On the Inflation-Uncertainty Hypothesis in The Gambia: A Multi-Sample View on Causality Linkages

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Abstract

The connection between inflation and inflation-uncertainty hypothesis has been tested in so many countries, yet in The Gambia testing the relationship and accounting for structural changes as not been given serious attention to the literature. This paper modelled the inflation-uncertainty hypothesis using monthly inflation series from 1970(1)-2017(5). The GJR-GARCH model was used to generate the conditional variance of the inflation proxied as inflation uncertainty. Then the Pearson correlation was employed across the various samples, and the results vary in sign and magnitude reflecting structural changes within The Gambia's economy. Finally, Toda Yamamoto (1995) causality test was employed. The results show strong support of a feedback relationship for both the Friedman-Ball and Cukierman-Meltzer hypothesis for the full sample as well as the post Economy Reform Program (ERP) sample; while during the Inflation Targeting Era (ITE) sample; the results indicate strong support of the Friedman-Ball hypothesis and no support of Cukierman-Meltzer hypothesis. The results provide evidence for both empirical and policy implications for the Central Bank. Firstly, the findings provide additional insights into the dynamic relationship between inflation and inflation uncertainty in The Gambia. Secondly, the findings provide policy implication for The Gambian monetary authority to adopt Inflation targeting (IT) as a policy tool.

Keywords: Inflation, Inflation-Uncertainty, GJR-GARCH, Toda Yamamoto Causality Test

JEL Classification: E3,E5.

1. INTRODUCTION

Inflation is considered to be a major economic problem in transition economies and thus fighting inflation and maintaining stable price is the main objective of monetary authorities. One cannot say with certainty whether the inflation is good or bad for an economy but if the debate focuses on inflation-uncertainty or instead of just inflation, economists have almost consensus about its adverse impact over some of the most important economic variables, like output and growth rate via different channels (Rizvi and Naqvi, 2008). Inflation can result in a decrease in the purchasing power of national currency leading to the aggravation of social conditions and living standards. Moreover, inflated prices worsen the country's terms of trade by making domestic goods expensive on regional and world market (Isakova, 2007). Most importantly, high and volatile inflation rate make inflation forecasting and by extension, inflation targeting very difficult for the central bank (Santos, Mapa, and Glindro, 2011). On the contrary, uncertainty is often cited as a major source of the cost of inflation. Uncertainty about the future levels of inflation will distort saving, and investment decisions since it cause the real value of future payments to be unknown (Crawford and Kasumovich, 1996). These distortions are believed to have an adverse effect on the efficiency level of resource allocation and the level of real economic activity (see Fischer,1981; Holland,1993; Golob,1994).

The central focus of theoretical and empirical studies is whether a rise in the level of inflation raises uncertainty about the future. Friedman (1977) argues that an increase in inflation leads to more uncertainty about the future rate of inflation. He argued that burst inflation creates stronger pressure to counter it. As a result, the policies go from one direction to the other, encouraging wide variation in inflation, which increases uncertainty and lowers output growth and welfare. The opposite type of causation between inflation and its uncertainty has also been analyzed in the theoretical macroeconomics literature. Cukierman and Meltzer (1986) argue that central banks tend to create inflation surprises in the presence of more inflation uncertainty. Fischer and Modigliani (1978) also point out those governments typically announce unrealistic stabilization programs as the inflation rate rises, thus increasing uncertainty about what the future path of price will be. Moreover, the importance of inflation uncertainty as a distinct channel in explaining the real effect has recently been given considerable empirical support (Grier and Tullock, 1989: Brunner and Hess, 1993; Ungar and Zilberfarb,1993; Judson and Orphanides,1999). Understanding the dynamics of inflation and its interaction with inflation uncertainty is an essential question in theory and practice, particularly for central banks and policymakers to conduct monetary policy (Conrad and Karanasos, 2005; Dai and Spyromitros, 2012).

The objective of this paper is to investigate the relationship between inflation and its uncertainty in The Gambia utilizing a full sample monthly data from 1970:01-2017:05. The issue of inflation and inflation uncertainty as not been an eternal topic of debate in macroeconomics (see Mohd, Baharumshah, and Fountas, 2012). Uncertainties about the global economic environment and sharp price increase in major commodities in the last few years pose new challenges for managing price stability. Faust and Henderson (2004) indicate that the best practice of monetary policy can be summarized into two goals: first, get mean inflation right, second get the variance inflation right. The specific feature of this paper is that unlike the earlier studies in The Gambia (see Hegerty, 2012), the paper relies on the GJR-GARCH (Glosten, Jagannanthan, and Runkle (1993)-Generalized Autoregressive Conditional Heteroskedasticity) model to construct the conditional variance inflation series. The paper then adopts the approach suggested by Toda and Yamamoto (1995) to test for the competing hypothesis on the inflation and inflation-uncertainty nexus in The Gambia over a whole period (1970:01-2017:05). As noted by Balcilar et al. (2010), in the presence of structural changes, the dynamic link between two series will indicate instability across different subsamples, and as such, the result may be inaccurate (Su, Yu, Chang, and Li, 2016). It is for these reasons; this study presents the results of two other subsamples believed to affect the inflation uncertainty in The Gambia. The "first-period" post-economic reform program (ERP) from (1985:01 - 2004:12). The "second period" was the inflation-targeting era from (2005:01-2017:05). As noted by Dittmar, Gavin, and Kydland (1999) even among countries that do not explicitly adopt inflation targets their policy behavior has been portrayed as if they have inflation targets.

The rest of the paper is structured as follows. Section 2 provides the literature review. Section 3 presents data and methodology. Section 4 reports the empirical results. Section 5 represents conclusions.

2. LITERATURE REVIEW

The direction of the relationship between inflation and inflation uncertainty has been a controversy in both the theoretical and empirical front. The theoretical linkage between inflation and inflation uncertainty was pioneered by Milton Friedman (1977) in his Noble lecture. Friedman-Ball hypothesis postulate that causality runs from inflation to inflation uncertainty without offering any specific economic modelling to support his hypothesis. Friedman (1977) postulates that by creating political pressure to reduce inflation, high inflation results in future inflation uncertainty. Ball (1992) extended the views of Friedman in a game-theory setting among the monetary authority and the public to demonstrate that inflation uncertainty tends to be high during high inflation periods. Ball's model assumes two policymakers who changes power stochastically of which only one is willing to dis-inflate the economy through the recession. He continued that at any point in time, private agents are uncertain as to whether the monetary authority is "conservative" or "liberal," since they alternate in the office stochastically, and do not know how long each of these authorities will preserve their position in the office. By Ball's definition, a conservative monetary authority cares only about keeping inflation low, while a liberal monetary authority is willing to trade some higher inflation for lower unemployment. When inflation is low, both conservative and liberals will target monetary policies at keeping inflation at a low rate (Entezarkheir, 2006). In this model, Ball (1992) argues that a higher current inflation rate creates more uncertainty about the level of future inflation because the public is not sure whether the strict type of policymakers will gain power and fight inflation.

In contrast to the Friedman-Ball hypothesis, Cukierman and Meltzer (1986) and Cukierman (1992), by considering the Barro-Gordon model of the federal's behavior, analyzed the other direction of causality between inflation and inflation uncertainty and postulates that causality runs from inflation-uncertainty to inflation. According to this argument, during periods of high inflation uncertainty, the monetary policy is discretionary due to lack of a commitment mechanism resulting to monetary authorities to act in opportunistically to maximize output growth by monetary expansion leading to high inflation. Unlike the dominant hypothesis of a positive association between inflation level and inflation uncertainty, other theories postulate an adverse relationship may exist, (see Pourgerami and Maskus 1987; Holland, 1995). Pourgerami and Maskus (1987) argue that higher inflation reduces inflation uncertainty as people invest resources to anticipate the future inflation rate better and to shelter themselves from its adverse effects. Holland (1995) has supplied a different argument based on stabilization motive of the monetary authority, the so-called "stabilizing Fed hypothesis". He argues that inflation-uncertainty rises due to increases in inflation, the monetary authority responds by contracting money supply growth, to eliminate inflation-uncertainty and the associated adverse welfare effects (Conrad and Karanasos, 2005). Holland (1993) provides the reason why inflation may precede uncertainty bases on Evans and Wachtel's (1993) model. Uncertainty about the parameters of the inflation process can lead to a link between the inflation rate and inflation uncertainty. Evans and Wachtel (1993) specify an inflation process of the form:

$$\pi_t = \alpha_t + \beta_t \pi_{t-1} + \varepsilon_t \qquad (1)$$

Where π_t denotes the inflation rate, ε_t denotes a disturbance with a mean zero and is identically distributed, α_t and β_t are the time-varying parameters that reflects changes in the inflation regime. In their model, one regime implies that inflation rated is stationary so the $\beta_t < 1$, and that no restrictions apply to α_t. The other implies that inflation rate is a random walk without drifts so that $\beta_t = 1$ and $\alpha_t = 0$. Holland (1993) shows that conditional variance of inflation represents inflation uncertainty as:

$$E(\pi_t - \pi_t^*) = E(\alpha_t - \alpha_t^*)^2 + E(\beta_t - \beta_t^*)^2(\pi_{t-1})^2 + E(\varepsilon_t)^2 \qquad (2)$$

Where π_t^*, α_t^*, β_t^* denotes the conditional expectation on information from period $t-1$. If the regime changes cause unpredictable changes in the persistence of inflation, then $E(\beta_t - \beta_t^*)^2 > 0$ and the lagged inflation squared is positively related to inflation uncertainty. An increase in the rate of inflation (or deflation) would precede an increase in inflation uncertainty and thus it postulates a negative effect of inflation uncertainty on inflation level.

The causation and correlation ambiguity between inflation and inflation uncertainty has inspired several studies in the literature, a considerable volume of empirical research has tested Freedman-Ball and Cukierman-Meltzer hypotheses in different countries, and they found mixed results. Davis and Kanago (2000) highlight that the mixed of results partly reflects differences in the countries studied, sample period, the frequency of data sets, and empirical methodologies including the representation of inflation uncertainty. The earlier paper on inflation and inflation uncertainty nexus that can be found in The Gambia is Hegerty (2012), using monthly inflation series from 1976-2012 and employing the Exponential GARCH (E-GARCH) model the result indicates a bidirectional causality between inflation and inflation-uncertainty. However, such conclusion is indeed too general especially when the country has gone through key structural changes; for instance, the post-Economic Reform Programme (ERP) in 1985, the 3-4 % inflation targeting by the central bank during the year 2005 onwards. As such, it is essential to revisit the inflation and inflation uncertainty nexus in The Gambia accounting for these structural changes.

3. DATA AND METHODOLOGY

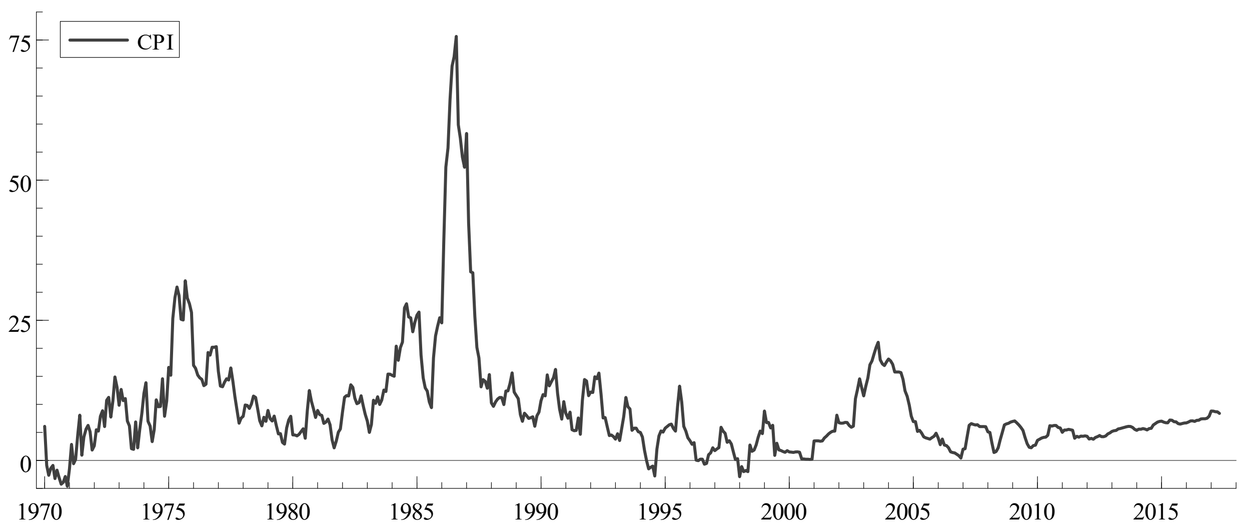
3.1. Data

The study used monthly data on the CPI (consumer price index) as a proxy for the price level. The data range from 1970:01 to 2017:05 comprising of a total of 569 monthly observations downloaded from International Monetary Fund (IMF) Database. The inflation rate is calibrated as the log difference of the month CPI series as the percentage value of the CPI with its value from the corresponding month of the previous year represented as:

$$\pi_t = \left[\frac{CPI_t - CPI_{t-12}}{CPI_{t-12}}\right] * 100 \quad (3)$$

Notably, there are several advantages of using the formula in equation (3) as compared to the month on month formula. Firstly, the inflation rate calibrated on year on year (y-o-y) basic are seasonally adjusted has each month compared with the corresponding month of the previous year. Secondly, the inflation series not only reflect the underlying trend of the data but capable of capturing deviation from expected seasonal behavior. Moreover, using high frequency data, specifically in this study, monthly inflation series, increase the efficiency of extracting model-based estimates of volatility from economic time series (see Sizova, 2009). Figure 1 plots of the evolution of the monthly inflation series in The Gambia from 1970:01-2017:05.

Figure 1. Plot of the Monthly Inflation Series



Source: International Monetary Fund (IMF) Database, *Authors' Graphical Representation*

In Figure 1, The Gambia is replete with deleterious effect of high and volatile inflation. During the post Economy Reform Program (ERP) in 1987 is one example in which The Gambia experience hyperinflation as inflation rate edge above 20 percent. The short albeit a life of high inflation in 1978 was attributed to rapid money supply, depreciation of the value of The Gambian dalasi that exacerbated the inflation rate (McPherson and Radelet, 1992). However, throughout the early 1990s inflation rate tends to remain at a single digit. Markedly, the inflation rate in 1997 was primarily due to an increased build-up of domestic debt as the Central bank of The Gambia continues to sell treasury bill for budget deficit financing and liquidity management purpose (De Vrijer, Kibuka, Jang, Izvorski, and Beddies, 1999). Again, in early 2000s inflation rate has not been excessive although it has frequently exceeded the 3-5 percent rate target of the central bank (Heintz, Oya, and Zepeda, 2008). However, it is important to note that inflationary pressure comes from supply shocks that affect key prices such as food and energy. Nevertheless, several studies suggest that inflation rate, e.g. (12-15) percent is are consistent with long-run economic growth (see Khan and Senhadji, 2001).

3.2. Unit Root Test

Checking the order of integration of included variables is crucial in any time series modelling. Notably, the first type to unit root test relatively common in the literature but has been criticized because due to their bias towards non-rejection of the null hypothesis of the unit root against the alternative trend stationarity in the presence of structural breaks and low power for near integrated process. These are the augmented Dickey and Fuller (1978) unit root test and the Phillips and Perron (1988) unit root test. The second type of unit root test allows for one break in the series and is the test developed by Zivot and Andrews (1992) and Lee and Strazicich (2004). The Zivot-Andrews unit root test considers the null hypothesis of unit root test in time. In the presence of a break under the null, however, the asymptotic results are valid, and the test exists size distortions such that the unit root null hypothesis is rejected too often. The Lee and Strazicich (2004) unit root with one endogenously determined structural break is based on the Lagrange multiplier (LM) test with a distribution invariant to breakpoint nuisance parameters and allows for a break under both the null and alternative hypothesis, such that the alternative hypothesis unambiguously implies trend stationarity.

3.3. The Two-Step Approach

To test the Friedman-Ball and Cukierman-Metzler hypothesis, the first step is to constructs an appropriate measure of inflation uncertainty. This should meet the background concept of this hypothesis in the sense that inflation uncertainty is the variance of an unpredictable component of inflation, as emphasized in (Grier and Perry, 1998). It is important to note that uncertainty is different from variability. Uncertainty can be regarded as unpredictable fluctuations. In contrast, variability captures both unpredictable and predictable fluctuations. Predictable components are included in a measure of variability, although they are not associated with any economic uncertainty. This argument explains why variability measures such as a moving standard deviation of the variable are inappropriate to capture uncertainty (see, Buth, Kakinaka, and Miyamoto, 2015). A widely applied method to mitigate this problem is to estimate the variance of unpredictable components in inflation as inflation uncertainty by applying Engle (1983) and (Bollerslev, 1986) generalized autoregressive conditional heteroskedasticity (GARCH) model. The time-varying conditional variance derived from the estimate of the GARCH model can be more constituent with the concept of the Friedman-Ball and Cukierman-Metzler hypothesis (Su, Yu, Chang, and Li, 2016). The GARCH (p,q) model is written by the following mean and variance equation:

Conditional mean equation

$$INF_t = \alpha_o + \sum_{i=1}^{k} \alpha_i INF_{t-i} + \epsilon_t \quad (4)$$

Conditional variance equation

$$h_t = \beta_o + \sum_{i=1}^{p} \beta_i \epsilon_{t-i}^2 + \sum_{i=1}^{q} \gamma_i h_{t-i} \quad (5)$$

Despite the apparent success of this simple parameterization, the ARCH and GARCH models cannot capture some salient features of the data. The most interesting futures not addressed by these models is the leverage effect of the asymmetric effects discovered by Black (1976) and confirmed by the findings of French, Schwert, and Stambaugh (1987), Nelson (1991) among many others. Brunner and Hess(1993), Joyce (1995), Fountas and Karanasos (2007) are of the view that a positive inflation shock is more likely to increase inflation uncertainty via a monetary mechanism as compared to negative inflation shock of equal size and magnitude. If this is correct, then the ARCH and GARCH models may provide a misleading estimate of inflation uncertainty (Su et al., 2016). Engle and Ng (1993) have devised a set of tests to confirm the asymmetry present in volatility if any. These tests are known as the sign and size bias test. In this study, however, to determine if an asymmetric model is adequate to capture the inflation uncertainty or whether the linear GARCH model in equation (4) and (5) above, can be adequate. Hence, from equation (5), the regression equation for the sign bias, negative size bias, positive size bias, and joint tests in the standardized residual to determine the asymmetric volatility model to news is as follows:

Sign bias test: $Z_t^2 = \alpha_0 + \beta S_t^- + e_t$ (6)

Negative size bias test: $Z_t^2 = \alpha_0 + \delta S_t^- \varepsilon_{t-1} + e_t$ (7)

Positive size bias test $Z_t^2 = \alpha_0 + \vartheta S_t^+ \varepsilon_{t-1} + e_t$ (8)

Joint test: $Z_t^2 = \alpha_0 + \beta S_t^- + \delta S_t^- \varepsilon_{t-1} + \vartheta S_t^+ \varepsilon_{t-1} + e_t$ (9)

Where α_0, β, δ, ϑ are constant coefficients, S_t^- is a dummy variable that take value one if $(\varepsilon_{t-1} < 0)$ and zero otherwise, S_t^+ is a dummy variable that take one if $(\varepsilon_{t-1} > 0)$ and zero otherwise, e_t denotes the residual series of the regression equation. The significance of β implies that the standardized residuals can be predicted by the dummy variable S_t^-. The Significance of δ implies that negative inflation shocks have different impact upon future inflation uncertainty. Moreover, the significance of ϑ implies that a positive inflation shocks have different effect on inflation uncertainty. To mitigate this problem, many nonlinear extension of the ARCH and GARCH model have been proposed such as exponential GARCH (E-GARCH) model by Nelson (1991), GJR-GARCH model by Glosten, Jagannanthan, and Runkle (1993), Threshold GARCH (T-GARCH) by Zakoian (1994). Unlike other asymmetric GARCH, the GJR-GARCH model is flexible because it allows past lags to display asymmetries, this gives an indication of the leverage effect (Fountas, Karanasos, and Karanassou, 2001; Wilson, 2006). GJR-GARCH is taken to be the best forecaster among asymmetric models and GARCH for one step or multi-step ahead forecasting (Glosten 1993; Labuschagne, Venter, and von Boetticher, 2015). Dhamija and Bhalla (2010),Monfared and Enke (2014) also finds GJR-GARCH outperforms other GARCH family models in the estimation of implied volatility. Thus, the conditional mean and variance equation of an AR(P)-GJR[GARCH] (1,1) is express as:

Conditional mean equation

$$INF_t = \omega_0 + \sum_{i=1}^{p} \emptyset INF_{t-i} + \varepsilon_t \quad (10)$$

Conditional variance equation

$$h_t = \omega_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \gamma \varepsilon_{t-1}^2 I_{t-1} \quad (11)$$

Where $I_{t-1} = 1$, if $\varepsilon_{t-1} < 0$, otherwise $I_{t-1} = 0$. Conditional volatility is positive when $\omega > 0$, $\alpha_i \geq 0$, $(\alpha_i + \gamma_i)/2 \geq 0$ for $i = 1$ to q and $\beta_j \geq 0$ for $j = 1$ to p. The process is covariance stationary if $[\sum_{i=1}^{q} (\alpha_i + \gamma_i)/2 + \sum_{j=1}^{p} \beta_j < 1]$. If the asymmetry γ is negative then the negative inflationary shocks results in the reduction of inflation uncertainty (Rizvi and Naqvi, 2008).

The second step of the empirical procedure involves testing the causality between inflation and inflation uncertainty. This study utilizes the methodology developed by Toda and Yamamoto (1995) to test for the causality between inflation rate and its uncertainty, which leads to chi-square (x^2) distributed statistic despite any possible non-stationarity or cointegration between the two series. In other words, the advantage of this methodology is that it does not require a knowledge of the cointegration properties of the system (see Zapata and Rambaldi,1997). The test is performed in two steps; the first step, the optimal lag length (k) of the system is determined by utilizing the Akaike Information Criteria (AIC). In the second step, a Vector Autoregression (VAR) of order $k^* = k + d_{max}$ is estimated (where d_{max} is the maximal integer order of integration suspected to occur in the system and the modified Wald (MWALD)) test is then applied to the first k vector autoregressive (VAR) coefficient matrices to make the Granger causal inference. The MWALD test statistics has asymptotic x^2 distribution with k degree of freedom. The Toda Yamamoto version of the Granger causality of the two variables is represented in the following VAR system:

$$INF_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} INF_{t-i} + \sum_{j=k+1}^{dmax} \alpha_{2j} INF_{t-j} + \sum_{i=1}^{k} \emptyset_{1i}\, INFUC_{t-i} + \sum_{j=k+1}^{dmax} \emptyset_{2j} INFUC_{t-j} + \epsilon_{1t} \quad (12)$$

$$INFUC_t = \beta_o + \sum_{i=1}^{k} \beta_{1i} INFUC_{t-i} + \sum_{j=k+1}^{dmax} \beta_{2j} INFUC_{t-j} + \sum_{i=1}^{k} \delta_{1i} INF_{t-i} + \sum_{j=k+1}^{dmax} \delta_{2j} INF_{t-j} + \varepsilon_{2t} \quad (13)$$

The Granger causality from $INFUC_t$ to INF_t in equation (12) implies $\emptyset_{1i} \neq 0 \forall_i$, similarly in equation (13) the INF_t Granger causes $INFUC_t$ if $\delta_{1i} \neq 0 \forall_i$.

4. RESULTS

Using monthly inflation data from 1970:01 to 2017:05, the first step involves a descriptive statistic of the inflation series, and the results are summarized in Table 1. The result implies that in The Gambia, the inflation series has a high standard deviation that exceeds the mean. The kurtosis statistics show that inflation rate is non-normal and skewed to the right indicating that the distribution of the inflation series is leptokurtic. The significant value of the Jarque-Bera (JB) statistic implies a deviation from normality, and the significant Q-statistic of the squared deviation of the inflation rate from its sample mean indicating the existence of an ARCH effect. This evidence is also supported by the highly statistically significance of the LM test at 1% implying that the inflation series in The Gambia exhibit an ARCH effect. Furthermore, Figure 1 provides a graphical analysis of the inflation series.

Table 1. Summary Statistic of The Inflation Series from 1970:01-2017:05

	μ	σ	Kur	JB	EK	$Q_{(5)}$	$Q^2_{(5)}$	LM (1-2)
INF	9.2295	9.8964	3.3895	6288.7	14.899	2217.13	1951.01	3363.1

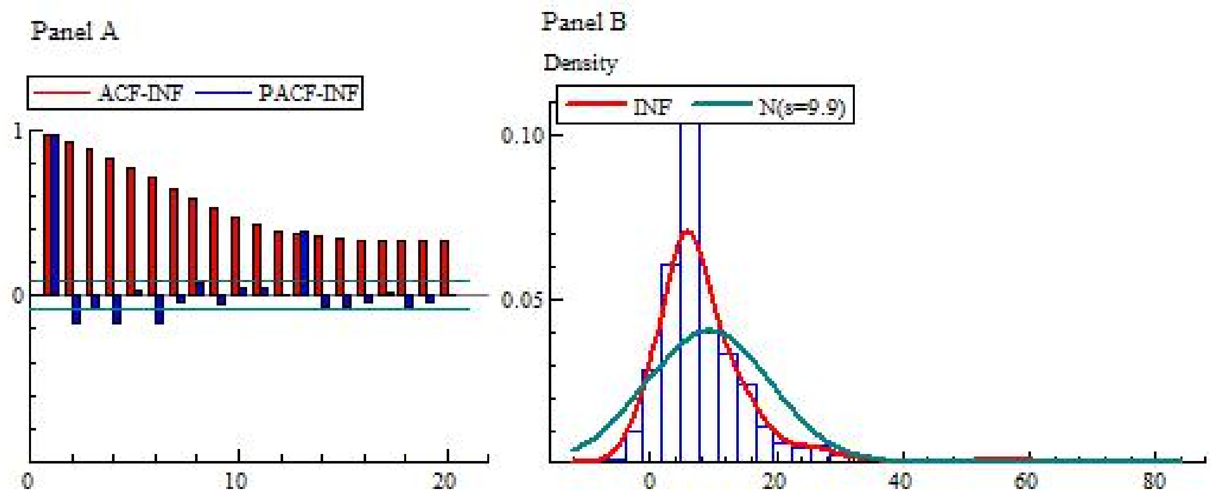
	(0.0000)	(0.0000)	(0.000))	(0.000)	(0.0000)

Source: International Monetary Fund (IMF) Database, *Authors' estimates using OxMetrics 6*

Notes: μ denote the mean, and **σ** indicates the standard deviation. **Kur** and **EK** are the estimated excess kurtosis and skewness respectively. **JB** indicates the Jarque Bera test for normality. Q_5 and Q_5^2 denotes the 5th oder Ljung-Box test for serial correlation in the deviation and squared deviation in the inflation series from its sample means. The LM denotes the Engle test for ARCH effects. Numbers in parenthesis denotes the P-values.

In Figure1, a plot of the autocorrelation function (20 lags) of the inflation series suggests the presence of autocorrelation. Notably, the autocorrelation of the inflation series exhibits a clear pattern of slow and decay persistence. Again, in Panel B, the distribution of the inflation series indicates a pattern of non-normal. Thus, implying that it would be appropriate to estimate the GARCH model using a non-normal distribution (see Lambert and Laurent, 2000; Peters, 2001).

Figure 1. Graphical Analysis of the Inflation Series



Source: International Monetary Fund (IMF) Database, *Authors' estimates using OxMetrics 6*

Note: In Panel A, the green dotted line displays the confidence band. In panel, B above the green line shows the normal reference distribution of the inflation series. The red line indicates the actual distribution of the inflation series while the histogram describes the extreme value in the inflation series.

Table 2 reports the unit root test for the inflation series over the full sample. Both the Augmented Dicky Fuller (henceforth ADF), and the Phillips Perron (henceforth PP) test reject the null hypothesis of the presence of unit root. The significant of the ADF and the PP test signifies that the inflation series is stationary or integrated of order zero, or I (0). Similarly, both the Zivot and Andrews (1993) (henceforth ZA) and Lee and Strazicich (2004) (henceforth LS) revealed the presence of a structural break in the inflation series. Notably, the breakpoint in February 1987 and December 1978 for the ZA and LS unit root test respectively coincides with the implementation of the Economic Reform program. The result of the ZA and LS implies that the inflation series has no presence of unit root over the sample period 1970:01-2017:05 and hence the inflation series can be modelled using a GARCH model.

Table 2. Unit Root Test of the Oder of Integration of the Inflation Series

INF	Statistic	Critical value @95%	P-value	Time Break

Augmented Dickey-Fuller (1979)	-3.735591**		(0.0208)
Phillips and Perron (1988)	-4.000645***		(0.0092)
Zivot and Andrews (1992)	-6.1521**	[5.80]	1987 M02
Lee and Strazicich (2004)	-5.965951**	[-4.037351]	1987M12

Source: International Monetary Fund (IMF) Database, *Authors' estimates using Eviews 9*
Notes: (1) The ADF statistics were generated from a random walk model with drift and trend. (2) The PP test used the Newey–West automatic bandwidth selection technique. (3) the numbers in parenthesis (*) denotes the P-values of ADF and PP unit root test while the numbers in parenthesis [*] denotes critical values of the ZA and LS unit root test. ** denotes rejection of the unit root hypothesis at the 5% level. *** P < 0.01 ** P< 0.05, *P<0.1.

The next step involves testing whether the inflation volatility responds asymmetrically to changes in the inflation rate. Table 3 reports the Engle and Ng (2003) sign bias test (henceforth SBT), negative sign bias test (henceforth NSBT), positive bias test (henceforth PSBT), and the joint test (henceforth JT) of the residual variance from a univariate GARCH (1,1) model.

Table 3. Engle and Ng (1993) Tests for Sign and Size Bias in Variance

	SBT	NSBT	PSBT	JT
GARCH (1,1)	1.40571	2.26223**	1.80693*	8.50657**
	(0.15981)	(0.02368)	(0.07077)	(0.03662)

Source: International Monetary Fund (IMF) Database, *Authors' estimates using GARCH package in OxMetrics 6*
Note: the GARCH (1,1) was estimated using the Skewed Student distribution. The asterisk denotes *** P < 0.01, ** P< 0.05, *P<0.1.

The results illustrate evidence against the null hypothesis of symmetric from the PSBT, NSBT and the joint test. The result is somewhat surprising for non-significance of the SBT although as Engle and Ng (1993) noted, the JT is more powerful than the individual test (see Harris and Sollis, 2003 p.236), hence indicating rejection of the symmetric GARCH (1,1) model and implying that an asymmetric GARCH model is adequate to model the inflation series. Tables 4 report the results of the asymmetric GARCH model.

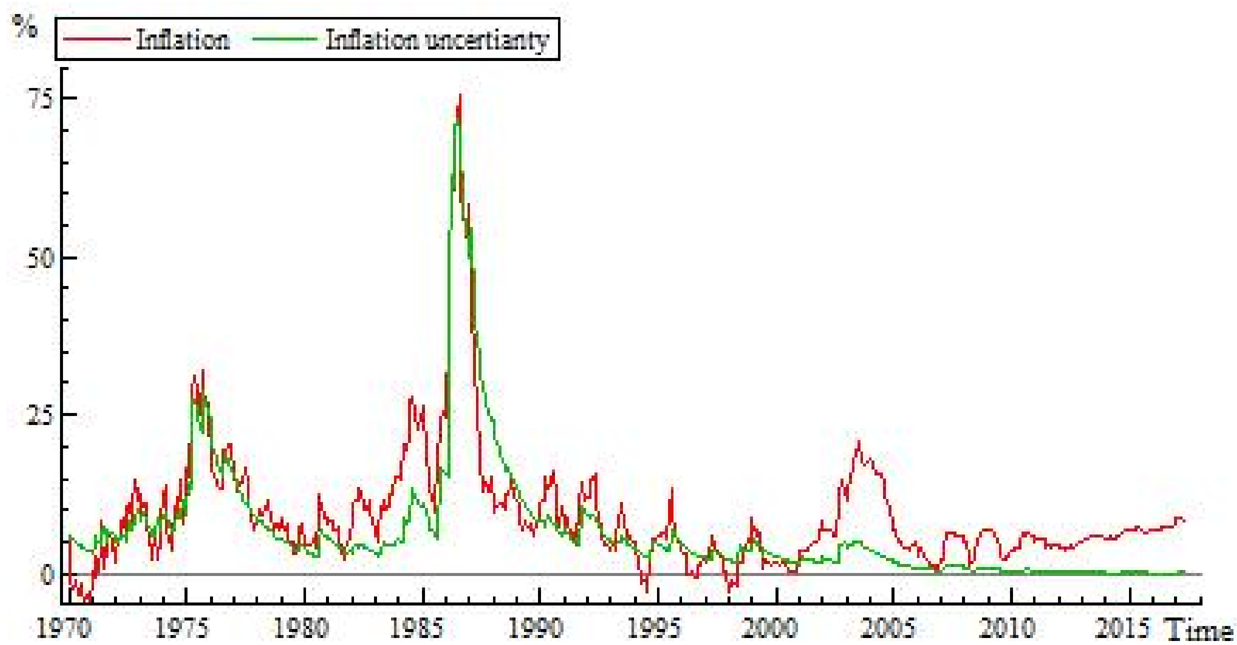
Table 4. AR(2)-GJR[GARCH] (1,1) Model for Inflation Series 1970:01-2017:05

Variables	Coefficients	Probability
Constant (M) ω	8.376507 ***	(0.0000)
INF_{t-1}	1.100227***	(0.0000)
INF_{t-2}	-0.126004**	(0.0338)
Constant (V) ω	-0.000239	(0.8189)
α	0.134388***	(0.0042)
β	0.951883***	(0.0000)
γ	-0.174243***	(0.0007)
Asymmetry	0.106767**	(0.0361)
Tail	3.341124***	(0.0000)
Information Criteria		
Akaike 3.587184	Shibata 3.586694	
Schwarz 3.655892	Hannan-Quin 3.613994	
Diagnostics Test		
$Q(5)$	2.17568 [0.5367549]	
RBD_{HET}	1.79287 [0.4080226]	

Source: International Monetary Fund (IMF) Database, *Authors' estimates using GARCH package in OxMetrics 6*
Notes: the student-t distribution was used when estimating AR(2)-GJR[GARCH] (1,1). The asterisk denotes *** P < 0.01, ** P< 0.05, *P<0.1.

In Table 4 both the Ljung-box test and residual based diagnostic test (RBD) of Tse (2000) indicates no evidence of autocorrelation and heteroscedasticity respectively, indicating that the AR (2)-GJR [GARCH] (1,1) model is free from model misspecification. The negative value of gamma as expected implies that negative inflation shock (good news) reduce inflation uncertainty. The results are meaningful since unpredictable fall in inflation produces less uncertainty than an unpredictable rise in inflation (see Giordani and Söderlind, 2003; Lahiri and Liu, 2006). One explanation may be that during the periods of unexpectable high inflation, people are uncertain about whether or not the monetary authorities will adopt a disinflationary policy at the potential cost of higher unemployment or lower growth rate of output a statement repeatedly argued by Ball (1992). Figure 2 plots the inflation series and its corresponding conditional variance (inflation uncertainty).

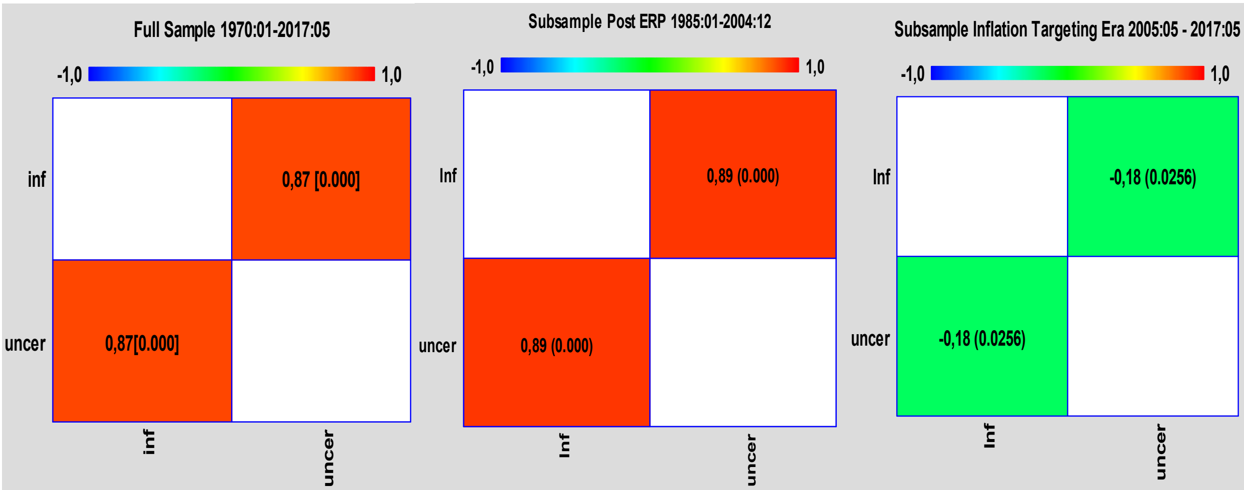
Figure 2. Inflation and Inflation Uncertainty in The Gambia



Source: International Monetary Fund (IMF) Database, *Authors' estimates using OxMetrics 6*

In Figure 2 based on the graphical analysis, inflation uncertainty tends to be high during the high inflationary period. Notably, both inflation and inflation uncertainty reached its peak in 1987. However, over the long-term horizon, the relationship becomes weaker especially during the inflation-targeting era from 2005 onwards. Thus, indicating variability between inflation and inflation uncertainty, reflecting structural changes within The Gambian economy. Furthermore, Figure 3 shows the Pearson product moment correlation ranging from -1 to +1 and measures the strength and significance of the linear relationship of between inflation and inflation uncertainty in The Gambia.

Figure 3. The Pearson moment Correlation between Inflation and Inflation across Difference Subsample



Source: International Monetary Fund (IMF) Database, *Authors' estimates using Star graphic Centurion Note the numbers in parenthesis (*) indicate p-values*

In Figure 3 above, evidently, all the p-values are below 0.05 indicating a statistical significant non-zero correlation between inflation and inflation uncertainty at the 95% confidence level. Notably, the results of the Pearson correlation are mixed and differ for each sub-sample. The results indicate an 87% positive correlation during the full sample, 89% positive correlation during the post economy recovery programme, and finally 18% negative correlation during the inflation-targeting era. Moreover, during the inflation targeting era, The Gambian inflation has been relatively stable, and there is no obvious positive relationship between inflation and inflation uncertainty from 2005-2017 reflecting the commitment of The Gambian Central bank to stabilizing inflation. Thus, given these vacillating scenarios between the correlation coefficients of inflation and inflation uncertainty across different samples, Table 5 reports the results of the Toda-Yamamoto causality between inflation and inflation uncertainty in The Gambia.

Table 5. Toda Yamamoto Causality Test of Inflation and Inflation-Uncertainty Hypothesis

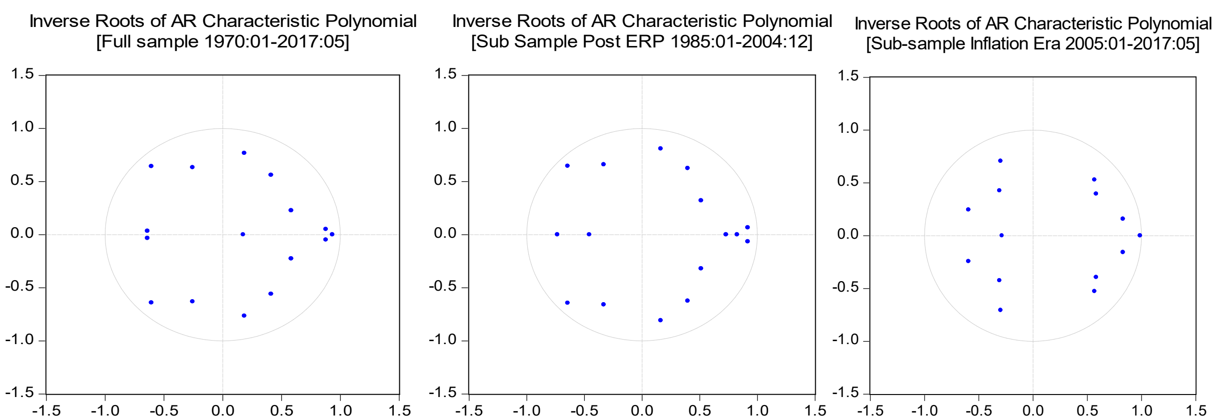
	Friedman Ball Hypothesis		Cukierman-Meltzer Hypothesis	
	H_0 Inflation does not granger cause Inflation uncertainty		H_0 Inflation uncertainty does not granger cause inflation	
Tests	MWALD Statistic	P-Value	MWALD statistic	P-Value
Full sample 1970:01-2017:05	695.8166***	(0.0000)	54.68250***	(0.0000)
Sub Sample Post ERP 1985:01-2004:12	287.8422***	(0.0000)	29.63281***	(0.0000)
Sub-sample Inflation Targeting Era 2005:01-2017:05	337.575***	(0.0000)	9.854963	(0.1969)

Source: International Monetary Fund (IMF) Database, *Authors' estimates using Eviews 9*

Note: the optimal lag length $(k+1)$ is based on the AIC. The optimal lag length is 8 for the full sample and ERP sample, while optimal lag length is 7 for the inflation targeting era. $dmax =\ 0$ since all the variables are integrated at order I (0) although the unit root for the conditional variable is not reported. The asterisk denotes *** P < 0.01, ** P< 0.05, *P<0.1.

The results in Table 5 are quite impressive. Firstly, the results of the full sample (1970:01-2017:05) indicate strong evidence of bi-directional causality between inflation and inflation uncertainty. The findings are consistent with Hegerty (2012) who concludes the existence of both the Friedman and Cukierman hypothesis in The Gambia. Secondly, during the post-Economic Reform Program (1985:01-2004:12) the results indicate a bidirectional causality between inflation and inflation uncertainty, again in favor of both Friedman and Cukierman hypothesis corresponding to the period in which The Gambia experience an economic crisis coupled with an over expansion in the public sector. Finally, during the inflation-targeting era, the results indicate a unidirectional causality is running from inflation to inflation uncertainty supporting the Friedman-Ball hypothesis. The results support the finding of Taş (2012) that inflation uncertainty is lower after the adoption of the inflation targeting in developing and emerging economies. In addition, the roots of the polynomial presented in Figure 4 below reveals that no root lies outside the unit circle, indicating that the estimated Toda Yamamoto models satisfies the stability conditions.

Figure 4. Inverse Root Polynomial of the Estimated Toda Yamamoto Causality Models



Source: International Monetary Fund (IMF) Database, *Authors' estimates using Eviews 9*

5. CONCLUSIONS

This paper examines the relationship between inflation and inflation uncertainty in The Gambia using monthly inflation series from 1970:01-2017:05. The GJR GARCH model was estimated to obtain the conditional variance inflation that is the inflation uncertainty, in The Gambia. The paper then applied the Pearson moment correlation to test the relationship between inflation and inflation uncertainty and the results indicated variability in sign and magnitude across the full sample, the post Economy Reform Program (ERP) and the Inflation Targeting Era (ITE) from 2005 onwards. The Toda Yamamoto (1995) Granger causality was adopted to test the competing hypothesis between inflation and inflation uncertainty accounting for the structural changes within The Gambian economy. The findings suggest that an increase in inflation raises inflation uncertainty, confirming the theoretical prediction made by Friedman (1977) and Ball (1992) for the full sample and subsamples. In contrast, the study finds weak evidence to confirm the effect of inflation uncertainty on inflation as suggested by Cukierman and Meltzer (1986) and Holland (1995) during the inflation-targeting era. The results provide evidence for both empirical and policy implications for the Central bank. Firstly, the findings provide additional insights into the dynamic relationship between inflation and inflation uncertainty. Finally, the results provide policy implications for The Gambia to adopt inflation targeting explicitly.

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