Asymmetric Behavior of Inflation Uncertainty, Unemployment Uncertainty and Economic Growth: Evidence from Pakistan

Submitted By:

AZAZ ALI ATHER BUKHARI

Supervised By:

DR. ATTIYA YASMIN JAVED

Roll No. 21 Session 2012-14

Department of Economics,

Pakistan Institute of Development Economics

Islamabad, Pakistan.

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By

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Roll No. 21 Session 2012-14

Department of Economics,

Pakistan Institute of Development Economics

Islamabad, Pakistan.

IN THE NAME OF ALLAH

THE MOST BENEFICENT

THE MOST MERCIFUL

Verily We have Created Man into Toil and Struggle… Have We not made for Him a Pair of Eyes, and a Tongue, and a Pair of Lips, and Shown him the Two Ways (Obedience and Disobedience) … ?

Qur'an, Al-Balad (90:4-10)

GOLDEN SAYING OF

THE HOLY PROPHET

[PEACE AND BLESSINGS OF ALLAH BE UPON HIM]

"Knowledge from which no Benefit is Derived is Like a Treasure out of Which Nothing is Spent in the Cause of God".

Al-Hadith, Al-Tirmidi (108)

GOLDEN SAYING OF

AMEER-UL- MOMANEEN

HAZRAT ALI [K.W]

"People are divided into three Categories: a Scholar who Devotes his Knowledge to Serve Allah, a Learner who Learns for the Sake of Rescuing Himself, and the Hooligan type of Rabbles that Follow Anyone who Cries Out, Turning Whichever the Way Wind Blows. The Last Category has not Been Illuminated by the Light of Knowledge and it has not fallen back upon Support that Offers Safety, Strength and Security."

(Dua-e-Kumail)

DEDICATED

TO

MY BELOVED PARENTS

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ABSTRACT

Macroeconomists devise legitimate consensus that uncertainty of inflation creates economic disorders by distorting price mechanism, deteriorating purchasing power, disturbing investment decisions and creating welfare losses on the part of the economy. This panorama was informally pioneered by Milton Friedman (1977) and then formally by Lawrence Ball (1992) suggesting that inflation raises its associated uncertainty. While this study analyses the nexus between inflation, its associated uncertainty, unemployment uncertainty and real GDP growth using quarterly time series of Pakistan ranging between 1981:01 and 2013:04. This study shows ARMA-EGARCH specification as a measure of uncertainties of both inflation and unemployment. Toda Yamamoto Augmented Granger Causality indicates that causality is uni-directional and the direction is running from inflation to its associated uncertainty *i.e.,* in line with Friedman-Ball Hypothesis. The findings also ratifies Ball's Hypothesis (1992) that inflation Granger causes unemployment uncertainty. Unemployment uncertainty being the costs of higher inflation therefore deserves equal billing with inflation uncertainty. The finale of this study reports Davis and Kanago's (1996) regression that uncertainties associated with both inflation and unemployment hampers real GDP growth thus also supports Friedman-Ball (1977, 1992) hypothesis. Since both uncertainties of inflation and unemployment are the cost of higher inflation therefore disturb real GDP growth then and there this study suggests its policy implication that the policymakers must target both variables so that the authorities could cope with uncertain economic environment and can minimize the uncertain economic environment.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Certainly economists believe that inflation is a contentious issue for every economy regardless of its different magnitudes over different time intervals. Inflation has also been the utmost observed and tested economic variable both theoretically and empirically that cost to the overall economy are well acknowledged. Since every country is afflicted by the specter of inflation so we can't form legitimate presumption that whether or not inflation is a good or bad phenomena for an economy, if the argue is all about its associated uncertainty, macroeconomists acknowledged several potential interactions between uncertainty of inflation and macroeconomic variables including output growth and unemployment *etc.* and formulate unanimous inference that uncertainty of inflation has undesirable effect on the part of the economy. Therefore macroeconomists devise legitimate consensus that uncertainty of inflation creates economic disorders by distorting price mechanism, deteriorating purchasing power, disturbing investment decisions and creating welfare losses on the part of the economy. Therefore uncertainty about inflation can cloud the choice of policymakers towards their targets. Nevertheless, one may argue that Central Bank aim to minimize the output variability and inflation nearby their target levels (Cecchetti and Krause, 2001) whereas substantial amount of literature arguing that inflation variability may be positively associated with the inflation rate.[1] If such a positive

[1] Arthur Okun (1971) formally found the positive association between average rate of inflation and its associated variability. Whereas Gordon criticized that such a relationship was not actually based upon economic mechanisms.

association exists, then it can be expected that higher inflation can lessen the welfare of the society perhaps be able to lower output growth, a panorama propagated by Milton Friedman (1977). Ball (1992) formally furnishes Friedman's proposition between inflation and its associated uncertainty, commonly known as Friedman-Ball hypothesis, henceforth. Since volatility means fluctuations in future price levels as a result of this uncertainty economic environment becomes unpredictable *i.e.,* this uncertainty of price levels is measured as the conditional variances obtained from the Generalized Autoregressive Conditional Hetroskedasticity (GARCH) models. Ball in his formal model postulates that economic agents faces an uncertain economic environment therefore by not having full information (asymmetric information) couldn't identify the move of central authority being "liberal" or "conservative". Since there is short run tradeoff between inflation and unemployment therefore by Ball's definition, a liberal monetary authority will try to trade higher inflation for lower rate of unemployment whereas the conventional monetary authority will try to maintain inflation at lower rates. When inflation is low, then the legitimate action of both liberals and conservatives will enact monetary policies to maintain inflation at lower rates. On the other hand if an exogenous shock rises the rate of inflation, then a conservative will instantly disinflate, however a liberal may waver. Thus higher inflation results in greater private agent inflation uncertainty whereas low inflation marks low private agent inflation uncertainty. Inflation uncertainty being the major costs of inflation deteriorates decision making of agents concerning future savings and investment. Due to loss of predictability of the real value of future nominal payments, it lengthens the severe effects of these spins to the level of real economic activity and efficient allocation of resources (Fischer 1981, Holland 1993 and Golob 1993). Now question arises by which channel inflation uncertainty works. Two well-known channels come from the effects that higher inflation has on inflation uncertainty. Theoretically, the first arises from the public's perception of erratic policy responses by the monetary authority to price level changes (Ball, 1992). In contrast, the second originates from the existence of menu costs (Sheshinsky & Weiss, 1977 or Rotemberg, 1983) or imperfect information (Lucas, 1973 or Barro, 1976). Both reduce market efficiency that is being coordinator of economic activity (Friedman, 1977) and also adversely disturbs the level of investment (Caballero, 1991). As shown by a large literature, these effects ultimately lead to a growth-dampening resource misallocation, even when inflation is low. Now question arises that how inflation uncertainty have effect on decision making regarding savings and investment. The overall costs of uncertainty about inflation is based upon two types of consequences *i.e.*, ex-ante consequences and ex-post consequences. Ex-ante are those where a rational economic agent anticipates future course of inflation through three different channels. Firstly, due to loss of predictability and delaying decisions the economy faces immiserizing growth therefore such uncertainty of inflation raises expected gains and long-term interest rates. Higher interest rates put pressure on savings and investment projects in the household and business sectors by a decline in investment in housing and durable goods and plants and equipment as well. Pindyck (1991) considers decision of economic agents towards investment as an inter-temporal choice and claims that current investment represents the opportunity cost to invest in the future. Such uncertain economic environment leads expected and potential returns of investment projects to become uncertain, thus hampers output growth and investment which is evident with delayed decisions.

Secondly, inflation uncertainty contributes ambiguities to interest rate and several other macroeconomic variables, therefore economic agents will be incapable to formulate contracts in accordance to inflation, which definitely rises wage uncertainty, taxes, rent, depreciation, and profits. This phenomena creates uncertainty in labor market thus delays hiring decisions of firms, ultimately disturbs level of investment and production. Since these decisions can't be altered, thus obstructs the economic activity at aggregate levels. Under a thematic framework, reduction in the level of investment reduces output growth. Likewise a Keynesian Model, a decline in level of investment leads to decrease in demand resultantly dampens output growth since this is argument confirms the findings of Marion and Aizenman (1993), for a cross-section of developing countries stating that there is a reverse correlation between measures of overall macroeconomic uncertainty and private investment.

Thirdly the mechanism is about productive v/s protective strategies, where uncertainty about inflation stimulates firms to alter the decision regarding resource allocation from more to less productive uses. In order to cope with increased level of uncertainty, firms update their information about expected inflation, including the behavior of arbitragers towards hedging of investments. Such consequences of inflation uncertainty compel firms to sidetrack its resources from productive to protective methods, which ultimately disturbs small industries and households (Golob, 1994). By another token Ex-post consequences of uncertainty of inflation postulates that due to over valuation or under valuation of real future payments against nominal ones trespasses the status quo between lender/borrower and employer/employee (Blanchard, 1997).

Since inflation and its associated uncertainty are inextricably intertwined however their issue of liaison is still ambiguous regarding direction of causality. Since the path breaking work of Friedman (1977) suggesting that high inflation raises its associated uncertainty. This inserts the argument of one way causality running from inflation to its associated uncertainty generally known as Friedman-Ball (1977, 1992) hypothesis. Another advancement from the Ball's Noble

Lecture which in fact not been explored in case of Pakistan, postulates that higher inflation not only increases uncertainty of the inflation but also increases uncertainty about future real economic activity[2].

Ball argues that if inflation raises its associated uncertainty *i.e.*, the conditional variance of inflation, then it also increases unemployment uncertainty. Since we are dealing with unemployment and output growth therefore we are coming across with the concept of Okun's law. Okun law states that employed persons help to produce output but unemployed persons do not so increase in unemployment rate should be associated with decrease in output. So according to Okun output variability also tends to increases with the level of inflation just in the way that uncertainties of both inflation and unemployment are positively correlated, that was Ball's findings. In addition Ramey and Ramey (1995) advocated the mechanism by which increased output volatility rises planning errors that leaves output growth to decrease substantially. Similarly Ball's explanation corroborates that inflation and its associated uncertainty are positively associated. Ball further postulated that inflation and uncertainty about unemployment are positively associated. Therefore the direction is running from inflation to the uncertainty of unemployment. Now the first step of this study is to measure inflation uncertainty for the case of Pakistan. For that matter we need to find a suitable proxy for inflation uncertainty and unemployment uncertainty so the first way out of this impasse is through survey of expectations, such as Livingston Surveys such as conducted in US that provides forecast of point estimates of many other variables like inflation, acquired from different individuals forecasters, uncertainties

[2] Phillips Curve, $U_t = U^n - \alpha(\pi_t - E_{t-1}\pi_t)$ (also part of Ball's model) where U_t *is* the rate of unemployment at time t, U^n being the natural rate of unemployment, expectation operator E_{t-1} ( ) is the based upon the information at time t-1 and π_t is inflation rate at time t and the proportion of the conditional variance of inflation and unemployment. Such that,

$$[E_{t-1}(U_t - U^n)^2] = \alpha^2 E_{t-1}[(\pi_t - E_{t-1}\pi_t)^2\,] \qquad (1.1)$$

about inflation and unemployment can be proxied by their variances through forecasts across cross sectional data. However Engle (1983) advanced path breaking work on modelling fluctuations or volatility of inflation as time varying or auto regressive conditional hetroskedasticity (ARCH), where he used a conventional equation of conditional variance *i.e.*, taken as a proxy for variability (or uncertainty) of inflation after assuming parameters to be fixed permitting the conditional variance of inflation to depend upon history. This study also fills the void that there is positive association between uncertainties about inflation and unemployment and the direction is running from inflation to unemployment uncertainty. The ultimate contribution of this study reports regression presenting the direction among uncertainties of both inflation and unemployment and real GDP growth. The results of the regressions will signpost that inflation uncertainty and unemployment uncertainty devise an adverse sway on real GDP growth.

1.2 Objectives of the Study

Following are the objectives of the study:

- To check the direction between inflation and its associated uncertainty in case of Pakistan.
- To check the direction between inflation and unemployment uncertainty in case of Pakistan.
- To check the direction of uncertainties of both inflation and unemployment on real GDP growth in case of Pakistan.

1.3 Significance of the Study

This study specifically discusses asymmetric behavior of uncertainty associated with both inflation and unemployment by employing EGARCH specifications and checks their further impact on economic growth of Pakistan which has not been discussed yet. So, this study particularly puts forward that unemployment uncertainty becomes the cost of higher inflation that may justify the equal billing with inflation uncertainty.

1.4 Delimitation of the Study

Since different shocks often yields different movements, such that the overall pattern is based upon the specified transmission mechanisms from shocks to outcomes so as so for along with other characteristics. Since modern monetary policy is forward-thinking therefore present research will be restricted to incorporate the detailed analysis of the central bank's contemporaneous response to shocks that can deviate inflation from the future targets and may ultimately affect uncertainties about inflation and unemployment. This study will also be limited to discuss the detailed analysis of the gap version, which is the impact of unemployment gap on output gap, first proposed by Arthur Okun (1962) who empirically observed the relationship between unemployment and losses in a country's production, and the inflation unemployment relationship as well.

1.5 Organization of the Study

The rest of the thesis is schematized in five thematic framework such as; the review of theoretical literature (*i.e.,* an overview of the rationale underlying dissimilar hypotheses concerning the association between inflation and its associated uncertainty and also the mechanism and theoretical backgrounds of unemployment uncertainty and economic growth) and empirical literature is discussed in Chapter 2. Chapter 3 is comprised of sources of data and methodology whereas empirical results and discussion is labelled in Chapter 4. The analysis of data, interpretation of the results along with some policy implications and its limitation is reported in Chapter 5.

CHAPTER 2

RELATED EMPIRICAL RESEARCH REVIEW

A large body of empirical literature has investigated the relationship between inflation with its associated uncertainty and also with unemployment uncertainty and economic growth. This chapter reviews the most relevant literature in this area. The section 2.1 reviews the theoretical literature on inflation uncertainty, inflation, unemployment uncertainty and growth. The empirical literature is reviewed in section 2.2.

2.1 Review of Theoretical Literature

- **Impact of Inflation on Inflation Uncertainty**

Arthur Okun (1971) pioneered the idea that inflation and uncertainty of inflation is positively associated. He argued that public policy disturbed agent's expectations and high volatile rate of inflation yields a stop-go pattern of economic time series and compel average rate of inflation rate to raise its associated variability. Furthermore, unanticipated variations in the rate of inflation urges welfare costs. Hence, monetary authority tried to refrain not only from higher rate of inflation because they are high but also because they are related with increased magnitude of inflation uncertainty.

Gordon (1971) commented on Okun that the so called positive link between inflation and its associated uncertainty happened just because of sample period since there was no systematic relationship that is attributed to inflation and inflation uncertainty. Friedman (1977) reemphasized the idea in support of Okun that such a positive relationship existed by pointing an argument that inflation may persuade an erratic policy by monetary authority thus increases inflation uncertainty.

According to Friedman (1977) there existed a political cohesiveness of a country where institutional provisions had been corrected to long-term price level. Therefore to carry favor of general public by offering monetary benefits (by keeping inflation low) to voters, government would ask monetary authority to reduce inflation since price stability is preferred as a motive to retain trust of voters. To end with the relationship, Friedman (1977) argued that due to such uncertainty of inflation there would be distortion of price mechanism, economic inefficiency and inefficient resource allocation, therefore reduces output growth thus increases unemployment.

Pourgerami-Maskus (1987) as well as Ungar and Zilberferb (1993) revealed that there is a negative association between inflation and its associated uncertainty. More precisely their study postulated that high inflation reduces its associated uncertainty. When inflation increased the economic agents would spend more resources in order to forecast future course of inflation more efficiently since they were interested in several decisions regarding employment, investment, consumption and production *etc*. In this way they would have best forecast and knew more about future inflation thus reduces inflation uncertainty.

Lawrence Ball (1992) intuitively derived the results of Friedman's hypothesis and withdrew a formal justification of Friedman's insight in a way that such a relationship is actually carried out under game of asymmetric information where there were two type of policy makers one is conservative and other one is liberal. Ball assumed that both conservative and liberal policymaker reacts differently in office in a stochastic manner. When inflation increases, public had asymmetric information since they didn't know the taste of policymakers for future course of inflation whether it would decrease in future or not. Thus inflation created more uncertainty about inflation.

- **Impact of Inflation Uncertainty on Inflation**

By another token, reverse association between inflation and its associated uncertainty was justified by Cukierman-Meltzer hypothesis (1986) and Cukierman (1992). Cukierman-Meltzer carried out the study on inflation and inflation uncertainty under different regimes of a country over a course of time. The study of Cukierman-Meltzer was actually based upon the model suggested by Barro-Gordon. Cukierman-Meltzer postulated that as uncertainty about inflation rises, by the same time to attain sustainable economic growth policymaker would perceive an incentive to create inflation surprises. Therefore inflation uncertainty likely to increase rate of inflation. There were several studies that are in line with Cukierman and Meltzer hypothesis, together with Baillie *et al*., (1996) and Grier and Perry (1998). Holland (1995) proposed stabilization hypothesis regarding inflation and inflation uncertainty. He claimed that a rise in uncertainty of inflation reduces level of inflation. Therefore, Holland suggested that if monetary authority aims to lessen welfare losses arising due to uncertainty about inflation then this would lower the average rate of inflation. Thus it opposes Cukierman-Meltzer (1986) hypothesis.

- **Impact of Inflation Uncertainty on Output Growth**

Friedman (1977) informally argued that due to such uncertainty of inflation there would be distortion of price mechanism, economic inefficiency may happen due to inefficient resource allocation, thus reduces output growth. Inflation uncertainty being the major costs of higher inflation deteriorates decision making of agents concerning future savings and investment. Due to loss of predictability of the real value of future nominal payments, it lengthened the severe effects of these distortions to the level of real economic activity and efficient allocation of resources thus output growth declines. Dotsey and Sarte (2000) formally addressed the nexus between uncertainty of inflation and output growth therefore postulated that such a relationship is positive in nature *i.e.*, in contrast to Friedman. They argued that when the economic agent is risk averser then precautionary savings were positively associated with uncertainty of inflation. In a situation of high uncertainty of inflation economic agents demand less real money balances which in turn raised savings and reduces consumption which leads to more economic growth.

- **Impact of Unemployment Uncertainty on Output Growth**

Ball (1992) informally argued that uncertainty about inflation not only affects output growth but also affects real economic activity or raises level of unemployment. If reduction in the rate of inflation caused a rise in unemployment rate then and there higher inflation would yield more uncertainty about the future direction of government policy and therefore future rates of inflation and unemployment. In this way inflation rate would make unemployment to be uncertain hence inflation caused unemployment uncertainty and unemployment uncertainty also affects output growth. These channels over and done with the association between inflation and inflation uncertainty along with unemployment uncertainty could be determined. Hayford (1999) formally confirms the Ball's hypothesis that inflation likely to affect unemployment uncertainty and uncertainties of both unemployment and inflation had adverse effect on output growth. Although these theories are based on economic rationale and on reasonable economic mechanisms and discussions but literature provides mixed results regarding inflation, its associated uncertainty and output or real GDP growth. The results of this study would conclude which of the above hypothesis holds true for the case of Pakistan.

Table 2.1 Summary of Testable Theories and Expected Signs

Testable Theories	Sign
▪ Inflation – Inflation Uncertainty	
Friedman-Ball Hypothesis (1977, 1992)	+
Pourgerami and Maskus (1987)	-
Ungar and Zilberferb (1993)	-
▪ Inflation Uncertainty – Inflation	
Cukierman-Meltzer Hypothesis (1986)	+
Holland (1995)	-
▪ Inflation Uncertainty – Output Growth	
Friedman (1977)	-
Dotsey and Sarte (2000)	+
▪ Unemployment Uncertainty – Output Growth	
Ball (1992)	-

2.2 Review of Empirical Literature

This section reviews some of the most relevant studies in this area. Bollerslev (1986) established GARCH model and investigated the association between inflation and uncertainty of inflation using quarterly time series ranging from 1948Q4 to 1983Q4 for US. The findings of his study revealed insignificant relationship between inflation and inflation uncertainty.

Chang (1993) took quarterly data of GNP-Deflator for US economy and the data is ranged from 1958:01 to 1998:04 using Markov Switching Hetroskedasticity. The study revealed the findings that uncertainty of inflation is the cost of inflation thus higher level of inflation raises its associated uncertainty.

Holland (1993), Davis and Kanago (1996) found that uncertainty about inflation and output growth are inversely related if and only if there is positive correlation between both uncertainties about inflation and unemployment and then negative impact of inflation uncertainty on output growth was actually be due to unemployment uncertainty.

Grier and Perry (1998) took monthly series ranged from the period of 1948 to 1993 for G-7 economies (including US, UK, Japan, Germany and France). To test the association between inflation and its associated uncertainty the study employs GARCH specification and Granger causality. The results documents the strong evidence of Friedman-Ball hypothesis for three of the G-7 economies (including US, UK and Germany) that higher inflation is likely to increase its associated uncertainty whereas the opposite causality *i.e.*, Cukierman-Meltzer hypothesis is found in Japan and France.

Hayford (1999), took quarterly data of uncertainties of both inflation, unemployment and unemployment uncertainty (proxy of real economic activity) using Livingstone Survey of US from the period 1961Q1-1997Q2 and proposed that inflation and unemployment uncertainty are positively related and Granger causality test also verified that direction is uni-variate is running from inflation to unemployment uncertainty. Following Davis and Kanago (1996), Hayford (1999) also established VAR Model and the study explored that inflation uncertainty, unemployment uncertainty (proxy by uncertainty about future real economic activity), growth rate of the relative prices of crude oil have an adverse sway on output growth.

Ruth and Athanasios (1999) examined the association between inflation its associated uncertainty and output growth for 119 countries and used monthly panel data which ranges from 1959 to 1992. The study postulated that uncertainty of inflation is inversely associated with output growth.

Nas and Perry (2000) put strong evidence regarding the relationship between inflation uncertainty about inflation on monthly data ranging between 1960:01 to 1998:03 in Turkey using GARCH specification and the results indicated that that there existed affirmative affiliation between inflation and its associated uncertainty and thus higher rate of inflation increases its uncertainty in Turkey, the results were akin to study developed by Neyapti and Kaya (2001).

Fountas and Karanasos (2000) contributed to the literature on the inflation and uncertainty of inflation by employing GARCH specifications that allows instantaneous feedback from conditional variance of inflation. The data covering the period from 1960M1-1999M2 consisted of US CPI had been used. Results confirmed that causality between inflation and its associated uncertainty is bi-directional in nature.

Fountas (2000) examined the association between inflation and its associated uncertainty for UK and annual data covers the span of 100 years from the period 1885 to 1998. By employing GARCH specification the study documented the results that are in line with Friedman (1977) Ball (1992) hypothesis for UK that high inflation raised inflation uncertainty.

Grier and Perry (2000) examined the link among inflation, its associated uncertainty and GDP growth for US economy whereas the data covered the period from 1948 to 1996. The study employed GARCH-in-Mean as a measure uncertainty. The found that higher output growth uncertainty or higher uncertainty of inflation don't increase inflation whereas uncertainty of inflation negatively affect output growth.

Fountas and Karanasos (2003) considered six European countries (France, Spain, Germany, Italy and Netherlands) to study the link between inflation and its associated uncertainty using annual time series ranging between 1960 and 1999 with EGARCH model. Summarizing the crux, except the case of Germany, inflation raised inflation uncertainty in all other countries. Whereas in Germany and Netherlands and direction was running from uncertainty of inflation to inflation whereas uncertainty reduced inflation. Whereas in Italy, Spain and France uncertainty of inflation increased inflation.

Chan and Xie (2003) used Hamilton's (2001) flexible regression model to find the nonlinear affiliation between inflation and its associated uncertainty using data on monthly basis for Taiwan's CPI from 1980:01 to 2002:12. The findings of the study supported Friedman-Ball hypothesis that higher inflation likely to increase its associated uncertainty.

Kontonikas (2004) assumed quarterly and monthly data of CPI (consumer price index) for United Kingdom from 1972-2002, using GARCH Models the results indicated that the link between inflation and its associated uncertainty was positive in nature.

Elton *et al.,* (2005) investigated the re-examining inflation and its uncertainty for twenty five developed and emerging economies and took the monthly data ranging from 1957:01 to 2005:05. To examine the link between inflation and its associated uncertainty this study established Periodic-GARCH (PGARCH) specification. This study documented its findings that for majority of the developed and emerging economies there is strong evidence of Friedman-Ball hypothesis whereas for opposite causality (Cukierman-Meltzer) the rest of the economies depicts mixed results.

Fountas and Bredin (2006) used a Markov Regime Switching Hetroskedasticity specification to test the relationship between inflation and its associated uncertainty in four European countries (Germany, Italy, UK, and Holland). Using quarterly data from 1968-2005 on GDP deflator (proxy for the price level) had been used. The results revealed the significant affiliation between inflation and its uncertainty.

Thornton (2006) employed GARCH specification on monthly time series and found that the link between inflation and its associated variability in India is positively related during 1957-2005. The direction of causality was uni-variate such that inflation raised its associated uncertainty. It is well acknowledged that inflation uncertainty influences output growth negatively see Hayford (1999). So, this makes stronger the case for the prime objective of central banks to show vigorous concentration on price stability.

Olan and Sandy (2006) took quarterly data for G-7 economies (US, Italy, Germany, Canada, Japan, UK and France) and the data differently covers the period from 1950:01 for all G-7 economies but ends in 2004:04 thus forms the 500 observations for each of the G-7 economies. They investigated the link between rate of dependence between inflation and its associated uncertainty and their asymmetries using T-GARCH methodology. They study depicts that dependence rate is found in US, UK and in Canada whereas uncertainty of inflation is found only in UK and Canada. This study also revealed that except Germany all the results are different form several studies done on these economies that supported Friedman-Ball hypothesis *i.e.*, due may be due to different specifications that authors carried out in this study.

Cheh (2006) examined the link between patterns of inflation and its associated uncertainty by employing Quintile Regression Approach therefore took cross sectional data of 161 economies whereas the data ranges from 1961 to 2002. The study documented the result in mixed nature that there was positive association between inflation and uncertainty of inflation that was in line with Friedman-Ball hypothesis and higher uncertainty of inflation also likely to increase rate of inflation *i.e.*, Cukierman-Meltzer hypothesis.

Thornton (2007), employed GARCH Models, and documents the results that are in line with Friedman-Ball hypothesis for all emerging markets, while Holland (1995) hypothesis got support for Israel, Mexico, Colombia and Turkey. Once again Thornton (2008), inserted the results that confirms Friedman-Ball hypothesis for Argentina.

Payne (2008) employed ARMA-GARCH models using monthly data based on CPI and extended the literature on the association between inflation and its associated uncertainty by probing three Caribbean countries (Jamaica, Barbados and Bahamas). The empirical findings showed that in all three countries inflation increases its associated uncertainty. Conversely, in Jamaica there existed bi-directional relationship between these two variables.

Paesani (2009) projected a time varying AR-GARCH specification using monthly Harmonized Index of Consumer Prices from 1980-2009 then investigated the relation between inflation and its associated uncertainty for the Euro area, in a VAR framework. The results showed that the Friedman-Ball hypothesis was empirically supported during the Euro period.

Rizvi and Naqvi (2009) used asymmetric GARCH specifications and investigated the link between inflation and its associated uncertainty in ten Asian Economies: China, Pakistan, Philippines, Hong Kong, Philippines, Malaysia, Singapore, South Korea, India, Indonesia and Thailand. The data set composed of quarterly CPI from 1987:01-2008:02. The findings for Pakistan, India, Indonesia and Thailand supported Friedman-Ball Hypothesis that inflation effected uncertainty about inflation conversely in other countries there existed bi-directional causality.

Paresh *et al.*, (2009) examined the link among inflation, its associated uncertainty and GDP growth for China economy using quarterly data which is ranged from 1987:01 to 2006:01. By employing Exponential-GARCH (EGARCH) specification the study revealed that higher level of uncertainty of inflation significantly reduced output growth in China. The study also demonstrates that there exists no strong evidence that output uncertainty increases the level of inflation.

Rizvi and Naqvi (2010) worked again on Friedman-Ball Hypothesis using GJR-GARCH and EGARCH specifications (to capture asymmetries) on quarterly data for Pakistan from 1976:01 to 2008:02 and also showed a significant level of asymmetry from news impact curves. The results depicted that in Pakistan, Friedman-Ball hypothesis holds.

Mojtaba *et al.*, (2010) examined the link between inflation and its associated uncertainty in Iran using quarterly data from 1959Q1 to 2009Q4 through E-GARCH framework. The results supported Friedman-Ball Hypothesis by showing the asymmetric liaison between inflation and inflation uncertainty. The positive shocks to inflation adversely affected its associated uncertainty instead of negative ones.

Khalil *et al.,* (2011) employed EGARCH model as a measure of uncertainty of inflation for SAARC economies (Pakistan, India and Sri Lanka), and explored the nexus between inflation and its associated uncertainty using quarterly time series from 1980Q1-2009Q4. The results obtained from this study demonstrated that there is a positive correlation and bi-directional Granger Causality between inflation and its associated uncertainty in each of the SAARC region countries. In fine, the crux which this study is drawing from the existing empirical literature besides unemployment uncertainty depicts that relationship between inflation and its associated uncertainty is mixed in nature. Given the theoretical ambiguity about this relationship, it is not quite astonishing because the statistical evidence is also mixed.

Mustafa *et al.,* (2011) examined the nexus between inflation uncertainty and economic growth consuming quarterly as well as monthly data for US economy ranging the period from 1985-2009. The study carried out the relationship by employing Markov Switching GARCH specification and revealed that the link between inflation uncertainty and output growth was negative in nature that higher the uncertainty of inflation lower would be the economic growth. Also arguing that under lower growth regimes inflation hurts output growth 4.5 time higher as compared to higher growth regimes.

Carlos and Kerstin (2011) took monthly data of CPI and subcategories to compare cross countries harmonized CPI (HCPI) from 1994 to 2009 for eight WAEMU African economies to test the nexus between inflation and relative price variability (RPV). The study extended its result that was in line with Friedman-Ball hypothesis that inflation raises the relative price variability in al WAEMU economies.

Ahmad *et al.,* (2011) carried out the study on inflation and inflation uncertainty using monthly data of two post-soviet economies including Russia and Ukraine whereas the data of

Russia ranged from 1991M2 to 2008M12 and for Ukraine it was from 1992M4 to 2008M12. By employing EGARCH-M estimation the study documents the results that there exists sudden jumps in uncertainty inflation that is the reason of the development under post-communist eras in both economies. The study also confirms the presence of Friedman-Balls hypothesis that inflation positively affect its associated uncertainty in both Russia and Ukraine.

Sajid *et al.,* (2012) tested the nexus between inflation and its associated uncertainty using monthly data of Pakistan covering the period from 1957:01 to 2007:12. Inflation uncertainty (proxy of variability of inflation) was estimated using ARCH/GARCH models. The findings of this study signposts the strong evidence of Friedman-Ball hypothesis that causality is uni-directional stating high inflation likely to increase its associated uncertainty.

Jafri *et al.,* (2012) investigated the association between inflation and its associated uncertainty among five MENA economies (Iran, Syria, Jordon, Egypt and Morocco) consuming monthly time series covering the period of 1991:10 to 2010:05. The study employed Full Information Maximum Likelihood (FIML) specification and drew the conclusion that inflation follows asymmetric behavior for all five economies of MENA. The study also signposted the strong evidence that positive shock of same magnitude comparable to negative shock affects uncertainty of inflation. Except Egypt rest four MENA economies were in line with the hypothesis of Friedman-Ball which postulated that high inflation likely to increase its associated uncertainty.

Ozcan (2012) took monthly data of Turkey from 2002 to 2011 and examined the nexus between inflation and its associated uncertainty. The study establishes ARMA-GARCH specification and the findings demonstrated the strong evidence of Friedman-Ball hypothesis stating that high inflation raised its associated uncertainty.

Chowdhury and Sarkar (2014) investigated the link between inflation and uncertainty of inflation for G7 economies using and monthly time series covering the period 1970 to 2013. They considered two regimes since the impact of inflation on its associated uncertainty was different in two regimes and each regime follows GRACH model. The empirical findings were in line with Friedman-Ball hypothesis that higher inflation likely to increase its associated uncertainty and their relationship is positive.

Adnen *et al.,* (2015) took monthly data from 1921:01 to 2012:12 investigated the nexus between inflation and its associated uncertainty for the case of South Africa. Whereas conditional variance of inflation (proxy of uncertainty of inflation) was measured by employing Seasonally Fractionally Integrated Smooth Transition Autoregressive Asymmetric Power GARCH (SEA-FISTAR-APGARCH). The results signposted the strong evidence of Friedman-Ball hypothesis for South Africa.

By reviewing theoretical and empirical literature we have found that there exists theoretical as well as empirical ambiguities since both marked mixed type of propositions, mechanisms and results regarding the relationship between inflation, its associated uncertainty, unemployment uncertainty and economic growth. Since inflation, unemployment and real GDP growth are the contentious issues of Pakistan's economy then this study fills the void to know more about the consequences of higher inflation affecting unemployment and ultimately disturbing real GDP growth of Pakistan.

CHAPTER 3

DATA AND METHODOLOGY

This chapter discusses the methodological framework, data sources and construction of variables.

3.1 Data Sources

The variables inflation, unemployment and output growth are under consideration in this study. The study uses quarterly data that covers the period from 1981Q01-2013Q04 and the data is taken from International Financial Statistics (IFS), Survey of Pakistan Economy and World Bank. Understanding the relationship among inflation uncertainty, unemployment uncertainty and real GDP growth is very important to macroeconomists and policy makers alike. First there is need to focus on suitable proxy for uncertainties of both inflation and unemployment. Common practice to cope with the problem like this is the survey of expectations, such as Livingston Survey conducted by University of Philadelphia. Given these forecasted measures from different individual forecasters. Batchelor and Dua (1996) suggests that such survey of expectations like Livingston Survey for the measure of forecast dispersion (uncertainty) are better proxies for macroeconomic variables like inflation and unemployment rather using time series proxies. To the best of my knowledge, such survey of expectations do not exist for Pakistan. Since a substitute approach is available to measure uncertainty of inflation using ARCH Models, starts with Engel (1982 & 1983) or time varying parameters specifications proposed by Evans and Wachtel (1993). Bollerslev and Taylor (1986), separately establish GARCH specifications, in which conditional variance is regressed on its own lags including the squared residuals terms lags (forecast errors). But the major drawback of ARCH or GARCH is that both fails to capture symmetric or asymmetric behavior of uncertainty to negative and positive shock. Conversely, it has been observed that the behavior of uncertainty about inflation is asymmetric rather than symmetric. Engle and Ng (1993) developed several tests to check the asymmetries, if any. These tests are also been criticized on the bases of biasness of sign and size tests but based on existing literature this study employs Exponential Generalized Autoregressive Conditional Hetroskedasticity (EGARCH) model of Nelson (1991) because it captures the asymmetries in terms of positive and negative shocks. In Pakistan four different types of price indicators are available: including the consumer price index (CPI), sensitive price index SPI), wholesale price index (WPI), and GDP deflator. Whereas the study of Bokhari and Faridun (2006) postulates that CPI is a finest measure since it accurately portrays living cost of Pakistan and also been updated on a regular basis in its calculations and composition. The data of inflation and unemployment is taken from International Financial Statistics (IFS).

3.1.2 Structural Breaks of Variables

- **Bai and Perron Test (1999)**

The present study has used Bai and Perron (1999) test for structural breaks. The standard model considered by authors is a multiple linear regression model with T time periods and *m* potential break points, which results in *m + 1* regimes. The model is given by

$$Y = X\beta + Z\delta + \varepsilon$$

Where Z is a set of variables whose coefficient vary across regimes and X is set of variable whose coefficient remain same across the regimes. There are three types of testing procedures in this test

- Global Maximizer
- Sequential Test.
- Hybrid Test (Mixture of Both Ones)

The analysis uses here sequential procedure and this sub-section only defines it. The steps involved in the testing are following. First full sample is considered and consistency of parameters of variables is tested. If the hypothesis is rejected then the data is divided into two subsets and possible presence of structural breaks is tested. The data is dived and the test for more and more regimes are performed until the hypothesis accept. Following F test is used for testing:

$$F = \frac{1}{T}\left(\frac{T-(l+1)q}{lq}\right)\hat{\delta}\text{R (RV }(\hat{\delta})\text{ R)}^{-1}\text{ R}\hat{\delta}$$

Where q is number of restrictions, l is number of potential break points R is restriction matrix and V is variance-covariance matrix.

3.1.3 Stationarity of Variables

- **HEGY Test (1990)**

To check the order of integration in the considered time series, this study conducts unit root tests in this section. Therefore the analysis starts with an examination of the time series properties of inflation, unemployment and output growth whether they are seriously affected by the problem of unit roots or not. Since the quarterly data is used so there is a possibility of seasonal unit root in the data. For this purpose Hyllberg, Engle, Granger and Yoo (HEGY (1990)) seasonal unit root test is more suitable for quarterly data. Seasonal unit root test to check the order of integration of the variable. Let y_t be variable then a seasonal auto regressive process can be represented as:

$$y_t = \alpha y_{t-4} + \epsilon_t$$

Where ϵ_t white noise process with zero mean and constant variance. The y_t process has four roots on the unit circle. When $\alpha = 1$; one at frequency $\theta = 0$, one at frequency $\theta = \pi$, and a pair of complex roots at frequencies $\theta = \pi/2 \,, 3\pi/2$. The framework proposed by HEGY is discussed here. We generate the variables as follows for quarterly data.

1. $y_{1,t} \equiv (1+L)(1+L^2)\, y_t = y_t + y_{t-1} + y_{t-2} + y_{t-3}$
2. $y_{2,t} \equiv -(1-L)(1+L^2)\, y_t = -(y_t - y_{t-1} + y_{t-2} - y_{t-3})$
3. $y_{3,t} \equiv (1-L)(1+L)\, y_t = y_t - y_{t-2}$
4. $y_{4,t} \equiv \Delta_4 y_t = y_t - y_{t-4}$

Then the following regression is estimated:

$$\Delta_4 y_t = \mu_t + \pi_1 y_{1,\, t-1} + \pi_2 y_{2,\, t-1} + \pi_3 y_{3,\, t-1} + \pi_4 y_{3,\, t-1} + \sum \alpha_i \Delta_4 y_{t-i} + \varepsilon_t$$

Hypotheses

1. H_A: $\pi_1 = 0 \Rightarrow$ Non seasonal unit root
2. H_B: $\pi_2 = 0 \Rightarrow$ Biannual unit root
3. H_C: $\pi_3 = \pi_4 = 0 \Rightarrow$ Annual unit root

Accept H_0	**Stationary Variable**
H_A, H_B, H_C	$\Delta_4 y_t$ (= y_{4t})
H_A, H_B,	$\Delta_2 y_t$ (= y_{3t})
H_A, H_C	$(1-L)(1+L^2)y_t$ (= y_{2t})
H_B, H_C	$(1+L)(1+L^2)y_t$ (= y_{1t})
H_A	$\Delta_1 y_t$
H_B	$(1+L)y_t$
H_C	$(1+L^2)y_t$
Rejected	y_t

3.2 Methodological Framework

The main objective of the study is three fold to find the relationship between inflation and its associated uncertainty, unemployment uncertainty real GDP growth. The empirical specification based on the theoretical model given in chapter 2 requires following steps to be undertaken.

3.2.1 Estimation Technique

The study employs ARCH models to measure uncertainty in inflation and unemployment. To capture asymmetry in uncertainty, Nelson's (1991) EGARCH model is selected. The causal relationship between inflation, inflation uncertainty, unemployment uncertainty and growth is tested by Toda-Yamamoto Augmented Granger Causality Test. The details of pre-specification diagnostics tests such as test of stationarity, procedure used to obtain uncertainty in inflation and unemployment, causality tests, required to undertake the analysis are discussed in detail below.

3.3 Model Selection for Uncertainty Variables

While dealing with uncertainty/variability, existing literature indicates that certain studies take benefit to exploit survey data and employ the dispersion across forecasters' forecasts (Livingstone Survey) while some researchers use a simple rolling/moving standard deviation (MSD) approach of the series as a measure of uncertainty for most of the economic variables. Since high frequency data have the problem of volatility clustering (*i.e.*, wild and calm periods) then and there researchers employ GARCH specification pertaining the conditional variance as a measure of uncertainty. So rationale for the selection of GARCH specification stands out to be a much sophisticated methodology instead of simple statistical tools or survey methods to generate measures of uncertainty that are criticized on several grounds. For instance, uncertainty measured from survey of expectations fails to estimate the true level of uncertainty and possibly can contain substantial measurement errors. By the same token, this methodology assigns equal weights its lags and raises considerable serial correlation. It is also been observed that the standard deviation measures variability and expected variations in inflation rate causes an increase in this measure even without the presence of uncertainty in the overall economic environment (Jansen 1989, Grier and Perry, 2000). So, in order to measure inflation and unemployment uncertainty we will use GARCH as our baseline model.

3.3.1 Modeling Inflation and Unemployment Uncertainty by GARCH Model

In this section, Autoregressive Conditional Hetroskedasticity (ARCH) model and its extension as Generalized Autoregressive Conditional Hetroskedasticity (GARCH) model are used to detect the ARCH/GARCH effects. These models explain the trend in inflation with the passage of time. ARCH models are specially modelled to forecast conditional variance. Concept of ARCH model was pioneered by Engle (1982). ARCH specification shows the variance of the residuals at time t based on the lags of squared error terms. So the ARCH (p) process will be as:

Mean Equation for Inflation

$$\pi_t = \varphi + \sum_{j=1}^{p} \delta_i \, \pi_{t-j} + \varepsilon_t \qquad \textbf{\textit{(1-a)}}$$

$$\varepsilon_t \sim N\ (0, h_t)$$

Mean Equation for Unemployment

$$U_t = \mu + \sum_{l=1}^{p} \theta_l \, U_{t-l} + u_t \qquad \textbf{\textit{(1-b)}}$$

$$u_t \sim N\ (0, h_t)$$

Where π_t and U_t denotes rate of inflation and unemployment respectively. Which is simply an autoregressive process. Whereas h_t denotes conditional variance which is a deterministic function of historical returns. To derive conditional variance for both variables like inflation and unemployment this study employs GARCH model that permits conditional variance to depend on its lags and on the lags of squared residual terms. In this case the GARCH (p, q) model will be as follows:

$$h_{\pi t} = \omega_0 + \sum_{i=1}^{p} \alpha_{\pi i}\, h_{t-i} + \sum_{j=1}^{q} \beta_{\pi i}\, \varepsilon_{t-j}^2 \qquad \textbf{\textit{(1-c)}}$$

$$h_{ut} = \omega_0 + \sum_{k=1}^{p} \alpha_{ui}\, h_{t-k} + \sum_{l=1}^{q} \beta_{ui}\, u_{t-l}^2 \qquad \textbf{\textit{(1-d)}}$$

3.3.2 Modeling Asymmetries in Inflation and Unemployment

To estimate uncertainty for inflation and unemployment this study employs Nelson's (1991) Exponential Generalized Autoregressive Conditional Hetroskedasticity (E-GARCH) which yields the conditional variance of both inflation and unemployment that can be proxied for uncertainties of both inflation and unemployment. As compared to conventional GARCH specifications E-GARCH models the logarithm of the conditional variance therefore is not restricted to follow the assumption of parameters to be non-negativity. The EGARCH model also permits for testing of asymmetries in terms of negative and positive shocks. The general variance equation for both variables inflation and unemployment is as:

$$ln(h_t) = \omega_0 + \sum_{i=1}^{p} \beta_i\, ln(h_{t-i}) + \sum_{j=1}^{q} \alpha_j \left| \frac{\varepsilon_{t-j}}{\sqrt{h_{t-j}}} \right| + \sum_{j=1}^{q} \gamma_j \frac{\varepsilon_{t-j}}{\sqrt{h_{t-j}}} \qquad \textbf{\textit{(1-e)}}$$

Whereas, β, α and γ are parameters to be estimated. When the magnitude of γ is non-zero, then the effect of inflation on its associated uncertainty and inflation on unemployment uncertainty is asymmetric, when γ is positive then a rise in inflation induces a further increase in inflation uncertainty as well as unemployment uncertainty and vice versa.

3.4 Toda-Yamamoto Augmented Granger Causality Test (TYAGCT)

To check correlation and direction between inflation, inflation uncertainty and unemployment uncertainty this study employs bi-variate causality. A number of estimation techniques have been formulated to test the causality or direction among several economic variables such as Granger (1969), Engle and Granger (1987) and Johansen and Juselius (1990). Whereas He and Maekawa (1999) postulates that if the data is non-stationary (at any stage) then applying Granger causality techniques can yield spurious results. Therefore Toda and Yamamoto (1995) have suggested that if such a situation exists when there are different order of integrations, or variables are not cointegrated or even both, then and there ECM is not applicable. So to overcome these methodological hazards Toda and Yamamoto (1995) devised a special test which is established on the assumption of asymptotic theory just to find the causality among economic variables irrespective of their different order of integrations. This test is widely known as Toda Yamamoto (1995) Augmented Granger Causality test. Rambaldi and Doran (1996) have revised Wald test which is more appropriate when Seemingly Unrelated Regression (SUR) Model is used in the estimation. SUR model is quite desirable in the sense that it takes into account the possible biasness of simultaneity in system of equations.

3.4.1 General Model

$$x_t = \alpha_1 + \sum_{i=1}^{n+d} \beta_{1i} x_{t-i} + \sum_{i=1}^{n+d} \gamma_{1i} y_{t-i} + \varepsilon_{1t} \qquad \textbf{\textit{(1-f)}}$$

$$y_t = \alpha_2 + \sum_{i=1}^{n+d} \beta_{2i} y_{t-i} + \sum_{i=1}^{n+d} \gamma_{2i} x_{t-i} + \varepsilon_{2t} \qquad \textbf{\textit{(1-g)}}$$

Where n is the optimal lag length that will be measured by the AIC or SBC criterions and d is the maximal order of integration.

3.4.2 The Procedure

To determine the maximal order of integration of our quarterly time series this study applies HEGY test to measure the order of integration for our variables under consideration. Whereas optimal lags will be considered through AIC or SBC criterions. Then by applying OLS residual sum of square is derived from equation (1-f) which is known as restricted residual sum of square. Then manually applying optimal lag lengths unrestricted version of equation (1-g) is estimated. Then Hypotheses are developed in a way that:

Hypothesis Testing

H_0: Equation (1-f) shows that inflation uncertainty Granger causes inflation

H_1: Equation (1-g) shows that inflation Granger causes inflation uncertainty

After calculations F-test for modified Wald test is estimated and if F-value is greater than its critical value then we will reject the null hypothesis and interpret it as direction is uni-variate. So to check the bi-variate causality among INF, INFUNC and UNEMPUNC following steps need to be undertaken.

3.5 Estimating Causal Relationships

3.5.1 Causality between Inflation and Inflation Uncertainty

This study employs Toda Yamamoto Augmented Granger Causality Test to check the direction between inflation, inflation uncertainty and unemployment through seemingly unrelated regression (SUR) model because SUR model provides efficient estimates. Therefore Vector Auto-Regressive (VAR) model consisted of following equations that is estimated through

Seemingly Unrelated Regression (SUR) Model to get the estimates of causality approach developed by Toda-Yamamoto (1995):

$$INF_t = \alpha_1 + \sum_{i=1}^{n} \beta_{1i} INF_{t-i} + \sum_{i=1}^{n} \gamma_{1i} INFUNC_{t-i} + \varepsilon_{1t} \quad \textbf{\textit{(1)}}$$

$$INFUNC_t = \alpha_2 + \sum_{i=1}^{n} \beta_{2i} INFUNC_{t-i} + \sum_{i=1}^{n} \gamma_{2i} INF_{t-i} + \varepsilon_{2t} \quad \textbf{\textit{(2)}}$$

Equation (1) shows that inflation uncertainty Granger causes inflation

Equation (2) shows that inflation Granger causes inflation uncertainty

Hypothesis for Equation (1):

$H_0: \gamma_{11} = 0 \; and \; \gamma_{12} = 0 \ldots and \; \gamma_k = 0$

$H_1: at\ least\ one\ one\ \gamma\ is\ different\ from$ 0

Hypothesis for Equation (2):

$H_0: \gamma_{21} = 0 \; and \; \gamma_{22} = 0 \ldots and \; \gamma_k = 0$

$H_1: at\ least\ one\ one\ \gamma\ is\ different\ from$ 0

Rejection of null hypothesis for equation (1) implies that inflation uncertainty Granger causes inflation but if this happens then we have two possibilities that whether it is Cukierman-Meltzer hypothesis or Holland hypothesis. So if the $\sum_{i=1}^{n} \gamma_{1i} > 0$ then this hypothesis is in line with Cukierman-Meltzer hypothesis and if $\sum_{i=1}^{n} \gamma_{1i} < 0$ then this supports Holland Hypothesis. Similarly rejection of null hypothesis for equation (2) implies that inflation Granger causes inflation uncertainty likewise previous we have two possibilities that whether it will be Friedman-Ball hypothesis or Pourgerami-Maskus hypothesis. So if the $\sum_{i=1}^{n} \gamma_{2i} > 0$ then this hypothesis is line with Friedman-Ball hypothesis and if $\sum_{i=1}^{n} \gamma_{2i} < 0$ then this supports Pourgerami-Maskus Hypothesis.

3.5.2 Causality between Inflation and Unemployment Uncertainty

$$INF_t = \alpha_3 + \sum_{i=1}^{n} \beta_{3i}\, INF_{t-i} + \sum_{i=1}^{n} \gamma_{3i}\, UNEMPUNC_{t-i} + \varepsilon_{3t} \quad \textbf{\textit{(3)}}$$

$$UNEMPUNC_t = \alpha_4 + \sum_{i=1}^{n} \beta_{4i}\, UNEMPUNC_{t-i} + \sum_{i=1}^{n} \gamma_{4i}\, INF_{t-i} + \varepsilon_{4t} \quad \textbf{\textit{(4)}}$$

Equation (3) shows that unemployment uncertainty Granger causes inflation

Equation (4) shows that inflation Granger causes unemployment uncertainty

Hypothesis for Equation (3):

$H_0: \gamma_{31} = 0\ and\ \gamma_{32} = 0 \ldots and\ \gamma_k = 0$

$H_1: at\ least\ one\ one\ \gamma\ is\ different\ from\ 0$

Hypothesis for Equation (4):

$H_0: \gamma_{41} = 0\ and\ \gamma_{42} = 0 \ldots and\ \gamma_k = 0$

$H_1: at\ least\ one\ one\ \gamma\ is\ different\ from\ 0$

Rejection of null hypothesis for equation (3) implies that unemployment uncertainty Granger causes inflation. So there exists two possibilities that if the $\sum_{i=1}^{n} \gamma_{3i} > 0$ then we have no such hypothesis that supports this situation and if $\sum_{i=1}^{n} \gamma_{3i} < 0$ again we have no such hypothesis that confirms any hypothesis. Similarly rejection of null hypothesis for equation (4) implies that inflation Granger causes unemployment uncertainty then there exists two possibilities that $\sum_{i=1}^{n} \gamma_{4i} > 0$ then this hypothesis is in line with Lawrence Ball hypothesis and if $\sum_{i=1}^{n} \gamma_{4i} < 0$ then we have no such hypothesis that confirms any hypothesis.

3.5.3 Causality between Inflation uncertainty and Unemployment Uncertainty

$$INFUNC_t = \alpha_5 + \sum_{i=1}^{n} \beta_{5i}\, INFUNC_{t-i} + \sum_{i=1}^{n} \gamma_{5i}\, UNEMPUNC_{t-i} + \varepsilon_{5t} \quad \textbf{\textit{(5)}}$$

$$UNEMPUNC_t = \alpha_6 + \sum_{i=1}^{n} \beta_{6i}\, UNEMPUNC_{t-i} + \sum_{i=1}^{n} \gamma_{6i}\, INFUNC_{t-i} + \varepsilon_{6t} \quad \textbf{\textit{(6)}}$$

Equation (5) shows that unemployment uncertainty Granger causes inflation uncertainty

Equation (6) shows that inflation uncertainty Granger causes unemployment uncertainty

Hypothesis for Equation (5):

$H_0: \gamma_{51} = 0 \; and \; \gamma_{52} = 0 \ldots and \; \gamma_k = 0$

$H_1: at \; least \; one \; one \; \gamma \; is \; different \; from \; 0$

Hypothesis for Equation (6):

$H_0: \gamma_{61} = 0 \; and \; \gamma_{62} = 0 \ldots and \; \gamma_k = 0$

$H_1: at \; least \; one \; one \; \gamma \; is \; different \; from \; 0$

Whereas same hypothesis is developed for equation (5) and (6) that be estimated for Granger causalities but there is no such hypothesis exists for these two equations.

3.5.4 Causality between Inflation-Unemployment (Uncertainties) and Real GDP Growth

A final contribution of our study reports a regression of Real GDP growth to depend upon uncertainties of both inflation and unemployment. We will estimate the Davis Kanago's (1996) regression:

$$Y_t = \alpha_0 + \sum_{i=1}^{k} \beta_{7i} Y_{t-i} + \sum_{i=1}^{k} \gamma_{7i} INFUNC_{t-i} + \sum_{i=1}^{k} \theta_{7i} UNEMPUNC_{t-i} + \varepsilon_{Yt} \qquad (\mathbf{7})$$

Hypothesis for Equation (7):

$H_0: \gamma_{71} = \theta_{81} = 0 \; and \; \gamma_{72} = \theta_{82} = 0 \ldots and \; \gamma_k = \theta_k = 0$

$H_1: at \; least \; one \; one \; \gamma \; and \; \theta \; is \; different \; from \; 0$

Rejection of null hypothesis for equation (7) implies that inflation uncertainty Granger causes real GDP growth likewise unemployment uncertainty Granger causes real GDP growth. Firstly for the case of inflation uncertainty and real GDP growth we have two possibilities that whether it is Friedman hypothesis or Dotsey-Sarte hypothesis. So if the $\sum_{i=1}^{n} \gamma_{7i} > 0$ then this will support the second argument of Friedman's hypothesis that uncertainty of inflation have negative sway on real GDP growth and if $\sum_{i=1}^{n} \gamma_{7i} < 0$ then this hypothesis will be in line with Dotsey-Sarte hypothesis that uncertainty of inflation have positive effect on real GDP growth. Secondly for the case of uncertainty about unemployment and real GDP growth if the $\sum_{i=1}^{n} \theta_{8i} > 0$ then this supports Lawrence Ball hypothesis that unemployment uncertainty have negative effect on real GDP growth if $\sum_{i=1}^{n} \theta_{8i} < 0$ this means that unemployment uncertainty have positive effect on real GDP growth but we have no such hypothesis that confirms any hypothesis.

Table 3.1 Variable Description

Variables	**Description**
INF	Inflation
INFUNC	Inflation Uncertainty
UNEMPUNC	Unemployment Uncertainty
Y	Real GDP Growth

CHAPTER 4

EMPIRICAL RESULTS AND DISCUSSION

The empirical results and interpretations are documented in this section, As this study is dealing with the nexus among inflation, unemployment and real GDP growth so analysis is started with the central and core problem of time series *i.e.,* structural change or breaks. If no attention is paid to structural break then one can end up with incorrect and misleading inferences and forecasts about such kind of relationships. The results of stationary test are reported in section 4.2 and GARCH and EGARCH results to estimate uncertainty in inflation and unemployment are presented in section 4.3. In section 4.4 the results of Toda Yamamoto Augmented Granger Causality test are reported

4.1 Results of Structural Breaks

Since this analysis cogitates quarterly data therefore Bai and Perron (1999) test is applied and found that structural breaks are present in inflation, unemployment and real GDP growth such as:

Table 4.1 Result of Structural Breaks

Breaks / Variables	Real GDP Growth	Unemployment	Inflation
1	1993Q1	1988Q1	1991Q1
2	2003Q2	1995Q1	1997Q1
3	2008Q1	2004Q2	2003Q2
4	-	2009Q1	2009Q2

The results reported in the above table 4.1 show that there are three structural breaks in real GDP growth whereas four breaks can be seen in unemployment and inflation. Applying dummies to such breaks yields the result that inflation and unemployment is not as much seriously affected by these breaks since parameters are happened to be insignificant. After allowing dummies to the parameters of real GDP growth (except 2003Q2) generates significant result means that the serious is seriously affected by these breaks.

4.2 Results of Unit Root

The analysis further moves to tackle with another problem of time series involving unit roots. After applying HEGY (1990) test the results show that inflation and unemployment have seasonal unit rates or they are integrated at fourth difference whereas real GDP growth is found to be stationary at level or integrated at order zero.

4.3 Results of Constructing Uncertainty of Variables through ARCH/GARCH Models

Before measuring uncertainty of both inflation and unemployment we applied LM-ARCH test on equation (1-a) and (1-b) and observed that ARCH effect is present in both inflation and unemployment such as:

Table 4.2 LM-ARCH Test

Variables	Lags (p)	Chi^2	Prob > Chi^2
Inflation	1	37.269	0.0000
Unemployment	1	130.328	0.0000

H_0: no ARCH effects vs. H_1: ARCH (p) disturbance

Followings table 4.2 further explores the conditional variances for both inflation and unemployment whereas ARCH/GARCH specifications are considered on value of Schwartz and Bayesian (SBC) criterion. These specifications try to help in explaining hetroskedasticity. These specifications are done in STATA under SBC criterion. Observing ACF and PACF in correlogram it can be seen that in mean equation the autoregressive order of unemployment series is three or AR (3) whereas the order of moving average is two or MA (2). Since variables could follows asymmetric behavior in terms of positive and negative shocks therefore unemployment uncertainty is measured through Exponential Autoregressive Conditional Hetroskedasticity (EGARCH) specification where we modeled unemployment uncertainty as EGARCH (1, 1).

Table 4.3 EGARCH (1, 1) and Mean Equation of Unemployment

Mean Equation			**Variance Equation**		
	Coefficient	**P-value**		**Coefficient**	**P-value**
Cons (M)	-1.714335	0.0000	**Cons (V)**	-.2723338	0.3620
AR(1)	2.253876	0.0000	$\boldsymbol{\alpha}$	-.0481301	0.5780
AR(2)	-2.053346	0.0000	$\boldsymbol{\beta}$	.417453	0.0720
AR(3)	.7534925	0.0000	$\boldsymbol{\delta}$	.8876548	0.0000
MA(1)	.0666454	0.0740			
MA(2)	.9491033	0.0000			

Note: Level of significance 1%, 5%, 10% above the parentheses shown by *, **, *** respectively.

Observing ACF and PACF in correlogram it can be seen that in mean equation the autoregressive order of inflation series is one or AR (1) whereas the order of moving average is also one or MA (1). Since we are interested in asymmetries in terms of positive and negative shocks therefore inflation uncertainty is also measured through Exponential Autoregressive Conditional Hetroskedasticity (EGARCH) specification where we modeled inflation uncertainty as EGARCH (2, 2).

Table 4.4 EGARCH (2, 2) and Mean Equation of Inflation

Mean Equation			**Variance Equation**		
	Coefficient	**P-value**		**Coefficient**	**P-value**
Cons (M)	.2098691	0.041	**Cons (V)**	.634802	0.0000
AR(1)	.4852757	0.049	$\boldsymbol{\alpha}$	.0514413	0.663
MA(1)	-.7085037	0.003	$\boldsymbol{\beta}$	.85076	0.0000
			$\boldsymbol{\delta}$	.4674459	0.001

Level of significance 1%, 5%, 10% above the parentheses shown by *, **, *** respectively.

Since δ captures asymmetries therefore the non-zero value of δ associated with both uncertainties of unemployment and inflation is 0.89 and 0.47 respectively providing that unemployment uncertainty and inflation uncertainty follows asymmetric behavior. The positive and significant value of δ shows that positive shock to both inflation and unemployment creates more uncertainty in Pakistan.

4.4 Results of Toda Yamamoto Augmented Granger Causality test between Inflation and Unemployment

To check the direction among inflation, inflation uncertainty and unemployment uncertainty we established Vector Autoregressive (VAR) Model that has been estimated through Seemingly Unrelated Regressions (SUR) model whereas the direction is confirmed through Toda Yamamoto Augmented Granger Causality (TYAGCT (1995)). While dealing with inflation and its associated uncertainty under Model 1 and Model 2 it is seen from the below table that causality is one way thus inflation Granger causes inflation uncertainty since the $\sum_{i=1}^{n} \gamma_{2i} > 0$ *i.e.,* 0.0156 [see Appendix Table A8] then this causation running from inflation to inflation uncertainty is in line with Friedman-Ball Hypothesis (1977, 1992) that inflation raises its associated uncertainty. Model 3 and Model 4 carries the relationship between inflation and unemployment uncertainty. Through their Prob values results show that the causality is uni-variate therefore running from inflation to unemployment uncertainty. Whereas $\sum_{i=1}^{n} \gamma_{4i} > 0$ *i.e.,* 0.00102 [see Appendix Table A9] thus supports Lawrence Ball (1992) Hypothesis that inflation Granger causes unemployment uncertainty and unemployment uncertainty is in fact the cost of higher inflation therefore deserves equal billing with inflation uncertainty. Finally, Model 5 and Model 6 depicts the causality between unemployment uncertainty and inflation uncertainty. TYAGC test signposts the results that unemployment uncertainty Granger causes inflation uncertainty but results indicate no literature and hypothesis concerning such kind of causality as well as their estimated signs.

Table 4.5 Toda Yamamoto Augmented Granger Causality

Model	**Null Hypothesis H_0**	**Test Statistic: Wald Test (χ^2-Statistics)**		
		Value	**df**	**Prob**
BIVARIATE CAUSALITY				
INF AND INFUNC				
Model 1	*INFUNC doesn't cause INF*	.6191 [0.734]	2	Can't Reject*
Model 2	*INF doesn't cause INFUNC*	7.887 [0.0194]	2	Reject*
INF AND UNEMPUNC				
Model 3	*UNEMPUNC doesn't cause INF*	0.73667[0.6920]	2	Can't Reject*
Model 4	*INF doesn't cause UNEMPUNC*	2598.60 [0.0000]	2	Reject*
UNEMPUNC AND INFUNC				
Model 5	*UNEMPUNC doesn't cause INFUNC*	9.9e+05 [0.0000]	3	Reject*
Model 6	*INFUNC doesn't cause UNEMPUNC*	2.9087 [0.4060]	3	Can't Reject*

P-value in Parenthesis

Reject* H_0

4.5 The Results of Toda Yamamoto Augmented Granger Causality test between Inflation Uncertainty, Unemployment Uncertainty and Real GDP Growth

Finally this study reports the Davis and Kanago's (1996) regression in which real GDP growth is regressed on its own lags including inflation uncertainty and unemployment uncertainty. Whereas their associated uncertainty is been estimated through EGARCH specification[3]. Since Friedman (1977) in his second argument postulated that inflation uncertainty have negative real effect on economic growth and Ball also stated that unemployment uncertainty have also negative effect on economic growth for that matter this study has employed the TYAGC test to check the direction whereas signs of (sum of parameters of INFUNC and ENEMPUNC) reveals the underlying hypothesis such as:

Table 4.6 Toda Yamamoto Augmented Granger Causality

Model	**Null Hypothesis H_0**	**Test Statistic: Wald Test (χ^2-Statistics)**		
		Value	**df**	**Prob**
UNIVARIATE CAUSALITY				
INFUNC, UNEMPUNC AND Y_t (Real GDP Growth)				
Model 7	*INFUNC doesn't cause Y_t*	7.013 [0.0003]	2	Reject*
	UNEMPUNC doesn't cause Y_t	8.180 [0.0168]	2	Reject*

P-value in Parenthesis

Reject* H_0

First about the relationship between inflation uncertainty and real GDP growth this study two expected hypothesis *i.e.,* Friedman (1977) and Dotsey and Sarte (2000). Model 7 signposts the results that inflation uncertainty Granger causes real GDP growth. Since $\sum_{i=1}^{n} \gamma_{7i} > 0$ *i.e.,* 0.0014 [see Appendix Table A6] then this confirms the second argument of Friedman's hypothesis that inflation uncertainty have negative effect on real GDP growth. Secondly Model 7 also shows that unemployment uncertainty Granger causes real GDP growth whereas $\sum_{i=1}^{n} \theta_{8i} > 0$ *i.e.,* 0.02680 [see Appendix Table A7] then this supports Lawrence Ball hypothesis that unemployment uncertainty have negative effect on real GDP growth.

[3] EGARCH (1, 1) for Unemployment whereas EGARCH (2, 2) for inflation.

CHAPTER 5

CONCLUSION

This study analyses the nexus between inflation, its associated uncertainty, unemployment uncertainty and real GDP growth using quarterly time series of Pakistan covering the period between 1981:01 to 2013:04. This study employs ARMA-EGARCH specification as a measure of uncertainties of both inflation and unemployment. The results indicate that the behavior of both inflation and unemployment is asymmetric whereas the direction is running from inflation to inflation uncertainty and as well as on unemployment uncertainty is asymmetric. Whereas the positive sign associated with both γ suggests that an increase in inflation raises more its associated uncertainty as well as unemployment uncertainty. Toda Yamamoto Augmented Granger Causality indicates that causality is uni-directional and is running from inflation to its associated uncertainty *i.e.,* in line with Friedman-Ball Hypothesis. The results also ratifies Ball's Hypothesis (1992) that inflation Granger causes unemployment uncertainty. In this way unemployment uncertainty also happens to be the costs of higher inflation therefore deserves equal billing with inflation uncertainty. As a final point of Friedman's second hypothesis, this study reports regression developed by Davis and Kanago (1996) that both uncertainties associated with inflation and unemployment obstructs real GDP growth these results also supports Friedman-Ball (1977, 1992) hypothesis.

5.1 Policy Recommendations

Since inflation and unemployment follows asymmetric behavior and higher rate of inflation raises inflation uncertainty in case of Pakistan. Resultantly there will be political pressure on State Bank of Pakistan to manage inflation at lower rates, by the same token conservative monetary authority will feel fear about the recessionary effect of contractionary monetary policy, and thus situation makes future monetary policy unpredictable for the economic agents which ultimately raises inflation uncertainty and unemployment uncertainty. In this way unemployment uncertainty also happens to be the costs of higher inflation therefore deserves equal billing with inflation uncertainty. Whereas both uncertainties disturb real GDP growth. Therefore this study inserts lucid and vivid suggestions to monetary authority of Pakistan to target inflation at lower average rates so that they could mark price stability. To ensure price stability, they could minimize the negative consequences of uncertainty. In this way monetary authority can cope with uncertain economic environment and can improve economic performance of Pakistan.

5.2 Limitation of the Study

This study is limited to discuss only bi-variate causality among inflation, inflation uncertainty, unemployment uncertainty and real GDP growth. Since we are only interested in the direction among inflation to inflation uncertainty, inflation to unemployment uncertainty and further to real GDP growth therefore this can be extended to more than four variables and further can discuss such phenomena through tri-variate or tetra-variate causalities *etc*.

APPENDIX

Table A1 ARIMA [3, 2] of Unemployment

Unemployment		Coefficients	Standard Error	Prob
Constant		-1.714335	.1241886	0.000
ARIMA	AR			
	L_1	2.253876	.0653647	0.000
	L_2	-2.053346	.1262717	0.000
	L_3	.7534925	.0745902	0.000
	MA			
	L_1	.0666454	.0373539	0.074
	L_2	.9491033	.0234459	0.000

Level of significance 1%, 5%, 10% above the parentheses shown by *, **, * respectively.**

Table A2 ARIMA [1, 1] of Inflation

Unemployment		Coefficients	Standard Error	Prob
Constant		.2098691	.1027155	0.041
ARIMA	AR			
	L_1	.4852757	.2466227	0.049
	MA			
	L_1	-.7085037	.2410724	0.003

Table A3 VAR-TYAGC-Wald Tests (INF & INFUNC)

Equation		Chi2	df	Prob
INF	INFUNC	.61909	2	0.734
INF	All	.61909	2	0.734
INFUNC	INF	7.887	2	0.019
INFUNC	All	7.887	2	0.019

Level of significance 1%, 5%, 10% above the parentheses shown by *, **, * respectively.**

Table A4 VAR-TYAGC-Wald Tests (INF & UNEMPUNC)

Equation		Chi^2	df	Prob
INF	UNEMPUNC	.73667	2	0.692
INF	All	.73667	2	0.692
UNEMPUNC	INF	2598.6	2	0.0000
UNEMPUNC	All	2598.6	2	0.0000

Level of significance 1%, 5%, 10% above the parentheses shown by *, **, * respectively.**

Table A5 VAR-TYAGC-Wald Tests (INFUNC & UNEMPUNC)

Equation		Chi^2	df	Prob
INFUNC	UNEMPUNC	9.9e+05	3	0.0000
INFUNC	All	9.9e+05	3	0.0000
UNEMPUNC	INFUNC	2.9087	3	0.4060
UNEMPUNC	All	2.9087	3	0.4060

Level of significance 1%, 5%, 10% above the parentheses shown by *, **, * respectively.**

Table A6 VAR-TYAGC-Wald Tests (INFUNC & Y_t)

Equation		Coefficients	Standard Error	Prob
Constant		.302324	.0304507	0.0000
$RGDP_g$				
	dg93	-.121975	.0196075	0.0000
	dg08	-.182015	.0271591	0.0000
	$RGDP_g$			
	L_1	1.658308	.038632	0.0000
	L_2	-.8743818	.0363592	0.0000
	INFUNC			
	L_1	0.001271	0.000496	0.005742
	L_2	0.000131	5.69E-05	0.011521

Level of significance 1%, 5%, 10% above the parentheses shown by *, **, * respectively.**

Table A7 VAR-TYAGC-Wald Tests (UNEMPUNC & Y_t)

Equation		Coefficients	Standard Error	Prob
Constant		.2756636	.0324291	0.0000
$RGDP_g$				
	dg93	-.1072865	.0204883	0.0000
	dg08	-.1726906	.0229201	0.0000
	$RGDP_g$			
	L_1	1.664618	.0378416	0.0000
	L_2	-.8866659	.0359036	0.0000
	UNEMPUNC			
	L_1	.0319318	.0183105	0.0810
	L_2	-.0051371	.0176034	0.7700

Level of significance 1%, 5%, 10% above the parentheses shown by *, **, * respectively.**

Table A8 VAR-TYAGC-Wald Tests (INF& INFUNC)

INFUNC		Coefficients	Standard Error	Prob
Constant		-0.4617932	.3226554	0.152
INFUNC	INF			
	L_1	.0128481	.0694868	0.853
	L_2	.0027248	.0712945	0.970
	INFUNC			
	L_1	.9866796	.0878305	0.000
	L_2	.0042036	.0900105	0.963

Table A9 VAR-TYAGC-Wald Tests (INF& UNEMPUNC)

UNEMPUNC		Coefficients	Standard Error	Prob
Constant		-0.0237944	.0021355	0.0000
UNEMPUNC	INF			
	L_1	.0004317	.0003176	0.174

	L_2	.0005837	.0003263	0.074
	UNEMPUNC			
	L_1	.9730604	.0026787	0.0000
	L_2	-.0012647	.0026673	0.635

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