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THE CONNECTION BETWEEN INFLATION UNCERTAINTY AND INFLATION: HIGH OR HIGHER INFLATION RATE EVIDENCE FROM THE EGYPTIAN ECONOMY (2011-2018)

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ABSTRACT

Uncertainty is the situation in which something is not well known, so inflation uncertainty can be simply defined as proportional deviation of inflation rate from its expected rate; that is the something matter in inflation uncertainty is the difference between the mean rate of inflation rate and its current rate regardless how high it is. After 25th Jan revolution; inflation has been one of the most serious problems that face Egyptian economy, so the present study examines the relationship between inflation uncertainty and inflation in Egyptian economy from 2011M1 to 2018M12 using two-step procedure. At the first step, a monthly data GARCH model of inflation is estimated to obtain the conditional variance which in turn use as approximation of the inflation uncertainty. Then, the Granger causality tests between inflation series and the obtained conditional variance (inflation uncertainty) series are implemented. Empirical results of the study provided an evidence for the mutual interdependence between the two variables, that is, higher inflation rate above its mean rate will lead to high inflation uncertainty and vice versa, and in the same time stable high inflation rate leads to less sensitiveness of inflation uncertainty to increase in inflation rate. In some context this result modifies both Friedman-Ball hypothesis and Cukierman and Meltzer hypothesis that higher (not high) inflation rate affect and affected by inflation uncertainty.

Keywords: inflation , inflation uncertainty, Friedman-Ball hypothesis, Cukierman and Meltzer Hypothesis

1. INTRODUCTION

No doubt that high level inflation rates are harmful for all economies, but it's more harmful for developing countries because of the existence of poverty, unemployment and inefficient financial

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sector; which make the economic structure of developing economies is dissimilar than the developed ones. So, someone could say that inflation makes monetary policy more confusing in developing nations. Consequently many aspects of inflation have been extensively paid the attention of the economic thought such as the relationship between inflation and its uncertainty because of inflation uncertainty represents one of the costs of inflation. In other words, we should keep in mind the fact that expected inflation has a vital role to play in an economic decision, so; economists need to focus on the connection between inflation and inflation uncertainty which often refers to unpredictable volatility (see, Barnett et al (2018), Rosi et al (2016)).

Inflation uncertainty may affect economy through two ways:

First the ex-ante effect; at which inflation uncertainty causes firms and households to make economic decisions differ from the ones they would make in certainty, so it affects the decisions related to the future expected inflation. So, the ex-ante effect moves through three channels:

- First, inflation uncertainty affects financial markets by increasing long-term interest rates. That is; if inflation is uncertain, the real return on long term debt will be more risky. As a result, investors will require higher returns, which imply higher long-term real interest rates.

- Second, inflation uncertainty leads to uncertainty about other economic variables (such as exchange rate, wages etc). In other words; when the payments in a contract are not indexed to inflation, inflation uncertainty causes the real value of future payments to be uncertain.

- Finally, inflation uncertainty encourages firms to spend resources avoiding the associated risks. For example, when inflation uncertainty is high firms will spend more resources to improve their forecast about inflation, besides; some organizations will try to hedge against unexpected inflation using specialized financial derivatives. But both forecasting and hedging activities imply that resources are diverted from other more productive business purposes.

The second is ex post effect; at which effects takes place after the decisions have been made, these effects occur when inflation differs from what had been expected. For instance; when inflation is higher than forecast, the real value of nominal payments is lower than expected, implies a transfer of wealth from the lender to the borrower, and many economic agent will hurt by an unexpected increase in inflation.

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However it is broadly recognized that high inflation is harmful for economic activities, there are different points of view about the direction of relation between inflation and its uncertainty in economic literature. Thus, the purpose of the study is to examine the connection between inflation and inflation uncertainty in Egypt over the period 2011M1-2018M12. Following the studies in this topic such as Grier and Perry (1998) and Nas and Perry (2000), two-step methodology has been used where in the first step is the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models are estimated to generate an approximation measure of inflation uncertainty and in the second step Granger causality test has been carried out. After the economic reform in 1990-1991, Egypt has considered Inflation Targeting (IT) as a monetary policy main objective after 1991. So, the results of this study have some implications for Egyptian Inflation Targeting Policy as well as the literature which concentrating on the association between inflation and inflation uncertainly particularly in developing countries.

The paper proceeds as following plan. Section 2 tries to preview the different hypothesis which connecting inflation and inflation uncertainty. Section 3 previews the related empirical studies and its results. Section 4 presents data and the methodological issues. Section 5 prevents empirical results, conclusion and offering the some policy implications.

2. LITERATURE REVIEW

Inflation is defined as a continuous increase in the overall price level, while inflation uncertainty denotes to the situation at which future inflation are unpredictable and most people do not know whether inflation level will rise or fall in the future. In other words future inflation rate is highly unpredictable to the public.

Uncertainty about Inflation is both a cause and a result of inflation, its well- known that without uncertainty economic units could plan better for the future, that is, as (Rizvi and Naqvi, 2008, p. 2) noted, uncertainty about inflation is considered one of the main costs of inflation since it not only misleads the decisions about saving and investment due to lower certainty of the real value of future payments, but also it distorts the efficiency of resource allocation so the level of real activity. So there is a question about how inflation uncertainty interdepends with the economy?

(Golob, 1994) stated that, whenever anticipated inflation is an element in economic decision making, inflation uncertainty is also likely to be a factor. But, the connection between inflation and inflation uncertainty is doubtful and there are different points of view about the direction of their relation in economic literature.

Friedman (1977) and Ball (1990) provide the so called Friedman - Ball hypothesis which stated that inflation causes inflation uncertainty. While Cukierman and Mezler (1986), and Perry and

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Grier (1998) provide evidence in adverse direction, and support that the causality running from inflation uncertainty to inflation. At the same time, Pourgerami and Maskus (1987) and Ungar and Zilberfarb (1993) as well as Holland (1995) confirmed that there is a negative association between inflation and inflation uncertainty. Accordingly, the association between inflation and inflation uncertainty has received considerable attention in economic literature, and divided into two groups of hypothesis; positive association hypotheses and the negative association hypotheses. These are some of the possible channels by which the connection between inflation and inflation uncertainty could be illustrated. Consequently, the result of this study will determine which of the above hypothesis holds true for the case of Egypt.

2.1 The positive association hypotheses:

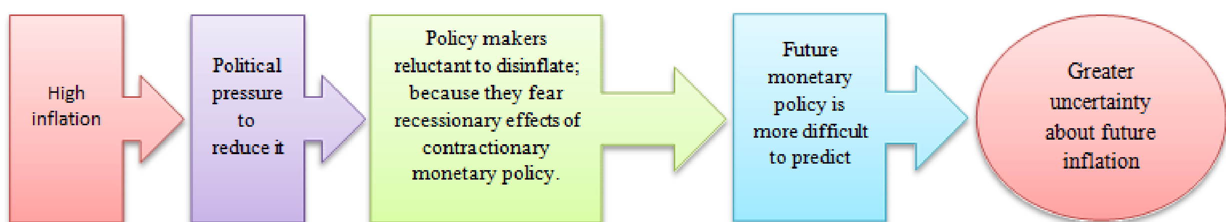
2.1.1 Friedman-Ball Hypothesis

The seminal work of Okun (1971) argued that inflation is positively connected with its standard deviation by using data of 17 OECD countries for the period from 1951 to 1968.

According to Okun there is a positive association between inflation and the variability of inflation the case at which monetary policy becomes more unpredictable in high inflation periods. So, Friedman (1977) outlined an argument about how an increase in inflation rate raises inflation variability in the case of unpredictable monetary policy that go together with inflationary periods. According to Friedman, high inflation rate makes a political pressure to reduce it; however policymakers may be reluctant to reduce inflation because they don't want the recessionary effects of contractionary monetary policy. Hence, the future monetary policy will be difficult to predict in high inflation periods, in other words, higher inflation results in larger uncertainty about future inflation.

In other words, Friedman (1977) stated that an increase in inflation rate may make an unpredictable policy response by monetary authorities and therefore, lead to more uncertainty about the future inflation rate. So his argument could be illustrated in this way:

Figure 1: Illustration of Friedman-Ball Hypothesis



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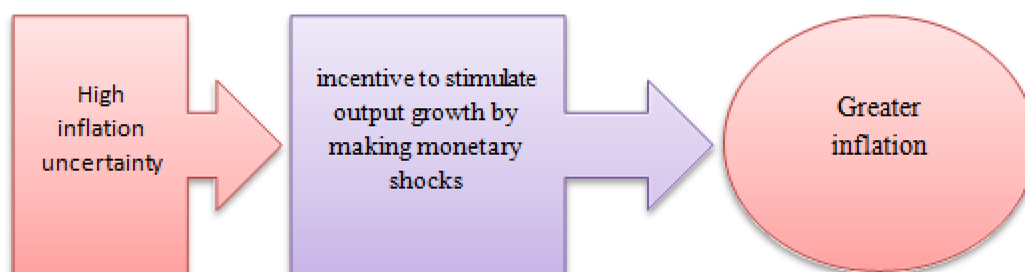
In the related literature, Ball (1992) built an economic model to support Friedman's hypothesis. Ball's model takes up two policymakers; one accepts to bear recession to reduce inflation, and the other is not. For the low levels of inflation, both of them will try to keep inflation rate low. However, for the high inflation rates, only the anti-inflation one will accept to bear the recession as an economic cost of disinflation. Consequently, during the periods of high inflation, the community will be uncertain about the future monetary policy because they do not know whether the policymakers are anti-inflation or not. So the contribution of Ball's Model and Friedman's argument is called **Friedman-Ball Hypothesis,** which stated that there is a positive relation from inflation to inflation uncertainty.

2.1.2 Cukierman and Meltzer Hypothesis:

The opposite connection stated that inflation variability will lead to higher inflation, that there is a positive relation from inflation uncertinity to inflation. Cukierman and Meltzer (1986) run the causality test from inflation uncertainty to inflation; assuming that policymakers have two inconsistent targets over time. The first target is that, monetary authority prefer to expanding output by making monetary shocks; however the second target is to keep inflation at low levels. Consequently, the monetary policy is then assumed to be stochastic due to nonspecific monetary control mechanism. Furthermore, inefficient policymakers may not able to use the most appropriate monetary instrument available when they determine the accuracy of monetary control. Particularly, during periods of increased uncertainty, monetary policy may be discretionary because of the increased incentive to stimulate output growth by making monetary shocks. Thus, inflation uncertainty may lead to higher rates of money growth and then leads to inflation. The argument that higher inflation uncertainty will lead to high inflation rate is called **Cukierman and Meltzer Hypothesis**. The hypothesis that could be illustrated in this way.

Figure 2: Illustration of Cukierman and Meltzer Hypothesis:



In brief words, Cukierman and Meltzer stated that the causality between inflation and inflation uncertinity runs from inflation uncertainty to inflation. That is, the more the inflation uncertainty, the more the incentive for policymakers to create inflation shock to achieve sustainable

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economic growth.

2.2 The negative association hypotheses:

2.2.1 Pourgerami and Maskus Hypothesis:

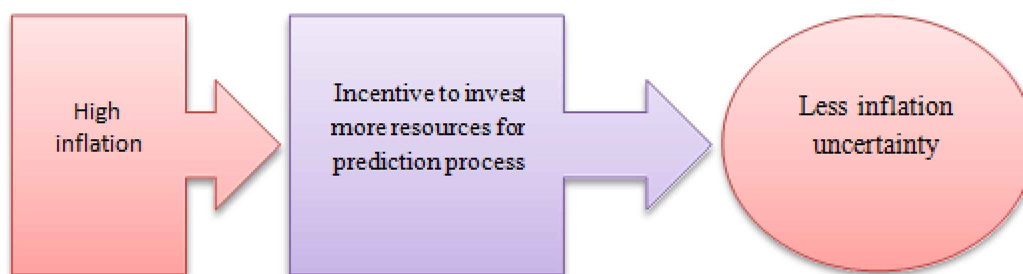
Against to Friedman-Ball Hypothesis, another contribution concerning the relationship between inflation and inflation uncertainty is stated by Pourgerami and Maskus (1987). They show that there is a negative association between inflation and inflation uncertainty, that is the more the inflation is; the less the inflation uncertainty will be.

They stated that higher inflation stimulates economic agents to invest in inflation prediction process to make accurate predictions about inflation, which reduces their prediction error. Therefore, in the higher inflation periods, economic units may forecast inflation better and decrease the inflation uncertainty. In other words, they assumed a negative relationship between inflation and inflation uncertainty. Because when inflation rates increases economic units use more resources in forecasting inflation because they have to take many decisions about investment, consumption, production etc. accordingly inflation can be anticipated and this will decrease the inflation uncertainty.

The described mechanism of the relation from higher inflation rate to lower inflation uncertainty is called **"Pourgerami and Maskus Hypothesis"**.

In a related context, Ungar and Zilberfarb (1993) developed this argument through the theoretical modeling of the hypothesis that economic units use more resource in inflation forecasting process in the periods of high inflation rates. Consequently, they supported that inflation itself generates a dynamic triggering more anticipated level of prices and decreasing the inflation uncertainty. So, the mechanism stated by Pourgerami and Maskus (1987) as well as by Ungar and Zilberfarb (1993). Could be illustrated as follows:

Figure 3: Illustration of Pourgerami and Maskus Hypothesis



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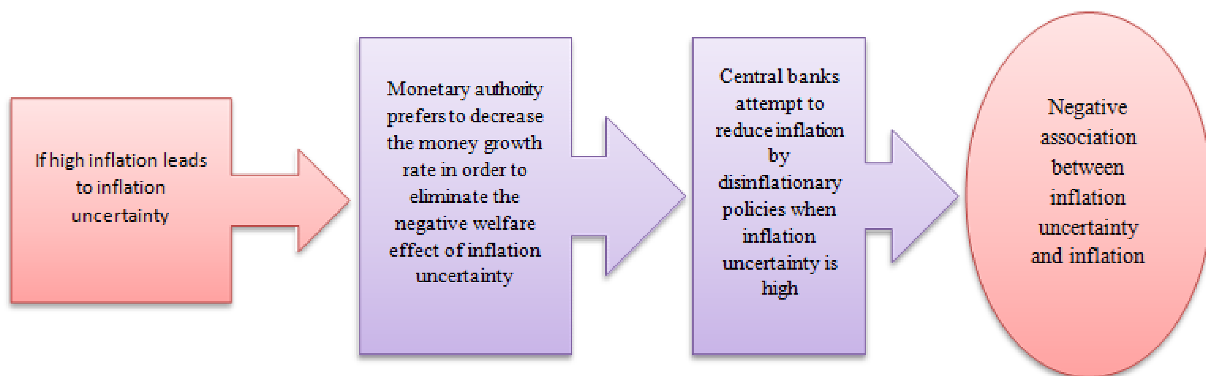
2.2.2 Holland stabilizing Fed Hypothesis:

Holland (1995) stated that higher inflation variability will lead to lower levels of inflation due to stabilization motives of policymakers. So, he contradicted Cukierman and Meltzer (1986) hypothesis and argued that more inflation uncertainty may lead to a lower inflation rate, if the monetary authority attempts to minimize the welfare losses caused by inflation uncertainty.

Holland argued the so-called "stabilizing Fed hypothesis", that is; inflation increases inflation uncertainty in US economy and that higher inflation uncertainty result in lower inflation rates. Holland assumed that stabilization propensity of monetary authority increases in high inflation period in order to decrease the cost of inflation uncertainty for the economy. Consequently, Holland's argument depends on the policymaker strong stabilization motive. By the rejecting of Cukierman-Meltzer's assumption, Holland stated that central banks usually prefer to decrease money supply growth rate in order to reduce the negative effect of inflation uncertainty on economic welfare arising from higher inflation levels. This is true if and only if the policymakers either have stabling motives or they governed by electionary commitment that requires price level stability.

The channel behind **"Holland Hypothesis"** may be illustrated as:

Figure 3: Illustration of Holland Hypothesis



So, according to the conceptual base, the connection between inflation and inflation uncertainty could be summarized in the following table:

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Table 1: How inflation and inflation uncertainty are related:

Causality	Positive association	Negative association
Inflation causes inflation uncertainty	Friedman and Ball hypothesis	Pourgerami and Maskus hypothesis
Inflation uncertainty causes inflation	Cukierman and Meltzer hypothesis	Holland hypothesis

3. IMPERIAL REVIEW

The empirical studies examined the interdependence between inflation and inflation uncertainty generally focused on HDCs. In these studies, Generalized Autoregressive Conditional Heteroskedasticity (GARCH) specifications are widespread; this is because (GARCH) estimates the conditional variance, so it can serve as a proxy for inflation uncertainty. According to the survey of Davis and Kanago (2000), studies focusing on developed countries mostly supported Friedman-Ball Hypothesis more than the hypothesis of Cukierman–Meltzer, at the same time there is a little evidence to the hypothesis of Pourgerami and Maskus and Holland.

Table 2: Some empirical studies examined the interdependence between inflation and inflation uncertainty

	High developed countries (HDCs) studies				
	Author	Country	Data	Tested by	The results supported*
2	Logue, Willet (1976)	41 Countries	1948–1970 (annual)	Inflation's mean and standard deviation	FB
1	Evans, Wachtel (1993)	USA	1955–1991 (quarterly)	Markov	CM
3	Grier, Perry (1998)	G7	1948–1993 (monthly)	GARCH	FB CM

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4	Fountas and Karanasos (2000)	USA	1960-1999 (monthly)	GARCH	FB CM
5	Hwang (2001)	USA	1947–1992 (monthly), 1926–1940 (monthly)	ARFIMA GARCH GARCH-M	PM CM
6	Fountas (2001)	England	1885–1998 (annual)	GARCH	FB
7	Bhar and Hamori (2001)	G7 countries	1961-1999 (Quarterly)	Markov Switching Heteroskedasticity model	FB
8	Kontonikas (2004)	England	1972–2002 (annual)	GARCH-M	FB
9	Fountas et al (2004)	Germany, France, Spain, England, Netherlands, Italia	1960–1999 (monthly)	EGARCH	FB H
10	Bredin and Fountas (2006)	Germany, Italy, UK, and Holland	1968-2005 (Quarterly)	Markov Switching Heteroskedasticity model	FB
11	Wilson (2006)	Japan	1957-2002 (Annual)	EGARCH-M	CM
12	Conrad, Karanasos (2005)	USA, Japan, England	1962–2001 (monthly)	ARFIMA FIGARCH	FB CM

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13	Fountas and Karanasos (2007)	for the G7	1957-2000 (monthly)	GARCH	FB
14	Karanasos, Schurer (2008)	Germany, Netherlands Sweden	1962–2004 (monthly)	PARCH	CM H FB
15	Coporale *et al* (2009)	Euro area	1980-2009 (monthly)	AR-GARCH	FB
16	Bhar, Mallik (2010)	USA	1957–2007 (monthly)	EGARCH-M	FB CM
17	Fountas (2010)	22 industrial countries	annual data over one century	GARCH-M	CM
18	Neanidis and Sava (2011)	EU members	2002-2011 (monthly)	GARCH-M	CM
	Less developed countries (LDCs) studies				
	Author	Country	Data	Tested by	The results supported*
1	Yamak (1996)	Turkey	1949–1992 (annual)	Two different methods was used as ARCH types	FB
2	Nas and Perry (2000)	Turkey	1960-1998 (monthly)	GARCH	FB CM
3	Berument et al (2001)	Turkey	1986–2000 (monthly)	EGARCH	CM
4	Telatar (2003)	Turkey	1987–2001 (monthly)	ARCH	FB

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5	Chan and Xie (2003)	Taiwan	1980-2002 (monthly)	Hamilton's flexible non-linear regression model	FB
6	Erdoğan, Bozkurt (2004)	Turkey	1983–2003 (monthly)	ARCH GARCH TARCH	FB
7	Ozer, Turkyılmaz (2005)	Turkey	1990–2004 (monthly)	EGARCH	FB
8	Grier and Grier (2006)	Mexico	1972-2001 (annual)	GARCH-M	FB
9	Thornton (2006)	India	1957-2005 (Monthly)	GARCH	FB
10	Thornton (2007)	12 Countries in emerging markets	Different periods for each countries	GARCH	FB
11	Ajevskis (2007)	Latvia	1994-2007 (monthly)	GARCH-M	FB CM
12	Erkam (2008)	Turkey	1982–2008 (monthly)	ARCH GARCH and PARCH	FB CM
13	Ozdemir, Fisunoğlu (2008)	Turkey, Jordan, Philippines	1987–2003 (monthly)	ARFIMA GARCH	FB CM
14	Omay (2008)	Turkey	1986–2007 — three different periods	GARCH	PM
15	Thornton (2008)	Argentine	1810–2005 (annual)	GARCH	FB
16	Rizvi and Naqvi (2008)	Pakistan	1976-2008 (monthly)	T-GARCH and EGARCH	FB

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17	Moradi (2008)	Iran	1959-2008 (monthly)	GARCH and TGARCH	FB
18	Korap, Saatcioğlu (2009)	Turkey	1987–2008 (monthly)	EGARCH	FB
19	Rizvi and Naqvi (2009)	China, Hong Kong, India, Malaysia, Pakistan, Philippines, Singapore, South Korea, Indonesia and Thailand.	1987-2008 (Quarterly)	GARCH	FB CM
20	Turkyılmaz, Ozer (2010)	Turkey	1997–2008 (monthly)	MGARCH	FB CM
21	Jiranyakul, Opiela (2010)	Indonesia, Malaysia, Philippines, Singapore, Thailand	1970–2007 (annual)	EGARCH	FB CM
22	Keskek and Orhan (2010)	Turkey	1984– 2005 (monthly)	GARCH-M	FB
23	Telatar and Telatar (2003)	Turkey	1995-2000 (monthly)	Markov Switching Heteroskedasticity model	FB
24	Nazar *et al* (2010)	Iran	1959-2009 (Quarterly)	EGARCH	FB

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25	Asghar et al (2011)	Pakistan, India and Sri Lanka	1980-2009 (Quarterly)	EGARCH	FB CM
26	Karahan (2012)	Turkey	2002-2011 (monthly)	ARMA-GARCH	FB
27	Balaji B. et al (2016)	India	1961- 2011 (monthly)	GARCH	FB H
* the hypothesis that had been supported					

FB: Friedman-Ball hypothesis

CM: Cukierman -Meltzer Hypothesis

PM: Pourgerami -Maskus Hypothesis

H: Holland Hypothesis

Accordingly; out of 18 studies for HDCs, 13 studies support Friedman-Ball hypothesis, 10 support Cukierman -Meltzer Hypothesi, 2 support Holland Hypothesis, and none support Pourgerami -Maskus Hypothesis, and out of 27 studies for LDCs, 25 studies support Friedman-Ball hypothesis, 9 support Cukierman -Meltzer Hypothesi, one supports Holland Hypothesis, and 2 support Pourgerami -Maskus Hypothesis.

4. DATA AND RESEARCH METHODOLOGY:

4.1 Data:

The variables used in this study are inflation (as a percentage change in consumer price index) and inflation uncertainty (as the conditional variance of GARCH model family). The data of inflation on monthly basis has been utilized from 2011:01-2018:11; and on annually basis from 1976-2016[1]. The inflation data obtained from the official website of central bank of Egypt.

The study has applied some descriptive statistics (include Mean, Median, Standard deviation, Skewness, Kurtosis and Jarque-Bera test) to the inflation series. These descriptive statistics are mostly used to describe the basic structures of the data in the study. Accordingly; The summary statistics of the inflation rate time series presented in Table 2 in the statistical appendix shows

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that the inflation rate time series follows normal distribution with statistically significant (at 5%) Jarque–Bera statistic .

The analysis begins with the examination of the inflation time series stationary using the Augmented Dickey Fuller (ADF) unit root test, which based on the null hypothesis that the time series are difference stationary using by the following three equations:

Without intercept and trend

$$\Delta\pi_t = \alpha\pi_{t-1} + \sum_{i=1}^{k} \beta_i \Delta\pi_{t-i} + e_t \text{ --------(1)}$$

With intercept

$$\Delta\pi_t = C + \alpha\pi_{t-1} + \sum_{i=1}^{k} \beta_i \Delta\pi_{t-i} + e_t \text{ -------(2)}$$

With intercept and trend

$$\Delta\pi_t = C + \alpha\pi_{t-1} + \sum_{i=1}^{k} \beta_i \Delta\pi_{t-i} + \gamma_t + e_t \text{ -------(3)}$$

Results of the ADF test have been presented in Table 3. All tests reject the null hypothesis of a unit root in the monthly inflation series at the 1% significance level. In other words; this means that the monthly inflation time series is integrated of zero order I(0).

4.2 Inflation Uncertainty Framework

To model inflation uncertainty different techniques have been applied for data analysis and for modeling purposes. So, the study has used GARCH, TARCH, EGARCH, and PARCH techniques to model the conditional variance which used as a proxy to inflation uncertainty.

The mean equation is

$$\pi_t = \bar{\pi} + e_t \text{ -------(4)}$$

Where $\bar{\pi}$ is the average value of inflation, so e_t is the deviation of its mean at the time t.

Breusch–Godfrey serial correlation LM test shows that there is no serial correlation in the residuals. In particular, the test statistics is statistically significant at 1%.

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1. The basic GARCH (1, 1) conditional variance equation is given by the following equation (5):

$$\delta_t^2 = C + \alpha . e_{t-1}^2 + \beta . \delta_{t-1}^2 \text{ -------(5)}$$

Where c is the constant term, e^2_{t-1} (the ARCH term) is the first lag of the squared residual from the mean equation and expresses news about the volatility from the previous period, and term δ^2_{t-1} (the GARCH term) represents last period's conditional variance. The specification of this model is consistent with the volatility that frequently seen in time series data, where large fluctuations are likely to be followed by large fluctuations and small fluctuations are likely to be followed by small fluctuations.

2. The TARCH (1,1) specification for the conditional variance is:

$$\delta_t^2 = C + \alpha . e_{t-1}^2 + \beta . \delta_{t-1}^2 + \gamma . e_{t-1}^2 . d_{t-1} \text{ -------(6)}$$

The model is based on the assumption that unexpected change (expressed in terms of e_t), has different effect on the conditional variance. That is, the basic GARCH model is extended to include the term, where the dummy variable $d_t = 1$ if $e_t < 0$, and 0 otherwise. In this model, If $\gamma > 0$ indicates that volatility tends to rise in response to positive shocks and fall in response to negative shocks.

3. The Exponential GARCH (EGARCH) specifies the conditional variance in logarithmic form:

$$log\ (\delta_t^2) = C + \sum_{i=1}^{p} \alpha_i . \left|\frac{e_{t-i}}{\delta_{t-1}}\right| + \sum_{j=1}^{q} \beta_j . \log(\delta_{t-j}^2) + \sum_{k=1}^{r} \gamma_k . \frac{e_{t-k}}{\delta_{t-k}} \text{ ----(7)}$$

The form of the equation indicates that conditional variance is an exponential function of the variables under analysis, which implying that any effects are exponential (ensures that shocks will have a stronger impact on the volatility than in TARCH) and the conditional variance is positive.

4. The Power-ARCH (PARCH) represents a general class of models that include both ARCH and GARCH models, The PARCH specification is given by equation:

$$\delta_t^\sigma = C + \sum_{i=1}^{p} \alpha_i . (|e_{t-1}| - \gamma_k . e_{t-i})^\sigma \left|\frac{e_{t-i}}{\delta_{t-1}}\right| + \sum_{j=1}^{q} \beta_j . \delta_{t-j}^\sigma \text{ -------(8)}$$

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Both the power parameter σ and the threshold parameter, γ, are predetermined, so, some models can be derived from this model For each value of σ, and γ.

4.3 Granger Causality Test

Granger Causality is the method that has been used in most of previous studies to test the causality between Inflation (π) and Inflation uncertainty (δ). The Granger causality test determines whether one variable is suitable in estimating the other or not. The bivariate regression function is as follows:

$$\pi_t = \propto_0 + \sum_{i=1}^{k} \propto_i \pi_{t-i} + \sum_{j=1}^{m} \propto_j \delta_{t-j} + \varepsilon_t \text{ -------(9)}$$

$$\delta_t = \beta_0 + \sum_{i=1}^{k} \beta_i \delta_{t-i} + \sum_{j=1}^{m} \beta_j \pi_{t-j} + \varepsilon_t \text{ -------(10)}$$

Where denotes the constant term in the Granger regression, m represents the lag length chosen. The null hypothesis in the first equation is that inflation uncertainty does not granger cause inflation. Similarly the null hypothesis in the second equation is that inflation does not granger cause inflation uncertainty.

Results of the Granger causality test between Inflation (π) and Inflation uncertainty (δ) obtained from GARCH, TARCH, EGARCH, and PARCH models presented in the following table:

Table 3: Causality test between inflation and inflation uncertainty

		Null Hypothesis inflation does not Granger Cause inflation uncertainty					
GARCH		**2lags**	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
	F-Statistic	6.29899	3.49830	2.87385	2.04015	1.99544	1.75099
	Prob	0.0028	0.0110	0.0143	0.0544	0.0490	0.0802
		Null Hypothesis inflation uncertainty does not Granger Cause inflation					
		2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
	F-Statistic	7.91183	6.45368	4.63599	3.84680	3.86285	2.77499
	Prob	0.0007	0.0001	0.0005	0.0009	0.0004	0.0049

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		Null Hypothesis inflation does not Granger Cause inflation uncertainty					
TARCH		**2lags**	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
	F-Statistic	1.56662	1.19221	1.34732	1.05794	1.20883	1.07985
	Prob	0.2146	0.3207	0.2473	0.4027	0.3032	0.3943
		Null Hypothesis inflation uncertainty does not Granger Cause inflation					
		2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
	F-Statistic	6.40472	5.68594	4.27850	3.65046	3.65411	2.60814
	Prob	0.0026	0.0004	0.0009	0.0014	0.0007	0.0078
EGARCH		Null Hypothesis inflation does not Granger Cause inflation uncertainty					
		2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
	F-Statistic	2.77953	2.90597	2.25622	1.71898	1.87198	1.33314
	Prob	0.0677	0.0267	0.0470	0.1097	0.0665	0.2266
		Null Hypothesis inflation uncertainty does not Granger Cause inflation					
		2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
	F-Statistic	0.83156	0.79046	0.83402	0.84810	0.93409	0.81620
	Prob	0.4388	0.5348	0.5475	0.5642	0.5088	0.6330
PARCH		Null Hypothesis inflation does not Granger Cause inflation uncertainty					
		2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
	F-Statistic	10.6560	7.35862	5.02268	4.01069	3.97955	2.93662
	Prob	7.E-05	4.E-05	0.0002	0.0006	0.0003	0.0032
		Null Hypothesis inflation uncertainty does not Granger Cause inflation					
		2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
	F-Statistic	54.2860	27.3636	18.5946	11.8627	9.35199	7.30655
	Prob	6.E-16	3.E-14	5.E-13	2.E-10	3.E-09	8.E-08

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The table shows a bi-directional causality between inflation and inflation uncertainty. In particular, the Granger-causality test rejects the null hypothesis that inflation does not Granger-cause inflation uncertainty across all lag lengths at the 1% level of significance. At the same time, the null hypothesis that inflation uncertainty does not Granger-cause inflation is also rejected for all the used lag lengths at one percent level of significance.

5. CONCLUSIONS

This paper has studied the association between inflation rate and inflation uncertainty in Egypt during the period January 2011–December 2018. Using two-step procedure, the estimated conditional variance from GARCH, TARCH, EGARCH and PARCH models are used as a measure of inflation uncertainty, and a Granger-causality test is accompanied to determine the causal relation between the two variables.

Results of the Granger causality test between Inflation and Inflation uncertainty obtained from GARCH family models show a bi-directional causality between inflation rate and inflation uncertainty.

But according to the coefficient of the error term (e) in the examined GARCH family models; it could be simply noticed that there is a significant positive association between inflation uncertainty and the error term (e), so where the error term represents the difference between inflation rate and the mean of inflation rate. It could be simply concluded that:

1. Inflation uncertainty is negatively associated with the mean of inflation rate, that is the more the mean of inflation rate, the less the inflation uncertainty at any high inflation rate.

2. Inflation uncertainty is positively associated with the inflation rate, in other words, the more the inflation rate, the more the inflation uncertainty at any high mean of inflation rate.

So, the results indicate a statistically significant positive, two-way relationship between higher (not high) inflation rate and inflation uncertainty, that is, higher inflation rate above its mean rate will lead to high inflation uncertainty and vice versa, and in the same time stable high inflation rate leads to less sensitiveness of inflation uncertainty to increase in inflation rate. In some context this result modifies both Friedman-Ball hypothesis and Cukierman and Meltzer Hypothesis that higher (not high) inflation rate affect and affected by inflation uncertainty. That is, according to the previous analyzes, one can simply conclude the following scenarios:

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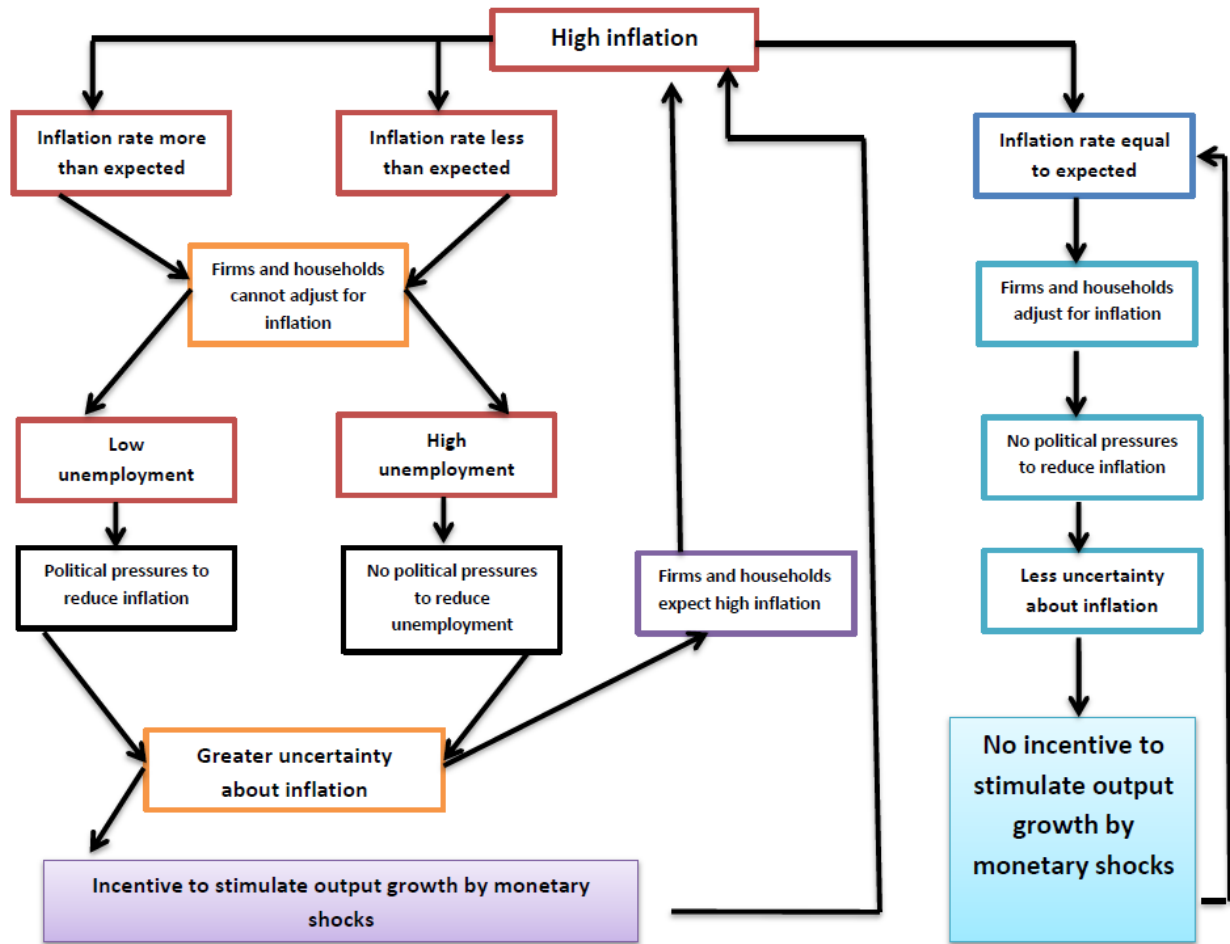

1. If inflation rate is more than expected, then firms and households cannot adjust for inflation, and unemployment rate will decrease, so there will be a political pressures to reduce high rate of inflation, hence the uncertainty about future inflation will increase, if this is the case, government may use monetary shocks to stimulate economic growth.

2. If inflation rate is less than expected, then firms and households cannot adjust for inflation, and unemployment rate will increase, so there will be a political pressures to reduce high rate of unemployment, hence the uncertainty about future inflation will increase, if this is the case, firms and households will expect high rate of inflation in the future which in turn promote for high inflation rate.

3. If inflation rate is equal to the expected, then firms and households can adjust for inflation, so there will not be a political pressures to reduce inflation even though if it is high, hence the uncertainty about future inflation will decrease, if this is the case,

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government haven't any incentive to use monetary shocks to stimulate economic growth and lose with economic stability.

Policy Implications

The bi-directional causality between inflation rate and inflation uncertainty that is found in this study has a vital implications for the monetary policy in Egypt. If the monetary policy attempt to control inflation uncertainty, then it should control the volatility of inflation rate (at any level of inflation itself), so it can stabilize inflation expectation and hence lower the inertia of inflation rates.

Where there is a considerable cost of inflation and inflation uncertainty especially when they have a mutual interdependence, the findings of this paper support the view of implementing inflation control target monetary policy in Egypt. Several studies (such as Tas and Ertugrul (2013) and Lin and Ye (2009)) have found that inflation targeting monetary policies have contributed to reduce both the level of inflation and its associated uncertainty.

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STATISTICAL APPENDIX

1. Summary of statistics

	Monthly;	**Annually;**
Mean	0.010641	11.46708
Median	0.010010	11.07810
Maximum	0.048500	23.86429
Minimum	-0.015350	2.269757
Std. Dev.	0.011391	5.629899
Skewness	0.564124	0.216911
Kurtosis	3.937336	2.317422
Jarque-Bera	8.337233	1.117445
Probability	0.015474	0.571939
Sum	0.989640	470.1504
Sum Sq. Dev.	0.011937	1267.830
Observations	93	41

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2. Unit root test;

Augmented Dickey-Fuller test statistic						
	Monthly			Annually		
	Intercept	Intercept & trend	none	Intercept	Intercept & trend	none
t-Statistic	-6.657809	-7.138874	-4.45787	-1.690101	-1.840943	-0.64238
prob	0.0000	0.0000	0.0000	0.4282	0.6654	0.4325

3. Estimation of inflation uncertainty:

Mean equation

Dependent Variable: INF
Method: Least Squares
Sample (adjusted): 2011M01 2018M09

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.010641	0.001181	9.008998	0.0000

R-squared	0.000000	Mean dependent var	0.010641
Adjusted R-squared	0.000000	S.D. dependent var	0.011391
S.E. of regression	0.011391	Akaike info criterion	-6.101303
Sum squared resid	0.011937	Schwarz criterion	-6.074071
Log likelihood	284.7106	Hannan-Quinn criter.	-6.090308
Durbin-Watson stat	1.338853		

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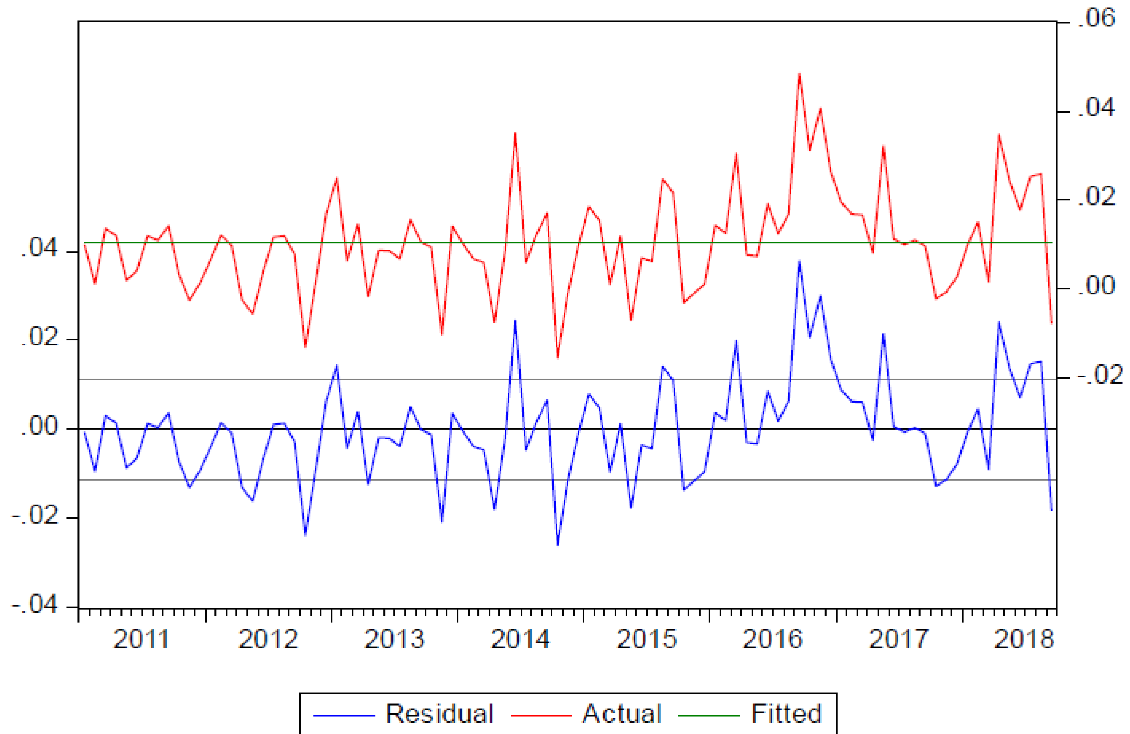

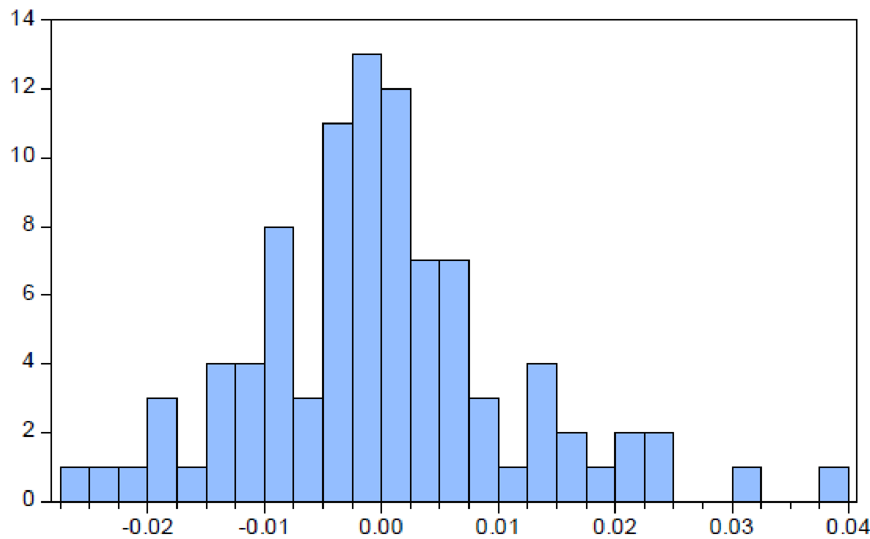

Series: Residuals	
Sample 1 93	
Observations 93	
Mean	7.46e-20
Median	-0.000631
Maximum	0.037859
Minimum	-0.025991
Std. Dev.	0.011391
Skewness	0.564124
Kurtosis	3.937336
Jarque-Bera	8.337233
Probability	0.015474

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	5.219224	Prob. F(2,90)	0.0072
Obs*R-squared	9.665378	Prob. Chi-Square(2)	0.0080

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4. Estimation of GARCH model

Dependent Variable: INF
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Included observations: 93
GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.009116	0.001254	7.267827	0.0000
Variance Equation				
C	1.51E-06	1.02E-06	1.484926	0.1376
RESID(-1)^2	-0.084143	0.021332	-3.944457	0.0001
GARCH(-1)	1.093513	0.000262	4170.569	0.0000

R-squared	-0.018123	Mean dependent var	0.010641
Adjusted R-squared	-0.018123	S.D. dependent var	0.011391
S.E. of regression	0.011494	Akaike info criterion	-6.266371
Sum squared resid	0.012154	Schwarz criterion	-6.157442
Log likelihood	295.3862	Hannan-Quinn criter.	-6.222388
Durbin-Watson stat	1.315020		

Causality test:

	Null Hypothesis inflation does not Granger Cause inflation uncertainty					
	2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
F-Statistic	6.29899	3.49830	2.87385	2.04015	1.99544	1.75099
Prob	0.0028	0.0110	0.0143	0.0544	0.0490	0.0802
	Null Hypothesis inflation uncertainty does not Granger Cause inflation					
	2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
F-Statistic	7.91183	6.45368	4.63599	3.84680	3.86285	2.77499
Prob	0.0007	0.0001	0.0005	0.0009	0.0004	0.0049

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5. Estimation of TARCH MODEL

Dependent Variable: INF
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Included observations: 93
GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*RESID(-1)^2*(RESID(-1)<0) +
C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.009134	0.001387	6.586075	0.0000
Variance Equation				
C	2.96E-06	2.77E-06	1.067455	0.2858
RESID(-1)^2	-0.084077	0.026368	-3.188592	0.0014
RESID(-1)^2*(RESID(-1)<0)	-0.043233	0.084429	-0.512065	0.6086
GARCH(-1)	1.093807	0.000236	4626.916	0.0000

R-squared	-0.017699	Mean dependent var	0.010641
Adjusted R-squared	-0.017699	S.D. dependent var	0.011391
S.E. of regression	0.011491	Akaike info criterion	-6.239529
Sum squared resid	0.012149	Schwarz criterion	-6.103368
Log likelihood	295.1381	Hannan-Quinn criter.	-6.184551
Durbin-Watson stat	1.315569		

Causality test:

	Null Hypothesis inflation does not Granger Cause inflation uncertainty					
	2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
F-Statistic	1.56662	1.19221	1.34732	1.05794	1.20883	1.07985
Prob	0.2146	0.3207	0.2473	0.4027	0.3032	0.3943
	Null Hypothesis inflation uncertainty does not Granger Cause inflation					
	2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
F-Statistic	6.40472	5.68594	4.27850	3.65046	3.65411	2.60814
Prob	0.0026	0.0004	0.0009	0.0014	0.0007	0.0078

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6. Estimation of EGARCH model

Dependent Variable: INF
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Included observations: 93
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.008935	0.000815	10.96387	0.0000
Variance Equation				
C(2)	-0.613756	0.001085	-565.4219	0.0000
C(3)	-0.549083	0.013194	-41.61689	0.0000
C(4)	0.188157	0.037300	5.044363	0.0000
C(5)	0.889286	1.8E-104	4.9E+103	0.0000

R-squared	-0.022671	Mean dependent var	0.010641
Adjusted R-squared	-0.022671	S.D. dependent var	0.011391
S.E. of regression	0.011519	Akaike info criterion	-6.250468
Sum squared resid	0.012208	Schwarz criterion	-6.114307
Log likelihood	295.6468	Hannan-Quinn criter.	-6.195490
Durbin-Watson stat	1.309172		

Causality test:

	Null Hypothesis inflation does not Granger Cause inflation uncertainty					
	2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
F-Statistic	2.77953	2.90597	2.25622	1.71898	1.87198	1.33314
Prob	0.0677	0.0267	0.0470	0.1097	0.0665	0.2266
	Null Hypothesis inflation uncertainty does not Granger Cause inflation					
	2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
F-Statistic	0.83156	0.79046	0.83402	0.84810	0.93409	0.81620
Prob	0.4388	0.5348	0.5475	0.5642	0.5088	0.6330

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7. Estimation of PARCH MODEL:

Dependent Variable: INF
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Included observations: 93
@SQRT(GARCH)^C(6) = C(2) + C(3)*(ABS(RESID(-1)) - C(4)*RESID(
-1))^C(6) + C(5)*@SQRT(GARCH(-1))^C(6)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.008234	0.001222	6.739239	0.0000
	Variance Equation			
C(2)	-1.15E-05	1.66E-05	-0.691301	0.4894
C(3)	-0.054599	0.059566	-0.916598	0.3594
C(4)	-0.817840	1.517865	-0.538810	0.5900
C(5)	1.090244	0.000248	4390.097	0.0000
C(6)	1.437166	0.010246	140.2603	0.0000

R-squared	-0.045152	Mean dependent var	0.010641
Adjusted R-squared	-0.045152	S.D. dependent var	0.011391
S.E. of regression	0.011645	Akaike info criterion	-6.193056
Sum squared resid	0.012476	Schwarz criterion	-6.029662
Log likelihood	293.9771	Hannan-Quinn criter.	-6.127082
Durbin-Watson stat	1.281012		

Causality test:

	Null Hypothesis inflation does not Granger Cause inflation uncertainty					
	2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
F-Statistic	10.6560	7.35862	5.02268	4.01069	3.97955	2.93662
Prob	7.E-05	4.E-05	0.0002	0.0006	0.0003	0.0032
	Null Hypothesis inflation uncertainty does not Granger Cause					
	inflation					
	2lags	**4lags**	**6lags**	**8lags**	**10 lags**	**12lags**
F-Statistic	54.2860	27.3636	18.5946	11.8627	9.35199	7.30655
Prob	6.E-16	3.E-14	5.E-13	2.E-10	3.E-09	8.E-08

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