Pakistan Journal of Applied Economics: Special Issue 2016, (137-151)

FORECASTING PAKISTAN'S STOCK MARKET VOLATILITY WITH MACROECONOMIC VARIABLES: Evidence from the Multivariate GARCH Model

Zohaib AZIZ* and Javed IQBAL**

Abstract

In an efficient stock market the stock prices embody the expected course of local and global economy which might impact the future prices in some way. This paper examines whether the volatility and dynamic linkages of Pakistani stock market with the US stock market are improved if local and foreign macroeconomic variables are augmented in a Multivariate GARCH model. Using the BEKK specification of Engle and Kroner (1995) with local and foreign macroeconomic variables as exogenous variables we estimate a multivariate GARCH model and use the Wald test to investigate whether the stock market volatility is significantly changed due to the local and foreign economic conditions. The monthly stock returns and some key macroeconomic variables are employed from July, 1997 to December 2015. Forecasts are evaluated using three measures namely, R^2 (coefficient of determination); Mean Absolute Percentage Error (MAPE) and Median Absolute Percentage Error (MdAPE). We also tested the sensitivity of forecast by using the global financial crisis (GFC) dummy to investigate whether the financial crisis has altered the volatility forecast. Although the both local and global variables significantly impact on the stock market volatility of Pakistan but the local macroeconomic variables contribute more than global to improve the forecast of Pakistan's stock market volatility. The results are to some extent sensitive to inclusion of the GFC dummy.

JEL Classification: C23, D31, O40.
Key Words: economic growth, inequality, developing economies.

I. Introduction

A stock market does not operate independently of the local and global economic conditions. For instance, in the dividend discount model, the stock prices depend on the expected future dividend and the discount rate. Economic variables that affect the

* Lecturer, Department of Statistics, Federal Urdu University of Arts, Sciences and Technology, Karachi,

** Associate Professor, Department of Statistics, University of Karachi. The authors are thankful to participants of the International Conference 2016 organized by the AERC; and the International Conference on Business, Economics and Education Management (ICBEM) organized by the IBA Sukkur, 2016 for their valuable comments. The financial support of the Federal Urdu University of Arts, Sciences and Technology, Karachi, Pakistan, is gratefully acknowledged. Comments and suggestions of Ayub Mehar, and Danish Siddiqui, are also thankfully acknowledged.

expected dividend or the discount rate will also influence the stock prices. There are several macroeconomic factors which may affect the stock prices through the dividend and discount rate channel. Changes in the inflation influence the interest rates and nominal cash flows hence dividends. Value of foreign earnings and export performance that ultimately affect the discount rate are affected by the changes in exchange rates. Changes in the industrial production would influence profits and hence dividends. The change in oil prices reflect its impact on the industry costs and via induced macro policy responses, possibly output and hence revenues. Moreover, shocks in the money supply, exchange rates, oil prices or the gold price may cause in the changing of interest rates and ultimately the discount rate [Clare and Thomas (1994)]. It is important to test the impact of other sectors of the economy in particular with local and global macroeconomic factors on stock market. Although, strong theoretical motivation about the relationship between stock market and macroeconomic variables exists in the literature but unfortunately, the empirical studies on stock market volatility and macroeconomic variables are very rare especially for emerging markets. Empirical finance literature explores that the macroeconomic variables help to explain the stock market volatility. For instance, Cutler, et al. (1989) identifies that macroeconomic news can explain only between one-fifth and one-third of the movements of a stock market index. Schwert (1989) explores the weak evidence of explaining the stock market volatility by macroeconomic volatility. Liljeblom and Stenius (1997) states that interval of one-sixth to above two-thirds of changes in aggregate stock volatility might be related to macroeconomic volatility. However, researchers point out that the weak evidence of relationship between macroeconomic variables and stock market volatility may be due to the poor identification technique. The major proportion of few empirical studies available on the relationship between macroeconomic variables and stock market volatility is based on developed countries. For emerging countries, especially for Pakistan a very few literature has been contributed. In uni-variate context, the analysis of Pakistani stock market volatility with local and global macroeconomic variables has been recently investigated by Iqbal and Javed (2012). In multivariate context the empirical evidence of the dynamic linkages of volatility and macro variable does not exist in the literature. Acuurate volatility forecasts are needed for several economic and financial activities.Reliable computation of value-at-risk (VaR), conditional asset pricing and option pricing are depending on accurate and reliable conditional volatility forecast.

Market liberalization, gradual technological change, international trading and financing between the economies etc., have increased the stock market integration. This integration may cause to improve the volatility forecast of stock market. A stock market may have the dynamic linkages with developed or developing markets. In this context, the dynamic linkages of stock market with the global stock market namely US are frequently checked. These dynamic linkages are important to check whether the integration of US market improves the volatility forecast of stock market. Volatility may be affected by the financial crisis due to the increase in the correlation between the stock markets. Jang and Sul (2002) give the empirical evidences that correlation between the stock market is increased during financial crisis. So, it is also interesting to check whether the financial crisis improves the volatility forecast of stock market.

The contribution of the paper is that this is the first study which incorporates both local and global macroeconomic variables to explain and forecast volatility of an emerging stock market in a multivariate GARCH framework. In particular the study investigates whether the dynamic linkages of the Pakistani stock market with the US stock market and the incorporation of global financial crisis (2007-2009) improve the volatility forecast of the Pakistani stock market. Having considered above all aspects, this paper attempts to investigate that the impact of national and international macroeconomic indicators, the dynamic linkages of the Pakistani stock market with the US stock market and the incorporation of global financial crisis (2007-2009) dummy improves the volatility forecast of the Pakistani stock market.

II. Literature Review

Against the strong theoretical motivation of impact of macroeconomic indicators on stock markets, there are very limited empirical studies on it some of which are reported here. Oluseyi (2015) inquires the link between stock market prices volatility and macroeconomic variables volatility in Nigeria. He uses five monthly macroeconomic variables i.e. GDP, inflation, exchange rate, interest rate and money supply from January 1990 to December 2014. Multivarite VAR is employed to test the granger causality while GARCH (1,1) is used to measure the volatilities of stock price and macroeconomic variables. In set of macroeconomic variables GDP, inflation and money supply are not found to Granger cause and significantly related to stock price volatility except interest rate and exchange rate. Zakaria and Shamsuddin (2012) test the relationship between stock market volatility returns and macroeconomic volatility for Malaysia. They use monthly stock market returns volatility and five macroeconomic variables in terms of volatility namely GDP, inflation, exchange rate, interest rates and money supply from January 2000 to June 2012. GARCH (1,1) is used to estimate the volatilities and bivariate and multivariate VAR Granger causality tests are employed to examine the relationship between the stock market volatility and macroeconomic variables. They found weak relationship between stock market volatility and macroeconomic volatilities.

Yogaswari, et al. (2012) examine the relationship between Indonesian stock market returns and three macroeconomic variables i.e., inflation, interest rate and exchange rate for the period January 2007 to December 2011. They use three stock price index namely, Jakarta composite Index, agricultural sector and basic industry sector stock prices and find their significant relationship to the employed macroeconomic variables. Hosseini, et al. (2011) use four macroeconomic variables namely crude oil prices, money supply, industrial production and inflation rate to test their relationship with stock market indices of China and India. Multivariate cointegration test and VECM technique are applied for the monthly data January 1999 to January 2009. The result finds both long run and short run significant linkages between macroeconomic variables and stock market index in each of these countries.Wang (2010) employs the EGARCH and lag-augmented models to examine the time series relationship between stock market volatility and macroeconomic variables volatility for China. He uses three macroeconomic variables i.e. inflation, interest rate and real GDP. He finds bilateral relationship between inflation and stock prices and unidirectional relationship between interest rate and stock prices. However no significant relationship is found between real GDP and stock prices.

Acikalin, et al. (2008), investigate the relationship between stock returns of Istanbul stock exchange and macroeconomic variables of Turkish economy. They employ GDP, interest rates, exchange rates and current account balance as economic indicators. Cointegration test and VECM are used to test the long term relationship and causality between stock returns and macroeconomic variables. Long term relationship and unidirectional causality is found between stock returns and macroeconomic variables. Abugri (2008) tests the empirical relationship between global macroeconomic volatility and stock returns for Latin American stock markets by vector autoregressive (VAR) model. He uses exchange rates, interest rates, industrial production and money supply for local macroeconomic indicators, whereas, MSCI world index and the US 3-month T-bill for global effect. The study supports that both global and local factors have significant influence in explaining returns in all the markets.

Morelli (2002) finds the relationship between conditional stock market volatility and conditional macroeconomic volatility on the UK data by using GARCH models. He uses macroeconomic variables including, industrial production, real retail sales, money supply, inflation, and an exchange rate variable. Liljeblom and Stenius (1997) also reveal the relationship between macroeconomic volatility stock market volatility on the monthly Finland data. They find some significant results that both stock market volatility and macroeconomic volatility support as a predictor for each other. While, they measure volatilities through simple weighted moving averages and GARCH estimation and make the comparisons in both techniques as well.

III. Data

1. Stock Price Index and Macroeconomic Variables

We take the daily and monthly KSE-100 (Karachi Stock Exchange) adjusted for dividends and splits and monthly S&P-500 from yahoo finance. Monthly Consumer Price Index (CPI), Money Stock (M2), Exchange Rate and Interest Rate (Call Money Rate) are used as local macroeconomic variables while US Industrial Production, Consumer price Index, Treasury Bill rate, world gold and oil prices (West Texas Intermediate spot price) as global. All global variables are obtained from the International financial statistics (IFS) except gold and oil prices that were downloaded from the website of World Gold Council (http://www.gold.org) and Federal Reserve Bank of St Louis Economic Data (https://fred.stlouisfed.org) respectively.[1] The data consist of 222 monthly observations from July, 1997 to December, 2015. All variables are employed in percent change except stock prices which are considered in percentage log returns.

2. *Global Financial Crisis Period*

In case of GFC, we code 1 to crisis dummy "D" form February, 2007 to March, 2009 (total 26 observations) while 0 is coded for pre and post crisis period i.e. July, 1997 to January 2007 (total 115) and April 2009 to December, 2015 (total 81 observations) respectively.

IV. Methodology

1. *The Models of Volatility Forecasting*

a) *The MGARCH Model*

The BEKK specification proposed by Engle and Kroner (1995) of multivariate GARCH model (MGARCH) is employed for volatility modeling. A bivariate asymmetric VARMA (1,1)-BEKK (1,1) model allowing the exogenous variables represented as follows:

b) *Mean Equation*

$$R_t = \Lambda + \Psi R_{t-1} + \Omega u_{t-1} + u_t,\ u_t|I_{t-1} \sim (0, H_t) \qquad (1)$$

c) *Volatility Equation*

$$H_t = \Gamma' \Gamma + \Theta' u_{t-1} u_{t-1}' \Theta + \Phi' H_{t-1} \Phi + A' \xi_{t-1} \xi_{t-1}' A + T' X_{t-1} T \qquad (2)$$

In order to forecast the volatility with GFC dummy, we consider BEKK (1,1) as:

$$H_t = \Gamma' \Gamma + \Theta' u_{t-1} u_{t-1}' \Theta + \Phi' H_{t-1} \Phi + A' \xi_{t-1} \xi_{t-1}' A + T' X_{t-1} T + G' DG \qquad (3)$$

[1] The use of World Gold Council as data source is very common for gold data in literature. The Fred data is also quite common for example in Ferraro, et al. (2015). Ferraro, Domenico, Kenneth Rogoff, and Barbara Rossi (2015), "Can oil prices forecast exchange rates: An empirical analysis of the relationship between commodity prices and exchange rates." Journal of International Money and Finance 54: 116-141].

where $R_t = [r_{1,t}$ & $r_{2,t}]'$ is the percentage log-returns vector. Here $u_t = [u_{1,t}$ & $u_{2,t}]'$ is the residual vector with conditional variance-covariance matrix $H_t = [h_{ij,t}]_{i,j=1,2}$. Here ξ_t is defined as equal to u_t if u_t is negative and zero otherwise. The set of information available at time (t-1) is expressed by I_{t-1}. Here =$[\lambda_1$ & $\lambda_2]'$, $\Psi = [\psi_{ij}]_{i,j=1,2}$ and $\Omega = [\omega_{ij}]_{i,j=1,2}$ are the coefficient matrices of constant terms, first lagged returns and the first lagged shocks for mean returns respectively. The parameter matrix of the volatility equation is denoted as $\Gamma = [\gamma_{ij}]_{i,j=1,2}$ which is an upper triangular matrix. The residual vector is explained by $u_t = [u_{1,t}$ & $u_{2,t}]'$ and the conditional variance-covariance matrix $H_t = [h_{ij,t}]_{i,j=1,2}$. ξ_t is defined as u_t if u_t is negative and zero otherwise. Note that here D is a diagonal matrix containing the global financial crisis dummy variables as defined above on its main diagonal. The set of given information available at time (t-1) is expressed by I_{t-1}. The parameter matrices of the volatility equations (2) and (3) are denoted as $\Gamma = [\gamma_{ij}]_{i,j=1,2}$ which is an upper triangular matrix, $\Theta = [\theta_{ij}]_{i,j=1,2}$, and $\Phi = [\phi_{ij}]_{i,j=1,2}$, restriction free ARCH and GARCH coefficient matrices respectively. Whereas, $A = [a_{ij}]_{i,j=1,2}$ is also the restriction free coefficient matrix of asymmetric response of volatility.$T = [\tau_{ij}]_{i,j=1,2}$ is the coefficient matrix of exogenous variable. $g = [g_{ij}]_{i,j=1,2}$ is used as the coefficients of financial crisis dummies.

2. *Estimation*

Berndt, Hall, Hall, and Hausman (BHHH) numerical maximization algorithmis used to maximize the following multivariate conditional log-likelihood function L(Ω)of the BEKK-MGARCH model.

$$L_t(\Omega) = -\log 2\pi - 1/2 \log|H_t| - 1/2\, u_t'(\Omega)\, H_t^{-1}(\Omega)\, u_t(\Omega) \tag{4}$$

and

$$L(\Omega) = \sum_{t=1}^{T} L_t(\Omega) \tag{5}$$

where Ω represents the vector of all unknown parameters, T is the total number of observations of each returns series of return vector R_t.

3. *Model Diagnostics: The Multivariate Portmanteau Test*

Hosking (1980) proposes the generalization of univariate Ljung-Box test into multivariate case namely the multivariate portmanteau test. The test considers all series simultaneously rather than separately and also considers the cross-moment serial correlations. The Hosking’s test statistic for testing no auto and cross correlations in the residual vector series u_t is given as:

$$Q_{k(m)} = T2 \sum_{l=1}^{m} 1/T\text{-}l \; tr(\hat{\Xi}' l \, \hat{\Xi}_0^{-1} \, \Xi_l \, \Xi_0^{-1} \quad (6)$$

where, k is the dimension of returns vector R_t, T is the total number of observations, m is the maximum lag length, tr(.) is the trace function of the matrix, which is the sum of the diagonal elements of a square matrix. The estimated correlation matrix at *lag-l* is denoted as $\Xi_l = [\xi_{ij}]_{i,j=1,2}$. Assuming that the null hypothesis is true Q*k(m)* follows asymptotically a Chi-Square distribution with (k^2 m) degrees of freedom. We use the multivariate Ljung-Box test to diagnose the adequacy of the model.

4. Hypothesis Tests: the Wald Test

The following Wald test is used to test mean and volatility spillover and cross market asymmetric response of volatility:

$$W = [S\hat{\beta}]' [S Var (\hat{\beta}) S']' [S\hat{\beta}] \sim \chi^2 (q) \quad (7)$$

where S is the parameter restriction matrix of order (dimension) q × k, q represents the number of restrictions while kis the number of regressors. β is a vector of estimated parameters of order (k × 1) and Var (β) is the heteroskedasticity-robust consistent estimator for the covariance matrix of the parameter estimates.

5. Evaluation of Volatility Forecast

a) *Realized Volatility Proxy*

Volatility is not directly observable. This characterstic of volatility builts the problems in comparison with forecast volatility. To avoid this issue the sum of square of daily returns of current month is considered as the realized proxy of volatility. However to expressing the forecast error in a more interpretable way we consider the square root value of realized volatility which is to be compared with one day ahead forecast of conditioal standard deviation.

b) *Recursive Estimation Method*

We use a recursive window estimation to compute the volatility forecasts. For monthly data, we estimate the volatility models using the first 162 observations and obtain one month ahead forecats conditional standard deviation to be compared with absolute return observation of the month 163. Keeping the first observation and including obsevarion for month 163 in the sample we estimate the volatility model and make forecast for the month 163. We repeat this process for the entire available data sample. This process yields a series of one period ahead forecast for 60 months which corresponds roughly to month of trading.

c) *Out of Sample Forecast Evaluation*

To evaluate forecast out of sample, several measures are employed in the literature. We consider MAPE, MdAPE and the coefficient of determination R2. Median absolute percentage error provides a better outlier resistant evaluation measure.

d) *Mean Absolute Percentage Error (MAPE)*

MAPE is given by:

$$\text{MAPE} = \text{Meanof} \left| \frac{\sigma_t - \sqrt{\hat{h}_t}}{\sigma_t} \right| \times 100 \tag{8}$$

where, σ_t day t is realized standard deviation obtained as the absolute day *t* return and $\hat{h}_t$ is the forecast variance for day *t* obtained from the volatility model.

e) *Median Absolute Percentage Error (MdAPE)*

MdAPE is given by:

$$\text{MdAPE} = \text{Meanof} \left| \frac{\sigma_t - \sqrt{\hat{h}_t}}{\sigma_t} \right| \times 100 \tag{9}$$

6. R^2 (Coefficient of Determination)

The following regression is estimated and the coefficient of determination R^2 is obtained.

$$\log(|r_t|) = \alpha + \beta \log\left(\sqrt{\hat{h}t}\right) + \varepsilon_t \tag{10}$$

V. Results and Discussion

Our analysis is based on the results presented in Tables 1 to 5. Tables 1 and 2 reports the estimated results of the bivariate asymmetric VARMA (1,1)-GARCH (1,1) models under BEKK specification for Pakistan-US stock market pair when local and global lagged macroeconomic variables and GFC crisis dummy are employed. Estimation is performed using multivariate student t distribution of errors. It is divided into three panels, panel-A and panel-B only provide the estimates and standard errors for the mean and variance equation of Pakistani market. Coefficients of US market equation and covariance equation of Pakistan-US are not reported due to our focus on the results of Pakistani stock market. While panel-C reports the diagnostics of estimated models. The multivariate Ljung-Box Q statistics for the 12thand 24th orders in squared standardized residuals show that there is no serial dependence in the squared standardized residuals, indicating the appropriateness of the fitted variance-covariance equations for all cases. Table 1 suggests the best models when lagged consumer price index and exchange rate are employed in the volatility as evident from the information criteria AIC and BIC. Moreover, in volatility equation the coefficients of exchange rate and interest rate are found significant at 1 per cent level of significance where τ_{11}indicates the coefficient of macro variables in Pakistani stock market volatility equation. On the contrary, in Table 2, AIC and BIC when lagged global macro variables are employed are not less than for the case of no macro variable. Except the coefficient of global consumer price index all global macroeconomic variables are individually insignificant. It suggests that the most of incorporated global macro variables do not have the significant impact on the Pakistani stock market volatility. GFC dummy is also found insignificant.

Table 3 reports Wald test, diagnostics and information criteria when set of all local, global and both local and global are considered with and without global financial crisis dummy simultaneously in variance-covariance equation. Although Wald test indicates the simultaneous impact of all local, global and both local and global are not significantly zero even in crisis dummy case but information criteria suggest that the best model to explain the Pakistani stock market volatility is achieved when local macro variables are employed without GFC dummy. But the question remains constant about the contribution of local and global macro variables in improvement of volatility forecast of Pakistan's stock market.

Table 4 shows the forecast error measures for univariate and multivariate case to understand whether the dynamic linkages of Pakistani stock market with the US improve the volatility forecast of the Pakistani market. The minimum values of MAPE and MdAPE for multivariate case and the maximum value of R2 in GFC dummy case indicate that US market improves the volatility forecast of Pakistani stock market even in crisis period. This result makes the base to test the impact of local and global macro variables in multivariate framework.

Table 5 reports the forecast error measures when local and global macroeconomic variables are employed in multivariate GARCH model. Among all local macro variables, interest rate and the exchange rate are found more contributed variable as measured by the minimum values of MAPE and MdAPE. In global set of macro variables, oil prices and then industrial production is the significant contributor for volatility forecast of Pakistani market. Thus it is found that linkages with the local monetary factors of interest rate and exchange rate improve volatility forecast. The same role is played by supply side factors e.g. oil prices and industrial production among the foreign variables.

In simultaneous case, the forecast measure i.e., MdAPE of all local variables and both local and global variables have low difference. Also, all forecast error measure criteria R^2, MAPE and MdAPE are giving the evidence of more contribution of local than the global variables. Although results suggest the significant impact of local and global macro variables on Pakistani stock market volatility but the contribution level of the local macro variables are greater than the global variables. Our results are somehow consistent with the univariate study by Iqbal and Javed (2012).

VI. Conclusion

This paper investigates whether the local or global macroeconomic variable improves the volatility forecast of Pakistani stock market. We uncover significantly impact of both local and global macro variables is seen on the Pakistani stock market volatility. The significant impact of global macro variables implies that Pakistani stock market is becoming increasingly integrated to the global economy. However, the contribution of the local macro variables is larger relative to the global variables to improve the volatility forecast of Pakistani stock market. Exchange rate and interest rate in set of local macro variables and oil price and industrial production among global variables are found prominent contributed variables that affect Pakistan's stock market volatility. The results are to some extent sensitive to inclusion of the GFC dummy. Although the foreign variables impact the stock market exogenously, there seems to be a role of local authorities through a monetary policy channel in stabilizing the Pakistani stock market volatility.

Federal Urdu University of Arts, Sciences and Technology, Karachi,
and Department of Statistics, University of Karachi, Pakistan.

Bibliography

Abugri, B.A., 2006, Empirical relationship between macroeconomic volatility and stock returns: Evidence from Latin American markets, International Review of Financial Analysis, 17: 396-410.

Aktas Acikalin, S.,R., and S. Unal, 2008, Relationships between stock markets and macroeconomic variables: An empirical analysis of the Istanbul Stock Exchange, Investment Management and Financial Innovations, 5(1): 8-16.

Clare, A.D., and S.H. Thomas, 1994, Macroeconomic factors, The APT and the UK Stock market, Journal of Business Finance & Accounting, 21(3): 309-330.

Cutler, D.M., J.M. Poterba, and L.H. Summers, 1989, What moves stock prices, Journal of Portfolio Management, 15: 4-12.

Engle R., F.K. Kroner, 1995, Multivariate simultaneous generalized ARCH, Econometric Theory, 11: 122-150.

Hosking, J.R.M., 1980, The multivariate portmanteau satatistic, Journal of American Statistical Association, 75: 602-608.

Hosseini, S.M., Z. Ahmad and Y.W. Lai, 2011, The role of macroeconomic variables on stock market index in China and India, International Journal of Economics and Finance, 3(6): 233.

Iqbal, J. and M. Javed, 2012, Do local and global macroeconomic variables help forecast volatility of Pakistani stock market, Pakistan Journal of Engineering and Applied Sciences, 2(1): 55-68.

Jang, H. and W. Sul, 2002, The Asian financial crisis and the co-movement of Asian stock markets, Journal of Asian Economics 13: 94-104.

Liljeblom, E., and M. Stenius, 1997, Macroeconomic volatility and stock market volatility: Empirical evidence on finnish data, Applied Financial Economics, 7: 419-426.

Morelli, D., 2002, The relationship between conditional stock market volatility and conditional macroeconomic volatility: Empirical evidence based on UK data, International Review of Financial Analysis, 11: 101-110.

Oluseyi, A.S., 2015, An empirical investigation of the relationship between stock market prices volatility and macroeconomic variables volatility in Nigeria, European Journal of Academic Essays, 2(11): 1-12.

Wang, X., 2010, The relationship between stock market volatility and macroeconomic volatility: Evidence from China, International Research Journal of Finance and Economics, 49(2): 149-160.

Yogaswari, D.D., A.B. Nugroho and N.C. Astuti, 2012, The effect of macroeconomic variables on stock price volatility: Evidence from Jakarta composite index, agriculture, and basic industry sector, School of Business and Management.

Zakaria, Z., and S. Shamsuddin, 2012, Empirical evidence on the relationship between stock market volatility and macroeconomics volatility in Malaysia, Journal of Business Studies Quarterly, 4(2): 61.

APPENDIX

TABLE 1

Estimated Coefficients for Bivariate Asymmetric Garch Model
with Local Macroeconomic Impact and its Diagnostics

Parameters	Bivariate Asymmetric VARMA(1, 1)-BEKK(1, 1)				
	Local (Pakistani) Macroeconomic Variables				
	No Macro Variable	Consumer Price Index	Money Stock (M2)	Exchange Rate	Interest Rate
Panel A: Estimated Coefficients of Mean Equations					
λ_1	1.881	1.976	1.949	1.425	2.383
	(0.144)	(0.007)	(0.004)	(0.044)	(0.000)
ψ_{11}	0.499	0.694	0.468	0.590	0.220
	(0.144)	(0.124)	(0.155)	(0.152)	(0.552)
ψ_{12}	-3.613	-4.143	-3.501	-3.766	-2.779
	(0.007)	(0.015)	(0.009)	(0.008)	(0.082)
ω_{11}	-0.004	-0.717	-0.506	-0.571	-0.132
	(0.943)	(0.106)	(0.128)	(0.169)	(0.726)
ω_{12}	0.476	4.845	4.292	4.362	2.828
	(0.102)	(0.003)	(0.001)	(0.002)	(0.082)
Panel B: Estimated Coefficients of Variance and Covariance Equations					
γ_{11}	3.122	4.023	2.043	3.831	3.177
	(0.000)	(0.000)	(0.505)	(0.000)	(0.000)
θ_{11}	-0.251	-0.241	0.278	-0.024	-0.066
	(0.018)	(0.033)	(0.035)	(0.896)	(0.603)
θ_{12}	-0.015	-0.025	0.007	-0.010	0.005
	(0.541)	(0.318)	(0.794)	(0.681)	(0.861)
ϕ_{11}	0.737	0.680	0.737	0.659	0.697
	0.000	0.000	0.000	0.000	0.000
ϕ_{12}	-0.027	0.006	-0.014	-0.020	-0.032
	(0.438)	(0.917)	(0.708)	(0.360)	(0.086)
a_{11}	-0.148	-0.203	-0.170	-0.242	-0.234
	(0.259)	(0.106)	(0.207)	(0.019)	(0.034)
a_{12}	0.054	0.062	0.054	0.034	0.042
	(0.020)	(0.011)	(0.022)	(0.103)	(0.067)
τ_{12}	-	-0.961	0.637	-1.439	0.052
		(0.302)	(0.669)	(0.004)	(0.004)
Panel C: Diagnostics					
LB(12)	47.208	47.769	48.336	38.793	52.026
	(0.505)	(0.482)	(0.459)	(0.825)	(0.320)
LB(24)	95.468	101.193	97.507	83.250	110.610
	(0.496)	(0.338)	(0.437)	(0.820)	(0.146)
$LB^2(12)$	34.363	46.417	30.342	44.178	39.906
	(0.930)	(0.537)	(0.978)	(0.630)	(0.790)
$LB^2(24)$	102.508	102.257	108.634	100.856	110.267
	(0.305)	(0.312)	(0.178)	(0.347)	(0.151)
Log-Likelihood	-1192.299	-1185.603	-1190.208	-1186.902	-1189.947
AIC	2436.599	2429.207	2438.417	2431.805	2437.895
BIC	2524.951	2527.753	2536.964	2530.351	2536.442

Value presented in the parentheses of Panel A, B and C is the P-value.
LB and LB_2 explain the multivariate Ljung-Box (portmanteau test) statistics for standardized and square standardized residuals respectively.

TABLE 2

Estimated Coefficients for Bivariate Asymmetric Garch Model with Global Macroeconomic and Global Financial Crisis Impact and its Diagnostics

Parameters	Bivariate Asymmetric VARMA(1,1)-BEKK(1,1)						
	Global (US) variables						
	No Macro Variable	Industrial Production	Consumer Price Index	Treasury Bill Rate	Oil Prices	Gold Prices	Crisis Dummy
Panel A: Estimated Coefficients of Mean Equations							
λ_1	1.881	2.167	1.883	1.923	1.994	1.773	1.950
	(0.144)	(0.002)	(0.001)	(0.004)	(0.004)	(0.013)	(0.003)
ψ_{11}	0.499	0.431	0.493	0.499	0.624	0.557	0.498
	(0.144)	(0.201)	(0.094)	(0.141)	(0.104)	(0.137)	(0.132)
ψ_{12}	(3.613)	(3.414)	(3.664)	(3.606)	(4.043)	(3.717)	(3.630)
	(0.007)	(0.014)	(0.002)	(0.008)	(0.010)	(0.008)	(0.007)
ω_{11}	(0.004)	(0.465)	(0.556)	(0.520)	(0.647)	(0.572)	(0.524)
	(0.943)	(0.166)	(0.057)	(0.128)	(0.088)	(0.119)	(0.121)
ω_{12}	0.476	4.179	4.495	4.311	4.915	4.405	4.350
	(0.102)	(0.002)	0.000	(0.001)	(0.001)	(0.001)	(0.001)
Panel B: Estimated Coefficients of Variance and Covariance Equations							
γ_{11}	3.122	3.153	2.288	3.258	3.301	3.440	3.187
	0.000	0.000	(0.006)	0.000	0.000	0.000	0.000
θ_{11}	(0.251)	(0.253)	(0.256)	0.233	(0.213)	0.216	0.238
	(0.018)	(0.041)	0.000	(0.034)	(0.037)	(0.083)	(0.032)
θ_{12}	(0.015)	(0.014)	0.003	0.024	(0.019)	0.021	0.011
	(0.541)	(0.596)	(0.899)	(0.399)	(0.534)	(0.411)	(0.620)
ϕ_{11}	0.737	0.721	0.794	0.726	0.700	0.686	0.733
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ϕ_{12}	(0.027)	(0.025)	0.009	(0.038)	0.095	(0.038)	(0.026)
	(0.438)	(0.549)	(0.627)	(0.356)	0.000	(0.293)	(0.291)
a_{11}	(0.148)	(0.169)	(0.071)	(0.162)	0.310	(0.204)	(0.169)
	(0.259)	(0.212)	(0.606)	(0.190)	(0.050)	(0.132)	(0.196)
a_{12}	0.054	0.053	0.066	0.058	(0.047)	0.048	0.042
	(0.020)	(0.055)	(0.001)	(0.014)	(0.078)	(0.042)	(0.052)
τ_{12}	-	-0.033	-9.831	-0.003	0.054	-0.036	-0.024
/Dummy Coeff.		(0.972)	0.000	(0.530)	(0.382)	(0.699)	(0.987)
Panel C: Diagnostics							
LB(12)	47.208	45.820	54.275	46.153	48.783	46.621	47.465
	(0.505)	(0.562)	(0.247)	(0.548)	(0.441)	(0.529)	(0.494)
LB(24)	95.468	94.003	104.596	95.778	97.909	97.359	94.830
	(0.496)	(0.538)	(0.257)	(0.487)	(0.426)	(0.442)	(0.514)
$LB_2(12)$	34.363	37.874	29.027	35.488	56.326	34.953	43.775
	(0.930)	(0.852)	(0.986)	(0.909)	(0.191)	(0.920)	(0.646)
$LB_2(24)$	102.508	99.501	102.353	109.006	117.106	107.597	106.359
	(0.305)	(0.382)	(0.309)	(0.171)	(0.070)	(0.197)	(0.220)
Log-Likelihood	-1192.299	-1190.485	-1189.261	-1191.272	-1190.120	-1191.406	-1191.156
AIC	2436.599	2438.971	2436.522	2440.544	2438.241	2440.812	2440.313
BIC	2524.951	2537.518	2535.069	2539.090	2536.787	2539.359	2538.860

Value presented in the parentheses of Panel A, B and C is the P-value.

LB and LB_2 explain the multivariate Ljung-Box (portmanteau test) statistics for standardized and square standardized residuals respectively.

TABLE 3

Incremental Contribution/Information Contents of Local, Global and All Macro Variables

	All Local Variables		All Global Variables		Local & Global Var.	
	No GFC*		No GFC	GFC	No GFC	GFC
Wald Test	21.5222	11.564	19.605	13.135	60.835	116.862
	(0.000)	(0.020)	(0.002)	(0.022)	(0.000)	(0.000)
AIC	2426.84	2436.51	2444.747	2461.008	2441.479	2445.431
BIC	2555.97	2575.834	2584.072	2610.527	2621.581	2635.728
Log-Likelihood	-1175.42	-1177.255	-1181.373	-1186.504	-1167.739	-1166.715
LB (12)	34.368	51.122	46.743	43.223	41.647	38.864
	(0.930)	(0.352)	(0.524)	(0.668)	(0.729)	(0.823)
LB(24)	81.443	110.914	102.127	92.271	78.829	89.128
	(0.855)	(0.142)	(0.315)	(0.588)	(0.898)	(0.677)
LB (12) sq.	68.972	64.66	58.032	74.17	55.473	58.238
	(0.025)	(0.055)	(0.152)	(0.009)	(0.214)	(0.147)
LB(24) sq.	130.262	114.006	95.513	128.623	78.13	132.089
	(0.011)	(0.101)	(0.494)	(0.015)	(0.908)	(0.008)

*No GFC: No global financial crisis dummy incorporated,
**GFC: Financial crisis dummy incorporated, Values in parenthesis are the P-values.

TABLE 4

Forecast Evaluation:
Finding the Best Forecast Model

Cases	R^2	Mape	Mdape
Univariate	0.0051	178.4211	162.1266
Multivariate	0.0005	120.4034	100.3845
Multivariate with GFC	0.0119	117.2948	106.5437

TABLE 5

Forecast Evaluation:
Macro Variables Impact

Macroeconomic Variables	R^2	MAPE	MdAPE
No Macro	0.0005	120.403	100.384
Local			
Consumer Price Index	0.0213	132.986	114.686
Money Stock (M2)	0.0192	125.003	115.875
Exchange Rate	0.0089	107.284	89.082
Interest Rate	0.0005	98.324	86.61
All Local Variables	0.0136	114.03	94.616
All Local Variables with GFC	0.0441	153.136	124.897
Global			
Industrial Production	0	104.76	96.784
Consumer Price Index	0.003	134.84	111.632
Treasury Bill Rate	0.0469	120.225	101.702
Oil	0.0101	112.482	97.216
Gold	0.0007	114.236	101.185
All Global Variables	0.0002	153.136	124.897
All Global Variables with GFC	0.0073	146.872	123.631
All			
Both Local and Global	0.0002	107.763	93.528
Both Local and Global with GFC (crisis dummy)	0.0001	125.003	115.875