Determinants of Time Varying Co-movements among International Stock Markets during Crisis and Non-crisis periods

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Abstract: In this paper, we use the DCC MIDAS approach to assess the validity of the wake-up call hypothesis for developed and emerging markets during the global financial crisis (GFC). We use this approach to decompose the total correlations into short- (daily) and long-run (quarterly) correlations for the period from 1999 to 2011. We then examine the transmission mechanisms by regressing the quarterly economic, financial, and behavioral variables on the quarterly DCC-MIDAS correlations. We find that country specific factors are crisis contingent transmission mechanisms for the co-movements of emerging country pairs and mixed pairs of advanced and emerging countries during the global financial crisis. However, we do not observe wake-up calls in the transmission of the crisis among advanced country pairs. The classification of the transmission mechanisms for crisis and non-crisis periods with the different country pairs has important implications for crisis management as well as for portfolio investment strategies. Thus, our findings contribute to the discussion on the role and effectiveness of the international financial architecture.

Key Words: Stock market Co-movement, Advanced and Emerging markets, Crisis, Transmission mechanisms.

JEL Classification: G01, G11, G12, G15.

1. Introduction

After the global financial crisis, theorists, empirical researchers, and practitioners began to pay increasing attention to the co-movements in the international stock markets. The global financial crisis of 2007 to 2009 has been called the worst crisis since the Great Depression of the 1930s. The crisis erupted in the United States and took on worldwide proportions shortly after the collapse of Lehman Brothers in September 2008, eventually affecting developed as well as emerging countries. The sudden and simultaneous economic turn-downs in many countries around the world triggered important questions about the determinants of co-movements. What are these determinants? And do the co-movements between different equity markets change during a crisis? When there is a crisis in one country, for example the United States, does it serve as a wake-up call to investors in other markets to re-assess the fundamentals? Are the stability and commonality of the determinants of the co-movements during crisis and non-crisis periods especially important? This paper answers these questions by investigating the co-movements of the international stock markets from 190 advanced[2] and emerging countries during the global financial crisis and during the non-crisis periods before and after the global crisis.

Despite the research on the factors driving the co-movements between the United States and other countries (see, e.g., Didier et al., 2010), little exists in the literature on the factors driving the co-movements across the world's equity markets. Van Rijckeghem and Weder (2003) examine volatility spillover through the lending channel of banks and how they contribute to the transmission of a currency crisis. Buchholz and Tonzer (2013) show how using certificates of deposit spreads a high degree of co-movement in sovereign credit risk. From their work on sovereign debt yields, Pagano and Sedunov (2014) show that the risk exposure of weaker nations has a spillover effect on stronger nations' financial systems. However, the research does not address the transmission mechanisms of the interlinkages among the various advanced and emerging markets. Moreover, recent studies demonstrate that emerging markets are more segmented compared to developed markets (e.g., Bekaert et al., 2014; Carrieri et al., 2007; Christoffersen et al., 2012) due to their fundamental characteristics such as size, institutional structure, and geographical location (Forbes and Rigobon, 2002; Carrieri et al., 2007; Christoffersen et al., 2012). Our study fills this research gap by investigating the drivers of the stock markets' co-movements during the global financial crisis and non-crisis periods among three country pairs (advanced-advanced, emerging-emerging, and mixed). We use Goldstein's (1998) "wake-up call" hypothesis and the theoretical work of Ahnert and Bertsch (2013) as the basis for our analysis. King and Wadhwani (1990) argue that due to incomplete information, market participants can be uncertain about the relevance of a financial crisis in one country for the fundamentals of another country. The literature assumes that the problems that cause a crisis in one country are common to a wider group of countries and that a crisis in one country leads to short-run pressures that thus, lead to crises in similar countries. However, the wake-up call hypothesis

[2] See Didier et al. (2010) for the definition of an advanced or developed market. We use the word advanced and developed interchangeably.

argues that a crisis in one country leads to a re-assessment of the fundamentals in other countries. A crisis in one country serves as a wake-up call to market participants in other countries by sending a signal that they should take a closer look at the fundamentals in their own country. If the investors detect any problems, then contagion occurs. This is different from King and Wadwani's (1990) argument that the signal from a wake-up call results in a closer look that removes the uncertainty about the relevance. Goldstein (1998, p. 18) clearly explains a wake-up call as: "I refer to it as a wake-up call because to judge from most market indicators of risk, private creditors and rating agencies were asleep prior to the outbreak of the crisis." Ahnert and Bertsch (2013) show in their theoretical model that contagion occurs even if investors learn later that the fundamentals have no correlation ex post and that common links do not exist.

The empirical work on the wake-up call hypothesis is very limited. Karas et al. (2013) examine crisis induced wake-up calls in terms of how they interact with the numbing effect of deposit insurance. Giordano et al. (2013) and Basu (2002) examine wake-up calls in bond markets, Van Rijckenghem and Weder (2003) in bank lending, and Ramirez and Zandenbergen (2013) in the historical context of bank runs. We analyze the wake-up call hypothesis by examining the transmission mechanisms across world stock markets in two ways: First, we examine the stable transmission mechanism or transmission mechanisms of interdependence that do not change in both non-crisis and crisis periods. Second, we investigate the transmission mechanism whose sign and significance only change during crises. These are crisis contingent variables that the market participants become aware of because of the wake-up call. These variables then identify the determinants of the co-movements.

We contribute to the literature by identifying the determinants of time-varying conditional correlations between stock markets during non-crisis and crisis periods. We do so by incorporating different combinations of country pairs. The time-varying nature of the co-movements is widely documented (e.g., Hamao et al., 1990; Bekaert and Harvey, 1995; Longin and Solnik, 1995, 2001; Caporale et al., 2005; Bekaert et al., 2009).[3] The common message from these studies is that the co-movements in the international stock market have changed over time due to globalization and liberalization. There are some studies on international financial markets (see, e.g., Corsetti et al., 2005; Chiang et al., 2007; Samarakoon, 2011) that address co-movements during crises. Among them, Samarakoon (2011) reports that US shocks drive interdependence, and emerging markets drive contagion. In brief, few studies that investigate the determinants of co-movements are silent regarding the stability and commonality of the transmission mechanisms among the country pairs (see Bracker and Koch, 1999; Carrieri et al. 2007; Wälti, 2011; Christoffersen et al. 2012). In particular, researchers are still silent about the country specific factors that make countries vulnerable to a crisis after a wake-up call and the exact mechanisms through which these factors are transmitted at any given time.

Further, this paper addresses the wake-up call hypothesis by combining high frequency (daily) data on the stock markets with low frequency (quarterly) economic and financial data for the period from 1999 to

[3] The studies are done mostly in mature markets except Bekaert and Harvey (1995) and Caporale et al. (2005).

2011. We use the Dynamic Conditional Correlation (DCC) model coupled with the Mixed-Data Sampling (MIDAS) approach of Colacito et al. (2011) to decompose the total correlations into daily and quarterly correlations. Thereafter, we use a panel regression for quarterly correlations of the economic and financial variables to investigate the transmission mechanism. The MIDAS framework was first introduced by Andreou and Ghysels (2004) and Ghysels et al. (2006) to allow data with different frequencies to enter into the same empirical model. Engle and Rangel (2008) apply this technique to the GARCH framework to form the spline GARCH model. Combining the spline GARCH framework and the volatility-decomposing approach (see Ding and Granger, 1996; Engle and Lee, 1999; Bauwens and Storti, 2009; Amado and Teräsvirta, 2013), Engle et al. (2013) creates the GARCH-MIDAS model to incorporate macroeconomic information into the long-run variance component. Conrad and Loch (forthcoming) use the GARCH-MIDAS framework to decompose stock returns into short- and long-run components to examine the long-run volatility component. Baele et al. (2010) and Colacito et al. (2011) apply the MIDAS technique to Engle's (2002) DCC model to decompose the co-movement of stocks and bonds into short- and long-run components. Further, Conrad et al. (2014) and Asgharian et al. (forthcoming) extend the DCC-MIDAS model by allowing the macro-finance variables to enter the long-run component of the correlations. To the best of our knowledge, the current study is the first to use the DCC MIDAS framework to test the validity of the wake-up call hypothesis. The dependent variable, pairwise conditional correlations of stock returns is estimated using short run-daily data and thus is very useful in testing the main research question, the wake-up call hypothesis.

We show that economic, financial, and cultural factors become important during crisis periods and that they also vary across developed and emerging country pairs. The results of our study support the wake-up call hypothesis and have an implication for macroeconomic policy during a crisis. Our results show that the conditional correlation is usually significantly higher for all country pairs during a global crisis compared to non-crisis periods, except for the advanced market pairs. When we study the transmission mechanisms in relation to the country specific variables, we observe that the transmission mechanism between a country pair is not always stable during crisis and non-crisis periods among the three country pairs. We show that a number of economic and financial factors (e.g., different market sizes, different inflation rates, different GDP growth rates, total trade size, different term spreads) and behavioral factors (e.g., similarity in religion, and cultural differences) drive cross-country co-movements in the equity markets. These factors are stable across crisis and non-crisis periods for advanced country pairs. However, the GDP growth rate and the term spread are crisis contingent variables for the mixed country pairs. We also find that bilateral trade and culture are additional wake-up call proxies for the emerging country groups. We further confirm that common religion[4] is the most stable transmission mechanism in the interdependence between stock markets.

The remainder of the paper is organized as follows: section 2 presents the data and method used in this paper; section 3 discusses the main empirical results; and section 4 concludes the paper.

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[4] Religion is a fundamental measure of social norms (see, e.g., Lucey and Zhang, 2010).

2. Data and Method

We use the MSCI daily US dollar denominated indices for 20 (ten advanced and ten emerging) stock markets for the period from 1999 to 2011. The indices are extracted from the Thomson Financial DataStream. The developed countries are Australia, Canada, France, Germany, Hong Kong, Italy, Japan, Sweden, the United Kingdom, and the United States. The emerging countries are Argentina, Brazil, Chile, China, India, Indonesia, Korea, Malaysia, Russia, and South Africa. We consider the frequently traded markets in the sample to get rid of thin trading bias. Because we are not focusing on the source country of the crisis, we choose only the major advanced and emerging countries with available long-term data series. As noted earlier, we arrange the three country pairs as advanced-advanced, emerging-emerging, and mixed with both developed and emerging markets. Further, we only examine the crisis period considering global financial crisis (GFC), that is, the period from 2007q4 to 2009q4.[5] The rest of the period is defined as non-crisis. We collect the economic and bilateral trade data from the IMF's Direction of Trade Statistics and the World Bank's development indicators. We also use Hosftede's (1994) cultural dimension score and culture index is calculated by using Kogut and Singh's (1988) procedures. Hofstede (1994) defines culture as the collective programming of the mind that affects people's attitude, behavior, and decisions. The variables used to construct the index are based on Kogut and Singh (1988), and Hosftede's cultural dimensions include different perspectives of the environment that people live and work in. Hosftede describes these dimensions in many ways such as individualism (see for example, Hirshliefer and Thakor, 1992), masculinity (see for example, Gleason et al., 2000), power distance (see for example, Delong and Smenov, 2002), and uncertainty avoidance (see for example, Riddle, 1992). It is important to note that we have added Hosftede's two other new dimension scores, such as long-term versus short-term orientation and indulgence versus restraint. Inflation, bilateral trade and cultural dimension variables have some missing values during the research period. The detailed descriptions of the variables are in Appendix 1.

2.1 The model

We use Colacito et al.'s (2011) version of the multivariate DCC-MIDAS model where the conditional covariance between the stock returns of $\text{country}_{\text{i}}$ and $\text{country}_{\text{j}}$ is given as:

$$q_{\text{ij},t} = \bar{\rho}_{\text{ij},t}(1-a-b) + a\xi_{\text{i},t-1}\xi_{\text{j},t-1} + bq_{\text{ij},t-1}, \tag{1}$$

where $\bar{\rho}_{ij,t}$ is the long-term component of the correlation defined as:

$$\bar{\rho}_{\text{ij},t} = \sum_{k=1}^{K} \varphi_k(w_1, w_2)\, C_{\text{ij},t-1} \tag{2}$$

$$C_{\text{ij},t} = \frac{\sum_{k=t-N}^{t} \xi_{\text{i},k}\xi_{\text{j},k}}{\sqrt{\sum_{k=t-N}^{t} \xi_{\text{i},k}^2}\sqrt{\sum_{k=t-N}^{t} \xi_{\text{j},k}^2}}, \tag{3}$$

where $\xi_{\text{i},t}$ and $\xi_{\text{j},t}$ are the standardized residuals from the univariate GARCH-GJR model. The $C_{\text{ij},t}$ is the realized correlation between the countries' stock returns $\xi_{\text{i},t}$ and $\xi_{\text{j},t}$ in the previous period.

[5] We follow Ahmed et al. (2012) and Mobarek et al. (2014) who consider the global financial crisis as from 2007q4 to 2009q4 because BNP Paribas ceased all of its banking operations on 9 August 2007.

The weighting scheme used in Eq. (2) is described by a beta lag polynomial:

$$\varphi_k(w_1, w_2) = \frac{\left(k/K\right)^{w_1-1}\left(1-k/K\right)^{w_2-1}}{\sum_{j=1}^{K}\left(k/K\right)^{w_1-1}\left(1-k/K\right)^{w_2-1}}, k = 1, \ldots, K. \quad (4)$$

The K indicates the number of lags used in the MIDAS. We use $K = 16$ quarters[6] in this paper. The correlations can then be computed as:

$$\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t+1}q_{jj,t}}}, \quad (5)$$

Following Engle (2002) and Colacito et al. (2011), we estimate the parameters by using a quasi-maximum likelihood method. The DCC-MIDAS model involves a large number of parameters, and it does not always converge to a global optimum through the conventional optimization algorithms. Therefore, we use the simulated annealing approach for the estimation (Goffe et al., 1994).

Further, the study by Bekaert et al. (2014) concludes that during the GFC, country specific factors matter. Therefore, we add the country specific determinants of the time-varying correlations during crisis and non-crisis periods and across country pairs by using the regression model described below (Eq. 6). We first investigate whether the determinants of the stock markets' co-movements are economic, financial, or cultural by using the panel data specification that allows for time fixed effects to control for common international shocks (Wälti, 2011). We estimate the base line regression as:

$$\begin{aligned}\rho_{i,j,t} = \alpha_0 + &+\beta_1 GDP\ Growth_{i,j,t} + \beta_2 Inflation\ Difference_{i,j,t} + \gamma_1 Bilateral\ Trade_{i,j,t} \\ &+ \gamma_2 Market\ Size_{i,j,t} + \gamma_3 Term\ Spread_{i,j,t} + \delta_1 Culture_{i,j,t} + \delta_2 Religion_{i,j,t} \\ &+ \lambda Crisis + \varepsilon_{i,j,t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(6)\end{aligned}$$

where $\rho_{i,j,t}$ is the z Fisher transformation of quarterly DCC-MIDAS correlation between country$_i$ and country$_j$ at time t, $GDP\ Growth_{i,j,t}$ is the absolute difference between the quarterly growth rate of real GDP between country$_i$ and country$_j$ at time t, $Inflation\ Difference_{i,j,t}$ is the absolute difference between the quarterly inflation rate between country$_i$ and country$_j$ at time t, $Market\ Size_{i,j,t}$ is the relative market size differential between country$_i$ and country$_j$ at time t, $Term\ Spread_{i,j,t}$ is the term spread between the 10-year government bond yield and the 3-month interbank rate between country$_i$ and country$_j$ at time t, $Bilateral\ Trade_{i,j,t}$ is the average bilateral trade size between country$_i$ and country$_j$ at time t, $Culture_{i,j,t}$is the difference in the cultural index between country$_i$ and country$_j$ at time t, $Religion_{i,j,t}$ is the religious commonality between country$_i$ and country$_j$, $Crisis$ is the crisis dummy for 2007q4-2009q4, and $\varepsilon_{i,j,t}$ is the error term. We classify the GDP growth and inflation rates as economic variables; the relative market size, bilateral trade, and term spread as financial variables; and culture and religion as behavioral variables. We estimate equation 6 first in the full sample and then for crisis and non-crisis periods separately.

2.2 Results

[6] We used Monte Carlo simulations to determine the number of lags for the weighting scheme we use in estimating pairwise conditional correlations in stock returns. We use the lag with the highest maximum likelihood value.

In Figure 1.1 we present the short and long-run correlations at the aggregated level for the advanced-advanced, emerging-emerging, and mixed country pairs. This figure demonstrates time-varying co-movements that differ among the three country pairs during the GFC quarters. Further, we randomly choose three pairs from each country pair. Figure 1.2 shows that the correlation for the advanced countries (e.g., France and the United Kingdom) is greater than 0.80, whereas for the mixed country pairs (e.g., Germany and Russia), the correlation is near 0.80 and in the emerging country pairs (e.g., India and Malaysia) the correlation is even lower at around 0.60. These results show that the correlation for the advanced countries is greater in range, but for the mixed country pairs, the correlation is more volatile, and also for the emerging country pairs. This is in line with the findings of Christoffersen et al. (2012) who report similar findings after applying a copula correlation (range of the correlation) to advanced and emerging country pairs in general. But their paper does not examine crisis and non-crisis periods separately. However, the change in the correlation from the GFC to the non-crisis periods among the country pairs is interesting because the changing patterns are not consistent. However, the GFC shows a clear pattern of change (volatility) mostly for the emerging and mixed country pairs. This finding motivates us to test whether the transmission mechanisms of the co-movements among different country pairs differ during the GFC.

[Insert Figure 1.1 and 1.2 about to be here]

Table 1 (panels A and B) presents the descriptive statistics for the average quarterly pair-wise correlations when using the DCC MIDAS. The sample comprises 190 country pairs of which 45 are advanced-advanced, 45 are emerging-emerging, and 100 are mixed country pairs. The results show that in general the aggregated conditional correlation is higher in the GFC than in the non-crisis periods. Panel A presents the results of the Z transformation of the conditional correlations for the GFC and non-crisis periods for different country pairs. The conditional correlation (mean) for the full sample is 0.38 (all years), but the conditional correlation is significantly higher during the GFC (0.44) than in the non-crisis periods (0.35). Similarly, the conditional correlations (mean) for the advanced-advanced pairs are different from the GFC (0.64) and non-crisis periods (0.58). The same is true for the emerging-emerging pairs (0.45 vs. 0.27) and the mixed country pairs (0.48 vs. 0.29), respectively. The pattern is consistent when we consider the median conditional correlation for all three periods (the full period and the GFC and non-crisis period), which are 0.32, 0.47, and 0.29, respectively. Similarly, the median conditional correlations for the advanced-advanced countries are smaller in the non-crisis periods (0.49) than the GFC (0.54). Further, the median conditional correlation for the emerging-emerging countries during the GFC (0.48) is larger than for the non-crisis periods (0.22). Meanwhile the mixed country pairs have a higher median conditional correlation during the GFC (0.46) than the non-crisis periods (0.27). Thus, we observe a higher mean and median conditional correlation during the GFC than during the non-crisis periods that indicates the correlation co-movements significantly vary between the GFC and the non-crisis periods irrespective of the country pairs. However, we find that although the advanced countries possibly have a higher correlation in magnitude because of higher globalization, we observe that the change in this correlation during the GFC is not higher in the advanced country pairs than in the emerging and mixed country pairs. The T-test shows that there are significant differences among advanced-advanced, emerging-emerging, advanced-emerging, and emerging-advanced. These differences indicate that the impact of the GFC differs for different country pairs.

Panel B presents the descriptive statistics for the explanatory variables (economic, financial and behavioral). We use a t-test on the economic and financial factors to show whether the mean difference between the GFC and the non-crisis periods is time invariant. We find that these explanatory variables increase during the GFC except for the relative market size, which has an insignificant t-value. This result indicates that the relative size of the individual market's capitalization to the world market's capitalization does not significantly decline during the GFC.

[Insert Table 1 to be about here]

We find that the absolute difference in the GDP growth rate's differential is higher (0.57%) during the GFC than during the non-crisis periods (0.54%). Further, as expected, we find that the average inflation rate's differential is much higher (-0.38) during the GFC than during the non-crisis periods (-0.53). This difference is not statistically different from our findings for the average relative market size of 0.70 for the GFC and 0.85 for the non-crisis periods. The average bilateral trade size is lower (3.41%) in the non-crisis periods compared to the GFC (4.03%). This result might be due to margin calls or portfolio rebalancing during the GFC. The average term spread's differential (as a proxy for market stress from illiquidity) is also higher during the GFC (0.62%) than during the non-crisis periods (0.30%). The significant t-statistics also show that the difference in the term spread is higher in the GFC than in the non-crisis periods. This finding suggests that during the GFC, the country specific term spread also increases, which indicates a liquidity problem. Nonetheless, we find (the results are not reported here but can be provided on request) an average religion commonality of 0.21, which is higher in the advanced market pairs compared to the mixed and emerging pairs. Similarly, as expected, we also find evidence that the bilateral average cultural difference is higher in the mixed pairs than in the advanced and emerging pairs.

3. Analysis and Discussion

We investigate whether the transmission mechanisms of different country pairs differ between the GFC and the non-crisis periods. We classify the country specific determinants of co-movement as economic (e.g., difference in GDP growth rates, difference in inflation rates), financial (e.g., the amount of bilateral trade, difference in the stock market's relative size, difference in term spreads), and behavioral (e.g., difference in culture and similarity in religion) variables. Tables 2-5 present the regression results for the full sample from the advanced-advanced, emerging-emerging, and mixed pairs. Table 2 reports the results for the determinants of the conditional correlations to analyze whether they vary during the GFC and the non-crisis periods for the full sample. Column 1 presents the results for the full sample, column 2 for the non-crisis periods, and column 3 for the GFC. Overall, the coefficient estimates for the GDP growth rate and inflation rate's differentials are negative (significant) for both periods. This finding indicates that the lower the difference between the two countries, the higher the co-movement between the pair. These results are consistent with Bracker and Koch (1999) and Johnson and Soenen (2002) who report that similar economic structures synchronize business cycles and market co-movements through diversification stages.

Further, we find that the coefficient estimate for bilateral trade is positive and consistent with the studies by Forbes and Chinn (2004) and Lucey and Zhang (2010), who also report a positive relation between bilateral trade size and stock market co-movement. If two countries have a strong bilateral trade relationship, then their economies and stock markets should be highly interdependent (Wälti, 2011). The empirical literature on the role of financial fundamentals in the business cycle synchronization is somewhat mixed. Bordo and Helbling (2004) conclude that financial fundamentals do not affect the synchronization, but Imbs (2004, 2006) and Kose et al. (2003) show that the integration of financial fundamentals positively impacts the synchronization. We also use the differences in term spreads and the relative size of the stock markets as determinants of the stock markets' co-movement. The coefficient estimate for the term spread's differential between the country pairs is significant for the full sample as well as for both the non-crisis periods and the GFC. The interpretation of the findings might be that a rise in the term spread also reduces co-movement. This interpretation supports the findings from Bekaert et al. (2014) that might be explained by differences in the dependence on liquidity or risk aversion. This variable identifies the aggregate financing implications of the liquidity problem in the financial markets. However, in general, the coefficient estimate for the stock market's relative size is negatively significant. This result for the size difference indicates that when the sizes of the stock markets in two countries of a country pair are similar, the time-varying correlations between those markets are higher. An explanation could be that to the extent the equities of a given country are extensively held internationally, a fall in that country's stock market initiates a negative wealth effect for asset holders around the world. Thus, this effect influences consumer demand and, in turn, output co-movements that then eventually increase co-movement via the business cycle synchronization. On the other hand, the international diversification of portfolios permits persistent consumption patterns without having to diversify production that leads to the possibility of greater specialization that reduces co-movement and to a positive relationship. We find that the indicator (relative) of the financial market's development is consistently significant (negative). This finding indicates that stock markets of similar size provide higher co-movement between pairs.

Further, we consider the behavioral fundamentals of the stock markets' co-movements. The coefficient estimate for the culture variable is negative and significant and indicates that the smaller the cultural difference between the country pairs, the higher the time-varying correlations. Aggarwal et al. (2012) and Lucey and Zhang (2010) use a cultural variable to explain the international portfolio flows and argue that cultural distance acts as a proxy for transaction costs, information asymmetries, and lower levels of familiarity, as well as the existence of agency problems that tend to make foreign investors shy away. We observe that during the GFC, the cultural distance variable becomes highly significant with larger coefficients that indicate the GFC transmits through behavioral factors. We use a religion dummy in the regression model. The coefficient estimates for the religion variable are positive and significant for all country groups. Our results indicate that when the country pairs have a shared religion, the time-varying correlations are higher. Lucey and Zhang (2010) argue that having the same religion represents a perceived similarity of culture and risk tolerance. We also assume that a similar religion among country pairs should be a proxy for a similarity in belief systems, which affect investor attitudes, behaviors and, ultimately, decisions.

Overall, our results in the full period for the economic, financial, and behavioral factors for the market co-movements are consistent with the literature. We do not observe any pattern of crisis contingent variables that change during the crisis. This finding might be because we have a combination of three kinds of country pairs with different market characteristics. Nevertheless, we find that the GFC dummy is highly and significantly positive that indicates the GFC increases the co-movement significantly among markets. The trends are also significant and indicate that the co-movement pattern increases over time perhaps due to integration and globalization.

[Insert Table 2 to be about here]

Table 3 reports the results for the determinants of the time-varying correlations for advanced country pairs during the non-crisis periods and the GFC. The results are similar to the full period except that the GFC dummy is insignificant. This result indicates that the GFC does not increase the co-movement within the advanced country pairs and thus the transmission mechanism is the same for both periods.

[Insert Table 3 to be about here]

Table 4 reports the results for the determinants of the time-varying correlations for the emerging country pairs during the non-crisis period and the GFC. The coefficient estimates for the GDP growth rate's differential is insignificant during both periods. However, the coefficient estimates for the inflation rate's differential and the stock markets' co-movement are negative but significant for the non-crisis periods. The inflation differential transmits shocks during the non-crisis periods, but not during the GFC. This result also supports the wake-up call hypothesis that investors reassess the economic fundamentals. Therefore, the fundamental negative relationship we expect between inflation differences and co-movements does not persist. The most interesting result is that the bilateral trade, which was insignificant during the non-crisis periods, becomes negatively significant during the GFC for the emerging market pairs. This might be due to portfolio rebalancing and the flight to quality to advanced market pairs. These findings are consistent with the negative trade impact during a crisis that Buchholz and Tonzer (2013) find in the CDS markets. Similar to the advanced market pairs, the coefficient estimates for religious similarity are positively (significant) related to co-movements during both periods. Thus, we can define this as a transmission mechanism of interdependence. Further, the coefficients for the cultural distance variable become highly significant during the GFC but are insignificant during the non-crisis periods. This finding indicates that investors reassess the country specific factors during the GFC and that behavioral factors matter. The coefficient estimates for the term spread's differential is nonsignificant for the emerging market pairs, but the relative market size is significant (negative) during both periods. Overall, our results indicate that the GFC dummy is highly significant in the emerging market pairs. Furthermore, the crisis contingent transmission mechanisms in the emerging markets are the inflation differential, bilateral trade's differential, and the cultural difference. These results support the findings of Buchholz and Tonzer (2013) on the CDS market's wake-up call contagion. The findings are also in line with the study by Van Rijckeghem and Weder (2003) who view the Russian crisis in 1998 as the outcome of a wake-up call to emerging markets.

[Insert Table 4 to be about here]

Table 5 reports the results for the determinants of the conditional correlations for the mixed country pairs during the non-crisis periods and the GFC. The coefficient estimates for the GDP growth rate's differential are positive but only significant during the GFC. This finding supports the wake-up call hypothesis and again might be due to margin calls and portfolio rebalancing during the crisis where investors exhibit a flight to quality to advanced countries. The coefficient estimates for the inflation rate's differential and the stock market's co-movement in the mixed pairs are negative (significant) for the non-crisis periods and become insignificant during the GFC. This finding indicates that the investors' reassessment of the fundamental economic variables during the crisis signals a wake-up call contagion. The coefficient estimates for bilateral trade are insignificant during both periods and indicate that the bilateral trade between the mixed country pairs are not linked to the co-movement in the mixed country pairs.

The coefficient estimates for the term spread's differential are insignificant during the non-crisis period and become positively significant during the GFC. This change also indicates the reassessment by the investors. The coefficient estimates for the stock markets' size differential are positive and significant during both crisis and non-crisis periods. This might be due to mixed country pairs with higher relative size differences. Because emerging markets might be significantly smaller in size in terms of market capitalization, it would be unusual for these markets to be in tandem with the other markets (Johnson and Soenen, 2002). This is also in line with the empirical study conducted by Carrieri et al. (2007) who assume a positive relationship between market development indicators and the economic integration of stock markets. Similar to the GDP growth rate, the term spread's differential is also a crisis contingent variable for the mixed country pairs. The coefficient for the difference is positively related to the co-movement during the GFC. This coefficient might be because investors prefer more liquid markets during a crisis. As expected, the coefficient estimates for the cultural distance variable and market co-movement are insignificant during both periods because the mixed country pairs represent investors with different cultural dimensions. The coefficient estimates for the religion variable are positive (significant) during both periods that indicate that country pairs with a similar religion have higher correlation coefficients.

[Insert Table 5 to be about here]

Thus our results show that investors behave differently during GFC that implies a change in the transmission mechanism during a crisis and, therefore, an increase in cross-market linkages after a shock hits the economy. These results are robust to alternative estimation techniques.[7]

4. Conclusions

This study is the first to use the DCC MIDAS approach to assess the validity of the wake-up call hypothesis for developed and emerging markets during the global financial crisis. When we examine the transition mechanism by regressing quarterly economic and financial variables on the quarterly DCC MIDAS correlations, we observe that the transmission mechanism among the country groups is not always stable during the GFC and the non-crisis periods. The dependent variable, pairwise quarterly conditional correlations of stock returns, is estimated using short run-daily data which is suitable in testing the main research question, the wake-up call hypothesis. We report that our results support the effect of the wake-up call during the GFC. We observe that the differences in bilateral trade and culture are crisis contingent determinants for the emerging country pairs and the GDP growth rate, inflation, and term spread are crisis contingent variables for the mixed country pairs. These determinants support the wake-up call hypothesis. However, religion acts as a stable and common driving force for all country pairs in both periods, which we term a transmission mechanism of interdependence. The findings however do not generalize to all crises, and they could be researched further as to whether it differs among different crises. The evidence of stable cross-market linkages suggests that the policy makers of the countries affected by a negative shock should take measures to improve their fundamentals to ensure financial stability. Further, portfolio investors or speculators should diversify and pursue arbitrage opportunities. However, the evidence of unstable cross-market linkages and, therefore, of shocks even when the fundamentals are sound might suggest the appropriateness of IMF interventions and bailouts and the need for adequate liquidity to survive contagions. Finally, the portfolio managers and investors need to know about the different mechanisms by which co-movements spread among the country pairs so they can make appropriate investment decisions. Policy makers also need to know about the mechanisms for the co-movements and their changes for appropriate policy decisions; otherwise, if they do not take these differences into account, they might do worse rather than better.

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[7] We use the two-step system GMM approach adopted by Arellano and Bover (1995) and Blundell and Bond (1998) for endogeneity tests in Eq. (6). This approach allows us to treat all of the explanatory variables as endogenous, and orthogonally uses their past values as their respective instruments. It also creates a matching equation of the first differences for all variables and estimates the model via the GMM by using the lagged values of the right-hand side variables. The results are robust, and hence are not reported.

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Table 1: Descriptive Statistics

This table reports the descriptive for the dependent and explanatory variables for the full period (1999q1-2011q4), the GFC (2007q4-2009q4), and the non-crisis periods (1999q1-2007q3; 2010q1-2011q4).

Variables	Sample Description	N	Mean	STD	Skewness	Kurtosis	P50	T test of Mean difference between crisis and non-crisis
Panel A: Dependent Variable								
DCCMIDASCORRZ	Full Sample	9880	.379	.283	1.647	7.315	.317	
DCCMIDASCORRZ	Non-Crisis Full sample	8170	.351	.273	1.775	7.993	.288	
DCCMIDASCORRZ	Crisis-Full sample	1710	.439	.193	1.436	6.415	.467	21.362***
DCCMIDASCORRZ	Non-crisis (AA)	1935	.575	.366	1.402	5.276	.489	
DCCMIDASCORRZ	Crisis (AA)	405	.636	.435	.912	3.304	.543	5.822***
DCCMIDASCORRZ	Non-crisis (EE)	1933	.267	.188	1.153	4.298	.222	
DCCMIDASCORRZ	Crisis (EE)	405	.446	.184	.665	3.151	.484	17.449***
DCCMIDASCORRZ	Non-crisis (Mixed)	4302	.291	.221	1.132	4.552	.274	
DCCMIDASCORRZ	Crisis (Mixed)	900	.479	.175	.654	4.334	.455	20.070***
Panel B: Explanatory Variabels								
Economic Variables								
GDP Growth	Full Sample	9721	.549	.557	-.862	4.462	.630	
GDP Growth	Non-crisis	8013	.544	.562	-.808	4.389	.618	
GDP Growth	Crisis	1708	.576	.530	-1.142	4.887	.679	2.203**

Inflation	Full Sample	9828	-.508	1.267	-.985	5.705	-.353	
Inflation	Non-crisis	8127	-.534	1.277	-.914	5.624	-.3884	
Inflation	Crisis	1701	-.381	1.210	-1.370	6.328	-.3170	4.523***
Financial Variables								
Market Size	Full Sample	9880	.826	3.339	-.088	2.999	.962	
Market Size	Non-crisis	8170	.852	3.355	-.095	2.988	1.018	
Market Size	Crisis	1710	.702	3.256	-.056	3.053	.755	(-1.692)
Bilateral Trade	Full Sample	7291	3.935	1.176	.007	2.922	3.865	
Bilateral Trade	Non-crisis	5923	3.412	1.177	.019	2.954	3.833	
Bilateral Trade	Crisis	1368	4.031	1.170	.039	2.795	4.028	3.376***
Term spread	Full Sample	7556	.366	1.413	2.059	78.130	.480	
Term spread	Non-crisis	6017	.302	1.436	2.677	91.617	.483	
Term spread	Crisis	1539	.616	1.288	-1.031	5.298	.723	7.832***
Behavioral Variables								
Religion	Full Sample	9880	.211	.408	1.420	3.017	0	NA
Culture	Full sample	9708	1.964	1.065	.697	3.512	1.818	NA

Note: The t-test tests for the differences between the mean crisis and non-crisis periods. The *** , ** , and * indicate significance at the 1, 5, and 10% levels respectively. Crisis indicates the GFC crisis period (2007q4-2009q4), and NA represents not applicable. DCCMIDASCORRZ is the Z transformation of the DCC MIDAS quarterly correlation. GDP Growth represents the absolute differences in the GDP growth rates, inflation represents the absolute differences between two countries ; Bilateral trade presents the average amount of export and import between two countries; Market size represents the average differences in market capitalization differences between two markets compared to world market capitalization; Term Spread represents the absolute differences between the 10-year government bond yield and the 3-month short-term interbank rate between two countries. AA represents advanced to advanced, EE represents emerging to emerging, and Mixed represents country pairs between advance to emerging and emerging to advance stock markets.

Table2: Determinants of stock market co-movement (full period country pairs) during crisis and non-crisis periods.

This table presents the results when the determinants change during the full sample. The dependent variable is the pair-wise Z transformation of DCC MIDAS conditional correlation. The ***, **, and * indicate significance at the 1, 5, and 10% levels respectively. GDP Growth represents the absolute differences in the GDP growth rates;, Inflation represents the absolute differences between two countries; Bilateral trade presents the average amount of export and import between two countries; Market size represents the average differences in market capitalization differences between two markets compared to world market capitalization; Term Spread represents the absolute differences between the 10-year government bond yield and the 3-month short-term interbank rate between two countries.

	Full Sample	Non-crisis	Turbulent
VARIABLES	Estimate	Estimate	Estimate
	(std error)	(std error)	(std error)
GDP Growth	-0.093***	-0.100***	-0.062***
	(0.007)	(0.008)	(0.016)
Inflation	-0.032***	-0.033***	-0.027***
	(0.003)	(0.004)	(0.007)
Bilateral Trade	0.053***	0.057***	0.039***
	(0.003)	(0.004)	(0.008)
Market Size	-0.010***	-0.010***	-0.009***
	(0.001)	(0.001)	(0.002)
Term spread	-0.022***	-0.020***	-0.033***
	(0.005)	(0.006)	(0.007)
Culture	-0.028***	-0.024***	-0.041***
	(0.003)	(0.004)	(0.008)
Religion	0.076***	0.070***	0.095***
	(0.008)	(0.009)	(0.019)
Trend	0.006***	0.006***	0.014***

	(0.000)	(0.000)	(0.003)
GFC crisis dummy	0.050***		
	(0.010)		
Constant	0.022	0.005	-0.269
	(0.019)	(0.021)	(0.192)
Number of countries	190	190	190
Observations	5,622	4,417	1,205
R-squared	0.270	0.290	0.178
F statistics	161.27***	146.39***	23.39***

Table 3: Determinants of stock market co-movement (advanced to advanced country pairs) during crisis and non-crisis periods.

This table presents the results when the determinants change during the crisis period for the advanced to advanced country pairs. The dependent variable is the pair-wise Z transformation of the DCC MIDAS conditional correlation. The ***, **, and * indicate significance at the 1, 5, and 10% levels respectively. GDP Growth represents the absolute differences in the GDP growth rates; inflation represents the absolute differences between two countries; Bilateral trade presents the average amount of export and import between two countries; Market size represents the average differences in market capitalization differences between two markets compared to world market capitalization; Term Spread represents the absolute differences between the 10-year government bond yield and the 3-month short-term interbank rate between two countries.

	Full Sample	Non-crisis	Turbulent
VARIABLES	Estimate	Estimate	Estimate
	(std error)	(std error)	(std error)
GDP Growth	-0.153***	-0.155***	-0.140***
	(0.014)	(0.015)	(0.041)
Inflation	-0.060***	-0.058***	-0.064***
	(0.007)	(0.007)	(0.017)
Bilateral Trade	0.152***	0.150***	0.145***
	(0.008)	(0.008)	(0.024)
Market Size	-0.051***	-0.051***	-0.046***
	(0.003)	(0.003)	(0.009)
Term spread	-0.040***	-0.028***	-0.116***
	(0.006)	(0.006)	(0.023)
Culture	-0.034***	-0.032***	-0.046***
	(0.006)	(0.006)	(0.017)
Religion	0.087***	0.074***	0.135***
	(0.014)	(0.014)	(0.039)
Trend	0.008***	0.008***	0.027***
	(0.000)	(0.000)	(0.008)
GFC crisis dummy	0.006		
	(0.024)		

Constant	-0.458***	-0.430***	-1.537***
	(0.041)	(0.043)	(0.470)
Number of countries	45	45	45
Observations	1,886	1,572	314
R-squared	0.458	0.471	0.421
F statistics	142.42***	128.32***	28.29***

Table 4: Determinants of stock market co-movement (emerging to emerging country pairs) during crisis and non-crisis periods.

This table presents the results when the determinants change during the crisis for the emerging to emerging country pairs. The dependent variable is the pair-wise Z transformation of the DCC MIDAS conditional correlation. The ***, **, and * indicate significance at the 1, 5, and 10% levels respectively. GDP Growth represents the absolute differences in the GDP growth rates; inflation represents the absolute differences between two countries; Bilateral trade presents the average amount of export and import between two countries; Market size represents the average differences in market capitalization differences between two markets compared to world market capitalization; Term Spread represents the absolute differences between the 10-year government bond yield and the 3-month short-term interbank rate between two countries.

	Full Sample	Non-crisis	Turbulent
VARIABLES	Estimate	Estimate	Estimate
	(std error)	(std error)	(std error)
GDP Growth	-0.061***	-0.062***	-0.053**
	(0.012)	(0.013)	(0.021)
Inflation	-0.014***	-0.014**	-0.006
	(0.005)	(0.006)	(0.011)
Bilateral Trade	-0.005	0.001	-0.023**
	(0.005)	(0.006)	(0.012)
Market Size	-0.006***	-0.005***	-0.011***
	(0.001)	(0.001)	(0.003)
Term spread	0.004	0.002	-0.003
	(0.005)	(0.006)	(0.013)
Culture	-0.007	0.006	-0.048***
	(0.006)	(0.007)	(0.012)
Religion	0.100***	0.073***	0.150***
	(0.016)	(0.018)	(0.031)
Trend	0.009***	0.010***	0.010**
	(0.001)	(0.001)	(0.004)
GFC crisis dummy	0.060***		
	(0.013)		
Constant	-0.058	-0.112***	0.143

	(0.037)	(0.040)	(0.245)
Number of Countries	45	45	45
Observations	959	707	252
R-squared	0.376	0.420	0.249
F statistics	64.05***	58.00***	9.24***

Table 5: Determinants of stock market co-movement (mixed country pairs) during crisis and non-crisis periods.

This table presents the results when the determinants change during the crisis for the mixed country pairs. The dependent variable is the pair-wise Z transformation of the DCC MIDAS conditional correlation. The ***, **, and * indicate significance at the 1, 5, and 10% levels respectively. GDP Growth represents the absolute differences in the GDP growth rates; Inflation represents the absolute differences between two countries; Bilateral trade presents the average amount of export and import between two countries; Market size represents the average differences in market capitalization differences between two markets compared to world market capitalization; Term Spread represents the absolute differences between the 10-year government bond yield and the 3-month short-term interbank rate between two countries.

	Full Sample	Non-crisis	Turbulent
VARIABLES	Estimate	Estimate	Estimate
	(std error)	(std error)	(std error)
GDP Growth	0.006	-0.001	0.048***
	(0.009)	(0.011)	(0.018)
Inflation	-0.014***	-0.018***	0.002
	(0.004)	(0.004)	(0.008)
Bilateral Trade	0.003	0.007	-0.006
	(0.004)	(0.005)	(0.008)
Market Size	0.003***	0.002*	0.006**
	(0.001)	(0.001)	(0.002)
Term spread	0.004	0.000	0.026***
	(0.003)	(0.003)	(0.007)
Culture	-0.002	-0.002	0.004
	(0.004)	(0.004)	(0.007)
Religion	0.089***	0.090***	0.087***
	(0.009)	(0.010)	(0.018)
Trend	0.007***	0.007***	0.019***
	(0.000)	(0.000)	(0.003)
GFC crisis dummy	0.046***		
	(0.010)		
Constant	0.050**	0.043	-0.633***
	(0.025)	(0.027)	(0.204)
Number of countries	100	100	100

Observations	2,777	2,138	639
R-squared	0.202	0.214	0.102
F statistics	83.08***	65.93***	10.38***

Figure 1.1: The short and long DCC MIDAS correlations at the aggregated levels of three country groups

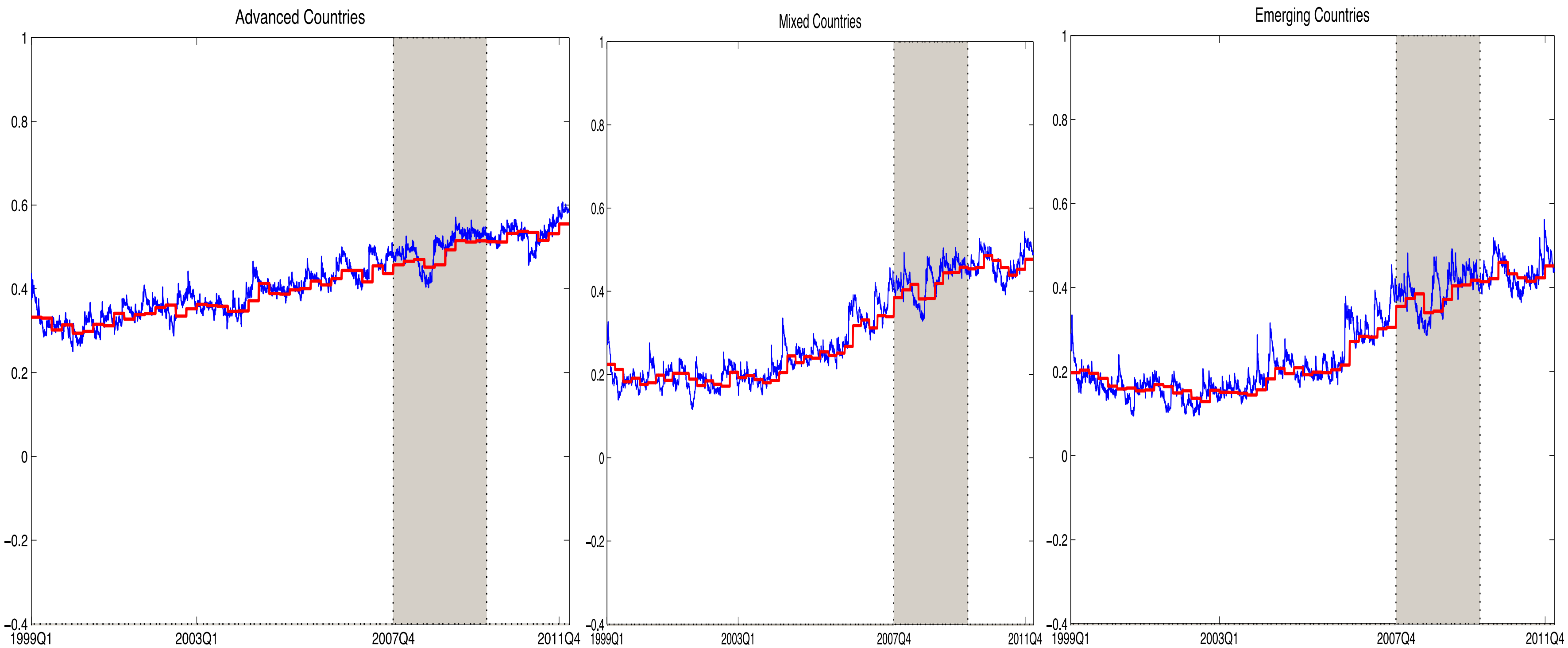
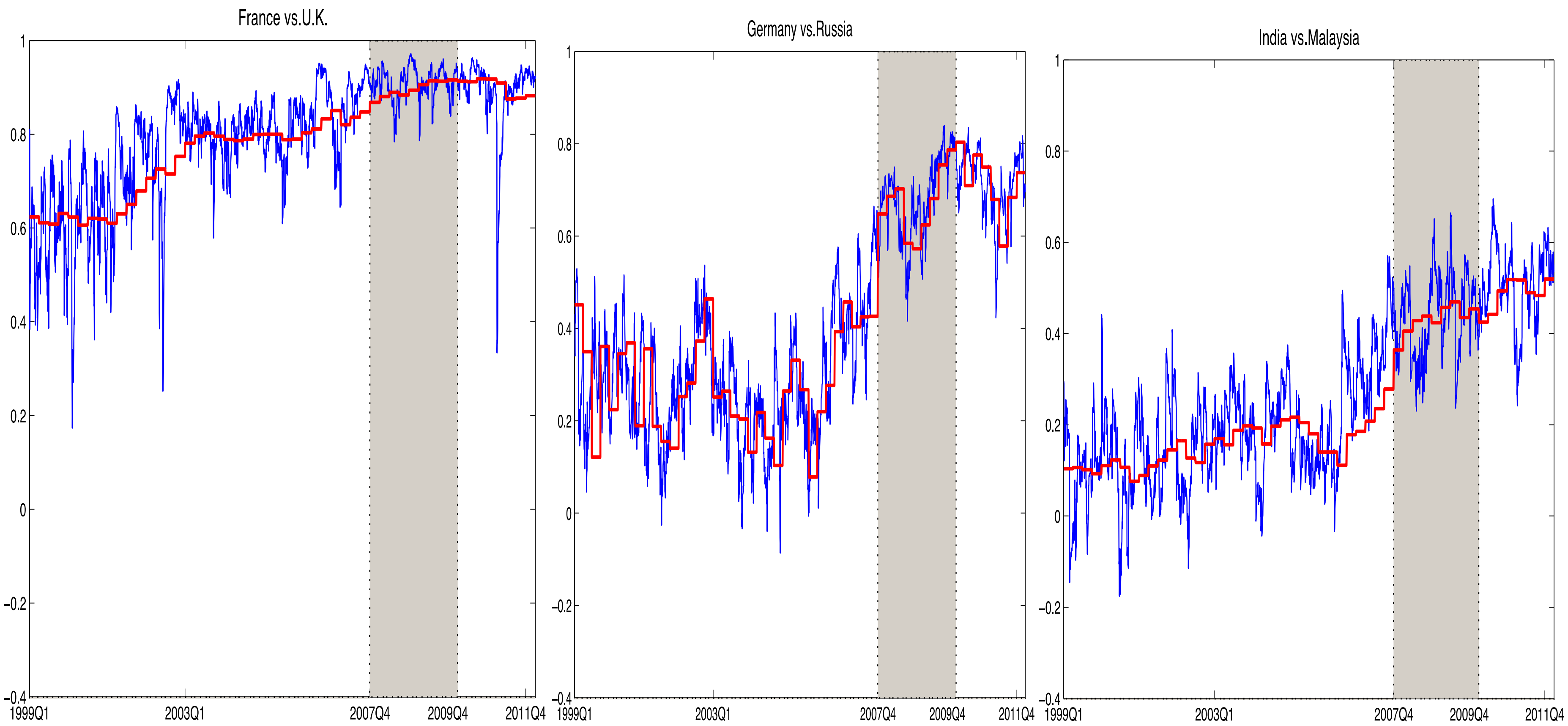


Figure 1.2: The short and long DCC MIDAS correlations for chosen countries



Appendix 1: Variable Definitions

Name of the variables (Proxy)	Definition
Panel A: Dependent Variable: Conditional Correlation	
Conditional correlation (DCC_MIDASCORRZ)	The Conditional Correlation is converted to the Fisher Z transformation between country pair i and j. The time-varying conditional correlation is calculated by using the DCC MIDAS model. We then use the Fisher Z transformation to adjust for the potential problem of non-normality with this analysis. The $\dot{\rho}_{ij}= \frac{1}{2} ln \left[\frac{1+\rho ij}{1-\rho ij}\right]$, ρij is the sample correlation, $\dot{\rho}$is is the transformed value of ϱ_{ij}, and ln is the natural logarithm. Related References: Colacito et al. (2011) and Beine and Candelon, 2011. Data Source: Datastream.
Panel B: Explanatory Variables: Economic	
GDP growth	This is defined as the absolute difference between the quarterly growth rate of real GDP between countryi and country. Log transformation of the quarterly GDP growth rate's differential between country pair i and j. The LnGDP(i-j)t = Ln[(gi-gj)t] between country i and j.. Related References: Johnson and Soenen (2002). Data Source: World bank (Quarterly).
Inflation	Absolute Inflation rate differential between markets i and j calculated from quarterly consumer price indices. Ln Inflation rate differential = Ln[(πi-πj)t]. Related References: Johnson and Soenen (2002). Data Source: World bank (Quarterly consumer price indices).
Panel C: Explanatory Variables: Financial	
Bilateral trade	This is the average amount of bilateral trade between country pair i and j. Quarterly bilateral trade between pair countries= [{(Xij /Xi)+(Xji /Xj)}+{(Mij /Mi)+(Mji /Mj)}] /4. Mi = total import of i; Mj = total Import of j; Xi = total import of i; M j = total import of j; where ij refers to from country i to country j, Ji refers to from country j to country i. Related References: Forbes and Chinn (2004) and Lucey and Zhang(2010). Data Source: Data stream, DOT (Quarterly)
Market size	Relative market size difference between country pair i and j. The Ln[(MVj/MVi] size differential between pair countries $[(size_i\text{-}size_j)_t]$; where size i =Mcapi/world MCAP; and where size j =Mcapj/world MCAP. Related References: Bracker et al. (1999) and Johnson and Soenen (2002). Data Source: Datastream (Quarterly).
Term Spread	This is the term spread difference between country pair i and j. This is the Ln(term Spread difference) where term spread =(long-term 10-year government bond yield to the 3-month interbank rate). Related References: Christoffersson et al.(2012). Data Source: Datastream (Quarterly).
Panel D: Explanatory Variables: Behavioral	
Culture	This is the bilateral cultural distance between country pair i and j. This is calculated as follows: $KS_{ij} = \sum_1^6 [(ICi - ICj)^2 /Vc]/6$, where KSij is the cultural distance between country i and country j. The Ici is the score for the cth cultural dimension of country i, Icj is the score for the cth cultural dimension of country j, and Vc is the variance in the cth cultural dimensions across all countries in sample. The larger the KS measure, the greater the cultural distance between country i and country j. We use Hosftede's development of the six factor dimension scores. Related References: Lucey and Zhang (2010) and Kogut and Singh (1988). Data Source: http://geerthofstede.nl/dimensions-of-national-cultures (Quarterly dummy).
Religion	Religion similarity dummy between country pair i and j. Religious commonality (1 for the same in both countries and 0 if they differ). Related References: Lucey and Zhang (2010). Data Source: Author's own calculation (Quarterly dummy).