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The relationship between Inflation, Inflation Uncertainty and Interest Rate in Ghana

By

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DECLARATION

I hereby declare that this submission is my own work towards the Master of Arts and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

This thesis is dedicated to the entire family, Mavis, my wife, Enoch, my son and my brothers and sisters for their prayers, support and encouragement throughout the course. God richly bless you all.

ABSTRACT

The study investigates the relationship between inflation, inflation uncertainty and interest rate for the period 1984-2011 of Ghana. The work uses the monthly Consumer Price Index and Treasury bill rate to proxy inflation and interest rate respectively. The General Autoregressive Heteroscedasticity (GARCH) model is employed to estimate the conditional variability of inflation with Full Information Maximum Likelihood technique in all the estimations. The work uses two procedures to find out the relationship between inflation and inflation uncertainty. The first one is the two-step procedure of Granger causality test, which obtains generated variables in stage one as dependent variable in stage two. The result of this approach suggests a positive relationship between inflation and its certainty and that inflation uncertainty Granger causes inflation. The second procedure involves inclusion of conditional variance and inflation in the mean and conditional variance equations respectively. The result also confirms the two-stage procedure supporting Cukierman-Meltzer hypothesis. The study also finds out whether the validity of Fisher hypothesis, which proposes one-to-one relationship between inflation and interest rate, holds. A GARCH specification of the hypothesis and also augmented Fisher, of which conditional variance in included in the fisher relation were estimated separately. A positive and statistically significant relationship is established between inflation and interest rate in both cases. However, the one-to one relationship is not established, hence Fisher effect holds in its weak form, which has given credence to Tobin (1965). The direct relationship between inflation uncertainty and interest rate does not hold. The coefficient of inflation uncertainty is negative and not statistically significant. However, since there is a relationship between inflation and inflation uncertainty and between inflation and interest rate, it implies that there is indirect association between variability of inflation and interest rate through inflation.

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LIST OF ACRONYMS

ADF	Augmented Dickey Fuller
AFIMA	Autoregressive Fractionally Moving Average
AIC	Akaike Information Criterion
ARCH	Autoregressive Conditional Heteroscedasticity
ARDL	Autoregressive Distributed Lag
ARMA	Auto Regressive Moving Average
BoG	Bank of Ghana
COLA	Cost-of-living-adjustment
CPI	Consumer Price Index
CUSUM	Cummulative Sum of Recursive Residuals
EGARCH	Exponential Generalized Autoregressive Conditional Heteroscedasticity
ERP	Economic Recovery Programme
FIML	Full Information Maximum Likelihood
FPC	Final Prediction Criterion
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
GDP	Gross Domestic Product
GMM	General Method of Moment
GSS	Ghana Statistical Service
HQI	Hannan-Quinn Information
IGARCH	Integrated Generalized Autoregressive Conditional Heteroscedasticity
IMF	International Monetary Fund
IT	Inflation Targeting
JB	Jarque-Bera
LM	Lagrange Multiplier
OLS	Ordinary Least Squares
PP	Phillips and Perron
SAP	Structural Adjustment Programme
SARB	South African Reserve Bank
SGE	State of the Ghanaian Economy
TGARCH	Threshold Generalized Autoregressive Conditional Heteroscedasticity
UK	United Kingdom
USA	United State of America
VAT	Value-Added Tax
WAMZ	West African Monetary Zone

APPENDICES

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God bless you all.

CHAPTER ONE

INTRODUCTION

1.0 Background

The relationship between inflation (which measures economic performance), inflation uncertainty, (measure of risk) and interest rates have since the beginning of the twenty first century occupied the minds of people in academics and policymakers. The concern for these macroeconomic variables, especially for the past two decades is as a result of availability of a wide range of literature. This intensifies when the objective of every economy is to stabilize and maintain its general price level to achieve economic growth and development.

In developing countries however, the influence of interest rate on inflation and its uncertainty is generally believed to be overwhelmingly negligible (Incoom 1992). The reason is that, most developing countries' financial markets are not initially well developed for flexible adjustment of rates. Also, the monetary authorities manipulate financial and monetary variables such as interest rate, making it difficult for it to move freely. In 1983 for instance, when Ghana turned to International Monetary Fund (IMF) and World Bank for assistance when her economy was in a shambles, the country operated under rigid financial system, where interest rates were regulated and monitored by the government decree instead of the market forces.

One of the major economic challenges Ghana found herself in is high and unstable inflation for over a decade. In all these years, the inflation rate is in the double digits. The end of year inflation rate ranges 10.7% in 2007 to 40.5% in 2000, the highest recorded within the period. The high inflation rates the country found itself in have compelled consumers to increase current consumption and decrease savings for future investment. An average Ghanaian prefers acquisition of goods and services that might not be needed today for fear that his current savings cannot afford the same quantity and quality of the same commodity tomorrow. The reason being that erosion of income due to inflation might far exceed savings. This is one of the contributing factors while savings is low in the economy. The saving deposits from private individuals continuous to decline. In 2007 for instance, private savings fell from 22.3% to 16.1% at the end of 2008 (Source: The State of the Ghanaian Economy, 2008).

Furthermore, the manufacturing sector of the economy is not also left out from this chronic disease of high rates of inflation. The high production cost can partially be attributed to one of these domestic problems, which makes it difficult to compete with their foreign counterparts, because of higher price of their products hence some are out of business others are producing at a loss or break-even.

Inflation is not only harmful due to its welfare cost as it erodes the value of financial assets that are not indexed but it also creates uncertainty in an economy in the long run, Neyapti (2000). According to Hubbard (2009) as cited in Arabi (2010), inflation uncertainty is defined as “a state of having limited knowledge where it is impossible to exactly describe existing state or future outcome, more than one possible outcome". Golob (1994) argue that uncertainty about inflation causes businesses and consumers to make decisions which differ from the ones they would make if there is no uncertainty in the economy. Ghana is clouded with high inflation uncertainty which emanates from the long period high inflation, making the whole economic climate murky. Contractors are uncertain about the real value of their future payment, both landlords and tenants, employers and employees are also uncertain about their future rent and wages respectively. Business owners also are not left out in this economic disease.

The financial institutions are of no exception to this economic canker. Although, inflation continues to fall currently with expectation that lending rates from commercial banks to the public would also decline along side, the realities on the ground is not the case. The year on year inflation rates at the end of December 2008, 2009 and 2010 show a decline as 18.13, 15.97 and 8.58 percent respectively but the lending rate from the commercial banks have shown exceptional downwards rigidity. The high cost of borrowing has a negative effect on investment hence high unemployment in the country. According to Sowa (2007), the high interest rate has a cyclical effect on the economy. It haunts the business sector, which affect the real output growth and ultimately hunt inflation.

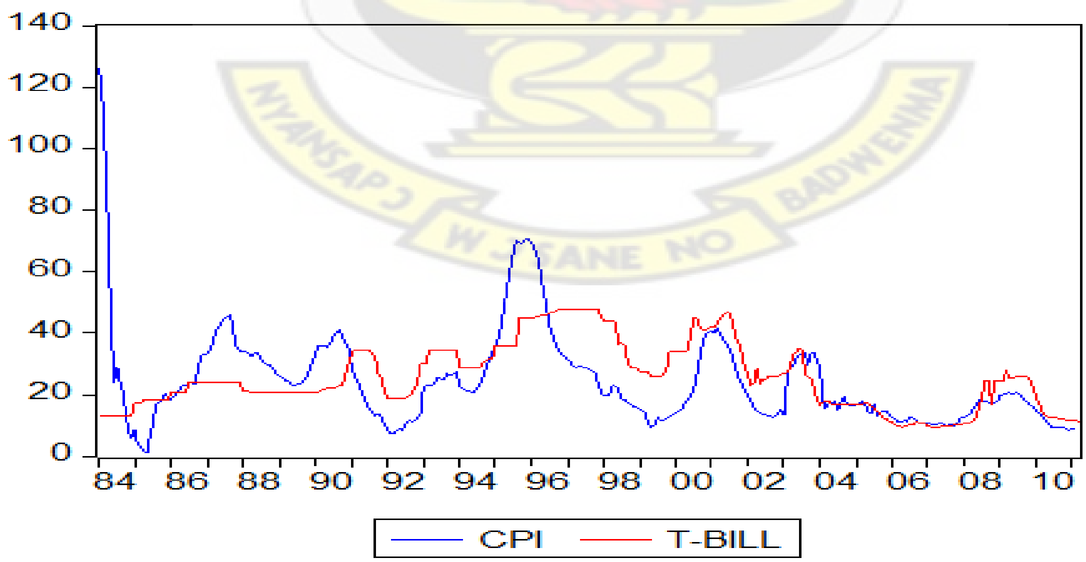
1.1 Evolution of Inflation, Inflation Uncertainty and Interest Rate in Ghana

In 1983, when the country was in serious economic crisis which has ever hit the economy since independence, of which a three digits inflation of 122.8% was registered, the highest ever registered so far in the Ghanaian economy. This was due to a severe drought couple with a bushfire that the country experienced in 1982 to 1983 of which there was a mass destruction of both cash and food crops in the country. The problem worsened when there was an alien compliance order in Nigeria, when Ghanaians in Nigeria returned home. The effect was upward pressure on the price of food, hence the high inflation. The problem aggravated when the cedi was overvalued with the major currencies of the trading partners of the country. The cedi was devalued about 937%, from ¢3.03 to ¢31.41 to the US dollar between 1982 and 1983 (Source: International Financial Statistics, 2002).

Following the economic crisis, Economic Recovery Programme (ERP) and Structural Adjustment Programme (SAP) were initiated by IMF and the World Bank to put the economy back on track through stabilization policies. The successful implementation of the policies has brought about a drastic reduction of inflation to 40.2% in 1984. The figure further reduced to 10% in 1985. The success of this significant decline in inflation was as a result of good harvest with abundance of food in 1984 which put downward pressure on the prices of foodstuffs. Within these periods, the financial sector is not competitive, banks were not liberalized. The BoG is not independent in its policies. Interest rates in general in the country do not vary over a long period of time. The 91-day Treasury bill rate for instance is pegged at 9.73% from June 1982 to November 1983. The government does not either issue securities to finance a greater percentage of its budget deficit or interest rate as a monetary tool to stabilize the economy. The real interest rate is negative, as the nominal interest rate is discounted for inflation. In figure A, which shows trends of monthly interest and inflation rates from 1984:1 to 2011:3, the plot of inflation rate lies above the interest rate, which indicate that the real rate of interest is negative.

Between 1986, of which the end of year inflation was 24.6% to the end of 2000, which also recorded inflation of 40.5%, the country still wallowed in high inflation. The average inflation within the period according to the author's computation is 30.59%. Within the period, the year-on-year inflation was double digits with the minimum of 10% in 1992 and maximum of 74.4% in 1995. In the early 1990's, especially the latter part of 1992, money supply expanded as a result of government budget deficit which was finance by the BoG. According to Amoah (2008), the government budget deficit in 1992 was 14.44 million Ghana cedi, constituting 4.2% of GDP of which 90% was financed by BoG. This results in high liquidity in the economy. Although, interest on government securities, which the BoG uses to finance budget deficit keep on increasing at least year after year, the real interest is still negative as the level of inflation exceeds the yield on these securities. Within the period July 1986 to December 1987, government's 91-day Treasury bill rate remains at 24.12%, a rate higher than the previous years.

Fig A: Trends in Monthly CPI and 91-Day Treasury Bill



Data Sources: Ghana Statistical Service, Statistics for Development and Progress. Bank of Ghana Quarterly Bulletins

Inflation still remained high and above the target set by ERP within the period 1989-92. The average yearly inflation although reduced from 31.4% to 25.2% in 1989 it exceeded the targeted 15%. In 1992, it was 10.02% which again was 2.02% above the targeted level of 8.0%. Although, the targets were not met, there was a reduction which was caused by a tight monetary policy embarked by the authorities. The bumper harvest of agricultural products in 1991 which reduced the food component of CPI and therefore overall CPI is another major contributing factor in the drop of inflation. In 1993, inflation rose to 24.9% and galloped to 74.4% in 1995, the highest since the introduction of ERP. The major contributing factor for such an increase was the introduction of Value-added Tax (VAT). The new tax regime sky rocketed prices of goods and services it has affected because the rate was higher than the existing sales tax it has come to replaced.

In 1996, inflation fell steadily from 46.6% to 12.6% at the end of 1999. However, this trend could not be sustained. As at the end of the year 2000, inflation had moved to 40.5%. The rise in inflation again was caused by expansionary monetary policy embarked upon by the existing government. In 1998-2000, the growth in money supply were 17.6%, 25.4% and 48.0% (Source: West African Journal of Monetary Integration, first Half 2003). The depreciation of the cedi with the currencies of the major trading partners of Ghana was another factor. In 1999 to 2000 the cedi depreciated from 33.0% to 49.5%, 16.5% increase in 2000 over 1999 figure. The expansionary fiscal operations resulted in borrowing from the Central Bank. Since independence and introduction of government securities, it is in this period that recorded the highest interest rate offer. The government borrows from the public through issuance of securities to finance a greater percentage of its budget deficit. The private investors compete with the government for the same funds. The effect is a fall in output and employment. The high interest on these treasury bill attracted investors, including banks and neglects the productive sectors of the economy where they brand as the high risk zone.

In the first quarter of 2001, as a result of excessive money supply for national election in the last quarter of 2000, shortage of domestic food stock and upward review of petroleum prices in February 2001 by 91% were the major cause of inflation to ascend to 41.9%. Conversely, at the end of 2001, the end of year inflation had come down significantly to 21.3%. Tight monetary policies with fairly stable cedi, which was pegged at ¢7300 per US dollar were the intervening forces for the decrease in the inflation rate. In 2003, end of year inflation of 23.6% was targeted to 9% with the objective of meeting one of the criteria of West African Monetary Zone (WAMZ) convergence of single digit inflation of member countries. The inability to meet the set target was due to a 100% increase in petroleum prices which translated into increase in the general prices of goods and services in the economy. In 2002, the Central Bank began to adopt Inflation Targeting (IT) measures through the use of interest rate as a monetary tool to stabilize the economy. The BoG securities rates do not remain fixed for several months unlike in the previous years. In 2002, when inflation fell, interest rates also declined accordingly compelling financial institutions and the public to invest in other sectors other than in government securities. Banks also responded by lowering their base rate on the average of about 35% from 50% at the beginning of 2002.

The 2005 inflation had fairly increased from 11.8% in 2004 to 14.8%. Again, the targeted 13.5% could not be met. The upward adjustment in the prices of petroleum products again by 50% couple with an increased in money supply which translated in to a rise in general price level of goods and services were the major contributing factors. From 2006 to the end of 2010 year on year inflation rate is below 20% with a single digit inflation of 8.6% recorded in 2010. Since 1971, when 9.2% year on year inflation was registered, it was in 2010 that the country ever witnessed single digit inflation. There is also anticipation that, all things being equal, 2011 end of year inflation will also record single digit, which is predicted to 8.5%, based on the trend of the monthly CPI for the past first and second quarters.

The success of this significant breakthrough in low and stable inflation currently is attributable to the prices of food which account for about 50 to 60 per cent in the basket of CPI is stabilized throughout the year over these periods. The stable exchange rate of the cedi with the major currencies couple with the world price of petroleum products not exceeding a threshold, which would affect domestic price are the major intervening factors for the falling inflation. Continued reduction in inflation rate coupled with stable economy compelled the BoG to reduce interest rate. In 2010, the prime rate for instance cumulatively declined by 450 basis points, as stated in BoG Monetary Policy Report 2011. Between November 2010 and January 2011, the 91-day Treasury bill rate declined from 12.32 to12.15 per cent. The 182-day Treasury bill also dropped from12.71 to12.53 per cent. The 1-year note and 2-year fixed rate also fell as well. However, commercial banks in the country are still holding to their high interest rate of loanable funds.

According to Sowa (1994) and cited in Ocran (2007), the reduction in inflation rate to acceptable threshold is one of the objectives of economic reform programme; however this has not been achieved. Over these years, the country has been wallowing in high inflation. Annual inflation averaged is in excess of 20% in more than half of the years under review. The whole economy is entangled with inflation uncertainty, as business forecast and investment behaviour are in a dark. The problem becomes exacerbated as the monetary authorities over these years were not able, in most cases, to meet the inflation target set by them. Inflation in most cases exceeds the target rate. The uncertainty compels the low and average income earners of the society, which constitutes the majority to translate their wealth in to other assets other than money. This put pressure on the demand for those commodities hence fuel inflation. Again, keeping wealth in other forms than money leads in a fall in savings, increasing liquidity which is to inflationary.

There are factors that occur sporadically and fuel inflation in the economy which affect the predictability of inflation rate making monetary authorities unable to meet their set targets. One of the factors is the domestic petroleum price which is determined by the price of crude oil in the international market. When there is political tension in oil-rich exporting countries, it affects the world supply hence an increase in the world price of crude oil. This translates in an upward adjustment of fuel in the economy, when the world price is above a threshold. The second round of shock to the economy emanates from the extent to which the business community factors the impact in to their pricing. The unpredictable depreciation of the cedi in the past, as discussed above has also impacted significantly on non-food inflation hence overall inflation. The food crises that hit some countries in the world hike overall world food prices. This phenomenon translates risk of increase imported food price in to the country and therefore inflation. The country imports a greater percentage of rice to supplement domestic production. In 2006, when the world price of rice increased due to a high demand in the world market, it affected the country of which there was a general increase in the price of rice.

The introduction of IT in 2002 is yielding a positive result. Inflation has declined currently to acceptable level and now in a single digit. Now that Ghana is also producing crude oil, a shock in the world price hikes, which is one of the external forces increasing inflation can now be curtail by the revenue the country would also obtain from its export of crude. There should be a conscious effort now to find a lasting solution to the maintaining the current level of inflation. Domestic factors, especially financing of huge budget deficit from sources that are inflationary should be discouraged. The government should always march its expenditure to expected revenue so that a huge deficit will not be created for financing. When inflation is maintained at the current low level for a long time, the long uncertainty created in the economy would also fall, which would put interest rate down as well. Fall in interest rate would promote investment and lead to growth in output.

1.2 Statement of the Problem

Ghana has been experiencing high interest rates in general: both inter-bank and Treasury bill rates currently. This is due to its tight monetary policy and perhaps to keep the interest rates with the high inflation the country wallows in for the past two decades. The average inflation for 2000 for instance was 40.5% with the corresponding annual Treasury bill 47.3%. When the average inflation rate reduced to 15.2% in 2002 and further to 10.9% in 2006, the corresponding inter-bank and Treasury bill rates also moved down from 24.5% to 12.50% and 23.68% to 9.41% respectively, during the same years.

As yearly average inflation further rose to 18.1% in 2008, the average annual bank rate and Treasury bill had also increased to 15.40% and 14.87% accordingly. Even though, the percentage rise and fall of the variables were not taken into account, there is a possible trend or relationship that seems to be emerging that calls for empirical investigation. According to Sowa (2003), the high interest rates in Ghana impact negatively on investment and therefore affect output growth and increase inflation. According to Bank of Ghana monetary policy report, inflation continues to decrease to appreciable level with stunted fall in commercial banks lending rates making the real lending rates in the economy still high. The high interest on borrowing makes the cost of borrowing unattractive for investment to boost output in the economy despites incessant fall in the inflation and its expectation. What is the missing link between inflation and interest rates in the country that the stakeholders are highly concern about?

Moreover, people with an average income in Ghana and businesses take into consideration the uncertainty about the future price level in their current transaction decisions. Most individuals acquire goods and services which are needed in the future. Financial institutions are much interested in short term transactions. According to the State of the Ghanaian Economy (SGE) (2008), the share of the 91-day instrument tripled from 6.62% in 2007 to 18.6% of the securities market in 2008. The share of 182-day Treasury bill instrument also approximately increased threefold. Meanwhile the market shares of 1-year, 2-year, 3-year notes and 5-year Government of Ghana bond recorded a decline in shares. According to the State of the Ghanaian Economy, 5-year government bond fell from 7.25% to 5.9% in 2008. The long term stocks had also fell in their market share of about 5 percentage points. However the yield on the long term securities is higher than the short term securities. What is the paradox in this phenomenon? Are the investors unable to work out the real value of their investments yield (interest rates) in the future? Golob (1994), posts that inflation uncertainty clouds decision making of consumers and businesses and discourage them to spend resources avoiding associated risks on long term rates that stakeholders are not certain about the real value of future earnings.

The empirical investigation of the association between inflation and its uncertainty alone is not sufficient without including an important variable such as interest rate. Interest rates link inflation and its uncertainty with the real side of the economy. It is therefore vital to include this important variable when accessing the relationship between the factors that determine its rate in an economy. Sentim-Boakye and Byekwaso (2005), for instance excluded interest rate when investigating the extent to which Ghana, Senegal and Uganda responded to the International Monetary Fund (IMF) and World Bank intervention in 1980s when their economies were in a shambles.

1.3 Objective of the Study

The aim of the study is to examine the linkage that exists between inflation, inflation uncertainty and interest rates in Ghana. In order to achieve this general objective, the study will specifically:

i. Estimate the relationship between the nominal interest rates and the level of inflation (Fisher hypothesis) in Ghana.
ii. Estimate the linkage between the rate of inflation and inflation uncertainty in Ghana.
iii. Determine the direction of the relationship in ii to ascertain which of the two hypotheses, Friedman–Ball and Cukierman–Meltzer holds in Ghana.
iv. Estimate the relationship between the nominal interest rates and inflation uncertainty in Ghana.

1.4 Hypothesis

Based on the objectives, the study hypothesizes that;

i. There is a positive relationship between interest rates and the rate of inflation (Fisher hypothesis).
ii. There is a positive relationship between inflation and inflation uncertainty.
iii. Inflation causes inflation uncertainty (Friedman–Ball hypothesis).
iv. Inflation uncertainty causes and inflation (Cukierman–Ball hypothesis).
v. There is a positive relationship between interest rates and inflation uncertainty.

1.5 The Rationale of the Study

The objective of every government, especially in developing countries is to increase growth in real output per capita in order to improve the living standard of the people. In order for an economy to achieve increase in real output, there must be stable macroeconomic environment of which inflation is of no exception as one of the conditions to boost investment. Interest rates and inflation uncertainty are some of the variables that are considered by the investors in their decision making. It is therefore crucial to investigate the relationship between the level of inflation, inflation uncertainty and interest rates in Ghana in order to equip the stakeholders to come out with accurate predictions.

One of the underlying reasons for the justification of the study is that high inflation and interest rates with their associated harmful effects become a worry to the government and policymakers. A possible undesirable consequence of high inflation rate as experienced in Ghana, is to increase inflation uncertainty that causes a drop in investment and ultimately in economic growth. The study will therefore assist the policymakers to determine the relationship and trend between the three variables under study which will enable them to carry out their planning and decision efficiently.

Inflation may not only affect the economy through uncertainty. Inflation causes higher tax payments in certain tax systems and distorts the optimal level of cash holdings by consumers. Also frequent changes in prices may be costly to firms and individuals as well, which ultimately reduces efficiency of the market prices. It is therefore prudent for policy analysts, portfolio managers, firms and consumers at large to understand the linkages that exist among the variables understudy to be able to make their informed judgments.

Furthermore, nominal interest rate is a vital instrument in decision making by individuals and investors. In asset valuation, it plays a pivotal role and therefore it is necessary to know its trend relationship with other important variables like inflation and its certainty. Investments are mainly estimated by rates, hence with real interest rate scarcely changes, the uncertainty aspect of inflation may tend to define the reactions to the expected path of inflation rates which guides nominal interest rate determination. So, knowing the direction of the relationship of the three variables will feed the stakeholders additional information with where to gauge the predictability of their rates and the corresponding action to embark upon. Fisher hypothesis has occupied a key position in economic literature. The real rate of interest plays a pivotal role in any economy's economic growth through savings and investments, while also affecting trade and capital flows through its influence on the exchange rate.

Finally, this study would help people in academia, as it would contribute towards the few existing literature (Testing of Fisher hypothesis and Friedman-Ball/Cukierman-Meltzer relationship) in Ghana. The relationship between the three variables acts as a pioneering work and therefore would acts as a guide and a foundation upon which future research would be built on. It would also be used on a basis upon which future researches or similar work in other countries would be compared.

1.6 Research Methodology

In order to capture inflation uncertainty that was used by the earlier researchers including Grier and Perry (2000), Caporale and Caporale (2002), Berument *et al* (2005), Berument *et al* (2007), Samimi and Motameni (2009), Farshid and Mojtaba (2010) and Heidari and Bashiri (2010), the study will employ the Generalized Autoregressive Conditional Heteroscedasticity henceforth GARCH model. Full Information Maximum Likelihood (FIML) technique of estimation will be used in the estimation. Data will be sourced from the Bank of Ghana Quarterly Bulletin and Ghana Statistical Service, Statistics for Progress and Development. The data include the monthly Consumer Price Index (CPI) and 91-day Treasury bill interest rate. The scope of the study is from 1984:1 to 2011:3.

1.7 Organization of the Study

The study is in five chapters. Chapter one comprises the background, evolution of inflation, inflation uncertainty and interest rate in Ghana, objective, hypothesis formulation, rational, methodology and the organization of the study. The second chapter which is the literature review entails theoretical and empirical reviews of the study. The theoretical review consists of the relationship between inflation and interest rates, inflation and inflation uncertainty, inflation uncertainty and interest rates; and finally inflation, inflation uncertainty, interest rates and other macroeconomic variables. The empirical literature is also segregated as in theoretical review. Chapter three, the methodology, includes description of the model to be used (GARCH), and the statistical and econometrics tests that would be carried out. This includes model specification, stationary and causality tests. Chapter four is made up of estimation and analysis of results. The final chapter is the conclusion, which includes the summary of findings, policy implication, recommendation and limitations of the study.

CHAPTER TWO

LITERATURE REVIEW

This chapter is divided into two main sections. Section one comprises the theoretical review and section two, the empirical review of the study. The chapter identifies among other things the various methods used in the empirical examination of the theoretical literature. This chapter will therefore serve as the basis upon which the appropriate model will be chosen for the empirical analysis.

2.1 THEORETICAL REVIEW

This section reviews theoretical literature on the relationship between inflation and interest rates, inflation and inflation uncertainty, inflation uncertainty and interest rates, and lastly, inflation, inflation uncertainty, interest rates and other macroeconomic variables.

2.1.1 Inflation and Interest Rates

The relationship between interest rate and the level of inflation also known as the Fisher effect or Fisher hypothesis can be traced to Irvin Fisher. According to Smant (2004) cited in Baci (2007), Fisher effect explains the reason behind the changes in interest rate can be attributed to changes in purchasing power of money. It states that the nominal interest rate is made up of the real interest rate and expected inflation. The nominal interest rate compensates for the loss in value of purchasing power of money due to inflation. Alternatively, Alkhazali (1997) states Fisher effect that at a constant real interest rate, the nominal interest rate is directly proportional to the level of inflation. The implication is that the nominal interest rate reflects market information concerning fluctuation in purchasing power of money. When inflation is high the purchasing power of money falls at the initial rate of nominal interest. The rational economic agents therefore are obliging adequate compensation for any erosion of their purchasing power as a result of increase in general price level.

Theoretically, Fisher effect postulates a one-for-one relationship between expected inflation and nominal interest rates with the real rate of interest constant in a long-run. According to Darby (1975) cited in Crowder *et al* (1996), the estimated coefficient of expected inflation in Fisher hypothesis is less than unity when the impact of tax is not factored in to the relation. When tax effects are considered, then the hypothesized coefficient of expected inflation should lie within 1.3 and 1.5 ranges. The reason is that, with tax effect on interest income, a unit change in inflation rate results in a more than proportional change in interest rate due to economic agent's propensity to increase nominal interest rates to a level that would include tax adjustment estimates of the future inflation into the relation. Weidmann (1997) pointed out that Fisher effect can only be achieved in an economy without taxes. Mishkin (1984) also supports Weidmann's argument but with different explanation that there is an inverse correlation between interest rate and inflation.

The constancy assumption of expected real rate of interest is questioned by Mundell and Tobin. According to Mundell (1963), cited in Tanzi (1984), individual portfolios are alternatively distributed among consumption and savings in an economy. A fall in one of the areas would result in an increase in the other. When there is a reduction in wealth due to erosion of real money balance caused by expected inflation, there is a fall in consumption and increase savings in an economy. As a result, equilibrium between higher saving and investment must occur at a lower expected real rate of interest, which induces real investment to rise to equate higher real savings. According to Tobin (1965), as inflation rises, the nominal interest rates and the cost of holding money also increase which induce individuals to switch from keeping idle money to bonds and other interest yielding assets. This increases savings, which is the supply of loanable funds. Given the demand condition remaining the same, there is a fall in real interest rate.

Fisher however concluded from empirical investigation that inflation premium is not the only parameter to keep the real interest rate constant. There are other interest sensitive variables that affect the real interest rate in an economy. Therefore, estimates of inflation coefficient less than unity implies that there is adjustment in the real interest rate in response to changes in expected inflation. The monetary authorities should stabilize inflation rate embedded in Fisher equation if their aim is to maintain nominal interest over a long period of time. Mayer *et al* (1993) have given conditions that, Fisher effect can holds completely only if the propensity to consume and the marginal efficiency of investment are not affected by the inflation rate. And also if people are able to predict correctly ex-post inflation rate then one-to-one relationship between nominal interest rate and expected inflation would be achieved.

Carmichael and Stebbing (1983); Mitchell-Innes (2006) also have come up with a different view on the linkage that exists among inflation, real and nominal interest rates known as the inverted Fisher effect. Their explanation is that a situation where money is substitute for other financial assets, given the hypothesis that nominal interest is constant over time and real interest rate and inflation are inversely related. The inability of Fisher's hypothesis not to hold in its strictest form empirically is as a result of the given explanation. The inverted Fisher effect (Fisher paradox) however has little empirical support.

2.1.2 Inflation and Inflation Uncertainty

The theoretical linkage between inflation and inflation uncertainty was pioneered by Milton Friedman, whose arguments concern the real effects of inflation. In periods of high inflation, more uncertainty about the future rate of inflation is created. According to Golob (1994), in period of low inflationary regime, monetary authorities try to maintain it at its low level. When this is achieved, then inflation level will be low and stable. On the other hand, when inflation is high, the monetary policy makers aim to reduce it to a low level through embarking on disinflationary policies. This policy of which the objective is to reduce inflation rate rather creates inflation variability and also uncertainty about inflation. The reason is that the timing and immediate impact of the policy on inflation is uncertain. The policy does not impact directly on inflation. It affects the financial system through to the real economy before it finally hits inflation. This takes predictable time for the impact to be felt on inflation. The complex nature of forecasting the amount and time period prices would adjust to monetary policy bring about uncertainty, despite that, the impact of the monetary policy is well known with certainty.

In stabilizing Fed hypothesis, Holland (1995) posits that as inflation uncertainty rises, as a result of increasing inflation, the monetary authority would respond by contracting money supply growth in order to reduce inflation uncertainty and its negative impact in the economy hence an inverse relationship between inflation uncertainty and inflation. The theoretical relationship between inflation and inflation uncertainty is therefore mixed. Ungar and Zilberfarb (1993); Miles and Schreyer (2009) weighs the effect of inflation on inflation uncertainty with the cost of inflation and the cost incurred in obtaining information to predict future inflation. In accordance with them, when the cost of inflation is higher than the cost of gathering information to predict it, then its uncertainty would be low. On the other hand, when the cost of inflation is lower than the cost incurred in gathering information in its prediction, then uncertainty of inflation would be high.

The direction of the relationship between inflation and inflation uncertainty has been a controversy in both theoretical and empirical arena in Economics and its related fields of study. Friedman (1977) argues that, high inflation creates more inflation uncertainty as policymakers through their monetary tools attempt to reduce future inflation. The reason is that, agents in the economy are uncertain about the action of the policymakers to reduce the general price level therefore; uncertainty about the future price level is created on the path of the future price increases.

Friedman's argument became well known by Ball (1990) in the examination of asymmetric information of the public reaction towards inflation uncertainty. In that, the public faces two different policymakers that are in office and whose economic policies differ from each other. Both groups are conscious to maintain inflation at low level, but in high inflation period, their disinflationary policy differs from each other. In times of high inflation, uncertainty is created about which policymaker will be in office in next period. The uncertainty rises as a result of the rate at which there is money growth and therefore inflation. During low inflation, the uncertainty does not rise. The rise of inflation uncertainty during high inflationary period and a fall in inflation uncertainty in low inflation time has been accredited to Friedman and Ball as Friedman-Ball hypothesis, which states that there is a positive impact of inflation on inflation uncertainty. Friedman-Ball hypothesis gained support as in Azariadis and Smith (1996) and cited in Fountas *et al* (2006) with different explanation that as inflation rate goes beyond a threshold, nominal uncertainty increases. It was deduced in a model formulated to investigate imperfections that arise in a financial market towards credit in the form of movement of information.

However, Cukierman and Meltzer (1986) also established a link between inflation and inflation uncertainty, but disagree with Friedman and Ball about the direction of the causality. They have come out that, inflation uncertainty rather causes inflation. That is, high inflation uncertainty cloudy out the economic environment which may provide monetary authorities an edge and incentive to surprise unsuspecting agents with measures that acts to increase inflation. This is what they term the opportunistic central banker behaviour. The motivation for policymakers to involve in this behavour is the benefits, among others, the seigniorage and reduction in the real value of government debt. The success of this phenomenon depends on the credibility of the monetary authorities upon which agents' response.

Evans and Wachtel (1993) have come out with two divisions of inflation uncertainty. These are regime uncertainty and certainty equivalence. In the former, future inflation may be uncertain as a result of the agents' inability to use current policy regime to predict or cannot determine if there would be changes in current economic policy regime. For the latter, even when the agents were able to forecast the current policy regime which is certainty equivalence, uncertainty would still exist about the structure of inflation process within each policy regime. The separation of inflation uncertainty has several economic consequences. According to Crawford and Kasumovich (1996), the level of inflation uncertainty would change in an economy as agents seek new information to update their perceptions of the economic climate and the policy regime. This implies that the level of uncertainty between transitional period to price stability and the period of stability itself would change.

Evans (1991) deepens the argument with the types of inflation uncertainties in which each has different effect on inflation rate. The first type is impulse uncertainty that is measured by the conditional variance of inflation to capture the inflation risk, which could be induced for the future by the information content of past inflation. The second type is the structural uncertainty, which captures the instability on the predictive power of past inflation for the future. The final one is steady-state inflation uncertainty, which involves the measurement of instability in the long run steady-state of inflation rate.

2.1.3 Inflation Uncertainty and Interest Rates

The connection between inflation uncertainty and interest rates has several theoretical explanations. Interest rate is one of the vital indicators in the transmission mechanism of inflation uncertainty on economic performance. At a high interest rates output falls by decreasing consumption and investment. More importantly, for many emerging economies, where debt sustainability is a problem, higher interest rates increase the debt burden and destabilize the financial system by leading to massive capital outflows (Blanchard 2003).

According to Markowitz (1952) cited in Berument (1999), gives description in a portfolio theory that risk adverse investors must be adequately compensated for higher returns for higher risk. The reason is that unanticipated inflation decreases the real returns of the Treasury bill rate. Higher conditional variability of inflation creates risk on real Treasury bill returns. Therefore inflation risk should be positively correlated with interest rates. Cheong, Kim and Podivinsky (2010) argue that there has been mixed reactions by economists about the relationship between inflation uncertainty and interest rates from both theoretical and empirical points of view. One group has come up that there is an inverse relationship between inflation uncertainty and nominal interest rates. When inflation uncertainty exists in an economy, it reduces investment and savings of risk-averse economic agents and put downward pressure on both demand and supply of loanable funds. If the decrease in the demand of loanable funds is larger than the reduced savings in the supply side, the nominal interest rates at equilibrium is lowered. Otherwise the reverse also holds. Others are of the view that when there is inflation uncertainty, risk-averse investors who dominate the market of loanable funds simply add risk premium to the nominal interest rates to compensate for the increase in inflation uncertainty.

Sentim-Aboagye and Byekwaso (1995) posit that interest rates play a vital role in valuation of assets and therefore it is important to assess the variables or factors that enter into the determination of its trend. Investors take their decision partly based on interest rates trends. Therefore, knowing that the real interest rates hardly change the uncertainty element of inflation rates tend to path the direction of interest rates. Hence, the trend-link between inflation and its associate uncertainty feed investors with additional information on the pegging and predictability of rates for appropriate decision to rely upon in the distribution of their investment portfolios.

2.1.4, Inflation, Inflation Uncertainty, Interest Rates and other Macroeconomic Variables

The three variables under study are not in isolation or link to each other alone but they relate to other macroeconomic variables. Interest rate refers to the price a borrower pays for temporary usage of capital. It also implies the returns a lender expects by postponing and parting with his/her liquidies. The interest rate is a double-hedge sword in that if it is high, holders of surplus funds will part with their resources, since they expect high returns in the future. On the other hand, higher interest rates discourage borrowing. In a state of equilibrium, interest rate equates demand (investment) and supply (saving) in the capital market. Real interest rate is an important determinant of saving and investment behaviour of households and businesses, and therefore crucial in the growth and development of an economy (Duetsche Bundesbank Report, 2001).

Both households and firms are mainly concerned with the real returns (interest) on their assets holding. Even though they know the nominal return (interest) on their assets holding, they are not certain about the direction of inflation in the current period (Berument and Malatyali, 1999). Given their expectations about the future real interest rates, they decide which assets to hold. If the uncertainty surrounding expected inflation is very high, they will expect the return on their investment to be higher.

The rate of inflation is the percentage rate of change in the general price level from one period to the other (Papell 1986). The rate of inflation has far-reaching implications for the performance of the economy. Higher rate of inflation reduces aggregate demand, production, employment, trade deficits and balance of payment as suppliers of funds for booming economic divert their resources into interest yielding activities. On the other hand, a low and moderate inflation will encourage economic activity, particularly production. This in turn will raise gross domestic product (GDP), reduce unemployment and ease the balance of payment problems (Obi, Nundeen and Wafure 2009). Andre and Hernando (1998) argue that inflation at any level reduces investment and therefore impedes economic growth.

Ma (1998) explains the relationship between inflation and relative price dispersion with alternative hypothesis that there could be fixed cost with variable prices in an economy. In this situation, the firm could be practicing an (S,s) pricing rule: it would hold the nominal price fixed until inflation brings real price down to some threshold, s at which point it would adjust the nominal price to bring the real price back to S. If fixed cost varies across firms or firms face shocks specific to themselves, then price changes in the economy would be staggered and higher inflation would increase the dispersion of relative prices. Secondly, an increase in inflation uncertainty as a result of high inflation results in "signal extraction'' problem. The greater is the inflation uncertainty, the less do the firms adjust output in response to shocks. Consequently, each market price has to rise to ensure equilibrium between demand and less-variable supply, and thus relative price disperse increases.

Romer (1996); Carlton (1982) argue that high inflation-induced relative price variability and disrupts markets where firms and customers form long-run relationships of which prices are not adjusted frequently. Inflation can have complicated effect on market structure, long-term relationships and efficiency. Hall, (1984) argue that inflation may cause individuals and firms to have problem accounting for inflation. Inflation can cause households and firms, which typically do their financial planning in nominal terms to make large errors in savings for their future usage.

According to Vale (2004), the relationship between inflation and economic growth comes from a frame work that has two assets: money and capital. An increase in the return on money would lead to a decrease in the capital (investment) portfolio, since they are substitutes in household portfolios. In other words, a high inflation (a fall in return of money) impacts positively on capital accumulation and consequently leads to growth. However, Jones and Mamelli (1995) point out that inflation is a tax on capital with cash-in-advance requirement for investment and, as a consequence, impacts negatively on growth.

Inflation uncertainty affects households and firms by making their real rate of return on their savings and investments more risky. The implication is that, since consumers (households and firms) are risk averse, an increase in inflation uncertainty creates an incentive for an inflation hedging which increases cost. According to Gantor (1983), household and firms should reallocate their savings and investments from equity and long term assets into short term assets, real estate development and other financial assets that allow them guard against inflation in order to enhance their welfare. He further explained that, hedging against inflation goes with its associated cost. That is in the adjustment process, there is transaction cost incur couple with efficiency cost through reallocation of resources.

Mayer et al (1993) deduced that indexing all wages would curb inflation and protect workers' real wages from deteriorating. Cost-of -living-adjustments (COLAs) avoid unwarranted gain or loss to some parties when the actual inflation differs from the one that was assumed in making indexed long term contracts. However, a fall in productivity growth or supply shock reduces output and therefore employees without index income suffer the full loss of their wage. Fountas (2001) realize that monetary economists link high inflation uncertainty to welfare loss. But accurate prediction of inflation should not lead to welfare loss since indexation will allow agents to reduce the cost of inflation. However, uncertainty about the future inflation distorts efficient allocation of resources that is based on the price mechanism. This distortion, according to Friedman (1977) cited in Caporale (2002) will lead to lower output. Furthermore, high inflation rates might result in more variable inflation; therefore, create more uncertainty about future inflation. Combining the links between inflation and inflation uncertainty and inflation uncertainty and output, a testable hypothesis emerged that higher inflation leads to lower output.

According to Ball (1993), inflation uncertainty lowers economic efficiency and temporarily reduces output and increase unemployment, changes optimal contract length and the degree of indexation. However, Dotsey and Sarte (2000); Arabi (2010) links inflation uncertainty and output growth positively. That is when there is a high uncertainty about monetary growth and therefore inflation, it makes return on real money balances uncertain, which leads to decrease in demand for real money balances and consumption. Therefore, economic agents would increase precautionary savings making funds available for investment and hence output growth. Availability of funds for investment is not the only factor that promotes output growth in an economy. When other output growth prompting factors can also affect growth in an economy.

2.2 EMPIRICAL REVIEW

This section is made up of the empirical review of the relationship between inflation and interest rates, inflation and inflation uncertainty, inflation uncertainty and interest rates and finally, inflation, inflation uncertainty, interest rates and other macroeconomic variables

2.2.1 Inflation and Interest Rates

The positive and one for one relationship between nominal interest rate and inflation was empirically evidenced by Berument *et al* (2007) for seven developed and forty five developing countries with various GARCH specifications for each country. Due to the problem of data availability, each country had different sample size and time periods for the study. There is also inclusion of inflation risk in the model in order to validate augmented Fisher hypothesis in the respective countries. That is to ascertain the relationship between inflation uncertainty and interest rates in the respective countries. Again, data limitation where taxes on interest income are neglected and also different variables was proxies as interest rates in the respective countries.

The result of the research shows that Fisher hypothesis holds in all the G-7 at one percent significance level. There is also a positive relationship between inflation risk and interest rate at five percent significance level for G-7 countries except UK and Japan where the significance levels are at ten and one percent respectively. This is in support of loanable fund theory. This result agreed with the work of Chen and Shrestha (1998). They investigated UK, US, Canada and Japan with the result that, there is a positive relationship between inflation and interest rates for all the countries in the long-run and for UK and Japan only in the short-run.

In developing countries, based on Berument *et al* (2007), Fisher hypothesis holds in twenty three out of forty five in its weak form at one or five percent level of significance. When inflation risk was added to the initial model, the augmented Fisher hypothesis holds in twenty one developing countries. The general conclusion to be drawn is that Fisher hypothesis does not hold in developing economies. The alternative explanations are that, the nominal interest rates do not respond to changes in inflation in the same direction. Moreover, in developing countries in general, their money market is not well developed where the nominal interest rates will regulate to the rate of change in inflation rate. The adjustment of the interest rate will be influenced by their cultural and religious believes as being a sin.

There is a direct contrast between Berument *et al* (2007) and Baci (2007) in their findings. Based on the former, Fisher effect or hypothesis fails to hold in seven advanced countries and also, no significant evidence was found to reject Fisher hypothesis in six developing countries. The difference in result might be as a result differences in the model and estimation techniques, sample size variability and structural changes in the time series data. Baci (2007) had also embarked on a multi- country analysis for ten advanced and ten developing economies. The study used twenty one year's quarterly data beginning from 1985 excluding Denmark and Finland where current data were used due to availability of data and Turkey's observation start from 1991. The proxy for nominal interest rate is Treasury bill rate, lending rate, government bond yield, deposit rate and saving deposit rate, depending on which of the data is available in the respective countries. The level of percentage change in CPI was used to also proxy for the measure of inflation. The study employed a co-integration analysis; that is a bound test which is based on Autoregressive Distributed Lag (ARDL) approach.

Obi et al (2009) examined Fisher effect in Nigeria and concluded that the relationship between interest rates and inflation hold in the short-run but holds in the long-run in its weak form between the periods, 1970-2007, which confirmed Berument *et al* (2007). They used co-integration and error correction method. Mitchell-Innes (2008) also investigated whether there is a link between nominal interest and inflation rates in South Africa during the period of inflation targeting (2000-2005). The result suggested that Fisher hypothesis does not hold in the short-run but there is a co-integration between inflation and interest rates which is not one to one. The attributed the reason on the South African Reserve Bank (SARB) for the cause of the problem. The reason was that SARB have the mandate of stabilising the economy of which short run interest rate is controlled. Mitchell-Innes (2008), used three months bankers' acceptance rate and ten year government bond to proxy for short and long terms interest rates respectively. The relationship was tested using Johansen's co-integration test. Although different periods and models were employed in South Africa for investigating the validity of Fisher hypothesis, all confirm each other's result.

2.2.2 Inflation and Inflation Uncertainty

Works on inflation and its uncertainty goes back 20 years ago. The pioneering works were done by Okun (1971); Friendman (1977) who concluded that countries with high inflation experience more variable inflation. He interpreted the greater variability of inflation to inflation uncertainty. After Okun's publication, there were so many works published especially in the advanced countries.

Recent empirical work focuses specifically on the direction of causality between inflation and inflation uncertainty. The theoretical bone of contention between Friedman-Ball and Cukierman -Meltzer with their associate policy implication demands empirical investigation. Fountas (2000) has provided strong evidence in favour of the hypothesis that inflationary periods are associated with high inflation uncertainty in UK. A long span of inflation data was used in the study. The annual CPI from 1885 to 1998 was selected to proxy inflation for the period. The GARCH (1, 1) was used after various specifications were estimated of which the model for inflation follows Auto-Regressive Moving Average (ARMA) process.

Thornton (2008) researched with long period CPI annual data of Argentina, between the period 1810 to 2005 and supported Friedman-Ball hypothesis that high inflation is associated with more uncertainty. The method for the study follows that of Fountas (2001). In contrast, Hwang (2001) found no evidence that high inflation led to a high variance of inflation in US from 1926 to 1992. The model for the study was Autoregressive Fractionally Integrated Moving Average (AFIMA) -GARCH which accommodate unit root problem that is associated with time series analysis and also provide useful information in the analysis of long run relationship. In consistent with Hwang *et al* (2002) who took similar study with Threshold GARCH (TGARCH) from 1961 to 2003 and found that inflationary shocks leads to more variable inflation in US. In Canada, there was a positive relationship between the variables under review and that inflation precedes inflation uncertainty which is in concomitant with Friedman–Ball hypothesis (Crawford and Kasumovich 1996).

Conrad and Koranason (2004) also took a study using data from Japan, USA and the UK and conclude that Friedman - Ball hypothesis holds in all the three countries and that in a period of high inflation, inflation uncertainty also increases. This study confirms the finding of Hwang (2001) and Fountas (2000). The work employs various GARCH specifications for the countries within the period 1962 and 2001 to capture inflation uncertainty. The three countries were examined on the basis of being the largest economies in the world. Therefore, the impact of inflation variability on output growth in these economies would significantly affect the rest of the world. And also, their economic policy varies for the past four decades.

Bredin and Fountas (2006) also examined the same work in four European countries between 1966 and 2005, except Italy and Holland whose data begin from 1960 and 1977 respectively. The study employs quarterly data of GDP and proxy inflation as the logarithm difference of GDP deflator but CPI for Italy. Markov regime-switching heteroscedasticity model was found to be appropriate for the study with the objective that, it allows regime shift in both the mean and the conditional variance of inflation in both short and long horizons which does not exist in the various GARCH models. It also segregates inflationary shocks in to permanent and transitory. The results show that the relationship between the two variables is different in both transitory and permanent shocks to inflation and across the countries. Again, there is a positive or no association for transitory shocks and negative or no association for negative shocks, which implies that Friedman hypothesis is partially established, only in the short run. This work does not totally agree with that of early researches. This might be due to choice of model and the kind of data used.

Bhar and Hamori (2004) earlier on took the same study in G-7 countries from 1961 to 1999 with the same approach interms of model specification, data choice and analysis. They found out that high inflation uncertainty is associated with high inflationary periods in Canada and Japan in the long run and USA in the short run. Germany experiences positive relationship between the two variables in both periods while Canada had an inverse relationship in the short run. During very high inflationary periods and its uncertainty in the short run, Germany and USA experienced less stable monetary policy. However, when inflation rate falls below the normal level, the monetary authorities have more room to operate monetary aggregates for stable economy in Canada. This implies that Germany and USA may have stable economic policy in the short run a whiles Canada would be less stable.

Yeh (2006) also used cross sectional data for the period 1962-2002 for 161 countries using quantile regression to establish the pattern and relationship between inflation and inflation uncertainty. The result was mix, with some countries in favour of Friedman-Ball relationship and the rest in support of Cukierman-Meltzer. And also, positive inflation shocks impacted strongly on inflation uncertainty than negative inflation shocks throughout all the quartiles of the regression functions. Furthermore, countries in the upper quantiles established a stronger relation between the two parameters as compared to countries in the lower quantile. The choice of this method is robust to extreme observations, as it is able to estimate several conditional quantile functions and therefore produces a complete picture of the entire observation. It also gives unique estimate to each quantile observation. As in Yeh's work where the coefficient of inflation increases with increase in quantile implying that countries in the upper quantile experience much impact effect than those in the lower quantile and therefore heterogeneity of each country can be ascertain. However, this method is plausible for cross country study. A policy maker whose objective is to promote growth is advised not to rely on cross country regression, Agel *et al* (2003).

Neyapti (2000) found that in the period of high inflation, more variable inflation also exists in Turkey, which is in agreement with Friedman hypothesis. The study used Turkey's monthly wholesale price index as a proxy for inflation from 1982 to 1999. The ARCH models to capture inflation uncertainty. The use of monthly wholesale price index as a measure of inflation in an economy does not measure a true general price level. The individuals, producers and the government as a whole do purchase commodities at retail price and therefore is more plausible to use consumer (retail) price index (CPI). Similar studies in the same country and elsewhere use CPI as a proxy for inflation.

Berument *et al* (2001) have also modelled inflation uncertainty with EGARCH (1, 1) in the Turkish economy during the period at which liberalization policies were embarked upon by the government in power (1984–2001) with monthly CPI. The chosen model is due to its ability to capture the magnitude of the effect of both negative and positive shock of inflation on inflation uncertainty. It also does not impose non-negativity constraints when in logarithmic form. The result of the study shows that, positive inflation shocks impact more on inflation uncertainty than negative with an equal magnitude. However, when monthly dummies are used, the effect of both shocks is symmetric on inflation risk. Based on the various works in Turkey, it can be generally said that the high inflation experienced in the recent past does not only cost the country through distorted prices and income but also through inflation uncertainty.

In the economy of Iran, Samimi and Motameni (2009) also investigated the association between inflation and its risk from 1990 to 2008. The monthly growth of CPI is used to proxy inflation and GARCH model for deriving inflation uncertainty. The EGARCH model is also integrated to examine the effect of inflation shock on inflation uncertainty in the economy. The findings were that positive inflation shocks have much impact on inflation uncertainty as compared to negative shock to inflation. Again, the application of Granger causality test came out that inflation Granger cause inflation uncertainty in the Iranian economy and that high inflation leads to more variable in inflation. Farshid and Mojtaba (2010) recently did similar work in the same economy with more data (1959–2009), the same method of study and data and concluded that Friedman–Ball hypothesis prevails in Iran. Also, shocks have asymmetric effects on the volatility of inflation and shocks inflation uncertainties which does not dissipate in the economy easily. Heidari and Bashiri (2010) also took the same study from 1990 to 2010 and obtained the same result. However, they used full information maximum likelihood technique of estimation to avoid two - step procedure which causes misspecification error in modelling.

In Africa, Arabi (2010) used annual data of CPI from 1960 to 2005 to examine the relationship between inflation and inflation uncertainty in Sudan. In the study, different varieties of GARCH related models were applied of which EGARCH was found to be most plausible for conditional variance specification. The outcome of the research was that, simultaneous feedback linkage exists between the two variables. However, this study does not clarify the two opposing hypotheses through causality test.

In the domestic country, Sintim-Aboagye and Byekwaso (2005) examine Ghana, Senegal and Uganda during the IMF and World Bank economic adjustment and recovery programmes from 1964, 1968 and 1981 respectively to 2004. The work employs various GARCH specifications for various regimes for each country. Their finding was that, during the pre-adjustment and the time the institutions were monitoring their economies, Cukierman–Meltzer hypothesis failed to hold in its true form. During the adjustment period, Ghana and Uganda experienced an inverse relationship between the variables concerned implying that the effort of monetary authorities to calm down inflation in response to increase inflation uncertainty. Also, Friedman–Ball hypothesis was observed in Ghana and Uganda over the entire regimes (pre-adjustment, adjustment, post adjustment and overall) but Senegal had mixed results.

2.3 Inflation Uncertainty and Interest Rates

There is not much empirical work on the relationship between inflation uncertainty and interest rates. This might be due to both theoretical and empirical relationship existing between inflation and its uncertainty; most researchers prefer using inflation in their study as a substitute for inflation uncertainty, except investigation of the two variables. Additionally, even though there are theoretical literatures, there is not any associated hypothesis unlike other two relationships already reviewed.

Hartman and Makin (1982) have work with UK data from 1959 to1980. Two models were developed for interest rates, one for risk- averse and the other for risk- neutral. The general result for both models was statistically significant that inflation uncertainty correlates with nominal interest rates. However, in terms of risk-neutrality model, inflation uncertainty impacts positively on expected real rate and negatively on nominal interest rates. Interpreting risk–averse model, inflation uncertainty impacts inversely on nominal interest rates but does not have any effect on expected real rate.

Berument (1999) uses UK quarterly data from 1958 to 1994 to explore the impact of inflation uncertainty on interest rates. The study used GARCH (2, 1) specification to capture conditional variance. The finding was that, the conditional variability (inflation uncertainty) correlates positively with US three-month treasury-bill rate which was proxy as nominal interest rates. The implication is that, if the government deflationary policies are not considered credible to the people, the expected inflation would outweigh the level of inflation and this would increase inflation risk which ultimately impacted negatively on output through transmission mechanism.

2.2.4 Inflation, Inflation Uncertainty, Interest Rates and other Macroeconomic Variables

The theoretical relationships among inflation, inflation uncertainty, interest rate and other macroeconomic variables have been established. It is upon this basis that empirical studies are conducted using different countries' data. Fountas *et al* **(**2006), use monthly data of inflation and output to examine the relationship among inflation, inflation uncertainty, output and output uncertainty of G7 countries. The countries over the past twenty years have been experiencing a reduction in the uncertainties of both inflation rate and output growth and improvement in economic performance, hence the need for empirical investigation. The study employs GARCH model in other to measure the uncertainties. The result shows that inflation impacts negatively on real economic growth both directly and indirectly, through the nominal uncertainty channel.

There is also a mixed result of Friedman-Ball and Cukierman-Meltzer hypotheses of the countries.

In investigating the relationship between inflation uncertainty and output uncertainty, Conrad and Konarasos (2008) and Grier and Perry (2000) use US data from 1960 to 2007 and1948 1996 respectively in their research. They employ GARCH model with log difference of CPI and industrial production index to proxy inflation and output growth respectively. In their findings, high inflation uncertainty has negative impacts on output, which conforms to Friedman's theoretical prediction, and also affects volatility of output growth positively. Moreover, Conrad and Karanaoso added a set of equations and therefore with additional result that higher output variability appears to increase output growth and lowers average inflation.

Vale (2004) had done similar study with bivariate GARCH-in-mean model in Brazillian economy. The work uses industrial production index and both CPI and producer price index (PPI) to proxy output and inflation respectively. The study was base on Friedman–Ball, Cukierman–Meltzer, Devereux and Ramsey and Ramsey hypotheses. The outcome of the work indicates that, Ramsey and Ramsey's hypothesis, which states that there is a negative relationship between growth uncertainty and growth, is contradicted when PPI was used. Also, inflation uncertainty impacts on growth negatively with the usage of CPI, and finally, Cukierman-Meltzer hypothesis prevails.

Tevfik *et al* (2001) presented a GARCH-M system of equations to simultaneously examine the inflation-inflation uncertainty and inflation uncertainty-real output growth relationships empirically in Turkey using monthly data. The evidence showed that Turkish inflation significantly raises inflation uncertainty and lowers real output growth during the 1963-1999 period. Further investigation indicated the adverse effects of inflation and inflation uncertainty on real output growth in Turkey. Based on the empirical evidence real output growth in Turkey will improve significantly if inflation continues its downward trend.

Inflation indirectly impacts on economic activities through its effect on the financial market. In the work of Gregorior and Guidotti (1995) and cited in Lee and Wong (2006), Latin American countries register low economic growth in the financial sector in 1970's and 1980's as a result of high inflation in their economies. Again, Lee and Wong (2006), use Taiwan and Japan data to investigate the linkage among inflation, financial development and economic growth. The result is that, when annual inflation rate is below a threshold of 7.25% and 9.66% respectively on Taiwan and Japan, financial development may enhance economic growth.

In conclusion, the relationship among the three variables have theoretical basis which has empirical backings in some countries. Generally, the Fisher effect (hypothesis) appears to hold in advanced countries in its strong form and in weak or not at all in developing countries. The positive association between inflation and inflation uncertainty has also been established in works reviewed. However, the bone of contention is which variable precedes the other. This has given birth to Friedman–Ball and Cukierman–Meltzer hypotheses. There are mixed results, some of the countries data support one of the two hypotheses, while others are in favour of the two at different periods. In terms of inflation - interest rates linkage and the three variables with other macroeconomic variables, not much empirical analysis is made especially in the developing economies, despite the theoretical literatures available as basis.

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter discusses the processes that are involved in the collection and analysis of the data for the study. It includes model specification, specification tests, parameter stability test, and time series properties of data which is unit root testing, Granger causality test and finally, data sources and description of the study.

3.1 Model Specification

3.1.1 Modeling Inflation and inflation Uncertainty

The model of the study may be derived as the GARCH, which was introduced by Bollerslev (1996) and cited in Sintim-Aboagye *et al* (2005), Berument *et al* (2007), and Heidari and Bashiri (2010). The general GARCH (p, q) specification which measure uncertainty in relation to inflation shock with conditional variance of residuals is given by:

$\pi_t = \beta_0 + \sum_{i=1}^{n} \beta_i \pi_{t-i} + \varepsilon_t$, (1)

$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{n} \alpha_i \varepsilon_{t-p}^2 + \sum_{j=1}^{q} \lambda_j \sigma_{t-q}^2$, (2) where i = 1… n, j = 1… q, $\alpha_0 > 0, \alpha_i^{,s}, \lambda_j^{,s} \geq 0$

The first equation is the mean and the second is the conditional variance equations of the GARCH model.

The mean equation includes, $\pi_t =$ inflation at time t, β_0 = intercept, β_i = coefficient of the i-th lag of inflation, ε_t = discrete time varying stochastic process and n = lag length. The mean equation follows an autoregressive process of order n. The discrete time varying stochastic process follows a normal conditional distribution with zero mean and variance $[\varepsilon_t \sim N(0,1)]$.

The variance equation is a function of its lags and the lags of the residuals generated from the mean equation. It is composed of three parts. The mean, which is the long term average (α_0), the second term is news about volatility from the previous period, the ARCH term ($\sum_{i=1}^{n} \alpha_i \varepsilon_{t-p}^2$) and the GARCH term ($\sum_{j=1}^{q} \lambda_j \sigma_{t-q}^2$). The summation of the coefficients of both the ARCH the GARCH terms should be less than unity $\left(\sum_{i=1}^{n} \alpha_i + \sum_{i=1}^{q} \lambda_j < 1\right)$ and that all coefficients should be positive ($\alpha_{0,>0,} \alpha_i^{,s}, \lambda_j^{,s} \geq 0$) as a sufficient condition to satisfy both stationary (non explosiveness) and non-negativity of the conditional variance. The general GARCH (p, q) represents p number of lags of the inflation residuals and q number of lags of the conditional variance in the conditional variance equation and account for time varying volatility.

The conditional variance equation assumes that the economic agents forecast of current level of variability of inflation is a weighted average of a long term average (constant term), the forecast from the previous period inflation and what have been learned about the past period inflation uncertainty. An unexpected change in inflation would increase variability of inflation in the next period. This implies that, when the coefficients in the variance equation are positive and statistically significant, then positive relationship would emerge between inflation and inflation uncertainty.

Most of the empirical studies on the relationship between inflation and inflation uncertainty make use of two-stage procedure. For instance Thornton (2007), Sintim-Aboagye (2005) and Caporale and Pac Sami (2009) all employed the GARCH model. They estimate the conditional variance of inflation by various GARCH models in the initial stage and later perform Granger causality test between the generated conditional variance and inflation in the second stage.

However Heidari and Bashiri (2010), using Full Information Maximum Likelihood estimation (FIML) procedure instead of two-stage procedure which might have misspecification problem. Friedman- Ball and Meltzer-Cukierman hypothesis posit that inflation causes inflation uncertainty and vice versa respectively. It implies that the mean and conditional variance equations in (2) and (3) may include conditional variance and inflation respectively and therefore re-specify as follow:

$$\pi_t = \beta_0 + \sum_{i=1}^{n} \beta_i \, \pi_{t-i} + \gamma\sigma_{t-q}^2 + \varepsilon_t, \qquad (3)$$

$\sigma_t^2 = \alpha_0 + \alpha_i \sigma_{t-q}^2 + \rho\pi_t$, i, q =1, 2, 3 (4)

The two equations are estimated jointly using FIML. In (4), if ρ>0 and significant is different from zero, it implies that there is a positive relationship between inflation and inflation uncertainty and that high inflation creates more variable inflation confirming Friedman-ball hypotheses. On the other way, if γ>0 in the mean equation, (3) and significant from zero also indicate a direct relationship between inflation and inflation uncertainty and that, inflation uncertainty causes inflation confirming Cukierman-Meltzer hypothesis.

3.1.2 Interest Rates Specification

Under the GARCH framework, the interest rates model may be specified as in Berument (1999), Berument *et al* (2007), which has Fisher hypothesis as the theoretical basis. According to Irvin Fisher, the nominal interest rate, R_t move in the same direction as expected inflation rate, π_t with a constant real rate of interest.

$R_t = C_0 + C_\pi \pi_t + \eta_t$, (5)

Where C_0 = intercept, which represents the real rate of interest, C_π = coefficient of inflation rate, η_t = error term. Inflation does not only affect interest rates, but also inflation uncertainty since both is a function of each other (Berument 1999, Berument *et al* 2007). Fisher equation would therefore be re-modeled as:

$R_t = C_0 + C_\pi \pi_t + C_\sigma \sigma_t^2 + \eta_t$, (6)

Fisher hypothesis would hold in its strong form if the coefficient of inflation c_π is significant and equals to positive one, which imply that there is one to one relationship between interest rates and expected inflation. It holds in its weak form if c_π is approximately less than one and statistically significant. The coefficient, c_σ measures the impact of inflation uncertainty on interest rate and the expected sign is positive based on a priori theoretical grounds.

The significance in the use of GARCH in this study is that, it captures the type of uncertainty modeled in the work of Cukierman and Meltzer and Deveraux, Grier and Perry (2000). It is more consistent in the measurement of inflation uncertainty which is the conditional variance as in the work of Grier and Perry (1988), Nas and Perry (2000), Fountas *et al* (2003). The rest are Evans (1991), Berument (2005), Caporale and Kontonikas (2009), Heidari and Bashiri (2010) and Arabi (2010).

Also, it is a parametric model unlike the survey method and therefore its estimation provides a test of whether the movement in the conditional variance of a variable over time is statistically significant. Furthermore, the GARCH model allows simultaneous estimation of both the mean and conditional variance equations which is more efficient than the two-step estimation when regressors are generated (Grier and Perry 2000: Pagan 1984).

However, one of the setbacks of the model is that, it does not take into account differences in both short and long run effects of inflation uncertainty (Caporale *et al* 2009). The use of this method also does not capture volatility as positive and negative shocks have the same effect on volatility because it depends upon the square of the previous shocks.

3.2 Granger Causality Test

The empirical causal relationship between variables can be examined by Granger-causality analysis. The objective is to test whether lagged values of one variable help to improve the explanation of another variable from its own past, Granger (1969, 1980) cited in Nwokoma (2003). A time series variable X is said to granger-cause another time series variable, Y if and only if the past value of X improves the prediction of the current Y. The test does not only establish causal relationship between two variables in a model but also the level by which one precedes the other. The causality could be bilateral or feedback, unidirectional or no causality (independence) between the variables under study.

To establish the causal relationship between inflation and inflation uncertainty, that is which variable Granger-causes the other to confirm the causal relationship established in equations (3) and (4) the following equations would be put in to test.

$$\pi_t = \beta_0 + \sum_{i=1}^{n} \beta_i \, \pi_{t-i} + \sum_{i=1}^{q} \gamma_i \sigma_{t-q}^2 + \varepsilon_t, \quad (7)$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \sigma_{t-q}^2 + \sum_{i=1}^{n} \rho_i \, \pi_{t-i}, \quad (8)$$

In equation (7), the testable hypothesis is that, inflation uncertainty does not Granger cause inflation for null hypothesis (H_0). The alternative hypothesis states that, inflation uncertain Granger causes inflation (H_1). The null hypothesis is accepted, if the sum of the coefficients of inflation uncertainty is statistically equal to zero. It follows F distribution, with m and n-k degree of freedom at a chosen confidence interval, where m is the number of lagged of independent variables, k is the number of parameters estimated and n is the sample size. In inflation uncertainty (conditional variance) equation, which is (8), the testable hypothesis is as follows: H_0: inflation does not Granger causes inflation uncertainty. H_1: inflation Granger causes inflation uncertainty.

3.3 Estimation Procedure

The technique that would be applied to generate the parameter estimates of the model is the Full Information Maximum Likelihood (FIML). The FIML technique involves all the system of equations in the model and yields all the structural estimates at the same time. Even though the technique is consistent and efficient among simultaneous equation models (Belsay and Wall (1976), its biasness increases as the samples size reduces. When the disturbance terms are normally distributed, the FIML is the most efficient estimator among simultaneous equation models (Greene 2002).

The FIML estimation technique operates under the following assumptions. The equations in the model should be over-identified. The mathematical form of all the equations in the model should be known. The random disturbances of all the structural equations should be normally distributed with zero mean and constant variance (X$\sim N(0, \sigma_x^2)$.

The procedure for the estimation technique as outlined in Koutsoyiannis (2003), is as follows. The structural equations in their reduced form is computed by substituting the identity equations into the behavoural equations and denote all the endogenous variables with the same letter but different subscripts ($y_{1,}$ $y_{2,...}y_k$) as well as pre-determined variables ($z_1, z_{2,...}z_k$), where the behavoural equations are assumed in this case to be three.

The Likelihood function (L) for all the endogenous variables is computed, which is the joint probabilities of all the endogenous variables. In order to make parameters to be estimated enter the function, the computation of the joint probabilities of the endogenous variables (y's) undergo transformation. The transformation is the product of likelihood function of errors (u's) and the partial derivatives of u's with respect to y's. The partial derivatives of u's with respect to y's is known as the Jacobian determinant $|J|$. The likelihood function of u's is the product of all probabilities of all u's of the random terms with the general probability density function,

$$f(u_i) = \frac{1}{\sqrt{2\pi\sigma_u^2}} exp\left\{-1/_2\left(\frac{u_i}{\sigma_u}\right)^2\right\}, u \sim N(0, \sigma_i^2) and\ E(u_i u_i) = 0$$

$$\pi = Constat, \sigma_u = Standard\ deviation\ of\ u$$

The Jacobian determinant for n observations is given by:

$$|J|^n = \left|\frac{\delta(u_{1i}, u_{2i}, u_{3i})}{\delta(y_1, y_2, y_3)}\right|^n$$

Therefore, L which is the joint probabilities of y's is given by:

$$L = P(y_1, y_2, y_3) = P(u_1, u_2, u_3)\left|\frac{\delta(u_{1i}, u_{2i}, u_3 i)}{\delta(y_1, y_2, y_3)}\right|$$

Substituting likelihood function of u's and Jacobian determinant in to L gives the general likelihood function. Taking natural logarithm to base e, the function becomes log likelihood function.

$$\ln L = L^{*} = ln|J| - nln\left(2\pi\sqrt{2\pi}\right) - nln\left(\sigma_{u_1}\sigma_{u_2}\sigma_{u_3}\right) - \frac{1}{2\sigma_{u_1}^{2}}\Sigma u_{1i}^{2} - \frac{1}{2\sigma_{u_2}^{2}}\Sigma u_{2i}^{2} - \frac{1}{2\sigma_{u_3}^{2}}\Sigma u_{3i}^{2}$$

The introduction of logarithm does not change the original function because all logarithmic functions are monotonic. The significance of the logarithm is to facilitate derivatives when maximizing L with respect to the parameter estimates.

Maximization of the likelihood function is the next process. The partial derivative of L^{*} with respect to all the parameter estimates and their corresponding variances and equate to zero. A set of equations are then derived and solve simultaneously to arrive at the maximum likelihood estimates. Performing partial differentiation, the following general equations are obtained:

$$\frac{\partial L^{*}}{\partial \alpha_i} = n\frac{1}{|J|}.\frac{\partial |J|}{\partial \alpha_i} + \Sigma\frac{\partial L^{*}.}{\partial u_1}\frac{\partial u_1}{\partial \alpha_i} = 0, \qquad i = 1,2$$

$$\frac{\partial L^{*}}{\partial \beta_i} = \frac{1}{|J|}.\frac{\partial |J|}{\partial \beta_i} + \Sigma\frac{\partial L^{*}}{\partial u_2}\frac{\partial u_2}{\partial \beta_i} = 0, \qquad i = 1,2.3,4$$

$$\frac{\partial L^{*}}{\partial \gamma_i} = n\frac{1}{|J|}.\frac{\partial |J|}{\partial \gamma_i} + \Sigma\frac{\partial L^{*}.}{\partial u_3}\frac{\partial u_1}{\partial \gamma_i} = 0, \qquad i = 1,2$$

$$\frac{\partial L^{*}}{\partial \sigma_{ui}} = -n\frac{1}{\sigma_{ui}} + \frac{1}{\sigma_{ui}^{3}}\Sigma(u_i)^{2} = 0, \qquad i = 1,2$$

This stage is complex, as series of equations (linear and non linear) are generated from the equations above and solve contemporaneously for the parameter estimates. One should note that all the partials equations and Jacobian determinant need to be computed and substituted into the appropriate relations before all the equations would be solved.

3.4 Specification Tests

The presence of autocorrelation in the model would result in specification bias. It would also appear as if there is presence of ARCH/GARCH effect. Akaike Information Criterion (AIC), Schwarz-Bayesian (SBC) Final Prediction Error (FPC) and Hannan-Quinn Information (HQI) criteria would be used to determine the optimal lag length for the estimation of the model. Several lag lengths would be used but the model with the minimum value of AIC, SBC, FPC and HQI is/are chosen as the most appropriate lag length.

In economic time series analysis, the magnitude of the residuals appears to correlates with each other for the presence of serial correlation or GARCH effect. The presence of this econometric problem affects accuracy of the estimates and therefore wrong inferences can be drawn. Engle outlined Lagrange Multiplier (LM) test, for verification of the presence or absence of ARCH effect or serial correlation. The LM follows a chi-square distribution with test statistic TR^2, where T is the sample size, R^2 is the proportion of variation explained by the explanatory variables ($TR^2 \sim \chi^2_{\alpha,p}$), α is the confidence interval and p is the number of autoregressive terms. The null hypothesis (H_0) states that there is no serial correlation or presence of ARCH effect (all the coefficients of the square lagged terms are statistically equal to zero). If $TR^2 > \chi^2_{\alpha,p}$, H_0 is rejected, implying that ARCH (p) effect is present in the original model.

Finally, normality test would be carried out to find out if the residuals are normally distributed. It is asymptotic test, and therefore incorporates measure of skewness (S) and kurtosis (K). The test statistic is Jarque-Bera (JB). For normally distributed variable, S and K should be 0 and 3 respectively. The null hypothesis states that, the residuals are normally distributed. If the computed probability is low, implying that JB test statistic is different from 0, the null hypothesis is rejected.

3.5 Parameter Stability Tests

The stability of the parameters to be estimated in the models is examined by the plots of the cumulative sum of recursive residuals (CUSUM). The instability of parameters arises due to structural changes and institution of different policy regimes over the sample period. The CUSUM test is useful for detecting systematic changes in the regression coefficients. If either of the straight lines in the graphs is crossed, the null hypothesis that the regression equation is correctly specified is rejected at 5 per cent significance level.

3.6 Time Series Properties of Data

3.6.1 Unit Root Procedure

A test for stationarity that is mostly used in recent time in time series analysis is unit root. Stationarity or stability of time series data plays a crucial role for quality inferences that can be drawn from the estimation process. This may also have a negative impact in terms of efficiency of the conditional variance estimate as well. Two or more time series data that are not stationary would result to spurious regression despite appealing R^2, Student's F and t tests of the explanatory variables. Based on the reasons, monthly consumer price index, which is the proxy for the measurement of inflation and 91-day Treasury bill rate for proxy for interest rate would be tested for stationarity.

Augmented Dickey-Fuller (ADF) as proposed by Dickey and Fuller (1979) and Philips and Perron (PP) (1988) tests would be used for the stationarity test. The ADF test is carried out on the regression: $\Delta X_t = \partial_0 + \delta_1 t + \delta_2 X_{t-1} + \sum_{i=1}^{K} \alpha_i \, \Delta X_{t-i} + U_t$, of which the existence of unit root in X_t variable at time t, the variable Δ_{t-1}expresses the first differences with k lags and final U_t is the variable that first adjust the errors of autocorrelation. The coefficients δ_0, δ_1 and δ_2 are the estimates. The null hypothesis for the existence of unit root as against alternative is: H_0 : $\delta_2 = 0$ for the existence of unit root; H_1 : $\delta_2 < 0$, for no unit root, that is the variable under test is stationary. When the absolute ADF (δ_2) test statistic is greater than the tau (τ) value, reject the null hypothesis and accept the alternative that unit root does not exist. This implies that, the variable X is stationary at levels.

PP test is a non parametric statistical test that takes care of serial correlation without adding lagged difference terms. In PP test, the regression $\Delta X_t = \sigma + \pi X_{t-1} + \varphi \left[t + \frac{T}{2} \right] + \varepsilon_t$ is done of which σ, π and φ are coefficients and T is the number of observations. The null hypothesis for the presence of unit root in the variable X_t as against the alternative is: $H_0 : \pi = 0$; $H_0 : \pi < 0$.

3.7 Data Description and Sources

The type of data that would be used in this analysis is from secondary source. Although a proxy for inflation uncertainty can alternatively be obtained from primary source, it has several limitations as already enumerated. The GARCH model also does not permit the use of data from primary sources.

According to Rosanna and Seater (1995) and cited in Baci (2007), the use of annual data creates aggregation problem and therefore monthly Consumer Price Index (CPI) would be used in the analysis. Inflation is measured as a monthly difference of the natural log of the CPI, which is given by; $\pi_t = (InCPI_t - InCPI_{t-1})$ where t=current period, t-1= immediate previous period. The Bank of Ghana (BoG) 91-day Treasury bill interest rate would also proxy interest rate. The sample period for the study is from 1984:01 to 2011:03. Data is obtained from the BoG Quarterly Bulletin from 1984:01 to 2011:03 and Ghana Statistical Service (GSS), Statistics for Development and Progress.

CHAPTER FOUR

RESULTS, ANALYSIS AND DISCUSSION

This chapter presents the findings and the discussion of the results. The chapter is made up of description of basic statistics of the data, inflation and interest (T-bill) rates, stationarity status of the data, Ordinary Least Squares (OLS) estimation of inflation, diagnostic tests, and estimation of GARCH model. It also finds out the relationship and causality between inflation and its uncertainty, the relationships between interest rate and inflation and interest rate and inflation uncertainty.

4.1 Description of Basic Statistics of Data

Table 4.1: The Summary Statistics of the Data

Variable	Mean	Max.	Min.	Std. Dev.	Skewness	Kurtosis	J.B	Prob.
Inflation	0.452	42.205	-29.008	11.094	0.555	4.793	42.786	0.000
Interest Rate	-0.003	0.374	-0.378	0.075	0.156	9.695	432.301	0.000

The average inflation rate is approximately 0.5. The implication is that, over the data span, inflation rises by 0.5 percentages. The mean rate is quite high showing that Ghana is a developing nation. The range between the maximum and the minimum inflation rate is very large, 71.213. The high range provides general information on the high volatility clustering of inflation rate recorded within the period. The standard deviation is also large, which confirms the range value of a high volatility of monthly inflation rate. The positive skewness also implies that the inflation rate is non-symmetric towards the right tail of the distribution. The Kurtosis exceeded its normal distribution value of 3 by 1.793, which is an indication that inflation rate has a small-tailed. The series therefore does not follow normal distribution. The Jarque–Bera (J.B) statistics of 42.786 rejects normality at 1% level. Figure E in page 55 shows the pattern of inflation rate under review.

The average interest rate is approximately zero. The difference between the maximum and the minimum interest rate is large. The standard deviation is small. This implies that the rate does not change much over a long period of time. There is a positive Skewness, indicating that the right tail is asymptotic and therefore interest rate is not symmetric. The Kurtosis of 9.695 far exceeded the normal value of 3. The Jarque-Bera test at 1% level also rejects normality of interest rate.

4.2 Unit Root Test Result

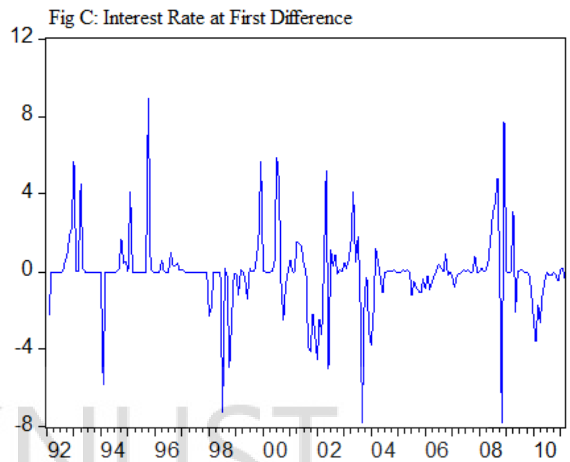
Stationarity test is conducted on the annualized monthly log difference of CPI, which proxy inflation rate and monthly interest rate using ADF and PP as discussed in chapter 3 of this study. Test is conducted on both intercept and intercept and trend at 1%, 5% and 10% levels of significance. The table below shows the result of the test.

Inflation rate is stationary (no unit root) in intercept as well as in trend and intercept at 1% level of significance at level with ADF and PP. Interest rate at its level was not stationary. It possessed a unit root in both intercept and trend and intercept when ADF and PP tests were conducted at 1% level of significant. However, at first difference it has no unit root in intercept and trend and intercepts using ADF and PP test at 1%. The time series plot of interest rate at both level and first difference are shown in figures B and C.

4.2: Augmented Dickey-Fuller and Phillips-Perron Stationarity Test Results for Inflation Rate and Treasury-bill

Variables	Test	Level/First Difference	Include in Test Equation	Statistics	Critical Values		
					1%	5%	10%
Inflation rate	ADF	Level	Intercept	-11.1294*	-3.4588	-2.8740	-2.5735
			Trend and intercept	-11.2260*	-3.9986	-3.4296	-3.1383
	PP	Level	Intercept	-11.6832*	-3.4588	-2.8740	-2.5735
			Trend and intercept	-11.7435*	-39986	-3.4296	-3.1383
Treasury bill	ADF	Level	Intercept	-1.2769	-3.4588	-2.8740	-2.5735
			Trend and intercept	-2.6196	-3.9986	-3.4296	-3.1383
		First Difference	Intercept	-14.5869*	-3.4592	-2.8741	-2.5736
			Trend and Intercept	-14.5540*	-3.9992	-3.4298	-3.1384
	PP	Level	Intercept	-1.4737	-3.4587	-2.8739	-2.5734
			Trend and intercept	-2.5680	-3.9985	-3.4295	-3.1382
		First Difference	Intercept	-31.9759*	-3.4590	-2.8740	-2.5735
			Trend and intercept	-8.5598*	-3.9986	-3.4296	-3.1383

* Indicates Null Hypothesis of a Unit Root is Rejected at 1% Significant Level



Data Source: Bank of Ghana Quarterly Bulletins

4.3 Estimation Results

It has been observed that the appropriate time series model for inflation for the period under study includes 1 and 3 of its lags. The lags selection is based on the minimum value of AIC and SBC criteria, significance of the t-values and R-square. The estimation result of inflation is as follows:

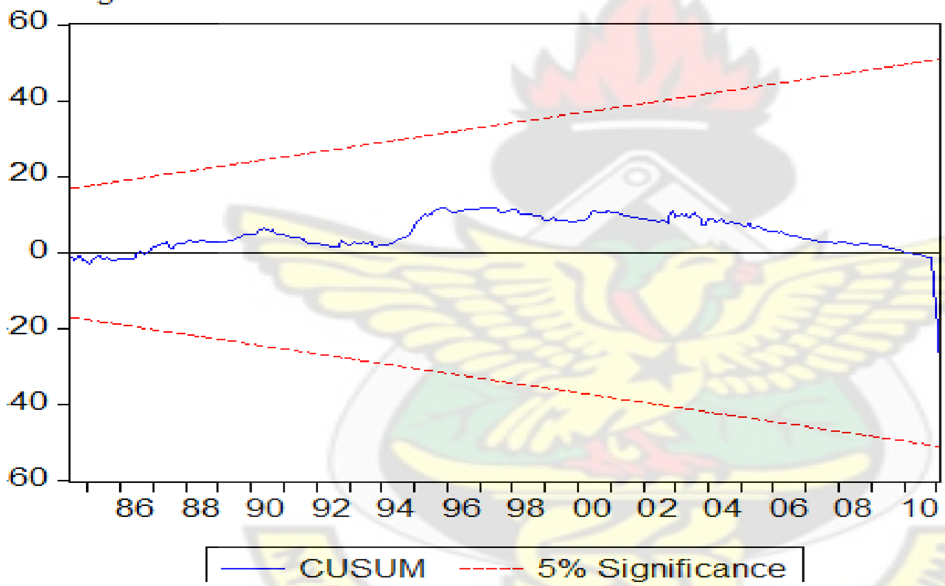
Table 4.3: Ordinary Least Squares Estimation of Inflation Rate

Variable	**Coefficient**	**Std. Error**	**t - statistic**	**Prob.**
Constant	1.351*	0.278	4.884	0.000
Π_{t-1}	1.255*	0.025	51.204	0.000
Π_{t-3}	-0.314*	0.022	-14.551	0.000

* Indicates Significant at 1% Level

The highly significant coefficients indicate that the current inflation is explained by its first and third lagged values. A month back inflation impacts directly on the current inflation whiles that of three back impacts negatively on the current inflation. The Cumulative Sum of Recursive Residuals (CUSUM) test for stability of parameters of the estimate for the sample period shows that there is no structural break in the estimation. Figure D shows the plot line of the parameter estimate, which can be found within the 5% critical lines bound, indicating that there is no systematic change in the coefficients of the regression parameters.

Fig D: The Plot of Cumulative Sum of Recursive Residuals



The two straight lines represent critical bound at 5% significant level

The next diagnostic test is to find out the existence of serial correlation, which is carried out using Breush-Godfrey serial correlation Lagrange multiplier (LM) test. The result of the test has a p-value of 0.219 which indicates that the null hypothesis does not reject the hypothesis of no serial correlation and therefore the residuals are not serially correlated.

Moreover, a test of GARCH (or ARCH) effect is performed on the square residuals to test for non-constant residual variance. The square residuals of inflation are repressed on its constant and on the 1^{st}, 4^{th}, 8^{th} and 12^{th} lags. The test result is shown in table 4.4

Table 4.4: ARCH LM Test

Lag	**Test Statistic**	**Prob.**
1	2.045	0.154
4	1.453	0.216
8	2.430	0.015
12	1.811	0.046

The result of ARCH test indicates that, the null hypothesis of no ARCH effect for lags 1 and 4 is rejected. This implies that the existence of ARCH effect is present in the residuals up to lag 4. However, the existence of ARCH effect for higher lags diminishes.

After determining the existence of ARCH effect in lags 1 and 4, which shows existence and persistence of non-constant conditional variance, the GARCH model is estimated as GARCH (1, 1) after various specifications were estimated of which the parsimonious model is considered on the basis of the level of significance of parameters estimates. The regression results are reported in table 4.5

Table 4.5: GARCH (1, 1) Estimation Results

Variable	Coefficient	Std. Error	Z - Statistic	Prob.
Mean Equation				
constant	0.409**	0.133	3.073	0.002
Π_{t-1}	1.296**	0.023	56.158	0.000
Π_{t-3}	-0.319**	0.022	-14.389	0.000
Conditional Variance Equation				
constant	0.303*	0.139	2.184	0.029
ε_{t-1}^2	0.313*	0.136	2.294	0.023
σ_{t-1}^2	0.680**	0.071	9.589	0.000

** (*) Significant at 1% (5%) level

The GARCH (1, 1) results from table 4.3 indicate that all coefficients were significant at 1% or 5% as shown in table 4.5. The estimated results satisfy Bollerslev's sufficient condition of model stationarity and therefore not explosive. That is the coefficients in the conditional variance equation are positive and the sum of the slopes (ARCH term and GARCH term) is less than unity. The sum of the ARCH term and GARCH term in the conditional variability equation is (0.313 + 0.680), 0.993, which is close to 1. The implication is that any shock to the variability of inflation does not die out but rather persist permanently. The ARCH (1) term, which has the value 0.313 is the volatility obtain from the news of the previous period. The last period forecast of the variance, GARCH (1) term (0.680) impacts on the current conditional variance more than the news about inflation generated from the previous period. This implies that the contribution of the previous inflation uncertainty to the current inflation uncertainty outweighs that of economic agents' information on the current news on inflation. The current inflation uncertainty is estimated as the weighted average of the three terms of the conditional variance, 0.303, 0.313 and 0.680.

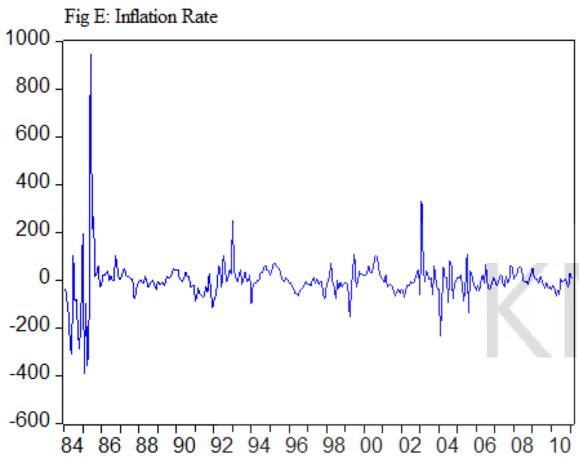
In GARCH model, it is only the magnitude of the unanticipated change in the mean equation that affects the volatility due to the square of the ARCH term in the conditional variance equation. Therefore, in GARCH estimation, (since conditional variance is invariant of the sign of the ARCH term) there is a positive relationship between inflation and its uncertainty. To determine whether inflation impact on inflation uncertainty or otherwise, equations 3 and 4 in chapter 3 were estimated jointly. In order to come out with unbiased estimate, Heidari and Bashiri (2010) suggested that all the lags in the system (GARCH model) should also be included in the estimation. The estimation results is shown in table 4.6

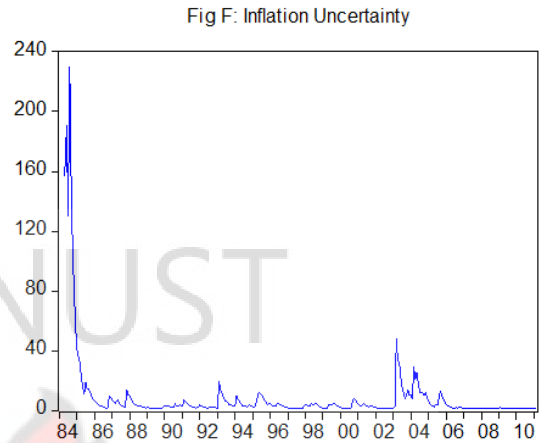
Table 4.6: The FIML Estimation Result of GARCH (1, 1)

Variable	**Coefficient**	**Std. Error**	**Z - statistic**	**Prob.**
Mean Equation				
constant	1.366**	0.315	4.33	0.000
Π_{t-1}	1.214**	0.019	63.724	0.000
Π_{t-3}	-0.267**	0.0173	-15.374	0.000
σ_t^2	0.021**	0.006	3.488	0.001
Conditional Variance Equation				
constant	-0.296	2.485	-0.119	0.905
σ_{t-1}^2	0.876**	0.008	105.776	0.000
π_t	0.038	0.0823	0.461	0.645

** Indicates Significant at 1% Level

The estimation results in the table 6 indicate that the coefficient of conditional variance which measure inflation uncertainty in the mean equation is positive and significant at 1% level. The implication is that inflation uncertainty positively relates to inflation and that high inflation variability increases inflation rate. This relationship supports Cukierman–Meltzer hypothesis. On the other hand, the coefficient of inflation was not significant in the conditional variance equation. This indicates that inflation does not affect inflation uncertainty; hence, Friedman-Ball hypothesis does not prevail.





Data Sources: Ghana Statistical Service, Statistics for Development and Progress

Figures E and F show the time series plot of inflation rate and conditional variance, which proxy's inflation uncertainty. The two figures display similarity in terms of degree of volatility clustering within the same period and trends, indicating that there is a direct relationship between the two variables. In the beginning of the two figures to somewhere 1986, the two figures show high volatility. Again, around 1986 through to somewhere 2008, when inflation rate displays a volatility which was not intense as compared to the previous period, figure F also follows similar trend. Around 2002 to 2005 when the volatility of inflation rate again was quite high, similar display can be seen in the figure of inflation uncertainty. Finally, at the end of the two figures, it can be observed that the two figures display similar trends, the volatility of both inflation rate and inflation uncertainty tappers off.

4.4 Granger Causality Test Result

The most popular test to establish the causality between two or more variables is the Granger causality test. To confirm the initial results of the causal relationship between inflation and inflation uncertainty the study further performed Granger causality test. Table 7 provides the estimation results.

Table 4.7: Granger Causality Test

Lag	Null Hypothesis	F - statistic	Prob.
Lag 1	Inflation uncertainty does not Granger cause inflation	51.104	6.0e-12*
	Inflation does not Granger cause inflation uncertainty	1.841	0.176
Lag 2	Inflation uncertainty does not Granger cause inflation	5.927	0.003*
	Inflation does not Granger cause inflation uncertainty	2.174	0.115

* Indicates Rejects the Null Hypothesis

Granger causality test was performed with several lag lengths. However, it was lags 1 and 2 that were statistically significant and confirms the initial result. In lags 1 and 2, in table 4.7, the null hypothesis of inflation uncertainty does not Granger causes inflation at 1% and 5% respectively are rejected. This implies that at both lags, inflation uncertainty Granger causes inflation. Therefore, the Granger causality test confirms the initial result that inflation uncertainty impacts on inflation, which is in support of Cukierman–Meltzer opportunistic central bank behaviour hypothesis.

4.5 Interest Rate Estimation Results

In order to establish the relationship between interest rate–inflation and interest rate - inflation uncertainty, equations 3 and 4 in chapter 3 were estimated in GARCH (1, 1) model with FIML estimation procedure. The result of the estimation is as follows:

Table 4.8: The FIML Estimation Result of GARCH (1, 1) with Augmented Fisher Relation

Variable	Coefficient	Std. Error	Z - statistic	Prob.
Mean Equation				
constant	0.619**	0.308	2.009	0.045
Π_{t-1}	1.194**	0.019	63.084	0.000
Π_{t-3}	-0.220**	0.015	-14.355	0.000
Conditional Variance Equation				
constant	0.353	1.155	0.205	0.760
ε_{t-1}^2	0.150**	0.012	12.365	0.000
σ_{t-1}^2	1.013**	0.013	79.238	0.000
Augmented Fisher Relation (Interest Rate with Inflation and Inflation Uncertainty)				
constant	15.634**	1.319	11.856	0.000
π_t	0.470**	0.046	10.251	0.000
σ_t^2	-0.084	0.175	-0.482	0.6301

** Indicates Significant at 1% Level

The result of the estimation of GARCH (1, 1) with interest rate equation involving inflation and inflation uncertainty shows that all the coefficients in the mean equation were significant at 1% level of significance except the constant term which was significant at 5%. The signs of the coefficients remain unchanged as they were in the initial GARCH model. In the conditional variance equation, the coefficients of the ARCH and the GARCH terms were significant at 1% with correct expected signs. However, the constant term was not significant but the positive expected sign was correctly estimated.

In the interest rate equation, both the constant and the coefficients of inflation were significant at 1% level of significance. However, the coefficient of inflation uncertainty was not significant and therefore we can say that there is no direct relationship between interest rate and inflation uncertainty. The significant coefficient of inflation in the interest rate equation gives an indication that there is a positive relationship between interest rate and inflation. To investigate the Fisherian hypothesis, coefficient of 0.470 is less than one and therefore the one to one relationship between inflation and interest rate proposed by Fisher does not hold. However, we can say that Fisher hypothesis holds in its weak form and lend support to Tobin (1965).

The next to find out is whether the relationship between interest rate and inflation without the influence of inflation uncertainty would improve or otherwise. Table 9 shows the estimation results.

Table 4.9: The FIML Estimation Results of GARCH (1, 1) with Fisher Equation

Variables	Coefficient	Std. Error	Z - statistic	Prob.
Mean Equation				
constant	0.625**	0.310	2.020	0.043
Π_{t-1}	1.195**	0.019	61.845	0.000
Π_{t-3}	-0.222**	0.016	-13.698	0.000
Conditional Variance Equation				
constant	0.387	1.128	0.344	0.731
ε_{t-1}^2	0.149**	0.012	12.584	0.000
σ_{t-1}^2	1.008**	0.021	41.359	0.000
Fisher Equation				
constant	14.834**	1.330	11.157	0.000
π_t	0.476**	0.046	10.314	0.000

** Indicates Significant at 1%   Level

The result of GARCH (1, 1) estimation with Fisher equation using FIML does not significantly differ from the initial estimation. All the results remain statistically the same. However, the conditional variation experience explosion, the sum of the ARCH and the GARCH terms was more than unity. The final estimation is to find out the impact of interest rate on only inflation uncertainty. The estimation result is in table 4.8.

Table 4.10: The FIML Estimation of GARCH (1, 1) with Interest Rate and Conditional Variance

Variable	Coefficient	Std. Error	Z - statistic	Prob.
Mean Equation				
constant	0.736**	0.352	2.093	0.036
Π_{t-1}	1.194**	0.022	53.960	0.000
Π_{t-3}	-0.225**	0.017	-13.236	0.000
Conditional Variance Equation				
constant	0.356	1.141	0.312	0.755
ε_{t-1}^2	0.150**	0.012	12.810	0.000
σ_{t-1}^2	1.013**	0.013	80.846	0.000
Interest Rate Equation with only Inflation Uncertainty				
constant	26.835**	0.775	34.627	0.000
σ_t^2	-0.098	0.114	-0.857	0.392

** Indicates Significant at 1% Level

The result does not statistically differ from the initial estimation where both inflation and inflation uncertainty were included in the interest rate equation. All the expected signs as in the initial estimation were correct with the probability values. However, the conditional variance equation experience explosion or was not stationary, where the sum of both the ARCH and GARCH terms was more than one. There is no direct relationship between interest rate and inflation uncertainty. The probability value of 0.392 is still not significant.

4.7 Discussion

The analysis of the estimation results of the three variables, inflation, inflation uncertainty and interest rate have come out that there is a direct relationship between inflation and inflation uncertainty, and that a rise in inflation uncertainty causes more average inflation which is in support of Cukierman-Meltzer hypothesis. There is also a positive relationship between inflation and interest rate. However, the linkage existing between them is weak; the coefficient of inflation is far below one, hence Fisher hypothesis holds in its weak form. The direct relationship between interest rate and inflation uncertainty does not hold.

The Cukierman-Meltzer hypothesis which states that uncertainty about inflation positively impacts on inflation found in the study coincides with the work of Conrad and Koranasos (2004), who use Japanese CPI monthly data from 1962 to2001. Even though, they use GARCH (1, 1) to capture inflation uncertainty, Fractionally Integrated GARCH (FIGARCH) model was selected in their study. Conrad and Koranasos (2008) embark on similar studies in US with GARCH-in-Mean model and obtain the same result. However, this study conflicts with that of Sintim-Aboagye *et al* (2005), who has worked with Ghana, Uganda and Senegalese data from 1981 to 2004 and found that a rise in inflation create more inflation uncertainty in Ghana and Uganda, but mix result for Senegal. Besides the relatively small sample size, the GARCH (1, 1) model use does not satisfy Bollerslev's non-negativity and stationarity of the coefficients of conditional variance conditions.

The sum of the ARCH term and GARCH term in the conditional variance equation is (0.313 + 0.680), 0.993, which is close to 1. The implication is that any shock to the variability of inflation does not die out but rather persist permanently. The high uncertainties that entangle the economic environment couple with high inflation the country experienced for more than three decades has contributed immensely to economic instability. After several disinflations, now in a single digit couple with BoG reduction in prime rate does not reflect in the lending rates of the credit sector of the economy. The economic agents' chronic experience of unstable economy, including unachievable end of year inflation targets does not dissipate, creating high risk in the economic environment, although, policymakers have assured maintaining stable economy, including single digit inflation, in to the future.

The full Fisher effect has failed to hold due to the fact that inflation does not play a major role in the determination of interest rate in Ghana. In recent times, the monthly CPI continues to fall with anticipation that interest rates in the country would fall alongside, but that is not the case. Interest on loans from commercial banks and other financial institutions are still very high. Interest rate in Ghana is also use as a policy tool by the monetary authorities to stabilize the economy of which inflation is one of the macroeconomic variables (Kwakye 2010). Moreover, the financial sector of the economy is not developed to the level that enables the forces in the market to determine interest rates freely without any external intervention (Ocran 2007).

The high lending rate is attributable to high lending risk including inadequate collateral, inadequate borrower identification and generally high loan default in the country. Others are operational inefficiencies, high operation cost and inadequate infrastructure. The proliferation of banks in the country does not bring any completion to improve efficiencies and therefore lower operational cost but rather engage in collusive practices.

Even though, some measures of macroeconomic stability has been achieved, including single digit inflation currently, which compelled BoG to decreased the policy rate further to 13.5%, the high interest rate has thwart the connection between banks lending and policy rates. The effect is to impede the transmission and effectiveness of the monetary policy.

Finally, the study established no direct evidence about the relationship between interest rate and inflation uncertainty in Ghana. This result coincides with Berument *et al* (2007) who investigated the relationship between inflation uncertainty and interest rate in Fisher equation in both G-7 and 45 developing countries including Ghana. The relationship between inflation risk and interest rate was not significant for the case of Ghana. All the G-7 countries were significance. The rest of the developing countries are mix in terms of the sign of risk and the significance level of the coefficient.

Unlike Cheong *et al* (2010) who have done similar work with US data with both Instrumental Variable (IV)-General Method of Moment (GMM) and FIML with the same results that inflation uncertainty negatively relates to interest rate at 5% significance level. However, Berument (1999) work with UK data with the same model with FIML and established a positive relationship between the two variables under discussion. There is therefore a mix results in different parts of the world concerning the relationship between inflation uncertainty and interest rate. One cannot therefore give any deduction that, a specific relationship is established in certain parts of the world unlike Fisher effect.

However, from transmission mechanism, one can deduce that inflation uncertainty enters interest rate equation indirectly at appreciable significance level through inflation. It has been established in the study that, there is a positive relationship between inflation and inflation uncertainty and that inflation uncertainty causes inflation. Also, the study established a positive relationship between inflation and interest rate, of which a rise in inflation causes interest rate also to rise through in Fisher equation with and without risk. These imply that, there is an indirect positive relationship between inflation uncertainty and interest rate. The linkage begins from inflation uncertainty to inflation (Cukierman-Meltzer hypothesis) and from inflation to interest rate (Fisher equation).

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

This section presents summary of the research findings and policy implications of the study. It further gives recommendations to policy makers in Ghana and finally the limitations the study suffers.

5.1 Summary of Findings

The study uses two approaches to establish the relationship between inflation and inflation uncertainty. The first method is a two-step procedure, of which GARCH (1, 1) is estimated in the first step and Granger causality test between the conditional variance and inflation in the second step. The second approach involves including conditional variance in the mean equation and inflation in the conditional variance equation of the GARCH model. The two yields the same result and that inflation and inflation uncertainty are positively related and that inflation uncertainty causes inflation. This confirms Cukierman-Meltzer hypothesis of central bank opportunistic behavour.

The second relationship the study establishes is between inflation and interest rate. The conditional variance is included in Fisher equation (inflation and interest rate). The equation is estimated with GARCH (1, 1), which involves mean and conditional variance equations. The result indicates that there is a positive relationship between inflation and interest rate. However, the coefficient of inflation in the equation is far below one and therefore the study has come out that, Fisher hypothesis holds in its weak form. That is the full Fisher effect does not hold. In order to investigate whether the coefficient of inflation would improve, that is approaching one, the study estimates only Fisher equation with GARCH (1, 1). However, there is no statistically significant change in the result.

The final estimation is to ascertain the link between inflation uncertainty and interest rate. The Fisher equation with conditional variance as used in inflation-interest rate relationship is used in this as well. However, attention is paid to the coefficient of conditional variance. The coefficient of conditional variance is positive but not significant which indicate that, there is no direct association between inflation and interest rate. The study again estimates inflation uncertainty and interest rate only with GARCH (1, 1) to ascertain if the coefficient will be significant. The result still remains the same and that there is no direct link between inflation and interest rate.

The study has therefore established that in the Ghanaian economy within the period 1984 to 2011, increase in volatility in inflation creates more inflation and that the former causes the latter. Secondly, a rise in inflation raises nominal interest rate but not on one-on one basis, hence full Fisher effect does not exist in Ghana. Finally, there is no direct relationship between inflation uncertainty and interest rate. However, through transmission mechanism, there is a relationship between variable inflation and interest rate, from uncertainty to inflation itself to interest rate.

5.2 Policy Implications

The positive relationship between inflation and inflation uncertainty in Ghana and that change in the variability of inflation impacts on inflation in the same direction. The inflation uncertainty–inflation as predicted by Cukierman and Meltzer opportunistic behavour of policymakers is evidenced in the study. An implication of this phenomenon in Ghana for the past three decades is that the monetary authorities were more concerned with the government policies to achieve rapid economic growth than reducing inflation to acceptable level, even though they seek to target single digit inflation. This unachievable target may only be cosmetic statement. Implementation of discretionary policies to stimulate growth, engage in time-inconsistent behaviour increases inflation uncertainty that causes an increase in the long run inflation rate.

After the country has returned from serious economic stagnation in 1984, coupled with being a developing country, various governments embark on economic policies that would fast track its development. Policymakers over the years engaged in rapid expansion of monetary policy in order to surprise the society with increase output. After the Economic Recovery Progamme (ERP), the country experienced stable and continuous economic growth for more than 20 years. The increase in economic growth however goes with hyper inflation of 27.44% on average per annum between 1984 to1991, according to the author's computation from a data obtain from GSS. The monetary authorities of the past had made efforts to reduce inflationary pressure of which it was not successful. According to Hutchful (2002); Ocran (2007), during the time of this rapid economic growth, the targeted inflation rate of 5% by the year 2000 was not realized. The inability of the policymakers to curb inflation to a threshold has created uncertainty in the economic business environment of Ghanaians over the years which affect businesses and ultimately increases general price level in the economy. Although, from July 2009, the monthly CPI of 20.9% continue to fall and entered a single digit of 9.5% in June 2010 but the inflation uncertainty in the economy does not die out. This has turned business environment to be cloudy making it difficult to forecast in to future investments.

Moreover, the high uncertainties that cloud the economy couple with high inflation the country has registered over the years have partially contributed to the high lending rate from the commercial banks. After consistent disinflation, couple with BOG persistent reduction in prime rate and assuring the players of the economy of maintaining stable macro economy including low inflation in to the future does not all carry enough confidence in the financial sector. This indicates that uncertainty that murk the economy still in persistence. The economic agents are still not confident with the stability of the macroeconomic variables in to the future as claimed by the policymakers because of the past experience for not meeting their set targets.

5.3 Recommendations

The study finds that, high inflation risk result in increase inflation in the Ghanaian economy. This implies that, when inflation uncertainty is reduced, inflation will also fall as well as nominal interest rate. It is therefore crucial to identify the factors that will curb inflation uncertainty, which will also bring inflation down, through a chain reaction; nominal interest rate will also trim down.

Policymakers should strictly adhere to their economic policies; achieve the macroeconomic target set by them as a pre-requisite in forestalling high inflationary expectation in the mind of the public. Although, it is known that every government in power has its political and economic ideologies and therefore appoints experts with the same believes to man such places. However, the prudent economic and financial policies established should not be ignored at a point in time to win cheap political goal as experienced especially during political electioneering seasons.

Furthermore, institutions that deal with computation of economic figures such as BoG, GSS, Institute of Statistical, Social and Economic Research and Ministry of Finance should share information on all drivers of domestic inflation with the general public to rationalize inflation expectation. They should make available to the public items that are included and their weight in the computation of CPI. Publishing information on these items, as well as inflation rate of major trading partners, projection of essential imports and exports prices will not put the public in the dark, hence a reduction in uncertainty of inflation.

Also, there should be timely education on inflationary developments by monetary authorities to the business communities to bridge the communication gap between the two parties. This will in the long run regain back confidence the public had lost in monetary authorities as far as strict implementation of policies, transparency and reliability of their operations are concerned.

Finally, the monetary authorities must exercise their regulatory authority invested in them to correct market failure in the financial system. They should set both interest rate ceiling and floor, on lending and savings deposit respectively, to the financial institutions.

5.4 Limitation of the Study

There are several ways by which inflation uncertainty is captured. It ranges from the class of GARCH models to the traditional survey methods. The study employed the GARCH model which should have been integrated with the survey method to find out from the agents themselves about the inflation uncertainty in the economy. However, the study gathered data from 1984 of which survey data for Ghana is very difficult to source, if even not in existence.

Secondly, for the research to generate current inflation uncertainty through the use of survey is limited by time and funds. The time limit and the amount of resource involved in carrying out such a task with reliable information are beyond the scope of this research. In recent times, as evident in the literature, the GARCH models (the GARCH, EGARCH, IGARCH, TGARCH, Component GARCH and others) are the common methods of generating inflation uncertainty of which GARCH model is the popular among them.

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APPENDICES

Appendix 1: Ordinary Least Squares Estimation of Inflation Rate

Dependent Variable: CPII

Method: Least Squares

Date: 06/28/11 Time: 11:38

Sample (adjusted): 4 326

Included observations: 323 after adjustments

CPII=C(1)+C(2)*CPII(-1)+C(3)*CPII(-3)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.351466	0.276724	4.883800	0.0000
C(2)	1.255374	0.024517	51.20416	0.0000
C(3)	-0.313784	0.021565	-14.55050	0.0000

R-squared	0.965571	Mean dependent var	23.83375
Adjusted R-squared	0.965356	S.D. dependent var	13.40456
S.E. of regression	2.494993	Akaike info criterion	4.675694
Sum squared resid	1991.997	Schwarz criterion	4.710780
Log likelihood	-752.1245	Durbin-Watson stat	1.592804

Appendix 2: Serial Autocorrelation Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.302474	Probability	0.219030
Obs*R-squared	15.65604	Probability	0.207503

Test Equation:

Dependent Variable: RESID

Method: Least Squares

Date: 06/27/11 Time: 15:34

Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.039375	0.118832	0.331347	0.7407
C(2)	-6.62E-05	0.000109	-0.605184	0.5457
C(3)	-4.40E-06	7.23E-06	-0.608919	0.5433
RESID(-1)	0.035248	0.069755	0.505303	0.6139
RESID(-2)	0.064589	0.069866	0.924465	0.3563
RESID(-3)	0.021272	0.069839	0.304586	0.7610
RESID(-4)	0.109790	0.069874	1.571258	0.1177
RESID(-5)	-0.058594	0.069778	-0.839716	0.4021
ARESID(-6)	0.049134	0.069959	0.702317	0.4833
RESID(-7)	0.008525	0.070307	0.121259	0.9036
RESID(-8)	0.116713	0.070662	1.651691	0.1001
RESID(-9)	0.006085	0.070812	0.085934	0.9316
RESID(-10)	-0.082983	0.070835	-1.171494	0.2428

RESID(-11)	-0.009673	0.071362	-0.135548	0.8923
RESID(-12)	-0.116106	0.071602	-1.621545	0.1064

R-squared	0.071164	Mean dependent var	1.05E-15
Adjusted R-squared	0.002867	S.D. dependent var	1.853057
S.E. of regression	1.850398	Akaike info criterion	4.138626
Sum squared resid	698.4906	Schwarz criterion	4.385435
Log likelihood	-439.2488	Durbin-Watson stat	2.002633

Appendix 3: Test for ARCH (GARCH) Effect

ARCH Test:(1)

F-statistic	2.044821	Probability	0.153701
Obs*R-squared	2.044536	Probability	0.152754

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 06/30/11 Time: 14:39

Sample (adjusted): 1984M05 2011M02

Included observations: 322 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.320427	1.627539	3.269002	0.0012
RESID^2(-1)	0.077653	0.054304	1.429972	0.1537

R-squared	0.006349	Mean dependent var	5.800686

Adjusted R-squared	0.003244	S.D. dependent var		28.62302
S.E. of regression	28.57655	Akaike info criterion		9.549242
Sum squared resid	261318.2	Schwarz criterion		9.572686
Log likelihood	-1535.428	F-statistic		2.044821
Durbin-Watson stat	2.089467	Prob(F-statistic)		0.153701

ARCH Test:(4)

F-statistic	1.453137	Probability		0.216377
Obs*R-squared	5.797781	Probability		0.214768

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 06/30/11 Time: 14:46

Sample (adjusted): 1984M08 2011M02

Included observations: 319 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.463126	0.617544	5.607906	0.0000
RESID^2(-1)	-0.012767	0.024920	-0.512320	0.6088
RESID^2(-2)	0.039218	0.024180	1.621912	0.1058
RESID^2(-3)	0.032022	0.022269	1.437977	0.1514
RESID^2(-4)	0.007622	0.022330	0.341320	0.7331
R-squared	0.018175	Mean dependent var		3.835766
Adjusted R-squared	0.005668	S.D. dependent var		10.51059

S.E. of regression	10.48076	Akaike info criterion	7.552509
Sum squared resid	34491.74	Schwarz criterion	7.611525
Log likelihood	-1199.625	F-statistic	1.453137
Durbin-Watson stat	1.865935	Prob(F-statistic)	0.216377

ARCH Test:(8)

F-statistic	2.429794	Probability	0.014704
Obs*R-squared	18.81487	Probability	0.015882

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 06/30/11 Time: 14:53

Sample (adjusted): 1984M12 2011M02

Included observations: 315 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.652146	0.703417	3.770374	0.0002
RESID^2(-1)	0.041795	0.057143	0.731406	0.4651
RESID^2(-2)	0.162220	0.056466	2.872856	0.0044
RESID^2(-3)	-0.021122	0.056626	-0.373004	0.7094
RESID^2(-4)	0.012286	0.056427	0.217737	0.8278
RESID^2(-5)	-0.032026	0.024727	-1.295201	0.1962
RESID^2(-6)	0.027826	0.024072	1.155971	0.2486
RESID^2(-7)	0.059443	0.022072	2.693168	0.0075
RESID^2(-8)	0.002597	0.022315	0.116377	0.9074

R-squared	0.059730	Mean dependent var	3.745155
Adjusted R-squared	0.035148	S.D. dependent var	10.50941
S.E. of regression	10.32307	Akaike info criterion	7.534794
Sum squared resid	32609.11	Schwarz criterion	7.642011
Log likelihood	-1177.730	F-statistic	2.429794
Durbin-Watson stat	2.001669	Prob(F-statistic)	0.014704

ARCH Test:(12)

F-statistic	1.810868	Probability	0.045844
Obs*R-squared	21.13705	Probability	0.048409

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 06/30/11 Time: 14:57

Sample (adjusted): 1985M04 2011M02

Included observations: 311 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.302377	0.765953	3.005899	0.0029
RESID^2(-1)	0.034635	0.057301	0.604453	0.5460
RESID^2(-2)	0.182449	0.057028	3.199299	0.0015
RESID^2(-3)	-0.020656	0.057939	-0.356504	0.7217
RESID^2(-4)	-0.013845	0.057744	-0.239774	0.8107

RESID^2(-5)	-0.002043	0.057722	-0.035387	0.9718
RESID^2(-6)	0.011537	0.056907	0.202729	0.8395
RESID^2(-7)	0.035269	0.056346	0.625949	0.5318
RESID^2(-8)	0.084009	0.056176	1.495470	0.1359
RESID^2(-9)	-0.050057	0.025049	-1.998361	0.0466
RESID^2(-10)	-0.018962	0.024408	-0.776877	0.4378
RESID^2(-11)	0.041533	0.022230	1.868315	0.0627
RESID^2(-12)	0.040855	0.022326	1.829899	0.0683

R-squared	0.067965	Mean dependent var	3.623681
Adjusted R-squared	0.030433	S.D. dependent var	10.42068
S.E. of regression	10.26089	Akaike info criterion	7.535458
Sum squared resid	31375.18	Schwarz criterion	7.691784
Log likelihood	-1158.764	F-statistic	1.810868
Durbin-Watson stat	1.998359	Prob(F-statistic)	0.045844

Appendix 4: GARCH (1, 1) Estimation

Dependent Variable: CPII

Method: ML - ARCH (Marquardt) - Student's t distribution

Date: 06/28/11 Time: 11:24

Sample (adjusted): 4 326

Included observations: 323 after adjustments

Convergence achieved after 34 iterations

Variance backcast: ON

CPII=C(1)+C(2)*CPII(-1)+C(3)*CPII(-3)

GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.408621	0.132959	3.073288	0.0021
C(2)	1.296087	0.023079	56.15822	0.0000
C(3)	-0.318509	0.022136	-14.38888	0.0000
	Variance Equation			
C	0.303185	0.138800	2.184340	0.0289
RESID(-1)^2	0.312926	0.136385	2.294427	0.0218
GARCH(-1)	0.679622	0.070876	9.588832	0.0000
T-DIST. DOF	3.100000	0.525773	5.896082	0.0000
R-squared	0.964132	Mean dependent var		23.83375
Adjusted R-squared	0.963451	S.D. dependent var		13.40456
S.E. of regression	2.562673	Akaike info criterion		3.808393
Sum squared resid	2075.265	Schwarz criterion		3.890262
Log likelihood	-608.0555	Durbin-Watson stat		1.605677

Appendix 5: GARCH (1, 1) Estimation

Variance in Mean Equation and Inflation in Variance Equation

System: UNTITLED

Estimation Method: Full Information Maximum Likelihood (Marquardt)

Date: 06/28/11 Time: 14:24

Sample: 4 326

Included observations: 323

Total system (balanced) observations 323

Convergence achieved after 1 iteration

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	1.365579	0.315025	4.334822	0.0000
C(2)	1.214003	0.019050	63.72641	0.0000
C(3)	-0.266851	0.017357	-15.37424	0.0000
C(4)	0.020756	0.005950	3.488113	0.0005

Log Likelihood	-747.7442
Determinant residual covariance	6.002153

Equation: CPII=C(1)+C(2)*CPII(-1)+C(3)*CPII(-3)+C(4)*GARCH03

Observations: 323

R-squared	0.966492	Mean dependent var	23.83375
Adjusted R-squared	0.966177	S.D. dependent var	13.40456
S.E. of regression	2.465241	Sum squared resid	1938.695
Durbin-Watson stat	1.490160		

System: UNTITLED

Estimation Method: Full Information Maximum Likelihood (Marquardt)

Date: 06/28/11 Time: 14:21

Sample: 5 326

Included observations: 322

Total system (balanced) observations 322

Convergence achieved after 169 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C(5)	-0.295820	2.487484	-0.118923	0.9053
C(6)	0.876007	0.008282	105.7761	0.0000
C(7)	0.037947	0.082348	0.460811	0.6449

Log Likelihood	-1155.667
Determinant residual covariance	76.72115

Equation: GARCH03=C(5)+C(6)*GARCH03(-1)+C(7)*CPII

Observations: 322

R-squared	0.861357	Mean dependent var	8.263295
Adjusted R-squared	0.860487	S.D. dependent var	23.56044
S.E. of regression	8.800152	Sum squared resid	24704.21
Durbin-Watson stat	2.674330		

Appendix 6: Granger Causality Test

Pairwise Granger Causality Tests

Date: 06/28/11 Time: 11:00

Sample: 1 326

Lags: 1

Null Hypothesis:	Obs	F-Statistic	Probability
GARCH02 does not Granger Cause CPII	322	51.1042	6.0E-12
CPII does not Granger Cause GARCH02		1.84074	0.17582

Pairwise Granger Causality Tests

Date: 06/28/11 Time: 11:26

Sample: 1 326

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
GARCH03 does not Granger Cause CPII	321	5.92734	0.00297
CPII does not Granger Cause GARCH03		2.17434	0.11538

Appendix 7: GARCH (1, 1) Estimation with Augmented Fisher Equation

System: UNTITLED

Estimation Method: Full Information Maximum Likelihood (Marquardt)

Date: 07/02/11 Time: 21:49

Sample: 1984M06 2011M02

Included observations: 321

Total system (balanced) observations 963

Convergence achieved after 296 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.619448	0.308370	2.008779	0.0446
C(2)	1.193683	0.018922	63.08426	0.0000
C(3)	-0.219796	0.015333	-14.33456	0.0000
C(4)	0.352774	1.154892	0.305461	0.7600
C(5)	0.149950	0.012127	12.36460	0.0000
C(6)	1.013028	0.012785	79.23816	0.0000
C(7)	15.63372	1.318671	11.85567	0.0000
C(8)	0.469884	0.045837	10.25125	0.0000
C(9)	-0.084126	0.174666	-0.481641	0.6301

Log Likelihood	-2983.962
Determinant residual covariance	23814.07

Equation: CPII=C(1)+C(2)*CPII(-1)+C(3)*CPII(-3)

Observations: 321

R-squared	0.972113	Mean dependent var	23.61620
Adjusted R-squared	0.971937	S.D. dependent var	13.10138
S.E. of regression	2.194734	Sum squared resid	1531.760
Durbin-Watson stat	1.787726		

Equation: GARCH01=C(4)+C(5)*RESID_2(-1)+C(6)*GARCH01(-1)

Observations: 321

R-squared	0.863647	Mean dependent var	7.776492
Adjusted R-squared	0.862789	S.D. dependent var	21.91538
S.E. of regression	8.117883	Sum squared resid	20956.21
Durbin-Watson stat	1.963971		

Equation: TBILL(-1)=C(7)+C(8)*CPII+C(9)*GARCH01

Observations: 321

R-squared	0.340458	Mean dependent var	26.07583
Adjusted R-squared	0.336310	S.D. dependent var	10.84703
S.E. of regression	8.836767	Sum squared resid	24832.13
Durbin-Watson stat	0.055221		

Appendix 8: GARCH (1, 1) Estimate with Fisher Equation

System: UNTITLED

Estimation Method: Full Information Maximum Likelihood (Marquardt)

Date: 07/02/11 Time: 21:54

Sample: 1984M06 2011M02

Included observations: 321

Total system (balanced) observations 963

Convergence achieved after 200 iterations

	Coefficient	Std. Error	z-Statistic	Prob.

C(1)	0.625499	0.309710	2.019630	0.0434
C(2)	1.195367	0.019329	61.84463	0.0000
C(3)	-0.221703	0.016186	-13.69756	0.0000
C(4)	0.387425	1.127589	0.343587	0.7312
C(5)	0.148529	0.011803	12.58398	0.0000
C(6)	1.007708	0.021278	47.35915	0.0000
C(10)	14.83363	1.329548	11.15689	0.0000
C(11)	0.476038	0.046155	10.31388	0.0000

Log Likelihood	-2989.933
Determinant residual covariance	24716.78

Equation: CPII=C(1)+C(2)*CPII(-1)+C(3)*CPII(-3)

Observations: 321

R-squared	0.972117	Mean dependent var	23.61620
Adjusted R-squared	0.971941	S.D. dependent var	13.10138
S.E. of regression	2.194583	Sum squared resid	1531.550
Durbin-Watson stat	1.791692		

Equation: GARCH01=C(4)+C(5)*RESID_2(-1)+C(6)*GARCH01(-1)

Observations: 321

R-squared	0.863630	Mean dependent var	7.776492
Adjusted R-squared	0.862772	S.D. dependent var	21.91538
S.E. of regression	8.118388	Sum squared resid	20958.82
Durbin-Watson stat	1.962769		

Equation: TBILL(-1)=C(10)+C(11)*CPII

Observations: 321

R-squared	0.315640	Mean dependent var	26.07583

Adjusted R-squared	0.313494	S.D. dependent var	10.84703
S.E. of regression	8.987376	Sum squared resid	25766.56
Durbin-Watson stat	0.046997		

Appendix 9: GARCH (1, 1) Estimation with Interest Rate and Conditional Variance

System: UNTITLED

Estimation Method: Full Information Maximum Likelihood (Marquardt)

Date: 07/02/11 Time: 21:58

Sample: 1984M06 2011M02

Included observations: 321

Total system (balanced) observations 963

Convergence achieved after 202 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.736215	0.351678	2.093437	0.0363
C(2)	1.193567	0.022120	53.95942	0.0000
C(3)	-0.224512	0.016962	-13.23631	0.0000
C(4)	0.356427	1.141344	0.312287	0.7548
C(5)	0.150310	0.011734	12.80997	0.0000
C(6)	1.012847	0.012528	80.84638	0.0000
C(12)	26.83480	0.774976	34.62664	0.0000
C(13)	-0.097555	0.113865	-0.856759	0.3916
Log Likelihood		-3046.241		

Determinant residual covariance 35103.79

Equation: CPII=C(1)+C(2)*CPII(-1)+C(3)*CPII(-3)

Observations: 321

R-squared	0.972108	Mean dependent var	23.61620
Adjusted R-squared	0.971933	S.D. dependent var	13.10138
S.E. of regression	2.194913	Sum squared resid	1532.011
Durbin-Watson stat	1.788314		

Equation: GARCH01=C(4)+C(5)*RESID_2(-1)+C(6)*GARCH01(-1)

Observations: 321

R-squared	0.863648	Mean dependent var	7.776492
Adjusted R-squared	0.862791	S.D. dependent var	21.91538
S.E. of regression	8.117848	Sum squared resid	20956.03
Durbin-Watson stat	1.961099		

Equation: TBILL(-1)=C(12)+C(13)*GARCH01

Observations: 321

R-squared	0.027245	Mean dependent var	26.07583
Adjusted R-squared	0.024196	S.D. dependent var	10.84703
S.E. of regression	10.71500	Sum squared resid	36624.79
Durbin-Watson stat	0.034691		