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INFLATION VOLATILITY USING GARCH-FAMILY MODELS: EMPIRICAL EVIDENCE FROM PAKISTAN *

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ABSTRACT

In this study we are in the quest for most appropriate GARCH-family model for modeling the differenced log Consumer Price Index (CPI) CPI i.e. percentage change in CPI for Pakistan. Using various specifications for mean equation, study estimated GARCH (1,1) and GJR-GARCH (1,1). The study also estimates EGARCH (1,1) for monthly data of CPI. The estimation results reveal that ARMA (1,1)- GARCH (1,1) comes out to be most appropriate specification for modeling inflation volatility. The study finds no evidence of asymmetry in the response of inflation volatility to negative and positive shocks.

Keywords: Inflation; volatility; GARCH; Leverage effect; Pakistan.

INTRODUCTION

Measuring inflation volatility is imperative for policy makers, especially at central bank because it provides them with guidance in formulating polices for achieving price stability. Price instability hampers investment by making returns on financial assets more uncertain. Similarly, higher inflation volatility renders future inflation expectations more uncertain. As most of the contracts are in nominal terms, uncertainty about the future inflation entails high risk premium and results in arbitrary distribution of wealth. This situation imposes considerable economics costs. Therefore, higher inflation volatility, for a given inflation rate, can negatively impact economic growth. (e. g. see Grier and Grier, 2006). Thus inflation volatility may have negative impact on the overall performance of the economy. This study aims at modeling inflation volatility using GARCH-family models and choosing the most suitable one among them. The ARCH model was first introduced by Engle (1982) for capturing time variant variance exhibited by almost all financial time series and many economic time series. The generalized version of ARCH model i.e. GARCH model was formulated by Bollerslev (1986) and Nelson (1990).

Economic literature on issue of inflation volatility is concerned with the positive relation of inflation level and conditional variance thereof. This notion dates back to the "Noble Prize Lecture" of Friedman in 1977 and which was formalized by Ball (1992). The

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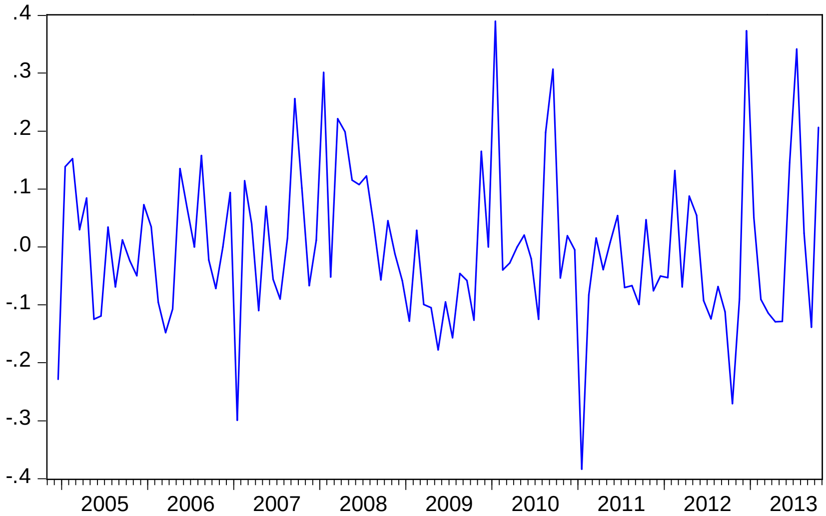
studies by Bruner & Hess (1993) and by Grier & Perry (1998) found evidence for Friedman-Ball hypothesis. These studies employed ARCH and GARCH models, respectively, for G-7 group of countries. Similarly, Nas and Perry (2000) got support for positive relation between level of inflation and uncertainty about inflation for Turkey. Such type of evidence was also found by Nayapti and Kaya (2001). Using GARCH model, Thornton (2007) found results supporting Friedman-Ball hypothesis for emerging economies. Nadia (2008) employed EGARCH model on monthly data for Pakistan and obtained the evidence of a positive relation of inflation with uncertainty about inflation.

DESCRIPTION OF DATA AND METHODOLOGY

An important characteristic of time series data of inflation of Pakistan is its high volatility which has been measured in term of CPI in log difference form as shown in following Figure 1:

FIGURE 1
Overtime Log Difference of CPI



Its clear from above figure that there is a high volatility in log difference of CPI i.e. percentage change in CPI. As this study is in quest of the most appropriate model for modeling volatility of percentage change in inflation measured in term of log difference of CPI, a brief description of models employed is given below.

GARCH (1,1) Model

As ARCH model formulated first by Engle (1982) has certain drawbacks, Bollerslev (1986) developed GARCH(q, p) model wherein equation for variance is given by following formula;

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \cdots + \alpha_q \epsilon_{t-q}^2 + \beta_1 \sigma_{t-1}^2 + \cdots + \beta_p \sigma_{t-p}^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2$$

σ_t^2 is the conditional variance and e_t^2 denotes the residual of log difference log CPI process. If a + b = 1, the process under consideration is stationary. We use ARMA (1, 1) to specify mean of log difference of CPI.

GJR-GARCH Model

This model was first formulated by Glosten et al (1993). This specification of GARCH is for the purpose of capturing leverage effect. GJR-GARCH is like a TARCH model which was suggested by Glosten and Zokodian (1990). However, in this version of

GARCH, rather than using conditional standard deviation, conditional variance is employed. GJR-GARCH model can be expressed as;

$$\sigma_t^2 = K + \delta\, \sigma_{t-1}^2 + \alpha\, \epsilon_{t-1}^2 + \phi\, \epsilon_{t-1}^2 I_{t-1}$$

Where $I_{t-1} = 1$ in case $e^2_{t-1} < 0$ and $I_{t-1} = 0$ otherwise.

If ϕ is greater than zero, this is evidence of that leverage effect is present. However, non-negativity requirement demands a + $\phi \geq 0$ and $\delta \geq 0$.

For the purpose of investigating nature of inflation volatility, we estimate ARMA(1,1)-GARCH (1,1), ARMA (1,1)-GJR-GARCH (1,1) and ARMA(1,1)-EGARCH(1,1) models, employing monthly data for CPI over the period of 2004M11 to 2013M10 for the economy of Pakistan.

RESULTS AND DISCUSSION

This study investigates the issue of inflation volatility in Pakistan by using three of the GARCH-family model as mentioned in last section. The result of ARMA (1, 1)-GARCH(1, 1) model is shown in Table 1.

TABLE 1

ARMA (1, 1)-GARCH(1, 1) Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.003129	0.017614	-0.177616	0.8590
AR(1)	-0.331359	0.351264	-0.943335	0.3455
MA(1)	0.555597	0.325341	1.707737	0.0877
Variance Equation				
C	0.002442	0.000832	2.936385	0.0033
RESID(-1)^2	-0.107465	0.014655	-7.333115	0.0000
GARCH(-1)	0.961849	0.043384	22.17059	0.0000

This table reveals that both the coefficients related with AR (1) and MA (1) terms in equation for mean of ARMA (1,1)-GARCH (1,1) are not statistically significant. However, both coefficients of the GARCH and ARCH terms in equation of variance are significant. As a + b = 0.8544, this implies that there is stationarity in volatility of differenced log of CPI. As we find autoregressive and moving average terms statistically insignificant, we estimated GARCH (1, 1) model including only constant in mean equation of difference of log CPI. The result is given in Table 2.

TABLE 2

GARCH (1, 1) Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.003387	0.011737	-0.288587	0.7729
Variance Equation				
C	0.013262	0.009807	1.352330	0.1763
RESID(-1)^2	-0.119521	0.049239	-2.427365	0.0152
GARCH(-1)	0.373139	0.555307	0.671951	0.5016

The result reveals that mean value of differenced log CPI, -0.003387 comes out to be insignificant again indicating that mean of differenced log CPI i.e. percentage change in CPI is in fact zero. Similarly, ARCH term in variance equation is statistically significant while GARCH comes out to be insignificant. Thus, it can be concluded that ARMA (1,1)-GARCH (1,1) model is not suitable for modeling conditional variance of percentage change in CPI.

GJR-GARCH can capture asymmetric response of negative and positive shocks on volatility. In this model, we expect $\phi > 0$ if volatility behaves asymmetrically in case of negative and positive shocks. This asymmetric response of volatility is termed as leverage effect. A truncated result of ARMA (1,1)-GJR-GARCH (1,1) is shown below.

TABLE 3

ARMA (1,1)-GJR-GARCH (1,1) Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	7.65E-05	0.014320	0.005343	0.9957
AR(1)	-0.353628	0.410498	-0.861462	0.3890
MA(1)	0.541649	0.376753	1.437677	0.1505
Variance Equation				
C	0.005204	0.004338	1.199541	0.2303
RESID(-1)^2	-0.068232	0.059708	-1.142755	0.2531
RESID(-1)^2*(RESID(-1)<0)	-0.068001	0.060279	-1.128088	0.2593
GARCH(-1)	0.781543	0.233110	3.352674	0.0008

The results given in this table reveal that the coefficients of both autoregressive and moving average terms are not statistically significant. Similarly, ϕ in the equation for variance is not only negative but also contrary to our expectation for the presence of leverage effect but statistically insignificant too. The only coefficient which comes out to be significant is that of GARCH.

Thus, we conclude that there is no evidence of suitability of ARMA (1,1)-GARCH (1,1) model for modeling the volatility of differenced log CPI. Hence, we estimated GJR-GARCH (1,1) with only constant in equation for mean , as we did previously. The truncated result of this model specification is as given in Table 4.

TABLE 4

GJR-GARCH (1,1) Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000959	0.012466	0.076911	0.9387
Variance Equation				
C	0.011874	0.011136	1.066256	0.2863
RESID(-1)^2	-0.123142	0.071597	-1.719919	0.0854
RESID(-1)^2*(RESID(-1)<0)	0.050781	0.132918	0.382048	0.7024
GARCH(-1)	0.427790	0.613926	0.696810	0.4859

Results in above table indicate that estimated coefficient in mean equation is not significant i.e. mean of differenced log CPI is, in fact, zero. Though $\phi > 0$ as we hypothesized, it comes out to be statistically insignificant. Coefficients of both ARCH and GARCH terms are insignificant too. So we conclude that no empirical evidence is present for leverage effect even if we use only constant in mean equation of difference log of CPI.

Another model which can capture asymmetry in response of conditional variance to negative and positive shocks is EGARCH. A truncated result of ARMA (1, 1)-EGARCH(1, 1) is reproduced in Table 5.

TABLE 5
ARMA (1, 1)-EGARCH(1, 1) Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.001264	0.015814	0.079951	0.9363
AR(1)	-0.632168	0.193843	-3.261243	0.0011
MA(1)	0.794977	0.150024	5.299003	0.0000
Variance Equation				
C(4)	-8.040513	0.298836	-26.90610	0.0000
C(5)	-0.137281	0.110739	-1.239685	0.2151
C(6)	0.017915	0.072973	0.245500	0.8061
C(7)	-0.974616	0.034839	-27.97510	0.0000

The coefficients of both AR(1) and MA(1) terms in equation for mean of differenced log CPI comes out to be significant. However, the coefficient of term involving lag residual allows the sign of residual to affect conditional variance (in this case, c(6)). In order for asymmetric volatility response to negative and positive shocks, this term must be negative and significant. Whereas, table 5 shows that this term is not only positive but insignificant too. This is evidence of no asymmetric response volatility of differenced log CPI to negative and positive shocks.

CONCLUSIONS

On the basis of estimation results of various model of GARCH-family, with various specifications for mean equation for differenced log CPI for Pakistan, this study concludes that ARMA (1,1)-GARCH (1,1) is the most suitable model for modeling volatility of differenced log CPI. However, coefficients of both autoregressive and moving average terms in mean equation for ARMA (1,1)-GARCH (1,1) model are statistically insignificant.

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