The Analysis of Bidirectional Causality between Stock Market Volatility and Macroeconomic Volatility

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Abstract

What underlies the volatility of financial securities has been researched for decades in parallel with the developments in time series analysis. The multivariate heteroscedastic variance models provide a convenient way to examine inherent time-varying dynamics of the volatility of stock indices. In this paper, we attempt to analyze the bidirectional causal relations between macroeconomic volatility and stock market volatility for some emerging markets with the multivariate GARCH model. The analysis of causality between stock market volatility and macroeconomic volatility provide some evidence that investors closely follow some macroeconomic variables as indicators of the riskiness of the country.

Keywords: Stock Market Volatitility, Granger Causality, Macro Economic Volatility

1. Introduction

There is vast amount of literature on volatility transmission between different types of markets such as between stock and bond markets, developed and emerging markets, and among emerging markets (Karolyi, 1995; Caporale et al., 2006; Goeij and Marquering, 2004; Baele et al., 2010). Common purpose of these studies is to figüre out the underlying dynamics of the volatility of stock markets. With this perspective, very little attention has been given to the interaction between macro economic volatility and stock market volatility especially in emerging markets. For the case of USA, Schwert (1989) is one of the very first studies in which it is attempted to figüre out the relation between stock market volatility and macroeconomic volatility. The findings of the study imply that there does not exist a significant relation between macro economic volatility and stock market volatility. In contrast to Schwert (1989), Binder and Mergers (2001) and Beltratti and Morana (2006) provide some evidence on the significant relation. The former study reports the quite strong relation in which they take interest rate, inflation, the equity risk premium and the ratio of expected profits to expected revenues for the economy as explanatory variables. The latter one reports that there is a bidirectional casual relation between stock market volatility and interest rates, money supply growth volatilities.

There are also studies for other developed countries in which the results support the significant relations between macro economic volatility and stock market volatility. Kearney and Daly (1998) report a very strong relation between Australian stock market volatility and money supply, industrial production and current account while there is no significant relation with the foreign exchange rate. Another research reporting the significant results is Errunza and Hogan (1998) in which they performed the analysis for 7 European countries, and they found that money supply is important for Germany, France, Italy, and the Netherlands and industrial production is important for UK, Switzerland and Belgium. However, the paper in which Morelli (2002) examines the relation for the case of UK do not support any significant relation. Even the methodologies are different in most of these studies, the results indicates that the relation between macro economic volatility and stock market volatility does exist to some extent even though significant macroeconomic variables are not the same for each country. To the best of our knowledge, there is a gap for emerging markets in the literature on analyzing the relation between macroeconomic volatility and stock market volatility. In terms of the relation between macroeconomic variables and stock markets, researches are especially focus on the relation in the mean level.

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On the other hand, in terms of volatility, researches are focus on the volatility spillover and contagion between stock markets in different countries. Since the results for the developed countries are contrary and specific to the stock market in question, the relation between macro economic volatility and stock market volatility for emerging countries is waiting to be found out. From theoretical point of view, the fundamental pricing formula in finance is the expectation of the present value of the future cash flows, which implies the strong relation between fundamentals and equities. At the aggregate level, it tells us that uncertainty in macroeconomic conditions of a country affects the riskiness of the stock index in that country by changing the cash flows and discount rates in the economy (Schwert, 1989). According to this, it is plausible to expect that the change in the macroeconomic volatility would cause a change in volatility of stock indices. On the other hand, some argue that stock markets are the indicators of the macroeconomic conditions of the countries by assuming that new information in the markets is almost simultaneously priced in the stock market. Therefore, the empirical analysis is needed to determine the direction of the relation if there is one.

In the most general terms, the relation between two variables can be described in two different ways: They may move together due to the same variables that they are affected, which shows itself in form of correlation. Or the changes in one variable can cause changes in the other one, i.e. causality in one direction or while the change in one variable affect the other, the change in the second variable can also affect the first one , i.e. bidirectional causality. In this paper, the bidirectional causal relations in Granger-sense between macro economic volatility and stock market volatility are analyzed.

There are two common methodologies to examine the relation between macroeconomic volatility and stock market volatility in the literature. One approach can be called two-step procedure, i.e to estimate the volatility series separately and then to apply the regression independently to these volatility series. This procedure may introduce bias into a number of diagnostics and causes invalid inferences (Kearney and Daly, 1998). The other approach is that Multivariate GARCH models provide a suitable way to examine the causal relations between variables simultaneously, which is used by most recent studies. As a result, in this paper, we attempt to find out if there is a casuality between macro economic volatility and stock market volatility for 4 emerging countries, namely Turkey, Czech Republic, Brazil and India by using BEKK-MGARCH(1,1) model. Macroeconomic variables are inflation and industrial production as the indicators of the real economic activity in the economy and Money supply and interest rate as the indicators of the monetary dynamics of the economy.

First section involves the description of the data and the methodology to analyze the causality. Next section presents the results of the empirical analysis results and the last section concludes the study.

2. Data and Methodology

In this section, the methodology for testing causality in bivariate setting and the important points about data are detailed, and the advantages and disadvantages of the methodology are discussed.

2.1 Data and Preliminary Analysis

In the paper, the causality between stock market return volatility and macro economic volatility in either direction for 4 emerging economies, namely Turkey, Czech Republic, Brazil and India are examined in bivariate setting. In parallel with the literature, industrial production and inflation for real activity; money supply and interest rate for the monetary dynamics of the country are chosen for the indicators of macro economic conditions of the counties. A detailed description of data, i.e sources, tickers, frequencies and time periods and abbreviations for the variables can be found in the Table 1. The fact that macro economic data for emerging markets does not have a long history requires us that time periods and frequencies are arranged specifically to each bivariate analysis in order to use the whole data in hand for each variable. Inflation, industrial production and money supply is in monthly frequency; as for interest rates, the frequency is either monthly or weekly where the decision is based on the availability of data in higher frequency and variation in the data. If the daily data exists, weekly data is obtained from the daily data by using the end-of-week date values since the daily variation is not enough to use it in daily frequency. Otherwise, monthly data is used when the daily data is not available.

All variables are expressed in terms of growth rates estimated as logarithmic return, $R_t = \ln(\frac{X_t}{X_{t-1}})$ where *Xt* is the variable value at date t in order to be parallel with the stock market return.

Before continue to analysis further and to evaluate the stationarity of time series, the unit root test of the return series are performed and presented in the Table 2 in which the results allow the further modeling. All the return variables, R_t, are filtered by AR(1) process with monthly dummy variables as in equation (1) due to the seasonal tendencies in macro economic variables.

$$R_t = \mu + \emptyset R_{t-1} + \sum_{i=1}^{12} \delta_i D_i + \varepsilon_t \quad (1)$$

where D_i are *ith* month of the year and δ_i corresponding regression coefficient.

2.2 Testing Causality

In this subsection, the concept of causality in Granger sense, BEKK presentation of MGARCH(1,1) model, which helps to examine the causality in Granger sense, and bootstrapped testing procedure are briefly introduced. The idea behind Granger causality is that cause must precede the effect. That is, if variable x causes variable y, then lagged variable x has a potential to explain variable y. In the literature, two common approaches are followed to test the causality in volatility of financial time series. One is based on the cross correlation function (CCF) of univariate time series in which the interaction between variables is ignored (Cheung and Ng, 1996; Kanas and Kouretas, 2002). The second approach is the use of multivariate GARCH models. Cheung and Ng (1996), in which they propose CCF, states that non-simultaneous modeling provides an easy way to implement for cases involving large number of variables and a robust way of examining causality to violations of the distributional assumptions. However, this non-synchronous estimation strategy introduces bias in a number of diagnostic test statistics and generates potentially invalid inferences. On the other hand, multivariate GARCH models, namely VEC and BEKK, provide very good set up for testing the lagged relations between variables by taking into account the interrelations between variables and time-varying dynamics.

The advantage of BEKK over VEC is that it requires less parameters to estimate and ensures the positive definiteness of the conditional covariance matrices, which is the most important issue for the estimation of the MGARCH models. For an N variable system, the number of parameters is $\frac{N(5N+1)}{2}$ in BEKK representation while it is $\frac{N(N+1)[N(N+1)+2]}{2}$ in VEC representation. Also for VEC representation , $[N^2(p+q) + 0.5(N+l)]$ number of restrictions in which p and q are the lags of GARCH specification have to be satisfied in order to guarantee the positive definiteness, which eventually increase the computational burden (Kearney and Patton, 2000). As a result, as in other studies in the literature such as Caporale et al. (2006), Caporale et al. (2002), Karolyi (1995), Goeij and Marquering (2004) etc and since emerging economies are more prone to changes in risk sensitivities due to shifting in industrial structure as stated in Campell (1994), the BEKK-MGARCH modeling is chosen for the analysis of the bidirectional causal relations. ε_t is the 2 by 1 vector of log return series obtained by equation (1) and $\varepsilon_t = R_t - \mu_t(\theta)$ where θ is a finite vector of parameters of conditional mean vector which is $\mu_t(\theta) = \mu + \emptyset R_{t-1} + \sum_{i=1}^{12} \delta_i D_i$

$$\varepsilon_t = H_t^{\frac{1}{2}}(\theta) \quad (2)$$

where H_t is a 2 by 2 positive definite covariance matrix and ξ_t is a 2 by 1 vector of random variables with the following first and second moments:

$$E(\xi_t) = 0$$
$$Var(\xi_t) = I_2 \quad (3)$$

I_2 is the 2 by 2 identity matrix. Conditional covariance matrix of the variables is $H_t = E_{t-1}(\epsilon_t \epsilon_t^{'})$, which is 2 by 2 positive definite matrix for the bivariate case. The covariance in the BEKK-MGARCH(1,1) model evolves according to

$$H_t = CC^{'} + A\epsilon_{t-1}\epsilon_{t-1}^{'}A^{'} + BH_{t-1}B^{'} \quad (4)$$

where C is the lower triangular matrix, A and B are 2 by 2 parameter matrices. In matrix notation:

$$\begin{bmatrix} H_{11,t} & H_{12,t} \\ H_{21,t} & H_{22,t} \end{bmatrix} = \begin{bmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{bmatrix}' + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \epsilon_{1,t-1} & \epsilon_{1,t-1}\epsilon_{2,t-1}' \\ \epsilon_{1,t-1}\epsilon_{2,t-1}' & \epsilon_{2,t-1} \end{bmatrix}$$
$$+ \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \epsilon_{1,t-1} & \epsilon_{1,t-1}\epsilon_{2,t-1}' \\ \epsilon_{1,t-1}\epsilon_{2,t-1}' & \epsilon_{2,t-1} \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$$
$$+ \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \begin{bmatrix} H_{11,t-1} & H_{12,t-1} \\ H_{21,t-1} & H_{22,t-1} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}' \qquad (5)$$

Here H_{11} and H_{22} are the conditional variance equation of the first and second variable, $H_{21} = H_{12}$ are the conditional covariance equation of the variables. In closed form:

$$H_{11,t} = c_{11}^2 + a_{11}^2\varepsilon_{1,t-1}^2 + 2a_{11}a_{12}\epsilon_{1,t-1}\epsilon_{2,t-1} + a_{12}^2\epsilon_{2,t-1}^2 + b_{11}^2H_{11,t-1} + 2b_{11}b_{12}H_{12,t-1} + b_{12}^2H_{22,t-1} \qquad (6)$$

$$H_{22,t} = c_{21}^2 + c_{21}^2 + a_{22}^2\varepsilon_{1,t-1}^2 + 2a_{22}a_{21}\epsilon_{1,t-1}\epsilon_{2,t-1} + a_{21}^2\epsilon_{2,t-1}^2 + b_{22}^2H_{22,t-1} + 2b_{22}b_{21}H_{21,t-1} + b_{21}^2H_{21,t-1} \qquad (7)$$

$$H_{21,t} = c_{11}c_{21} + (a_{22}a_{11} + a_{12}a_{21})\epsilon_{1,t-1}\epsilon_{2,t-1} + a_{11}a_{21}\epsilon_{1,t-1}^2 + a_{12}\,a_{22}\epsilon_{2,t-1}^2 + b_{11}b_{21}H_{11,t-1} + b_{22}b_{12}H_{22,t-1} + (b_{22}b_{11} + b_{12}b_{21})H_{21,t-1} \qquad (8)$$

As it can be seen from the different written forms of bivariate BEKK GARCH(1,1) model, off diagonal elements of A and B matrices in fact models the volatility transmission between variables. To apply zero restrictions on these coefficients allows one to test the causality between variables. If A and B are restricted as an(a) upper(lower) triangular form, it provides us to test the causality from second (first) variable to first(second) variable by means of likelihood ratio (LR) tests. However, the existence of the significant causal relations between variables is directly related to the critical values of LR test and therefore distributional assumptions are of paramount importance for statistical inference. This is where the importance of bootstrapped testing comes into play. The bootstrapped testing procedure has the following advantages over the standard testing procedure : (1) It does not use an asymptotic result and will work well even when the sample size is not very large. (2) It does not make specific distributional assumptions, whereas the standard test procedure assumes a multinominal distribution of the variables with unknown parameters. (3) Bootstrap results are almost always more accurate compared to asymptotic results (Efron and Tibshirani, 1993). Especially the distributional assumptions becomes much more critical for the emerging markets since macro economic data is not long enough to satisfy asymptotic result. Therefore a bootstrap procedure analogous to that described in Davison and Hinkley (1997) is used in the study. Let define likelihood ratio as

$$LR = 2(\ell_{UNRES} - \ell_{RES}) \qquad (9)$$

where ℓ_{UNRES} and ℓ_{RES} are the likelihood value of unrestricted and restricted model, respectively. Zero hypothesis of LR test is that there is no significant difference between restricted and unrestricted model. Large positive values of LR give favorable evidence to unrestricted model according to equation (9). Bootstrapping the likelihood ratio consists of generating R (in this paper $R = 999$) data sets from the model under the null hypothesis, i.e. restricted model, with the parameters substituted by their Quasi Maximum Likelihood estimates and then ordering likelihood ratios as $LR_1^* < LR_2^* < \cdots < LR_R^*$. If α is chosen as the significance level of the test then the bootstrapped critical value of the likelihood ratio is calculated as $LR_{(R+1)(1-\alpha)}^*$.

As for the weaknesses of the methodology, the first issue is the estimations of the conditional mean and conditional covariance parameters separately.

However, the fact that the macro economic history of the data is not very long for the emerging economies leads us to the choice of least number of parameters estimates as much as possible, which is a common approach in the literature as in Engle and Sheppard (2001) and Bauwens et al. (2006). Also, Carnero and Eratalay (2009) performs Monte Carlo experiments to compare the finite sample of multi-step estimators of various MGARCH models[3] and they reported that the small sample behaviors of the multi-step estimators are very similar. Secondly, the bivariate analysis may lead to exclusion of other important variables, but again, the issue of data availability for macroeconomic variables makes multivariate analysis more than two not so appropriate due to increasing number of parameters.

3. Results

The BEKK-GARCH(1,1) parameter estimates with robust standard errors are reported in Tables 3 to 10 for Turkey, Czech Republic, Brazil and India. Tables also include the loglikelihood ratio test statistics, their corresponding chi-square p values and Ljung-Box (LB) diagnostics. According to LB test statistics, overall results provide the evidence that lag (1,1) structure is sufficiently capture the autocorrelation in both residuals and squared residuals except for a few cases. Before examining the causality between macroeconomic volatility and corresponding stock market volatility, there are some common points that deserve attention from the parameter estimations of the bivariate BEKK-MGARCH(1,1) model. First of all, cross section volatility dependence shows itself in the conditional covariance coefficients for both stock market volatilities and corresponding macro variable volatility. This is not a surprise but it is a sign of that the models are capable of catching the dynamics of the bivariate analysis.

That is, if there exits cross sectional relation between variables it shows itself in the parameters of the conditional covariances, $H21$ or equivalently $H12$, not in the parameter estimates of conditional variances of the other variable $H22$ when $H11$ is the primary variable that we examine the volatility dynamics[4]. Secondly, the persistence in the conditional covariances of the bivariates are varied. Some, e.g. those of ISE-INT, SENSEX-M1 show high persistence, while some shows almost none, e.g ISE-M1 and PX-IP[5]. This implies that, for instance, when the covariation of ISE and short term interest rates volatility increases, this high covariation continues for a certain period of time. Lastly, for some bivariate models, e.g ISE-IP, ISE-INT, PX-INT and IBOV-M1, the sign of the coefficient of conditional covariance in the stock market volatility is negative. At first look, this seems paradoxical in the sense that how the volatility of stock markets could decrease when the covariation between variables increase, however, this might be a sign of lead-lag relation between variables, hence indirectly the sign of existence of the causality between corresponding variables since if one of the variable volatility is leading to another then it may show itself in the negative correlation.

When the causality between bivariates are examined, the log likelihoods ratios of restricted and unrestricted models and their p-values according to chi-square distribution can be found in Tables 3 to 10. According to these results, most of the bivariates show causality in either one direction or bidirection. However, when bootstrapped test results, whose details are introduced in the previous section, are examined in Table 11, only a few of them indicate the significant causal relations. For the case of Turkey, there exists a casual relation between stock market and industrial production, i.e. stock market is Granger-cause of industrial production, which may imply that expectations about the production level of the country show itself in the stock market and investors take into account the industrial production level when they are making decisions while inflation level is not[6]. This is the case where the stock market is the indicator of the macro economic conditions of the country. The other important result is that the money supply M1 is Granger-cause of ISE. Hence, the variation in the money supply of the Turkish economy affects the volatility of stock markets.

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[3] Unfortunately BEKK is out of the scope their studies.

[4] Check the equations (6), (7) and (8) to see the whole parameterization structure for conditional variances

[5] Please check the table in the appendix for abbreviations.

[6] The variable name is used directly to say the volatility of the corresponding variable. For instance, instead of saying that the volatility of the stock market is Granger-cause of volatility of the industrial production, a shorter version is preferred for the convenience, which is the stock market is the Granger-cause of the industrial production since the focus of the study is only on causal relations in the second moments of the variables

This indicates that investors in Turkey give considerable importance to monetary policies of Central Bank of Turkey, which is the primary authority controlling the money supply in the economy. The interest rate is not a statistically significant Granger-cause of stock market according to the bootstrapped test result, however, the LR test statistic and bootstrapped critical value are very close to each other. For Czech Republic, according to the bootstrapped test results industrial production and interest rate are the Granger causes of the Prag stock exchange. This indicates that the variation in production growth gives early warning signals about the risk level of the country for the investors in Prag Stock Exchange. When it comes to the casuality from short-term interest rate, determination of which is the one of main responsibilities of Czech National Bank (CNB), to stock market, this may imply that the variation in the repo rates that CNB determines gives signals about the increase risk in the Czech economy to investors. For Brazil, there is a bidirectional causality between the short term interest rate and Bovespa stock exchange, i.e the short term interest rate is the Granger-cause of stock market and stock market is the Granger-cause of the short term interest rate at the same time. However, when the parameter estimates are examined, the effect of conditional covariances are very small. The fact that they are mostly driven by their own conditional variances and that the conditional covariance is very persistence may indicate Central Bank SELIC rates and stock market in Brazil are driven by the same dynamics but not by a casual relation between them.

Lastly, for the case of India, none of the bivariate analysis provides evidence to casual relation in between. In India, the main role of The Reserve Bank of India is to maintain credible financial system via regulations, which makes it different from the other cases in which central banks have critical role in monetary policies. This distinction between the role of central banks in the countries shows itself in the causal relation between corresponding macro variable and stock market. This distinction is another supportive result for that the empirical analysis has capable of catching the volatility dynamics between variables. Overall, the casual analysis between stock market volatility and macro economic volatility provide some evidence that investors closely follow some macroeconomic variables as indicators of the riskiness of the country.

4. Conclusion

Underlying dynamics of volatility of financial securities have been researched in order to obtain better understanding and hence have better control over financial and investment decisions. In this perspective, the volatility transmissions between financial markets and stock exchanges of countries have been the subject of considerable number of studies for both developed and emerging markets. As for the relation between macroeconomic volatility and stock market volatility, some of the researches provide evidence to significant relation for developed markets while some do not. On the other hand, this relation has been barely examined for emerging markets. This study is an attempt to provide some insight in this relation from causality perspective with the help of MGARCH models. The results provide some evidence to causal relation between macro economic volatility, i.e. inflation, industrial production, money supply and short term interest rate, and stock market volatility for countries comprising Turkey, Czech Republic, Brazil and India. The results can be summarized as follows:

The industrial production is an important macroeconomic indicators for the cases of Turkey and Czech Republic. Also, for these countries, the policies of central banks give signals about the riskiness of the country for the investors in stock markets. For the case of Turkey, money supply which is controlled by central bank of Turkey, is found as Granger-cause of stock market, while short-term interest rate is Grangercause of stock market for the case Czech Republic in which repo rates are determined by Czech National Bank. For the case of Brazil, the test results indicates the bidirectional causality between short term interest rate and stock market, however, this bidirectional causality seems to be due to the fact that they are driven by the same underlying dynamics, not because of causality. For India, none of the chosen macro variables shows causal relation with the stock market, which may indicate that the other macroeconomic variables not included in the study are followed by the investor as indicators. Overall, it is not wrong to say that there exits causal relation between macroeconomic indicators of the countries and their stock markets, but they are specific to countries dynamics.

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Table 1: Details of Data

Turkey					
Variable	Source	Ticker	Period	Obs	Frequency
CPI	Bloomberg	TUCPI	31.01.1992-30.05.2010	221	monthly
IP	Bloomberg	TUIOI	31.01.1997-30.05.2010	161	monthly
M1	Datastream	-	31.01.1992-30.05.2010	221	monthly
INT	Bloomberg	TRLIB3M	02.08.2002-23.07.2010	417	weekly
Stock Exchange	Bloomberg	XU100	31.01.1992- 23.07.2010	*	*
Czech Republic					
Variable	Source	Ticker	Period	Obs	Frequency
CPI	Bloomberg	9356639	31.01.1994-30.06.2010	198	monthly
IP	Bloomberg	9356629	31.01.1998 - 30.06.2010	150	monthly
M1	Bloomberg	CZMSM1	31.01.1994 - 30.06.2010	198	monthly
INT	Bloomberg	PRIB01M	09.01.1998 - 29.01.2010	630	weekly
Stock Exchange	Bloomberg	PX	31.01.1994- 01.09.2010	*	*
Brazil					
Variable	Source	Ticker	Period	Obs	Frequency
CPI	Bloomberg	2236639	31.01.1991 - 30.06.2010	234	monthly
IP	Bloomberg	2236629	31.01.1991 - 30.06.2010	234	monthly
M1	Bloomberg	BZMS1	31.01.1995 - 30.06.2010	186	monthly
INT	Bloomberg	BZDIOVRA	29.07.1994-30.06.2010	195	monthly
Stock Exchange	Bloomberg	IBOV	31.01.1991- 02.09.2010	*	*
India					
Variable	Source	Ticker	Period	Obs	Frequency
CPI	Bloomberg	5346639	31.01.1980 - 31.05.2010	365	monthly
IP	Bloomberg	5346657	31.01.1980 - 31.05.2010	365	monthly
M1	Bloomberg	5341137	31.01.1980 - 31.05.2010	365	monthly
INT	Bloomberg	GINAY91	05.09.1997 - 29.09.2010	669	weekly
Stock Exchange	Bloomberg	SENSEX	31.01.1980 - 29.09.2010	*	*

Note: CPI, IP, M1, INT stand for consumer price index, industrial production, money supply M1 and short term interest rate, respectively. Stock exchanges used in the study are Istanbul Stock Exchange 100 index, ISE, for Turkey; Praue Stock Exchange, PX, for Czech Republic; Brazil Bovespa Index, IBOV, for Brazil and Bombay Stock Exchange Sensitive Index, SENSEX, for India. A * indicates that the number of observation and frequency of the stock exchange is set according to macro variable with which it is analyzed.

Table 2: ADF test results

Turkey		Czech		Brazil		India	
CPI	45.1	CPI	75.5	CPI	81.5	CPI	78.8
IP	173.1	IP	104.9	IP	92.0	IP	465.1
M1	159.9	M1	124.8	M1	130.2	M1	106.9
INT	163.9	INT	220.2	INT	131.8	INT	260.5
Monthly	114.1	*Monthly(CPI,M1)*	70.5	*Monthly(M1)*	93.8	*Monthly*	1719.1
Weekly	193.8	*Monthly(IP)*	59.0	*Monthly(CPI, IP)*	72.1	*Weekly*	2163.5
		Weekly	258.5	*Monthly(INT)*	1301.4		

Note: CPI, IP, M1 and INT are respectively stand for the inflation, industrial production, money supply and short term interest rate. As for the stock exchange, since the analysis is performed in the bivariate setting, stock exchange data are rearrange according to corresponding macroeconomic variable and therefore the frequency and the period for the stock exchanges varies. The words in italic is for the stock exchange and presents the frequency of the series, the words in the paranthesis is used to show the corresponding macro variable used in bivariate analysis with the stock exchange. Different monthly series for different macro variables are due to the different time intervals of the data.

Table 3: BEKK-MGARCH(1.1) estimates for Turkey

	Upper Restricted		Lower Restricted		Unrestricted	
Parameters	Coeff	S.E	Coeff	S.E.	Coeff	S.E.
ISE and Inflation						
c11	0.1374	0.0001	0.1373	0.0001	0.1374	0.0001
c21	-0.0006	0.0000	-0.0007	0.0000	-0.0006	0.0000
c22	0.0176	0.0000	0.0175	0.0000	0.0175	0.0000
a11	-0.0863	0.0188	-0.1027	0.0243	-0.0877	0.0212
a21	-0.2069*	0.1281	0.0000	0.0000	-0.0014	0.0000
a12	0.0000	0.0000	-0.0022	0.0000	-0.2011	0.0928
a22	0.2458	0.0040	0.2451	0.0039	0.2458	0.0038
b11	0.0000*	0.0001	0.0000*	0.0019	0.0000*	0.0001
b21	0.0000*	0.0005	0.0000	0.0000	0.0000*	0.0005
b12	0.0000*	0.0000	0.0000*	0.0000	0.0000*	0.0047
b22	0.0000*	0.0001	0.0000*	0.0075	0.0000*	0.0001
LogL	695.6851		695.6089		695.6893	
LR Test	0.0084	(0.9958)	0.1609	(0.9227)		
LB(5)-CPI	3.4118	(0.6367)	3.3821	(0.6413)	3.4106	(0.6369)
LB2(5)-CPI	2.819	(0.7278)	2.7897	(0.7323)	2.8199	(0.7277)
LB(5)-ISE	9.7592	(8.24E-02)	9.7594	(0.0823)	9.7751	(0.08186)
LB2(5)-ISE	1.94E-01	(0.9991)	0.22677	(0.9988)	0.1942	(0.99917)
ISE and Industrial Production						
c11	0.0883	0.0203	0.1032	0.0012	0.0011	0.0002
c21	0.0071	0.0005	0.0197	0.0002	-0.0319	0.0000
c22	-0.0470	0.0000	0.0000*	0.0000	0.0000*	0.0037
a11	0.4523	0.0501	-0.0970	0.0151	0.1230	0.0100
a21	0.9959	0.1334	0.0000	0.0000	-0.1617	0.0026
a12	0.0000	0.0000	-0.1586	0.0019	0.1782	0.0372
a22	-0.0695*	0.0422	0.5419	0.0177	0.5308	0.0159
b11	0.0408*	0.0282	-0.6149	0.1410	0.9794	0.0001
b21	-1.3292	13.6116	0.0000	0.0000	0.0250	0.0010
b12	0.0000	0.0000	0.1975	0.0098	-0.3104	0.0498
b22	0.1901	0.0799	0.3578	0.0184	0.3993	0.0112
LogL	358.9427		361.6509		365.7137	
LR Test	13.5421	(0.0011)	8.1256	(0.0172)		
LB(5)-IP	1.8662	(0.8673)	4.0801	(0.5379)	3.2592	(0.6600)
LB2(5)-IP	0.33381	(0.9969)	2.6182	(0.7586)	1.4961	(0.9135)
LB(5)-ISE	14.326	(0.0136)	14.332	(0.0136)	13.707	(0.0175)
LB2(5)-ISE	8.4584	(0.1327)	4.497	(0.4802)	4.7651	(0.4452)

Note: Details of the data and variables can be found in the appendix. Parameters are from the equation (5) or (6), (7), (8). The number in the parenthesis are the probability values of the corresponding tests. LB(5) and LB2(5) are respectively the Ljung-Box test of significance of autocorrelations of five lags in the standardized and standardized squared residuals. A * indicates the rejection at the 5 percent level

Table 4: BEKK-MGARCH(1.1) estimates for Turkey (cont.)

	Upper Restricted		Lower Restricted		Unrestricted	
Parameters	Coeff	S.E	Coeff	S.E.	Coeff	S.E.
ISE and Money Supply						
c11	0.1211	0.0001	0.1380	0.0001	0.1230	0.0001
c21	0.0067	0.0000	0.0025	0.0000	0.0063	0.0000
c22	0.0433	0.0000	0.0414	0.0000	0.0418	0.0000
a11	0.1072	0.0144	0.0126	0.0035	0.1324	0.0114
a21	-1.5230	0.2719	0.0000	0.0000	0.0672	0.0009
a12	0.0000	0.0000	0.0976	0.0039	-1.4276	0.2822
a22	0.1711	0.0230	0.1551*	0.1680	0.2199	0.0132
b11	0.0000*	0.0004	0.0000*	0.0184	0.0000*	0.0000
b21	0.0000*	0.0002	0.0000	0.0000	0.0000*	0.0000
b12	0.0000	0.0000	0.0000*	0.0242	0.0000*	0.0002
b22	0.0000*	0.0000	0.0000*	0.0221	0.0000*	0.0001
LogL	501.3319		499.3072		502.7745	
LR Test	2.8851	(0.2363)	11.9919	(0.0174)		
LB(5)-CPI	3.4616	(0.6292)	3.3256	(0.6499)	3.6199	(0.6053)
LB2(5)-CPI	1.2852	(0.9365)	2.7534	(0.7379)	1.4501	(0.9188)
LB(5)-ISE	21.4600	(0.0007)	20.6990	(0.0009)	21.3980	(0.0007)
LB2(5)-ISE	8.8940	(0.1134)	6.1872	(0.2884)	7.2155	(0.2051)
ISE and Interest Rate						
c11	0.0144	0.0000	0.0357	0.0002	0.0169	0.0001
c21	-0.0007	0.0000	-0.0077	0.0000	-0.0040	0.0000
c22	0.0058	0.0000	0.0000	0.0000	0.0000	0.0000
a11	-0.2315	0.0038	-0.2140	0.0837	-0.1945	0.0600
a21	-0.0233	0.0150	0.0000	0.0000	-0.0804	0.0201
a12	0.0000	0.0000	-0.0658	0.0166	0.0919	0.0331
a22	0.4071	0.0075	0.3594	0.0145	0.3020	0.0200
b11	0.9092	0.0030	0.5555	0.1739	0.8686	0.0219
b21	-0.0640	0.0082	0.0000	0.0000	0.0628	0.0014
b12	0.0000	0.0000	0.1447	0.0120	-0.2284	0.0098
b22	0.8965	0.0012	0.8663	0.0058	0.9396	0.0028
LogL	1643.1544		1645.6457		1651.2243	
LR Test	16.1396	(0.0003)	11.1572	(0.0038)		
LB(5)-IP	2.0807	(0.8379)	1.7429	(0.8835)	2.0101	(0.8477)
LB2(5)-IP	1.4198	(0.9221)	3.8907	(0.5653)	1.9912	(0.8504)
LB(5)-ISE	14.6330	(0.0121)	13.1700	(0.0218)	12.7430	(0.0259)
LB2(5)-ISE	8.8006	(0.1173)	6.5519	(0.2562)	9.2886	(0.0981)

Note: As in Table 3.

Table 5: BEKK-MGARCH(1.1) estimates for Czech Republic

	Upper Restricted		Lower Restricted		Unrestricted	
Parameters	Coeff	S.E	Coeff	S.E.	Coeff	S.E.
PX and Inflation						
c11	0.0575	0.0001	0.0536	0.0002	0.0588	0.0001
c21	-0.0006	0.0000	-0.0007	0.0000	-0.0009	0.0000
c22	0.0014	0.0000	0.0013	0.0000	0.0002	0.0001
a11	0.4866	0.0161	0.4187	0.0097	0.4632	0.0164
a21	5.0789*	24.4846	0.0000	0.0000	0.0068	0.0000
a12	0.0000	0.0000	0.0022	0.0000	5.0588*	15.0188
a22	0.3900	0.0824	0.4378	0.0271	0.4260	0.0652
b11	-0.3061*	0.2418	0.5487	0.0497	-0.2662	0.1600
b21	-2.9805*	24.0106	0.0000	0.0000	-0.0128	0.0007
b12	0.0000	0.0000	0.0055	0.0001	-3.1342*	14.2786
b22	0.8641	0.0051	0.8581	0.0028	0.8426	0.0191
LogL	1044.4380		1041.7250		1045.4914	
LR Test	2.1067	(0.3488)	7.5328	(0.0231)		
LB(5)-CPI	2.608	(0.7601)	2.0722	(0.8390)	2.5978	(0.7617)
LB2(5)-CPI	2.5381	(0.7707)	0.91593	(0.9690)	2.6596	(0.7522)
LB(5)-PX	6.619	(0.2505)	7.7986	(0.1676)	7.966	(0.1581)
LB2(5)-PX	3.5225	(0.6199)	3.7372	(0.5878)	3.1196	(0.6820)
PX and Industrial Production						
c11	-0.0044	0.0001	0.0315	0.0059	-0.0003	0.0000
c21	0.0138	0.0000	0.0094	0.0006	-0.0176	0.0000
c22	0.0000	0.0000	-0.0131*	0.0119	0.0000*	0.0006
a11	0.4147*	0.0125	0.3084*	0.5227	0.3281	0.0141
a21	-0.7890	0.0401	0.0000	0.0000	0.1763	0.0028
a12	0.0000	0.0000	0.1728*	0.1422	-0.8323	0.0260
a22	0.2451	0.0125	0.2206*	0.6207	0.1399	0.0084
b11	0.8260	0.0031	0.8573*	0.4750	0.8207	0.0021
b21	0.2266	0.0114	0.0000	0.0000	-0.0953	0.0008
b12	0.0000	0.0000	-0.1028	0.0087	0.3289	0.0079
b22	0.9093	0.0007	0.8296*	1.6702	0.8211	0.0097
LogL	450.3855		444.4832		455.7636	
LR Test	10.7564	(0.0046)	22.5608	(0.0000)		
LB(5)-IP	3.3851	(0.6408)	3.4577	(0.6298)	3.4780	(0.6267)
LB2(5)-IP	2.7993	(0.7309)	0.8932	(0.9707)	2.5104	(0.7749)
LB(5)-PX	28.5710	(0.0000)	32.9000	(0.0000)	30.3130	(0.0000)
LB2(5)-PX	9.2177	(0.1007)	9.3515	(0.0958)	6.6663	(0.2467)

Note: As in Table 3.

Table 6: BEKK-MGARCH(1.1) estimates for Czech Republic (cont.)

	Upper Restricted		Lower Restricted		Unrestricted	
Parameters	Coeff	S.E	Coeff	S.E.	Coeff	S.E.
			PX and Money Suppy			
c11	0.0253	0.0002	0.0161	0.0000	0.0214	0.0001
c21	-0.0090	0.0000	-0.0034	0.0000	-0.0084	0.0000
c22	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000
a11	0.3135	0.0138	0.2732	0.0053	0.2929	0.0203
a21	-0.2959	0.1209	0.0000	0.0000	-0.0026	0.0005
a12	0.0000	0.0000	-0.0338	0.0001	-0.2879	0.1051
a22	0.1955	0.0104	-0.0751	0.0118	0.1981	0.0100
b11	0.8650	0.0114	0.9366	0.0004	0.8973	0.0077
b21	0.6165	0.0815	0.0000	0.0000	-0.0054	0.0002
b12	0.0000	0.0000	0.0206	0.0000	0.5519	0.0593
b22	0.8833	0.0024	0.9751	0.0003	0.8949	0.0031
LogL	723.7554		726.1669		724.0383	
LR Test	0.5659	(0.7536)	4.2571	(0.1190)		
LB(5)-M1	1.7250	(0.8857)	1.7094	(0.8877)	1.7269	(0.8855)
LB2(5)-M1	1.8512	(0.8693)	0.6263	(0.9868)	2.0720	(0.8391)
LB(5)-PX	5.0222	(0.4132)	6.3954	(0.2696)	5.0665	(0.4078)
LB2(5)-PX	0.7481	(0.9802)	1.1884	(0.9460)	0.7585	(0.9796)
			PX and Interest Rate			
c11	0.0053	0.0000	0.0096	0.0000	0.0019	0.0000
c21	-0.0208	0.0000	-0.0097	0.0000	-0.0139	0.0000
c22	0.0000*	0.0006	0.0107	0.0001	0.0000	0.0002
a11	0.3615	0.0152	0.3581	0.0204	0.1600	0.0148
a21	-0.2233	0.0070	0.0000	0.0000	-0.3874	0.0084
a12	0.0000	0.0000	-0.3532	0.0130	0.0747	0.0182
a22	-0.6433	0.2075	0.2408	0.1019	0.2714	0.0547
b11	0.8999	0.0022	0.8962	0.0036	0.9341	0.0006
b21	-0.1484	0.0173	0.0000	0.0000	0.1414	0.0057
b12	0.0000	0.0000	0.1829	0.0101	-0.3654	0.0256
b22	0.0218	0.0052	0.5101	0.0472	0.5088	0.0242
LogL	2771.8162		2792.7041		2801.6426	
LR Test	59.6527	(0.0000)	17.8770	(0.0001)		
LB(5)-INT	7.4383	(0.1900)	6.0323	(0.3031)	7.2362	(0.2037)
LB2(5)-INT	6.0557	(0.3008)	4.7142	(0.4518)	3.7327	(0.5885)
LB(5)-PX	11.6640	(0.0397)	8.3152	(0.1397)	8.7609	(0.1190)
LB2(5)-PX	1.5847	(0.9031)	1.3739	(0.9272)	1.5109	(0.9118)

Note: As in Table 3.

Table 7: BEKK-MGARCH(1.1) estimates for Brazil

	Upper Restricted		Lower Restricted		Unrestricted	
Parameters	Coeff	S.E	Coeff	S.E.	Coeff	S.E.
IBOV and Inflation						
c11	0.0235	0.0001	0.0238	0.0000	0.0249	0.0000
c21	0.0001	0.0000	0.0014	0.0000	-0.0008	0.0000
c22	0.0046	0.0000	0.0048	0.0000	0.0049	0.0000
a11	0.3935	0.0064	0.3554	0.0076	0.3998	0.0072
a21	-1.2095	0.2941	0.0000	0.0000	0.0246	0.0002
a12	0.0000	0.0000	0.0264	0.0004	-1.1849	0.2110
a22	0.6074	0.0463	0.6365	0.0673	0.5541	0.0427
b11	0.9003	0.0007	0.9179	0.0006	0.8970	0.0007
b21	0.5961	0.2381	0.0000	0.0000	-0.0009	0.0003
b12	0.0000	0.0000	-0.0064	0.0004	0.2768*	0.3559
b22	0.7161	0.0350	0.6265	0.0467	0.6678	0.0274
LogL	870.2703		870.3009		873.7644	
LR Test	6.9881	(0.0304)	6.9270	(0.0313)		
LB(5)-CPI	18.3010	(0.0026)	19.0420	(0.0019)	18.1300	(0.0028)
LB2(5)-CPI	0.5795	(0.9889)	0.8152	(0.9761)	0.6291	(0.9866)
LB(5)-IBOV	10.1090	(0.0722)	7.7031	(0.1734)	8.3623	(0.1374)
LB2(5)-IBOV	1.5554	(0.9066)	1.8705	(0.8668)	1.7588	(0.8814)
IBOVand Industrial Production						
c11	0.0217	0.0000	0.0242	0.0000	0.0218	0.0001
c21	0.0010	0.0000	0.0017	0.0000	-0.0033	0.0001
c22	0.0045	0.0000	-0.0061	0.0000	-0.0059	0.0000
a11	0.3547	0.0110	0.4025	0.0081	0.3968	0.0297
a21	-1.0626*	0.9866	0.0000	0.0000	0.0790	0.0002
a12	0.0000	0.0000	0.0771	0.0003	-1.1284	0.5116
a22	0.7011	0.0295	0.6654	0.0100	0.6177	0.0102
b11	0.9160	0.0008	0.9058	0.0008	0.9047	0.0010
b21	0.4635*	0.4401	0.0000	0.0000	-0.0035	0.0004
b12	0.0000	0.0000	-0.0164	0.0002	0.1066*	0.6488
b22	0.7140	0.0092	0.3796	0.0204	0.3629	0.0059
LogL	822.5474		823.0684		826.0505	
LR Test	7.0061	(0.0301)	5.9641	(0.0507)		
LB(5)-IP	19.5780	(0.0015)	18.4930	(0.0024)	18.5780	(0.0023)
LB2(5)-IP	0.7701	(0.9789)	0.7117	(0.9823)	1.2721	(0.9378)
LB(5)-IBOV	7.9854	(0.1570)	11.3820	(0.0443)	9.4371	(0.0928)
LB2(5)-IBOV	7.4280	(0.1907)	13.5700	(0.0186)	21.3940	(0.0007)

Note: : As in Table 3.

Table 8: BEKK-MGARCH(1.1) estimates for Brazil (cont.)

	Upper Restricted		Lower Restricted		Unrestricted	
Parameters	Coeff	S.E	Coeff	S.E.	Coeff	S.E.
IBOV and Money Suppy						
c11	0.0119	0.0000	0.0173	0.0001	0.0139	0.0000
c21	0.0085	0.0000	0.0094	0.0000	0.0087	0.0000
c22	-0.0069	0.0000	0.0000*	0.0000	-0.0037	0.0001
a11	-0.0715	0.0034	0.1770	0.0122	0.0024*	0.0028
a21	0.2470	0.0493	0.0000	0.0000	0.0497	0.0003
a12	0.0000	0.0000	0.0638	0.0005	0.2031	0.0492
a22	0.7293	0.0209	0.7478	0.0208	0.7595	0.0219
b11	0.9821	0.0001	0.9657	0.0013	0.9825	0.0001
b21	-0.2803	0.0112	0.0000	0.0000	-0.0023	0.0001
b12	0.0000	0.0000	-0.0225	0.0002	-0.2524	0.0100
b22	0.6900	0.0035	0.6879	0.0042	0.6848	0.0043
LogL	579.5591		574.8205		581.6586	
LR Test	4.1989	(0.1225)	13.6761	(0.0011)		
LB(5)-M1	5.6155	(0.3454)	6.3219	(0.2762)	5.8851	(0.3176)
LB2(5)-M1	2.8466	(0.7236)	2.9457	(0.7084)	3.1645	(0.6746)
LB(5)-IBOV	3.9611	(0.5550)	5.2268	(0.3888)	4.6805	(0.4561)
LB2(5)-IBOV	5.4341	(0.3652)	3.6995	(0.5934)	3.9822	(0.5520)
IBOV and Interest Rate						
c11	0.0119	0.0001	0.0767	0.0013	0.0163	0.0000
c21	-0.0055	0.0000	-0.0005	0.0001	-0.0147	0.0001
c22	0.0000	0.0000	0.0000*	0.0004	0.0000*	0.0000
a11	-0.2765	0.0082	-0.0346	0.0086	-0.1060	0.0090
a21	0.1133	0.0138	0.0000	0.0000	0.7317	0.0358
a12	0.0000	0.0000	0.7131	0.0367	0.1051	0.0022
a22	0.2463	0.0231	0.0935	0.0090	0.0649	0.0269
b11	0.9393	0.0004	0.6204	0.1538	0.9698	0.0004
b21	-0.0309	0.0006	0.0000	0.0000	0.0495	0.0017
b12	0.0000	0.0000	-0.0754	0.0093	0.0086	0.0011
b22	0.9693	0.0003	0.7605	0.0032	0.7544	0.0030
LogL	355.5677		370.7388		379.0605	
LR Test	46.9856	(0.0000)	16.6434	(0.0002)		
LB(5)-INT	4.6585	(0.4590)	6.8504	(0.2320)	3.8892	(0.5655)
LB2(5)-INT	1.0537	(0.9581)	10.3920	(0.0649)	2.5738	(0.7654)
LB(5)-IBOV	5.6308	(0.3438)	6.6862	(0.2450)	6.6107	(0.2512)
LB2(5)-IBOV	0.5696	(0.9894)	1.0114	(0.9617)	2.3166	(0.8038)

Note: : As in Table 3.

Table 9: BEKK-MGARCH(1.1) estimates for India

	Upper Restricted		Lower Restricted		Unrestricted	
Parameters	Coeff	S.E	Coeff	S.E.	Coeff	S.E.
SENSEX and Inflation						
c11	0.0150	0.0000	0.0176	0.0001	0.0159	0.0007
c21	0.0001	0.0000	-0.0008	0.0000	-0.0004	0.0000
c22	0.0025	0.0000	0.0023	0.0000	0.0028	0.0002
a11	0.2811	0.0029	0.3060	0.0051	0.2924	0.0223
a21	-0.1877*	3.2312	0.0000	0.0000	-0.0146	0.0016
a12	0.0000	0.0000	-0.0134	0.0001	-0.2257*	1.6204
a22	0.2664	0.0448	0.2676	0.0094	0.2808	0.1283
b11	0.9424	0.0005	0.9298	0.0013	0.9354	0.0057
b21	-0.1285*	3.1448	0.0000	0.0000	0.0057	0.0002
b12	0.0000	0.0000	0.0054	0.0000	-0.2925*	12.8869
b22	0.8673	0.1072	0.8563	0.0274	0.8139*	2.0448
LogL	1758.7683		1760.6897		1760.9533	
LR Test	4.3700	(0.1125)	0.5271	(0.7683)		
LB(5)-CPI	0.72349	(0.9816)	0.9202	(0.9687)	0.7614	(0.9794)
LB2(5)-CPI	4.849	(0.4345)	5.2361	(0.3877)	5.0674	(0.4077)
LB(5)-SENSEX	1.791	(0.8772)	1.3566	(0.9290)	1.2838	(0.9365)
LB2(5)-SENSEX	3.2421	(0.6627)	6.6977	(0.2441)	5.5535	(0.3520)
SENSEX and Industrial Production						
c11	0.0139	0.0000	0.0146	0.0000	0.0119	0.0024
c21	0.0207	0.0002	-0.0153	0.0014	0.0089	0.0175
c22	-0.0068	0.0016	-0.0138	0.0020	0.0194	0.0035
a11	0.2631	0.0067	0.2837	0.0033	0.2329	0.0810
a21	0.0985	0.0256	0.0000	0.0000	0.0742	0.0023
a12	0.0000	0.0000	0.0724	0.0020	0.0581	0.0187
a22	0.5873	0.0074	0.5468	0.0070	0.5511	0.0085
b11	0.9440	0.0002	0.9439	0.0002	0.9294	0.0024
b21	0.0863*	0.1159	0.0000	0.0000	0.0316*	0.0375
b12	0.0000	0.0000	0.0796	0.0106	0.3915*	1.7574
b22	-0.2169	0.0270	-0.1896	0.0186	-0.1515*	0.1131
LogL	1225.4369		1229.3138		1229.4013	
LR Test	7.9288	(0.0190)	0.1749	(0.9163)		
LB(5)-IP	0.7004	(0.9830)	0.6520	(0.9855)	0.7692	(0.9790)
LB2(5)-IP	4.3092	(0.5058)	3.9799	(0.5523)	3.6457	(0.6015)
LB(5)-SENSEX	18.2470	(0.0027)	19.1050	(0.0018)	18.9570	(0.0020)
LB2(5)-SENSEX	2.0298	(0.8450)	3.5979	(0.6086)	3.6457	(0.6015)

Note: As in Table 3.

Table 10: BEKK-MGARCH(1.1) estimates for India (cont.)

	Upper Restricted		Lower Restricted		Unrestricted	
Parameters	Coeff	S.E	Coeff	S.E.	Coeff	S.E.
SENSEX and Money Suppy						
c11	0.0122	0.0140	0.0132	0.0000	0.0144	0.0000
c21	0.0015	0.0067	-0.0010	0.0000	-0.0020	0.0000
c22	0.0077	0.0007	0.0009	0.0000	0.0004	0.0000
a11	0.2849	0.0028	0.2943	0.0051	0.3080	0.0053
a21	-0.7665*	62.6993	0.0000	0.0000	-0.0176	0.0003
a12	0.0000	0.0000	-0.0179	0.0002	-0.1712*	0.3054
a22	-0.2375*	0.2840	-0.0754	0.0033	-0.0758	0.0112
b11	0.9409	0.0005	0.9431	0.0005	0.9357	0.0006
b21	-0.4327*	217.1592	0.0000	0.0000	0.0077	0.0000
b12	0.0000	0.0000	0.0074	0.0000	0.1111	0.0256
b22	0.6925*	14.2005	0.9812	0.0002	0.9715	0.0005
LogL	1526.6755		1524.6543		1527.3413	
LR Test	5.3741	(0.0681)	1.3317	(0.5138)		
LB(5)-M1	0.8832	(0.9714)	0.7670	(0.9791)	0.7963	(0.9773)
LB2(5)-M1	4.3856	(0.4953)	4.6239	(0.4635)	4.7487	(0.4473)
LB(5)-SENSEX	9.4559	(0.0922)	10.6260	(0.0593)	10.5430	(0.0612)
LB2(5)-SENSEX	2.5049	(0.7758)	1.9896	(0.8506)	2.3808	(0.7943)
SENSEXand Interest Rate						
c11	0.0054	0.0000	0.0050	0.0000	0.0054	0.0000
c21	-0.0116	0.0000	-0.0031	0.0000	-0.0092	0.0000
c22	0.0097	0.0000	0.0140	0.0000	-0.0093	0.0000
a11	0.2293	0.0018	0.2478	0.0017	0.1662	0.0046
a21	-0.0822	0.0019	0.0000	0.0000	0.1419	0.0050
a12	0.0000	0.0000	0.1354	0.0057	-0.0759	0.0015
a22	0.4400	0.0083	0.4349	0.0059	0.4218	0.0063
b11	0.9647	0.0001	0.9608	0.0001	0.9754	0.0002
b21	0.0832	0.0011	0.0000	0.0000	-0.0259	0.0006
b12	0.0000	0.0000	-0.0270	0.0011	0.0769	0.0007
b22	0.7946	0.0043	0.7963	0.0041	0.8186	0.0039
LogL	2603.6710		2606.0433		2609.0698	
LR Test	10.7976	(0.0045)	6.0531	(0.0485)		
LB(5)-INT	3.8230	(0.5752)	3.1931	(0.6702)	3.7642	(0.5838)
LB2(5)-INT	5.9009	(0.3160)	7.2519	(0.2026)	12.1530	(0.0328)
LB(5)-SENSEX	3.6638	(0.5988)	3.6649	(0.5986)	3.5310	(0.6187)
LB2(5)-SENSEX	3.0084	(0.6987)	3.7524	(0.5856)	3.6580	(0.5996)

Note: As in Table 3.

Table11: Critical Values Of Bootstrapped Likelihood Ratio Tests

	Turkey				Czech			
	ISE--->MV		**MV---->ISE**		**PX--->MV**		**MV---->PX**	
	LR	Bootstrapped LR	LR	Bootstrapped LR	LR	Bootstrapped LR	LR	Bootstrapped LR
CPI	0,0084	NP	0,1609	NP	2,1067	NP	7,5328	13,1668
IP	13,5421	12,4384	8,1256	11,3527	10,7564	13,2516	22,5608	12,9781
M1	2,8851	NP	11,9919	9,9093	0,5659	NP	-4,2571	NP
INT	16,1396	24,4976	11,1572	11,8445	59,6527	15,5309	17,8770	15,2415
	Brazil				**India**			
	IBOV--->MV		**MV---->IBOV**		**SENSEX--->MV**		**MV---->SENSEX**	
	LR	Bootstrapped LR	LR	Bootstrapped LR	LR	Bootstrapped LR	LR	Bootstrapped LR
CPI	6,9881	57,0310	6,9270	35,7855	4,3700	NP	0,5271	NP
IP	7,0061	41,3430	5,9641	NP	7,9288	15,0174	0,1749	NP
M1	4,1989	NP	13,6761	14,9187	5,3741	NP	1,3317	NP
INT	46,9856	15,7014	16,6434	13,0476	10,7976	18,8287	6,0531	13,8153

Note: For those bivariate analysis in which the LR statistics is already insigni_cant according to asymptotic critical values of X2 distribution, the bootstrapped testing has not been performed in order to reduce the computational burden. The abbreviation NP, which stands for "Not Performed" is used to show these cases. Arrows in the columns show the direction of the causal relation between bivariates. In this representation, MV stands for the macro economic variable in the corresponding row of the test statistic. Please check the table in the Appendix for the abbreviation of the stock market exchanges.