Inflation Uncertainty and Economic Growth in Iran

1Ahmad Jafari Samimi, 2Behnam Shahryar

1Professor of Economics, Mazandaran University, Babolsar, Iran. 2PhD Student of Mazandaran University, Babolsar, Iran.

Abstract: This paper examines the effects of inflation uncertainties on real GDP growth in Iran. We argue that inflation uncertainty has negative impacts on real GDP growth. In this paper, we use GARCH and GARCH-M models for formulating inflation uncertainty and its effect on real GDP growth and inflation. The empirical evidence, based on time series models, points out that uncertainty arising has negative impacts on real GDP growth. However, the effect of uncertainty due to heteroskedasticity in disturbances (conditional variance) on real GDP growth is significant. Moreover, there is a positive inflation and inflation uncertainty.

Key words: Inflation Uncertainty; Real GDP Growth; GARCH Models.

INTRODUCTION

Economists have long been interested in the effects of inflation on real economic variables. In the past two decades, this line of research has expanded greatly, spurred on by the relatively high inflation rates in the developed economies beginning in the 1970s and the coincident slowing in the rate of output growth. One traditional and widely accepted notion is that anticipated inflation has little or no effect on real variables, except for those effects arising from institutional features such as incompletely indexed tax codes and zero interest payments on currency and reserves. It is also widely accepted that unanticipated inflation affects real variables, at least in the short run. Many analysts also hold that uncertainty about future inflation rates affects real variables. Indeed, Marshall (1886) expressed concern about the negative effects of an uncertain future value of the English pound on output over 100 years ago. More recent arguments in this spirit are contained in Okun (1971) and Friedman (1977), who argue that uncertainty about future inflation is detrimental to real economic activity.

Furthermore, they suggest that uncertainty about future inflation is linked to the mean rate of inflation by the policy environment. Friedman, in particular, argues that nations might temporarily pursue a set of goals for real variables (for example, output, and unemployment) that leads to a high inflation rate. The high inflation rate induces strong political pressure to reduce it, leading to stop-go policies and attendant uncertainty about future inflation. Thus, high inflation coexists with increased inflation uncertainty, as individuals become less certain about the political choice over future inflation paths.

Friedman postulates a negative effect of a highly volatile inflation rate on economic efficiency for two reasons. First, increased volatility in inflation makes long-term contracts more costly because the future value of dollar payments is more uncertain. Second, increased volatility in inflation reduces the ability of markets to convey information to market participants about relative price movements. By reducing economic efficiency, greater inflation uncertainty should at least temporarily increase the rate of unemployment and reduce economic growth. It follows from the Phillips' Curve,

\[ U_t = U_n - \beta (\bar{P}_t - E(\bar{P})) \]  \hspace{1cm} (1)

Where \( U_t \) is the unemployment rate at \( t \), \( U_n \) is the natural rate of unemployment, \( E(\bar{P}) \) is the expectation of inflation and \( \bar{P}_t \) is the rate of inflation at time \( t \). The conditional variance of unemployment is proportional to the conditional variance of inflation. That is,

\[ E[(U_t - U_n)^2] = \gamma E[ (\bar{P}_t - E(\bar{P}))^2] \]  \hspace{1cm} (2)

\( \gamma = \beta^2 \)
Hence, if inflation increases the conditional variance of inflation, that is "inflation uncertainty", then it also increases uncertainty about unemployment. By Okun's Law it also follows that output uncertainty also increases with the level of inflation. If explanation of the positive correlation between inflation and inflation uncertainty is consistent with the data (Ball 1992), then uncertainty about unemployment will be positively correlated with inflation and inflation will Granger Cause unemployment uncertainty.

At least since Friedman (1977), economists have argued that inflation uncertainty reduces economic growth. A number of empirical studies support this argument (see Holland 1993 for a survey and Davis and Kanago 1996 as a recent example). Since inflation uncertainty and unemployment uncertainty are positively correlated, these empirical studies may be capturing in part the effect of uncertainty about future economic activity on output. There are several reasons why uncertainty about future economic activity may reduce economic growth.

One channel through which this may occur is investment. Higher unemployment uncertainty, or equivalently via Okun's Law output uncertainty, implies greater uncertainty about the future marginal product of capital. For irreversible and postponable investment projects, greater uncertainty about the marginal product of capital leads to less investment (See Dixit and Pindyck 1994). In a growth accounting framework, lower levels of investment lead to slower growth. In a Keynesian model, decreased investment implies decreased demand which in turn results in temporarily slower growth of output. Consistent with this channel, Aizenman and Marion (1993) find, for a cross-section of developing countries, a negative correlation between private investment and measures of macroeconomic uncertainty.

Ramey and Barney (1995) suggest an alternative channel through which output uncertainty leads to slower growth. Ramey and Barney find that countries with higher output volatility (measured as the variance of the growth rate of per capita output) have lower growth. However, inconsistent with output uncertainty causing less investment, they find that a country's investment share of output is uncorrelated with output volatility. Ramey and Ramey suggest that increased output volatility leads to increased planning errors, which result in decreased output growth. Though these theoretical concerns about the effect of inflation uncertainty seem reasonable and persist in economic discussions, existing studies provide only mixed support for them.

This paper studies the relationships between the variance (conditional variance) of the inflation rate and output growth rate for the Islamic Republic of Iran in another attempt to identify the hypothesized negative relationship of inflation uncertainty on rate of output growth. To put this study into perspective, the following section briefly reviews the findings of several previous studies, with particular attention to the relationship between the measure of inflation uncertainty employed in each study and evidence about the link between inflation uncertainty and real economic variables.

Review of the Recent Literature: Empirical studies of the effect of inflation uncertainty tend to follow one of three broad approaches. The first is that used by Okun (1971), who gathers data for 17 developed countries over 17 years and calculates the mean and variance of the inflation rate for each country. By plotting the mean inflation rate vs. the standard deviation of the inflation rate for these countries, he finds that these two variables are positively related. Logue and Sweeney (1981) use Okun's methodology and find that both the mean and variance of inflation are positively related to the variance of output growth. Gale (1981) gives reasons to doubt that this homogeneity exists, including noncomparability of indexes and different levels of development across countries. Indeed, Katsimbris (1985) strongly rejects the hypothesis of homogeneity across countries.

Katsimbris (1985) does this for 18 OECD countries. He constructs proxies for the time-varying mean and variance of inflation and output growth as eight-quarter, non-overlapping, moving averages. He finds few countries for which the mean and variance of inflation are related in a statistically significant way and even fewer for which the variance of inflation and the mean or variance of output growth are related. In particular, he finds no significant relationship between inflation uncertainty and output growth in the United States. Thornton (1988), in a recent study employing this methodology, obtains the same results. Katsimbíé’s study of individual countries is but one example of a number of studies that use this second approach. Their main feature is the construction of proxies for inflation uncertainty. In addition to Katsimbíé’s eight-quarter, no overlapping, moving averages, others estimate time series models for the inflation rate and the real variables and use the residuals to construct overlapping moving-average measures to proxy for the time-varying variance of inflation. All of these studies estimate a model of inflation under the maintained hypothesis of homoskedasticity and then estimate a proxy for the time-varying (heteroskedastic) conditional variance from the residuals, but more recent studies use ARCH and GARCH models for modeling inflation uncertainty.
Mullineaux (1980) uses the standard deviation of individual inflation forecasts about the mean value to measure inflation uncertainty. He finds that the sum of current and lagged values of this measure of inflation uncertainty is significantly and positively related to the unemployment rate and significantly and negatively related to the level of industrial production. A more recent study by Hafer (1986) confirms these results with an alternative survey of inflation expectations.

Jyh-Lin, Show-Lin, Hsiu-Yun (2003), based on arch models by using Quarterly data of real GDP and the consumer price index (CPI) for the United States, find that The effect of uncertainty due to heteroskedasticity in disturbances on real GDP is insignificant.

The Model:
Granger Causality Test:
A time series \( \hat{P} \) is said to Granger-cause GR (\( \hat{P} \) and \( GR \) are inflation and output growth rate) if it can be shown, usually through a series of F-tests on lagged values of \( \hat{P} \) (and with lagged values of \( GR \) also known); that those \( \hat{P} \) values provide statistically significant information about future values of \( GR \). this can be shown by a VAR model. In fact, an approach to explore the link between output growth and inflation is to estimate a VAR model between these variables. As we know, a VAR model uses historical data to predict future values and study innovations in a variable in another variable. In this case, based on Granger causality test, we study effect of innovations in inflation uncertainty result in reductions in output growth. We can write mentioned VAR model as follows:

\[
X = \mu + B(L)X + e
\]

Where \( X \) is a \((2 \times l)\) vector of variables (\( \hat{P} \) and \( GR \)), \( \mu \) is a \((2 \times l)\) vector of constant terms, \( B(L) \) is a polynomial of degree \( m \) in the lag operator \((L)\), and \( e \) is a \((2 \times l)\) vector of error terms.

Volatility Model:
In this paper, we use conditional heteroskedastic variance for modeling volatility of inflation as inflation uncertainty. The class of ARCH models allows us to estimate time varying conditional variance. Generalized ARCH (GARCH) models include lags of the conditional variance to estimate the conditional variance of the model. Nelson (1991) proposes an extended version of such models: EGARCH. EGARCH method is more advantageous than both ARCH and GARCH methods to model inflation uncertainty for the following reasons. First, it allows for the asymmetry in the responsiveness of inflation uncertainty to the sign of shocks to inflation. Second, unlike GARCH specification, the EGARCH model, specified in logarithms, does not impose the nonnegativity constraints on parameters.

In econometrics, an autoregressive conditional heteroskedasticity (ARCH, Engle (1982)) model considers the variance of the current error term to be a function of the variances of the previous time period's error terms. ARCH relates the error variance to the square of a previous period's error. It is employed commonly in modeling time series that exhibit time-varying volatility clustering, i.e. periods of swings followed by periods of relative calm. We can show an ARCH (p) model (where \( p \) is length of \( \varepsilon \) lags) as follows:

\[
\text{Conditional Mean, } AR(n): X_{t,0} = \alpha_0 + \sum_{j=1}^{n} \alpha_j X_{t-j,0} + \varepsilon_{t,0}, \quad j=1,2
\]

\[
\text{Conditional Variance, ARCH(p): } \sigma_{t,0}^2 = \beta_0 + \sum_{j=1}^{p} \beta_j \varepsilon_{t-j,0}^2 + \nu_t
\]

Where \( \nu \) is a standard normal variable, \( j \) is index of variables \( \hat{P} \) and \( GR \). If an autoregressive moving average model (ARMA model) is assumed for the error variance, the model is a generalized autoregressive conditional heteroskedasticity (GARCH, Bollerslev (1986)) model. In that case, the GARCH (q, p) model (where \( q \) is the order of the GARCH terms and \( p \) is the order of the ARCH terms) is given by

\[
\text{GARCH(q,p): } \sigma_{t,0}^2 = \omega + \sum_{i=1}^{p} \beta_i \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \gamma_i \sigma_{t-i}^2 + \nu_t
\]
The number of lags of GARCH and ARCH models' functions can be counted by the use of Akaike and Schwarz criterions and also other related criterions. For recognizing the test of non-existence of ARCH or/and GARCH models, we can use recognizing test of heteroscedasticity in Lagrange-Engle multiplier (1982).

As we see in equations (4) and (5), ARCH and GARCH model are symmetric models. In these models, negative and positive volatilities have the same weights. But, as Brunner and Hess (1993) and Joyce (1995) have shown, positive volatilities include more uncertainty than negative volatilities, consequently, we should use asymmetric models. The one of these models is Exponential GARCH or EGARCH. The exponential general autoregressive conditional heteroskedastic (EGARCH) model is introduced by Nelson (1991). The specification for the conditional variance is

\[ \text{EGARCH}(q, p) : \log \sigma_t^2 = \omega + \sum_{j=1}^{p} \beta_j \left( \frac{\varepsilon_{j,t-1}}{\sigma_{j,t-1}} \right) + \mu \left( \frac{\varepsilon_{j,t-1}}{\sigma_{j,t-1}} \right) + \sum_{k=1}^{q} \gamma_{jk} \log \sigma_{j,t-k}^2 + u_t \]  

(4)

Since may be negative there are no (fewer) restrictions on the parameters. Note that the left-hand side is the log of the conditional variance. This implies that the leverage effect is exponential, rather than quadratic, and that forecasts of the conditional variance are guaranteed to be nonnegative. The presence of leverage effects can be tested by the hypothesis that \( \mu = 0 \). The impact is asymmetric if \( \mu > 0 \). An important generalization of ARCH and GARCH models that we will employ in this paper is the ARCH-M, GARCH-M or EGARCH-M models, that allows for the variance terms of both \( \varepsilon_t \) and \( \sigma_t \) to enter the conditional mean equations for both those. Consequently, we can see affecting conditional variances on mean variances. For this, we can write equation (4) as follows:

\[ \text{Conditional Mean, ARMA}(p, m) : X_{jt} = \alpha_0 + \sum_{k=1}^{p} \alpha_k X_{j,t-k} + \sum_{k=1}^{m} \varepsilon_{j,t-k} + \sum_{j=1}^{2} \gamma_{j} \left( \log \sigma_{j,t}^2 \right), \quad j = 1, 2 \]

\[ \log \sigma_t^2 = \omega + \sum_{j=1}^{p} \beta_{jt} \left( \frac{\varepsilon_{j,t-1}}{\sigma_{j,t-1}} \right) + \mu \left( \frac{\varepsilon_{j,t-1}}{\sigma_{j,t-1}} \right) + \sum_{k=1}^{q} \gamma_{jk} \log \sigma_{j,t-k}^2 + u_t \]  

(5)

**Empirical Results:**

The literature on the costs of inflation suggests innovations in inflation uncertainty result in reductions in output growth. So that, this study investigates the effects of inflation uncertainty by looking at a seasonal time series of data for the Iran, following the second approach discussed above. Unlike most previous studies, however, this investigation uses a statistical technique, the GARCH model, which parameterizes the mean and variance relationships under investigation. This permits straightforward estimation and hypothesis testing in an internally consistent framework. The measure of inflation uncertainty employed here is the time-varying conditional variance of the inflation equation. We model the inflation, meal output growth system over the 1988:4-2006:4 periods using seasonally data on real GDP and the CPI growth rate as inflation. Considering figure 1, we can see a negative relationship between variables GH and GR, so that it can be said innovation in INR has a negative effects on GR overtime.

Preliminary diagnostic tests were conducted to check for unit roots and time trends in the variables (INR, GR). These are reported in table 1. Neither inflation nor output growth exhibited a time trend. For output growth, the null hypothesis of a unit root was rejected. Augmented Dickey-Fuller test for unit root in the inflation variance and output growth rate processes are test failed to do so, in the other words, both GR and INR are stationary. Afterwards, by using a VAR model, we examine Granger causality test as test of causality relationship between GR and INR. Based on this test, GR has been function of INR. In the other words, according to the table 2, causality relationship between output growth rate (GR) and inflation rate is significant at 5% level in lags 5. Consequently, we can study relationship between output growth rate (GR) and inflation rate in EGARCH-M model.

The ARCH-LM test, also reported in table 3, rejects the null hypothesis of homoscedasticity for the both inflation and output growth equations. Whereas, based on correlogram Q-statistics that are exhibited in appendix 1, we had specified ARMA models for series, and so that, we have estimated two GARCH models for these conditional variances (but lags of GARCH models are selected by Akaike “AIC” criterion). The results of ARMA and GARCH models are shown in table 4. In this table, inflation rate (INR) and GDP growth rate are the ARMA (3, 1) and ARMA (1, 1). Predicted conditional variances are shown in figure 2.
Table 1: Unit Root Test of Series

<table>
<thead>
<tr>
<th>Series</th>
<th>ADF Statistic</th>
<th>1% Critical Value</th>
<th>5% Critical Value</th>
<th>10% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR</td>
<td>-4.447474</td>
<td>-3.5682</td>
<td>-2.9215</td>
<td>-2.5983</td>
</tr>
<tr>
<td>INR</td>
<td>-3.184427</td>
<td>-3.5814</td>
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Table 2: Granger Causality Test of Series

<table>
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<tr>
<th>Null Hypothesis</th>
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<th>Probability</th>
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<tr>
<td>INR does not Granger Cause GR</td>
<td>64</td>
<td>2.63592</td>
<td>0.01780</td>
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<td>GR does not Granger Cause INR</td>
<td>0.89337</td>
<td>0.58038</td>
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Table 3: ARCH-LM Test of Series

<table>
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<tr>
<td>GR</td>
<td>F-statistic</td>
<td>3.158979</td>
</tr>
<tr>
<td></td>
<td>Obs*R-squared</td>
<td>8.740462</td>
</tr>
<tr>
<td>INR</td>
<td>F-statistic</td>
<td>9.664508</td>
</tr>
<tr>
<td></td>
<td>Obs*R-squared</td>
<td>8.645115</td>
</tr>
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Fig. 1: Scatter Graph between INR and GR

Fig. 2: EGARCH Processes of Inflation and Output Growth

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2923
To determine the sensitivity of the results to the conditional variances, we use GARCH-M model. The coefficients on the conditional variance terms entering the output growth equation are significant at the 5 percent level, but the same coefficients entering inflation equation are significant at the 5 percent and 10 percent level for conditional variances of inflation (ING) and output growth (GG), respectively. In the other words, conditional variances affect on both series. As it is known from table 5, the relationship between ING and GR is significantly negative, but the relationship between ING and INR is positive. According to this statement, inflation uncertainty affects negatively on GDP growth rate and cause increasing in inflation. Furthermore, conditional variance of output growth affects positively on inflation and output growth equations. In fact, economic volatilities and fluctuations motivate economic growth and inflation. Therefore, it is obvious that we can confirm Friedman’s statement about undesirable effects of high inflation on economic growth and inflation rates in Iran.

Table 4: ARMA and GARCH Models of Series

<table>
<thead>
<tr>
<th>Series</th>
<th>ARCH-LM Test:</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR</td>
<td>F-statistic 3.158979</td>
<td>0.002819</td>
</tr>
<tr>
<td>INR</td>
<td>F-statistic 9.664508</td>
<td>0.003279</td>
</tr>
</tbody>
</table>

Table 5: GARCH-M Models of Series

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GG</td>
<td>0.031</td>
<td>0.018</td>
<td>1.608</td>
<td>0.113</td>
</tr>
<tr>
<td>ING</td>
<td>0.079</td>
<td>0.042</td>
<td>1.928</td>
<td>0.000</td>
</tr>
<tr>
<td>C</td>
<td>4.215</td>
<td>0.156</td>
<td>2.704</td>
<td>0.007</td>
</tr>
<tr>
<td>AR(1)</td>
<td>-0.499498</td>
<td>0.110796</td>
<td>-4.508286</td>
<td>0.000</td>
</tr>
<tr>
<td>AR(2)</td>
<td>0.512659</td>
<td>0.078893</td>
<td>6.498133</td>
<td>0.000</td>
</tr>
<tr>
<td>MA(1)</td>
<td>-0.378135</td>
<td>0.189420</td>
<td>-1.996281</td>
<td>0.045</td>
</tr>
<tr>
<td>F-statistic</td>
<td>3.161</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.307</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obs*R-squared</td>
<td>8.645115</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probability</td>
<td>0.032948</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusion:

The evidence presented here lends support to the hypothesis that uncertainty about the future inflation rate leads to a reduction in the rate of output growth. Further, using a long series of Iran inflation and real output growth data, we have provided strong evidence in favor of hypotheses that “inflationary periods are associated with high inflation uncertainty” and “inflation uncertainty affects negatively on real economics activity”. These results support the Friedman hypothesis. Consequently, more inflation uncertainty leads to lower output growth.

REFERENCES


