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Inflation and Inflation Uncertainty in Iran: An Application of GARCH-in-Mean Model with FIML Method of Estimation

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Abstract

This paper investigates the relationship between inflation and inflation uncertainty for the period of 1990-2009 by using monthly data in the Iranian economy. The results of a two-step procedure such as Granger causality test which uses generated variables from the first stage as regressors in the second stage, suggests a positive relation between the mean and the variance of inflation. However, Pagan (1984) criticizes this two-step procedure for its misspecifications due to the use of generated variables from the first stage as regressors in the second stage. This paper uses the Full Information Maximum Likelihood (FIML) method to address this issue. The estimates we gathered with the new set of specifications suggest that inflation causes inflation uncertainty, supporting the Friedman–Ball hypothesis.

Keywords: Inflation Uncertainty, GARCH models, FIML, Iran

JEL Classification: C22, E31

1. Introduction:

The relationship between inflation and inflation uncertainty has been the matter of interest among economists in recent decades. As the impact of inflation and inflation uncertainty on growth and welfare are significant (see e.g. Ma, 1998; Vale, 2005; Fountas & Kraranasos, 2006; Wilson, 2006; Hwang, 2007; Fang, et. Al, 2008), determining the direction of the causality between inflation and inflation uncertainty can help the policy makers to make appropriate decisions. Friedman (1977) points out the potential of increased inflation to crate nominal

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uncertainty, which adversely affect real economic activity as inflation uncertainty reduces the information content of prices, distorts relative prices, and therefore lowers economic efficiency (welfare and output growth). Ball (1992) formalizes and supports Friedman's hypothesis in a game theoretical framework. Cukierman and Meltzer (1986) and Cukierman (1992), on the other hand, argue that increases in inflation uncertainty raise the optimal inflation rate by increasing the incentive for the policy maker to create inflation surprises in a game theoretical framework.

On the empirical side of the inflation uncertainty literature, the results are mixed (see e.g. Golob, 1995; Baillie et al., 1996; Crawford and Kasmovich, 1996; Joyce, 1997; Grier and Perry, 1990, 1998, 2000; Davis and Kanago, 2000; Perry and Tevfik, 2000; Fountas, 2001; Fountas, et. al. 2001; Hwang, 2001; Berument and Yuksel, 2002; Fountas, et. al. 2002; Bhar and Hamori, 2004; Kontonikas, 2004; Berument and Nargez Dincer, 2005; Conrad and Karanasos, 2005; Vale, 2005; Artan, 2006; Caporale and Kontonikas, 2006; Grier and Grier, 2006; Thornton, 2007; Heidari and Montakhab, 2008; Heidari and Bashiri, 2009; Jafari Samimi and Motameni 2009; Berument, et al, 2009; Jiranyakul and Opiela, 2010).Heidari and Montakhab (2008); Heidari and Bashiri (2009); and Jafari Samimi and Motameni (2009) investigate the relationship between inflation and inflation uncertainty with Iranian data. Their results are in line with others around world, supporting Friedman's hypothesis.

Although most of the empirical studies use the GARCH type of specifications as their common method to assess the relationship between inflation and inflation uncertainty, some studies make use of a two-step procedure. For example, with Iranian data Farzinvash and Abbasi (2005); Emami and Salmanpour (2006); Tashkini (2006); Heidari and Montakhab (2008) and Jafari Samimi and Motameni (2009) estimate the conditional variance of inflation, as a measure of inflation uncertainty, by applying GARCH family models, and then perform the Granger causality tests between these generated conditional variance measures and inflation series. However, Pagan (1984) criticises two-step procedure for its misspecifications due to the use of generated variables from the first stage as regressors in the second stage.

This paper examines the relationship between inflation and inflation uncertainty with Iranian data for the period of 1990 to 2009 and FIML method of estimation. The paper contributes to the literature in several respects: First, we employ monthly Iranian data, a country that has experienced significant uncertainty in inflation over the last 40 years. Second this paper estimates inflation uncertainty by assuming that uncertainty is due to the shocks of inflation, and therefore measures inflation uncertainty by using the conditional variance of inflation. In this method, various GARCH models are applied to estimate a time-varying conditional residual variance, as a standard measure of inflation uncertainty. Third the novelty of the paper with Iranian data is that the causality between inflation and inflation uncertainty is tested by using the FIML method of estimation. The estimates with the new set of specification system confirm our results from Granger causality tests, supporting the Friedman-Ball hypothesis.

The rest of the paper is organized as follows: Section 2 introduces the model. Section 3 discusses the data. In section 4, the estimation results are presented and finally, section 5 concludes.

2. The Model

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

$$\pi_t = \beta_0 + \sum_{i=1}^{n} \beta_i \pi_{t-i} + \varepsilon_t \quad (1)$$

$$\sigma^2{}_{\varepsilon t} = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \alpha_2 \sigma^2_{\varepsilon t-1} \quad (2)$$

Where π_t is the inflation, ε_t is the residual of equation (1), $\sigma^2{}_{\varepsilon t}$ is the conditional variance of the residual term taken as inflation uncertainty at time t, and n is the lag length. Equation.(1) is an autoregressive representation of inflation, and equation.(2) is a GARCH(1,1) representation of conditional variance.

Although most empirical studies with Iranian data, used this general GARCH model to investigate the relationship between inflation and inflation uncertainty, they make use of a two-stage procedure.[1] For example, Jafari Samimi and Motameni (2009) estimate the conditional variance of inflation by GARCH(1,1) and Exponentiol GARCH (EGARCH) models in the first step, and then perform the Granger causality tests between these generated conditional variance and inflation in the second step. However, Pagan (1984) criticises this two-step procedure and Pagan and Ullah (1988) suggest using the FIML method of estimation to address the misspecifications of using two-step procedure. As Berument and Narrgiz Dincer (2005) mentions, if the inflation affects the inflation uncertainty, and the inflation uncertainty affects the inflation, then the inflation variable and the inflation uncertainty needs to include in the inflation uncertainty (variance equation) and inflation (mean equation) specifications, respectively. Thus the alternative specification for the equations (1) and (2) are:

$$\pi_t = \beta_0 + \sum_{i=1}^{n} \beta_i \pi_{t-1} + \lambda \sigma_{\varepsilon t}^2 + \varepsilon_t \qquad (3)$$

$$\sigma_{\varepsilon t}^2 = \alpha_0 + \alpha_1 \sigma_{\varepsilon t-1}^2 + \rho \pi_{t-1} \qquad (4)$$

Following Pagan and Ullah (1988) we estimate equations (3) and (4) jointly using the FIML method of estimation. In this model the value of $\rho \succ 0$ shows that inflation uncertainty increases as inflation rises. Hence a positive and significant ρ can be considered as confirmation of Friedman-Ball hypothesis and also means that inflation uncertainty is a cost of inflation. However, λ in the mean equation could be positive or negative. A positive λ means that inflation uncertainty has a positive effect on the level of inflation, but a negative λ means that inflation uncertainty has a negative impact on the level of inflation which can be explained by the stabilization motive of policy makers.

[1] Heidari, et. Al. (Forthcoming). Employs a Quesi Maximum Likelihood

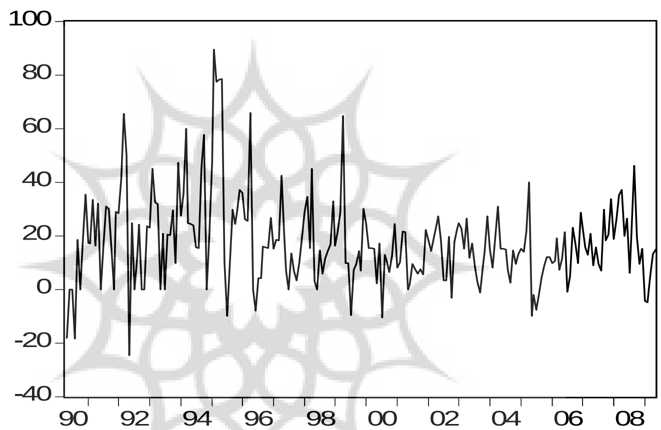
3. Data

The paper uses monthly Consumer Price Index (CPI) inflation, taken from the Central Bank of Iran for the period of 1990–2009. Inflation is the annualized monthly difference of the log of the CPI: (see, e.g. Asteriou, 2006).

$$\pi_t = (\ln cpi_t - \ln cpi_{t-1}) \times 1200 \qquad (5)$$

Figure (1) shows the inflation rate in the Iranian economy during 1990-2009.

Figure 1. Inflation Rate in the Iranian Economy



As Figure 1 shows the Iranian economy has experienced high and volatile inflation rate during last two decades.

The summary statistics for the data is given in Table (1). The large value of the Jargue- Bera statistic implies a deviation from normality.

Table 1. Summary statistics for Iranian inflation

Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jargua-Bera	Probability
17.7015	15.4840	89.4030	-24.7431	16.6848	1.21719	6.13495	150.3212	0.0000

3.1 Unit Root Test:

In order to investigate the stationary of the data, the paper uses the Augmented Dickey-Fuller (ADF), Philips-Perron(PP) and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) tests. Table (2) shows the ADF, PP and KPSS tests results for the Iranian inflation.

Table 2. ADF, PP and KPSS tests results for the Iranian inflation

	Include in test equation	Statistic	Critical values 10% level	Critical values 5% level	Critical values 1% level
ADF	Intercepet	-9.733669***	-2.573502	-2.874029	-3.45893
	trend and intercepet	-9.998044***	-3.138345	-3.429657	-3.998815
	none	-0.760497	-1.615725	-1.942296	-2.575662
PP	Intercepet	-9.704863***	-2.573502	-2.874029	-3.458973
	trend and intercepet	-9.955510***	-3.138345	-3.429657	-3.998815
	none	-5.686860***	-1.615772	-1.942224	-2.575144
KPSS	Intercepet	0.512000**	0.347000	0.463000	0.739000
	trend and intercepet	0.131385*	0.119000	0.146000	0.216000

Note: * denotes significance at the 10 % level,
** denotes significance at the 10%, 5 % level
*** denotes significance at the 10%, 5%, 1 % level.

As can be seen from Table (2), the inflation rate is stationary.

3-2 Test of Structural Breaks in the Mean of Iranian Inflation:

To carry out a test of no structural break against an unknown number of breaks in the Iranian inflation, this paper uses the endogenously determined multiple break test developed by Bai and Perron (1998). This method tests for the presence of breaks when neither the number nor the timing of breaks is known aprior. This approach allows us to test for the presence of m breaks in the mean of inflation rate at unknown times using the following model:

$$\pi_t = \mu_j + \eta_t \qquad t = T_{j-1}+1,\ldots,T_j \qquad (6)$$
$$j = 1,2,\ldots,(m+1)$$

Where π_t is the inflation, μ_j is the regime-specific mean inflation rate, and η_t is an error term, and $T_0 = 0$ and $T_{m+1} = T$.

Bai and Perron (1998) introduced two tests of the null hypothesis of no structural break against an unknown number of breaks given some upper bound (for most empirical applications this bound is 5, see, e.g., Bai and Perron, 2003). These tests are called Double Maximum tests ($D\max$). The first is an equal weighted (we set all weights equal to unity) labeled by $UD\max$. The second test, $WD\max$, applies weights to the individual tests such that the marginal $p-$values are equal across the values of breaks. In both of these tests, break points are estimated by using the global minimization of the sum of squared residuals (for more details see, Bai and Perron, 1998 and 2003).

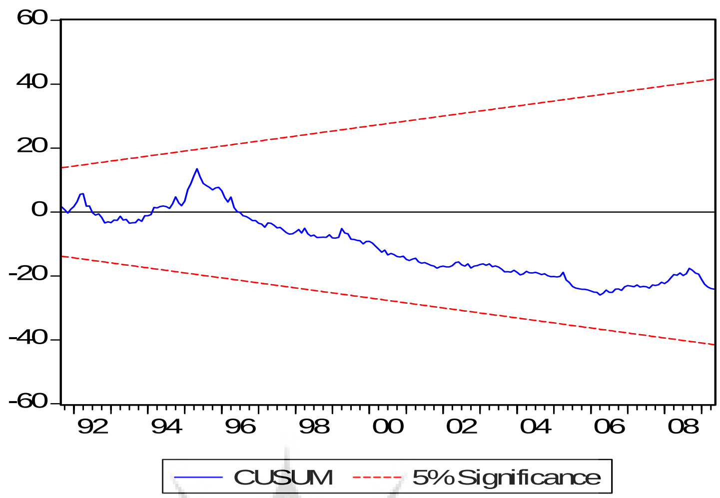
Table 3. $UD\max$ and $WD\max$ tests results

Tests	$UD\max$	$WD\max$
Values	5.6793	5.6793

Table (3) presents results of $D\max$ tests. These tests show that we have no break in the mean of the Iranian inflation. These results are strongly supported by the $SupF_T(m)$ test introduced by Andrews (1993) and CUSUM test.

Figure (2) shows that the cumulative sum of the recersive residuals is with in the five percent significance lines, sugessting of coefficient stablity.

Figure 2. CUSUM test



4. Estimates

We find that the best fitting time series model for the Iranian inflation includes 1, 11, 12 of its lages. The results from estimation of this model are as follow: (t-statistics are in paranthesses)

$$\pi_t = \beta_0 + \beta_1 \pi_{t-1} + \beta_{11}\pi_{t-11} + \beta_{12}\pi_{t-12} + \varepsilon_t \qquad (7)$$

$$\pi_t = 5.159789 + 0.326384\pi_{t-1} + 0.149431\pi_{t-11} + 0.242599\pi_{t-12} + \varepsilon_t$$

$$(2.97) \qquad (5.36) \qquad (2.34) \qquad (3.70)$$

In order to find out whether the residuals are serialy correlated, we use Breush-Godfrey serial correlation Lagrange Multiplier (LM) Test.

Table 4. Breush-Godfrey Serial Correlation LM Test

LM test	0.611851	Probability	0.736441

The Table (4) shows that the test does not reject the hypothesis of no serial correlation and so indicate that the residuals are not serialy correlated.

More ever to test whether there are any remaining ARCH effects in the residuals, we use the LM test for ARCH in the residuals (see, e.g. Engle 1982). The results of the ARCH-LM test in Table (5) expresses that the hypothesis of no remaining ARCH effects in the residuals can not be rejected. Thus, there is ARCH effect in the residuals.

Table 5. ARCH LM Test

LM test	18.02908	Probability	0.000022

Since higher order ARCH indicates persistence in the conditional variance, the model is estimated as a GARCH(1,1) process. This resultes are reported in Table (6).

Table 6. GARCH(1,1) model estimation results

Mean equation				
	Coefficient	Std.Error	z-Statistic	Prob.
β_0	5.810381	1.653598	3.513781	0.0004
β_1	0.243595	0.065029	3.745943	0.0002
β_{11}	0.067373	0.037569	1.793334	0.0729
β_{12}	0.305883	0.040692	7.517105	0.0000
Variance equation				
α_0	38.29479	15.79927	2.423834	0.0154
α_1	0.393997	0.109163	3.609259	0.0003
α_2	0.423619	0.133668	3.169195	0.0015

The results in Table (6) show that in the mean and variance equation, all coefficients are highly significant.

Table (7) reports the result of Granger Causality test between inflation and inflation uncertainty. In fact, in this table we repeated the analysis of two-step procedure which is done in Heidari and Montakhab (2008) and Jafari Samimi and Motameni (2009), among others.

Table 7. Granger Causality Tests

Null Hypothesis	F-Statistic	Probability
Inflation does not Granger Cause inflation uncertainty	32.4027	5.4E-13
Inflation uncertainty does not Granger Cause inflation	1.74102	0.17786

These results suggest that inflation Granger-causes inflation uncertainty, supporting the Friedman–Ball hypothesis, that high inflation is associated with more variable inflation.

The novelty of the paper is setting up a system of equation and estimate the new set of specification using FIML method of estimation. Table (8) presents jointly estimation result of equations (4) and (5) using FIML method. As excluding further lags of inflation and inflation uncertainty measure from the system would lead to biased estimates of parameters, we include further lags of these variables in the system.

Table 8. The estimation result of the system by using FIML

	Coefficient	Std.Error	z-Statistic	Prob.
β_0	5.036655	2.149435	2.343246	0.0191
β_1	0.337726	0.064536	5.233141	0.0000
β_{11}	0.158938	0.052911	3.003841	0.0027
β_{12}	0.257024	0.052922	4.856672	0.0000
λ	-0.003104	0.004618	-0.672138	0.5015
α_0	1.851772	26.33859	-0.070306	0.9439
α_1	0.687742	0.041315	16.64629	0.0000
ρ	3.590882	0.242053	14.83511	0.0000

Our results of Table (8) express that the coefficient of lagged inflation in the variance equation (ρ) is positive and highly significant. This supports the Friedman-Ball hypothesis that inflation increases that inflation uncertainty, and is in line with Heidari and Montakhab (2008) and Jafari Samimi and Motameni (2009). However, the coefficient of conditional variance in the mean equation is insignificant, which means that inflation uncertainty doesn't affect the level of inflation. This result is robust to the different order of lags of inflation uncertainty.

5. Conclusion

This paper investigates the relationship between inflation and inflation uncertainty for the period of 1990-2009 by using monthly data and applying GARCH model in the Iranian economy. The paper uses the Full Information Maximum Likelihood (FIML) method to address this issue. The estimates we gathered with the new set of specifications suggest that inflation causes inflation uncertainty, supporting the Friedman–Ball hypothesis.

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