Inflation Volatility: An Asian Perspective

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Abstract

The primary purpose of this study is to model and analyze inflation volatility in ten selected Asian economies. We used quarterly data of inflation from 1987Q1 to 2008Q4 to model inflation volatility as time varying process through different symmetric and asymmetric GARCH specifications. We also proposed to model inflation volatility on the basis of cyclic component of inflation obtained from HP filter instead of actual inflation when the latter does not fulfill the criterion of stationarity. Through news impact curves we tried to highlight the behavior of inflation volatility in response to lagged inflation shocks under different GARCH specifications for selected economies. Bivariate granger causality test is also applied to analyze the direction of causality between inflation and different volatility estimates.

We get few important results. At first, leverage parameter shows expected sign and is significant for almost all countries suggesting strong asymmetry in inflation volatility. The hyperbolic sign integral shape of news impact curves based on GJR-GARCH is consistent with the results of our previous study based on Pakistani data (Rizvi and Naqvi, 2008) and highlights the importance of inflation stabilization programs particularly because of the subsequent evidences obtained in favor of bidirectional causality running between inflation and inflation volatility. There are also evidences in favor of the argument that cyclic component of inflation could be a used as a suitable proxy of inflation for volatility estimation.

Keywords: Inflation Volatility, Uncertainty, GJR-GARCH, EGARCH, Asymmetry, Asia

JEL Classification: C22, E31, E37

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1. Introduction

The primary purpose of this paper is to investigate about and to analyze the behavior of inflation volatility in different Asian economies. There is a consensus about the negative consequences of inflation volatility on different financial and economic variables which eventually deteriorate the economic growth and welfare. Abundant literature has been available on different channels through which inflation volatility distorts the decision making regarding future saving and investment, the efficiency of resource allocation and the level of real output. (Fischer 1981, Golob 1993, Holland 1993b)

However there are two issues which are still debatable and there exist significantly different thoughts about them in economic literature. First issue is about the causality running between inflation and inflation volatility. Friedman (1977), Ball and Cecchetti (1990), Cukierman and Wachtel (1979), Evans (1991), and Grier and Perry (1998), among others, provide evidences in support of a positive impact of average rate of inflation on inflation volatility, which is more commonly known as "Friedman-Ball Hypothesis". On the other hand Cukierman-Meltzer (1986), Holland (1995), Baillie et al (1996) for UK, Argentina, Brazil and Israel and Grier and Perry (1998) for Japan and France provide some evidences, contrary to above and in support of causality running from inflation volatility to inflation, which is more commonly known as "Cukierman-Meltzer Hypothesis".

Second issue is about the suitable proxy for inflation volatility or uncertainty. Most common way to estimate inflation volatility is from surveys of expectations, such as Livingston survey in the United States in which inflation volatility is captured as variance of inflation forecasts across cross sectional data. However, in his remarkable contribution, Engle (1983) first modeled inflation volatility as autoregressive or time varying conditional hetersoscedasticity (ARCH), in which he used conventional inflation equation with fixed parameters but allowed the conditional variance of inflation shocks (forecast errors) to vary overtime, suggesting that this variance could be used as a proxy for inflation volatility. Empirical research on ARCH model often identified long lag processes for the squared residuals, showing persistent effects of shocks on inflation volatility. To model this persistence many researchers subsequently suggested variations or extensions to the simple ARCH model to test the inflation uncertainty hypothesis. Bollerslev (1986) and Taylor (1986) independently developed the generalized ARCH (GARCH) model, in which the conditional variance is a function of lagged values of forecast errors and the conditional variance. Beside Bollerslev (1986) there are several studies which modeled inflation volatility through GARCH frameworks, such as Bruner and Hess (1993) for US CPI data, Joyce (1995) for UK retail prices, Della Mea and Peña (1996) for Uruguay, Corporal and McKiernan (1997) for the annualized US inflation rate, Grier and Perry (1998) for G7 countries, Grier and Grier (1998) for Mexican Inflation, Magendzo (1998) for Inflation in Chile, Fountas et al (2000) for G7 countries , and Kontonikas (2004) for UK. All these studies modeled inflation volatility through GARCH model in one way or other.

The major drawback of typical ARCH or GARCH models is that they assume symmetric response of conditional variance (volatility) to positive and negative shocks. However, it has been argued that the behavior of inflation volatility is asymmetric rather than symmetric. Brunner and Hess (1993), Joyce (1995), Fountas et al (2006), Bordes et al (2007) are of the view that positive inflation shocks increases inflation volatility more than the negative inflation shocks of equal magnitude. Beyond that there are some evidences from Pakistani data that not only having lesser impact on inflation volatility, negative inflation shocks can even contribute in reducing inflation volatility, Rizvi and Naqvi(2008). If this is correct, the symmetric ARCH and GARCH models may provide misleading estimates of inflation uncertainty [Crawford and Kasumovich, 1996].

The three most commonly used GARCH formulations to capture asymmetric behavior of conditional variance, are the GJR or Threshold GARCH (TGARCH) models of Glosten, Jagannathan and Runkle (1993) and Zakoïan (1994), the Asymmetric GARCH (AGARCH) model of Engle and Ng (1993), and the Exponential GARCH (EGARCH) model of Nelson (1991).

In this paper we tried to model inflation volatility for ten South Asian economies with the help of dynamic structure for mean inflation and different GARCH specifications for inflation volatility. For those countries where inflation series is found to be non stationary, we model cyclic component of inflation obtained through Hodrick Prescott filter, in addition to actual inflation series to extract inflation volatility from it. We also graphically depict the impact of inflation shock on degree of asymmetry of next period volatility through News Impact Curves proposed by Pagan and Schwart (199). And finally we present the categorized results of bivariate Granger Causality test between inflation and different volatility estimates for the economies under consideration.

The paper is organized as follows: description of data and preliminary stationarity analysis of time series is provided in section 2; section 3 presents the empirical framework; section 4 provides estimation and results. Section 5 concludes.

2. Description and Preliminary Analysis of Data

2.1 Core vs. Headline Inflation

The choice between core vs. headline inflation as a suitable proxy of inflation is crucial while modeling inflation volatility. It is generally believed that headline inflation is more volatile than core inflation due to the large commodity representation including oil and food. Mishkin (2007) is of the view that despite of the fact that core inflation may not represent a true picture of the inflation, monetary authorities should respond and target core inflation as it is more appropriate than responding headline inflation due to its inherently highly volatile and less persistent structure.

The above argument has certain shortcomings; many economists raised the questions that if the core inflation does not truly represent the inflation in economy, do we really need to follow or even control it? The second argument is the persistent increase in oil prices during recent decades, which is definitely reflecting a changing global demand structure for oil and thus the control of which is undoubtedly the part of the medium term and the long term policies of monetary authorities.

The myth about core inflation as a better predictor of persistent inflation and thus should be the key measure to watch, came under serious threat after the release of a research conducted by Federal Reserve Bank of Philadelphia in May 2008 saying that "***We find that food and energy prices are <u>not</u> the most volatile components of inflation and that, depending on which inflation measure is used, core inflation is not necessarily the best predictor of total inflation"***[**] . They also strongly suggest considering both core and headline inflation as opposed to only core inflation because both measures provide independent information and the dual focus can significantly improve the accuracy of inflation forecasting model.

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In the light of above arguments and keeping in view the fact that our data set is primarily composed of emerging or less developed countries where the oil price is the major determinant of other products' prices, the overall prices are downward sticky and the percentage of disposable personal income on food consumption is more than 50 percent as opposed to developed countries where this percentage is between 9 to 15 percent, it is very difficult for monetary authorities to ignore oil and food prices while modeling and coping with inflation. Therefore, we decide to model inflation volatility on the basis of quarterly series of CPI calculated on Y-o-Y basis.

2.2 Data Set

Our data set is composed of quarterly estimates of inflation for 10 Asian economies; China, Hong Kong, India, , Indonesia, Malaysia, Pakistan, Philippines, Singapore, South Korea and Thailand. All data is taken from International Financial Statistics Database (IFS) of IMF and covers the time period from 1987Q1 to 2008Q4.

Table 1: Descriptive Statistics of Inflation in South Asian Economies (1987 to 2008)

	China	Hong Kong	India	Indonesia	Malaysia	Pakistan	Philippines	Singapore	SKorea	Thailand
Mean	6.472663	4.112253	7.496943	11.48022	2.900090	8.015435	7.395483	1.558834	4.611135	3.946988
Median	3.703700	5.174015	7.170915	8.793350	2.795090	8.392045	7.261205	1.501500	4.434340	3.978555
Maximum	27.62790	11.93870	17.86040	78.38900	7.934510	19.34580	19.78290	6.625120	10.98050	10.36330
Minimum	-2.054300	-5.867270	0.461538	-0.572565	0.262055	1.780680	-1.465110	-1.455890	0.594059	-0.927835
Std. Dev.	7.813791	5.072901	3.412916	12.80605	1.471188	3.535190	4.024894	1.350859	2.311062	2.239606
Skewness	1.329162	-0.253206	0.573607	3.955498	0.818512	0.262860	0.627741	0.503718	0.535520	0.204393
Kurtosis	3.804831	1.717406	3.027992	19.03415	4.087578	2.780538	4.348371	4.195422	2.799835	2.738530
Jarque-Bera	27.96483	6.972164	4.828574	1172.152	14.16314	1.162950	12.44591	8.655699	4.204641	0.863397
Probability	0.000001	0.030621	0.089431	0.000000	0.000840	0.559073	0.001983	0.013196	0.122173	0.649405
Observations	87	88	88	88	88	86	88	85	85	88

2.3 Stationarity of Variables

To check the order of integration, we conduct the panel unit root tests for inflation in this section. Table 2 reports the summary statistics of five different panel unit root tests each with two classifications, first with constant term only and the second with both constant and trend term. Two out of five tests assume common unit root process in all cross sections where as the rest of three assume individual unit root processes for each cross section, which is more realistic assumption. Only LLC test does not reject the null hypothesis of common unit root in both specifications, rest of the tests clearly reject the null hypothesis of common or individual unit root and are highly significant.

Table 2: Panel Unit Root Tests

Exogenous variables:	**Individual effects**		**Individual effects, individual linear trends**			
	Statistic	**Prob.****	**Statistic**	**Prob.****	**Cross-sections**	**Obs**
Null: Unit root (assumes common unit root process)						
Levin, Lin & Chu t*	0.66668	0.7475	2.84705	0.9978	10	826
Breitung t-stat			-2.01232	0.0221	10	816
Null: Unit root (assumes individual unit root process)						
Im, Pesaran and Shin W-stat	-3.69279	0.0001	-2.78323	0.0027	10	826
ADF - Fisher Chi-square	61.4599	0.0000	54.8758	0.0000	10	826
PP - Fisher Chi-square	45.8235	0.0009	38.2066	0.0084	10	861

The rejection of null in IPS, ADF and PP test is little big vague in the sense that it leads us to accept the alternative of "some cross sections without unit root". To have a deep insight about each cross section we report the Im, Pesaran and Shin W-statistics for individual cross sections in table 3, considering only intercept term and automatic lag selection based on SIC. The reason for dropping linear trend term is that in our opinion economic theory does not provide enough evidences in support of assumption about the presence of any long term linear trend in inflation rate.

Table 3: Unit Root Test Statistics for Individual Cross Section

Cross section	**t-Stat**	**E(t)**	**E(Var)**	**Lag**	**Max Lag**	**Obs**
China	-2.7397	-1.477	0.802	5	11	81
Hong Kong*	-0.9262	-1.481	0.788	4	11	83
India*	-1.4050	-1.427	0.855	8	11	79
Indonesia	-6.4052	-1.526	0.749	1	11	86
Malaysia	-2.7681	-1.526	0.749	1	11	86
Pakistan*	-0.9892	-1.476	0.803	5	11	80
Philippines	-2.4992	-1.478	0.801	5	11	82
Singapore	-2.0354	-1.525	0.750	1	11	83
SKorea	-1.6866	-1.478	0.791	4	11	80
Thailand	-3.8036	-1.526	0.749	1	11	86

*Fail to reject the null of unit root

From table 3 it is clear that at least in three countries which are Hong Kong, India and Pakistan, t-statistic falls within the acceptance region of null of unit root, thus indicating that inflation is non stationary there. Some other tests force us to believe the same thing for Singapore and South Korea.

3. Empirical Framework

3.1 Construction of Mean Equation

There are certain economic and financial variables believed as important determinants of inflation however we choose to model inflation dynamically, through an autoregressive process (equation 1) in which inflation in one period is a function of its lagged values. The reason for the inclusion of autoregressive term $\delta(L)\pi_t$is straight forward as Inflation, like many other economic variables, has shown strong inertia in various studies. Cecchetti et al (2000), for US data, verified that none of the single indicator out of 19 which are generally believed as an important determinant of inflation, is able to improve the forecasts of autoregressive model clearly and consistently. Binner et al (2009) also did not find significant support for the usefulness of monetary aggregates in the process of forecasting inflation thus declared non linear autoregressive model based on kernel methods as the best for the job.

The decision about the number of lags to be included in each cross section is based on AIC and BIC. To check the presence of serial correlation in the residuals of AR model we applied Breusch-Godfrey test and Ljung-Box Q statistics and then introduced appropriate AR or MA terms for errors, as indicated by the correlogram, to eliminate serial correlation (equation 2). There are many approaches to estimate models with AR or MA error specifications like Cochrane-Orcutt, Paris-Winsten, Hatanaka, and Hildreth-Lu procedures but they all are bound to operate in the horizon of standard linear regression thus there results are not reliable when model contains lagged dependent variable as regressor, as we have in our mean equation [Davidson and MacKinnon

(1993, p. 329-341), Greene (1997, p. 600-607)]. To overcome this problem we applied non linear estimation which is applicable even when model contain endogenous right hand side variables and whose estimates are asymptotically equivalent to maximum likely hood estimates and are asymptotically efficient. Fair (1984, p. 210-214), Davidson and MacKinnon (1993, p. 331-341).

$$\pi_t = \lambda + \sum_{i=1}^{k} \delta_i \pi_{t-i} + u_t \qquad \textbf{Equation 1}$$

$$u_t = \sum_{i=1}^{p} \rho_i u_{t-i} + \sum_{i=1}^{q} \theta_i u_{t-i} + \varepsilon_t \qquad \textbf{Equation 2}$$

3.2 Modeling of Non stationary Inflation:

One can argue that the results obtained from the above model could possibly be questionable for those countries where inflation series is found to be non-stationary. To cope with this problem we proposed to model cyclical component of inflation, obtained from Hodrick-Prescott filter, instead of Inflation to capture conditional variance or inflation volatility through different GARCH specifications. The use of HP filter as a tool for detrending is popular among researchers and its advantage, compared to traditional differencing method, is that it removes only the slowly moving stochastic long term trend from the original series thus keeping the persistence of data preserved in the cyclic component. There are also evidences that first difference detrending removes not only the trend but also some other useful information from the original series (Fiorito, 2008). Though there are certain limitations of HP filter pointed out by Harvey and Jaeger (1993) such as spurious cyclical structure and spurious correlations when the series is I(0), but still its usability in detrending cannot be ruled out completely,(Ahumada, 1999). Thus keeping in view the above methodology we model πC (Cyclic component of Inflation) as well as π (Inflation) for Hongkong, India, Pakistan, Singapore and South Korea where we don’t have enough evidences to reject the null of unit root in Inflation series. Structure of equation 1 will become as equation 3 and rest of the structures related to residuals and conditional variance will remain same.

$$\pi C_t = \lambda + \sum_{i=1}^{k} \delta_i \, \pi C_{t-i} + u_t \qquad \textbf{Equation 3}$$

3.3 Volatility Estimates:

We choose GARCH specification to model inflation volatility as there are many evidences available which suggest that GARCH specification is better than ARCH. In an study about the performance of different volatility models, (Hansen and Lunde, 2001) find that while comparing the competing models on the basis of their out of sample predictive abilities, they do not have enough evidences to reject the hypothesis that none of other volatility models are better than GARCH (1,1).

$$h_t = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} \qquad \textbf{Equation 4}$$

$$Where\ \omega > 0, \alpha_i \geq 0\ and\ i = 1, 2, \ldots \ldots, q$$

$$\beta_j \geq 0\ and\ j = 1, 2, \ldots \ldots, p$$

GARCH is more parsimonious compared to ARCH as it captures the effect of infinite number of past squared residuals on current volatility with only three parameters and is less likely to breach non-negativity constraints artificially imposed on ARCH, Bollerslev (1986). But the primary restriction of GARCH model is that it enforces a symmetric response of volatility to positive and negative shocks. According to Brunner and Hess (1993) and Joyce (1995), a positive inflation shock is more likely to increase Inflation volatility via monetary policy mechanism, as compared to negative inflation shock of equal size. If it is true then we cannot rely on the estimates of symmetric ARCH and GARCH models and will have to go for asymmetric GARCH models. To capture those asymmetric responses of inflation volatility we used two asymmetric formulations of GARCH which are GJR or Threshold GARCH (TGARCH) models of Glosten, Jagannathan and Runkle (1993) and Zakoïan (1994), and the exponential GARCH (EGARCH) model proposed by Nelson (1991).

GJR-GARCH is simply an extension of GARCH(p,q) with an additional term to capture the possible asymmetries (leverage effects). The conditional variance is now

$$\boldsymbol{h_t = \omega + \alpha_i \varepsilon_{t-i}^2 + \gamma_i \varepsilon_{t-i}^2 I_{t-i} + \beta_j h_{t-j}} \qquad \textbf{Equation 5}$$

Where I_{t-1}= 1, if ε_{t-1} < 0, otherwise I_{t-1}= 0. If the asymmetry parameter γ is negative then negative inflationary shocks result in the reduction of inflation volatility. (Bordes et al. 2007).

Conditional volatility is positive when $\omega > 0, \alpha_i \geq 0$, $(\alpha_i + \gamma_i)/2 \geq 0$ for $i = 1 \; to \; q$, and $\beta_j \geq 0$, for $j = 1 \; to \; p$. The process is covariance stationary if and only if $\left[\sum_{i=1}^{q} (\alpha_i + \gamma_i)/2 \; + \; \sum_{j=1}^{p} \beta_j < 1\right]$(Hentschel 1995)

The exponential GARCH model was proposed by Nelson (1991). There are various ways to express the conditional variance equation, but one possible specification is

$$\boldsymbol{log h_t = \omega + \sum_{j=1}^{p} \beta_j \, log h_{t-j} + \sum_{i=1}^{q} \alpha_i \left| \frac{\varepsilon_{t-i}}{\sqrt{h_{t-i}}} \right| + \sum_{k=1}^{r} \gamma_k \frac{\varepsilon_{t-k}}{\sqrt{h_{t-k}}}} \qquad \textbf{Equation 6}$$

Both of these asymmetric GARCH models have several advantages over the traditional ARCH and GARCH specifications. First, variance specification represented in equations 5 and 6 make it possible to capture the asymmetric effects of good news and bad news on one period ahead conditional variance, which is preferable in the context of modeling Inflation and Inflation volatility. Additionally in EGARCH specification, since the conditional variance is modeled in its logarithmic form, then even in the presence of negative parameters, h_t will be positive thus relieving the non-negativity constraints artificially imposed on GARCH parameters.

3.4 Impact of News on Volatility (Policy Effectiveness)

For further investigation of asymmetric behavior of inflation volatility, we analyzed the effects of news on volatility or inflation uncertainty with the help of “News Impact Curve”. The idea was primarily proposed by Pagan and Schwert (1990) and Engle and NG (1993) to relate how news impact stock volatility. By keeping constant all the information at t-2 and earlier, we can examine the implied relation between ε_{t-1} and h_t which we called as "News Impact Curve". Primary purpose of News Impact Curve is to graphically represent the impact of past shocks of inflation (news) on current volatility. It is a pictorial representation of the degree of asymmetry of volatility to positive and negative shocks and it plots next period volatility h_t that would arise from various positive and negative values (news) of past inflation shocks (ε_{t-1}) [Pagan and Schwert, 1990], which will effectively help in determining the effectiveness of inflation stabilization programs and inflation targeting policies. For the standard GARCH model, news impact curve is a quadratic function centered at $\varepsilon_{t-1} = 0$. The equations of news impact curve for the GARCH, GJR-GARCH and EGARCH models are provided in table 4.

Table 4: News Impact Curve for different GARCH processes

GARCH(1,1)	$h_t = A + \alpha_1\varepsilon_{t-1}^2$ Where $A = \omega + \beta_1\bar{\sigma}^2$ And $\bar{\sigma}^2 = \omega/[1 - \alpha_1 - \beta_1]$
GJR-GARCH(1,1) **Or** **TGARCH(1,1)**	$h_t = A + (\alpha_1 + \gamma_1 I_{t-1})\varepsilon_{t-1}^2$ Where $A = \omega + \beta_1\bar{\sigma}^2$ And $\bar{\sigma}^2 = \omega/[1 - \alpha_1 - \beta_1 - \left(\frac{\gamma_1}{2}\right)]$
EGARCH(1,1)	$h_t = A \exp\left\{\frac{\alpha_1(\lvert\varepsilon_{t-1}\rvert + \gamma_1\varepsilon_{t-1})}{\bar{\sigma}}\right\}$ Where $A = \bar{\sigma}^{2\beta_1}\exp\{\omega\}$ $\bar{\sigma}^2 = \exp\left\{\frac{\omega + \alpha_1\sqrt{2/\pi}}{1 - \beta_1}\right\}$

Source: Engle and Ng (1993), Eric Zevot (2008) "Practical Issues in the Analysis of Univariate GARCH Models"

Where $h_t$is the conditional variance at time t, $\varepsilon_{t-1}$is inflation shock at time t-1, $\bar{\sigma}$ is the unconditional standard deviation of inflation shocks, ω and β_1 are constant term and parameter corresponding to h_{t-1}in GARHC, GJR-GARCH and EGARCH specifications.

The shape of news impact curve depends upon the slope values for positive and negative shocks. For GARCH specifications slope values are same for all shocks thus generating symmetric news impact curve. However in GJR-GARCH model, for bad news when

$\varepsilon_{t-1} > 0$, the slope of NIC is equal to $\alpha_1$only and equals to $(\alpha_1 + \gamma_1)$ when $\varepsilon_{t-1} < 0$ which is a case of good news where $\gamma_1$is asymmetry parameter or leverage parameter in GJR-GARCH and EGARCH specifications.

3.5 Direction of Causality between Inflation and Inflation Volatility (Granger Causality Test)

In order to investigate the direction of causality running between Inflation and Inflation volatility and to check the authentication of Friedman-Ball or Cukierman-Meltzer hypotheses, we implement Bivariate Granger-Causality test up to 10 lags, between inflation and volatility estimates obtained from GARCH, EGARCH and GJR-GARCH specifications. We report Wald statistics and corresponding p-values for the null hypothesis that "X does not cause Volatility" in the first column and that "Volatility does not cause X" in the second column by placing Inflation as X for all countries and by placing cyclic component of Inflation as X for those countries where inflation is nonstationary under GARCH, EGARCH and GJR-GARCH specifications (Appx. Table 11.a to 11.o).

4. Results and Findings

4.1 GARCH Specification

We checked the stability condition of GARCH specification for all countries and found some violations, such as in case of South Korean inflation and its cyclic component the ARCH coefficient (α) is negative, for Malaysia and Indonesia the GARCH coefficient (β) is negative; in addition to that there is also a violation of second order stationarity condition in case of China and Indonesia where $(\alpha + \beta) > 1$ due to which, for these two countries, the long run mean reverting level of volatility is negative. (Appx. Table 5)

4.2 GJR-GARCH Specification

The results of GJR GARCH are very promising. Almost for all instances, except for the cyclic component of inflation in Singapore, the leverage or asymmetry parameter (γ) is negative (significant at 5 percent or below for Pakistan, China, Indonesia, Thailand and India) which is expected and indicating the fact that negative inflation shocks (good news) in one period reduce the next period volatility. The condition for volatility to be covariance stationary i.e.; $[\sum_{i=1}^{q}(\alpha_i + \gamma_i)/2 + \sum_{j=1}^{p}\beta_j < 1]$ is also fulfilled for all cases. However the non negativity constraint $[(\alpha_i + \gamma_i)/2 \geq 0]$ is not fulfilled in case of Pakistan, Indonesia, Thailand and India, the obvious reason for which is that the asymmetry parameter is much larger as well as highly significant than ARCH coefficient for these countries $(\gamma_i > \alpha_i)$. (Appx. Table 5)

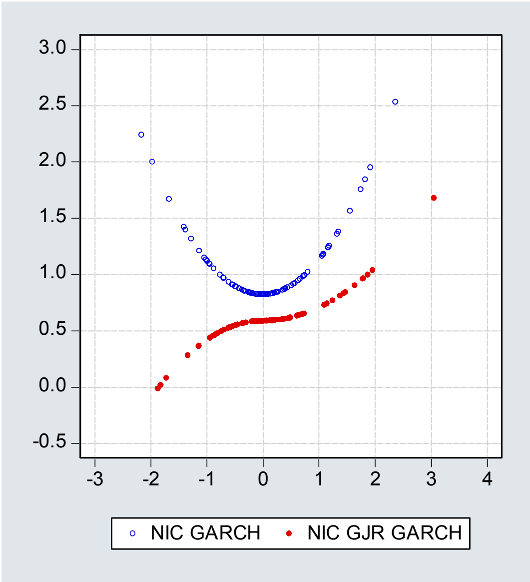
4.3 EGARCH Specification

EGARCH specification provides us the relationship between lagged shocks of Inflation and the logarithm of the conditional volatility. Because of this logarithmic specification, EGARCH is convenient to handle compared to other GARCH specifications as there are no restrictions on its parameters. In EGARCH specification, past negative shocks have an impact $\alpha_i - \gamma_i$ on the log of the conditional variance, while it is $\alpha_i + \gamma_i$ for positive shocks. Generally it is observed that impact is greater in case of negative shocks $[(\alpha_i - \gamma_i) > (\alpha_i + \gamma_i)]$ because γ_i is expected to be negative or less than zero, but that assumption is valid only if we are modeling returns. For Inflation, the converse is true; here we must expect that γ_i is positive so that $[(\alpha_i - \gamma_i) < (\alpha_i + \gamma_i)]$ and the impact is lesser on conditional volatility in case of negative inflation shocks (good news) compared to the situation of positive inflation shocks (bad news), [reported in the last two columns of Appx. Table 5]. In can also be viewed in Appx. Table 8, that asymmetry parameter γ_i is positive as per expectation in all 15 instances and is significant at 5 percent or below in 8 out of 15 instances.

4.4 News Impact Curves

News impact curves obtained by using the equations of Table 4 are reported in Appx. Figure 1. We would like to highlight specifically the cases of India, Indonesia, Pakistan and Thailand where the news impact curve based on GJR GARCH is quite different from its widely believed parabolic shape as mentioned below in figure 1.

Figure 1

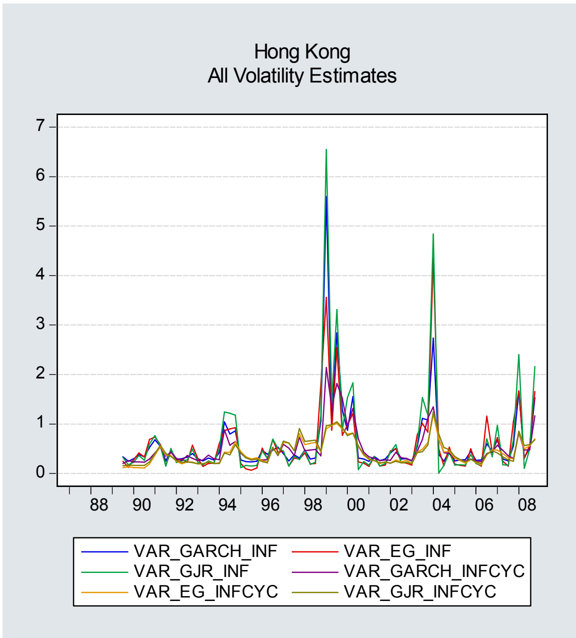


This hyperbolic sign integral shape of GJR-NIC is extremely important for monetary authorities and highlights the importance of inflation stabilization programs or inflation targeting policies, which reduces the next period volatility (Jonhson, 2002). The results are also consistent with our previous study (Rizvi and Naqvi, 2008) where the same hyperbolic sign integral shape of GJR-NIC was found for Pakistani inflation with a data set consists of relatively larger time period.

4.5 Modelling cyclic component of Inflation to capture Inflation Volatility

As we mentioned above that for the countries where we found inflation nonstationary we ran additional regressions of cyclic component of inflation and modelled inflation volatility based on the residuals of cyclic inflation. We then compare the volatility based on inflation and the volatility based on cyclic component of inflation for these countries to check how much reliable this procedure is in the volatility estimation when the original series is nonstationary. Appx. Table 9 reports the results of tests of equality of mean and variance between the two volatility estimates based on Inflation and on its Cyclic component. (Graphical representation of volatility estimates for Hong Kong is presented below in Figure 2, for other four countries it is provided in Appx. Figure 2.a to 2.e) T-test and Anova F-test assume the equal mean and variance for both volatility estimates where as Satterthwaite-Welch t-test and Welch F-test assume equal mean but allow for unequal variances. According to these results we can not reject the null of equal mean and variance of both volatility estimates in four out of five countries under GJR-GARCH specification. Put it in another way, it doesn't matter whether we model inflation volatility from total inflation or its cyclic component because there are evidences that the volatility estimates obtained from both variables are close enough as long as we applied GJR-GARCH specification.

Figure 2



4.6 Causality between Inflation and Inflation Volatility

Appx. Table 10 reports the categorized results based on the quantitative results provided in Appx. Table (11.a to 11.o) and highlights the fact that GARCH specification is not very successful in capturing the causality running between inflation and inflation volatility. Though the results are cumbersome but if we focus on asymmetric models (EGARCH and GJR-GARCH) the results strongly favor the presence of Friedman-ball hypothesis and clearly reject the presence of Cuckierman-meltzer hypothesis for Indonesia, Malaysia, Pakistan and Phillipines. The results for other countries are though biased in favour of Friedman ball hypothesis but are mixed and support significantly the presence of both hypothesis, leading us to the conclusion that there is a bidirectional causality running between inflation and inflation volatility. Hongkong is a special case for which both asymmetric models strongly reject the presence of any causality between inflation and volatility no matter whether we base our analysis on total inflation or on the cyclic component of inflation.

5. Conclusion

This study contributes the following in the existing body of knowledge. First of all it can be argued that the asymmetric GJR-GARCH and EGARCH models performed better than symmetric GARCH in capturing inflation volatility for selected Asian economies. The hyperbolic sign integral shape of news impact curve based on GJR-GARCH for India, Indonesia, Pakistan and Thailand is not only consistent with the results of our previous study based on Pakistani data (Rizvi and Naqvi, 2008) but also highlight the importance of inflation stabilization programs and inflation targeting policies where negative inflation shocks reduces one period ahead volatility which will subsequently reduces inflation in further periods and so on. Evidences of bidirectional causality between inflation and inflation volatility also strengthen the idea of having such type of chain reaction. It can also be claimed that volatility estimates obtained from total inflation and cyclic component of inflation exhibit the equal mean and variance properties under GJR-GARCH specification, thus making the cyclic component of inflation, obtained from HP filter, a suitable proxy of inflation in volatility modelling for those countries where inflation is non stationary.

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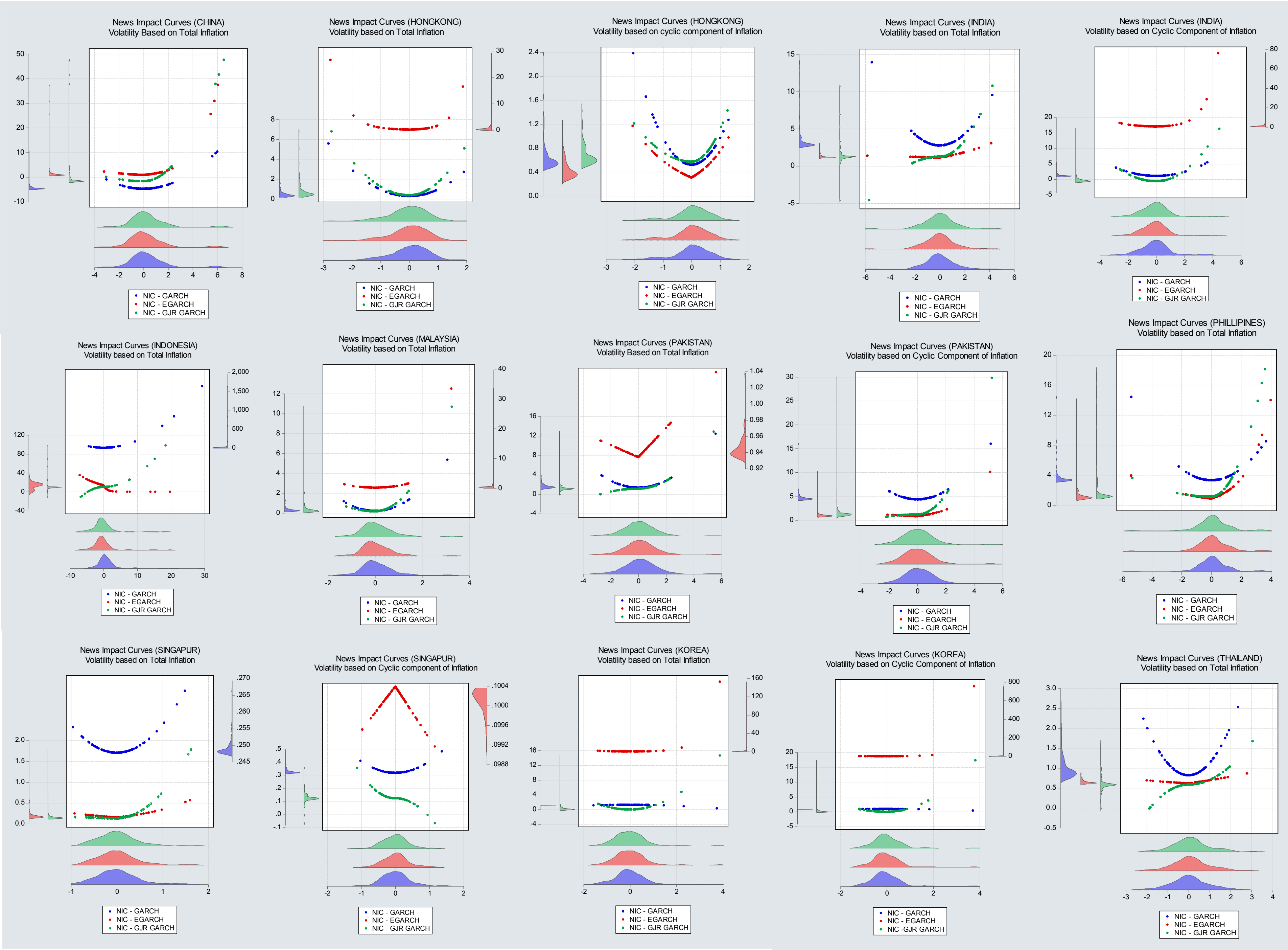
Appendix -Figure 1



APPENDIX-Tables

Table 5: Coefficients Restrictions on Volatility Models

	GARCH (Mean Reverting Level)	GARCH (Stability)	GJR-GARCH (Covariance Stationarity)	GJR –GARCH (Non Negativity)	EGARCH $\alpha_i - \gamma_i$	EGARCH $\alpha_i + \gamma_i$
CHINA	**-8.2851**	**1.020863**	0.456016	0.098152	0.201157	0.843743
HONGKONG	0.817041	0.727299	0.395387	0.438464	1.247568	1.531182
HONGKONG (Cyclic)	0.937769	0.860247	0.657212	0.07826	0.366703	0.688071
INDIA	4.417416	0.946739	0.542511	**-0.09041**	-0.6009	0.908148
INDIA (cyclic)	1.610521	0.849445	0.625568	0.292448	0.820412	1.112438
INDONESIA	**-4.37187**	**1.854417**	0.269814	**-0.23007**	-2.33769	0.30183
MALAYSIA	0.419635	0.101467	-0.08363	0.160531	0.924166	0.925238
PAKISTAN	2.066967	0.65295	0.564163	**-0.07614**	-0.40042	0.426501
PAKISTAN (Cyclic)	7.629162	0.970386	0.306752	**-0.0505**	-0.15674	0.830713
PHILIPPINES	5.358836	0.918545	0.15968	0.044748	0.144877	0.996703
SINGAPUR	0.249842	0.534586	0.148038	0.015517	0.099954	0.505912
Singapore (Cyclic)	0.346369	0.980668	0.810881	0.092052	-0.08109	0.074869
SKOREA	1.137714	0.533554	0.659215	0.410593	1.15812	1.172058
SKOREA (Cyclic)	0.871926	0.47909	0.548528	0.299523	0.709121	1.246789
THAILAND	1.179098	0.605412	0.831552	**-0.0863**	-0.28006	0.427316

***Bold Values represent violations**

Table 6: GARCH Specification

Country	CHN	HKN[1]	HKN(Cyc)[1]	IND	IND(Cyc)	NDS	MLY	PAK	PAK(Cyc)	PHL	SNG	SNG(Cyc)	SKOR	SKOR(Cyc)	TLN
λ	0.045954	0.018922	-0.001049	0.058756	-0.005063	1.484208***	0.281897*	0.181303	-0.057884	0.134991	0.015423	-0.000792	-0.018147	-0.001391	0.097857
δ_1	1.603851***	1.535378***	1.230251***	1.249537***	0.936348***	1.093169***	1.304491***	1.484289***	1.271754***	1.500361***	1.523460***	1.073894***	0.986233***	0.753511***	1.348317***
δ_2	-0.635760***	-0.548384***	-0.384900**	-0.263443	-0.258466	-0.308437***	-0.404359***	-0.511078***	-0.466799***	-0.526718***	-0.535463***	-0.318257**			-0.375148**
ρ_1		-0.522387***	-0.488810**												
ρ_4		-0.365908***	-0.408268***			-0.266862***	-0.327085***	-0.624402***	-0.548687***						
θ_1															
θ_4	-0.640871***			-0.915237***	-0.960053***					-0.926633***	-0.873307***	-0.898275***	-0.959262***	-0.971121***	-0.759718***
ω	0.172852	0.222808***	0.131056	0.235276	0.242472	3.735401***	0.377056***	0.717341	0.225930	0.436504*	0.116280	0.006696	0.530682***	0.454195**	0.465258
α	0.419361*	0.670459**	0.446452	0.376525**	0.331923**	1.884675***	0.546886*	0.355595**	0.432361**	0.385109**	0.008386	0.087615*	-0.067087	-0.040918***	0.304677
β	0.601502***	0.056840	0.413795	0.570214***	0.517522***	-0.030258	-0.445419	0.297355	0.538025***	0.533436***	0.526200	0.893053***	0.600641***	0.520008**	0.300735
Adj R^2	0.962878	0.977696	0.773874	0.852128	0.776289	0.847551	0.769835	0.877253	0.705477	0.896286	0.884522	0.805243	0.892215	0.775941	0.804962
AIC	3.439067	2.149183	2.064715	3.241209	2.834162	5.101463	1.867303	3.268057	3.091147	3.338663	1.363933	0.984167	2.626359	2.351225	2.756383
SIC	3.640226	2.390896	2.306428	3.440982	3.033935	5.306914	2.072755	3.476485	3.299574	3.538436	1.567932	1.188166	2.799988	2.524855	2.956156
F-Stat	364.1335***	483.1825***	38.64545***	82.63722***	50.15907***	76.05417***	46.15348***	95.09971***	32.53841***	123.4270	105.6825***	57.50610***	138.4101***	58.48779***	59.46863***

[1]For Hong kong and its cyclic component consider ρ_1 and ρ_4 as ρ_4 and ρ_8 respectively

Note:***,**,* respectively indicates rejection of the null at 1%, 5% and 10% significance levels.

Table 7: GJR GARCH or TGARCH Specification

Country	CHN	HKN[1]	HKN(Cyc)[1]	IND	IND(Cyc)	NDS	MLY	PAK	PAK(Cyc)	PHL	SNG	SNG(Cyc)	SKOR	SKOR(Cyc)	TLN
λ	0.075365	0.050665	0.003795	0.146628*	-0.014457	1.754165***	0.268897	0.219229	0.016632	0.148204	0.004074	0.004243	0.082058	-0.004631	-0.056919
δ_1	1.538845***	1.615259***	1.202471***	1.379822***	0.711794***	1.485867***	1.188609***	1.493402***	1.222602***	1.496904***	1.398911***	1.196454***	0.964142***	0.744053***	1.274895***
δ_2	-0.580911***	-0.629885***	-0.379042***	-0.403882***	-0.080039	-0.636588***	-0.281512*	-0.517517***	-0.380957***	-0.526335***	-0.413944***	-0.521752***			-0.269251***
ρ_1		-0.525595***	-0.496227***												
ρ_4		-0.384515***	-0.389596***			-0.426080***	-0.369747***	-0.603399***	-0.557872***						
θ_1															
θ_4	-0.576702***			-0.916417***	-0.943847***					-0.932085***	-0.904857***	-0.892173***	-0.970195***	-0.947597***	-0.892648***
ω	0.179292*	0.157279**	0.064695	0.292477***	0.108094*	5.576977	0.264034***	0.301625	0.382819**	0.683623***	0.111098*	0.032199	0.090362*	0.078963**	0.062652*
α	1.154837***	1.275976*	0.537534	0.526391**	0.845174	0.257231	0.988899**	0.394843**	1.031866**	1.305053*	0.622322*	-0.141545***	0.976033***	1.189094***	0.116599
γ	-0.958532**	-0.399049	-0.381014	-0.707217***	-0.260279	-0.717372**	-0.667837	-0.547115***	-1.132863***	-1.215558	-0.591289	0.325648	-0.154847	-0.590048	-0.289203**
β	0.357863***	-0.043077	0.578952**	0.632924***	0.333120	0.499884	-0.244165	0.640299***	0.357250	0.114932	0.132521	0.718829***	0.248622***	0.249005**	0.917854***
Adj R^2	0.959473	0.977339	0.769251	0.844983	0.759167	0.905427	0.767075	0.877706	0.696557	0.893621	0.877090	0.811574	0.890053	0.770677	0.799030
AIC	3.335648	2.100246	2.056323	3.066536	2.736736	5.200215	1.867619	3.114269	2.955616	3.297456	1.249534	0.871409	2.132409	1.895128	2.626257
SIC	3.565545	2.372174	2.328251	3.294847	2.965047	5.435017	2.102421	3.352472	3.193818	3.525768	1.482675	1.104550	2.334977	2.097696	2.854568
F-Stat	285.0969***	416.1121***	33.08692***	67.18970***	39.27740***	111.7826***	39.10741***	81.99744***	26.90655***	103.0048***	84.59353***	51.45484***	112.9851***	47.48904***	49.27834***

Table 8: EGARCH Specification

Country	CHN	HKN[1]	HKN(Cyc)[1]	IND	IND(Cyc)	NDS	MLY	PAK	PAK(Cyc)	PHL	SNG	SNG(Cyc)	SKOR	SKOR(Cyc)	TLN
λ	0.083643	0.041972	0.009608	0.116437	-0.012479	1.849843***	0.282653**	0.115142	0.029709	0.148201	0.004435	-0.003575	0.071171	0.000822	0.010679
δ_1	1.612123***	1.570863***	1.235424***	1.354564***	0.715817***	1.426739***	1.225077***	1.450011***	1.241523***	1.404193***	1.431692***	1.308494***	0.966372***	0.835296***	1.301882***
δ_2	-0.645129***	-0.587913***	-0.388306***	-0.372991***	-0.077254	-0.581560***	-0.321904***	-0.464967***	-0.422968***	-0.433432***	-0.444566***	-0.548329***			-0.312298**
ρ_1		-0.520582***	-0.518639***												
ρ_4		-0.376575***	-0.411553***			-0.383506***	-0.442754***	-0.599388***	-0.582201***						
θ_1															
θ_4	-0.600860***			-0.903622***	-0.953488***					-0.927227***	-0.901537***	-0.888155***	-0.967053***	-0.958201***	-0.837196***
ω	-0.394045*	-1.588311***	-0.562562*	-0.027716	-0.805952***	1.917839***	-2.311859***	-0.022040	-0.257020	-0.231147	-0.811989	-4.794491***	-1.145580***	-2.554814***	-0.117975
α	0.522450*	1.389375***	0.527387*	0.153622	0.966425***	-1.017929***	0.924702**	0.013040	0.336986*	0.570790*	0.302933	-0.003112	1.165089***	0.977955***	0.073628
γ	0.321293**	0.141807	0.160684	0.754526***	0.146013	1.319759***	0.000536	0.413461**	0.493727***	0.425913*	0.202979	0.077981	0.006969	0.268834***	0.353688**
β	0.840639***	0.515620***	0.815985***	0.620963***	0.777922***	0.388253***	-0.327627	0.798333***	0.529532**	0.275480	0.656998*	-1.084575***	0.725478***	-0.444877**	0.862470***
Adj R^2	0.962513	0.977339	0.771343	0.844104	0.761322	0.902204	0.766317	0.875221	0.704361	0.896388	0.879387	0.809996	0.890203	0.769486	0.802894
AIC	3.321456	2.117697	2.030690	3.130520	2.746561	4.916108	1.820280	3.128454	2.982521	3.252806	1.266261	0.747647	2.087935	1.766475	2.637711
SIC	3.551352	2.389625	2.302618	3.358832	2.974872	5.150910	2.055082	3.366656	3.220723	3.481117	1.499403	0.980788	2.290503	1.969043	2.866023
F-Stat	309.1099***	416.1112***	33.46856***	66.74782***	39.73254***	107.7504***	38.94613***	80.15983***	27.88827***	106.0521***	86.40846***	50.93841***	113.1567***	47.17755***	50.46294***

Table 9 : Test of Equality of Mean and Variance between volatility estimates

	Pakistan		Hongkong		SKorea		Singapore		India	
GARCH	**Test**	**Prob**	**Test**	**Prob**	**Test**	**Prob**	**Test**	**Prob**	**Test**	**Prob**
t-test	3.504503	**0.0006**	0.831023	0.4072	13.89522	**0.0000**	25.34913	**0.0000**	2.892351	**0.0043**
Satterthwaite-Welch t-test*	3.504503	**0.0006**	0.831023	0.4074	13.89522	**0.0000**	25.34913	**0.0000**	2.892351	**0.0044**
Anova F-test	12.28154	**0.0006**	0.690600	0.4072	193.0772	**0.0000**	642.5785	**0.0000**	8.365696	**0.0043**
Welch F-test*	12.28154	**0.0006**	0.690600	0.4074	193.0772	**0.0000**	642.5785	**0.0000**	8.365696	**0.0044**
EGARCH										
t-test	1.031383	0.3039	1.482889	0.1401	2.112509	**0.0361**	5.185889	**0.0000**	2.133933	**0.0343**
Satterthwaite-Welch t-test*	1.031383	0.3039	1.482889	0.1408	2.112509	**0.0365**	5.185889	**0.0000**	2.133933	**0.0343**
Anova F-test	1.063752	0.3039	2.198958	0.1401	4.462694	**0.0361**	26.89344	**0.0000**	4.553670	**0.0343**
Welch F-test*	1.063752	0.3039	2.198958	0.1408	4.462694	**0.0365**	26.89344	**0.0000**	4.553670	**0.0343**
GJR-GARCH										
t-test	0.406648	0.6848	1.509353	0.1333	0.857462	0.3924	4.005910	**0.0001**	0.558485	0.5772
Satterthwaite-Welch t-test*	0.406648	0.6849	1.509353	0.1343	0.857462	0.3924	4.005910	**0.0001**	0.558485	0.5773
Anova F-test	0.165362	0.6848	2.278146	0.1333	0.735241	0.3924	16.04732	**0.0001**	0.311905	0.5772
Welch F-test*	0.165362	0.6849	2.278146	0.1343	0.735241	0.3924	16.04732	**0.0001**	0.311905	0.5773

*Tests allow for Unequal variances

Bold values represent rejection of null of Equality of mean and variance at a significance level of 5 percent or below

Table 10: Categorized Results of Granger Causality Test between Inflation and Inflation Volatility

	GARCH		EGARCH		GJR GARCH	
	Friedman Ball Hypothesis	***Cukierman Meltzer Hypothesi***	***Friedman Ball Hypothesis***	***Cukierman Meltzer Hypothesi***	***Friedman Ball Hypothesis***	***Cukierman Meltzer Hypothesi***
CHINA	Strong Evidence	Moderate Evidence	Strong Evidence	Strong Evidence	Strong Evidence	Strong Evidence
HONGKONG	Moderate Evidence	No Evidence	No Evidence	No Evidence	No Evidence	No Evidence
HONGKONG (Cyclic)	Strong Evidence	No Evidence	No Evidence	No Evidence	No Evidence	No Evidence
INDIA	Strong Evidence	Moderate Evidence	Strong Evidence	Strong Evidence	Strong Evidence	Strong Evidence
INDIA (cyclic)	Strong Evidence	No Evidence	Strong Evidence	No Evidence	Strong Evidence	No Evidence
INDONESIA	Strong Evidence	No Evidence	Strong Evidence	Strong Evidence	Strong Evidence	No Evidence
MALAYSIA	Strong Evidence	No Evidence	Moderate Evidence	No Evidence	Strong Evidence	No Evidence
PAKISTAN	No Evidence	No Evidence	Strong Evidence	No Evidence	Strong Evidence	No Evidence
PAKISTAN (Cyclic)	No Evidence	No Evidence	Strong Evidence	Moderate Evidence	Strong Evidence	Moderate Evidence
PHILIPPINES	No Evidence	No Evidence	Strong Evidence	No Evidence	Strong Evidence	No Evidence
SINGAPUR	No Evidence	No Evidence	Strong Evidence	Strong Evidence	Strong Evidence	Strong Evidence
Singapore (Cyclic)	No Evidence	No Evidence	Strong Evidence	Moderate Evidence	Strong Evidence	Strong Evidence
SKOREA	Strong Evidence	No Evidence	Strong Evidence	Moderate Evidence	Strong Evidence	Moderate Evidence
SKOREA (Cyclic)	Strong Evidence	No Evidence	No Evidence	No Evidence	Strong Evidence	No Evidence
THAILAND	No Evidence	No Evidence	Strong Evidence	Moderate Evidence	Strong Evidence	Moderate Evidence

Note: These results are based on the frequency of occurrence of significant wald statistics at less than 1 percent level, reported in table 11.a to 11.o. We categorize the results according to the following criteria:

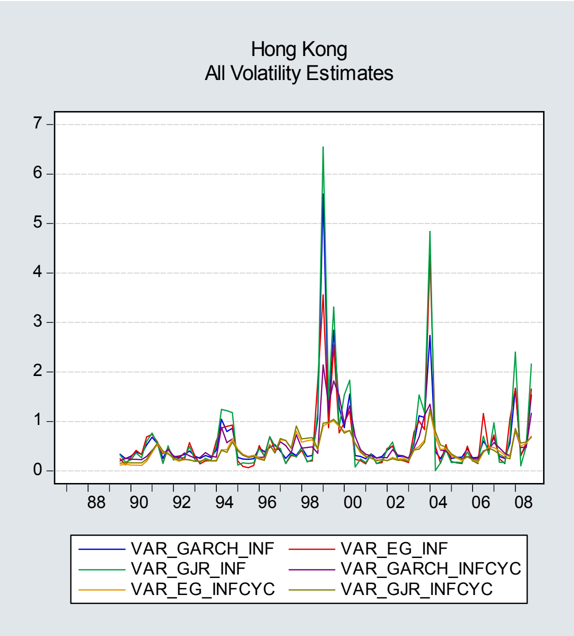
Strong Evidence = More than 70 percent times wald statistic is significant at less than 1 percent, from 1 to 10 lags.

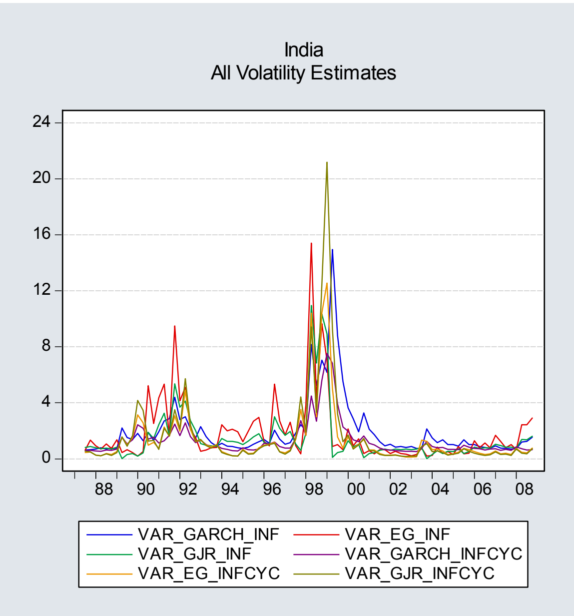
Moderate Evidence = 50 percent to 70 percent times wald statistic is significant at less than 1 percent, from 1 to 10 lags.

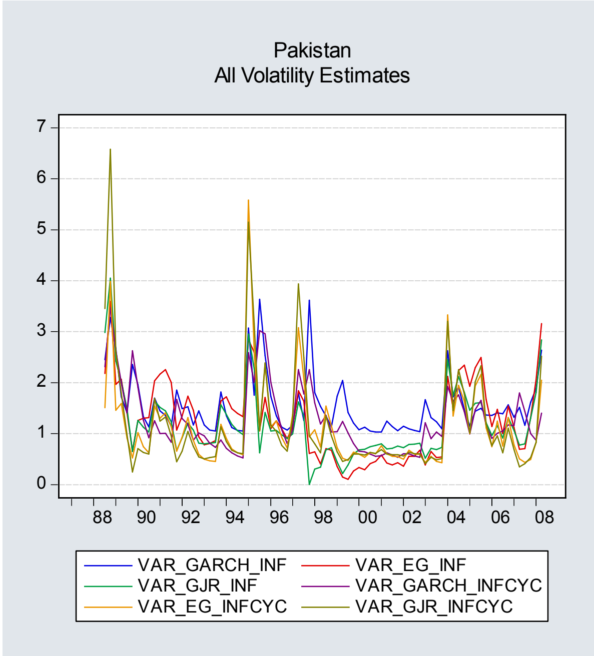
No Evidence = Less than 50 percent times wald statistic is significant at less than 1 percent, from 1 to 10 lags.

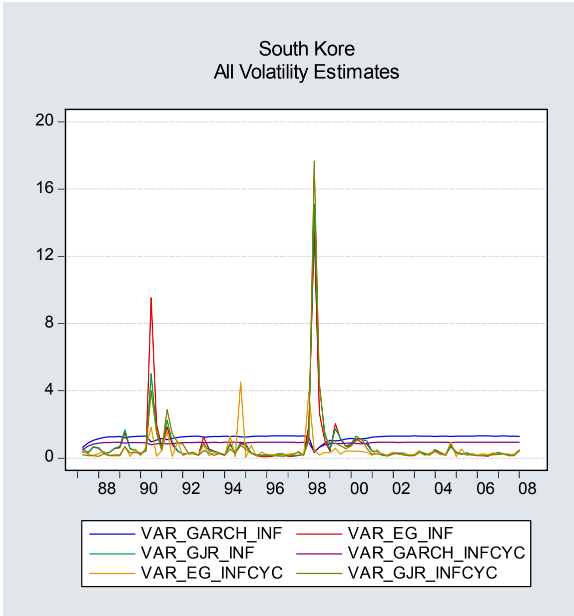
Volatility Estimates Based on Total and Cyclic component of Inflation

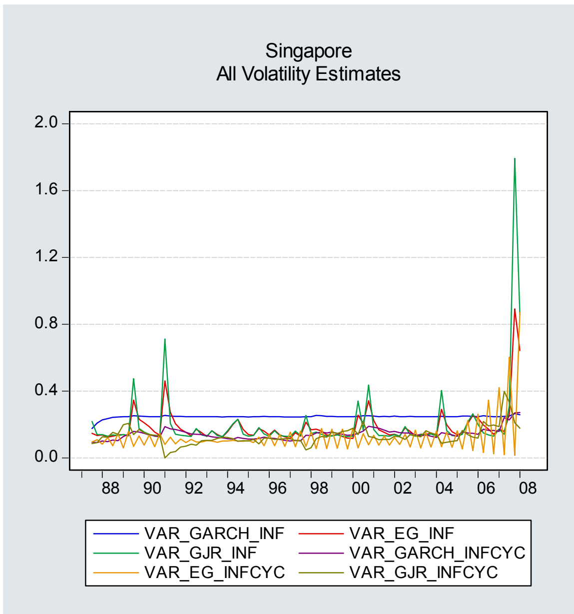
Figure 2.a to 2.e











Granger Causality Test between Inflation and Different Volatility Estimates

Table 11.a to 11.o (Wald Statistics and Corresponding P-Values)

Table 11.a: CHINA

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π	
1	35.7749	6.E-08	2.44062	0.1221	31.2295	3.E-07	1.24682	0.2675	30.4723	4.E-07	0.70566	0.4034
2	24.9587	4.E-09	1.18514	0.3111	38.1428	3.E-12	1.40857	0.2506	39.0211	2.E-12	0.80251	0.4519
3	24.3188	4.E-11	3.83543	0.0130	34.8350	3.E-14	10.1269	1.E-05	35.9982	2.E-14	9.99379	1.E-05
4	19.7344	5.E-11	6.52536	0.0002	30.0465	1.E-14	8.20701	2.E-05	31.4709	4.E-15	7.80431	3.E-05
5	20.6210	2.E-12	5.17576	0.0004	28.4043	2.E-15	6.58909	5.E-05	28.0085	2.E-15	6.29418	7.E-05
6	10.9827	2.E-08	3.09931	0.0098	16.0231	3.E-11	4.02900	0.0017	16.5993	1.E-11	3.74747	0.0029
7	10.2074	2.E-08	6.24358	1.E-05	14.7403	3.E-11	7.31225	2.E-06	15.2107	2.E-11	6.98927	4.E-06
8	7.90481	3.E-07	5.78230	2.E-05	10.5440	4.E-09	6.91252	2.E-06	10.5923	4.E-09	6.36253	6.E-06
9	7.25241	6.E-07	3.67829	0.0011	9.80373	7.E-09	4.87635	8.E-05	9.69372	8.E-09	4.86904	8.E-05
10	7.27327	4.E-07	3.25350	0.0024	9.15911	1.E-08	3.53452	0.0012	9.19028	1.E-08	3.42708	0.0016

Table 11.b: HONGKONG

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π	
1	3.58276	0.0623	0.18125	0.6715	2.93534	0.0908	0.40945	0.5242	3.41228	0.0687	0.00117	0.9728
2	10.0552	0.0001	0.93801	0.3962	2.64801	0.0778	1.20149	0.3068	5.37842	0.0067	0.50031	0.6085
3	6.52439	0.0006	2.00178	0.1219	2.16941	0.0996	0.77247	0.5134	3.92642	0.0120	0.66628	0.5757
4	4.54097	0.0027	1.46703	0.2224	2.13073	0.0869	0.69304	0.5995	3.21860	0.0179	0.59234	0.6694
5	3.57412	0.0066	1.00546	0.4221	2.03917	0.0854	0.61145	0.6914	2.80317	0.0240	0.60555	0.6959
6	3.24028	0.0081	0.76547	0.6000	1.66269	0.1463	0.56878	0.7535	2.40580	0.0380	0.54799	0.7695
7	2.97820	0.0100	0.81428	0.5793	1.58449	0.1591	0.58412	0.7659	2.34531	0.0358	0.59108	0.7604
8	2.99544	0.0076	0.78764	0.6156	2.05026	0.0578	0.63330	0.7461	2.55416	0.0196	0.58611	0.7848
9	2.58897	0.0156	0.58484	0.8032	1.88423	0.0761	0.42910	0.9131	2.20996	0.0368	0.42528	0.9153
10	2.48803	0.0174	0.39770	0.9411	1.66327	0.1182	0.31023	0.9748	2.11943	0.0415	0.29273	0.9796

Table 11.c: HONGKONG (CYCLIC)

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π	
1	8.27143	0.0053	0.24662	0.6209	0.83302	0.3644	0.04125	0.8396	0.64481	0.4245	0.11309	0.7376
2	12.2018	3.E-05	1.44675	0.2422	0.38190	0.6840	0.22337	0.8004	0.32985	0.7201	0.39374	0.6760
3	7.74194	0.0002	2.26774	0.0884	1.68668	0.1780	0.72740	0.5392	1.44484	0.2374	0.83086	0.4815
4	4.37066	0.0034	2.35641	0.0628	1.61651	0.1807	0.81530	0.5200	1.69607	0.1616	0.97914	0.4252
5	3.47357	0.0078	1.60715	0.1714	1.39788	0.2375	0.71173	0.6169	1.45781	0.2166	1.00527	0.4222
6	3.60944	0.0041	1.17200	0.3336	1.33435	0.2565	1.04158	0.4080	1.47510	0.2024	1.35199	0.2491
7	3.10840	0.0077	1.27692	0.2785	1.62823	0.1465	0.97759	0.4567	1.60960	0.1517	1.24224	0.2958
8	3.63816	0.0019	1.10856	0.3726	2.34640	0.0307	1.07478	0.3948	2.31655	0.0327	1.31545	0.2563
9	3.26971	0.0034	0.81637	0.6037	1.95940	0.0645	0.75552	0.6570	1.88498	0.0760	0.92731	0.5099
10	3.22701	0.0031	0.68682	0.7312	1.69347	0.1105	0.81418	0.6165	1.64877	0.1221	0.85451	0.5804

Table 11.d: INDIA

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π	
1	4.02080	0.0482	3.36154	0.0704	22.0517	1.E-05	2.82374	0.0967	13.2261	0.0005	0.02388	0.8776
2	6.26825	0.0030	0.79449	0.4554	22.7781	2.E-08	3.29938	0.0421	33.3213	3.E-11	1.87573	0.1600
3	5.21578	0.0025	0.66612	0.5754	15.5792	5.E-08	42.7603	3.E-16	22.9924	1.E-10	27.4466	4.E-12
4	7.58864	4.E-05	0.44377	0.7766	20.8071	2.E-11	34.8070	3.E-16	19.1386	8.E-11	26.7000	1.E-13
5	6.03786	0.0001	3.93174	0.0034	16.2332	1.E-10	20.3334	2.E-12	16.5277	1.E-10	15.8894	2.E-10
6	5.06880	0.0002	3.21722	0.0078	16.6156	1.E-11	16.7721	1.E-11	14.7504	1.E-10	12.7889	1.E-09
7	4.22667	0.0007	3.66654	0.0022	13.2891	2.E-10	14.3607	5.E-11	12.9903	3.E-10	12.0990	1.E-09
8	5.14990	6.E-05	3.07688	0.0056	11.4457	9.E-10	12.9628	1.E-10	10.1762	7.E-09	10.8850	2.E-09
9	4.52983	0.0002	2.29298	0.0281	11.8645	2.E-10	9.05992	2.E-08	9.74324	7.E-09	6.50454	2.E-06
10	4.77859	6.E-05	2.49942	0.0149	11.7249	2.E-10	8.44552	4.E-08	8.55409	3.E-08	6.13060	3.E-06

Table 11.e: INDIA

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*	
1	14.9519	0.0002	1.39087	0.2417	14.1465	0.0003	0.03495	0.8522	22.5839	8.E-06	1.10900	0.2954
2	7.77080	0.0008	0.35898	0.6995	11.3803	5.E-05	0.86835	0.4236	14.6115	4.E-06	1.06562	0.3494
3	5.55238	0.0017	0.80446	0.4952	7.89161	0.0001	5.07319	0.0030	10.3141	9.E-06	1.59939	0.1965
4	4.68381	0.0020	0.70109	0.5937	5.06893	0.0012	3.87735	0.0065	7.26778	6.E-05	1.70942	0.1571
5	4.53056	0.0012	3.19381	0.0118	5.58482	0.0002	3.14650	0.0128	6.28382	7.E-05	2.10568	0.0748
6	3.62912	0.0035	2.51919	0.0293	4.62691	0.0005	2.62257	0.0241	5.14055	0.0002	1.61289	0.1572
7	3.02295	0.0083	1.95636	0.0751	3.91653	0.0013	2.72554	0.0154	5.17845	0.0001	1.87021	0.0892
8	3.39886	0.0027	1.46426	0.1891	4.41722	0.0003	2.06725	0.0530	5.40420	4.E-05	1.32023	0.2508
9	2.83919	0.0077	1.27774	0.2686	3.91337	0.0006	1.44938	0.1889	4.73614	0.0001	0.83555	0.5866
10	2.61011	0.0114	1.83028	0.0766	3.66741	0.0008	1.72433	0.0983	4.51680	0.0001	1.07008	0.4006

Table 11.f: INDONESIA

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*	
1	30.1164	5.E-07	0.06664	0.7970	7.99135	0.0060	9.68536	0.0026	34.7515	9.E-08	0.34973	0.5560
2	75.2548	1.E-18	2.77053	0.0690	36.6934	8.E-12	2.01996	0.1398	71.2127	5.E-18	1.02713	0.3630
3	79.3952	9.E-23	3.29186	0.0254	129.834	6.E-29	7.24660	0.0003	143.255	3.E-30	0.93150	0.4300
4	70.4105	1.E-23	5.24051	0.0010	131.987	1.E-31	6.35163	0.0002	152.416	2.E-33	4.20682	0.0042
5	68.6529	8.E-25	5.11315	0.0005	120.609	8.E-32	6.27161	8.E-05	117.147	2.E-31	3.90365	0.0037
6	56.7271	2.E-23	3.10508	0.0100	119.197	2.E-32	4.47225	0.0008	97.5105	6.E-30	2.66339	0.0229
7	50.3744	9.E-23	2.44558	0.0283	105.284	3.E-31	3.67793	0.0023	81.9748	3.E-28	2.42274	0.0297
8	43.6496	2.E-21	2.10181	0.0504	88.6766	3.E-29	3.42627	0.0028	73.6110	3.E-27	2.06894	0.0541
9	41.5529	4.E-21	1.82041	0.0856	86.4038	8.E-29	3.39256	0.0023	68.6852	2.E-26	1.79165	0.0912
10	37.7226	4.E-20	1.75648	0.0933	76.0780	4.E-27	2.88218	0.0063	64.7651	2.E-25	1.51410	0.1616

Table 11.g: MALAYSIA

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*	
1	11.7197	0.0010	0.72502	0.3971	2.24488	0.1381	0.04791	0.8273	10.7704	0.0015	0.34625	0.5579
2	18.2754	3.E-07	0.38266	0.6834	6.98091	0.0017	1.02548	0.3636	24.9703	5.E-09	0.67670	0.5114
3	14.0720	3.E-07	0.84785	0.4723	6.76707	0.0004	0.67821	0.5682	19.5573	2.E-09	3.01831	0.0353
4	10.2501	1.E-06	0.79009	0.5356	4.34330	0.0034	1.75995	0.1469	14.5696	1.E-08	2.22290	0.0754
5	8.31563	4.E-06	0.59515	0.7037	4.00186	0.0031	1.76164	0.1330	11.2678	7.E-08	1.25333	0.2947
6	7.40149	5.E-06	0.61409	0.7182	3.57813	0.0041	1.62822	0.1541	9.96788	1.E-07	1.30308	0.2689
7	7.92027	9.E-07	0.51456	0.8200	3.22917	0.0057	1.38724	0.2274	10.7591	1.E-08	1.34877	0.2438
8	6.79961	3.E-06	0.58093	0.7893	2.77507	0.0116	1.21126	0.3091	9.65523	2.E-08	1.61872	0.1398
9	6.00228	9.E-06	0.51795	0.8552	2.57644	0.0151	0.84527	0.5784	8.68743	6.E-08	1.16550	0.3355
10	6.22396	4.E-06	0.55529	0.8419	2.99512	0.0048	1.05832	0.4107	8.11677	1.E-07	1.05233	0.4153

Table 11.h: PAKISTAN

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*	
1	5.17291	0.0258	3.06592	0.0840	10.6781	0.0016	0.06392	0.8011	3.00089	0.0873	0.43950	0.5094
2	2.49456	0.0895	2.10931	0.1287	57.1932	1.E-15	0.42785	0.6535	37.4906	6.E-12	0.50759	0.6041
3	2.25405	0.0896	1.57850	0.2023	48.6904	4.E-17	4.20851	0.0085	32.0351	4.E-13	3.74653	0.0148
4	2.07423	0.0939	1.21725	0.3118	41.4832	2.E-17	9.90093	2.E-06	26.7058	3.E-13	9.14067	6.E-06
5	1.57160	0.1808	0.97314	0.4410	50.4157	7.E-21	3.75054	0.0049	22.4288	6.E-13	4.24984	0.0021
6	1.97461	0.0832	1.11003	0.3671	110.175	8.E-31	1.31944	0.2623	38.3777	6.E-19	1.80329	0.1134
7	1.84236	0.0963	0.89518	0.5164	100.093	5.E-30	2.01618	0.0683	33.5926	4.E-18	2.01106	0.0690
8	1.65201	0.1315	0.73754	0.6580	82.0602	9.E-28	2.17135	0.0440	27.9583	9.E-17	2.06450	0.0553
9	1.57666	0.1470	0.86174	0.5644	69.2629	9.E-26	1.70205	0.1122	24.6192	9.E-16	1.83863	0.0831
10	1.75654	0.0945	0.81557	0.6151	62.5853	2.E-24	1.72935	0.1006	19.7500	6.E-14	1.31834	0.2474

Table 11.i: PAKISTAN (Cyclic)

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*	
1	5.40685	0.0227	3.90626	0.0517	25.0452	4.E-06	1.11784	0.2937	18.3872	5.E-05	0.54520	0.4626
2	2.48658	0.0902	2.44231	0.0940	17.5262	6.E-07	0.88338	0.4178	23.6308	1.E-08	0.41945	0.6590
3	2.38459	0.0765	1.88658	0.1398	18.3186	7.E-09	3.73556	0.0150	21.6506	5.E-10	3.56996	0.0183
4	2.20814	0.0774	2.35825	0.0622	15.5922	5.E-09	7.38717	5.E-05	16.9944	1.E-09	7.78510	3.E-05
5	1.87336	0.1114	1.73069	0.1403	11.9546	3.E-08	3.03747	0.0160	14.4319	2.E-09	3.42255	0.0084
6	2.25023	0.0501	2.62552	0.0249	13.2369	2.E-09	2.37635	0.0397	14.5540	3.E-10	2.88795	0.0152
7	2.18332	0.0489	2.50103	0.0257	11.8684	3.E-09	3.07296	0.0080	13.7290	3.E-10	3.51880	0.0033
8	1.55649	0.1595	2.56703	0.0187	10.1979	1.E-08	4.16459	0.0006	11.3728	2.E-09	3.81584	0.0013
9	1.67129	0.1199	2.29376	0.0298	8.71593	8.E-08	3.43642	0.0022	10.0403	1.E-08	3.05813	0.0052
10	1.48362	0.1741	2.75611	0.0089	7.54745	4.E-07	3.03284	0.0046	9.10912	3.E-08	2.99639	0.0050

Table 11.k SINGAPUR

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*	
1	0.57154	0.4519	0.76626	0.3840	2.12610	0.1488	18.6041	5.E-05	1.74596	0.1902	24.9360	3.E-06
2	2.46144	0.0921	7.27730	0.0013	14.9996	3.E-06	8.77016	0.0004	12.7295	2.E-05	9.13154	0.0003
3	1.76377	0.1616	4.57013	0.0055	12.6505	1.E-06	11.3136	4.E-06	9.98655	1.E-05	13.6802	4.E-07
4	1.28062	0.2859	3.50903	0.0114	10.7839	7.E-07	9.78441	2.E-06	8.63803	1.E-05	9.66050	3.E-06
5	1.10507	0.3661	3.13568	0.0133	9.08624	1.E-06	6.56733	5.E-05	6.85425	3.E-05	6.50942	5.E-05
6	1.04588	0.4044	2.62483	0.0245	8.28795	1.E-06	4.66355	0.0005	5.84667	7.E-05	4.68756	0.0005
7	0.98142	0.4531	2.42700	0.0292	6.78649	6.E-06	3.71884	0.0021	4.74521	0.0003	4.02461	0.0011
8	0.97831	0.4621	1.83836	0.0881	7.18484	1.E-06	4.17704	0.0005	4.95697	0.0001	3.95781	0.0009
9	0.90062	0.5312	2.67712	0.0118	6.00074	8.E-06	3.26425	0.0030	4.28503	0.0003	3.26880	0.0030
10	1.08880	0.3878	2.29000	0.0260	6.36273	3.E-06	2.49384	0.0158	4.78653	7.E-05	2.41913	0.0190

Table 11.j: PHILLIPINES

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*	
1	0.04915	0.8251	0.00043	0.9835	2.73474	0.1020	1.32706	0.2527	1.23597	0.2695	0.81229	0.3701
2	0.48611	0.6168	0.46175	0.6319	4.50927	0.0140	0.82863	0.4404	6.50553	0.0024	0.24676	0.7819
3	0.47256	0.7023	0.32681	0.8060	5.69595	0.0014	2.55865	0.0613	9.45984	2.E-05	6.12948	0.0009
4	0.66287	0.6198	1.24916	0.2979	4.35853	0.0032	2.89687	0.0277	8.91837	6.E-06	5.72791	0.0005
5	1.22344	0.3074	0.52552	0.7562	3.94565	0.0033	2.34972	0.0497	8.84603	2.E-06	3.19529	0.0118
6	0.94506	0.4691	0.76213	0.6022	4.07741	0.0015	1.16558	0.3352	7.57717	3.E-06	2.25289	0.0486
7	0.84348	0.5557	0.67819	0.6898	3.55613	0.0027	1.32811	0.2518	6.90079	4.E-06	1.96408	0.0739
8	0.79079	0.6127	1.13282	0.3547	3.11428	0.0052	1.63072	0.1348	5.92611	1.E-05	1.84464	0.0859
9	0.70844	0.6987	1.01542	0.4387	2.96123	0.0058	1.29059	0.2618	5.27344	3.E-05	1.59656	0.1378
10	0.69655	0.7233	0.74921	0.6755	2.86496	0.0060	0.81942	0.6114	4.86680	5.E-05	1.12919	0.3581

Table 11.l: SINGAPUR (CYCLIC)

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*		*π does not cause h_t*		*h_t does not cause π*	
1	0.03494	0.8522	8.04326	0.0058	0.22096	0.6396	0.00703	0.9334	15.6334	0.0002	22.9664	8.E-06
2	0.86626	0.4246	4.84096	0.0105	1.70291	0.1890	8.42099	0.0005	15.1894	3.E-06	5.45532	0.0061
3	0.50900	0.6773	3.03070	0.0347	7.25104	0.0003	5.51395	0.0018	17.9983	8.E-09	10.8657	6.E-06
4	0.44145	0.7782	2.41332	0.0570	5.48657	0.0007	6.42473	0.0002	38.0348	7.E-17	9.81496	2.E-06
5	0.72280	0.6087	1.89445	0.1069	7.20432	2.E-05	5.13113	0.0005	43.5797	9.E-20	7.21099	2.E-05
6	1.30342	0.2685	1.42599	0.2186	10.0517	8.E-08	4.56379	0.0007	35.2978	2.E-18	6.06859	5.E-05
7	1.63845	0.1417	1.25947	0.2855	10.5927	1.E-08	3.67319	0.0023	30.0818	2.E-17	5.23603	0.0001
8	2.24273	0.0369	1.20448	0.3126	9.77905	2.E-08	3.55373	0.0021	27.7168	4.E-17	5.35798	5.E-05
9	2.74452	0.0101	1.33401	0.2412	9.32709	2.E-08	2.70558	0.0111	27.3011	3.E-17	4.01883	0.0005
10	2.30299	0.0252	1.02825	0.4334	7.44608	3.E-07	1.84794	0.0749	24.2461	3.E-16	2.74914	0.0085

Table 11.m SKOREA

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π	
1	5.35415	0.0232	0.61018	0.4370	7.69646	0.0069	0.28507	0.5949	6.45217	0.0130	0.76898	0.3832
2	7.94164	0.0007	0.37095	0.6913	10.6923	8.E-05	0.08172	0.9216	10.3312	0.0001	0.47022	0.6266
3	5.27544	0.0024	2.20365	0.0948	6.90665	0.0004	9.78066	2.E-05	6.79821	0.0004	9.99585	1.E-05
4	4.94904	0.0014	8.08054	2.E-05	9.16620	5.E-06	8.09768	2.E-05	9.64857	3.E-06	9.05849	6.E-06
5	8.72825	2.E-06	4.56782	0.0012	8.70467	2.E-06	4.37285	0.0016	9.54776	6.E-07	4.61938	0.0011
6	7.83162	2.E-06	3.71249	0.0031	8.16175	1.E-06	3.54910	0.0042	8.67892	6.E-07	3.69319	0.0032
7	6.53204	9.E-06	3.07983	0.0075	6.79022	6.E-06	3.46977	0.0034	7.16683	3.E-06	3.63438	0.0024
8	5.66498	2.E-05	2.68728	0.0137	5.98885	1.E-05	2.72561	0.0126	6.60214	4.E-06	2.87572	0.0090
9	5.54806	2.E-05	2.01646	0.0542	5.41063	3.E-05	1.72632	0.1044	5.83323	1.E-05	1.97265	0.0600
10	5.67020	1.E-05	1.73831	0.0962	5.27836	2.E-05	1.47702	0.1741	5.75031	9.E-06	1.67402	0.1116

Table 11.n SKOREA (CYCLIC)

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π	
1	11.2928	0.0012	0.00224	0.9624	4.10923	0.0460	0.35415	0.5535	17.8940	6.E-05	0.00557	0.9407
2	10.6716	8.E-05	0.22666	0.7977	4.42014	0.0152	1.54466	0.2199	15.0417	3.E-06	0.33722	0.7148
3	6.99826	0.0003	2.49487	0.0665	3.76088	0.0143	1.08932	0.3590	9.95573	1.E-05	8.59021	6.E-05
4	6.61961	0.0001	3.98224	0.0057	2.72415	0.0360	1.39272	0.2453	13.1804	4.E-08	5.16573	0.0010
5	9.75522	5.E-07	2.66734	0.0292	2.35986	0.0491	0.76219	0.5802	13.8124	3.E-09	3.09628	0.0141
6	7.77856	3.E-06	2.14992	0.0593	2.43236	0.0350	0.70313	0.6481	11.0880	2.E-08	2.40442	0.0368
7	6.57242	8.E-06	2.40209	0.0305	2.10933	0.0556	0.53947	0.8013	9.39790	7.E-08	3.13196	0.0068
8	6.97725	2.E-06	1.73333	0.1095	1.79622	0.0960	0.62942	0.7498	9.22718	4.E-08	2.00485	0.0614
9	6.46669	3.E-06	1.23069	0.2954	1.52318	0.1625	0.77186	0.6426	8.75176	5.E-08	1.49844	0.1712
10	6.08501	4.E-06	1.11897	0.3659	1.41067	0.2013	0.72053	0.7015	8.06410	1.E-07	1.35994	0.2245

Table 11.o THAILAND

Lags	GARCH				EGARCH				GJR-GARCH			
	π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π		π does not cause h_t		h_t does not cause π	
1	3.96631	0.0497	4.55614	0.0358	31.2349	3.E-07	12.0199	0.0008	22.8032	8.E-06	9.06246	0.0035
2	2.06461	0.1337	1.72639	0.1846	57.3730	4.E-16	2.33938	0.1030	55.3543	9.E-16	1.03781	0.3590
3	1.35697	0.2624	2.46162	0.0690	36.5200	1.E-14	2.56484	0.0608	33.2447	8.E-14	1.26442	0.2926
4	1.12195	0.3528	2.09017	0.0908	59.5475	3.E-22	8.17566	2.E-05	27.6428	6.E-14	6.19906	0.0002
5	1.29692	0.2752	3.37834	0.0086	70.8973	5.E-26	4.91517	0.0007	59.9318	6.E-24	3.26126	0.0105
6	0.94202	0.4712	2.72054	0.0200	56.2679	3.E-24	4.62574	0.0005	51.6550	3.E-23	3.64842	0.0034
7	0.98496	0.4501	2.55181	0.0221	48.0570	4.E-23	3.76448	0.0018	43.0914	8.E-22	3.15828	0.0062
8	1.02556	0.4269	2.36423	0.0276	40.7705	1.E-21	4.05896	0.0006	37.1890	1.E-20	3.45441	0.0024
9	0.82173	0.5986	2.73961	0.0098	51.1128	3.E-24	2.87230	0.0071	35.7285	2.E-20	3.05419	0.0046
10	0.89589	0.5430	1.84099	0.0746	46.8954	3.E-23	1.86412	0.0706	31.3417	3.E-19	1.34975	0.2283