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AN EMPIRICAL INVESTIGATION OF THE EFFECTS OF INFLATION UNCERTAINTY ON ECONOMIC GROWTH IN IRAN

This paper investigates the relationship between inflation uncertainty and economic growth for the period of 1988-2007 by using quarterly data and applying GARCH-M model for Iranian economy. We estimate inflation uncertainty by assuming that uncertainty is due to shocks in the inflation process, and therefore measures inflation uncertainty by using the conditional variance of inflation. In this method, the GARCH model is applied to estimate a time-varying conditional residual variance. Our empirical evidence shows that inflation uncertainty does not affect the level of economic growth.

Keywords: *inflation uncertainty; economic growth; GARCH-M models; Iran.*

JEL Classification: C22; E32.

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ЕМПІРИЧНЕ ДОСЛІДЖЕННЯ ВПЛИВУ ІНФЛЯЦІЙНОЇ НЕВИЗНАЧЕНОСТІ НА ЕКОНОМІЧНЕ ЗРОСТАННЯ ІРАНУ

У статті вивчено зв'язок між інфляційною невизначеністю і економічним зростанням за період 1988-2007 років за допомогою квартальних даних і застосування моделі GARCH-M для іранської економіки. Інфляційну невизначеність оцінено виходячи з припущення, що невизначеність пов'язана з потрясіннями в інфляційних процесах, і тому її слід вимірювати за допомогою умовної дисперсії інфляції. У цьому методі застосовується модель GARCH для оцінювання умовної залишкової дисперсії, що змінюється в часі. Наші емпіричні дані показують, що інфляційна невизначеність не впливає на рівень економічного зростання.

Ключові слова: *інфляційна невизначеність; економічне зростання; моделі GARCH-M; Іран.*

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ЭМПИРИЧЕСКОЕ ИССЛЕДОВАНИЕ ВЛИЯНИЯ ИНФЛЯЦИОННОЙ НЕОПРЕДЕЛЕННОСТИ НА ЭКОНОМИЧЕСКИЙ РОСТ ИРАНА

В статье изучена связь между инфляционной неопределенностью и экономическим ростом за период 1988-2007 годов с помощью квартальных данных и применения модели GARCH-M для иранской экономики. Инфляционная неопределенность оценивается исходя из предположения, что неопределенность связана с потрясениями в инфляционных процессах, и поэтому ее следует измерять с помощью условной дисперсии инфляции. В этом методе применяется модель GARCH для оценки изменяющейся во времени условной остаточной дисперсии. Наши эмпирические данные показывают, что инфляционная неопределенность не влияет на уровень экономического роста.

Ключевые слова: *инфляционная неопределенность; экономический рост; модели GARCH-M; Иран.*

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1. Introduction. Since the first economic development planning in 1990-91, there was an increasing interest in empirical research related to economic growth in Iran. The motivation of this type of literature is to identify the variables which have a robust effect on economic growth in Iran (see Taghavi and Mohammadi, 2006; Delavari et al., 2008; Komijani and Nazari, 2009). Since economic theory provides a wide class of possible determinants, the methodology to identify the true explanatory variables is extremely important (Lensink et al., 1999, p. 379). In recent years a few papers constructed a large set of possible explanatory variables and used regression analysis to identify the variables which have a statistically significant impact on economic growth (see Tovfighi, 2002; Gorji and Madani, 2003; Haji Rahimi and Torkamani, 2003; Moshiri and Jahangard, 2004; Behbudi et al., 2008; Delavari et al., 2008; Ghanbari and Basakha, 2008; Mohammadi and Akbari Fard, 2008; Behbudi et al., 2009 and Komijani and Nazari, 2009, among others). None of these empirical growth studies considers the effect of inflation uncertainty on economic growth. This is a remarkable vacuum, as there is a vast theoretical and empirical literature that emphasizes the importance of inflation uncertainty for economic growth. He points out that a rise in the average rate of inflation leads to more uncertainty about the rate of inflation, economic inefficiency, and a lower output. Friedman (1977) assumes that rising inflation creates a strong pressure to counter it, and that the perception of such pressure subsequently increases private agent uncertainty about the course of future inflation. As a result of this increase in inflation uncertainty, market prices became a less efficient system for coordinating economic activity, thus causing a decline in output growth.

There is a lot of empirical investigation of Friedman's hypothesis in the literature. Farzinvash and Abbasi (2005); Emami and Salmanpour (2006); Tashkini (2006); Heidari and Montakhab (2008); Jafari Samimi and Motameni (2009); and Heidari and Bashiri (2010) investigated the relationship between inflation and inflation uncertainty with Iranian data. Their results are in line with others, supporting Friedman's hypothesis (see Fountas, 2001; Fountas et al., 2002; Grier et al., 2004; Apergis, 2004; Kontonikas, 2004 among others).

To the best of our knowledge, there is no empirical study assessing the relationship between output growth and inflation uncertainty with Iranian data. However, this relationship with other countries data has been mixed, at best. Salai-Martin (1991); Davis and Kanago (1996); Al-Marhubi (1998); Lensink et al. (1999); Judson and Orphanides (1999); Vork (1999); Wilson and Culver (1999); Grier and Perry (2000); Hayford (2000); Perry and Nas (2000); Caporale and Caporale (2002); Fountas et al. (2002); Grier et al. (2004); Apergis (2004); Vale (2005); Grier and Grier (2006); Wilson (2006); Hwang (2007) all find a negative relationship between inflation uncertainty and output growth, while Coulson and Robins (1985); Thornton (1988); Jansen (1989); Levine and Renelt (1992); Levine and Zervos (1993); Bohara and Sauer (1994); Clark (1997) and Ma (1998) fail to provide such support.

This paper investigates the impact of inflationary uncertainty on economic growth in Iran. There are different types of uncertainty in conventional econometrics analysis (see Wu et al. (2003) for more discussion). However, we estimate inflation uncertainty by assuming that uncertainty is due to shocks in the inflation process, and therefore we measure inflation uncertainty by using the conditional variance of inflation. In this method, the generalized autoregressive conditional heteroscedasticity (GARCH) model is applied to estimate a time-varying conditional residual variance.

The paper contributes to the literature in several respects. First, this paper employs quarterly Iranian data, a country that experienced significant variability in inflation as well as economic growth over the last 30 years. As far as we know, there was no empirical investigation of impact of inflation uncertainty on economic growth for Iranian economy in a single variate GARCH-in-Mean (GARCH-M) model. Second, we use 3 alternative GARCH models in dealing with the measurement of inflation uncertainty: Bollerslev's (1986) model, Schwert's (1990) model, and Nelson's (1991) exponential GARCH (EGARCH) model. Third, by using the last two aforementioned models to measure inflation uncertainty, we will be able to examine the possibility of asymmetry in inflation uncertainty. Fourth, we use 3 different specifications of the inflation uncertainty measurement: conditional variance, conditional standard deviation, and natural logarithm of the conditional variance. Our main result in this paper is that inflation uncertainty doesn't affect the level of Iranian economic growth.

The rest of the paper proceeds as follows: Section 2 provides a brief description of the GARCH family models. Section 3 presents the data and its property, section 4 presents and discusses the empirical results and the final section concludes the paper.

2. Theoretical frameworks: GARCH models. In conventional econometric models, the variance of the disturbance term is assumed to be constant over time. However, many economic time series exhibit periods of unusually high volatility followed by more tranquil periods of low volatility. In such cases, the assumption of homoskedasticity is no longer valid, and it is preferable to examine patterns that allow the variance to depend upon its history. In technical words, in such instances, it is better to examine not the unconditional variance, but the conditional, with the condition being its past behaviour. Engle (1982) suggested that it is better to simultaneously model the mean and the variance of a series when we suspect that the conditional variance is not constant.

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

$$\pi_t = \theta_0 + \theta_1 \pi_{t-1} + \theta_2 \pi_{t-4} + \theta_3 \pi_{t-6} + v_t \quad (1)$$

$$\sigma^2{}_{\upsilon t} = \phi_1 + \phi_2 \upsilon_{t-1}^2 + \theta \sigma_{\upsilon_{t-1}}^2 \quad (2)$$

where π_t is the inflation, v_t is the residual of equation (1), σ^2_{vt} is the conditional variance of the residual term taken as inflation uncertainty at time t. Equation (1) is an autoregressive representation of inflation, and equation (2) is a GARCH (1, 1) representation of conditional variance.

To investigate the relationship between inflation uncertainty and economic growth, we use GARCH-M model.

In the GARCH-M model, we introduce variance (or standard deviation) into the mean equation (see Engle et al., 1987). So the mean equation for economic growth in the GARCH-M model can be formulated as:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \lambda \sigma_{v_t}^2 + \varepsilon_t \quad (3)$$

$$\sigma^2_{\varepsilon_t} = \omega + \alpha\varepsilon^2_{t-1} + \beta\sigma^2_{\varepsilon_{t-1}} \quad (4)$$

where y_t is the proxy for economic growth, ε_t is the residual of equation (3), $\sigma^2_{\varepsilon t}$ is the conditional variance of the residual term taken as growth uncertainty at time t.

3. Data. In our empirical analysis we use the consumer price index (CPI) and the gross domestic product (GDP) for Iran as proxies for the price level and output, respectively. The data have quarterly frequency and range from 1988:Q2 to 2007:Q2. Inflation is measured by the difference of the log of CPI: (Asteriou, 2006)

$$\pi_t = (\ln cpi_t - \ln cpi_{t-1}) \times 400 \quad (5)$$

Real output growth (here after growth) as the proxy for economic growth is measured by the difference in the log of the GDP:

$$y_t = (\ln GDP_t - \ln GDP_{t-1}) \times 400 \quad (6)$$

Figure 1 shows the inflation rate and growth rate of GDP in the Iranian economy during 1988-2007.

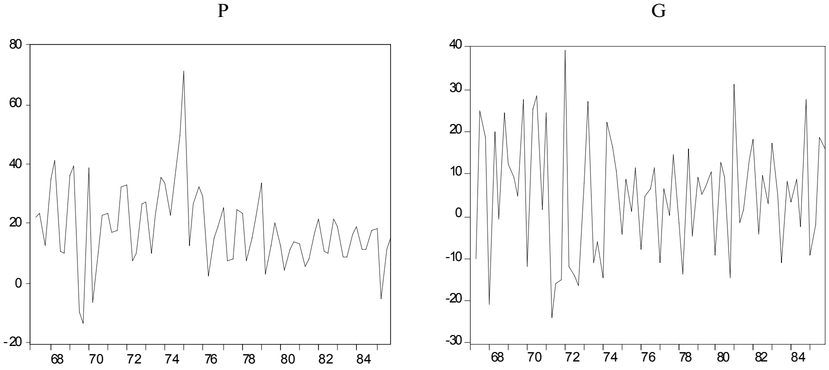

Figure 1. **Inflation and Growth Rate in Iranian Economy**

As Figure 1 shows, Iranian economy experienced volatile inflation and growth rate during the last 3 decades.

The summary statistics for the data is given in Table 1. The large value of the Jargue-Bera statistics for inflation implies a deviation from normality. The value of the Jargue-Bera statistics for growth implies that the series are normally distributed.

Table 1. **Summary statistics for Iranian inflation and growth**

	Inflation	Growth
Mean	17.9419	5.26218
Median	16.7609	6.41796
Maximum	71.0550	39.0916
Minimum	-14.2872	-23.8725
Std. dev.	13.0538	14.0937
Skewness	0.82163	0.07409
Kurtosis	5.84904	2.30495
Jargua-Bera	34.25522	1.57828
Probability	0.0000	0.454233

We test for the stationarity properties of our data using the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The results of these tests suggest that the inflation rate and the growth rate are stationary processes. The sensitivity of our results to the order of augmentation of the unit root tests is checked by including both a small and a large number of lagged differenced terms in ADF regressions. Similarly, we use both a low and a high truncation lag for Bartlett kernel in PP tests.

4. Empirical results and discussion. We find that the best fitting time series model for Iranian inflation includes 1, 4 and 6 of its lags, and only one lag for the growth:

$$\pi_t = \theta_0 + \theta_1 \pi_{t-1} + \theta_2 \pi_{t-4} + \theta_3 \pi_{t-6} + v_t \tag{7}$$

$$y_t = \beta_0 + \beta_1 y_{t-1} + \varepsilon_t \tag{8}$$

In order to find out whether the residuals are serially correlated, we use Breush-Godfrey serial correlation Lagrange multiplier (LM) test. Table 2 shows that the residuals are not serially correlated.

Table 2. **Breush-Godfrey Serial Correlation LM Test**

	LM test	Probability
Inflation	1.918515	0.3832
Growth	3.072019	0.2152

Moreover, to test whether there are any remaining ARCH effects in the residuals, we use the LM test for ARCH in the residuals (Engle, 1982). The results of the ARCH-LM test expresses that the hypothesis of no remaining ARCH effects in the residuals cannot be rejected. Thus, there is ARCH effect in the residuals. The Breush-Godfrey serial correlation LM test rejects first through 12 order serial correlation at all standard significance levels. However, LM tests for ARCH effect reject the null of no first or eighth order conditional heteroskedasticity of 1% level of significance. As higher order ARCH indicates persistence in the conditional variance, the model is estimated as a GARCH(1,1) process. These results are reported in Tables 3 and 4.

Table 3. **GARCH (1, 1) model estimation of inflation**

Parameter	θ_0	θ_1	θ_2	θ_3	ϕ_1	ϕ_2	θ
Coefficient	8.1856	0.2492	0.3858	-0.1550	41.3531	0.69058	-0.1498
Prob	0.0000	0.0085	0.0000	0.0141	0.0001	0.0080	0.3026

Table 4. **GARCH (1, 1) model estimation of growth**

Parameter	β_0	β_1	ω	α	β
Coefficient	6.671938	0.276958-	21.37965	0.172128	0.695364
Prob	0.0000	0.0170	0.4961	0.3417	0.0267

The results in Tables 3 and 4 reveal that in the mean and variance equations, all the coefficients are highly significant.

The estimation result of GARCH-M model to investigate the relationship between inflation uncertainty and growth in Iran is reported in Table 5.

Table 5. **Estimation of GARCH-M (1, 1) model for growth**

	$\sigma^2_{\varepsilon_t}$	σ_{ε_t}	$\ln \sigma^2_{\varepsilon_t}$
λ	0.003661 (0.8500)	-0.166053 (0.6419)	-2.525945 (0.0770)
ω	26.13371 (0.5525)	22.21711 (0.5762)	15.35040 (0.5358)
α	0.191807 (0.3786)	0.174944 (0.3695)	0.182372 (0.3142)
β	0.651882 (0.1304)	0.688587 (0.0748)	0.715884 (0.0065)

The coefficient of conditional variance in the mean equation is insignificant, which means that inflation uncertainty doesn't affect the level of growth.

4.1. The TGARCH Model:

In this section, we investigate whether the magnitude of the effect of positive and negative inflation innovations on uncertainty is the same or not. To do this, we use TGARCH model. Considering the role of the asymmetry we can define our TGARCH model as follows:

$$\pi_t = \theta_0 + \theta_1 \pi_{t-1} + \theta_2 \pi_{t-4} + \theta_3 \pi_{t-6} + v_t \tag{9}$$

$$\sigma^2_{Tv_t} = \phi_1 + \phi_2 v^2_{t-1} + \gamma v^2_{t-1} D + \theta \sigma^2_{Tv_{t-1}} \tag{10}$$

In this model, good news ($v_{t-1} \geq 0$) and bad news ($v_{t-1} < 0$) have different effects on the conditional variance. This model allows negative inflationary shocks to have a different effect on inflation uncertainty than positive ones. Specially, negative shocks have impact $\phi_2 + \gamma$, whereas positive shocks have an effect equal to ϕ_2. If γ is statistically different from zero, these shocks have an asymmetric effect on inflation uncertainty.

The estimation result of the above TGARCH model is presented in Table 6:

Table 6. **TGARCH (1,1) estimation of inflation uncertainty**

Parameters	θ_0	θ_1	θ_2	θ_3	ϕ_1	ϕ_2	γ	θ
Coefficient	9.66902	0.17666	0.42294	-0.1632	31.1222	0.17823	-0.3092	0.4440
Prob	0.0000	0.0085	0.0000	0.0450	0.2802	0.0805	0.0056	0.3947

As can be seen from Table (6), in the estimated model, γ is negative and significant which means that the news impact is asymmetric and there is a leverage effect. Based on the above estimation results, the impact of good news is equal to 0.17823, while the impact of bad news is equal to 0.13097. So our results show that negative inflationary shocks have less effect on inflation uncertainty, compaed with positive ones. This result is in line with Heidari and Bashiri (2010).

We can test the asymmetry in the news impact by testing the null hypothesis that γ is equal to zero ($H_0 : \gamma = 0$) against the alternative hypothesis that it is different from zero ($H_1 : \gamma \neq 0$). If we reject the null, the news impact is asymmetric. With this result in hand, we can't reject the null that the news impact is asymmetric.

Table 7. **Wald test result for the asymmetry**

Probability	F-statistics
0.0073	7.683645

We need to choose the form in which the time-varying variance enters the specification of the mean to determine the inflation uncertainty measurement. Caporale and McKiernan (1996) found that the logarithm of the conditional variance works better in their estimation of the time-varying risk premia. However, as noted by Pagan and Hong (1991), the use of $\ln\sigma^2_t$ is possibly unsatisfactory: first, for $\sigma^2_t > 1$ and $g(\sigma^2_t) < 0$, which leads to a negative sign for the risk premium. Second, as $\sigma^2_t \to 0$, conditional volatility in logs becomes very large and, therefore, the implicit relationship between conditional volatility and y_t is overstated. One can use the conditional standard deviation as a regressor in the conditional mean (Henry and Olekalns, 2002). Therefore we employ all 3 specifications for the time-varying variance. The estimation results of TGARCH-M model with these 3 specifications for the inflation uncertainty measurement are reported in Table 8.

Table 8. **TGARCH-M (1, 1) estimation results for the mean equation**

	$\sigma^2_{T\varepsilon_t}$	$\sigma_{T\varepsilon_t}$	$\ln\sigma^2_{T\varepsilon_t}$
λ	0.018735 (0.1113)	0.231762 (0.7856)	0.476173 (0.8616)
ω	25.15063 (0.5481)	25.22278 (0.5571)	25.16954 (0.5665)
α	0.183023 (0.3653)	0.181323 (0.3702)	0.180040 (0.3730)
β	0.664202 (0.1068)	0.665809 (0.1110)	0.667534 (0.1131)

To investigate the relationship between inflation uncertainty and growth, we estimate the following TGARCH-M model:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \lambda\sigma^2_{Tv_t} + \varepsilon_t \tag{11}$$

$$\sigma^2_{\varepsilon_t} = \omega + \alpha\varepsilon^2_{t-1} + \beta\sigma^2_{\varepsilon_{t-1}} \tag{12}$$

The coefficient of conditional variance in the mean equation is positive and insignificant, which means that inflation uncertainty doesn't affect the level of growth.

4.2.The EGARCH Model:

Nelson (1991) proposes an extended version of GARCH models: EGARCH. EGARCH method is more advantageous than 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 inflation shocks. Second, unlike GARCH specification, the EGARCH model, specified in logarithms, does not impose the non-negativity constraints on parameters. Finally, modeling inflation and its uncertainty in logarithms hampers the effects of outliers on the estimation results. The best EGARCH specification for Iranian inflation can be defined as follows:

$$\pi_t = \theta_0 + \theta_1\pi_{t-1} + \theta_2\pi_{t-4} + \theta_3\pi_{t-6} + v_t \tag{13}$$

$$\log(\sigma^2_{Ev_t}) = \phi_1 + \phi_2\left|\frac{\upsilon_{t-1}}{\sigma_{E\upsilon_{t-1}}}\right| + \gamma\frac{\upsilon_{t-1}}{\sigma_{E\upsilon_{t-1}}} + \theta\log(\sigma^2_{Ev_{t-1}}) \tag{14}$$

We report the results of the above model specification in Table 9. In this table negative value of ϕ_2 means that a deviation of $\left|\frac{\varepsilon_{t-i}}{\sigma_{t-j}}\right|$ from its expected value causes inflation uncertainty to reduce. Positive value of γ means that the inflation uncertainty will rise more in response to positive inflation shocks ($v_{t-i} > 0$) than to negative shocks ($v_{t-i} < 0$).

Table 9. **EGARCH (1, 1) model estimation of inflation**

Parameter	θ_0	θ_1	θ_2	θ_3	ϕ_1	ϕ_2	γ	θ
Coefficients	9.02906	0.22041	0.35751	-0.09588	0.67896	-0.31149	0.30251	0.8851
Prob	0.0000	0.0078	0.0000	0.1014	0.0578	0.0529	0.0002	0.0000

To investigate the relationship between inflation uncertainty and growth, we use EGARCH-M model as follows:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \lambda\sigma^2_{Tv_t} + \varepsilon_t \quad (15)$$

$$\sigma^2_{\varepsilon_t} = \omega + \alpha\varepsilon^2_{t-1} + \beta\sigma^2_{\varepsilon_{t-1}} \quad (16)$$

Table 10 reports the estimation results of our EGARCH-M model.

Table 10. **EGARCH-M model estimation of growth**

	$\sigma^2_{E\varepsilon_t}$	$\sigma_{E\varepsilon_t}$	$\ln\sigma^2_{E\varepsilon_t}$
λ	-0.043963 (0.2533)	-0.609618 (0.2476)	-1.628287 (0.2918)
ω	20.85355 (0.5620)	20.54313 (0.5564)	21.09765 (0.5514)
α	0.176290 (0.3870)	0.177865 (0.3849)	0.181667 (0.3800)
β	0.693703 (0.0654)	0.693962 (0.0603)	0.687632 (0.0640)

The coefficient of the conditional variance (λ) in the mean equation is negative and insignificant, which means that inflation uncertainty doesn't affect the level of growth. This result is not surprising. In fact, Friedman (1977) stresses that inflation uncertainty adversely affects real economic activity as inflation uncertainty reduces the information content of prices, distorts relative prices and long-run contracts, and therefore lowers economic efficiency (welfare and output growth). In Iranian economy, relative prices are distorted and because of polices instability, entering long-run contracts is difficult.

Moreover, the ineffectiveness of inflation uncertainty on growth indicates that because of economical structure and its limitations, expansionary macroeconomic policies (demand-oriented polices) increases inflation rather than growth in Iranian economy.

5. Conclusion. In this paper, we have investigated empirically the relationship between inflation uncertainty and economic growth in Iran for the period of 1988-2007 by using quarterly data and applying GARCH-M model. The results show that inflation uncertainty doesn't affect the growth level. This result is in line with those of Thornton (1988); Jansen (1989); Levine and Renelt (1992); Levine and Zervos

(1993); Bohara and Sauer (1994); Clark (1997) and Ma (1998) among others. Also our results show that negative inflationary shocks have less effect on inflation uncertainty, comparing with positive ones. This result is in line with Heidari and Bashiri (2010).

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