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The Relation Between Inflation and Inflation Uncertainty In Iran

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Abstract

Decreasing inflation uncertainty, as the major source of welfare costs, requires finding the driving factors of this variable. Counting inflation as one of the driving factors of inflation uncertainty has created some concern due to the ambiguity over the causality between inflation and inflation uncertainty. This ambiguity has inspired several studies in the literature, which mostly focuses on testing two separate hypotheses to solve this ambiguity. These hypotheses are Friedman-Ball hypothesis, which assumes higher inflation leads to higher inflation uncertainty, and Cukierman-Meltzer hypothesis, which claims the reverse. After testing for Friedman-Ball and Cukierman-Meltzer hypotheses in Iranian economy, with applying TGARCH and EGARCH models, this study reveals that EGARCH model supports the asymmetry in error terms distribution of Iranian data and accepts both hypotheses. However, results based on TGARCH approach do not support the asymmetry in error terms distribution, which implies TGARCH model is not reliable for Iranian data.

Keywords: Inflation, Inflation uncertainty, Autoregressive Conditional Heteroskedasticity (ARCH), Conditional Variance.

1- Introduction

Inflation uncertainty is a major source of the welfare costs. Uncertainty about future inflation distorts efficient allocation of resources, which causes to lower level of economic activity, and reduces the real value of government liabilities held by the public.[1] Inflation uncertainty also improves the position of debtors, while worsens the position of creditors in the contracts that are written in nominal terms. These costs and their impacts on the economy make the analysis of driving factors of inflation uncertainty imperative.

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1- Crawford and Kasomuvich (1996); Alexandros Kontonikas (2001)

One of the driving factors of inflation uncertainty is the inflation rate. However, inflation uncertainty sometimes increases the inflation rate as well. These relations have raised the question of causality between these two variables in the literature. Previous studies in the literature mostly focus on testing two hypotheses, based on different methodologies, for different developed countries to decide the direction of this causality. These hypotheses are Friedman-Ball hypothesis (F-B), which is higher inflation leads to higher inflation uncertainty, and Cukierman-Meltzer hypothesis (C-M), which is higher inflation uncertainty leads to higher inflation. All based on developed countries, some of the studies support F-B and C-M, while others accept one of them. As a result, literature cannot provide a common agreement on accepting or rejecting the hypotheses in the context of investigated developed countries.

Despite the fact that such an analysis might assist Iranian policy makers in controlling the welfare costs of inflation uncertainty, the analysis of these hypotheses for Iranian economy has not been made in the literature. As a result, the purpose of this paper is making a contribution to this analysis on Iranian economy from1960 to 2000.

Previous studies mostly employ a proxy variable for measuring inflation uncertainty, since there is no observable data for this variable. In general, based on the literature, there are two possible proxy variables for inflation uncertainty, which are the survey-based measure and the conditional variance of autoregressive Conditional heteroskedasticity (ARCH) class of models. The survey-based measure is not available for Iranian data, which leaves the Iranian analysis of these hypotheses with no choice other than relying on the conditional variance of the ARCH class of models.[1]

The framework of the paper is as follows:

Section one outlines different ARCH class of models as well as a review over the literature; section two and three contain data analysis and estimates; and section four displays concluding remarks.

1- For detailed explanation of the survey-based proxy refer to Marc D.Hayford (2000).

2- ARCH-GARCH Class of models and literature review

Friedman (1977) in his Nobel lecture argued that higher inflation leads to higher inflation uncertainty without offering any specific economic modeling to support his hypothesis. He explained that higher inflation uncertainty, resulted from higher inflation, distorts the efficient allocation of resources, and decreases economic growth. These relations create a testable hypothesis that higher inflation leads to lower output; i.e. a positively sloped Philips curve. A further justification for this relation could be explained through another economic channel. Higher inflation rate could raise inflation uncertainty and unemployment uncertainty. This is equivalent to a raise in output uncertainty via Okun's Law. This situation implies higher uncertainty about the future marginal product of capital that leads to less investment, according to Dixit and Pindyc (1994). This causes lower economic growth based on the Growth Accounting framework.

Ball (1992) presented a theoretical model for Friedman's idea in the context of an asymmetric information game between the public and the policy maker. He argued that the positive correlation between inflation and inflation uncertainty is due to the increase in private agents' uncertainty about future monetary policy. He continued that at any point in time, private agents are uncertain as to whether the monetary authority is "conservative" or "liberal," since they alternate in the office stochastically, and do not know how long each of these authorities will preserve their position in the office. By Ball's definition, a conservative monetary authority cares only about keeping inflation low, while a liberal monetary authority is willing to trade some higher inflation for lower unemployment. When inflation is low, both conservative and liberals will target monetary policies at keeping inflation at a low rate. However, if some exogenous shock increases the inflation rate, a conservative will immediately adopt monetary policies to decrease inflation rate, while liberals may dither. Thus lower inflation results in lower private agent's uncertainty on inflation and vice versa.

Cukierman (1992) and Cukierman and Meltzer (1986), with considering the Barro-Gordon model of federal's behavior, analyzed the other direction of causality between inflation and inflation uncertainty. They pointed that the federal (policy maker) dislikes inflation, but seeks to stimulate the economy with surprise inflation. Their model includes both the policy-maker's objective function and the money supply process as random variables, which implies that the public has an inference problem when observing higher inflation. They should ask themselves whether the federal's weight on increased employment has gone up, or the higher inflation is the result of a random money supply disturbance. Cukierman and Meltzer showed that an increase in inflation uncertainty raises the optimal average inflation rate, by increasing the federal's incentive to create inflation surprises to stimulate real activity.

The causation and correlation ambiguity between inflation and inflation uncertainty has inspired several studies in the literature, and a considerable volume of empirical research has tested F-B and C-M hypotheses in different countries, and they found different results. Conventional ARCH-GARCH models, which have the assumption of linearity and normality, as one of the approaches for testing these hypotheses, were almost used for the first time by Engle (1982) for UK, and Bollerslev (1986) for US. Their models were symmetric, which means positive and negative shocks have the same effects. Engle and Bollerslev did not perform a statistical test for F-B hypothesis. They only compared the estimated conditional variance series with the average inflation rate, and they found no significant relation between inflation and inflation uncertainty.

According to the literature, conventional ARCH (p) and GARCH (p,q) models to test F-B hypothesis are as follows[1]:

$$\pi_t = \mu + \gamma_1\pi_{t-1} + \ldots + \gamma_n\pi_{t-n} + \varepsilon_t \quad (1)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \ldots + \alpha_p\varepsilon_{t-p}^2 + \delta_2\,\pi_{t-1} \quad (2)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \ldots + \alpha_p\varepsilon_{t-p}^2 + \beta_1\sigma_{t-1}^2 + \beta_2\sigma_{t-2}^2 + \ldots + \beta_q\sigma_{t-q}^2 + \delta_2\,\pi_{t-1} \quad (3)$$

Where equation (1) is the mean equation, and Equations (2) and (3) are Conditional variance functions or the proxy for inflation uncertainty in ARCH (p) and GARCH (p,q) models, respectively. [2] Error terms are normally distributed according to $\varepsilon_t \mid \Psi_t \sim N(0, \sigma_t^2)$, where Ψ_t is an information matrix. The level of inflation, π_t, should be considered in conditional variance equation

1-Greene (2003) pages 240 and 241.

for testing the F-B hypothesis. If δ_2 is positive and significant, F-B hypothesis is accepted.

Conventional ARCH (p) and GARCH (p,q) models for testing C-M hypothesis are given in equations (4)-(6), and if γ_2 is significant, C-M hypothesis is accepted:[1]

$$\pi_t = \mu + \gamma_1\pi_{t-1} + \ldots + \gamma_n\pi_{t-n} + \gamma_2\sigma_t^2 + \varepsilon_t \quad (4)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \ldots + \alpha_p\varepsilon_{t-p}^2 \quad (5)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \ldots + \alpha_p\varepsilon_{t-p}^2 + \beta_1\sigma_{t-1}^2 + \beta_2\sigma_{t-2}^2 + \ldots + \beta_q\sigma_{t-q}^2 \quad (6)$$

Grier and perry (1998) employed the conventional GARCH model for both F-B and C-M hypotheses, and found that in all G7 countries[2] over the period of 1948-1993, inflation caused inflation uncertainty. Weaker evidence was found that inflation uncertainty Caused higher inflation. In three countries of G7 (US, UK and Germany) increased inflation uncertainty lowered inflation while in two countries (Japan and France) increased inflation uncertainty raised inflation. Thus increased uncertainty significantly affected future inflation in more than half of the countries in the sample. These different responses to inflation uncertainty are correlated with a measures of central bank independence. Using Cukierman's (1992) ratings, the US and Germany's central banks average is 0.585 on an independence scale that goes from zero to one (maximum independence), while Japan and France average is only 0.220.This implies that the most independent central banks are in countries where inflation falls in response to increased uncertainty.

Asymmetric ARCH and GARCH models have also been employed in the literature. In these models positive and negative shocks do not have the same effects. Some of these models are threshold GARCH or TGARCH, introduced by Zakoian (1991), and exponential GARCH or EGARCH, introduced by Nelson (1991).

Bruner and Hess (1993), and Joyce (1995) both rejected the symmetry restriction in their GARCH models for UK and US data, but Crawford and Kasumovich (1996) did not found asymmetry in Canada, when they estimated

1- Greene (2003) pages 240 and 241.
2- US, Canada, Japan, France, Germany, Italy, and the United Kingdom.

average GARCH or AGARCH, and TGARCH[1] models instead of a conventional GARCH model. Furthermore, Joyce (1995) with using GARCH, AGARCH, EGARCH[2] and TGARCH found mixed result for Canada. Baillie et al (1996) for UK, Argentina, Brazil, Israel, and G7 and, Grier and Perry (1998) for G7 countries found different results for different countries.

The literature provides the TGARCH and EGARCH models to test F-B hypothesis as follows:

$$\pi_t = \mu + \gamma_1\pi_{t-1} + \ldots + \gamma_n\pi_{t-n} + \varepsilon_t \qquad (7)$$

$$\sigma_t = \alpha_0 + \alpha_1^+ \varepsilon_{t-1}^+ - \alpha_1^- \varepsilon_{t-1}^- + \ldots + \alpha_p^+ \varepsilon_{t-p}^+ - \alpha_p^- \varepsilon_{t-p}^- + \delta_1\sigma_{t-1} + \delta_2\sigma_{t-2} + \ldots + \delta_q\sigma_{t-q} \; {}^{3} \qquad (8)$$

$$\varepsilon_t^+ = \max(\varepsilon_t, 0) \text{ and } \varepsilon_t^- = \min(\varepsilon_t, 0)$$

$$\log \sigma_t^2 = \alpha_0 + \alpha_1 \log \sigma_{t-1}^2 + \alpha_2 |(\varepsilon_{t-1}/\sqrt{\sigma_{t-1}^2})| + \alpha_3(\varepsilon_{t-1}/\sqrt{\sigma_{t-1}^2}) + \delta_2\pi_{t-1} \; {}^{4} \qquad (9)$$

Equations (8) and (9) are Conditional variance functions or the proxy for inflation uncertainty[5] in TGARCH and EGARCH models, respectively. However, estimating TGARCH with this equation in practice is difficult. The practical specification of TGARCH model is: [6]

$$\pi_t = \mu + \gamma_1\pi_{t-1} + \ldots + \gamma_n\pi_{t-n} + \varepsilon_t \qquad (10)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \delta_1\sigma_{t-1}^2 + \varphi\tau_{t-1}\varepsilon_{t-1}^2 + \delta_2\pi_{t-1}$$

$$\tau_{t-1} = \begin{cases} 0 & \text{if } \varepsilon_{t-1} \geq 0 \text{ (Positive shock)} \\ 1 & \text{if } \varepsilon_{t-1} < 0 \text{ (Negative shock)} \end{cases} \qquad (11)$$

α_3 and φ is the asymmetric parameters in equations (9) and (11), respectively. If $\varphi \neq 0$ in TAGRCH and $\alpha_3 \neq 0$ in EGARCH, it implies asymmetry in error terms distribution of the model. In both models, if δ_2 is positive and significant, it means the F-B hypothesis is accepted. τ is also threshold indicator function in TGARCH model.

1- Threshold GARCH.
2- Exponential GARCH.
3- Zakoian (1990).
4- Nelson (1991).
5- Greene (2003) page 240.
6- Johnson (2002).

TGARCH and EGARCH models to test C-M hypothesis are displayed as follows:

$$\pi_t = \mu + \gamma_1 \pi_{t-1} ++ \ldots + \gamma_n \pi_{t-n} + \gamma_2 \sigma_t^2 + \varepsilon_t \qquad (12)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \delta_1 \sigma_{t-1}^2 + \varphi \tau_{t-1} \varepsilon_{t-1}^2$$

$$\tau_{t-1} = \begin{cases} 0 & \text{if } \varepsilon_{t-1} \geq 0 \text{ (Positive shock)} \\ 1 & \text{if } \varepsilon_{t-1} < 0 \text{ (Negative shock)} \end{cases} \qquad (13)$$

$$\log \sigma_t^2 = \alpha_0 + \alpha_1 \log \sigma_{t-1}^2 + \alpha_2 |(\varepsilon_{t-1}/\sqrt{\sigma_{t-1}^2})| + \alpha_3(\varepsilon_{t-1}/\sqrt{\sigma_{t-1}^2}) \qquad (14)$$

In both models, if γ_2 in equation (12) is positive and significant it means the C-M hypothesis is accepted.

The literature provides further empirical studies on these hypotheses. Stilianos Fountas (2000) used TGARCH in UK to test F-B hypothesis and found positive and significant relation. Bilin Neyapti (2000) used just a simple ARCH model to test F-B hypothesis in Turkey and accepted this hypothesis. Table one in the appendix shows a summary of previous works for testing these hypotheses in the literature.

3- Data Analysis

The average Iranian inflation from 1960 to 2000 was 14.33%, and the standard deviation was 11.08%. Figure 1 displays Iranian inflation based on annual Iranian Consumer Price Index, and it shows an upward trend in inflation rate with several fluctuations.[1]

1- www.cbi.ir
The inflation has been calculated according to following formula:
$P = \pi_t = ((CPI - CPI(-1))/CPI(-1)) \times 100$

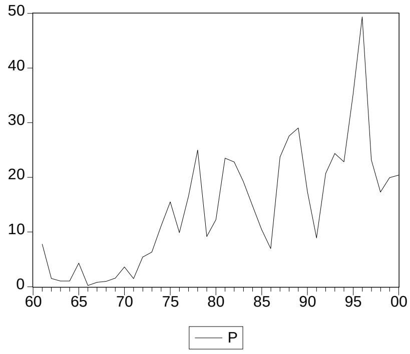

Figure 1

There are some historical reasons for such an inflationary experience over this period. Before 1973, price levels were decided by a supply and demand mechanism. From 1973 to 1978, oil prices increased that accumulated a huge financial reserve for Iranian economy. The injection of this income to economy raised the demand level, while Iranian economy was not able to provide this demand, and ended in higher inflation rate. This situation forced government toward controlling inflation rate which required direct government intervention in the market. From 1979 to 1989, revolution and eight years Iraq-Iran war happened, which further made government to intervene in price mechanism. In 1989-1994, war was over and economy began to recover from war. Government intervention in price mechanism decreased, but country was still struggling with high inflation. After 1994, government used price control policies again. In 1996, liberals took office from conservatives, which promoted inflation rate again. The economy was also struggling with its debt payments, because the due dates of debts arrived at the beginning of the liberal's authority. Since then, economy has been struggling with inflation, and government has been controlling the price mechanism.[1]

Descriptive statistics of inflation time-series display that this variable has a Leptokurtic distribution. In addition, this time series is stationary, based on Aumented Dicky-Fuller (ADF) and Phillips-Perron (PP) tests.[2] ADF statistics

1- Behkish (2001) pages 160-163.
2- Maddala and Kim (2002) page 77.

with trend and intercept is -4.814234, and PP statistics with trend and intercept is –3.987860.

OLS approach assists in finding the residual distribution of equation (15) before testing F-B, and C-M hypotheses. In this equation, D is a dummy variable for the period of war, or 1981-1989 that assigns one for war period and zero otherwise. The lowest amounts of Akaike and Schwarz criterion, 6.98 and 7.11 respectively, indicate that only one lag is appropriate for this equation:

$$\underset{(2)}{\pi_t=3.86}+\underset{(0.115)}{0.712\,\pi_{t-1}}+\underset{(0.155)}{0.129\,D\pi_{t-1}}+\varepsilon_t \qquad (15)$$

[1]

Estimates show that lagged inflation rate has a positive significant effect on inflation rate, but war Dummy variable has an insignificant effect. The intense government intervention during the war could be a reason for this insignificant effect. Descriptive analysis reveals that the distribution of error terms in equation (15) has a positive skewness equal to 0.61, which indicates asymmetry in distribution. Furthermore, the kurtosis of the distribution is 3.5, which is bigger than 3. Hence error terms are not normally distributed and the unconditional distribution is non-normal.

A Gauss Newton Regression (GNR) equation with two lags, because of annual data, has been estimated to test the hypothesis of no serial autocorrelation. [2] The maximum likelihood test statistics is $nR^2=37*0.09=3.33$, which implies residuals are not identically independent distributed, and the hypothesis is rejected at 5% level of significance. This result further supports the existence of time varying conditional variance or ARCH effect in residuals.

4- Estimation

Iranian data displays skewness and Kurtosis in error terms distribution, which implies asymmetry or different effect from positive and negative shocks. As a result, Iranian data requires an application of asymmetric ARCH class of

1- Std error

2- For more detailed explanation on this equation refer to Davidson and Mackinnon (2003), Chapter 5.

models. The question is on choosing the appropriate asymmetric model. Specifying a general model that nests all the ARCH- GARCH class of models facilitates the finding of an appropriate asymmetric model. Box-Cox AGARCH model presented by Hentschel (1995) nests all of the symmetric and asymmetric ARCH-GARCH class of models. This general representation is able to simulate actual volatility process such as GARCH, TGARCH and EGARCH after imposing specific restrictions. In the case of Box-Cox-AGARCH (1, 1), this general model is:

$$((\sigma_t^{\lambda}-1)/\lambda)=\beta_0+\gamma_1\, \sigma_{t-1}^{\lambda} f^{\nu}\, (\varepsilon_{t-1}/\, \sigma_{t-1})+\beta_1\, ((\sigma_{t-1}^{\lambda}-1)/\lambda)+\sum \psi_s y_{t-s} \qquad (16)$$

$$f\, (\varepsilon_{t-1}/\, \sigma_{t-1})=|\, (\varepsilon_{t-1}/\, \sigma_{t-1})-\delta_0|-\delta_1((\varepsilon_{t-1}/\, \sigma_{t-1})-\delta_0) \qquad (17)$$

Asymmetry in Box-Cox-AGARCH (1, 1) comes from $f\, (\varepsilon_{t-1}/\, \sigma_{t-1})$ function in equation (17). This equation has δ_0 and δ_1, which are representing the asymmetric evolution of σ_t^2 when positive or negative shocks affect inflation, and λ, which is displaying transformation coefficient. Likelihood Ratio test (LR), by testing the hypothesis that restricted and unrestricted equations are equal, finds the appropriate model from ARCH-GARCH class of models. When LR statistics that has χ^2 distribution is rejected, it means the unrestricted model or Box-Cox-AGARCH specification is the appropriate model for a given data set.

Another approach in deciding the appropriate model is estimating TGARCH and EGARCH models, and checking the asymmetry in error term distribution of estimated models by finding that whether asymmetric coefficients are significant or not. In order to estimate TGARHC and EGARCH models for Iranian data consistently, quasi-maximum likelihood technique (QMLE) should be applied, because of non-normality in the distribution of Iranian data.[1]The mean equation in EAGRCH and TGARCH models for Iranian data is equation (15). Following specification shows the results for testing F-B by TGARCH model:

$$\pi_t=4.54+0.705\, \pi_{t-1}+0.061\, D\pi_{t-1}+\varepsilon_t \qquad (18)$$

1- Bollerslev and Wooldridge (1992) believe to solve such misspecification, we could use QMLE approach.

(1.15)[1] (0.103) (0.11)

$\sigma_t^2 = 21.64+0.103\varepsilon_{t-1}^2+0.317\ \sigma_{t-1}^2 +1.46\ \pi_{t-1}-0.463\ \varepsilon_{t-1}^2\ \tau_{t-1}$ (19)

(10.05) (0.236) (0.469) (0.936) (0.137)

$\tau_{t-1}=$ 0 if $\varepsilon_{t-1}\geq 0$ (Positive shock)

1 if $\varepsilon_{t-1}< 0$ (Negative shock)

The coefficient of the asymmetric component is significant at 5% level of significance in equation (19), which indicates asymmetry in error terms distribution. With regards to the coefficient of π_{t-1} in equation (19), F-B hypothesis is rejected at 5% level of significance.

For C-M hypothesis, the asymmetric component parameter is insignificant at 5% level of significance in equation (21). This implies employing TGARCH model for testing C-M is not appropriate, because it does not show the expected asymmetry in error terms distribution:

$\pi_t =6.55+0.789\ \pi_{t-1}+0.003\ D\pi_{t-1} -0.064\ \sigma_t^2 +\varepsilon_t$ (20)

(1.55) (0.08) (0.097) (0.04)

$\sigma_t^2 =17.1+0.1\varepsilon_{t-1}^2+0.799\ \sigma_{t-1}^2 -0.674\ \varepsilon_{t-1}^2\ \tau_{t-1}$ (21)

(13.36) (0.089) (0.29) (0.599)

$\tau_{t-1}=$ 0 if $\varepsilon_{t-1}\geq 0$ (Positive shock)

1 if $\varepsilon_{t-1}< 0$ (Negative shock)

The results based on EGARCH model for testing F-B are as follows:

$\pi_t =1.85+0.825\ \pi_{t-1} -0.007D\pi_{t-1} +\varepsilon_t$ (22)

(0.64) (0.026) (0.085)

$\sigma_t^2 =4.88-1.036\ \sigma_{t-1}^2 +0.623\ |\ (\varepsilon_{t-1}/\sqrt{}\ \sigma_{t-1}^2)|\ -0.445\ (\varepsilon_{t-1}/\sqrt{}\ \sigma_{t-1}^2) + 0.158\ \pi_{t-1}$ (23)

(0.318) (0.068) (0.352) (0.184) (0.003)

The asymmetric parameter and the coefficient of π_{t-1} are significant at 5% level of significance in equation (23). This means F-B hypothesis is accepted.

EGARCH model in testing C-M is:

$\pi_t=0.311+0.557\ \pi_{t-1}+0.395D\pi_{t-1} +0.11\ \sigma_t+\varepsilon_t$ $l(\theta)=-125.1$ (24)

1- Std Error.

$$\underset{(0.371)}{\sigma_t=5.41}\underset{(0.046)}{-0.69}\,\sigma_{t-1}\underset{(0.321)}{+0.516}\,|(\varepsilon_{t-1}/\sqrt{\sigma_{t-1}})|\underset{(0.118)}{+0.404}\,(\varepsilon_{t-1}/\sqrt{\sigma_{t-1}}) \qquad (25)$$

(1.31) (0.084) (0.061) (0.043)

The coefficient of $(\varepsilon_{t-1}/\sqrt{h_{t-1}})$ is positive and significant at 5% level of significance in equation (25), which implies asymmetry in error terms distribution. The coefficient of σ_t in equation (24) is positive and significant, and C-M hypothesis is accepted.

In TGARCH model, the asymmetric component is only significant in the case of testing F-B. Nevertheless, Iranian data shows asymmetry, and TGARCH model does not support the asymmetry in the case of C-M. In EGARCH model to test F-B and C-M, asymmetric component is significant in both cases. This means EGARCH model supports asymmetry completely. Furthermore, EGARCH model accepts C-M hypothesis, but TGARCH model to test C-M does not show any asymmetry in first place that makes any discussion about acceptance or non-acceptance of C-M irrelevant.

Iran does not have an independent central bank. As a result, an increase in inflation uncertainty should lead to higher inflation i.e. acceptance of C-M, because, according to Grier and Perry (1998), the most independent central banks are in countries where inflation falls in response to increased uncertainty. EGARCH model for testing C-M supports Grier and Perry's idea, but TGARCH does not show such a support. These evidences imply that EGARCH model and its results are more reliable. Based on EGARCH model, both hypotheses are accepted for Iranian data.

5- Conclusion

This paper has analyzed the relation between inflation, measured by the Iranian Consumer Price Index, and inflation uncertainty, measured by the conditional variance of different asymmetric ARCH-GARCH models.

The estimated results from employing EGARCH and TGARCH models in testing F-B and C-M hypotheses do not provide the same conclusions. An explanation is that maximum likelihood approach results in local minimum rather than global minimum in its optimization process. The other reason is the possibility of reaching to saddle point in estimations. Having access to a more accurate data set, and a longer time series on CPI variable could solve such shortcomings.

Estimates based on EGARCH model are more reliable for Iranian data. The estimate of asymmetric component of EGARCH model, in testing both of the F-B and C-M, is significant. This implies that EGARCH model supports the existing asymmetry in the Iranian data. Furthermore, EGARCH model accepts C-M hypothesis which supports the idea of the dependence of Iranian Central Bank on government.

Previous studies in the literature on other countries, which employed EGARCH model, have found different results regarding accepting these hypotheses, but this paper shows that EGARCH model accepts both hypotheses. This difference in results could be related to several factors. Most of the analyzed countries in previous studies were developed countries and located in different regions of the world. However, Iran is a developing county with different economic conditions. Despite the fact that Iranian government tried to control inflation rate over 1960-2000, Iranian economy experienced high inflation rate, but most of the investigated countries in the literature did not experience such high inflation rate.

6- Future Avenues for Research

The major focus of this paper is on time series analysis. The extension of this study to an analysis based on a cross-sectional time-series data set, which analyzes the impact of more similar countries-such as countries in the Middle East- over time on Iranian inflation, could be more realistic. These countries are in the same geographic region as Iran, and most of them have oil income. As a result, a better mean equation specification for testing C-M hypothesis could be

$$\pi_{ti} = \gamma_1 \pi_{it-1} + \gamma_2 \sigma_t^2 + \alpha_i + \varepsilon_t \qquad (26)$$

where α_i captures heterogeneity across Middle Eastern countries.

Appendix:

Table 1

Researcher	Sample	Model	Major finding and other explanation
Okun (1971)	Seventeen industrial countries from OECD 1951-1968	He uses unconditional variance of observed inflation as uncertainty and then compares it with inflation rate	He finds a high positive correlation between the average rate of inflation and its variability but his homogeneity assumption both across countries and within countries makes his result questionable.
Fischer (1981)	US 1806-1979 1945-1976 1947:q_1-1980:q_2	He uses survey-based data for inflation uncertainty and then compares them with inflation rate.	The relationship for 1806-1979 and 1947:q_1-1980:q_2 is positive. For 1945-1976 is positive but uses only seven observations so it is not significant.
Engle (1983)	UK 1958-1977	ARCH	He only compares the estimated conditional variance series with the average inflation rate. He finds no significant relationship between inflation and inflation uncertainty.
Bollerslev (1986)	US 1948-1983	GARCH	He only compares the estimated conditional variance series with the average inflation rate same as Engle. He finds no significant relationship between inflation and inflation uncertainty.
Zarnowits and Lambros (1987)	US 1969-1981	They use confidence interval for individual inflation forecasts as inflation uncertainty that the respondent with wider interval is more uncertain and then compare it with inflation rate.	They say it is better not to use Livingston data for inflation uncertainty because it provides only a measure of the heterogeneity of expectations across individual forecasters. They prefer to use confidence interval for individual inflation forecasts. They find positive relationship between these variables with regards to these probabilistic forecasts.

Evans (1991)	US 1960-1988	Time-varying parameter GARCH Model	Evans considers changes of policy regime on private sector behavior. He finds an unexpected negative relation between these variables in short-run. However, long run uncertainty, which is measured by conditional variance of steady state inflation, was positively related to inflation.
Ball (1992)	Without empirical studies	Barro-Gordon model (1983)	He formalizes Friedman's idea (1977) in the context of an asymmetric information game and concludes that low inflation results in low private agent inflation uncertainty
Cukierman (1992), Cukierman and Meltzer (1986)	Without empirical studies	Barro-Gordon model (1983)	They examine Ball's hypothesis but in opposite direction and conclude that higher inflation uncertainty causes to higher inflation rate.
Bruner and Hess (1993)	US $1947q_1$-$1992q_4$	State-dependant model and EGARCH	They find that a positive inflation shock would create more uncertainty on inflation than a negative shock of equal size so they think asymmetric case exists. They find significant relationship between these two variables.
Joyce (1995)	UK, Canada 1950-1994	GARCH, AGARCH, EGARCH and TGARCH	He finds that positive and negative shocks do not have same effects. He finds mixed results for UK and Canada.

Holland (1995)	US 1954-1990	He uses survey-based data for inflation uncertainty and compares it with inflation rate	He uses a semi-annual, survey based, measure of inflation uncertainty and conducts Granger-causality tests. He finds that inflation Granger causes inflation uncertainty and the uncertainty has a weak but negative effect on average inflation.
Crawford and Kasumovich (1996)	Canada ($1916q_2$-$1994q_3$) ($1963q_3$-$1994q_3$)	They consider two models for mean equation that are autoregressive model and reduced-form Philips curve in GARCH. Also they use AGARCH and TGARCH	In GARCH, in autoregressive case they find a positive significant relationship. In reduced-form Philips curve model they find no significant relationship at %5. In AGARCH and TGARCH they discover no asymmetric effects.
Baillie et al (1996)	UK,Argentina,Brazil and Israel plus G7	GARCH-M	They discover positive bi-directional relationship between inflation and inflation uncertainty only in UK, Argentina, Brazil and Israel.
Grier and Perry (1998)	G7 countries1948-1993	GARCH, AGARCH and used Granger causality test.	In all countries inflation has positive and significant effect on inflation uncertainty but in US, UK and Germany inflation uncertainty lowers inflation. However, in Japan and France inflation uncertainty raises inflation.
Stilianos Fountas (2000)	UK 1885-1998	TGARCH	Inflation has positive and significant effect on inflation uncertainty.
Bilin Neyapti (2000)	Turkey 1982-1999	ARCH	Friedman-Ball hypothesis is accepted.

Marc D.Hayford (2000)	US 1963-1997	He uses Livingston survey based-data and then compares them with inflation rate.Also he does Granger-causality test.	He discovers positive and significant bi-directional effect.
Stilianos Fountas, Meneloas Karanasos and Marika Karanassou (2000)	US 1960-1992	GARCH-M	They find bi-directional relationship.

References

1- BAILLIE R., C. C. A. T. M. (1996), Analyzing Inflation by the Fractionally Integrated ARFIMA-GARCH Model, *Journal of applied Econometrics*, Vol.11, No.1, 1-118.

2- BALL.L (1992), Why Does Higher Inflation Raise Inflation Uncertainty? ,*Journal of Monetary Economics*, Vol.29, 371-378.

3-BARRO.R, and GORDON.D (1983), A Positive Theory of Monetary Policy in a Natural Rate Model, *Journal of political economy*, Vol.91, No.4, 589-610.

4-BERA.ANIL.K, and HIGGINS.MATTHEW.L (1993), Arch Models: Properties, Estimations and Testing, *Journal of Economic Surveys*, Vol.7.

5-BOLLERSLEV.T (1986), Generalized Autoregressive Conditional Heteroskedasticity, *Journal of Political Economy*, Vol.31, 307-327.

6- BRUNNER.A and HESS.G (1993), Are Higher Levels of Inflation Less Predictable? A State-Dependant Conditional Heteroskedasticity Approach, *Journal of business and Economic statistics*, Vol.11, No.2, 187-197.

7- CRAWFORD.ALLAN, and KASUMOVICH.MARCEL (1996), Does Inflation Uncertainty Vary with the Level of Inflation, *Working Paper 96-9, Bank of Canada*.

8- CUKIERMAN.A (1992), Central Bank Strategy: Credibility and Independence, Cambridge, MIT press.

9- CUKIERMAN.A, and MELTZER.A (1986), A Theory of Ambiguity, Credibility and Inflation under Discretion and Asymmetric Information, *Econometrica*, Vol.54, No.5, 1099-1128.

10- DAVIDSON, R., and MACKINNON.J.G (2003), *Economic Theory and Methods*, New York, Oxford University Press.

11- DAVIS, G. K., and K. BRYCE.E (2000), The Level of Uncertainty of Inflation: Results from OECD Forecasts, *Economic Inquiry*, Vol.38, 58-72.

12- DRIFFILL.J, MIZON.G, and ULPHA.A (1990), Costs of Inflation, *Handbook of Monetary economics*, Vol.2, 1014-1066.

13- ENGLE.R (1990), Stock Volatility and the Crash of 87: Discussion, *Review of financial studies*, Vol.3, 103-106.

14- ENGLE.R.F, LILIEN.D, and ROBINS.R (1987), Estimation of Time Varying Risk Premiums in the Term Structure, *Econometrica*, Vol.55, No.2, 391-408.

15- FISCHER.S (1981), Towards an Understanding of the Costs of Inflation: II, *Carnegie-Rochester Conference Series on Public Policy*, 5-41.

16- FOUNTAS.STILIANOS, KARANASOS.MENELOAS, and KARANASSOU.MARIKA (2000), A GARCH Model of Inflation and Inflation Uncertainty with Simultaneous Feedback, *Downloadable at: http://www.york.ac.uk/depts./econ/dp/0024.pdf*.

17- FRIEDMAN.M (1977), Nobel Lecture: Inflation and Unemployment, *Journal of political Economy*, Vol.85, 451-472.

18- GALE.W (1981), Temporal Variability of the Us Consumer Price Index, *Journal of money credit and banking*, Vol.13, No.3, 279-297.

19- GLOSTEN.L, JAGANNATHAN.R, and RUNKLE.D (1993), On the Relation between the Expected Value and the Volatility of the Normal Excess Return on Stocks, *Journal of Finance*, Vol.48, No.5, 1779-1801.

20- GREENE.WILLIAM.H (2003), *Econometric Analysis*, New York, Prentice Hall.

21- GRIER.KEVIN.B, and PERRY.MARK.J (1998), On Inflation and Inflation Uncertainty in the G7 Countries, *Journal of international and money finance*, Vol.17, No.4, 671-689.

22- HANSEN (1982), Large Sample Properties of Generalized Method of Moments Estimators, *Econometrica*, Vol.50, No.4, 1029-1054.

23- HAYFORD.MARC.D (2000), Inflation Uncertainty, Unemployment Uncertainty and Economic Activity, *Journal of Macroeconomics*, Vol.22, No.2, 315-329.

24- HENTSCHEL.L (1995), All in the Family. Nesting Symmetric and Asymmetric GARCH Models, *Journal of Financial Economics*, Vol.39, 71-104.

25- HOLLAND.S (1995), Inflation and Uncertainty: Tests for Temporal Ordering, *Journal of money credit and banking*, Vol.27, No.3, 827-837.

26- JOHNSON.CHRISTIAN.A (2002), Inflation Uncertainty in Chile: Assymmetries and the News Impact Curve, *Revista de analisis Economica*, Vol.17, 3-20.

27- JOYCE.M (1995), Modeling UK Inflation Uncertainty: The Impact of News and The Relationship with Inflation, *Bank of England working paper, No 30*.

28- KONTONIKAS.ALEXANDROS (2001), Inflation and Inflation Uncertainty in the United Kingdom Evidence from GARCH Modeling, *Department of Economics and Finance, Brunel University. Downloadable at: http://www.brunel.ac.uk/329/efwps//02-28.pdf.*

29- LI.C.W and LI.W.K (1996), On a Double-Threshold Autoregressive Heteroskedastic Time Series Model, *Journal of applied econometrics*, Vol.11, No.3, 253-274.

30- NELSON.D.B (1991), Conditional Heteroskedasticity in Asset Returns: A New Approach," *Econometrica*, Vol.59, No.2, 347-370.

31- NEYAPTI.BILIN, and KAYA.NESLIHAN (2000), Inflation and Inflation Uncertainty in Turkey: Evidence from the Past Two Decades, *Bilkent University*, *Downloadable at:*

http://www.bilkent.edu.tr/~neyapti/shortstudies/012000.pdf.

32- OKUN.A (1971), The Mirage of Steady Inflation, *Brooking papers on Economic Activity*, Vol.1971, No.2, 485-498.

33- RABEMANANJARA.R, and ZAKOIAN.J.M (1993), Threshold Arch Models and Asymmetries in Volatility, *Journal of applied econometrics*, Vol.8, No.1, 31-49.

34- STILIANOS, F. (2000), The Relationship between Inflation and Inflation Uncertainty in the UK: 1885-1998, Department of Economics, National

University of Ireland, Galway, Downloadable at: http://www.economics.nuigalway.ie/downloads/papers/0048paper.pdf

35- STOCK.JAMES.H and WATSON.MARK.W (2003), *Introduction to Econometrics*, Addison Wesley.

36- ZAKOIAN.J.M (1991), Threshold Heteroskedastic Models, *D.P.INSEE*.

37- ZARNOWITZ.V, and LAMBROS.P (1987), Consensus and Uncertainty in Economic Prediction, Journal *of political economy*, Vol.95, 591-621.