Inflation Rates and Inflation Uncertainty in Africa: A Quantile Regression Approach

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Abstract
Inflation and its associated uncertainty impose costs on real economic output in every economy. In developing economies, this welfare cost is higher than those obtainable in developed countries because inflation rate is still higher than desired, mostly double-digit in Africa. In contrast to conventional conditional mean approaches, this study employed quantile regressions and cross-sectional data from 44 African countries for the period 1986 to 2015 to examine the relationship between the level of inflation and inflation uncertainty. This study considers two measures of inflation – Inflation rate and mean inflation, and three different measures of inflation uncertainty – standard deviation, relative variation and median deviation of the inflation rate. The study found evidence of positive and significant association between inflation and its uncertainty across quantiles. It also found that higher inflation brings about more inflation variability, thereby supporting the Friedman-Ball hypothesis and on the other hand high inflation uncertainty prompts rises in inflation, confirming the Cukierman-Meltzer hypothesis. The study therefore recommend that policy makers should target low average inflation rates in order to reduce the negative consequences of inflation uncertainty, which in turn can improve economic performance in Africa.
Keywords: Inflation, Inflation Uncertainty, Inflation Targeting, Quantile Regression

1. Introduction

Inflation is considered to be a major economic problem all over the world; therefore, the central banks devote a significant amount of resources at their disposal to fight it. Hence, the primary objective of monetary policy is to ensure price stability. The focus by most central banks on price stability derived from the overwhelming empirical evidence that it is only in the midst of price stability that sustainable growth can be achieved. Price stability however does not connote constant price level, but it simply means that the rate of change of the general price level is such that economic agents do not worry about it. Thus inflationary conditions imply that general price level keeps increasing over time.

The policy makers are so obsessed about inflation because of its implication on the economy. Low and stable inflation rates allow the private sector to plan for the future which leads to a lower need for costly price adjustments, prevent tax distortion and thus create a stable business environment. On the other side, high and unstable inflation, discourages long term planning, reduces savings and capital accumulation, reduces investment, brings about shift in the distribution of real income and consequent misallocation of resources and creates uncertainty and distortions in the economy (Friedman, 1977; Dotsey and Ireland, 1996; Lucas, 2003). Therefore, inflation rate serves as the nominal anchor on which the central banks rely to maintain price stability. However, in managing the inflation rate in an economy, information on the link between inflation and its uncertainty play an important role (Elder, 2004; Fountas et al., 2006; Chowdhury, 2014).

Accordng to Tsyplakov (2010), a paramount question of the monetary theory is whether the inflation rates are positively correlated with uncertainty about the future price level and whether a causal link exists between inflation and inflation uncertainty. Hence, the direction of the relationship between inflation rates and its uncertainty has become the focus of theoretical and empirical investigations. Based on the hypothesis that higher inflation is related to greater inflation uncertainty put forward by Arthur M. Okun, Friedman (1977) and Ball (1992) provided intuitive and formal arguments that show a positive influence of higher inflation on the uncertainty about inflation. The main thrust of their argument hinges on the uncertainty on the part of agents in an economy trying to gauge the preferences of monetary policy makers toward inflation and the policy responses to rising rate of inflation (Sintim-Aboagye and Byekwaso, 2005). Cukierman and Meltzer (1986) on the other hand present a theoretical proposition based on Barro-Gordon set up (Barro and Gordon, 1983) and show that an increase in uncertainty about money growth and inflation will increase the optimal average inflation rate because it provides an incentive to the policymaker to create an inflation surprise in order to stimulate output growth.

Other theoretical explanation of the inflation and inflation uncertainty link is provided by Pourgerami-Maskus and Holland Hypotheses, which reject the harmful effect high inflation has on predictability of prices such that negative relation between inflation and inflation uncertainty thus exist, by these hypotheses. In contrast to Friedman (1977) and Ball (1992), Pourgerami and Maskus (1987) predicts that an increase in inflation may be associated with lower average uncertainty, since agents invest more resources in forecasting inflation. Similarly, Holland (1995) asserts that an increase in inflation uncertainty can bring a reduction in inflation rate as an outcome of the stabilization policy pursued in times of greater inflation uncertainty. In the so-called “stabilizing Fed hypothesis”, Holland assumes that stabilization tendencies of central bank increase in high inflation periods in order to reduce the welfare costs of disinflationary policies when inflation uncertainty is high (Javed, Khan, Haider and Shaheen, 2012; Barimah and Amuakwa-Mensah, n.d).

Inflation and its associated uncertainty impose costs on real economic output in every economy. In developing economies, this welfare cost is higher than those obtainable in developed countries because inflation rate is still higher than desired, especially in Africa where inflation rates is often double-digit. Thus, there is need for policy makers in African region to understand the major channels through which inflation affects the real economy so as to reduce the detrimental economic consequences and welfare costs of rise in the inflation rate. According Chowdhury (2011), one of such channel comes from the effects that higher inflation has on inflation uncertainty. Hence, this study exist to investigate inflation – inflation uncertainty relationship for African economies.

A significant amount of research has been conducted in developed countries and emerging economies to establish these hypotheses and mixed results are reported: among the most recent papers are those by Yeh, Wang and Suen (2009), Tsyplakov (2010), Javed, Khan, Haider and Shaheen (2012), Hegerty (2012), Nasr, Ajmi, Gupta and Eyden (2014), Falahi and Hajamini (2015), Bamanga, Musa, Salihu, Udoette, Adejo, Edem, Bukar and Udechukwu-peterclaver (2016). These studies found the evidence supporting Friedman and Ball hypothesis using variant of Generalized Autoregressive Conditional Heteroskedasticity (GARCH), except Tsyplakov (2010) and Nasr, Ajmi, Gupta and Eyden (2014) who employs Vector Autoregression with timevarying parameters and Gaussian Markov switching vector autoregressive framework respectively.

Using quantile regression, Fang, Miller and Yeh (2007) finds support for both Friedman - Ball and Cukierman - Meltzer hypotheses and some other studies confirm the result employing GARCH framework (Fountas, Karanasos and Karanassou, 2000; Sintim-Aboagye and Byekwaso, 2005; Barimah and Amuakwa (n.d.); Chowdhury, 2011; Otenga-Abayie and Doe, 2013; Sharaf, 2015). Testing Cukierman – Meltzer hypothesis, Hachicha and Lean (2013) confirms the hypothesis for Tunisia while Grier et al. (2004) using GARCH model on US data and Thornton (2007) study on Israel, Mexico, Colombia and Turkey data, fail to support Cukierman – Meltzer hypothesis but report that inflation uncertainty affects inflation rate negatively thus provide evidence for Holland hypothesis.

In contrast to time-series tests in individual countries, this study applies quantile regressions to the unconditional inflation and inflation uncertainty relationships for a cross-section of 44 African countries over 1986 to 2015. This study is different from the previous studies in two regards. First, almost all studies (except Fang, Miller and Yeh, 2007 and Yeh, Wang and Suen, 2009) on the relationship between inflation and its uncertainty use GARCH type models, variants of VAR specification, Pearson product-moment correlations or ordinary least squares (OLS) regression analysis, to determine the mean effects of inflation variables via the conditional mean regression. These methods only provide summary statistics for measuring the impact of covariates without characterizing the full distributional impact of inflation. In contrast, this paper applies the quantile regression introduced by Koenker and Bassett (1978), to examine the validity of the Friedman-Ball and Cukierman – Meltzer hypotheses across different quantiles of the unconditional inflation uncertainty distribution.

Contrary to Fang et al. (2007) that applies quantile regression method to examine two-way causality between inflation and measures inflation uncertainty for 152 countries of both developed and developing economies from 1993 to 2003, this study focuses on sample of 44 African countries over 1986 to 2015, since, a larger sample size can minimize the chances of spurious results from relatively few observations. The empirical study that focuses on African economies is important following the debate on whether implementation of inflation targeting would help in improving its macroeconomic performance. Hence, the hypotheses which stipulate that rapid price increases lead to rise in inflation uncertainty and/or its reversal effect need to be investigated. Since quantile regression has become an ever more important instrument in estimating quantile-specific effects that describe the impact of variables not only on the center but also on the tails of the outcome distribution, the study provide new empirical insight to inflation-inflation uncertainty nexus in Africa.

Second, the study considered a measure of inflation – the mean inflation and three different measures of inflation uncertainty – the standard deviation, relative variation, median deviation to examine the robustness of the relationship between inflation and its volatility.

The paper is structured as follows: the next section describes quantile regression framework and section 3 presents data and method employs in this study. Section 4 provides estimation and analysis of the results; while section 5 concludes the study and offer policy implications.

2. QUANTILE REGRESSION

Quantile regression as introduced in Koenker and Bassett (1978) is an extension of classical least squares estimation of conditional mean models to the estimation of the whole conditional distribution of response variable (see Koenker, 2005, for a more recent treatment).

Given the data $(y_t, \mathbf{x}_t')'$ for t = 1, . . . , T, where $\mathbf{x}_t$ is k × 1, consider the following linear specification for the conditional quantiles of y:

$$y_t = \mathbf{x}_t'\boldsymbol{\beta} + e_t \qquad (1)$$

where y_t is the dependent variable and $\mathbf{x}_t$ is a vector of explanatory variables. Our primary objective is to estimate **β** for different conditional quantile functions. Assuming that the specification above is correct, we will be able to depict the conditional distribution in detail when more quantile regressions are estimated. Moreover, the conditional distribution would be skewed to the left if the upper quantile lines are close to each other, relative to the lower quantile lines. It has been found in many applications that the estimated quantile regressions are quite different across quantiles. This suggests that regressors may have distinct impacts on the dependent variable at different locations of the conditional distribution (Kuan, 2007).

While the formulation of the quantile regression model is analogous to the conventional mean regression model, important differences arise in model estimation. The essential feature of a regression analysis is to examine the manner in which a set of explanatory variables affects the conditional distribution of a dependent variable. In the classical econometric techniques (Ordinary Least Squares, Instrumental Variable and Generalized Least Squares), the component around which the dependent variable randomly fluctuates is the conditional mean E[y/**x**, β]. However, unlike the classical approach, which amounts to estimating the conditional mean of the conditional distribution of y, the quantile estimator is employed on different quantiles of the conditional distribution.

As described by Koenker and Bassett (1978), the estimation of **β** is done by minimizing equation (2);

$$\hat{\beta}_\tau = min_{\beta \epsilon \Re} k \, [\tau \textstyle\sum_{yt \geq xt\beta} | y_t - \boldsymbol{x}_t'\boldsymbol{\beta} | \; + \; (1-\tau) \textstyle\sum_{yt < xt\beta} | y_t - \boldsymbol{x}_t'\boldsymbol{\beta} | \qquad (2)$$

The quantile function is a weighted sum of the absolute values of the residuals. Where the weights are symmetric for the median regression case in τ = ½, the minimization problem above reduces to $min_{\beta \epsilon \Re}$ k $\sum_{t=1}^{T} |(y_t - x_t'\boldsymbol{\beta})|$ and asymmetric otherwise. It thus can be observed that varying the parameter τ on the [0,1] interval will generate the entire conditional distribution of inflation rates and/or inflation uncertainty series. The coefficient $\beta_i(\tau)$ can then be interpreted as the marginal impact on the τ^{th} conditional quantile due to a marginal change in the i^{th} policy variable.

The quantile regression approach makes it possible to identify the effects of the covariates at different points on the conditional distribution of the dependent variable. For example, if the dependent variable is the inflation rate and suppose τ =0.05, i.e countries that are in the left tail of the conditional distribution of inflation rate (low-inflation countries) and τ =.95, that is, countries that are in the upper tail of the conditional distribution of inflation rate (high-inflation countries). Under traditional mean regression methods the slope coefficient is constrained to be the same for all quantiles, as such there is insufficient information on how policy variables affect countries differently. Mello and Novo (2002) construed that the ability to distinguish the effects of policy variables among different quantiles is important empirically.

3. DATA AND METHOD (WITH MODEL SPECIFICATION)

Following Fang, Miller and Yeh (2007), the study estimate the following linear quantile regression models specified as;

$$infunc_i = \alpha_\tau + \beta_\tau inf_i + \varepsilon_{\tau i} \text{ (Friedman-Ball Regression Model)} \quad (3)$$

$$inf_i = \mu_\tau + \delta_\tau infunc_i + \epsilon_{\tau i} \text{ (Cukierman-Meltzer Regression Model)} \quad (4)$$

where $infunc_i$ equals the measure of the inflation uncertainty of country i and inf_i equals the measure of the inflation rate of country i; α_τ, β_τ, μ_τ and δ_τ equal parameters to be estimated for different values of τ, and, $\varepsilon_{\tau i}$ and $\epsilon_{\tau i}$ are the random error terms. By varying from 0 to 1, the study can trace the entire distribution of inflation uncertainty (or inflation), conditional on inflation (or inflation uncertainty). Friedman and Ball predict that $\beta_\tau > 0$ and Cukierman and Meltzer, that $\delta_\tau > 0$.

Using quantile regressions and cross-sectional data from 44 African countries over the period 1986 to 2015, the study examines the relationship between inflation and its uncertainty. For reason discuss in section two, the quantile regression is employed because it has the appealing feature that allows for estimation of family of unconditional quantile function which provides a more complete picture of covariate effects. This study considers two measures of inflation – Inflation rate (equals the annual rate calculated as the percentage change in the logarithm of consumer price index) and mean inflation (average inflation for sample countries) and three different measures of inflation uncertainty – standard deviation (uncertainty1), relative variation (uncertainty2) and median deviation (uncertainty3) of the inflation rate. The relative variation is defined as standard deviation of inflation divided by one plus the mean of inflation as suggested by Davis and Kanago (1992).

4. EMPIRICAL RESULTS

Table 1 shows the summary statistics as well as statistics for the seven countries with the highest and lowest means and standard deviations of the inflation rates. It reveals that both the mean and the median exhibit highly right-skewed distributions with outliers, as evidenced by a larger mean than the median. Therefore, the data features provide justification for the use of quantile regression since the departures from normality with skewed tails is evident.

Table 1: Summary of Statistics

Panel A: Descriptive Statistics							
Variable	**Mean**	**Median**	**Standard Deviation**	**Minimum**	**Maximum**	**Skewness**	**Ex. kurtosis**
Mean Inflation	11.8540	8.5726	10.3679	1.9252	38.0161	1.4315	0.7447
uncertainty1	13.8761	8.4917	11.8336	3.0548	51.4331	1.5239	1.3867
uncertainty2	0.8493	0.7529	0.4154	0.1182	2.0270	0.7221	-0.0040
uncertainty3	8.9876	5.4168	7.4866	2.1306	31.0264	1.5166	1.1733
Panel B: Seven Countries with Lowest Mean Inflation							
	Zimbabwe	Morocco	Burkina Faso	Niger	Cabo Verde	Senegal	Comoros
Mean Inflation	**1.9252**	**3.1766**	**3.2342**	**3.7017**	**3.7437**	**3.9009**	**4.2650**
uncertainty1	15.2802	3.2007	4.3647	6.7245	11.2786	6.3903	4.3010
uncertainty2	0.1182	0.7562	0.6028	0.4792	0.3049	0.5278	0.8045
uncertainty3	7.8487	2.6456	3.3173	4.1196	6.3969	3.7486	3.0020
Panel C: Seven Countries with Highest Mean Inflation							
	Mozambique	Guinea-Bissau	Ghana	Sierra Leone	Uganda	Zambia	Sudan
Mean Inflation	24.8574	29.6434	30.5316	34.4258	35.6427	37.4695	38.0161
uncertainty1	34.2901	33.9557	22.6779	38.1626	51.4331	40.5662	36.5373
uncertainty2	0.7043	0.8480	1.2894	0.8790	0.6797	0.9014	1.0127
uncertainty	18.5754	26.3537	13.7001	25.0003	31.0263	25.2893	24.0121

y3							
Panel D: Seven Countries with Lowest Standard Deviation Inflation (uncertainty1)							
	Mauritius	Morocco	Tunisia	South Africa	Comoros	Burkina Faso	Cameroon
Mean Inflation	6.6640	3.1766	5.6308	10.4028	4.0650	3.2342	4.4218
uncertainty1	3.0548	3.2007	3.3503	4.1319	4.3010	4.3647	5.1242
uncertainty2	1.6435	0.7562	1.2943	2.0270	0.8045	0.6028	0.7220
uncertainty3	2.4190	2.6456	2.1306	3.4721	3.0020	3.3173	3.2344
Panel E: Seven Countries with Highest Standard Deviation Inflation (uncertainty1)							
	Nigeria	Guinea Bissau	Mozambique	Sudan	Sierra Leone	Zambia	Uganda
Mean Inflation	23.0215	29.6434	24.8574	38.0161	34.4258	37.4695	35.6427
uncertainty1	27.9286	33.9557	34.2901	36.5373	38.1626	40.5662	51.4331
uncertainty2	0.7958	0.8480	0.7043	1.0127	0.8790	0.9014	0.6797
uncertainty3	17.6585	26.3537	18.5754	24.0121	25.0003	25.2893	31.0263
Panel F: Seven Countries with Lowest Relative Variation of Inflation (uncertainty2)							
	Zimbabwe	Cabo Verde	Congo Republic	Gabon	Chad	Equatorial Guinea	Cote d'Ivoire
Mean Inflation	1.9252	3.7437	6.4406	5.5432	5.0423	10.6279	4.5894
uncertainty1	15.2802	11.2786	16.2972	13.2096	11.3589	23.1481	8.6662
uncertainty2	0.1182	0.3049	0.3723	0.3901	0.4079	0.4401	0.4747
uncertainty3	7.8487	6.3969	12.4908	9.7489	7.8894	17.6289	4.6133
Panel G: Seven Countries with Highest Relative Variation of Inflation (uncertainty2)							
	Madagascar	Lesotho	Botswana	Egypt	Namibia	Mauritius	South Africa

Mean Inflation	14.2862	9.1943	9.3729	10.4731	9.8426	6.6640	10.4028
uncertainty1	9.6014	5.7108	5.8168	6.0250	5.2947	3.0548	4.1319
uncertainty2	1.3475	1.3700	1.3749	1.4908	1.5636	1.6435	2.0270
uncertainty3	6.3262	4.3426	4.6131	4.2582	3.9855	2.4190	3.4721
Panel H: Seven Countries with Lowest Median Deviation Inflation (uncertainty3)							
	Tunisia	Mauritius	Morocco	Comoros	Cameroon	Burkina Faso	South Africa
Mean Inflation	5.6308	6.6640	3.1766	4.2650	4.4218	3.2342	10.4028
uncertainty1	3.3503	3.0548	3.2007	4.3010	5.1242	4.3647	4.1319
uncertainty2	1.2943	1.6435	0.7562	0.8045	0.7220	0.6028	2.0270
uncertainty3	2.1306	2.4190	2.6456	3.0020	3.2344	3.3173	3.4721
Panel I: Seven Countries with Highest Median Deviation Inflation (uncertainty3)							
	Nigeria	Mozambique	Sudan	Sierra Leone	Zambia	Guinea Bissau	Uganda
Mean Inflation	23.0215	24.8574	38.0161	34.4258	37.4695	29.6434	35.6427
uncertainty1	27.9286	34.2901	36.5373	38.1626	40.5662	33.9557	51.4331
uncertainty2	0.7958	0.7043	1.0127	0.8790	0.9014	0.8480	0.6797
uncertainty3	17.6585	18.5754	24.0121	25.0003	25.2893	26.3537	31.0263

From Table 1, the seven countries with the highest inflation rates (standard deviations) face higher standard deviations (inflation rates), while countries with the lowest inflation rates (standard deviations) face lower standard deviations (inflation rates). The descriptive statistics suggests that there is a positive correlation between inflation rate and inflation uncertainty. Countries such as Burkina Faso, Comoros, Cabo Verde, Morocco and Zimbabwe demonstrate that low inflation rate correlate with low inflation uncertainty. On the other hand, high inflation rate goes with high inflation volatility as evident with data from Guinea-Bissau, Mozambique, Sudan, Sierra Leone, Uganda and Zambia. Nevertheless, some countries such as Zimbabwe and

Niger with low inflation rate do not have corresponding low inflation volatility. Therefore, low-inflation countries may exhibit different patterns between inflation rate and its uncertainty from high-inflation countries.

Table 2: Mean and Standard Deviation of the Inflation Rate

Panel A	Friedman-Ball Regression Model, infunc = $\alpha + \beta\ inf_i + \varepsilon_i$					
Variable	OLS	0.05 Quantile	0.25 Quantile	0.50 Quantile	0.75 Quantile	0.95 Quantile
α	1.8882 [0.1475]	-2.6699[a] (-9.5163)	0.8803 (0.5812)	1.8755[a] (2.0296)	3.0149[a] (4.8526)	11.1308[a] (3.9975)
β	1.0112[a] [0.0000]	0.8302[a] (46.3717)	0.7139[a] (7.3862)	1.0325[a] (17.5115)	1.0821[a] (27.2950)	1.1307[a] (6.3637)
Panel B	Cukierman-Meltzer Regression Model, inf = $\alpha + \beta\ infunc_i + \epsilon_i$					
Variable	OLS	0.05 Quantile	0.25 Quantile	0.50 Quantile	0.75 Quantile	0.95 Quantile
α	1.0822 [0.3469]	-2.3170[a] (-4.2297)	-0.8864 (-0.9807)	0.2423 (0.1766)	4.1554[a] (3.8521)	6.6071[a] (5.6175)
β	0.7762[a] [0.0000]	0.7102[a] (14.2617)	0.8156[a] (10.7911)	0.8156[a] (10.7911)	0.8212[a] (13.8170)	0.9186[a] (14.1753)
[] – p-value, () – t-ratio; [a, b, c] significant at 1%, 5% and 10%						

Panel A in Table 2 reports the results of estimating the Friedman-Ball hypothesis. The OLS regression generates positive and significant coefficient of inflation at the 1% level. The five-quantile regression (τ = 0.05, 0.25, 0.50, 0.75 and 0.95,) estimates of inflation, conditional on inflation uncertainty, all prove positive and significant at the 1% level. These results support the Friedman-Ball hypothesis that inflation creates inflation uncertainty. Moreover, the quantile regression results illustrate that the marginal effect of inflation on inflation uncertainty increases as one moves from lower to higher inflation variability quantiles, except in 0.25 quantile where the marginal effect falls by 14 percent. That is, at higher inflation uncertainty quantiles, inflation exerts a larger effect on inflation uncertainty such countries as Uganda, Zambia and Sierra Leone. This evidence suggests that potential information gains associate with the estimation of the entire conditional distribution of inflation volatility, as opposed to the conditional mean only.

Panel B of Table 2 reports the results of estimating the Cukierman-Meltzer hypothesis. All estimates of inflation uncertainty show positive and significant at the 1% level. The marginal effects of inflation uncertainty on inflation rise significantly across quantiles for countries such as Sudan, Zambia and Uganda. Therefore, the findings surmise that higher quantiles in both cases lead to larger marginal effects of inflation (inflation uncertainty) on inflation uncertainty (inflation). Hence, using Mean and Standard Deviation of the Inflation rate, both Friedman-Ball hypothesis and Cukierman-Meltzer hypothesis are supported for African countries.

Table 3: Mean and Relative Variation of the Inflation Rate

Panel A	Friedman-Ball Regression Model, infunc = $\alpha + \beta\ inf_i + \varepsilon_i$					
Variable	OLS	0.05 Quantile	0.25 Quantile	0.50 Quantile	0.75 Quantile	0.95 Quantile
α	0.7350[a] [0.0000]	0.2609[a] (5.8683)	0.4329[a] (11.6192)	0.5713[a] (11.3946)	1.0260[a] (3.7442)	1.7423[a] (25.7072)
β	0.0096 [0.1155]	0.0117[a] (4.1422)	0.0125[a] (5.2587)	0.0097[a] (3.0470)	0.0086 (0.4932)	-0.0148[a] (-3.4296)
Panel B	Cukierman-Meltzer Regression Model, inf = $\alpha + \beta\ infunc_i + \epsilon_i$					
Variable	OLS	0.05 Quantile	0.25 Quantile	0.50 Quantile	0.75 Quantile	0.95 Quantile
α	6.7511[c] [0.0624]	1.2472 (1.3300)	2.2054[a] (2.9398)	2.9961[a] (3.2444)	8.8537[a] (4.9610)	30.7976[a] (3.8898)
β	6.0076 [0.1155]	3.2959[a] (3.3160)	4.0439[a] (5.0856)	5.0153[a] (5.1238)	4.0313[a] (2.1311)	7.1275 (0.8493)
[] – p-value, () – t-ratio; [a, b, c] significant at 1%, 5% and 10%						

Table 3 reports the OLS and quantile estimates for the Friedman-Ball and Cukierman-Meltzer hypotheses, using the mean and the relative measure of variation of the inflation rate. The result of ordinary least squares regressions is found to be positive but not statistically significant. The results of quantile regression reported in Panel A shows that at the 0.05th, 0.25th, and 0.75th quantiles, inflation has positive and significant effect on inflation uncertainty, although the coefficients is small in magnitude ranging from 0.0097 to 0.0125. similarly, Panel B shows that Inflation uncertainty positively affects the inflation rate significantly except at the 0.95th quantile, when the estimated coefficient is insignificant. It can also be observed that the inflation uncertainty progressively rises across quantiles up to the 0.5 quantile while the marginal effect falls by 20% in the 0.75 quartile. Thus, using relative variation as a measure of uncertainty, the study finds support for the Friedman-Ball and Cukierman-Meltzer hypotheses in the quantile specifications.

However, at the 0.95 quantile in Panel A, there is an evidence of negative association between inflation and inflation uncertainty as suggested by Pourgerami and Maskus (1987),that inflation rate gives a lower level of uncertainty using a model in which economic agents invest more resources in forecasting inflation as inflation rises, subsequently leading to lower nominal uncertainty. A formal analysis of this effect is presented Ungar and Ziberfarb (1993).

Table 4: Mean and Median Deviation of inflation

Panel A	Friedman-Ball Regression Model, infunc = $\alpha + \beta\ inf_i + \varepsilon_i$					
Variable	OLS	0.05 Quantile	0.25 Quantile	0.50 Quantile	0.75 Quantile	0.95 Quantile
α	1.3680[c] [0.0928]	-0.7307[a] (-15.0570)	0.6103 (0.6424)	1.2454[a] (2.5839)	1.9081[a] (15.0034)	8.4027[a] (2.6784)
β	0.6427[a] [0.0000]	0.4726[a] (152.6130)	0.4726[a] (7.7960)	0.6416[a] (20.8633)	0.6841[a] (84.2978)	0.6347[a] (3.1705)
Panel B	Cukierman-Meltzer Regression Model, inf = $\alpha + \beta\ infunc_i + \epsilon_i$					
Variable	OLS	0.05 Quantile	0.25 Quantile	0.50 Quantile	0.75 Quantile	0.95 Quantile
α	0.7747 [0.4981]	0.9127 (1.4587)	-0.8463[c] (-1.6785)	-0.3205 (-0.3338)	3.1042[c] (1.5897)	5.1398[a] (6.2195)
β	1.2327[a] [0.0000]	0.4425[a] (8.2348)	1.1569[a] (26.7142)	1.3218[a] (16.0282)	1.3588[a] (8.1020)	1.5157[a] (21.3552)
[] – p-value, () – t-ratio; [a, b, c] significant at 1%, 5% and 10%						

The OLS regressions results presented in Table 4 find a significant positive inflation-uncertainty relationship. Table 4 reports the estimates for the Friedman-Ball and Cukierman-Meltzer hypotheses, using the mean and median deviation of the inflation rate. Inflation rate significantly and increasingly affects the inflation uncertainty at each of the quantiles except at 0.95 quantile in Panel A, where the marginal impact of inflation reduces by 7%. Similarly, inflation uncertainty significantly and increasingly affects inflation rate at each of the quantiles. Therefore, the use of the mean and the median deviation produces a positive correlation, supporting the Friedman-Ball and Cukierman-Meltzer hypotheses and confirming the findings for the mean and standard deviation as well as the mean and the relative variation.

Table 5: Inflation rate and Inflation Uncertainty (Conditional Variance)

Panel A	Friedman-Ball Regression Model, infunc = $\alpha + \beta\ inf_i + \varepsilon_i$					
Variable	OLS	0.05 Quantile	0.25 Quantile	0.50 Quantile	0.75 Quantile	0.95 Quantile
α	8.8393[a] [0.0000]	1.4229[a] [0.0000]	3.5074[a] [0.0000]	6.1264[a] [0.0000]	10.8363[a] [0.0000]	29.8397[a] [0.0000]
β	0.5942[a] [0.0000]	0.1635[a] [0.0000]	0.2089[a] [0.0000]	0.3150[a] [0.0000]	0.4894[a] [0.0000]	1.0645[a] [0.0000]
Panel B	Cukierman-Meltzer Regression Model, inf = $\alpha + \beta\ infunc_i + \epsilon_i$					
Variable	OLS	0.05 Quantile	0.25 Quantile	0.50 Quantile	0.75 Quantile	0.95 Quantile
α	9.1167[a] [0.0000]	-4.1791[a] [0.0000]	2.3647[a] [0.0000]	4.6589[a] [0.0000]	6.3583[a] [0.0000]	11.1753[a] [0.0000]

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2017, Vol. 7, No. 11
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β	0.1730[a] [0.0000]	0.0106[c] [0.061]	0.0111[c] [0.072]	0.2497[a] [0.0000]	0.7211[a] [0.0000]	1.7567[a] [0.0000]
[] – p-value, () – t-ratio; [a, b, c] significant at 1%, 5% and 10%						

Unlike estimation results reported in Table 2-4 which was based on average series for both measures of inflation and inflation uncertainty, Table 5 reported the OLS and quantile estimates for the Friedman-Ball and Cukierman-Meltzer hypotheses, using 1496 observations of inflation rates and ARCH generated series for inflation uncertainty for the sample countries. The OLS regressions results find a significant positive inflation-uncertainty relationship. Positive correlation was confirmed for both Friedman-Ball and Cukierman-Meltzer hypotheses.

In Panel A, inflation increasingly affects inflation uncertainty at each of the quantiles steadily until at 0.95 quantile when the impact becomes more than 200 per cent of what the impact was at 0.75 quantile. Countries that might have this high positive impact of inflation rate on uncertainty are Uganda and Sierra Leone. Similarly in Panel B, at quantiles 0.5 through 0.95, the marginal impact of uncertainty on inflation increase successively by more than 240%. Whereas, the impact of inflation uncertainty on inflation rate is small and statistically insignificant at 5% level in quantile 0.05 and quantile 0.25, but it is significant at 10% level.

In sum, the finding shows that the effect of inflation on the inflation uncertainty is stronger for countries in the upper quantiles than for those in the lower quantiles, that is the inflation uncertainty incurs high costs for countries in the top quantiles. There is a feedback process between inflation and inflation uncertainty, such that the Friedman-Ball and Cukierman-Meltzer hypotheses hold simultaneously in sample Africa Countries. These findings is similar to the results reported on nine Africa countries in Hegerty (2012), Sharaf (2015) on Egypt, Barimah and Amuakwa-Mensah (n.d) and Albulescu, Twari, Miller and Gupta (2015) on U.S. data. Nevertheless,

5. Summary and Concluding Remark

Inflation and its associated uncertainty impose costs on real economic output in every economy. This welfare cost is higher in developing African economies, where inflation rate is mostly double digit. Hence, there is need for policy makers in African region to understand the major channels through which inflation affects the real economy so as to reduce the detrimental economic effects and welfare costs of rise in the inflation rate.

Therefore, the study employed quantile regressions and cross-sectional data from 44 African countries for the period 1986 to 2015 to examine the relationship between the level of inflation and inflation uncertainty. The main finding of the study is evidence in positive and significant association between inflation and its uncertainty across quantiles. It also found that higher inflation brings about more inflation variability, thereby supporting the Friedman-Ball hypothesis and on the other hand high inflation uncertainty prompts rises in inflation, supporting the Cukierman-Meltzer hypothesis.

These have important implications for the relationship between inflation and output given the substantial empirical evidence that higher inflation uncertainty is detrimental to economic growth as asserted in Sharaf (2015). The study therefore recommend that policy makers should target low average inflation rates in order to reduce the negative consequences of inflation uncertainty, which in turn can improve economic performance in Africa.

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Appendix

Country	Average Annual Inflation (%)	Standard Deviation of Inflation	Relative Variation of Inflation	Mean Deviation of Inflation
Algeria	12.13	12.22	0.917	8.823
Benin	4.444	6.851	0.566	3.714
Botswana	9.372	5.816	1.374[H]	4.613
Burkina Faso	3.234[L]	4.364[L]	0.602	3.317[L]
Burundi	10.62	9.251	1.036	6.852
Cabo Verde	3.743[L]	11.27	0.304[L]	6.396
Cameroon	4.421	5.124[L]	0.722	3.234[L]
Central African Rep.	4.889	8.306	0.525	5.253
Chad	5.042	11.35	0.407[L]	7.889
Comoros	4.265[L]	4.301[L]	0.804	3.002[L]
Congo Rep.	6.440	16.29	0.372[L]	12.49
Cote d'Ivoire	4.589	8.666	0.474[L]	4.613
Egypt	10.47	6.025	1.490[H]	4.258
Equatorial Guinea	10.62	23.14	0.440[L]	17.62
Ethiopia	8.464	10.61	0.728	8.175
Gabon	5.543	13.20	0.390[L]	9.748
Gambia, The	11.87	23.62	0.482	9.578
Ghana	30.53[H]	22.67	1.289	13.70
Guinea Bissau	29.64[H]	33.95[H]	0.848	26.35[H]
Kenya	10.69	7.799	1.215	4.876
Lesotho	9.194	5.710	1.370[H]	4.342
Liberia	4.342	7.217	0.528	5.104
Madagascar	14.28	9.601	1.347[H]	6.326
Malawi	21.39	16.09	1.251	10.72
Mali	4.746	7.931	0.531	4.834
Mauritania	8.631	8.169	0.941	5.247
Mauritius	6.664	3.054[L]	1.643[H]	2.419[L]
Morocco	3.176[L]	3.200[L]	0.756	2.645[L]
Mozambique	24.85[H]	34.29[H]	0.704	18.57[H]
Namibia	9.842	5.294	1.563[H]	3.985
Niger	3.701[L]	6.724	0.479	4.119
Nigeria	23.02	27.92[H]	0.795	17.65[H]

Rwanda	8.513	10.35	0.749	6.815
Senegal	3.900[L]	6.390	0.527	3.748
Seychelles	5.749	8.317	0.617	5.373
Sierra Leone	34.42[H]	38.16[H]	0.879	25.00[H]
South Africa	10.40	4.131[L]	2.027[H]	3.472[L]
Sudan	38.01[H]	36.53[H]	1.012	24.01[H]
Swaziland	10.26	8.206	1.114	5.460
Togo	4.721	7.690	0.543	4.774
Tunisia	5.630	3.350[L]	1.294	2.130[L]
Uganda	35.64[H]	51.43[H]	0.679	31.02[H]
Zambia	37.46[H]	40.56[H]	0.901	25.28[H]
Zimbabwe	1.925[L]	15.28	0.118[L]	7.848

H = High
L = Low