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Inflation, Output Growth and Macroeconomic Uncertainties in Pakistan and India

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Abstract

This paper examines the dynamic relationships among inflation, output growth and their uncertainties for Pakistan and India for the period 1982-M4 to 2012-M12. We use various GARCH models to estimate the conditional variances that are used as proxies for the uncertainties of inflation and output growth. Finally, we use the bi-variate ARMA (p,q)-GARCH-M (1,1) models with diagonal BEKK specification to find the twelve causal relationships among inflation, output growth and their uncertainties. Our evidence supports the number of important conclusions. Firstly, we find that Friedman (1977) hypothesis, i.e., inflation leads to increase the inflation uncertainty is not supported in both Pakistan and India. Secondly, Cukierman-Meltzer (1986) hypothesis is accepted in Pakistan and Holland (1995) hypothesis is accepted in India. Thirdly, Black (1987) hypothesis is accepted in Pakistan and Deveraux (1989) hypothesis is accepted in India. We also find the strong relationship that higher output growth reduces the inflation in both India and Pakistan. We also conclude that the policy makers of both countries may take measures to reduce inflation rate because output growth is inversely related to inflation and the prevailing uncertainty in the economy.

Keywords: Inflation, Output Growth, Uncertainty, GARCH Models
JEL Classification Codes: C58, E31, E32

I. Introduction

Inflation, as an economic indicator, plays a crucial role in any economy because of its significant impact on economic development or growth. The theoretical and empirical literature points out certain causality relationships among inflation, output growth, inflation uncertainty and output growth uncertainty. Friedman (1977) argues that higher inflation leads to higher uncertainty of inflation, which changes the efficiency of price mechanism in allocating resources efficiently, and thus creates economic inefficiency and lowers output growth rate. Further, the uncertainty of inflation is being affected by interest rates creating impacts on the intertemporal distribution of resources. The findings of Fountas (2001), Kontonikas (2004) and Balciliar and Ozdemir (2013) strongly support the findings of Friedman Hypothesis that inflation cause's positive effect on inflation uncertainty. Cukierman and Meltzer (1986) provide a positive pivotal effect of inflation uncertainty on inflation, whereas Holland (1995) points out the negative contributing relationship between inflation and its uncertainty. The findings of Apergis (2004) and Jiranyakul and Opiela (2010) strongly support Cukierman and Meltzer Hypothesis. While Holland's Hypothesis is supported by Payne (2007) and Balcilar and Ozdemir (2013). Moreover, Mirman (1971) and Black (1987) find that the higher uncertainty of output growth increases output growth. Dejuan and Gurr (2004), Fountas et al. (2006) and Naryan and Naryan (2013) support the positive relationship between the uncertainty of output growth and output growth. Furthermore, Deveraux (1989) shows that higher uncertainty of output growth increases inflation; whereas Black (1987) finds that higher uncertainty of output growth reduces inflation. Grier and Perry (2000) fail to find any evidence to support the Deveraux (1989) hypothesis and support Black (1987). Fountas et al. (2002) fails to support the Black (1987) hypothesis and support the Deveraux (1989). Naryan and Naryan (2013) support the Black (1987) hypothesis.

Given this dynamic relationship among inflation, output growth and their uncertainties is one of the important issues in both theoretical and empirical aspects. However, the empirical evidence on these relationships remains scant or nonexistent; and need to be explored particularly for the developing countries like Pakistan and India specifically.

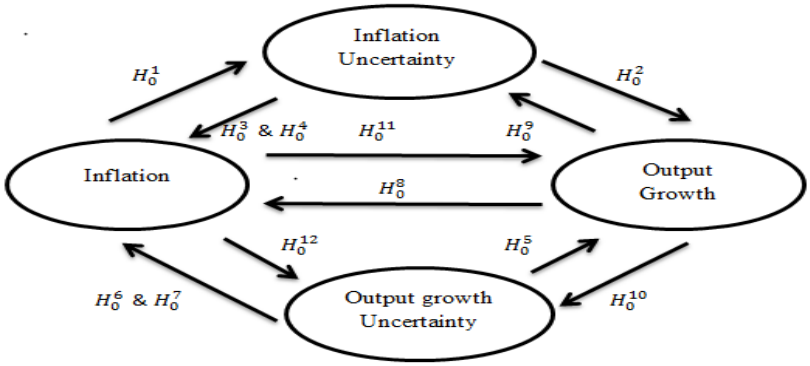
Therefore, the primary objective of this paper is to undertake the comprehensive analysis of relationships among inflation, output growth and their uncertainties considering both theoretical and empirical literature for developing countries like Pakistan and India. It examines the dynamic linkages among inflation, inflation uncertainty, output growth and output growth uncertainty. Further, it investigates 12 causality relationships among them using bi-variate GARCH-M (1, 1) Models. Specifically, it tests the following hypotheses (1) Friedman (1977) Hypothesis; (2) Cukierman-Meltzer (1986) Hypothesis; (3) Holland (1995) Hypothesis; (4) Black (1987) Hypothesis; (5) Mirman (1971) and Black (1987) Hypothesis; (6) Deveraux (1989) Hypothesis (1989) for Pakistan and India.

The structure of paper is as follows: Section 2 presents macroeconomic framework. Section 3 presents model specification and methodology. Section 4 reports data, preliminary analysis, estimated GARCH models and empirical results. Section 5 provides conclusion and policy recommendations.

II. Macroeconomic Framework

Friedman (1977) points out the ambiguous relationship of inflation and inflation uncertainty for the first time in his Nobel lecture and focuses the two main points. First, higher inflation leads to higher inflation uncertainty. Second, higher inflation leads to reduce the overall growth of the economy. Ball (1992) formalizes the first part of the Friedman (1977) hypothesis and examines that there is half-truth between public and policy makers regarding future inflation policy (monetary policy). He concludes that uncertainty of inflation is the main cause of high inflation, known as the Friedman-Ball hypothesis. Due to uncertainty of future inflation, the average rate of inflation is likely to be exaggerated. This critical point is not clear-cut in terms of theoretical aspects. Cukierman and Meltzer (1986) claims that uncertainty about future inflation is owed to the rate of money supply growth and the uncertainty about what the policy makers will do. They show that higher inflation uncertainty increases mean inflation, known as the Cukierman-Meltzer (1986) hypothesis. On the other hand, Holland (1995) tries to establish the importance of central bank in order to adopt strict monetary policy and control higher inflation (the Holland's hypothesis) and finds negative relationship between inflation and its uncertainty.

Figure 1: The Dynamic Relationship among Inflation, Output Growth and their Uncertainties



The second part of Friedman (1977) hypothesis points out that higher inflation uncertainty reduces the ratio of economic growth of the overall economy and establishes the negative relationship between both variables. Mirman (1971) concludes that higher output uncertainty increases output growth. Following this line further work is being much clearer by Deveraux (1989) and Black (1987). Theoretically, output growth uncertainty may reduce the inflation rate. This is known as Taylor (1979) effect, if Cukierman-Meltzer (1986) hypothesis grips, the rate of inflation. Deveraux (1989) reinforces the linkage between an increase in uncertainty of real variables and inflation in a positive theory of monetary policy framework. He determines that higher output volatility increases mean inflation and known as the Deveraux (1989) Hypothesis. He also considers the wage indexation and point out that the uncertainty of real variables lowers prime amount of wage indexation. Black (1987) considers the node between output uncertainty and average growth rate. He also highlights the relationship between

risk and return and claims that when any economy finance in a specified risky technology, the result leads to the higher economic growth. This indicates that better technology leads to increase the output growth and reduce inflation –an antithesis to Deveraux's (1989) view. The dynamic relationship among inflation, output growth and their uncertainties are shown through the Figure 1.

III. Model Specification and Methodology

We use Bivariate Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models to inspect the link among inflation, output growth and their uncertainties. These models are able to explain the dynamics among inflation, output growth and their uncertainties. We use univariate GARCH models like GARCH (1,1), EGARCH (1,1) and GJR-GARCH (1,1) to find the conditional variances of both inflation and output growth to be used as inflation and output growth uncertainties for further analysis. We also use Bivariate GARCH-M (1,1) model with diagonal BEKK specification to estimate the relationship between inflation and output growth by using conditional variances and conditional means of inflation and output growth as explanatory variables in the conditional mean equation.

A. Conditional Mean Specification

Autoregressive Moving Average (ARMA) model is used to identify the conditional mean equation. ARMA (p,q) is used to approximate the inflation and output growth series. That is;

$$X_t = c + \sum_{i=1}^{p} \delta_i X_{t-i} + \sum_{j=1}^{q} \varphi_j \varepsilon_{t-j} + \varepsilon_t \qquad (1)$$

Equation (1) is the mean equation, where X_t shows inflation and output growth at time *t-i* and *t* respectively and ε_t is residual.

B. Conditional Variance Specifications

GARCH (1, 1)

The most widely used model in practice is GARCH (1, 1) containing three parameters for conditional variance equation, very parsimonious and shown to be very adequate to capture the volatility clustering in data without the requirement of higher order models (Brooks, 2002). As GARCH (1,1) is found to be the most appropriate of the symmetric GARCH models for return data, this model is employed in this research study to find the conditional variances if inflation and output growth.

$$\sigma_{Xt}^2 = \omega_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{X(t-1)}^2 \qquad (2)$$

Equation (2) is conditional variance equation, where σ_{Xt}^2 shows conditional variances of inflation rate and output growth respectively, ε_{t-1}^2 is past shocks (ARCH term) and $\sigma_{X(t-1)}^2$ is past variance (GARCH term). For the positivity of conditional variance $\omega_0 > 0$, $\alpha_1 \geq 0$ and $\beta_1 \geq 0$ and for stationarity condition $\alpha_1 + \beta_1 < 1$.

EGARCH (1, 1)

The Exponential GARCH model proposed by Nelson (1991) incorporates skewness or asymmetric effects. EGARCH model overwhelms two foremost drawbacks

of symmetric GARCH model. This model is specified to capture the leverage effect and abolish the non- negativity constraint. In EGARCH (1, 1) model, the conditional variance equation is specified as follows:

$$ln\sigma^{2}_{Xt} = \omega_0 + \alpha_1 \left[\theta_1 \frac{\varepsilon_{t-1}}{\sqrt{\sqrt{\sigma^2_{Xt-1}}}} + \theta_2 \left\{ \frac{|\varepsilon_{t-1}|}{\sqrt{\sigma^2_{Xt-1}}} - E\left(\frac{|\varepsilon_{t-1}|}{\sqrt{\sigma^2_{Xt-1}}}\right) \right\} \right] + \beta_1 ln\sigma^2_{X(t-1)} \qquad (3)$$

Equation (3) specifies conditional variance in logarithmic form which guaranteed to be positive regardless of the values of the coefficients. The θ_1 reflects the sign effect and θ_2 reflects the magnitude effect. If the asymmetry effect is present, then $\theta_1 < 0$, while there is no asymmetry effect, if $\theta_1 = 0$. When $\theta_1 < 0$, positive shock increases volatility less than negative shock. When $\theta_1 > 0$, negative shock increases volatility less than positive shock.

GJR-GARCH (1, 1)

The GJR- GARCH model proposed by Glosten, Jagannathan and Runkle (1993) incorporates asymmetric effects. The GJR-GARCH model considers positive shocks and negative shocks and both have different effect on uncertainties.
The GJR-GARCH (p,q) model is specified as;

$$\sigma^2_{Xt} = \omega_0 + \sum_{i=1}^{q}(\alpha_i \varepsilon^2_{t-i} + \gamma_i \varepsilon^2_{t-i} S_{t-i}) + \sum_{j=1}^{p} \beta_1 \sigma^2{}_{X(t-1)} \qquad (4)$$

Equation (4) specifies S_t (dummy variable) = 1 if $\gamma_i < 0$, and 0 if $\gamma_i > 0$, in the model, good news ($\varepsilon_{t-1} > 0$), and bad news ($\varepsilon_{t-1} < 0$), acts differentially on the conditional variance. If $\gamma_i > 0$, bad news increases volatility (uncertainties) and leverage effect exists. The news impact is symmetric if $\gamma_i = 0$, i.e. past bad news (negative shocks) impacts similarly on current volatility as good news (positive shocks). For the existence of the second moment, the regularity condition is $(\alpha_1 + \beta_1 + \gamma_1) / 2 < 1$.

C. Bi-variate ARMA (p,q) - GARCH-M (1,1) Models of Inflation and Output Growth

We apply a bi-variate ARMA (p,q) GARCH-M (1,1) with diagonal BEKK specification (Engle & Korner , 1995) to estimate the relationships among inflation, output growth and their uncertainties simultaneously. The dependent variables in the model are inflation and output growth. The explanatory variables could predict the inflation and output growth in mean equations and their uncertainties in variance equations. This model allows the conditional mean be a function of conditional variance so that the conditional volatility can generate uncertainties being part of the specified model. An ARMA (p,q)- GARCH-M (1,1) is specified as follows:

$$\pi_t = c + \sum_{i=1}^{p} \delta_i \pi_{t-i} + \sum_{j=1}^{q} \varphi_j \varepsilon_{t-j} + \theta_1 \sigma^2_{\pi t} + \theta_2 \sigma^2_{yt} + \sum_{k=1}^{n} \tau_k Y_{t-k} + \varepsilon_t \qquad (5)$$

$$\sigma^2_{\pi t} = \omega_0 + \alpha_1 \varepsilon^2_{t-1} + \beta_1 \sigma^2_{\pi(t-1)} + \sum_{i=1}^{p} \delta_i \pi_{t-i} + \sum_{k=1}^{n} \tau_k Y_{t-k} \qquad (6)$$

$$Y_t = c + \sum_{i=1}^{p} k_i Y_{t-i} + \sum_{j=1}^{q} \emptyset_j \varepsilon_{t-j} + \partial_1 \sigma^2_{Yt} + \partial_2 \sigma^2_{\pi t} + \sum_{k=1}^{n} \rho_k \pi_{t-k} u_t \qquad (7)$$

$$\sigma_{Yt}^2 = \omega_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{Y(t-1)}^2 + \sum_{i=1}^{p} k_i Y_{t-i} + \sum_{k=1}^{n} \rho_k \pi_{t-k} \quad (8)$$

$$COV = \rho_{\varepsilon\mu} \sigma_{\varepsilon t} \sigma_{\mu t} \quad (9)$$

Where, Equation (5) describes mean inflation (π_t) as a function of p and q lags of the autoregressive and moving average components, conditional variances of inflation ($\sigma_{\pi t}^2$) and output growth (σ_{Yt}^2) and real output growth (Y_t). Equation (6) describes the conditional variance of inflation. Equation (7) describes output growth (Y_t) as a function of p and q lags of the autoregressive and moving average components, conditional variances of inflation ($\sigma_{\pi t}^2$) and output growth (σ_{Yt}^2) and inflation (π_t). Equation (8) describes the conditional variance of output growth. Equation (9) represents the constant conditional correlation model of the covariance between the residuals of Eq. (5 & 7). In Eq. (6 & 8), for the positivity of GARCH, $\omega_0 > 0$, $\alpha_1 > 0$ and $\beta_1 > 0$. The stationarity condition of bi-variate GARCH (1, 1) with diagonal BEKK specification is $(\alpha_1)^2 + (\beta_1)^2 < 1$.

For the estimation of GARCH Models, various specifications of the ARMA (p,q) model are examined, prior to modeling the conditional variance simultaneously with the conditional mean equation. The maximum-likelihood estimation (MLE) is employed in the estimation of GARCH models. The model selection criteria for GARCH models include AIC (Akaike Information Criteria) and SIC (Schwartz Criteria), log-likelihood values, LM ARCH test, Box-Pierce Q and Q^2 Statistics are used with normal and t-distribution. The ML estimates are consistent and asymptotically normally distributed provided the conditional mean and variance functions of the GARCH model are correctly specified. The Broyden–Fletcher–Goldfarb-Shanno (Fletcher, 1987) numerical optimization algorithm is used to obtain the ML estimates of the parameters. For the estimation of Bi-variate GARCH models, Diag- BEKK model (Engle & Korner, 1995) condition for inflation and output growth is used.

IV. Data and Preliminary Analysis

The relationship among inflation, output growth and their uncertainties are tested for Pakistan and India. In our analysis, we use consumer price index and industrial production/ manufacturing production as proxies for inflation and output growth. Monthly Data is employed in this study ranges from 1982-4 to 2012-12, obtained from International Financial Statistics (IFS) data base. Inflation is measured by the monthly difference in the log of CPI ($\pi_t = \log(CPI_t/CPI_{t-1}) * 100$) and output growth is measured by the monthly difference in the log of Industrial production / manufacturing production($Y_t = \log(IP_t/IP_{t-1}) * 100$. Because uncertainties of both inflation and output growth cannot be directly observable, therefore monthly squared returns series are used as proxies of realized uncertainties.

Figure 2 & 3 indicate no definite patterns for both inflation and output growth; they also revert quickly to their means. Variances changes overtime and volatility tends to cluster, also high volatility periods distinguished from low volatility periods. Since, the conditional variance is not directly computable, squared returns are used as a proxy of uncertainties for both variables (inflation and output growth). In Figure 4 & 5, squared

inflation and output growth returns are shown, which have "spiky" looks demonstrating variation in volatility. They reveal that extreme returns contribute more to the volatility.

Figure 2: Return Series of Inflation and Output Growth of Pakistan

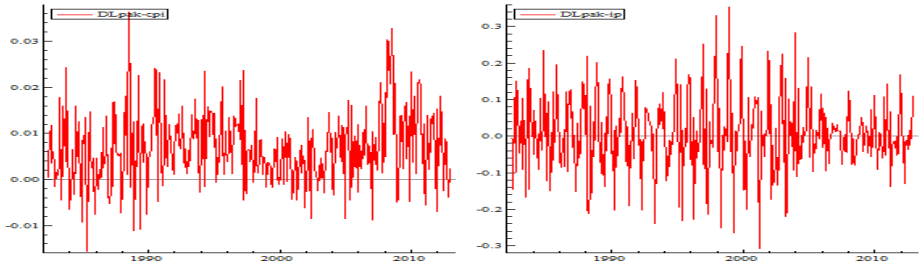


Figure 3: Return Series of Inflation and Output Growth of India

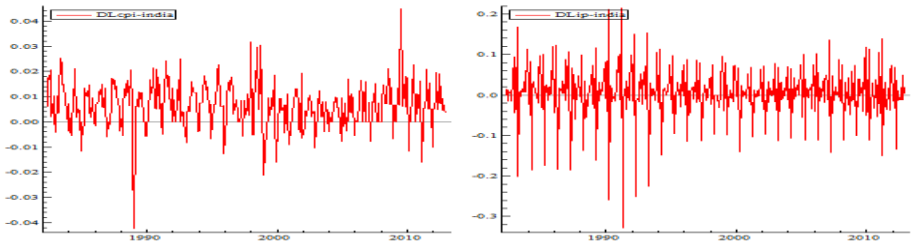


Figure 4: Squared Return Series of Inflation and Output Growth of Pakistan

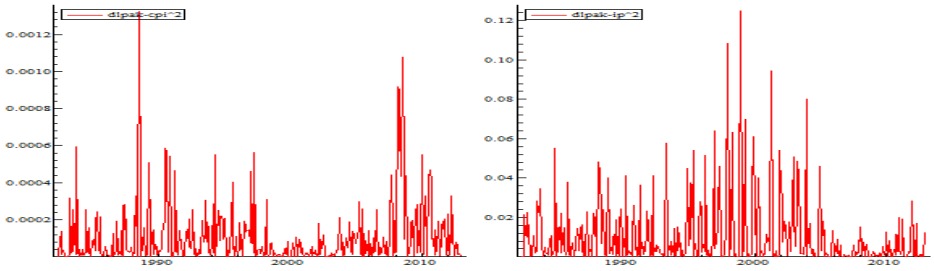
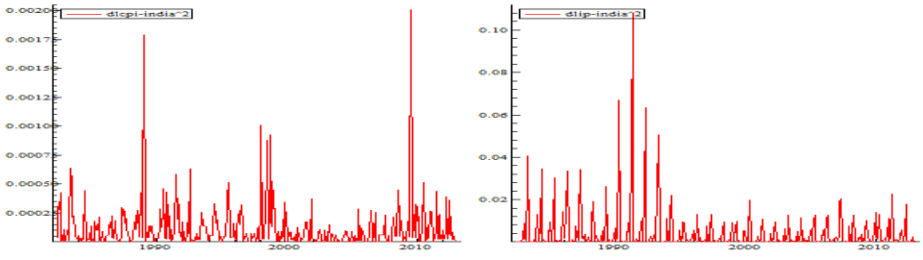


Figure 5: Squared Return Series of Inflation and Output Growth of India



The descriptive statistics for the monthly inflation and output growth return series of both Pakistan and India are presented in table 4.1. It shows the mean of both inflation and output growth series are positive for both countries.

Table 1: Descriptive Statistics Inflation and Output Growth Return Series

	Mean	Std.Dev.	Skewness	Excess Kurtosis	J-B
Pak-INF	0.0067028	0.0087363	0.48819	0.85265	25.765**
Pak-IP	0.0046579	0.064692	0.063900	0.80503	10.188**
India-INF	0.0063859	0.0076042	-0.28639	3.3763	179.82**
India-IP	0.0054939	0.099134	-1.0176	4.1858	332.17**

Note: INF- denotes inflation and IP- denotes industrial production/ manufacturing production ** indicates significant at 1%

Table 1 presents the summary statistics of monthly inflation and output growth return series for both Pakistan and India. Mean values of both inflation and output growth are positive, values of skewness is positive for Pakistan (indicating positive skewness) and negative for India (indicating negative skewness) but statistically significant. Excess Kurtosis is positive and significant, showing that both returns (inflation and output growth) are heavy tailed and have leptokurtic distribution. The Jarque-Bera statistics is used to test the normality of data, are positive and statistically significant.

To test the stationarity of time series, Kwiatkowski-Phillips-Schmidt-Shin (KPSS; 1992) test with constant and trend terms is used. The results in Table 4.2 show non-stationarity of all the variables in level form and stationarity of all the variables in first difference form.

Table 2: Unit Root Tests

	KPSS Test Statistic					
	Level			First Difference		
Variables	With Constant	With Constant and Trend	Results	With Constant	With Constant and Trend	Results
Pak-Inf	12.1741***	0.8227***	Non-Stationary	0.0097***	0.0071***	Stationary
Pak-IP	11.246***	0.36148***	Non-Stationary	0.0081***	0.0067***	Stationary
India-Inf	12.1825***	2.1643***	Non-Stationary	0.1885***	0.1151**	Stationary
India-IP	12.1276***	0.30141***	Non-Stationary	0.5477*	0.1956*	Stationary
Critical Values (KPSS)						
	1%	5%	10%			
No Trend	0.739	0.463	0.347			
With Trend	0.216	0.146	0.119			

Note: Level represents the Lag value of Monthly Consumer Price Index and Industrial Production/Manufacturing Production and First Difference represents the difference operator of both considered variables. *** shows Stationary/Non-Stationary at 10% level of significance, ** at shows Stationary/Non-Stationary at 5% level of significance and * shows Stationary/Non-Stationary at 1% level of significance, at level and 1st difference with trend and without trend.

In order to check the conditional heteroskedasticity, Lagrange Multiplier test and the Ljung-Box test are employed on return series of both inflation and output growth for Pakistan and India. The Ljung-Box-Pierce Q and Q^2 statistics at lag 4, 8 and 12 are significant indicating the presence of serial correlation in both residual and square residuals. LM test also support the strong evidence for the presence of ARCH effect in square residuals of both inflation and output growth series for Pakistan and India. Results are shown in the Table 3.

Table 3: ARCH Test

	Lags	Pak-Inf	Pak-IP	India-Inf	India-IP
Q-Statistics on Raw Data	**4**	34.4402 [0.0000006]**	27.2025 [0.0000181]**	61.8236 [0.0000000]**	95.1683 [0.0000000]**
	8	37.3829 [0.0000098]**	131.062 [0.0000000]**	124.163 [0.0000000]**	116.551 [0.0000000]**
	12	88.4460 [0.0000000]**	307.506 [0.0000000]**	220.305 [0.0000000]**	420.309 [0.0000000]**
Q-Statistics on Squared Data	**4**	85.2637 [0.0000000]**	13.7607 [0.0080994]**	14.7582 [0.0052299]**	37.7500 [0.0000001]**
	8	90.3150 [0.0000000]**	28.4970 [0.0003884]**	20.3964 [0.0089360]**	56.6802 [0.0000000]**
	12	101.420 [0.0000000]**	165.753 [0.0000000]**	41.0827 [0.0000475]**	332.906 [0.0000000]**
ARCH LM Test (F-Statistics)	**ARCH1-2**	17.017 [0.0000]**	2.8060 [0.0618]	4.5932 [0.0107]*	26.785 [0.0000]**
	ARCH1-4	15.760 [0.0000]**	3.7509 [0.0053]**	3.9412 [0.0038]**	13.538 [0.0000]**
	ARCH1-8	7.8818 [0.0000]**	3.5321 [0.0006]**	2.6283 [0.0083]**	8.9753 [0.0000]**

Note: Inf- denotes inflation and Ip- denotes industrial production/ manufacturing production, ***p* – values** are in parentheses ** indicates significant at 1% and * significant at 5% level of significance.

The evidences of non-stationarity, non-normal distribution and significant volatility of both inflation and output growth return series leads to imply the use of non-linear models to model volatility. Hence, we estimate different GARCH models like GARCH (1,1), EGARCH(1,1) and GJR-GARCH(1,1) with normal and student's t-distribution for both inflation and output growth return series.

A. Estimation of Conditional variances

In order to find the best fitted model for each return series of inflation and output growth rate, we estimate the GARCH, EGARCH and GJR-GARCH models with both normal and student's t-distribution. Estimation of conditional variances of both (inflation and output growth) series depends upon the basis of Maximum Likelihood (ML), the Akaike Information Criteria (AIC), Autoregressive (AR) and Moving Average (MA) by Least Squares (LS) are used. For Pakistan, by applying different ARMA(p,q)-GARCH(1,1) models, ARMA(1,1)-GJR(1,1) with t- distribution is used for estimating the conditional variance of inflation rate and ARMA(3,4)-GARCH(1,1) with t-distribution is used for estimating the conditional variance of industrial production being used as proxy for their uncertainties by considering the ACF, PACF and minimum information criterion. For India, ARMA(1,1)-GJR(1,1) with normal distribution is used for estimating the conditional variance of inflation rate and ARMA(3,2)-GARCH(1,1)

with normal distribution is used for estimating the conditional variance of industrial production being used as proxy for their uncertainties by considering the ACF, PACF and minimum information criterion. Both satisfy the positivity condition of GARCH models and the stationarity condition i.e., $\alpha + \beta < 1$.

B. Estimated GARCH-in- Mean Model of Inflation and Output Growth

Pakistan

The results from the bi-variate GARCH-M (1, 1) with diagonal BEKK specification model for both (inflation and output growth) series are given below. An ARMA (0, 3) – bi-variate GARCH-M (1, 1) is specified as follows:

$$\pi_t = \underset{(0.0635)*}{0.001206} + \underset{(0.3782)}{0.523005}\pi_{t-1} + \underset{(0.4749)}{0.391740}\pi_{t-2} - \underset{(0.4851)}{0.413478}\varepsilon_{t-1} - \underset{(0.2321)}{0.564113}\varepsilon_{t-2} + \underset{(0.0159)**}{0.105663}\varepsilon_{t-3} - \underset{(0.7266)}{2.192575}\sigma_{\pi t}^2 - \underset{(0.0784)*}{0.084674}\sigma_{yt}^2 - \underset{(0.2580)}{0.004587}Y_{t-1} - \underset{(0.1940)}{0.005932}Y_{t-2} + \underset{(0.3513)}{0.006361}Y_{t-3} + \varepsilon_t \quad (4.1)$$

$$\sigma_{\pi t}^2 = \underset{(0.3854)}{0.001508} + \underset{(0.1794)}{0.218506}\varepsilon_{t-1}^2 + \underset{(0.0000)***}{0.784219}\sigma_{\pi(t-1)}^2 - \underset{(0.0000)***}{0.042023}\pi_{t-3} + \underset{(0.1044)}{0.003633}Y_{t-4} \quad (4.2)$$

$$Y_t = \underset{(0.0130)**}{0.003436} + \underset{(0.0000)***}{0.743092}Y_{t-1} + \underset{(0.0000)***}{0.547887}Y_{t-2} - \underset{(0.0000)***}{0.767769}Y_{t-3} - \underset{(0.0000)***}{0.974783}\varepsilon_{t-1} - \underset{(0.0000)***}{0.610564}\varepsilon_{t-2} + \underset{(0.0000)***}{0.736402}\varepsilon_{t-3} + \underset{(0.7698)}{0.065453}\sigma_{Yt}^2 - \underset{(0.4851)}{0.413478}\sigma_{\pi t}^2 - \underset{(0.0099)***}{0.901073}\pi_{t-1} + \underset{(0.0019)***}{1.539379}\pi_{t-2} + u_t \quad (4.3)$$

$$\sigma_{Yt}^2 = \underset{(0.3739)}{0.000003} + \underset{(0.0000)**}{0.236995}\varepsilon_{t-1}^2 + \underset{(0.0000)***}{0.947793}\sigma_{Y(t-1)}^2 - \underset{(0.0002)***}{0.059956}Y_{t-4} - \underset{(0.9991)}{0.000026}\pi_{t-3} \quad (4.4)$$

$$COV = \underset{(0.5965)}{-0.002009}\sigma_{\varepsilon t}\sigma_{\mu t} \quad (4.5)$$

In equation (1) and (2), results of mean inflation and inflation uncertainty are stated. Our results do not support the findings of Friedman (1977) hypothesis i.e., higher inflation increases inflation uncertainty as Daal *et al.* (2005) supported the Friedman (1977) hypothesis for Pakistan. Second part of Friedman (1977) hypothesis that is, higher inflation increases its uncertainty is insignificant in our study. Cukierman-Meltzer (1986) hypothesis is not accepted in case of Pakistan means higher inflation uncertainty increases inflation. As, Rizvi and Naqvi (2009) and Javed *et al.* (2012) also do not support the Cukierman-Meltzer (1986) Hypothesis. Holland (1995) hypothesis is accepted in case of Pakistan. In equation (4.3) and (4.4), results of output growth and its uncertainty are stated. Black (1987) hypothesis is also accepted that is, Higher output growth uncertainty reduces inflation. Results also supports that higher output growth reduces inflation and higher output growth uncertainty reduces output growth. Also suggested by Ayyoub *et al.* (2011) in his study that in case of Pakistan, higher prices leads to increase the inflation lead to increase the inflation uncertainty and decrease the overall growth of the economy. Equation (4.5) represents the constant conditional correlation model of the covariance between the residuals of equations (4.2) and (4.4). For both (inflation and output growth) series β (past variance means GARCH term) is significant at 1%, 5% and 10% level of significance but α (past shocks means ARCH term) is insignificant for inflation series. The values of $\alpha^2 + \beta^2 < 1$ i.e., 0.66275 for inflation series and 0.95448 for output growth series, satisfying the stationary condition. Diagnostic testing of final model, the Q-statistic for the standardized residuals indicates

presence of serial autocorrelation. Q^2-statistic for the squared standardized residuals indicates absence of serial autocorrelation up to 12 lags shown in table-A 4.4.

India

The results from the bi-variate GARCH-M (1,1) model with diagonal BEKK specification for both (inflation and output growth) series are given below. An ARMA (0,2)- bi-variate GARCH-M (1,1) is specified as follows;

$$\pi_t = \underset{(0.0001)***}{0.006817} - \underset{(0.9730)}{0.003903}\pi_{t-1} - \underset{(0.0002)***}{0.346063}\pi_{t-2} + \underset{(0.000)***}{0.296878}\pi_{t-3} + \underset{(0.0011)***}{0.368542}\varepsilon_{t-1} + \underset{(0.0001)***}{0.419014}\varepsilon_{t-2} - \underset{(0.0891)*}{33.345737}\sigma^2_{\pi t} + \underset{(0.0060)***}{1.005598}\sigma^2_{yt} - \underset{(0.0000)***}{0.040043}Y_{t-1} - \underset{(0.0000)***}{0.065081}Y_{t-2} - \underset{(0.0000)***}{0.053396}Y_{t-3} + \varepsilon_t \quad (4.6)$$

$$\sigma^2_{\pi t} = \underset{(0.0000)***}{0.004602} + \underset{(0.0000)***}{0.484200}\varepsilon^2_{t-1} + \underset{(0.0000)***}{0.613947}\sigma^2_{\pi(t-1)} - \underset{(0.1839)}{0.016988}\pi_{t-4} + \underset{(1.00000)}{0.0000000}Y_{t-4} \quad (4.7)$$

$$Y_t = \underset{(0.0000)***}{0.062212} - \underset{(0.0000)***}{0.645664}Y_{t-1} - \underset{(0.0000)***}{0.571452}Y_{t-2} - \underset{(0.0922)*}{0.121577}Y_{t-3} + \underset{(0.0002)***}{0.222008}\varepsilon_{t-1} + \underset{(0.0000)***}{0.696337}\varepsilon_{t-2} - \underset{(0.0032)***}{24.976281}\sigma^2_{Yt} - \underset{(0.0000)***}{21.523299}\sigma^2_{\pi t} - \underset{(0.0040)***}{1.138295}\pi_{t-1} + \underset{(0.2016)}{0.335237}\pi_{t-2} - \underset{(0.0000)***}{1.572178}\pi_{t-3} + u_t \quad (4.8)$$

$$\sigma^2_{Yt} = \underset{(1.0000)}{0.000002} + \underset{(0.0300)**}{0.175295}\varepsilon^2_{t-1} + \underset{(0.0000)***}{0.903245}\sigma^2_{Y(t-1)} + \underset{(1.0000)}{0.0000003}Y_{t-4} + \underset{(0.0000)***}{0.200620}\pi_{t-4} \quad (4.9)$$

$$COV = \underset{(0.8281)}{-0.001331}\sigma_{\varepsilon t}\sigma_{\mu t} \quad (4.10)$$

Results of mean inflation and its uncertainty are reported in equation (4.6) and (4.7). Our results do not support the findings of Friedman (1977) hypothesis that is, higher inflation increases inflation uncertainty except we found that higher inflation reduces inflation uncertainty contrary to the findings of Chowdhury (2014), as in his study Friedman (1977) hypothesis does not hold for India. Second part of the Friedman (1977) hypothesis, that is, uncertainty of inflation reduces output growth is supported in this study. Cukierman-Meltzer (1986) hypothesis is also not accepted in case of India means higher inflation uncertainty increases inflation as also supported for India by Naryan and Naryan (2013) and Chowdhury (2014). Holland (1995) hypothesis is accepted in this study for India. Results of output growth and its uncertainty are reported in equation (4.8) and (4.9). Black (1987) hypothesis is not accepted that is, higher output uncertainty reduces inflation as suggested by Naryan and Naryan (2013) in their study. whereas, Deveraux(1989) hypothesis is accepted in this study, that is, higher output growth uncertainty increases inflation. Also found that higher output growth reduces inflation as well as inflation uncertainty. Higher output growth reduces output growth uncertainty. Whereas, higher inflation reduces output growth and increases output growth uncertainty. Equation (4.10) represents the constant conditional correlation model of the covariance between the residuals of equations (4.7) and (4.9). For both (inflation and output growth) series β (past variances) is significant at 1%, 5% and 10% significance level but α (past shocks) is insignificant for inflation series. The values of $\alpha^2 + \beta^2 < 1$ i.e., 0.61139 for inflation series and 0.84658 for output growth series, satisfying the stationary condition. Q-statistic for the standardized residuals indicates presence of serial

autocorrelation. Q^2-statistic for the squared standardized residuals indicates absence of serial autocorrelation up to 12 lags shown in table-A 4.4.

V. Conclusion and Policy Recommendations

This paper empirically investigates the causal relationship between inflation and output growth along with theirs uncertainties for India and Pakistan. We use bi-variate GARCH-in-Mean (1, 1) with diagonal BEKK specification, to estimate the 12 Causal relationships between these variables. Firstly, we find that Friedman (1977) Hypothesis i.e., inflation increases inflation uncertainty is not accepted in both Pakistan and India. On the other hand, its second part i.e., inflation uncertainty reduces output growth is accepted in India. Secondly, Cukierman-Meltzer (1986) hypothesis is accepted in case of Pakistan and Holland (1995) Hypothesis is accepted in case of India. Black (1987) Hypothesis is accepted in Pakistan and Deveraux (1989) Hypothesis is accepted in India.

In this study, we also find some other relationship ambiguous relationship among these variables (inflation, output growth and their uncertainties). Firstly, find strong relationship that higher output growth reduces the inflation in both India and Pakistan as previously investigated in developing countries by many researchers (Briault, 1995; Klump, 2003). We also find that in Pakistan, higher inflation decreases output growth uncertainty. In case of India, higher output growth reduces inflation, its uncertainty and output growth uncertainty. Also find that in India, higher inflation reduces output growth as well. In conclusion, the governments of developing countries must take into account the inflation rate to lower the inflation because output growth is cruelly disturbed by inflation and its prevailing uncertainty in the economy.

This study unlocks the opportunities for future research with more detailed structural breaks of inflation, output growth as well as their uncertainties of data. Researcher may take into account some other variables like price stability, investment, foreign exchange rate and political instability to get more accurate results that how inflation disturbs the output growth of the economy via different channels. The causality relationship among the variables (inflation, output growth and their uncertainties) may also depend on the political situation of an economy especially for the developing countries like Pakistan and India.

From policy maker's point of view, uncertainty of inflation must be controlled in the developing countries because it leads to increased uncertainty of inflation in these countries. Its side effect is exchange rate volatility, which in turn leads very hazardous situation for any developing economy to survive. So price stability must be the main fundamental objective of developing economies. The positive association between inflation and its uncertainty leads to create the uncertainty of future monetary policy in the minds of public and investors. It must be controlled by central banks to ensure the price stability as well as public confidence. Central banks not only have to control the prices but also achieve the goal of higher output growth by considering nominal and real uncertainties. Spillover effects between the real and nominal uncertainties need a policy to stable the negative impressions of inflation and output growth prevailing in the economy. From Pakistan perspective, there is a need of strong monetary policy to ensure the price stability in the economy and overall increase in the output growth of the economy.

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