Contagion in International Asset Markets during the Global Financial Crisis and Eurozone Debt Crisis

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ABSTRACT

The paper examines existence of financial contagion between Indian, Eurozone, Japanese and U.S. stock and currency markets during the Global Financial Crisis of 2008-09 and the Eurozone debt crisis of 2010-11. We attempt to address a lacuna of the contagion literature which is the absence of cross-asset market evidence. Contagion is defined as a significant rise in correlations between asset market returns during crisis time periods vis-à-vis normal time periods. The data consists of returns on Euro Area, India, Japan and U.S. stock market returns and the returns on €/$, ₹/$, and ¥/$ exchange rates.

The methodology involves a stage wise estimation with the first stage involving the identification of crisis periods by employing country/region-specific (U.S. and Eurozone) Markov-switching vector autoregressions. Thereafter, the second stage estimates the time-varying conditional correlation coefficients using Dynamic Conditional Correlation model (Engle, 2002). In the final stage, crisis periods identified from the first stage are used as dummy variables and regressed on the conditional correlation coefficients obtained from the second stage to test for contagion effects utilizing OLS.

We find evidence of significant contagion across the stock markets during the two crisis episodes. Further, the evidence for the currency markets is found to be mixed with only the €/$ and ₹/$ market pairs displaying contagion. A negative relationship is found between the stock and currency pairs involving €/$ and ₹/$ rates. On the other hand, the pairs with stock markets and ¥/$ rate depict a positive relationship and contagion effects.

Keywords: Financial contagion; Global Financial Crisis; Eurozone Crisis; Dynamic Conditional Correlation; Markov Switching
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1. INTRODUCTION

It is beyond doubt that the post 1980s period has witnessed several instances of systemic crises in the Emerging Market Economies (EMEs). The literature is replete with examples such as the debt-crisis in Latin American economies in early 1980s, ERM attacks of 1992, followed by the Tequila crisis in 1994-97, Mexican-peso collapse of 1994, the East-Asian crisis of 1997, the subsequent Russian crisis in 1998 and the Brazilian devaluation of 1999. The myth that EMEs are more susceptible to crises due to their fragile financial structure may be dispelled in view of the world's largest economy tumbling into a crisis. The Financial crisis of 2008-09 will remain embedded in history as the largest crisis that shook the developed world post the Great Depression of 1930. The intensity and spread of the crisis seems to be unparalleled and so are the repercussion effects thereof. These events have led to an increasing interest in contagion and its causes.

The issue of spread of crises is critical from the perspective of stability of international asset markets and the systemic risk exposure of the financial system as a whole. Simultaneous downfall of markets around the world exposes institutions which hold internationally diversified portfolios to danger and may have implications for the payment and settlement process. This is notwithstanding the possible effects on the real economy which may result in severe macroeconomic fluctuations and may trigger recessions in several economies.

Contagion has been defined in several ways in the existing literature. In a study, Calvo and Reinhart (1996) differentiate between 'fundamentals-based' contagion and 'true' contagion. The former occurs when a crisis-hit economy infects other economies which are closely linked to it via trade or financial relations. On the other hand, the latter is the outcome of 'animal spirits' or investors' herding behaviour and takes place when all the common shocks and possible channels to transmission have been controlled for. The most widely recognised channels of transmission for contagion would be trade links and financial flows. More interlinked economies characterized by high trade dependence or large financial flows are likely to be plagued due to faster transmission of shocks via strong economic linkages.

In the last few years, post the Global Financial Crisis of 2008-09 and the Eurozone Debt Crisis of 2010-11, it has become increasingly apparent that the spread of crises across countries (and financial markets) is not merely contingent on having similar economic structures or close economic linkages. Further, it is not clear whether '*tranquil'* and '*crisis'* periods are different regimes i.e. whether the international transmission mechanism is discontinuous or if the shocks are transmitted via different and more active channels during periods of turbulence in the financial markets. The increased co-movement of markets during crises has significant implications[2] for the portfolio diversification strategy of international investors.

[2] However, the possible impact of such co-movement on the overall welfare of an economy is not immediately obvious and neither is it evident that policies to mitigate such adverse effects can be formulated.

Traditional econometric techniques which a majority of the literature employ are inappropriate for the measurement of contagion (or testing for a structural change in the transmission of shocks during crises) since the data are plagued by heteroscedasticity, omitted variable bias and endogeniety (Dungey *et al.*, 2005). The existing literature on contagion has mainly utilized correlation-breakdowns (Forbes and Rigobon, 2002; Corsetti *et al.*, 2005) or panel-data estimation techniques (Eichengreen *et al.*, 1996). Pesaran and Pick (2007) have shown that both these methods could be biased. In particular, they criticize the studies for selection of crisis periods apriori which leads to sample selection bias and recommend inclusion of market-specific variables in the case of correlation-based testing approach.

Contagion as defined in Dornbusch, Park and Claessens (2000, p. 177) is "*a significant increase in cross-market linkages after a shock to an individual country (or groups of countries) as measured by the degree to which asset prices or financial flows move together across markets relative to this co-movement in tranquil times*". Favero and Giavazzi (2002) have raised doubts in describing the transmission of shocks post a crisis in an economy or region as '*contagion'*. They point out that this precludes the prospect of flight-to-safety effects which may possibly lead to the lowering of correlations across assets in the post crisis scenario. Therefore, the question of measurement involves the following key points-Identification of tranquil/ crisis (or turbulent) time periods, measurement of the degree of co-movement among asset markets, and testing for a significant increase in the co-movement during turmoil times. The objective of this paper is to test for contagion effects in the context of multiple assets viz. stock and foreign currency markets. There are few other studies such as Granger *et al.* (2000), Hartmann *et al.* (2004), Bekaert *et al.* (2005) and Bütner and Hayo (2010) which have examined inter-linkages across asset classes in the context of contagion.

The issue of selection of the tranquil and turmoil time periods has been circumvented using a Markov-switching model (Gravelle *et al.*, 2006; Mandilaras and Bird, 2010; Ahmad *et al.*, 2013) which endogenously classifies the time periods as turmoil or crisis regimes. We identify the crisis periods by using MS-VAR models for U.S. and Eurozone economies. Thereafter, we estimate the time-varying conditional correlation across stock and currency markets by applying the DCC-GARCH model (Engle, 2002). Finally, we test for contagion effects as well appraise the role played by risk and crisis-related news effects in the transmission process.

The rest of the paper is organized as follows: Section 2 succinctly reviews the existing empirical literature on contagion across international financial markets. The theoretical background is presented in the third section. We present the data and empirical model in section four. The results of our study would form part of section 5. The last section spells out the conclusions.

2. STUDIES ON CONTAGION

Measurement of contagion in the empirical context has been a fraught with various technical difficulties. Some of the techniques which have been routinely employed in the empirical literature to test for contagion effects are correlation-breakdowns, ARCH/GARCH framework, cointegration, and logit and probit models. Doubts have been raised on the efficacy and reliability of these techniques by several studies (Forbes and Rigobon, 2002; Dungey *et al.*, 2005; Pesaran and Pick, 2007). The analyses using correlation-breakdowns have been criticized for selecting the crisis periods apriori and not including market-specific variables, ARCH/GARCH based papers focus mostly on the transmission of volatility across asset markets but do not test if the transmission changes significantly in the aftermath of a crisis. Cointegration methodology intends to assess the changes in the long-run relationship between markets and is likely to overlook contagion effects which occur in short spurts. Finally, Pesaran and Pick (2007) have shown that both Ordinary Least Squares (OLS) and probit estimates are biased upwards possibly due to neglect of some of the interdependence effects in the equation errors for the different economies in a sample.

A lacunae of the existing literature stems from the inadequate attention that has been paid to the transmission of shocks internationally in a crisis situation across asset classes. The present paper attempts to address this gap.

Studies dealing with contagion across stock and currency markets include Baig and Goldfajn (1999), Dungey and Martin (2007) Granger *et al.* (2000), Kanas (2005), Tai (2007), and Walid *et al.* (2011). Dungey and Martin (2007) study the international spillovers and contagion effects in case of stock and currency markets during the Asian crisis and find both spillovers and contagion to have significant impact on volatility. Kanas (2005) investigates the volatility regime linkages among the Mexican currency market and EME equity markets of and finds evidence of interdependence among the markets and no contagion. Baig and Golfajn (1999) consider a set of Asian financial markets and find evidence of contagion to be mixed for equity markets but a significant rise in correlations for currency markets and sovereign spreads. Even after controlling for news effects and other fundamentals, they find significant cross-country contagion effects in the currency and stock markets. Granger *et al.* (2000) test for the Granger-causality between stock prices and exchange rates of several Asian economies during the Asian crisis and find a negative and significant relationship between stock prices and exchange rates during the crisis in accordance with the portfolio approach as well as the capital movements associated with the Asian countries. Tai (2007) investigates the issue of integration of the Asian stock markets with world capital markets post their official liberalization and the existence of pure contagion effects between stock and currency markets of the economies during the East-Asian crisis of 1997-98 and finds that return shocks from the stock markets positively impact the foreign exchange market during the East-Asian crisis. Kallberg *et al.* (2005) study the regime shifts in returns and volatility of foreign exchange and stock markets in the countries of selected Asian countries during the East-Asian crisis of 1997-98 and provide evidence of a significant structural break during the crisis and significant spillovers across markets resulting from the crisis. Flavin *et al.* (2008) test for shift-contagion and pure contagion effects using a Markov regime switching framework in the domestic equity and currency markets for a sample of East-Asian emerging market economies and find that the linkages between the stock and foreign exchange markets of the economies are not stable.

Papers which focus on contagion across bonds and stocks or currency markets include Hartmann *et al.* (2004), Gravelle *et al.* (2006), and Longstaff (2010). Boschi (2004), Büttner and Hayo (2010), and Guo *et al.* (2011) have investigated the existence of contagion effects across multiple asset classes. Büttner and Hayo (2010) utilize the DCC-GARCH framework to study the bivariate conditional correlations in the financial markets (interest rates, bond yields, exchange rates and stock prices) of a sample of European economies and find that there is significant impact of shocks on the conditional correlations between foreign exchange and stock markets. Boschi (2004) studies the possibility of spread of contagion due to the Argentine crisis to the foreign exchange, stock exchange and sovereign debt markets of Brazil, Mexico, Russia, Turkey, Uruguay, and Venezuela and concludes that there is no evidence of contagion during the crisis.

In the present study, we employ a combination of Markov-switching VAR, DCC-GARCH and OLS and other univariate techniques to test for and analyse contagion effects across stock and currency markets. This approach has been utilized by several recent papers in the literature. The advantages of this approach include that we do not need to specify the crisis periods apriori, we estimate time-varying conditional correlations using a model that captures the dynamic effects and finally, test for contagion explicitly.

3. THEORETICAL BACKGROUND

The spread of financial contagion may be through direct economic linkages such as trade and financial inter-relations among two economies or due to indirect effects like a change in global investor attitude. Further, the unmatched and quick spread of the East Asian Crisis could not be explained by the traditional Balance of Payments Approach to understand crises as it did not explicitly model the phenomenon of contagion. As a result, the subsequent theoretical literature has been targeted towards the role played by portfolio constraints and informational asymmetries in a bid to spurn contagion.

The theoretical literature broadly focusses on several major causes of contagion-fundamental causes such as common global shocks (Masson, 1999b; Mishkin, 1997; Calvo *et al.*, 1996), close trade ties (Gerlach and Smets, 1995; Eichengreen, Rose and Wyplosz, 1996; Glick and Rose, 1999; Corsetti *et al.*, 2000; Forbes, 2002), significant financial linkages (Goldfajn and Valdés, 1997; Van Rijckeghem and Weder, 2001), changes in investor behaviour due to liquidity constraints (Valdés, 1997, and Kaminsky *et al.*, 2001), incentive issues (Schinasi and Smith, 2001; Kaminsky *et al.,* 2001, and Broner, Gelos and Reinhart, 2004), asymmetries in information (Calvo and Mendoza, 1990 and Agenór and Aizenman, 1998), market coordination problems (Jeanne, 1997; Masson, 1998, and Chang and Majnoni, 2001), and risk reassessment by investors. Observed investor herd behaviour is attributed to uncertain beliefs and asymmetric information on the part of market participants which leads to contagion effects.

Among the theoretical studies that have been geared towards explaining the phenomenon of financial contagion, we focus our attention on Pavlova and Rigobon (2008) who examine the problem in a multiple asset formulation. Pavlova and Rigobon (2008) propounded a Center-Periphery dynamic equilibrium model to examine the inter-linkages between stock prices and exchange rates with three-goods and three-countries. They propose consistent explanations for empirical phenomenon like contagion, amplification and flight to quality by encompassing terms of trade and common discount factor channels in a general equilibrium formulation with log-linear preferences. They have attributed the excess co-movement of stock prices to the portfolio constraints faced by the Center's investors which lead to wealth transfers to contagion effects.

4. DATA AND EMPIRICAL MODEL

In view of the estimation methodology described in the previous section and the theoretical background presented in section 3, we formulate the empirical modelling strategy which allows us to estimate and test for contagion across stock and currency markets. This section contains all the aspects in this regard.

4.1 Data

In order to test for contagion during the Global Financial Crisis (GFC) and the Eurozone Debt Crisis (EZDC), we collect secondary data at weekly frequency from the Bloomberg database. The sample under study is from June, 2003 to August, 2013[3]. The data for the stock and currency markets in Eurozone, India, Japan and U.S. namely S&P Euro 75 Index, Euro/ USD exchange rate, CNX Nifty Index, INR/USD exchange rate, Nikkei Index, Yen/ USD exchange rate and S&P 500 Index (we have defined the exchange rates of India, Eurozone and Japan with respect to that of the U.S.) have been used. Further, we intend to analyse the impact of the crises on one developed economy i.e. Japan and one EME which is India apart from the crisis-hit U.S. and Eurozone economies in the present study. As has been standard in the literature, the time series for stock market prices and exchange rates are modelled as the logarithmic first differences or in returns form.

The descriptive statistics and the unconditional correlation matrix for the returns in the seven markets are presented in Table 1 (Panel A and B). The average weekly returns are highest for Nifty50 and lowest for Euro/USD rate. Further, Nifty50 index has the most volatile returns and the least volatile series happens to be the returns on INR/USD rate. Further, the unconditional correlation among the stock markets is generally high (more than 0.5) and positive. The unconditional correlation across exchange rate returns is positive for 2 out of 3 cases and are relatively much lower in magnitude. However, the correlation coefficients between stock market and exchange rate pairs is mixed (positive as well as negative). The market returns are skewed as well as leptokurtic.

4.2 Empirical Modelling Strategy

The empirical modelling strategy consists of the following steps. In the first step, we test for the stationarity of the financial market returns. We undertake two unit root tests namely,

[3] The time period has been truncated as we did not wish to study the IT bubble-burst episode which occurred in 2001-02.

DF-GLS and Lee and Strazicich (2003). Results of the tests have been shown in Table 2 (Panels A, B and C). The null hypothesis of existence of a unit root is rejected for all the time series. In the second step, we intend to identify the crisis periods endogenously by utilizing a Markov-switching vector autoregression formulation for the stock and currency markets of U.S. and Eurozone. We corroborate the timeline obtained from the Markov-switching models by comparing it with the major events highlighted during the crises by the Federal Reserve Bank of St. Louis, European Central Bank, The Guradian, The Telegraph and other sources that have constructed a timeline of the events that transpired during the two crisis periods. We then go on to specify a DCC-GARCH model which yields time-varying conditional correlations across the financial markets. Finally, we test for the existence of contagion effects in the international equity and foreign exchange markets. An alternative formulation is also estimated and its findings employed to validate the robustness of our results.

4.3 Identification of Crisis Periods

Dungey *et al.* (2005) and Pesaran and Pick (2007) have highlighted that contagion tests may be biased if we select the crisis periods apriori. To circumvent this issue, we construct a Markov-switching VAR model (Hamilton, 1989) for the stock and exchange returns in U.S. and Eurozone where the Global Financial crisis (GFC) and Eurozone debt crisis (EZDC) originated. This strategy has been adopted by several other studies in the literature such as Ahmad *et al.* (2013) and Dimitriou and Kenourgios (2013). These models enable us to identify and endogenously select the crisis periods for the GFC and EZDC.

The first and second moments of returns in the Eurozone and U.S. stock and exchange rate returns are depicted by a two-dimensional Multivariate Markov switching model with heteroscedasticity. This framework allows us to characterize the tranquil and crisis phases or regimes and in particular, endogenously select the dates for the Global Financial Crisis and Eurozone Sovereign Debt Crisis.

We utilize the Markov Switching Intercept Heteroscedasticity (MSIAH) model discussed in Guidolin (2011) which has the following general form for a 2-regime MSVAR (*p*) process

$$y_t = \mu_{S_t} + \sum_{j=1}^{p} A_{j,S_t} y_{t-j} + \varepsilon_t \qquad (1)$$

where $y_t = \begin{pmatrix} s^{US\ or\ EZ} \\ e^{¥\ or\ €} \end{pmatrix}$ is the 2× 1 vector of endogenous variables i.e. returns on the U.S. (or Eurozone) stock market, returns and returns on the ¥/$ (or €/$) exchange rate; μ_{S_t} is a 2× 1 vector of regime-dependent mean returns; A_{j,S_t} is the 2×2 matrix of regime-dependent (V)AR coefficients; $S_t = 1, 2$ is a latent state variable driving all the parameter matrices and is an irreducible, aperiodic ergodic 2-state Markov chain process with transition matrix

$$P = \begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix} \qquad (2)$$

$$P\{S_t = j | S_{t-1} = i, S_{t-2} = k, \dots, y_{t-1}, y_{t-2}, \dots\} = P\{S_t = j | S_{t-1} = i\} = p_{ij} \quad (3)$$

Such a process will be called a 2-state Markov chain with transition probabilities $\{p_{ij}\}_{i,j=1,2}$. The residuals follow a standard Gaussian distribution conditional on the state i.e. $\varepsilon_t \sim N(0, \Sigma_{S_t})$. The 2×2 matrix Σ_{S_t} represents the state S_t factor in a regime-dependent variance-covariance matrix such that

$$\Sigma_{S_t} = \begin{bmatrix} \sigma_{1,1,S_t} & \sigma_{1,2,S_t} \\ \sigma_{2,1,S_t} & \sigma_{2,2,S_t} \end{bmatrix} \quad (4)$$

The estimates for the Markov Switching models for U.S. and Eurozone (EZ) have been formulated as outlined above. Further, the appropriate lag length is selected by using the standard VAR lag selection criterion viz. Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC), Hannan-Quinn (HQ) and F-statistics. Thereafter, the intercept switching, intercept-heteroscedasticity switching, coefficient switching, coefficient-heteroscedasticity switching, mean switching and mean-heteroscedasticity switching specifications (Hamilton, 1990) were estimated as given in Krolzig (1997) for both U.S. and E.Z. and the AIC, BIC and HQ statistics are calculated. The best specification i.e. Markov switching in intercept and heteroscedasticity (MSIH) specification was selected for both the US and EZ models. Subsequently, the models are estimated using EM Algorithm and the RCM-regime classification measure (Ang and Bekaert, 2002) was calculated. Smoothed probabilities from the models were used to deduce the likelihood of a certain time period to be a crisis (or a tranquil/non crisis) period. This allows us to specify the time periods for Global Financial Crisis and Eurozone Debt Crisis endogenously. These timeline were then corroborated using various sources such as Bloomberg, St. Louis Fed Timeline, European Central Bank Timeline, The Guardian and so on. Thus, smoothed probabilities derived from the MS-VAR model encompassing US stock market returns and currency market returns are utilized to select the time periods for the Global Financial Crisis, and smoothed probabilities calculated from the MS-VAR model consisting of Eurozone stock market returns and currency market returns are used to specify the periods for the Eurozone Debt Crisis. The time varying variances of the markets have also been calculated in accordance with Wang and Theobald (2008)[4].

The Markov-switching model captures two regimes for each of the country markets. The first regime or the crisis state is associated with lower (or negative) returns and higher volatility in comparison to the second regime or the tranquil state which is depicted by higher (or positive) returns and lower volatility. Estimates for the MS-VAR models have been presented in Table 3 (Panels A and B). It may be observed that the first regime is the crisis regime. Further, both the regimes are persistent with p_{ii} around 0.94. The RCM statistic (Ang and Bekaert, 2002) allows us to infer whether the Markov-switching models are performing

[4] Wang and Theobald (2008) have proposed constructing the time-varying market volatility for each of the markets based on the full information set by using the smoothed probabilities and the parameter estimates under
$E[\tilde{\sigma}_t^2 | \mathcal{F}_T] = \tilde{\sigma}_1^2 E[S_t = 1 | \mathcal{F}_T] + \tilde{\sigma}_2^2 E[S_t = 2 | \mathcal{F}_T]$, (5)
where $\tilde{\sigma}_1^2$ and $\tilde{\sigma}_2^2$ are the estimated conditional variances for regimes one and two respectively and $\mathcal{F}_T$ is the full information set upto time T.

well. We find that both the models have low RCM[5] statistic and are adequate. The smoothed probabilities and time-varying volatilities of the GFC and EZDC crisis regimes are given in Figure 1 Panels A and B. As has been conventional in the literature, we define the threshold of 0.85 and above as signifying a high likelihood of the markets being in the crisis regime. Given this rule of thumb, we identify the time periods for which we construct the following set of dummy variables- $DGFC_1$, $DGFC_2$, $DGFC_3$ and $EZDC$ to capture the various crisis episodes which can be seen in Figure 1 (Panels A and B). Further, this crisis timeline is corroborated from news related to the crisis which we have collated and presented in Table 4 (Panels A and B). The crisis regimes identified from the Markov-switching models correspond to the events highlighted in the table. Further, GFC has been divided into three phases-pre-crisis phase, phase I and phase II.

Pre-crisis GFC dummy (2008): $DGFC_1 = \begin{cases} 1 \; if \; t \in \{04.01.2008 - 01.02.2008\} \\ 0 \; otherwise \end{cases}$

Phase I GFC dummy (2008): $DGFC_2 = \begin{cases} 1 \; if \; t \in \{19.09.2008 - 24.10.2008\} \\ 0 \; otherwise \end{cases}$

Phase II GFC dummy (2008-09): $DGFC_3 = \begin{cases} 1 \; if \; t \in \{31.10.2008 - 24.07.2009\} \\ 0 \; otherwise \end{cases}$

Dummy for EZDC:

$$EZDC = \begin{cases} 1 \; if \; t \in \{7.05.2010 - 02.07.2010 \; and \; 15.07.2011 - 16.12.2011\} \\ 0 \; otherwise \end{cases}$$

4.4 Dynamic Conditional Correlation Specification

We utilize DCC-GARCH model proposed by Engle (2002) to estimate the dynamic conditional correlations across the selected markets. We use AR(1) specification to correct for possible autocorrelation as well as these act as market-specific regressors in our model.

$$r_t = \delta_0 + \delta_1 r_{t-1} + \delta_2 x_t + \varepsilon_t \tag{6}$$

where $r_t = (r_{1t}, r_{2t}, \dots, r_{7t})'$; $x_t = (x_{1t}, x_{2t}, \dots, x_{7t})'$ are the exogenous regressors; $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t}, \dots, \varepsilon_{7t})'$, and $\varepsilon_t | \mathcal{F}_{t-1} \sim (0, \Sigma_{t|t-1})$.

The DCC-GARCH model is estimated in two steps. In the first step, GARCH parameters are estimated followed by correlations in the second step

$$\Sigma_{t|t-1} = D_t R_t D_t \tag{7}$$

[5] A cut off of about 50 is considered to be standard in the literature.

$\Sigma_{t|t-1}$ is the $(n \times n)$ conditional covariance matrix, R_t is the $(n \times n)$ conditional correlation matrix and D_t is the $(n \times n)$ diagonal matrix with time-varying standard deviations on the diagonal obtained from the univariate GARCH models.

4.5 Dynamics of Changes in Correlation Coefficients

To test for the impact of the two crises in the markets, we use Ordinary Least Squares (OLS) with robust standard errors to estimate the following specification for the dynamic conditional correlation estimates obtained from the DCC-GARCH model:

$$\rho_{ij,t} = \beta_0 + \beta_1 DGFC_1 + \beta_2 DGFC_2 + \beta_3 DGFC_3 + \beta_4 DEZDC + \vartheta_t \qquad (8)$$

where $\rho_{ij,t}$ is the pairwise TVCC coefficient between market *i* and market *j*; *i* and *j* denote the stock and currency markets of Eurozone, India, Japan and U.S., and the dummies $DGFC_1, DGFC_2, DGFC_3$ and $DEZDC$ are as defined above. A positive and significant coefficient $\beta_i, i = 1, \dots, 4$ indicates a significant rise in the conditional correlation coefficients during that time period vis-à-vis the stable period.

Further, to test assess the role played by risk in the markets, the following regression model is estimated using Ordinary Least Squares (OLS) for the time-varying conditional correlation coefficients (TVCCs):

$$\rho_{ij,t} = \alpha_0 + \alpha_1 h_{ii,t} + \alpha_2 h_{jj,t} + u_t \qquad (9)$$

where $\rho_{ij,t}$ is defined above, and $h_{ii,t}$ and $h_{jj,t}$ represent the estimated conditional volatility in market *i* and market *j* respectively. A positive coefficient $\alpha_i, i = 1,2$ indicates that the dynamic conditional correlation between market *i* and market *j* goes up as the volatility of market *i* (or market *j*) rises.

Finally, to analyse the role played by news effects about the events occurring during both the crises, we specify the following AR-GARCH model for each of the TVCCs:

$$\rho_{ij,t} = \nu_0 + \sum_{p=1}^{P} \nu_p \, \rho_{ij,t-p} + \sum_{k=1}^{3} \omega_k \, DGFC_{k,t} + \omega_4 DEZDC_t + e_{ij,t} \qquad (10)$$

$$h_{ij,t} = B_0 + B_1 h_{ij,t-1} + D_1 \varepsilon_{t-1}^2 + \sum_{k=1}^{3} \gamma_k \, DGFC_{k,t} + \gamma_4 DEZDC_t$$

where $\rho_{ij,t}$ as defined above. A positive and significant mean coefficient is indicative that the TVCCs rose due to extreme crisis events. A significant coefficient in the variance equation implies that the volatility of TVCCs increased as a consequence of the exogenous news or shocks during the crises. The lag selection of the AR terms has been undertaken on the basis of SBC.

5. RESULTS

5.1 Estimates from the Dynamic Conditional Correlation Model

Table 5 (Panels A and B) present the results of the multivariate DCC-GARCH model[6] for stock and currency markets of Eurozone, India, Japan and U.S. To begin with, we test for the presence of multivariate ARCH effects and results indicate that the null hypothesis of no multivariate ARCH effects is rejected at 1% level of significance. We then go on to test for the appropriateness of the Constant Conditional Correlation-GARCH (CCC-GARCH) specification (Tse, 2000) and the null hypothesis of constant conditional correlation is rejected at 1% level of significance. Further, given the fat-tailed distributions for asset returns, we have employed the DCC-GARCH model based on the t-distribution. The lagged term or the AR(1) term in the mean equation is significant at 1% level for all the markets. The estimated GARCH-DCC(1,1) specification with significant parameters α and β at 1% level indicate that there is a great deal of time-varying co-movement in the asset markets. Further, stock and exchange market returns exhibit high volatility persistence as the same varies from 0.95 to 0.99 for the markets during the study period. The lowest volatility persistence is displayed by the Nifty 50 returns and the highest by the ₹/$ exchange rate returns. Moreover, the coefficients for lagged volatility and lagged error terms in the variance equations for the markets are all significant at 5% level which implies that the multivariate GARCH(1,1) specification is appropriate.

Several recent studies such as Chiang *et al.* (2007), Syllignakis and Kouretas (2011), Min and Hwang (2012), Dimitriou and Kenourgios (2013) and Ahmad *et al.* (2013) have estimated the pairwise conditional correlation across financial markets using a DCC-GARCH framework and utilized it to analyse and test for contagion. Dornbusch *et al.* (2000, p. 177) have defined the phenomenon of contagion as "*a significant increase in cross-market linkages after a shock to an individual country (or groups of countries) as measured by the degree to which asset prices or financial flows move together across markets relative to this co-movement in tranquil times.*" The estimation framework therefore, allows us to test for the existence of contagion or interdependence across stock and currency markets where in a significant rise in correlation is taken to be signal of the heightened transmission across the markets during the period under study.

The results for the impact of GFC and EZDC on the dynamic conditional coefficients across asset markets are presented in Table 6. It should be noted that the relationship across stock and currency markets is not necessarily positive but in fact mixed. Therefore, contagion may not essentially manifest itself as increased, but most likely sharper, conditional correlation coefficients. The crisis period results for the market pairs are compared with the stable period. We find that the correlation coefficients across the stock markets are positive and significant during the stable period. The stock markets are highly correlated with the lowest correlation coefficient of 0.53 during the stable period. Further, if we compare across the three phases of the GFC then we observe that the 1st and 2nd phases of the crisis triggered significant and large contagious effects across the stock markets. Stock markets, across the board, depicted higher (and never significantly lower) correlation during the crisis periods. The magnitude of the contagion effects has been lower in the EZDC phases than the pre-GFC period. Among the currency market pairs, €/$ and ¥/$ are positively and significantly related during the stable

[6] The time-varying conditional correlation plots are available from the Authors on request.

periods, whereas ¥/$ and ₹/$ have a negligible but significantly negative correlation coefficient. Further, it is interesting to note that here again, the 1st and 2nd phase of the GFC have been most severe in terms of the transmission of shocks across the markets. Moreover, during the crisis periods the cross-markets pairs involving the ¥/$ rate have witnessed a significant decline in the correlation while the €/$-₹/$ pair have been more closely and significantly related. Finally, when we analyse the cross-asset class market pairs we again find that all the correlation coefficients are negative and significant in the stable period, apart from those involving the stock markets and the ¥/$ rate. Further, the stock markets were displaying negative returns during most of the crisis time periods but it seems that the ¥/$ returns were also negative or the ¥ was in fact appreciating (vis-à-vis the $) during these periods. Interestingly, the correlation coefficients for these stock markets and ¥/$ exchange rate increased significantly during the crises phases with the 1st phase of GFC having witnessed the sharpest increases. Among the cross asset class market pairs, the ₹/$ rate is negatively and significantly correlated with all the stock markets and has the largest magnitudes. The rest of the stock market-currency market pairs display negative and significant relationship during stable periods and virtually all of these pairs exhibit negative and significantly lower conditional correlation coefficients during the crisis periods. This was especially true for the 1st and 2nd phase of the GFC during which the magnitudes were the highest and significant at 1% level. The pre-crisis phase of the GFC does not seem to have affected most of these pairs but they display significant transmission effects during the EZDC although the magnitudes are much lower in comparison to the GFC.

One of the reasons for the existence of contagion effects is that both U.S. and Eurozone are major trading partners for India (Table 9). Therefore, there are strong economic linkages of the Indian economy with these two countries. Further, Japan shares close trade ties with U.S. and Eurozone as well. All this is notwithstanding the fact that the U.S. and Eurozone economies have strong trade linkages with each other as well. Moreover, the ₹ seems to be a fragile currency especially since the Global Financial Crisis first broke out in September of 2008. Further, and India has been receiving external assistance from Japan, major Eurozone economies like Germany and the U.S. which indicates presence of financial inter-linkages. These trade linkages and financial linkages reinforce the contagion effects arising out of investor panic during the crises.

5.2 Cross market co-movements and the role of risk

We now go on to analyse the time-varying conditional correlation coefficients across and within asset classes for the sample at hand. Most of the existing studies on stock markets (Chiang *et al.*, 2007; Syllignakis and Kouretas, 2011; Ahmad *et al.*, 2013) and currency markets (Dimitriou and Kenourgios, 2013) have advanced evidence suggesting that the international cross-market linkages vary directly with the level of risk in the markets. To examine the impact of risk on the TVCCs, we estimate equation 9. The results of the regression are presented in Table 7. These results have significant implications for international portfolio investment as the purpose of diversification of assets internationally is hedging of risk.

In the case of the stock markets, the α_i coefficients are all positive and significant except for the conditional correlation coefficient for the pair of U.S. and Indian stock markets which is negative and significant for the risk in the Indian stock market. In Table 6, we have seen that for the U.S. and Indian stock markets there was no contagion but only interdependence during the pre-GFC phase. At the same time, during the first and second phases of the GFC, the rise in conditional correlation between Indian and other stock markets turned out to be the least for the U.S. market relative to Eurozone and Japan stock markets. It seems that a rising risk in the Indian market (while the risk in the U.S. stock market is constant) leads to a flight-to-quality phenomenon and divergence between the Indian and U.S. stock market returns. The explanatory power of the regressions indicated by the adjusted-R^2 is high which is between 37% and 54% for the stock market pairs.

Moving on to the case of the currency markets, an increase in the risk associated with lower co-movement as it drives investors away from the €/$-¥/$ and ₹/$-¥/$ pairs. This is also depicts the flight-to-quality across these pairs and the deviation in these currency returns. The €/$-₹/$ pair, however, depicts higher co-movement as the risk rises in either of the markets. The explanatory power of the regression for the currency market pairs is between 27% and 47%.

Finally, we examine the stock and currency market pairs. The time-varying conditional correlation coefficients between the ¥/$ rate and the stock markets are associated positively with the risk in the markets. On the other hand, the rest of the currency-stock market correlation pairs have negative coefficients for risk implying that an increase in the risk in the markets leads to divergence, rather than convergence, of the stock and currency market pairs. Moreover, this highlights a possible avenue for the portfolio diversification during high risk periods. The explanatory power of the regressions focussing on the co-movement of the stock markets with the ¥/$ rate is high at about 40% to 57%. However, it is quite low between 17% and 29% for the rest of the stock and currency market pairs.

5.3 Impact of extreme events during the GFC and EZDC on the TVCC

We now assess the possible impact of the various phases of the crisis episodes on the pair-wise conditional correlation coefficients by investigating the impact that the crisis periods may have had on the level and volatility of the dynamic conditional correlation coefficients (Chiang *et al.*, 2007; Min and Hwang, 2007). From the above analysis, it is evident that the conditional correlation coefficients within and across asset classes were sharper and more variable during the GFC as well as EZDC. The dummy variables constructed above to represent the crisis periods are now utilized to examine the dynamic pattern of the time-varying conditional correlation across stock and currency markets in a AR(*l*)-GARCH(p,q) framework for the correlation coefficients.

The AR(*l*)-GARCH(p,q)[7] models were estimated for the 21 pairs of dynamic conditional correlation coefficients using maximum-likelihood technique and are shown in Table 8.

[7] The order of the GARCH specification for the TVCCs was tested using the conventional tests.

To begin with, in the case of the stock markets, in the Eurozone-Japan pair the mean equation was not impacted by the extreme crisis events. However, the rest of the stock market pairs experienced a positive and significant effect of the adverse news announcements and market turmoil during the crisis periods. The maximum impact has been witnessed during the 1st phase of the GFC which was synonymous with the news about the Lehman Brothers' bankruptcy along with the collapse of several other banking giants. The significant rise in correlations across equity markets in response to news surprises during the crises may be a result of the herd behaviour of investors. The stock markets also depict high volatility persistence and volatility changes are more significantly affected during the 2nd and longer phase of the GFC and during the EZDC as well.

Next, we move on to the foreign exchange markets, the €/$-¥/$ pair experienced significantly lower correlations during all the crisis periods with the 1st phase of the GFC impacting the correlations the most. However, no significant impact is found in the case of volatility changes. The €/$-₹/$ pair was resilient to extreme news events but the volatility increased significantly during the EZDC. Finally, the ¥/$-₹/$ pair experienced lower correlation in the pre-crisis phase of the GFC and 1st phase of the GFC with the latter having a larger impact but no effect is witnessed for the volatility of the conditional correlations.

Lastly, we study the dynamic behaviour of the cross asset-class market pairs. The correlation of the stock market pairs with the ¥/$ rate experienced significant impact of the crisis on the variability. However, only the Nifty 50 and ¥/$ rate correlations were positively and significantly affected during the 1st and 2nd phases of the GFC and EZDC with GFC phase-I having caused the maximum impact. For the stock market pairs with the €/$ rate, all the pairs with the exception of Nifty 50 underwent significantly lower conditional correlations in the face of major upheavals during the EZDC. Further, the variability was much higher during most of the crisis periods for all the pairs. Finally, we look at the pairs involving the stock markets and ₹/$ rate. The variability increased for the S&P 500 and ₹/$ pair during the 2nd phase of the GFC and EZDC. The correlations were unaffected but significantly accentuated volatility during phase II of GFC and EZDC. The Nifty 50 and ₹/$ witnessed significantly lower correlations post the crisis shocks in phases I and II of GFC as well the EZDC and also higher variance during phase II of GFC. Finally, the correlation with Nikkei stock market was slightly but significantly higher in response to the pre-crisis news events of GFC but declined in the rest of the crisis episodes.

We verify the robustness of our results by estimating an alternative specification which includes U.S. Economic Policy Uncertainty Index in the equations for the stock market returns and change in LIBOR in the equations for the currency market returns. The results[8] are in tandem with those discussed in the above sections.

The policy makers need to pay urgent attention to the development of an institutional financial system which will help contain the risk of contagion across the stock markets. The

[8] Detailed results are available with the Authors on request.

advantages of international portfolio diversification across stock markets seems to be little at the times when they are needed the most. In view of the possible impact of a simultaneous downfall of the world stock markets and possibility of transmission of the shocks to the investment in an economy via Tobin's q and thereafter further domino effects to the real economy, international policy coordination is required to insulate the real sectors of the economy from such external shocks.

6. CONCLUSIONS

The objective of this paper is to test for contagion in the context of multiple assets viz. stock and currency markets of Eurozone, India, Japan and U.S. We employ a Markov-switching VAR framework to endogenously select the crisis periods. The timeline so derived corresponds with the major events that took place during the two crisis episodes. Thereafter, we estimate the time-varying conditional correlation coefficients across the financial markets by using the DCC-GARCH model proposed by Engle (2002). The conditional correlation coefficients have a distinct pattern during the crisis time periods. We subsequently test for the existence of contagion effects in stock and currency markets. Our results indicate that there was significant contagion both within and across asset classes. Further, we also obtain evidence of flight-to-quality in some of the cases. In particular, the behaviour of the ¥/$ rate is markedly different from that of the €/$ and ₹/$ rates. We also examine the impact of rising risk in the markets and the results suggest that risk is an important factor that governs the correlation of assets. Finally, we find that extreme crisis events impact the markets. Further, the results are robust as findings from the alternative specification are in line with the results from the main specification.

Contagion leads to erosion of the benefit of international portfolio diversification especially across stock markets. However, our results indicate that there may be scope for diversification across asset classes even during such turbulent times. The trade and financial linkages across the economies may be reinforcing the spillover effects from a crisis. Lastly, in view of the possible impact of a simultaneous downfall of the world stock markets and possibility of transmission of the shocks to the investment in an economy via Tobin's q and thereafter further domino effects to the real economy, international policy coordination is required to insulate the real sectors of the economy from such external shocks.

REFERENCES

Ahmad, W., S., Sehgal and N.R. Bhanumurthy (2013), Eurozone Crisis and BRIICKS Stock Markets: Contagion or Market Interdependence?, *Economic Modelling*, Vol. 33, 209-225.

Agénor, P.-R., and J. Aizenman (1997), Contagion and Volatility with Imperfect Credit Markets, NBER, Working Paper No. 6080.

Baig, T., and I. Goldfajn (1999), Financial Market Contagion in the Asian Crisis, *IMF Staff Papers,* Vol. 46, 167-195.

Bekaert, G., C.R. Harvey, and A. Ng (2005), Market Integration and Contagion, *The Journal of Business*, Vol. 78, 39-69.

Bollerslev, T. (1990), Modelling the Coherence in Short-run Nominal Exchange Rates: A Multivariate Generalized ARCH model, *Review of Economics and Statistics,* Vol. 72, 498-505.

Boschi, M. (2005), International Financial Contagion: Evidence from the Argentine Crisis of 2001–2002, *Applied Financial Economics,* Vol. 15, 153-163.

Broner, F., R.G. Gelos, and C. Reinhart (2004), When in Peril, Retrench: Testing the Portfolio Theory of Contagion, IMF Working Paper No. 04/131.

Büttner, D., and B. Hayo (2010), News and Correlations of CEEC-3 Financial Markets, *Economic Modelling,* Vol. 27, 915-922.

Calvo, G. and E. Mendoza (2000), Rational Contagion and the Globalization of Securities Markets, *Journal of International Economics,* Vol. 51, 79-113.

Calvo, S. and C.M. Reinhart (1996), Capital flows to Latin America: is there evidence of contagion effects, in G.A. Calvo, M. Goldstein and E. Hochreitter (Eds.), *Private Capital Flows to Emerging Markets*, Institute for International Economics, Washington DC.

Chang, R., and G. Majnoni (2001), International Contagion: Implications for Policy, in S. Claessens and K. Forbes (Eds.), *International Financial Contagion*, Boston, MA: Kluwer Academic Publishers.

Chiang, T.C., B.N. Jeon, and H. Li (2007), Dynamic Correlation Analysis of Financial Contagion: Evidence from Asian Markets, *Journal of International Money and Finance,* Vol. 26, 1206-1228.

Corsetti, G., P. Pesenti, and C. Tille (2000), Competitive Devaluations: Toward a Welfare-Based Approach, *Journal of International Economics,* Vol. 51, 217-41.

Corsetti, G., M. Pericoli and M. Sbracia (2005), 'Some Contagion, Some Interdependence': More Pitfalls in Tests of Financial Contagion, *Journal of International Money and Finance*, Vol. 24, 1177-1199.

Dimitriou, D. and D. Kenourgios (2013), Financial Crises and Dynamic Linkages among International Currencies, *Journal of International Financial Markets*, *Institutions and Money*, Vol. 26, 319-332.

Dornbusch, R., Y.C. Park and S. Claessens (2000), Contagion: Understanding How it Spreads, *The World Bank Research Observer,* Vol. 15, 177-197.

Dungey, M. and V.L. Martin (2007), Unravelling Financial Market Linkages during Crises, *Journal of Applied Econometrics*, Vol. 22, 89-119.

Dungey, M., R. Fry, B. González-Hermosillo and V.L. Martin (2005), Empirical Modelling of Contagion: A Review of Methodologies, *Quantitative Finance*, Vol. 5, 9-24.

Eichengreen, B., A. Rose and C. Wyplosz (1996), Contagious Currency Crises, *Scandinavian Economic Review*, Vol. 98, 463–84.

Elliott, G., T.J. Rothenberg and J.H. Stock (1996), Efficient Tests for an Autoregressive Unit Root, *Econometrica*, 64, 813-36.

Engle, R.F. (2002), Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroscedasticity Models, *Journal of Business and Statistics*, 20, 339-350.

Favero, C.A., and F. Giavazzi (2002), Is the International Propagation of Financial Shocks Non-Linear? Evidence from the ERM, *Journal of International Economics*, Vol. 51, 231-246.

Flavin, T.J., E. Panopoulou, and D. Unalmis (2008), On the Stability of Domestic Financial Market Linkages in the Presence of Time-varying Volatility. *Emerging Markets Review*, Vol. 9, 280-301.

Forbes, K. (2002), Are Trade Linkages Important Determinants of Country Vulnerability to Crises?, in S. Edwards and J.A. Frankel (Eds.), *Preventing Currency Crises in Emerging Markets*, Chicago: The University of Chicago Press, 77–124.

Forbes, K. and R. Rigobon (2002), No Contagion, Only Interdependence: Measuring Stock Market Co-movements, *Journal of Finance*, Vol. 57, 2223-2261.

Gerlach, S. and F. Smets (1995), Contagious Speculative Attacks, *European Journal of Political Economy*, Vol. 11, 5-63.

Glick, R., and A.K. Rose (1999), Contagion and Trade: Why are Currency Crises Regional?, *Journal of International Money and Finance*, Vol. 18, 603-617.

Goldfajn, I., and R. Valdés (1997), Capital Flows and Twin Crises: The Role of Liquidity, IMF Working Paper No. 97/87.

Granger, C., B. Huang and C. Yang (2000), Bivariate Causality between Stock Prices and Exchange Rates in Asian Countries, *The Quarterly Review of Economics and Finance*, Vol. 40, 337-354.

Gravelle, T., M., Kichian and J. Morley (2006), Detecting Shift-contagion in Currency and Bond Markets, *Journal of International Economics*, Vol. 68, 409-423.

Guidolin, M. (2011), Markov switching models in empirical finance, Missing Data Methods: Time-series Methods and Applications, *Advances in Econometrics*, Vol. 27B, 1-86.

Guo, F., C.R. Chen, and Y. S. Huang (2011), Markets Contagion during Financial Crisis: A Regime-switching Approach, *International Review of Economics & Finance*, Vol. 20, 95-109.

Hamilton, J.D. (1989), A new approach to the economic analysis of nonstationary time series and the business cycle, *Econometrica*, Vol. 57, 357-384.

Hamilton, J.D. (1990), Analysis of time series subject to changes in regime, *Journal of Econometrics*, Vol. 45, 39-70.

Hartmann, P., S. Straetmans, and C.G. De Vries (2004), Asset Market Linkages in Crisis Periods, *The Review of Economics and Statistics*, Vol. 86, 313-326.

Jeanne, O. (1997), Are Currency Crisis Self Fulfilling?, *Journal of International Economics*, Vol. 43, 263-286.

Kallberg, J.G., C.H. Liu, and P. Pasquariello (2005), An Examination of the Asian Crisis: Regime Shifts in Currency and Equity Markets, *The Journal of Business*, Vol. 78, 169-211.

Kaminsky, G.L., R. Lyons and S. Schmukler (2001), Mutual Fund Investment in Emerging Markets: An Overview, in S. Claessens and K. Forbes (Eds.), *International Financial Contagion*. Boston: Kluwer Academic Publishers, 158-85.

Kanas, A. (2005), Regime Linkages between the Mexican Currency Market and Emerging Equity Markets, *Economic Modelling*, Vol. 22, 109-125.

Krolzig, H.-M. (1997), *Markov-switching Vector Autoregressions: Modelling, Statistical Inference, and Application to Business Cycle Analysis*, Lecture Notes in Economics and Mathematical Systems 454, Berlin: Springer-Verlag.

Lee, J. and M.C. Strazicich (2003), Minimum Lagrange Multiplier Unit Root Test with Structural Breaks, *The Review of Economics and Statistics*, 85, 1082-1089.

Longstaff, F.A. (2010), The Subprime Credit Crisis and Contagion in Financial Markets, *Journal of Financial Economics*, Vol. 97, 436-450.

Masson, P. (1998), Contagion: Monsoonal Effects, Spillovers, and Jumps Between Multiple Equilibria, *IMF Working Paper* No. 98/142.

Masson, P. (1999b), Contagion: Monsoonal Effects, Spillovers, and Jumps Between Multiple Equilibria, in P.R. Agénor, M. Miller, D. Vines and A. Weber (Eds.), *The Asian Financial Crisis: Causes, Contagion and Consequences*, Cambridge ,UK: Cambridge University Press.

Min, H.-G., and Y.-S. Hwang (2012), Dynamic Correlation Analysis of US Financial Crisis and Contagion: Evidence from Four OECD Countries, *Applied Financial Economics*, Vol. 22, 2063-2074.

Mishkin, F. (1997), Understanding Financial Crises: A Developing Country Perspective, in M. Bruno and B. Pleskovic (Eds.), *Annual World Bank Conference on Development Economics*, Washington: World Bank, 29–62.

Pavlova, A., and R. Rigobon (2008), The Role of Portfolio Constraints in the International Propagation of Shocks, *Review of Economic Studies*, Vol. 75, 1215-1256.

Pesaran, M.H. and A. Pick (2007), Econometric issues in the analysis of contagion, *Journal of Economic Dynamics and Control*, Vol. 31, 1245-1277.

Schinasi, G.J., and T. Smith (2001), Portfolio Diversification, Leverage, and Financial Contagion, in S. Claessens and K. Forbes (Eds.), *International Financial Contagion*, Boston, MA: Kluwer Academic Publishers, 187–223.

Syllignakis, M.N., and G.P. Kouretas (2011), Dynamic Correlation Analysis of Financial Contagion: Evidence from the Central and Eastern European Markets, *International Review of Economics & Finance*, Vol. 20, 717-732.

Tai, C.-S. (2007), Market Integration and Contagion: Evidence from Asian Emerging Stock and Foreign Exchange Markets, *Emerging Markets Review*, Vol. 8, 264-283.

Tse, Y.K. (2000), A Test for Constant Correlations in a Multivariate GARCH Model, *Journal of Econometrics*, Vol. 98, 107-127.

Valdés, R. (1997), Emerging Markets Contagion: Evidence and Theory, Central Bank of Chile, Working Paper No.7.

Van Rijckeghem, C. and B. Weder (2001), Sources of Contagion: Is it Finance or Trade?, *Journal of International Economics*, Vol. 54, 293-308.

Walid, C., A. Chaker, O. Masood, and J. Fry (2011), Stock Market Volatility and Exchange Rates in Emerging Countries: A Markov-state Switching Approach, *Emerging Markets Review*, Vol. 12, 272-292.

Wang, P., and M. Theobald (2008), Regime-switching Volatility of Six East Asian Emerging Markets, *Research in International Business and Finance*, Vol. 22, 267-283.

APPENDIX: TABLES AND FIGURES

TABLES

Table 1: Descriptive Statistics and Unconditional Correlations

Panel A-Descriptive Statistics

	s^{IND}	s^{US}	$e^{₹}$	s^{EZ}	$e^{€}$	s^{JAP}	$e^{¥}$
Mean	0.003173	0.001028	0.000569	0.00061	-0.00023	0.000919	-0.00035
Std. Dev	0.0312	0.019619	0.008829	0.024289	0.011586	0.026805	0.011205
Skewness	-0.45083	-1.48229	0.044583	-0.84258	0.006583	-0.89209	-0.13897
Kurtosis	6.078742	12.18077	6.107187	5.974845	5.038687	8.10998	4.231629
Maximum	0.163679	0.070561	0.036441	0.076478	0.043951	0.106082	0.045906
Minimum	-0.1481	-0.15278	-0.04122	-0.12476	-0.0643	-0.17782	-0.04803

Table 1: Panel B-Unconditional Correlations

	s^{IND}	s^{US}	$e^{₹}$	s^{EZ}	$e^{€}$	s^{JAP}	$e^{¥}$
s^{IND}	1						
s^{US}	0.577931	1					
$e^{₹}$	-0.55613	-0.50696	1				
s^{EZ}	0.635968	0.860679	-0.50336	1			
$e^{€}$	-0.28792	-0.37474	0.400559	-0.30327	1		
s^{JAP}	0.567198	0.699398	-0.4032	0.703516	-0.2062	1	
$e^{¥}$	0.184791	0.244239	-0.04912	0.259007	0.19101	0.458246	1

Note: $s^{IND}, s^{US}, e^{₹}, s^{EZ}, e^{€}, s^{JAP}$ and $e^{¥}$ denote the returns on Indian stock market, U.S. stock market, Rs. Vs. USD exchange rate, Eurozone stock market, Euro vs. USD exchange rate, Japanese stock market and Yen vs. USD exchange rate.

Table 2: Unit Root Test Results

Panel A: DF-GLS Test (Constant and Trend)

Variable	DF-GLS Statistic	DF-GLS: Inference
s^{IND}	-9.142556***	I (0)
s^{US}	-5.926941***	I (0)
$e^{₹}$	-14.70931***	I (0)
s^{EZ}	-4.452369***	I (0)
$e^{€}$	-16.11474***	I (0)
s^{JAP}	-7.452786***	I (0)
$e^{¥}$	-17.18074***	I (0)
	Critical Values	
10%	-2.570000	
5%	-2.890000	
1%	-3.480000	

Note: *, ** and *** indicate significance at 10%, 5% and 1% respectively. Note: $s^{IND}, s^{US}, e^{₹}, s^{EZ}, e^{€}, s^{JAP}$ and $e^{¥}$ denote the returns on Indian stock market, U.S. stock market, Rs. Vs. USD exchange rate, Eurozone stock market, Euro vs. USD exchange rate, Japanese stock market and Yen vs. USD exchange rate.

Panel B: Lee-Strazicich Unit Root Test for Structural Change

Variable	**Trend Break Model**	**Crash Model**	**Inference**
s^{IND}	-20.0469***	-17.4881***	I (0)
s^{US}	-20.6871***	-17.8988***	I (0)
$e^{₹}$	-17.5192***	-12.0386***	I (0)
s^{EZ}	-20.7736***	-17.0869***	I (0)
$e^{€}$	-17.7669***	-16.7206***	I (0)
s^{JAP}	-19.8866***	-16.6360***	I (0)
$e^{¥}$	-18.4113***	-18.2137***	I (0)
	Critical Values		
Crash Model	1%	5%	10%
LM_{τ}	-4.545	-3.842	-3.504
Trend Break Model		λ_2	
λ_1	0.4	0.6	0.8
0.2	-6.16, -5.59, -5.27	-6.41, -5.74, -5.32	-6.33, -5.71, -5.33
0.4	-	-6.45, -5.67, -5.31	-6.42, -5.65, -5.32
0.6	-	-	-6.32, -5.73, -5.32

Note: Critical values are at the 1%, 5% and 10% levels, respectively. λ_j denotes the location of breaks. Note: $s^{IND}, s^{US}, e^{₹}, s^{EZ}, e^{€}, s^{JAP}$ and $e^{¥}$ denote the returns on Indian stock market, U.S. stock market, Rs. Vs. USD exchange rate, Eurozone stock market, Euro vs. USD exchange rate, Japanese stock market and Yen vs. USD exchange rate.

Panel C: Summary of Unit root test results

Variable	**DF-GLS**	**Lee-Strazicich (2003)**	**Conclusion**
s^{IND}	I (0)	I (0)	I (0)
s^{US}	I (0)	I (0)	I (0)
$e^{₹}$	I (0)	I (0)	I (0)
s^{EZ}	I (0)	I (0)	I (0)
$e^{€}$	I (0)	I (0)	I (0)
s^{JAP}	I (0)	I (0)	I (0)
$e^{¥}$	I (0)	I (0)	I (0)

Note: $s^{IND}, s^{US}, e^{₹}, s^{EZ}, e^{€}, s^{JAP}$ and $e^{¥}$ denote the returns on Indian stock market, U.S. stock market, Rs. Vs. USD exchange rate, Eurozone stock market, Euro vs. USD exchange rate, Japanese stock market and Yen vs. USD exchange rate.

Table 3: Parameter estimates for multivariate two-state MSIH model

Panel A: US Stock and Currency Markets: s^{US}, $e^{¥}$

	s^{US}	$e^{¥}$
μ_1	0.00033	-0.00281
μ_2	0.00203	-0.00478
$\beta_{s^{US}}$	0.14900	-0.05770
$\beta_{e^{¥}}$	-0.02740	0.26640
σ_1	0.00132	0.00021
σ_2	0.00016	0.00010
P_{11}	0.94690	
P_{22}	0.89000	
RCM	9.5155	

Note: *,** and *** indicate significance at 10%, 5% and 1% respectively. All the variance terms are significant at 1% level. Note: s^{IND}, s^{US}, $e^{₹}$, s^{EZ}, $e^{€}$, s^{JAP} and $e^{¥}$ denote the returns on Indian stock market, U.S. stock market, Rs. Vs. USD exchange rate, Eurozone stock market, Euro vs. USD exchange rate, Japanese stock market and Yen vs. USD exchange rate.

Panel B: Eurozone Stock and Currency Markets: s^{EZ}, $e^{€}$

	s^{EZ}	$e^{€}$
μ_1	-0.00723	0.00192
μ_2	0.00267	-0.00076
$\beta_{s^{EZ}}$	0.15900	0.02390
$\beta_{e^{€}}$	0.02850	0.27620
σ_1	0.00191	0.00030
σ_2	0.00029	0.00009
P_{11}	0.93510	
P_{22}	0.98790	
RCM	10.961	

Note: *,** and *** indicate significance at 10%, 5% and 1% respectively. All the variance terms are significant at 1% level. Note: s^{IND}, s^{US}, $e^{₹}$, s^{EZ}, $e^{€}$, s^{JAP} and $e^{¥}$ denote the returns on Indian stock market, U.S. stock market, Rs. Vs. USD exchange rate, Eurozone stock market, Euro vs. USD exchange rate, Japanese stock market and Yen vs. USD exchange rate.

Table 4: Crisis Timeline (Selected Events and Dates)

Panel A: Global Financial Crisis (2008-09)

Date	Events
11th January, 2008	Countrywide Financial is to be purchased by Bank of America for $4 billion
18th January, 2008	Ambac Financial Group's rating is downgraded by Fitch Ratings and Standard and Poor's to negative on the Credit Watch
24th January, 2008	US home sales witness largest single-year drop in a quarter of a century
15th September, 2008	Lehman Brothers files for bankruptcy and Bank of America takes over Merill Lynch
17th-21st September, 2008	Stock prices of UK mortgage lender HBOS nosedive causing Lloyds TSB to rescue it
25th-29th September, 2008	US banks Washington Mutual and Wachovia collapse
20th July, 2009	A 0.7% rise in the US leading economic indicators' index for June impels US stock markets up
24th July, 2009	Dow Jones Industrial Index closes at a high of 9093.24 surpassing its past high in January that year

Panel B: Eurozone Debt Crisis (2010-11)

Date	Events
2nd May , 2010	Eurozone finance ministers grant loans worth €110 billion to bail out Greece for the first time
30th June, 2010	Having served its purpose of bringing stability, the covered bond programme is discontinued by the European Central Bank
21st July, 2011	Eurozone leaders meet in Brussels in the wake of the ongoing Debt Crisis and Greece is bailed out again
9th December, 2011	Eurozone leaders convene in Brussels again with the intention of building a stronger Economic Union
21st December, 2011	In a long term financing operation involving three year loans at low rates of interest, the European Central Bank allocates €489 billion to more than 500 European banks

Sources: Compiled using Crisis Timeline by Federal Reserve Bank of St. Louis; European Central Bank, The Guardian; The Telegraph; Bloomberg Business Week and BBC News

Table 5: Estimation Results from the DCC-GARCH Model

Panel A: Preliminary Tests	
Test	**Statistic**
Multivariate ARCH Effects	2972.91***
CCC-GARCH specification	40.646***

Panel B: Estimates							
	s^{IND}	s^{US}	$e^{₹}$	s^{EZ}	$e^{€}$	s^{JAP}	$e^{¥}$
Mean Equations							
Constant	0.004***	0.002***	-0.0002	0.002***	-0.0008**	0.002***	0.00002
Lagged Term	0.196***	0.096***	0.326***	0.155***	0.197***	0.221***	0.208***
Variance Equations							
C	0.00004**	0.00001***	0.000001	0.00001**	0.000002*	0.00002*	0.000004*
A	0.084***	0.085***	0.119***	0.075***	0.055**	0.048**	0.071***
B	0.870***	0.877***	0.874***	0.899***	0.929***	0.914***	0.891***
Persistence	0.954	0.962	0.993	0.974	0.984	0.962	0.962
Standardized Residuals Q(6)	0.3469	0.4299	0.5326	0.4431	0.3925	0.6991	0.4431
Multivariate DCC Equation							
DCC 1	0.024***						
DCC 2	0.948***						
t-distribution	8.485***						

Note: *, ** and *** indicate significance at 10%, 5% and 1% respectively. Note: $s^{IND}, s^{US}, e^{₹}, s^{EZ}, e^{€}, s^{JAP}$ and $e^{¥}$ denote the returns on Indian stock market, U.S. stock market, Rs. Vs. USD exchange rate, Eurozone stock market, Euro vs. USD exchange rate, Japanese stock market and Yen vs. USD exchange rate.

Table 6: Tests of Impact on Dynamic Conditional Correlations among asset markets during the phases of Global Financial Crisis and Eurozone Debt Crisis

	$DGFC_1$	$DGFC_2$	$DGFC_3$	DEZDC	Stable Period
Stock Markets					
s^{US} and s^{EZ}	0.002	0.011	0.051***	0.015***	0.853***
s^{US} and s^{IND}	-0.003	0.067***	0.105***	0.033***	0.561***
s^{US} and s^{JAP}	0.074***	0.115***	0.109***	0.027***	0.681***
s^{EZ} and s^{IND}	0.044*	0.145***	0.148***	-0.016	0.613***
s^{EZ} and s^{JAP}	0.045***	0.106***	0.130***	0.014***	0.689***
s^{IND} and s^{JAP}	0.053***	0.120***	0.185***	-0.007	0.536***
Currency Markets					
	$DGFC_1$	$DGFC_2$	$DGFC_3$	DEZDC	Stable Period
$e^{€}$ and $e^{¥}$	-0.005	-0.090*	-0.203***	-0.066***	0.213***
$e^{€}$ and $e^{₹}$	0.027***	0.048	0.144***	0.033***	0.386***
$e^{¥}$ and $e^{₹}$	-0.074***	-0.227***	-0.144***	-0.113***	-0.029***
Stock and Currency Markets					
	$DGFC_1$	$DGFC_2$	$DGFC_3$	DEZDC	Stable Period
s^{US} and $e^{¥}$	0.220***	0.235***	0.118***	0.035**	0.222***
s^{US} and $e^{₹}$	0.004	-0.031*	-0.135***	-0.039***	-0.493***
s^{US} and $e^{€}$	0.064***	0.061	-0.122***	-0.063***	-0.352***
s^{EZ} and $e^{¥}$	0.138***	0.215***	0.143***	0.015***	0.243***
s^{EZ} and $e^{₹}$	-0.003	-0.083***	-0.180***	-0.040***	-0.486***
s^{EZ} and $e^{€}$	-0.006	0.047	-0.145***	-0.144***	-0.275***
s^{IND} and $e^{¥}$	0.062***	0.235***	0.198***	0.084***	0.155***
s^{IND} and $e^{₹}$	-0.013	-0.039***	-0.201***	-0.051***	-0.520***
s^{IND} and $e^{€}$	-0.087***	0.111***	-0.162***	-0.046***	-0.266***
s^{JAP} and $e^{¥}$	0.152***	0.165***	0.117***	0.015	0.426***
s^{JAP} and $e^{₹}$	-0.002	-0.116***	-0.214***	-0.076***	-0.372***
s^{JAP} and $e^{€}$	-0.031***	-0.063	-0.247***	-0.080***	-0.177***

Note: *, ** and *** indicate significance at 10%, 5% and 1% respectively. Note: s^{IND}, s^{US}, $e^{₹}$, s^{EZ}, $e^{€}$, s^{JAP} and $e^{¥}$ denote the returns on Indian stock market, U.S. stock market, Rs. Vs. USD exchange rate, Eurozone stock market, Euro vs. USD exchange rate, Japanese stock market and Yen vs. USD exchange rate.

Table 7: Tests of Impact of Time-varying Conditional Variances on the DCC Estimates

	α_1	α_2	Adj. R^2
Stock Markets			
s^{US} and s^{EZ}	0.03***	0.01**	0.39
s^{US} and s^{IND}	0.09***	-0.01***	0.43
s^{US} and s^{JAP}	0.07***	0.02***	0.54
s^{EZ} and s^{IND}	0.03***	0.05***	0.45
s^{EZ} and s^{JAP}	0.05***	0.06***	0.51
s^{IND} and s^{JAP}	0.07***	0.03***	0.37
Currency Markets			
	α_1	α_2	Adj. R^2
$e^{€}$ and $e^{¥}$	-0.55***	-0.53***	0.27
$e^{€}$ and $e^{₹}$	0.37***	0.26***	0.46
$e^{¥}$ and $e^{₹}$	-0.08	-0.91***	0.36
Stock and Currency Markets			
	α_1	α_2	Adj. R^2
s^{US} and $e^{¥}$	0.08***	0.54***	0.22
s^{US} and $e^{₹}$	-0.07***	-0.16***	0.40
s^{US} and $e^{€}$	-0.10***	0.004	0.17
s^{EZ} and $e^{¥}$	0.03**	0.74***	0.21
s^{EZ} and $e^{₹}$	-0.05***	-0.54***	0.57
s^{EZ} and $e^{€}$	-0.22***	0.62***	0.29
s^{IND} and $e^{¥}$	0.04***	0.52***	0.22
s^{IND} and $e^{₹}$	0.003	-0.85***	0.48
s^{IND} and $e^{€}$	-0.004	-0.48***	0.17
s^{JAP} and $e^{¥}$	0.13***	0.40**	0.26
s^{JAP} and $e^{₹}$	-0.08***	-0.56***	0.54
s^{JAP} and $e^{€}$	-0.03**	-0.66***	0.22

Note: *, ** and *** indicate significance at 10%, 5% and 1% respectively. Note: s^{IND}, s^{US}, $e^{₹}$, s^{EZ}, $e^{€}$, s^{JAP} and $e^{¥}$ denote the returns on Indian stock market, U.S. stock market, Rs. Vs. USD exchange rate, Eurozone stock market, Euro vs. USD exchange rate, Japanese stock market and Yen vs. USD exchange rate.

Table 8: Testing for the changes in dynamic conditional correlation during GFC and EZDC

AR-GARCH Specification-I							
	$\rho^{s^{US}s^{EZ}}$	$\rho^{s^{US}s^{IND}}$	$\rho^{s^{US}s^{JAP}}$	$\rho^{s^{EZ}s^{IND}}$	$\rho^{s^{EZ}s^{JAP}}$	$\rho^{s^{IND}s^{JAP}}$	$\rho^{e^{€}e^{¥}}$
Mean Equations							
Constant	0.023***	0.025***	0.023***	0.017***	0.011	0.015***	0.006***
$\boldsymbol{\rho_{t-1}}$	0.972***	0.955***	0.965***	0.973***	0.984***	0.970***	0.968***
$\boldsymbol{DGFC_1}$	-0.003	6.80E-05	0.012**	0.022	0.003	0.002	-0.009***
$\boldsymbol{DGFC_2}$	0.007	0.019**	0.024	0.014**	0.024	0.022**	-0.018***
$\boldsymbol{DGFC_3}$	0.002*	0.004	0.001	0.002	-0.0007	0.004	-0.004***
DEZDC	0.001	0.006*	0.005	0.001	0.003	0.007**	-0.002***
Variance Equations							
Constant	5.34E-06***	4.19E-05***	3.42E-05***	5.66E-05***	8.53E-05***	0.0002***	0.0003
$\boldsymbol{\varepsilon^2_{t-1}}$	-0.009	0.053***	-0.014	0.223***	-0.0002	0.057***	0.045
$\boldsymbol{\sigma^2_{t-1}}$	0.585***	0.600***	0.539***	0.393***	0.130	-0.089	0.231
$\boldsymbol{DGFC_1}$	0.0001	0.0005	2.13E-05	0.001	-4.30E-05	0.0007	5.88E-05
$\boldsymbol{DGFC_2}$	0.0003	0.0001	0.0009	3.33E-05	0.0006	0.0002	0.017
$\boldsymbol{DGFC_3}$	-2.16E-07	0.0001***	3.60E-05**	6.73E-05***	6.53E-06	0.0004***	0.001
DEZDC	5.34E-05***	5.21E-05*	5.81E-05**	0.0002***	0.0002***	-6.63E-05*	0.0004
Q (6)	4.4362	3.006	3.255	3.427	2.928	2.257	8.056
ARCH (6)	0.855	1.823	3.222	1.641	2.969	0.780	2.084

Note: *, ** and *** indicate significance at 10%, 5% and 1% respectively. $s^{IND}, s^{US}, e^{₹}, s^{EZ}, e^{€}, s^{JAP}$ and $e^{¥}$ denote the returns on Indian stock market, U.S. stock market, Rs. Vs. USD exchange rate, Eurozone stock market, Euro vs. USD exchange rate, Japanese stock market and Yen vs. USD exchange rate.

AR-GARCH Specification-II							
	$\rho^{e^{€}e^{₹}}$	$\rho^{e^{¥}e^{₹}}$	$\rho^{s^{US}e^{¥}}$	$\rho^{s^{US}e^{₹}}$	$\rho^{s^{US}e^{€}}$	$\rho^{s^{EZ}e^{¥}}$	$\rho^{s^{EZ}e^{₹}}$
Mean Equations							
Constant	0.011**	-0.002***	0.004**	-0.012**	-0.005**	0.009***	-0.017***
ρ_{t-1}	0.969***	1.019***	0.982***	0.974***	0.982***	0.967***	1.006***
ρ_{t-2}	-	-0.047***	-	-	-	-	0.092
ρ_{t-3}	-	-	-	-	-	-	-0.134**
$DGFC_1$	0.005	-0.003***	0.017	0.006	-0.0008	0.008	0.008***
$DGFC_2$	0.027	-0.017***	0.042	-0.020	-0.026	0.035	-0.024*
$DGFC_3$	0.003	0.0001	-0.007	-0.003	-0.004	-0.004	-0.005*
DEZDC	0.003	0.0004	-0.003	-0.007	-0.011***	-0.006	-0.007
Variance Equations							
Constant	3.33E-05***	8.43E-05*	0.0002***	2.83E-05***	3.03E-05***	0.0003***	2.45E-05***
ε^2_{t-1}	0.123***	0.132	-0.021	0.128***	0.003	-0.019***	0.147***
σ^2_{t-1}	0.696***	0.556***	0.155	0.598***	0.832***	0.197	0.691***
$DGFC_1$	-3.57E-05	-8.49E-05	0.0005	5.28E-05	0.0003**	1.63E-05	-3.38E-05**
$DGFC_2$	0.001	0.003	0.006	0.0006	0.002**	0.002*	0.0002
$DGFC_3$	-1.44E-06	0.0005	0.0009***	0.0001***	-2.41E-05***	0.0008**	1.52E-05
DEZDC	0.0001***	0.0003	0.0003**	0.0003***	9.18E-05***	0.0006**	0.0002***
Q (6)	9.513	4.619	5.144	4.571	7.754	4.607	1.604
ARCH (6)	2.082	3.989	2.304	6.729	4.192	3.137	2.172

Note: *, ** and *** indicate significance at 10%, 5% and 1% respectively. $s^{IND}, s^{US}, e^{₹}, s^{EZ}, e^{€}, s^{JAP}$ and $e^{¥}$ denote the returns on Indian stock market, U.S. stock market, Rs. Vs. USD exchange rate, Eurozone stock market, Euro vs. USD exchange rate, Japanese stock market and Yen vs. USD exchange rate.

AR-GARCH Specification-III							
	$\rho^{s^{EZ}e^{€}}$	$\rho^{s^{IND}e^{¥}}$	$\rho^{s^{IND}e^{₹}}$	$\rho^{s^{IND}e^{€}}$	$\rho^{s^{JAP}e^{¥}}$	$\rho^{s^{JAP}e^{₹}}$	$\rho^{s^{JAP}e^{€}}$
Mean Equations							
Constant	-0.004	0.003*	-0.032***	-0.004	0.007***	-0.014***	-0.003*
ρ_{t-1}	0.984***	0.973***	0.938***	0.981***	0.989***	0.964***	0.977***
$DGFC_1$	-0.006	-0.0007	0.003	-0.012	0.014	0.003***	-0.002
$DGFC_2$	-0.032	0.031*	-0.023***	-0.024	0.034	-0.015***	-0.036*
$DGFC_3$	-0.004	0.009**	-0.017***	-0.003	-0.003	-0.0054***	-0.004
DEZDC	-0.012***	0.005*	-0.008***	-0.007	-0.003	-0.008***	-0.01***
Variance Equations							
Constant	3.09E-05***	-	1.62E-05***	3.18E-05***	0.0002***	4.70E-05*	5.48E-05***
ε_{t-1}^2	0.028**	0.052***	0.288***	0.098***	0.779***	0.123	-0.014**
σ_{t-1}^2	0.836***	0.948***	0.692***	0.783***	0.070**	0.682***	0.864***
$DGFC_1$	0.0001	0.0001**	8.41E-05	0.0002	0.0002	0.0002	0.0002**
$DGFC_2$	0.002**	0.0003	7.55E-05	0.001*	0.002	0.002	0.001**
$DGFC_3$	-2.88E-05***	-4.69E-05***	6.17E-05**	-1.87E-05*	0.0003***	2.16E-05	-4.21E-05***
DEZDC	0.0001***	1.05E-05***	1.89E-05	5.53E-05**	-7.61E-06	0.0002	6.55E-07
Q (6)	6.427	4.281	3.433	4.956	3.189	2.036	6.392
ARCH (6)	3.229	2.721	4.060	5.012	2.801	2.407	3.207

Note: *, ** and *** indicate significance at 10%, 5% and 1% respectively. $s^{IND}, s^{US}, e^{₹}, s^{EZ}, e^{€}, s^{JAP}$ and $e^{¥}$ denote the returns on Indian stock market, U.S. stock market, Rs. Vs. USD exchange rate, Eurozone stock market, Euro vs. USD exchange rate, Japanese stock market and Yen vs. USD exchange rate.

Table 9: Trade and Financial Linkages between India and European, Japanese and U.S. Economies

Panel A: Trade Linkages

Countries/ Region	Share of Imports (% age)	Growth of Imports (2007-08 to 2008-09)	Growth of Imports (Apr-Sept 2008 to Apr-Sept 2009)	Share of Exports (% age)	Growth of Exports (2007-08 to 2008-09)	Growth of Exports (Apr-Sept 2008 to Apr-Sept 2009)
EU (27)	13.5	11.1	-32	20	13.9	-30.4
USA	6	-11.9	-27.5	12.2	2	-25.3
Japan	2.5	24.7	-29.8	1.9	-21.6	-15

Source: DGCI&S, Kolkata (Economic Survey, 2012)

Panel B: Financial Linkages

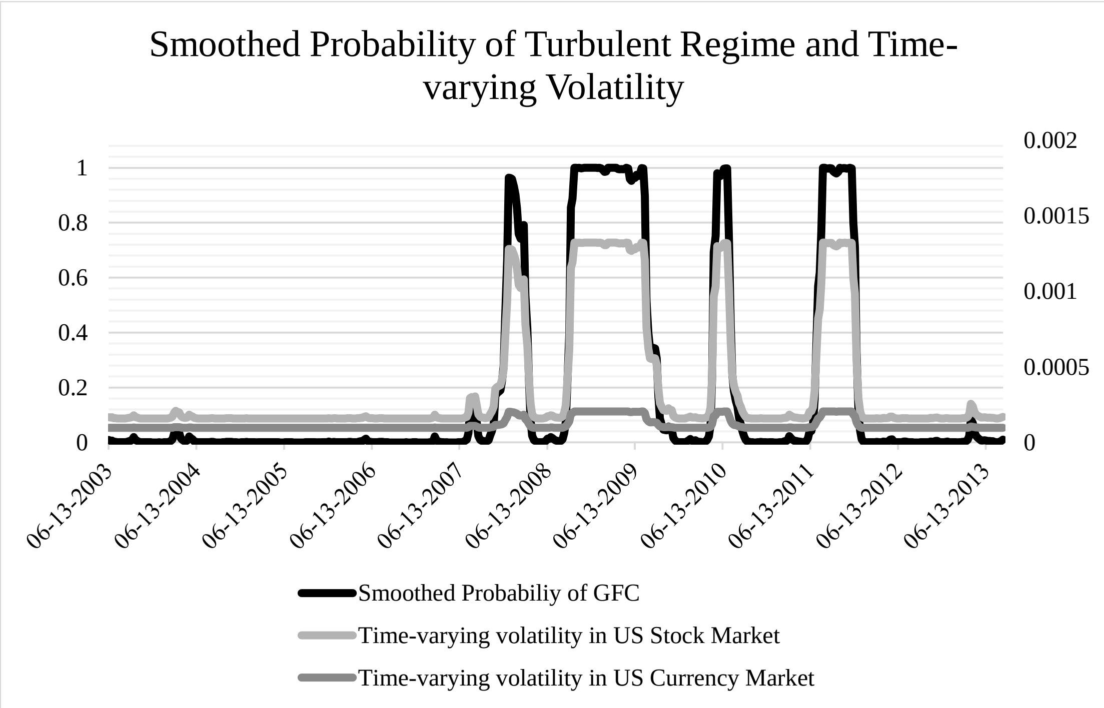
Utilization of External Assistance by Source for India (US$ Million)					
Country/Region	2005-06	2006-07	2007-08	2008-09	2009-10[p]
Japan	615.1	505.4	866.7	1160.5	701.9
USA	11.8	10.3	16	11.3	3.1
Germany	42.9	91.3	61.1	186.7	39
Russian Federation and East European Countries	248.1	326.5	245.4	173.1	152.1

Source: Department of Economic Affairs, Ministry of Finance (Economic Survey, 2012)

FIGURES

Figure 1: Smoothed Probability of the Turbulent Regime, Time-varying volatility and Identification of Crisis Periods from multivariate MSIH models

Figure 1A: U.S. Stock and Currency Markets



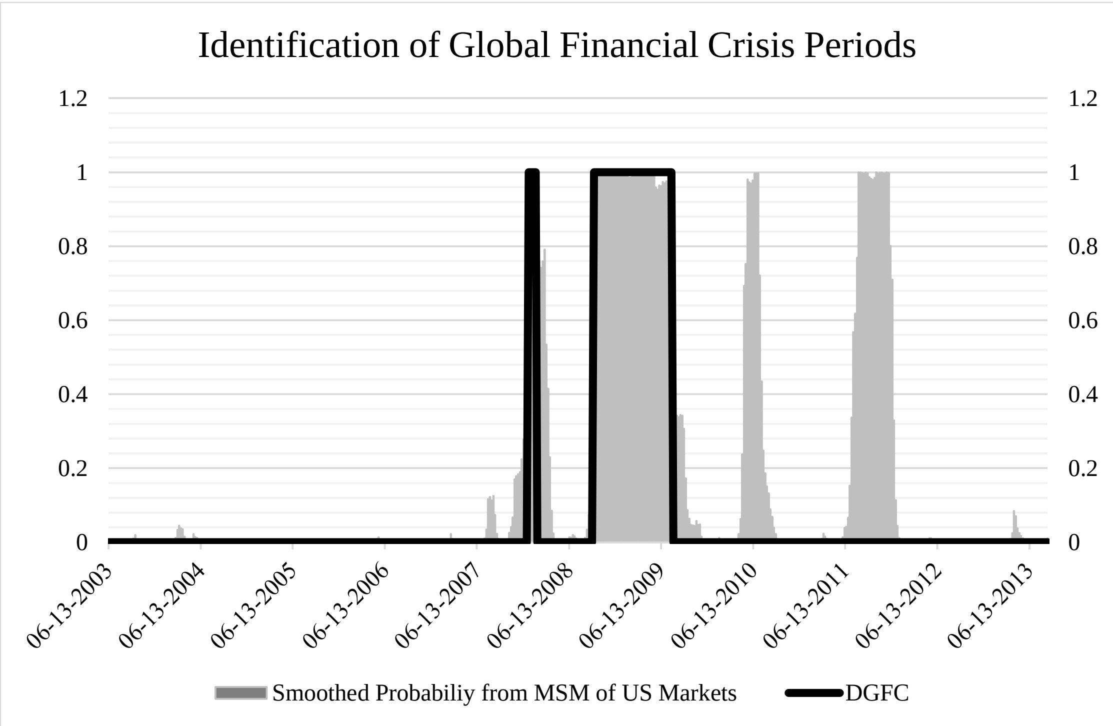


Figure 1B: E.Z. Stock and Currency Markets