Does Higher Inflation Lead to More Inflation Uncertainty? (The case of Iran)

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<u>Abstract</u>

This article examines the relationship between inflation and inflation-uncertainty in Iranian economy for the period 1369:1 to 1385:3 .The purpose of this study is to test the hypothesis that inflation uncertainty increases at higher levels of inflation. Analysis of this study is based on the generalized autoregressive conditional heteroscedasticity (which allow the conditional variance of the error term to be time-varying). Since this variance is a proxy for inflation uncertainty, a positive relationship between the conditional variance and inflation would be interpreted as an evidence that inflation uncertainty increases with the level of inflation.

Our findings indicate that inflation causes inflation uncertainty as there is a significant positive relationship between inflation and inflation uncertainty. According to this result the role of Central Bank of Iran is so crucial in reducing inflation uncertainty by conducting proper policies.

Key Words: Inflation, Inflation uncertainty, Distortion, GARCH model, Granger-Causality.

1- Introduction

The relationship between inflation and inflation uncertainty has always been of interest among economists. Inflation uncertainty is often cited as a major source of the costs of inflation. Uncertainty about future levels of inflation will distort saving and investment decisions since it causes the real value of future nominal payments to be unknown. These distortions are believed to have

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adverse effects on the efficiency of resource allocation and the level of real activity. The random nature of shocks and imperfect knowledge of the structure of the economy means that some inflation uncertainty will exist under any policy regime. Although uncertainty cannot be eliminated, it may be that inflation uncertainty (and therefore its costs) could be minimized by adopting a particular policy regime. According to many analysts, uncertainty about future inflation rises as inflation rises. As a result, these analysts argue that the Central Banks could reduce inflation uncertainty by reducing inflation. Other analysts argue that high inflation creates no more uncertainty than low inflation, as long as inflation remains stable. As a result, these analysts argue that high inflation does not necessarily interfere with decision making or reduce economic well-being.

In particular, since some theoretical models predict that inflation uncertainty increases with the level of inflation, the costs of inflation uncertainty might be minimized by pursuing a policy of price stability. This conclusion has led to numerous empirical studies since the 1970s on the link between inflation and inflation uncertainty and on the real effects of uncertainty.

This article examines the relationship between inflation and inflation-uncertainty in Iranian economy for the period from 1369:1 to 1385:5. It test two hypothesis: (1) higher inflation leads to greater variability of inflation; (2) greater inflation variability implies greater uncertainty about future inflation. Analysis of this study is based on the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) class of models, which allow the conditional variance of the error term to be time-varying. This variance can be used as a proxy for inflation uncertainty. Thus, a positive relationship between the conditional variance and inflation would be interpreted as evidence that inflation uncertainty increases with the level of inflation.

2- What is Inflation Uncertainty?

Inflation uncertainty arises from a lack of complete knowledge about how future price levels are determined. Of course, an individual typically will have enough information to make some forecast of future inflation rates. A given

estimate of next period's inflation can be thought of as the mean of some underlying probability distributions.

The analysis presented here deals with inflation uncertainty for a representative individual. Though the level of an individual's uncertainty about inflation is not directly observable, ways of estimating it have been suggested in the literature. One of these is to use the variance or standard deviation of the errors made in forecasting inflation. A forecaster is trying to predict the outcome of a process that has both systematic and random components. With an unbiased forecast of the inflation rate, the variance of the forecast errors indicates the importance of the random component and can be considered as an estimate of the level of inflation uncertainty. An implicit assumption in this type of analysis is that the variance need not be constant but may vary over time.

3- Consequences of inflation uncertainty

Uncertainty about inflation has two types of economic effects. First, inflation uncertainty causes businesses and consumers to make economic decisions that differ from the ones they would make otherwise. Analysts refer to these effects as ex ante, because the decisions anticipate future inflation. The second category of effects takes place after the decisions have been made, or ex post. These effects occur when inflation differs from what had been expected.

Ex ante effects: Uncertainty about inflation can affect the economy ex ante through three channels. First, inflation uncertainty affects financial markets by raising long-term interest rates. Second, inflation uncertainty leads to uncertainty about other variables that are important in economic decisions. Finally, inflation uncertainty encourages businesses to spend resources avoiding the associated risks.

Ex post effects: The other effects of inflation uncertainty-the ex post effects-occur when inflation differs from what had been expected. When inflation is higher than forecast, the real value of nominal payments is lower than expected. A fixed-rate mortgage provides one example where unexpected inflation implies a transfer of wealth from the lender to the borrower. If inflation is unexpectedly high, the real value of the mortgage payments to the lender is

less than had been expected. Similar effects occur in wage and rent contracts. When wages and rents are fixed, employees and landlords are hurt by an unexpected increase in inflation.

4- Sources of inflation uncertainty

In general, Friedman's (1977) Nobel address is the idea that a rise in the level of inflation raises uncertainty about future inflation. In the model by Ball (1992), there are two types of policymakers who stochastically alternate in power. When inflation is low both types of policymakers will try to keep it so, thus uncertainty concerning future inflation will also be low. However, when inflation is high, uncertainty about the future monetary stance and the future path of inflation will be greater, since the public doesn't know how long it will be before a tough type comes along and disinflates.

Cukierman and Meltzer (1986) and Cukierman (1992) show that higher inflation uncertainty will raise the average inflation rate. Both studies build upon the traditional Barro-Gordon framework: the policymaker maximmises his own objective function that is positively-related to economic stimulation through monetary surprises and negatively-related to monetary growth. The relative weights assigned to each target evolve stochastically over time. The money supply process is also random, due to imprecise monetary control procedures. Thus, the public faces an inference problem when trying to distinguish between persistent changes in the objectives and transitory monetary control errors. An exogenous increase in the variance of monetary control errors, which raises the variance of inflation, provides the policymaker with an incentive to create an inflation surprise to stimulate real activity leading to a positive correlation between uncertainty and average inflation.

In empirical investigations of the inflation-uncertainty relationship, a measure for uncertainty needs to be employed. Early studies use unconditional volatility measures.

5- Previous Research

Research on inflation uncertainty goes back over 50 years. In the first study on the issue, Okun found that countries with high inflation also had more variable inflation. He interpreted the greater variability as an indication of greater uncertainty. Some Previous research on the relationships between inflation rate and inflation uncertainty are reported in table (1).

Table1: Previous research on the relationships between Inflation rate and Inflation uncertainty

	Countries Studies	Time periods	Major Findings
Okun (1971)	17 industrialized OECD countries	1951-1968	High correlation between the average annual percentage increase in the GNP deflator and the standard deviation of annual rates.
Gordon(1971)	Same as Okun	1960-1968	Smaller correlation than in Okun. Also, if five relatively small countries are omitted correlation disappears.
Logue and Willett(1976)	41 industrialized and nonindustrialized countries	1949-1970	Inflation rates of no more than 2-4 percent cause no problem of increased variability of inflation.
Jeff and Kleiman (1977)	Same as Okun	1951-1971 1955-1971	a) Positive correlation across countries between inflation and its variance, through correlation is weak during 1960s. b) Positive relationship between mean and standard deviation of inflation rates expected.
Foster(1978)	40 countries	1954-1975	Large correlations between inflation and the average absolute change in inflation.
Cukierman and Wachtel (1979)	United States	1948-1975 1955-1976	Variance of expected inflation across individuals positively related to variance of actual inflation.
Yaylor(1981)	7 large industrialized countries	1954-1979	Strong correlation between average inflation and its standard deviation, which is at least partially due to association between average inflation and inflationary shocks.
Fischer (1981)	United States	1806-1979 1954-1976 1950-1980	a) Positive relationship between inflation and its variability. b) Variance of expected inflation across individuals is positively associated with actual, expected and unanticipated inflation. c) No significant association between the rate of inflation and the variance of residuals from a forecasting equation of the inflation rate.

Frohman, Laney and Willett(1981)	United States	1954-1976	Positive relationship between both actual and expected inflation and the variance of expected inflation across individuals using the Livingstone survey.
Hafer and Heyne Hafer (1981)	Same as Logue and Willett, excluding Chile.	1970-1979	Inflation and its variability are positively related, may require rates as high as 9 oercent.
Pagan, Hall and Trivedi(1983)	Australia	1973-1981 1968-1982	Inflation affects variance of errors in forecasting, as measured by squared estimated forecast errors.
Engle(1983)	United States	1947-1979	Inflation does not affect squared value of estimated forecast errors. Past values of squared forecast errors do.
Ball and Cecchetti (1990)	United States	1973-1988	Higher inflation increase long-run uncertainty.
Johnson (2002)	11 Countries	1973-2000	strong positive link between past inflation and cureent uncertainty

6- The survey strategy

The first strategy for estimating uncertainty about inflation uses surveys of economists and consumers. Analysts estimate inflation uncertainty from the surveys using two different approaches. One approach estimates uncertainty by asking respondents to provide a range of values over which inflation might fall. For example, one respondent might expect inflation of 3 to 4 percent, while another one might expect inflation of 2 to 5 percent. Because the second respondent identified a wider range of possible outcomes, this respondent is presumed to be more uncertain about future inflation.

The second approach to estimate inflation uncertainty from surveys is based on the variability, or dispersion, of inflation expectations across survey participants. Unlike the first approach where uncertainty can be estimated for an individual, the variability estimate of uncertainty requires several survey participants. When survey participants have similar expectations of future inflation, uncertainty is presumed to be low. But if they disagree about the inflation outlook, uncertainty is presumed to be high. For example, if 90 percent of participants' median inflation forecasts are between 3 and 4 percent, uncertainty is lower than if only 60 percent of the forecasts are in this

range.When inflation uncertainty is estimated from surveys, researchers consistently find that uncertainty is high during periods of high inflation.

7- The forecasting model strategy

The second strategy for estimating inflation uncertainty uses economic forecasting models. In this approach researchers use an econometric model of inflation to forecast future inflation. Large forecast errors from the model imply high uncertainty, while small forecast errors imply low uncertainty. Analysis of this way is based on the generalized autoregressive conditional heteroscedasticity (which allow the conditional variance of the error term to be time-varying).

8- The general method

The GARCH specification, which is generally used for inflation and time-varying residual variance as a measure of inflation uncertainty, is as follow:

$$\Pi_t = \beta. + \sum_{i=1}^{n} \beta_i \Pi_{t-i} + \varepsilon_t \tag{1}$$

$$\sigma_{\varepsilon t}^2 = \alpha. + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \sigma_{\varepsilon t-1}^2 \tag{2}$$

Where Π_t is the inflation, ε_t is the residual of Eq.(1), $\sigma_{\varepsilon t}^2$ is the conditional variance of residual term taken as inflation uncertainty at time t, and n is the lag length. Eq. (2) is a GARCH(1,1) Representation of the conditional variance.

If inflation affects inflation uncertainty and inflation uncertainty affects inflation then the inflation and inflation uncertainty measures should appear in the inflation uncertainty and inflation specification, respectively. Thus, an alternative specification that is generally used is the component GARCH model:

$$\Pi_t = \beta. + \sum_{i=1}^{n} \beta_i \Pi_{t-i} + \gamma \sigma_{\varepsilon t}^2 + \varepsilon_t \tag{3}$$

$$\sigma_{\varepsilon t}^2 = \alpha. + \alpha_1 (\varepsilon_{t-1}^2 - q_{t-1}) + \alpha_2 (\sigma_{\varepsilon t-1}^2 - q_{t-1}) + \lambda \Pi_{t-1} \tag{4}$$

Where

$$q_1 = \alpha. + \rho q_{t-1} + \alpha_3 (\varepsilon_{t-1}^2 - \sigma_{\varepsilon t-1}^2) \tag{5}$$

However, assuming that just the current value of uncertainty measure affects the level of inflation and just the first lagged value of inflation affects the inflation uncertainty measure might be too restrictive. Both of these series are persistent and highly correlated. Therefore, excluding further lags would lead to biased estimated parameters.

9- Model specification with extended lags

In this section, we included further lags of inflation and inflation uncertainty in the inflation uncertainty and inflation specification, respectively. When we tested the joint significance of these lags, we called them Granger causality tests. To be specific , we estimated Eqs.(1.1) and (2.1) to see whether all γ_i's are jointly statistically significant (to test if inflation uncertainty Granger causes inflation) and all μ_i's are jointly statistically significant (to test if inflation Granger causes inflation uncertainty).

$$\Pi_t = \beta. + \sum_{i=1}^{n} \beta_i \Pi_{t-i} + \gamma \sum_{i=.}^{n-1} \delta_i \sigma_{\varepsilon t-1}^2 + \varepsilon_t \tag{1-1}$$

$$\sigma_{\varepsilon t}^2 = \alpha. + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \sigma_{\varepsilon t-1}^2 + \sum_{i=1}^{n} \mu_i \Pi_{t-1} \tag{1-2}$$

In order to assess the Granger causality test within the component GARCH specification, we estimate the following
    equation:

$$\Pi_t = \beta_. + \sum_{i=1}^{n} \beta_i \Pi_{t-i} + \gamma \sum_{i=0}^{n-1} \delta_i \sigma_{\varepsilon t-1}^2 + \varepsilon_t \tag{1-3}$$

$$\sigma_{\varepsilon t}^2 = q_1 + \alpha_1(\varepsilon_{t-1}^2 - q_{t-1}) + \alpha_2(\sigma_{\varepsilon t-1}^2 - q_{t-1}) + \sum_{i=1}^{n} \lambda_i \Pi_{t-1} \tag{1-4}$$

10- An overview of Iran inflation data

In our Estimates, we used the monthly consumer price index inflation (for the period 1369:1 to 1385:3) taken from the Central Bank of Iran. Inflation is measured as the first difference of the log consumer price index (CPI). Figures (2) and (3) plot the consumer price index and inflation rate for period of 1369:1 to 1385:3. Figure (4) plots the year to year mean and S.D. of annual inflation. It appears that periods of higher average inflation correspond to periods of more volatile inflation.
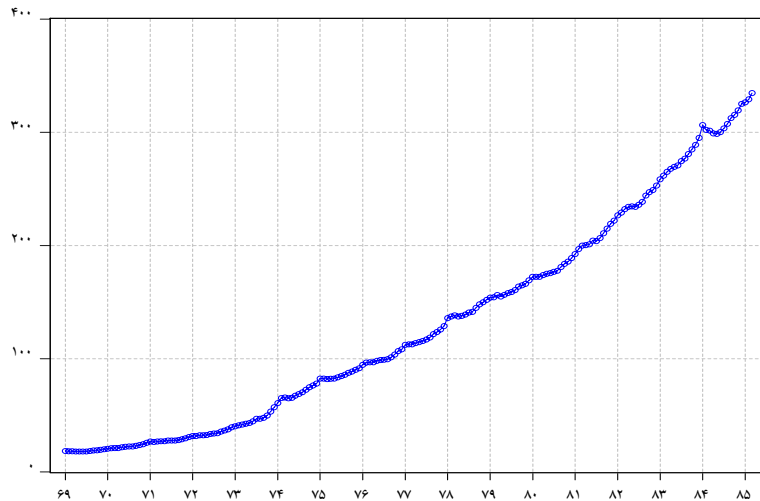
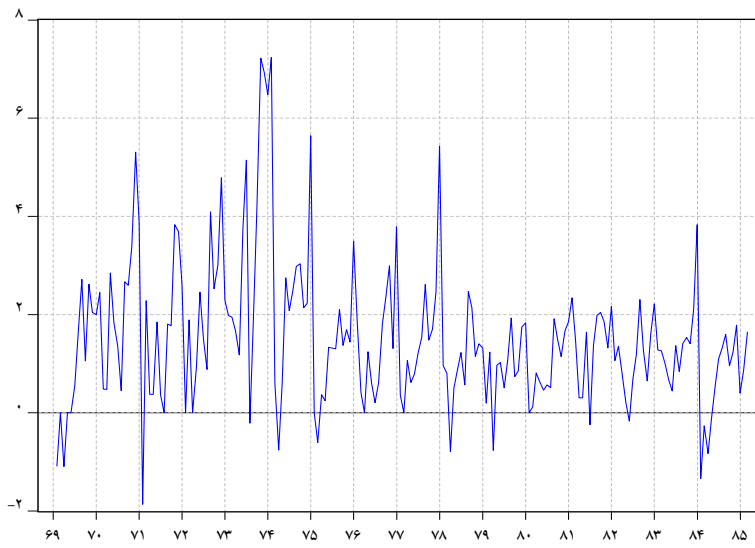**Figure 2: Consumer price index (1369:1-1385:3)**

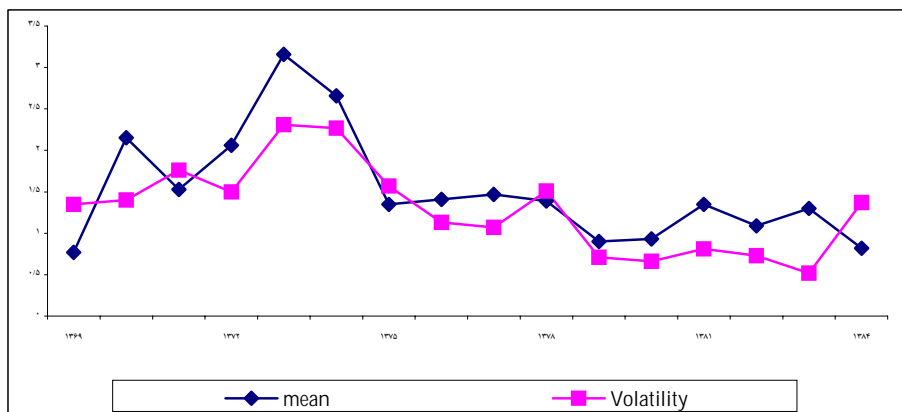**Figure 3: Inflation rate(1369:1-1385:3)**

Figure 4: Mean and S.D. of annual inflation rate

11- Estimation of model

This section is to investigations the time series properties of the data using the augmented Dickey Fuller(ADF)test. Table(5) reports the results of ADF test for the level and growth of the CPI. The results indicate that CPI is non-stationary, but inflation rate is stationary. In other words,CPI is I(1) and inflation rate is I(0).

Table5: Unit Root result on CPI and inflation rate

	Consumer price index	Inflation
With Trend and Intercept	-1.2	-3.9
Critical Value	-3.5	-3.5
Lagged Number	1	0
With Trend and Intercept	0.25	-
Critical Value	-2.9	-
Lagged Number	1	-
With Trend and Intercept	-0.2	-
Critical Value	-1.9	-
Lagged Number	1	-

In follow, for testing a non-constant residual variance, the squared OLS residuals are regressed against a constant and their lagged values.

$$\varepsilon_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \ldots + \alpha_p \varepsilon_{t-p}^2,$$

the constant-variance null hypothesis is defined by the restriction

$$\alpha_1 = \ldots = \alpha_p = 0.$$

The result of this test is reported in table(6).

Table6: Tests for GARCH effects

	GARCH(1)	GARCH(12)
Autoregressive 1369:1-1385:3	19.49*	62.56*

The LM test is distributed chi-squared with p degree of freedom.

* Significant at the 5 percent level of significance.

According to this results, we can reject the constant-variance null hypothesis in 1 and 12 lags. It means variance is time-varying.

at this stage, we should estimate a model that allow the conditional variance of the error term to be time-varying. For this purpose a GARCH (1,1) model is estimated. The result of this model is reported in table (7).

Table7: The result of GARCH (1,1) model

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.526620	0.166895	3.155402	0.0016
RCPI(-1)	0.201275	0.076287	2.638406	0.0083
RCPI(-12)	0.375997	0.043352	8.673191	0.0000
Variance Equation				
C	0.292529	0.112339	2.603994	0.0092
ARCH(1)	0.473911	0.125090	3.788558	0.0002
GARCH(1)	0.386283	0.133952	2.883750	0.0039
R-squared	0.268898	Mean dependent var		1.593427
Adjusted R-squared	0.246743	S.D. dependent var		1.516524
S.E. of regression	1.316197	Akaike info criterion		3.082158
Sum squared resid	285.8416	Schwarz criterion		3.192391
Log likelihood	-257.5245	F-statistic		12.13734
Durbin-Watson stat	1.678750	Prob(F-statistic)		0.000000

According to this model, we can derive conditional standard deviation as a proxy for inflation uncertainty. Conditional SD is indicated in Figure(8).
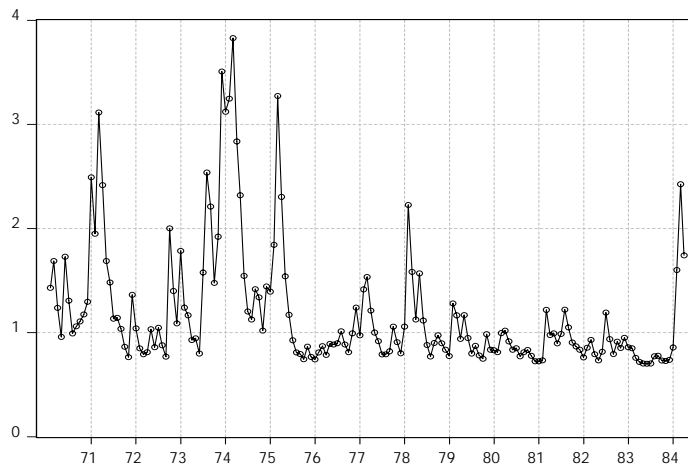

Figure 8: Conditional Standard Deviation

Now we test relatioship between inflation and inflation uncertainty with using Granger-Causality. The result of this test is reported in table(9).

Table 9: Granger-causality tests between inflation and inflation uncertainty

Null Hypothesis	Test Statistic
Inflation does not Granger-Cauaslilty inflation uncertainty.	12.1 *
Inflation uncertainty does not Granger-Cauaslilty inflation.	0.26

* Significant at the 5 percent level of significance.

In the first row, we tested the null hypothesis that inflation doesnot Granger cause inflation uncertainty, whereas the second row represents the results of the analysis with the null hypothesis that inflation uncertainty doesnot granger-cause inflation. Table (9) suggests that inflation Granger causes inflation uncertainty (null hypothesis that inflation doesnot Granger cause inflation uncertainty is rejected), but inflation uncertainty doesnot Granger-causes inflation.

12- Conclusion

The relationship between inflation and inflation uncertainty has always been of interest among economists. Inflation uncertainty is often cited as a major source of the inflation costs. Theoretical models have suggested a number of reasons why inflation uncertainty may increase at higher levels of inflation. This article examined the relationship between inflation and inflation-uncertainty in Iranian economy for the period 1369:1 to 1385:3. The results indicate that inflation causes inflation uncertainty as there is a significant positive relationship between inflation and inflation uncertainty. According to this result, Central Bank of Iran can reduce inflation uncertainty by reducing inflation.

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