf_{t-2}$

Explanation result of the model two for regime one, G=0

$GDP_t=0.15+0.98GDP_{t-1}+0.001Inf_t+0.001Inf_{t-1}+0.002Inf_{t-2}+0.01Inv_t+0.01Inv_{t-1}+0.004Inv_t-2$

For regime two G=1

$GDP_t=11.8+0.49GDP_{t-1}+0.14Inf_t+0.25Inf_{t-1}+0.07Inf_{t-2}+0.87Inv_t+1.56Inv_{t-1}+0.07Inv_t-2$

The estimated coefficients of inflation are positive and statistically significant in both regimes in equation (1) and equation (2). However the influence of inflation is greater in second regime. The estimated results demonstrate that the inflation growth relationship in Pakistan is non-linear. The non-linearity also confirmed by the figure 4.1 and figure 4.2 in chapter 4.The GDP growth has been influenced positively by the inflation below the threshold level of inflation 9.68 percent and negatively affected above this threshold level of inflation.

CHAPTER 6

CONCLUSION AND POLICY RECOMMENDATIONS

6.1 Conclusion

This study explored the possibility of non-linearity of inflation and GDP growth relationship in Pakistan, by using time series annual data from 1972 to 2013 and data taken from WDI (World Bank, World development indicators, 2015).The recent developed STAR (smooth transition autoregressive) methodology used because it is suitable for estimating the non-linearity, incorporates the structural break in the data and it also accounts the possibility of regime reversal. ARDL methodology is also used to analyze the short run and long run dynamics of the data.

Firstly we checked the stationarity of data by using ADF and Zivot-Anders (1992).ADF test is biased towards the non-rejection of null hypothesis in the presence of structural break and due to this, Zivot-Anders methodology was used because it incorporate such breaks in the data. Then we applied ARDL (Auto regressive distributive lag) methodology to estimate the short run and long run dynamics of the data. There are three equations are used here GDP growth taken as dependent variable in first equation, inflation and inflation square are used as explanatory variable. The threshold level of inflation in this model is 6.93 percent and short run behavior is the same as in the long run. In the second equation investment included as additional explanatory variable due to this threshold level of inflation increased to 7.84 percent and short run behaves is in similar pattern as in behave in long run. Finally in third equation dummy variable used due to this we find an interesting result that the threshold level of inflation further increased to 8.27 percent and in the short run behavior is same as in the long run. Results of this study more or less consistent with

the earlier studies of Pakistan e.g. Mubarik (2005); Hussain (2005); Ayyoub (2011); Nasir and Nawaz (2009) etc. But all these studies, methodologies and including our present estimation of ARDL are not appropriate to analyze the non-linearity. However the recent develop STAR methodology is more appropriate for estimate the non-linearity and in this studies our concern to estimate the non-linearity so this methodology used here.

LSTAR estimation methodology used two type of equations for estimation, GDP growth treat as dependent variable in both equations. In first equation only inflation used with two lags used as explanatory variable. The finding of this equation is 9.68 percent threshold level of inflation with 1.46 slope parameter. In second equation investment included as additional explanatory variable with two lags then inflation threshold level increased to 13.5 percent with 2.39 slope parameter. Result of equation (1) consistent with Khan and Sendji (2000) suggest 7-11 percent threshold level of inflation for developing countries. The relationship between inflation and GDP growth below certain threshold level of inflation is significantly positive and above that certain threshold level the relationship between these variables becomes significantly negative and this certain threshold level of inflation is 9.68 percent in Pakistan.

6.2 Policy Recommendations

The above findings have some policy recommendations for policy makers and central bank. As price stability is the most important goal for policy makers and central bank as high inflation harmful for economic growth and development. The findings of this study suggest that the policy makers and central bank should concentrate on those policies in which the inflation rate stable and below the threshold level of inflation 9.68 percent which helpful to achieve the sustainable economic

growth and development in the country. Moderate and stable inflation is necessary to minimize the uncertainties and fluctuations in the economy. The inflation uncertainties badly affect the economic activities i.e. investment and GDP growth reduces. So policy makers and central bank resolve the issue of high inflation on priority basis to reduce the inflation above the threshold level of inflation 9.68 percent.

REFERENCES

Ayyoub, M., Chaudhry, I. S., & Farooq, F. (2011). Does inflation affect economic growth? The case of Pakistan. Pakistan Journal of Social Sciences,31(1), 51-64.

Barro, R. J. (1995). Inflation and economic growth (No. w5326). National bureau of economic research.

Bick, A. (2010). Threshold effects of inflation on economic growth in developing countries. *Economics Letters*, *108*(2), 126-129.

Bruno, M., & Easterly, W. (1996). Inflation and growth: in search of a stable relationship. Federal reserve Bank of st. louis Review, 78(May/June 1996).

Bruno, M., & Easterly, W. (1998). Inflation crises and long-run growth. *Journal of Monetary Economics*, *41*(1), 3-26.

Burdekin, R. C., & Weidenmier, M. D. (2001). Inflation is always and everywhere a monetary phenomenon: Richmond vs. Houston in 1864.*American Economic Review*, 1621-1630.

Burdekin, R. C., Denzau, A. T., Keil, M. W., Sitthiyot, T., & Willett, T. D. (2004). When does inflation hurt economic growth? Different nonlinearities for different economies. *Journal of Macroeconomics*, *26*(3), 519-532.

Chan, F., McAleer, M., & Medeiros, M. (2011). *Structure and Asymptotic theory for nonlinear models with GARCH errors* (No. EI 2010-79, pp. 1-27). Econometric Institute Research Papers.

Chan, F., McAleer, M., & Medeiros, M. C. Structure and Asymptotic Theory for STAR (1)-GARCH (1, 1) Models.

Chan, K. S., & Tong, H. (1986). On estimating thresholds in autoregressive models. Journal of time series..

Cooray, N. S. (2013). An Empirical Analysis of Inflation-Growth Nexus in Developing Countries: The Case of Sri Lanka (No. EMS_2013_21).

Eggoh, J. C., & Khan, M. (2014). On the nonlinear relationship between inflation and economic growth. Research in Economics, 68(2), 133-143.

Eitrheim, Ø., & Teräsvirta, T. (1996). Testing the adequacy of smooth transition autoregressive models. Journal of Econometrics, 74(1), 59-75.

Granger, C. W., & Terasvirta, T. (1993). Modelling non-linear economic relationships. OUP Catalogue.

Espinoza, R. A., Prasad, A., & Leon, H. L. (2010). *Estimating The Inflation-Growth Nexus-A Smooth Transition Model*. International Monetary Fund.

Faria, J. R., & Carneiro, F. G. (2001). Does high inflation affect growth in the long and short run?. Journal of Applied Economics, 4(1), 89-105.

Ghosh, A., & Phillips, S. (1998). Warning: inflation may be harmful to your growth. *Staff Papers-International Monetary Fund*, 672-710.

Girma, F. D. (2012). Relationship between Inflation and Economic Growth in Ethiopia: An Empirical

Gokal, V., & Hanif, S. (2004). Relationship between inflation and economic growth. Economics Department, Reserve Bank of Fiji.

Gylfason, T., & Herbertsson, T. T. (1996). *Does Inflation Matter for Growth?*(No. 1503). CEPR Discussion Paper.

Gylfason, T., & Herbertsson, T. T. (2001). Does inflation matter for growth?.*Japan and the World Economy*, *13*(4), 405-428.

Hamilton, J. D. (1990). Analysis of time series subject to changes in regime.*Journal of econometrics*, *45*(1), 39-70.

Hossain, M. E., Ghosh, B. C., & Islam, M. K. (2012). Inflation and Economic Growth in Bangladesh. Researchers World: Journal of Arts, Science & Commerce, 3.

Hussain, M. (2005). Inflation and growth: Estimation of threshold point for Pakistan. Economic Policy Department, State Bank of Pakistan, October.

Hussain, S., & Malik, S. (2011). Inflation and economic growth: evidence from Pakistan. International Journal of Economics and Finance, 3(5), p262.

Ibarra, R., & Trupkin, D. (2011). The relationship between inflation and growth: A panel smooth transition regression approach for developed and developing countries. Banco Central del Uruguay Working Paper Series, 006-2011.

Inyiama, O. I. (2013). Does Inflation Weaken Economic Growth? Evidence from Nigeria. European Journal of Accounting Auditing and Finance Research, 1(4), 139-150.

Iqbal, N., & Nawaz, S. (2009). Investment, inflation and economic growth nexus. The Pakistan Development Review, 863-874.

Jayathileke, P. M. B., & Rathnayake, R. M. K. T. (2013). Testing the Link between Inflation and Economic Growth: Evidence from Asia.

Kasidi, F., & Mwakanemela, K. (2013). Impact of inflation on economic growth: a case study of Tanzania. Asian Journal of Empirical Research, 3(4), 363-380.

Khan, M. S., & Ssnhadji, A. S. (2001). Threshold effects in the relationship between inflation and growth. IMF Staff papers, 1-21.

Kim, C. J. (1994). Dynamic linear models with Markov-switching. Journal of Econometrics, 60(1), 1-22.

Kremer, S., Bick, A., & Nautz, D. (2013). Inflation and growth: new evidence from a dynamic panel threshold analysis. *Empirical Economics*, *44*(2), 861-878.

Li, M. (2006). Inflation and economic growth: threshold effects and transmission mechanisms. Department of Economics, University of Alberta, 8-14.

Makuria, A. G. (2014). The relationship between inflation and economic growth in Ethiopia.

Mallik, G., & Chowdhury, A. (2001). Inflation and economic growth: evidence from four south Asian countries. Asia-Pacific Development Journal, 8(1), 123-135.

Marbuah, G. (2011). On the inflation-growth nexus: Testing for optimal inflation for Ghana. Journal of Monetary and Economic Integration, 11(2), 54-82.

Mubarik, Y. A., & Riazuddin, R. (2005). Inflation and growth: An estimate of the threshold level of inflation in Pakistan. State Bank of Pakistan.

Öcal, N. (2000). Nonlinear models for UK macroeconomic time series. *Studies in Nonlinear Dynamics & Econometrics*, *4*(3).

Perron, P. (1990). Testing for a unit root in a time series with a changing mean.
Journal of Business & Economic Statistics, 8(2), 153-162.

Qayyum, A. (2006). Money, inflation, and growth in Pakistan. The Pakistan Development Review, 203-212.

Rahman, Z. (2014). Asian Journal of Empirical Research. Asian Journal of Empirical Research, 4(4), 240-253.

Rousseau, P. L., & Wachtel, P. (2002). Inflation thresholds and the finance–growth nexus. Journal of International Money and Finance, 21(6), 777-793.

Salian, P., & Gopakumar, K. (2008). Inflation and Economic Growth in India–An Empirical Analysis.

Sarel, M. (Ed.). (1996). *Growth in East Asia: what we can and what we cannot infer* (Vol. 1). International Monetary Fund.

Seleteng, M., Bittencourt, M., & Van Eyden, R. (2013). Non-linearities in inflation–growth nexus in the SADC region: A panel smooth transition regression approach. Economic Modelling, 30, 149-156.

Shamim, A., & Mortaza, G. (2005). Inflation and Economic Growth in Bangladesh: 1981-2005. Policy Analysis Unit, Research Department, Bangladesh Bank, Working Paper Series: WP, 604.

Terasvirta, T., & Anderson, H. M. (1992). Characterizing nonlinearities in business cycles using smooth transition autoregressive models. Journal of Applied Econometrics, 7(S1), S119-S136.

Thanh, S. D. (2014). Threshold Effects of Inflation on Growth in the ASEAN-5 Countries: A Panel Smooth Transition Regression Approach. Available at SSRN 2411931.

Tong, H. (1978). *On a threshold model* (No. 29, pp. 575-586). Sijthoff & Noordhoff.

Tong, H. (1990). Non-linear time series: a dynamical system approach. Oxford University Press.

Tong, H., & Lim, K. S. (1980). Threshold auto regression, limit cycles and cyclical data. Journal of the Royal Statistical Society. Series B (Methodological), 245-292.

Tsay, R. S. (1998). Testing and modeling multivariate threshold models. Journal of the American Statistical Association, 93(443), 1188-1202.

Vinayagathasan, T. (2013). Inflation and economic growth: A dynamic panel threshold analysis for Asian economies. Journal of Asian Economics, 26, 31-41.

Xicang, Z., & Zuojie, Z. (2011). Study of Nonlinear Co integration Relationship between Oil Price Fluctuations and China's Inflation. *Journal of Jiangsu University (Social Science Edition)*, *5*, 017.