# Spillover Effects of the Recent Financial Crisis on Selected Emerging Markets vs. Developed EU Markets

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# ABSTRACT

This thesis examines the existence of interdependencies and dynamic correlation behaviour among the selected emerging and developed stock markets during tranquil and turbulent periods to provide an empirical analysis and comparison of the spillover effects of the recent global financial crisis (GFC) and the European sovereign debt crisis (ESDC) using two different data sets. In the first part, the spillover effects on fast growing emerging economies and the developed markets that resulted from the global financial crisis is investigated. The emerging economies are represented by BRIC-Turkey plus three CEE markets (an acronym used to describe Brazil, Russia, India, China, Turkey and three emerging central European countries, namely the Czech Republic, Hungary, and Poland). The developed markets are represented by the UK, Germany, and France – hereafter the EU3. To measure the impact of the global financial crisis on these countries, the US stock price index is used. In addition to this, to precisely account for indirect transmissions and the regional factor in emerging economies, the EUROSTOXX50 (EU) index, which includes the 50 "blue chip" companies operating in twelve advanced European countries, is included as a proxy for Eurozone.

Since the operating hours among the above markets are different, a weekly stock market index from Wednesday to Wednesday is used in order to minimise the cross-country differences and the end-of-week effect for each country for the period of 3 January 2001 to 13 November 2013. All of the stock prices are obtained from Thomson Reuters Datastream Professional in dollar terms (as a

common currency) to account for the local inflation rate. A multivariate GARCH framework is used in studying the correlation spillovers between each country with the US and EU indexes and to capture the time-variability of the conditional correlations, a dynamic structure is included by using the DCC model of Engle (2002).

The empirical results suggest that the EU3 stock markets are less affected when compared to the emerging markets because there was already higher market interdependence between the EU3 and the USA before the crisis. Second, the emerging markets have not been affected as immediately as the EU3 countries, although the effects have been more long-lasting albeit not permanent, falling as from 2013. Third, the EU index has a significant and greater volatility impact on BRIC-Turkey as compared to the crisis-originating country, the USA. However, the three CEE markets felt more impact from the USA. This is because the correlation between the three CEE markets and the EU index was already high, even before the GFC period. Fourth, we noted the dynamic evolution of the CEE markets have considerably changed and become more volatile from 2009 until the end of the sample, although they experienced a short calming period during the third quarter of 2011 due to ECB and IMF intervention, before then starting to increase again. Therefore, the impacts of the European sovereign debt crisis (ESDC) were stronger on the CEE markets than on BRIC-Turkey.

Consequently, the second part of this thesis will investigate the degree to which the three CEE markets have been affected by the hard-hit GIPSI (Greece, Ireland, Portugal, Spain and Italy) countries and by the EU3. We include the EU3 in order to understand whether the spillover effect is greater within crisis

borne countries or the EU3, which have more trade and financial ties with the three CEE countries. It is worth mentioning that the GFC resulted in the ESDC that broke out in 2009. Accordingly, the second part of this thesis examines the impacts of the ESDC and compares the post-ESDC period to the GFC period. Daily data in local currency is used from 3 May 2004 to 22 November 2013, involving splitting it into three sub-samples: pre-crisis (stable) period, GFC period, and ESDC/post period.

Applying the same methodology as that used in the first part, the results are as follow. First, comparing the correlation to the pre-crisis (stable) period, there are substantial spillover effects during the GFC and ESDC; however, the impacts are felt more during the GFC. In addition to this, during the GFC the spillover effect is observed from all of the countries, unlike during the ESDC period. Second, due to strong trade and financial linkages, we found consistent strong market interdependences between EU3 and the CEE markets. Third, among the three CEE countries, the stock market of Poland showed a significantly higher level of average conditional correlation with EU3 when compared to Hungary and the Czech Republic. Fourth, the EU3 have a higher level of average correlation as compared to GIPSI, among the GIPSI countries, Spain and Italy have higher levels of correlations with the three CEE countries. Fifth, out of all the markets, Portugal remains the most contagious market (i.e. highest spillover effect) during both the GFC and the ESDC periods to all of the three CEE countries. Among the CEE markets, the most affected market is the Czech Republic. Finally from the policy perspective the study argues that policymakers should focus on improving fundamentals in order to enable them mitigate the shock.

**Keywords:** Conditional Correlations, DCC-GARCH, Interdependence, Spillover effect, Contagion, Emerging markets, developed markets.

# ÖZ

Bu tezde, iki farklı veri seti kullanılarak, durgun ve kriz dönemleri için seçilmiş yükselen ve gelişmiş ülkelerin hisse senedi piyasaları arasındaki bağımlılık ilişkisi ile dinamik korelasyon davranışları incelenmek suretiyle bu piyasalara küresel finansal krizin (GFC) ile Avrupa devlet borç krizinin yayılma etkisis ampirik olarak incelenmekte ve kıyaslanmaktadır. İlk kısımda, küresel finansal krizin yayılma etkisi hızlı büyüme gösteren yükselen ekonomiler ile gelişmiş ekonomiler için araştırılmıştır. Yükselen ekonomiler, BRIC-T (Brezilya, Rusya, Hindistan, Çin ve Türkiye) ile CEE (Orta Doğu Avrupa ülkeleri, ismen, Çek Cumhuriyeti, Macaristan ve Polanya) ile temsil edilmiştir. Gelişmiş ülkeleri temsilen ise İngiltere, Almanya ve Fransa (EU3) hisse senedi piyasaları incelenmiştir. Sözkonusu ülkelere küresel finansal krizin yayılma etkisinin ölçülmesinde ise ABD hisse senedi endeksi kullanılmıştır. Ayrıca, çalışmada krizin örneklenen yükselen ekonomilere dolaylı iletimi ve bölgesel etkenin göz önüne alınabilmesi bakımından, Avrupa bölgesini temsilen on iki gelişmiş Avrupa ülkesinde faaliyet gösteren 50 “blue chip” firmalarına ait EUROSTOXX50 (EU) endeksi kullanılmıştır. Veri olarak 3 Ocak 2001 ile 13 Kasım 2013 dönemi için araştırma konusu ülkeler arasındaki çalışma saatı farklılığı ile hafta sonu etkisinin arındırılması maksadı ile Çarşamba’dan Çarşamba’ya haftalık hisse senedi endeksleri kullanılmıştır. Tüm veriler ABD Doları cinsinden ve ‘Thomson Reuters Datastream Professional’ veri tabanından sağlanmıştır. Örneklenen her bir ülkenin hisse senedi getirisi ile ABD ve EU endeksi getirileri arasındaki korelasyona bağlı olarak krizin yayılma etkisisnin incelenmesinde zaman etkisinin de dahil edilmesi bakımından çoklu GARCH

yaklaşımı için Engle'in (2002) Dinamik Koşullu Korelasyon (DCC) modeli kullanılmıştır. Ampirik bulgulara göre, gelişmiş Avrupa ülkeleri (EU3) piyasaları yükselen piyasalar kıyasla küresel finansal krizden daha az etkilenmişlerdir: bu ülkelerle ABD piyasaları arasında kriz öncesinde de zaten yüksek bağımlılık ilişkisi bulunmaktaydı. İkinci olarak, yükselen piyasa ekonomileri EU3 ülkeleri gibi küresel finansal krizden hemen etkilenmemekle birlikte, etki uzun süreli olup ancak 2013 yılından itibaren azalma eğilimine girmiştir. Üçüncü bulgu ise Avrupa endeksi hareketlerinin BRIC-T piyasalarında, krizin çıktığı ülke ABD endeks hareketlerine kıyasla daha etkili olduğudur. Ancak Avrupa'daki üç CEE ülkesi piyasaları ABD'den kaynaklanan krizden oldukça etkilenmişlerdir; CEE ülkeleri piyasa endeksleri ile Avrupa (EU) endeks getirileri arasındaki korelasyon kriz öncesinde de oldukça yüksek seyretmektedir. Dördüncüsü, CEE piyasa endeksleri ile olan dinamik korelasyon yapısı önemli derecede değişim göstererek 2009 itibari ile daha oynak bir seyir izlemiştir. Dolayısı ile hernekadar Avrupa Merkez Bankası ile IMF'nin müdahaleleri sonucunda 2011 yılının üçüncü çeyreğinde geçici olarak bir rahatlama gözlenmişse de CEE ülkeleri piyasalarında Avrupa devlet borç krizinin BRIC-T ülkelerine kıyasla daha etkili olduğu önemli bir diğer bulgu olarak görülmektedir. Buna bağlı olarak, çalışmanın ikinci bölümünde, üç CEE ülkesi, krizin yayılmasında krize neden olan GIPSI (Yunanistan, İrlanda, Portekiz, ispanya ve İtalya) ile gelişmiş Avrupa ülkelerinden (EU3) ne derece etkilendikleri incelenerek karşılaştırılmıştır; küresel finansal kriz sonucunda 2009 yılında ortaya çıkan Avrupa krizinin yayılmasında CEE ülkeleri ile daha yakın ticaret ve finansal bağları olan EU3 ülkeleri mi yoksa krizin ilk çıktığı GIPSI ülkeleri mi daha etkili olmuştur. İkinci kısımda, ülkelerin kendi para

birimleri cinsinden ve günlük veri kullanılarak 3 Mayıs 2004 – 22 Kasım 2013 dönemi kriz öncesi (durgun dönem) küresel finansal kriz dönemi ve Avrupa krizi/sonrası olmak üzere üç ayrı alt örnek olarak incelenmiştir. Tahmin sonuçları, kriz öncesi durgun döneme kıyasla, küresel finansal kriz ve Avrupa krizi dönemlerinde ortalama korelasyon katsayılarındaki yüksek artış ile krizin yayılma etkisinin yüksek olduğunu, ancak, küresel finansal krizin Avrupa krizine kıyasla daha belirgin olduğunu ortaya koymuştur. Ayrıca, küresel finansal kriz döneminde, Avrupa krizi döneminin aksine, krizin yayılma etkisi tüm ülkelerde görülmüştür. İkinci bulgu, yakın ticari ve finansal bağı olan CEE ve EU3 ülkeleri arasında daha yüksek bağımlılık ilişkisidir olduğu yöndedir. Üçüncü olarak, CEE ülkeleri arasında EU3 ülkeleri ile en yüksek ortalama korelasyon katsayısı Polonya hisse senedi için tahmin edilmiştir. Diğer yandan, GIPSI ülkeleri arasından CEE ülkelerini en çok etkileyen İspanya ve İtalya'nın olduğudur. Son olarak, hem küresel kriz hem de Avrupa krizi dönemlerinde en bulaşıcı piyasanın Portekiz olduğu, CEE ülkeleri arasında da en çok etkilenen Çek Cumhuriyeti piyasası olduğudur. Çalışmada, ayrıca, krizin etkilerinin hafifletilmesi için makroekonomik temel göstergelerin geliştirilmesinin gerekli olduğu vurgulanmaktadır.

**Anahtar Kelimeler**: Koşullu korelasyon, DCC-GARCH, bağımlılık, yayılma etkisi, bulaşma, yükselen piyasalar, gelişmiş piyasalar.

# DEDICATION

To My Family

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| | |
|---|---|
| ADF | Augmented Dickey-Fuller |
| AIC | Akaike information criteria |
| ARCH | Autoregressive conditional heteroscedasticity |
| BIS | Bank for International Settlement |
| BRIC | Brazil, Russia, India, China |
| CEE | Czech Republic, Hungary, Poland |
| DCC | Dynamic conditional correlation |
| ESDC | European sovereign debt crisis |
| EU3 | UK, Germany, France |
| EU INDEX | EUROSTOXX50 |
| EGARCH | Exponential generalised autoregressive conditional heteroscedasticity |
| FED | Federal Reserve Bank of St. Louis |
| GARCH | Generalised autoregressive conditional heteroscedasticity |
| GFC | Global financial crisis |
| GIPSI | Greece, Ireland, Portugal, Spain, Italy |
| GJR | Glosten-Jagannathan-Runkle |
| QE | The Ljung-Box statistics on level standardized returns |
| $QE^2$ | The Ljung-Box statistics on squared standardized returns |
| VAR | Vector Autoregression |

# Chapter 1

# INTRODUCTION

## 1.1 Research Background and Motivation

The global financial crisis, which started as the result of the subprime mortgage crisis in the summer of 2007 and triggered by the collapse of Lehman Brothers in 2008, quickly spread globally and thus energized researchers, decision makers to debate on the policy implications, severity across countries, and possible solutions. A central and important question remains regarding who should be blamed for originating and triggering the crisis, although most tend to agree that this was due to the absence of sound regulations to protect savers and lenders, agreement on the part of the corporate banking elite to loot lump sums from the financial markets through fraud, and the outright untruthfulness of credit agencies concerning the inherent risk to the public.

Indeed, the global financial crisis (GFC) cost the USA trillions of dollars and, understanding the need for intervention, the US government responded with hash fiscal and monetary expansionary policies in order to stabilise both the economy and the financial market. Additionally, it came up with the biggest ever stimulation programme, which was worth more than one trillion to bring about the recovery by bailing out any banks exposed to bankruptcy and at risk of collapsing. With the turmoil taking place in the most powerful world economy, the catastrophe was quick

to spread across countries, contracting real economy activity and triggering capital flight. In particular, the impact was severely felt in European countries due to the excessive financial interconnectedness and strong trade ties with the USA.

Numerous of studies have documented how the European economies felt the impact of the GFC the most due to at least three reasons. First, some of the major European financial institutions, such as the German banks and other European banks, had direct exposure to the US sub-prime mortgages and so, during the first phase of the GFC, the European banks continued to extend credit without carefully considering the creditworthiness of their customers (Lapavitsas et al. 2010). Second, credit expansion and asset price increases just prior to the crisis were also common phenomena in many crisis hit countries, including the United Kingdom, Spain, Ireland, East European countries, and some other advanced economics (Claessens et al. 2010). Third, the European Union is composed of countries that have balance of payments problems such as high current account deficits and high debts (e.g. Arghyrous and Kontonikas 2012).

The above-mentioned points all contributed to creating and triggering the European sovereign debt crisis (ESDC), which began in late 2009. It is worth remembering that the GFC and ESDC both led to a reduction in employment opportunities, created record high inequality, lowered the demand for goods, and ultimately reduced exports and imports. Equally, stock markets across the involved countries experienced one of the most difficult trading times in history, recording tremendous financial losses and causing loss of confidence among investors. Therefore, it remains important for international investors, institutional and corporate investors

and financial managers to determine which emerging markets provide lower correlation with the developed markets (The USA and EU) during such turmoil.

## 1.2 Objectives of the Study

By now, it is well-documented in the existing literature that the global financial crisis has had a devastating impact on the economic growth of many advanced economies, while the emerging economies have been less affected. However, the impacts of the global financial crisis on the stock markets of developed countries and emerging markets remain ambiguous. Given the importance of studying the transmission mechanism for policy implication (for effective policy making) it is important to understand how the shocks are quickly spread globally. Therefore, the first part of this thesis will investigate the extent to which the global financial crisis affected the developed markets (as represented by the three largest European countries, namely the UK, Germany, France; hereafter, the EU3) and emerging stock markets (as represented by Brazil, Russia, India, China, Turkey, Czech Republic, Hungary and Poland; hereafter BRIC-Turkey plus the three CEE countries). Are the impacts of the GFC temporary or permanent across developed and emerging markets? Also, are the selected emerging markets directly affected by the crisis originating country (the USA) or indirectly through the European index (EU index)?

In the second part of this thesis, we investigate the spillovers from the hard-hit crisis countries, the GIPSI (Greece, Ireland, Portugal, Spain and Italy) and the EU3, to the three CEE (Czech Republic, Hungary and Poland) markets. We included the EU3 because these countries have strong financial and trade ties with the three CEE markets and to understand whether the impacts are felt more in these countries. In addition, in these sections we compare the spillover effects of the GFC and ESDC by

dividing the sample study into three. Comparing the two crises is important since the GIPSI experienced high volatility beginning from the GFC period and continuing during the ESDC period. This comparison in the second part will help in understanding which of these crises was more severe on the three CEE markets.

## 1.3 Contributions and Methodology of the Study

This thesis contributes to the existing literature in three ways. First, this study provides a comparion of the impacts of GFC with those of EU crisis on fast growing emerging markets. This is important as these emerging markets have been attracting large captal inflow both from the US and EU markets. Second, the study also considers identifying whether the GFC has had a greater impact on advanced countries than on emerging economies. Third , it compares the spillover effects of the ESDC with those of the GFC on the three CEE markets, which will help in understanding the regional role involved in transmitting the crisis. For this purpose it will investigate how the conditional correlations changed during the Eurozone crisis between the most affected markets, the GIPSI, the largest EU3 markets, and the three CEE countries. we used is the multivariate GARCH framework to study the correlation spillovers between pairs of crisis originating markets and the crisis hit countries to account for the time-variability of the conditional correlations, and a dynamic structure is included by using the DCC model of Engle (2002). Finally, the data concerning the stock markets cover up to present time, which will assist in determining whether there is a long-term or short-term impact of the GFC.

## 1.4 Findings and Structure of the Study

The empirical research revealed very important findings. First, the results showed that the impact of the GFC on the stock market of emerging countries is much greater

when compared to the advanced market. Evidence of this can be seen in the fact that the conditional correlations for the advanced countries have been high the whole time, while for the emerging markets the correlations almost doubled during the GFC period. Second, during the GFC/post period, the EU index has had a greater impact on BRIC-Turkey, whereas the US index (S&P 500) has had a greater impact on the three CEE markets. The EU index already had higher levels correlations with the CEE, even before the GFC period. However, with the US, the correlations have increased drastically during the GFC/post period. Third, we observed substantial spillover effects to the emerging CEE markets during both the GFC and ESDC periods, although the impacts were felt more during the GFC period. In addition, during the GFC period the impacts were felt from all of the countries. Interestingly, during the ESDC period, we did not observe contagion in the CEE markets from the Greek market, which was the most affected country by the Eurozone crisis. Fourth, the CEE markets have higher unconditional and conditional correlations with the EU3 when compared to the GIPSI. This is expected since the CEE countries have greater trade and financial ties with the EU3. Fifth, among the GIPSI markets, Portugal remains the most contagious country. All these findings can be useful for international investors who want to benefit from portfolio diversification and for policy makers in revising the regulation of the financial markets.

The remainder of this thesis is structured as follows. Chapter Two will discuss the contagion theory. Chapter Three will detail the methodology and crisis identification. This is followed by Chapter Four which studies the impacts of the global financial crisis on the selected emerging and the developed stock markets. Chapter Five presents the spillover effects from the GIPSI and EU3 to the three CEE markets

during the GFC and ESDC periods. Finally, Chapter Six will provide a summary of the research and then conclude with policy recommendations.

# Chapter 2

# MARKET INTERDEPENDENCE AND CONTAGION

## 2.1 Definition of Contagion

There is now a large body of empirical and theoretical studies that have investigated the existence of contagion during crisis periods. So far, however, there is no general agreement among academics/researchers on the definition of contagion. The influential work of Forbes and Rigobon (2002) describes contagion as a significant increase in correlations across markets after a shock in one country. Therefore, according to Forbes and Rigobon (2002), the term “contagion” describes the international transmission of crises from one country or a group of countries to an individual country or a group of countries. This types of definition of contagion (Forbes and Rigobon 2002) allows one to distinguish between fundamentals based contagion (non-crisis- contingent or interdependence) and investors-induced contagion (or pure contagion or crisis contingent). This is because, according to this definition, the transmission mechanism doesn’t change for the interdependent markets as shocks are transmitted through real linkages. However in case of pure contagion, investors’ behaviour changes thereby increasing the cross-market co-movements after a shock. The transmission channels are explained in more detail in the following sections. In line with this, Eichengreen et al. (1996) define contagion as the association of excess returns in one country with excess returns in another country after controlling for the effects of fundamentals. Kaminsky and Reinhart

(2000) also define contagion as only arising after accounting for common shocks and controlling for all economic interrelationships. Dornbusch et al. (2000) define contagion in a broad sense, as the spread of disturbances across markets that can be observed in co-movements of exchange rates, stock markets, capital flows and sovereign default swap.

## 2.2 Crisis Contingent Channels

Generally, crisis contingent channels are a behavioural or temporary state of affairs that result from the fact that investors' appetite for risk assets changes during the crisis period. As masson (1999) explains, investors expectation shift the ecoomy from good equilibrium to bad equilibrium which is also called "pure contagion" or "shift contagion" (see Kaminski, Reinhart & Vegh, 2003).This type of contagion can be avoided, and policy tools are instrumental in curbing the related impacts see Pesaran and Pick, (2007).

The term "pure contagion" is more commonly found in the financial economies literature, particularly in studies that focus on stock market volatility transmission and spillover among stock markets during turmoil. Generally, during periods of crisis, international investors' appetite for investments declines due to herding behaviour and/or a desire to rebalance their portfolio (Masson 1999; Flavin et al. 2008). The phrase "herding behaviour" most commonly appears in the finance literature due to its importance, and it refers to investors following other investors in selling stocks. Furthermore, pure contagion could also be the result of the investor-induced contagion hypothesis (rebalancing of the portfolio). This type of contagion occurs because of the liquidation of stocks held by foreigners in one country in order

to meet their margin requirements in a different country that has been hit by a shock. Boyer, Kumagai and Yuan (2006) showed that a relatively high rate of foreign holdings of domestic assets may be leading to investor-induced contagion. The authors empirically demonstrated that foreign investor holdings have been particularly instrumental in spreading the Asian crisis by using data for emerging and developed markets. From the above examples, it is clear that pure contagion does not require real links or market interdependence in order to occur.

## 2.3 Crisis Non-Contingent Channels

Crisis non-contingent channels work through real links such as trades. The type of contagion is also called fundamentals-based contagion, which is characterised by the fact that the transmission mechanism can appear during both crisis and non-crisis periods(Calvo & Reinhart, 1996). This is because macroeconomic variables among countries are interrelated, and often there is a dynamic interrelationship. Therefore, the contagion that arises as a result of the fundamentals-based contagion could have a structural and permanent effect on the market. Pesaran and Pick (2007) argued that if the contagion is due real links then policy intervention is ineffective. There are three main channels that facilitate fundamentals-based contagion: trade, financial, and common shocks or monsoonal effects.

### 2.3.1 Trade channel

Over the last three decades, the world has experienced a series of trade reforms, with the major step being the formulation of the General Agreement on Tariff and Trade (GATT), which stresses reducing tariffs and eliminating measures that hinder the free movements of goods. Equally, there have been more regional and bilateral trade agreements among developed and emerging economies. Such bilateral trade can

significantly transmit crises from one country to others, and it can result in a quantity effect or a price effect or both. Quantity effect refers to the notion that when one country is hit by a shock, it is expected that importation will decline from its trading partner, which is due to the fact that during financial crises household expenditures decline and/or postponed to sometime in the future. Conversely, the price effect is due to currency devaluation that can negatively affect the other trading partner due to the decline of import prices. Both of these effects can have severe impacts on the trade balance of the trading partners (Reside Jr and Gochoco-Bautista 1999; Hail and Pozo 2008). There are also other researches who doucemtned that international trade linkages transmit country-specific crises through stock markets to others in the world see Forbes (2002) . However, as shown in Boyer et al. (2006), trade linkages can only partially explain the reaction of stock markets elsewhere.

### 2.3.2 Financial channel

The financial channel is also a significant channel for transmitting the crisis from the initial crisis-hit country to another. The spillover effects through this channel might be greater than that through trade and common shock because of financial globalisation, which refers to the integration among emerging markets and developed markets. On one hand, financial globalisation has resulted in some benefits, including the opportunity for firms to obtain funds in order to enlarge capacity and boost investment, the ability of lenders to obtain competitive rates in their funds, and the allocation of capital to the most desired place (Charie and Henry 2004; Bekaert et al. 2005; Persade et al. 2003). On the other hand, there is a high cost associated with these benefits, since financial globalisation advocates allowing foreign (international) investors into the domestic market and allowing international firms to be listed in stock markets. Therefore, when one country faces financial turmoil (stock prices go

down), it can spread to other stock markets because international investors may sell their assets, not only in the crisis hit country but also in other stock markets in order to rebalance their portfolios (Calva 1999; Stiglitz 2004). Several authors also argued that financial channel plays an important role in the transmission mechanism. (Kaminski & Reinhart, 2000; Kaminski, Reinhart & Vegh, 2003; Pericoli & Sbracia, 2003 etc.). In line with the above studies Rigobon( 2002) argued that the impact of a crisis might change the structure of financial linkages across markets imposing a permanenet effect on the economy. Moreover, there are studies that examine banking channel and whether financial liberalization can triger crisis. In this regard, Kaminsky & Reinhart (1999) show that financial liberalization increases probability of banking crisis by 40%. They also show that sudden increase in the credit to GDP ratio and boom-bust cycle in stock price leads to crises. Hellmann et al. (2000) reveals that financial liberalization can lead banking industry to take more risk since government stand committed to bailout during the bankruptcy, the banks have an incentive to invest in highly risky assets; in cases they make profit they are free to go but if they lose the burden transfers to government.

### 2.3.3 Common shocks or monsoonal effects

Common shocks refer to the situation where policy changes by the US and European countries have the same impact on other markets, simultaneously making it difficult for international investors to distinguish between markets (Masson 1999). Masson (1999) further defines this link as the presence of crisis in different countries that have similarities in their macroeconomics policy and conditions. Policy changes such as interest rate increase (decrease) in the US and EU normal they do have impact other financial markets.

## 2.4 Definition of Market Interdependence

Market interdependence is defined as the absence of a significant increase in the across-market co-movements after a shock in one country. The existence of strong and dynamic macroeconomic linkages among countries and the growing capital account capitalisation both greatly contribute to the existence of higher market interdependence (Longin and Solnik 1995). In line with this study, Forbes & Rigobon, (2002) report that impact of a financial crisis is the result of existence of strong financial interdependences across markets, not contagion, so effect is only short-term. However, the biggest issue remains how to identify and distinguish between market interdependence and contagion. This is because, so far, there has not been a general agreement on the methodology in use or the appropriate set of control variables (Dungey, Fry, Gonzalez-Hermosillo and Martin 2003).

# Chapter 3

# METHODOLOGY AND CRISIS IDENTIFICATION

## 3.1 Methodology used

In measuring the spillover effects, several methodologies has been used in the literature such as vector autoregressive (VAR) models, cointegration, causality tests, principle components and correlation analysis. (Kenourgios et al. (2013)) However, these methodologies have been criticised by researchers. For example, VAR and cointegration test, there is a problem of capturing the effects precisely and not suitable for high-frequency data. Regarding correlation analysis Forbes and Rigobon, (2002) argued this model does not take into account the problem of heteroscedasticity, endogeneity and omitted variable bias.

Researchers, to overcome these problems, have been using more advanced techniques, including regime-switching models, dynamic copulas with and without regime-switching, dynamic conditional correlation (DCC) models, and nonparametric approaches. For instance, to account for heteroscedasticity, the contagion model must involve evidence of a dynamic increment in the regressions, affecting at least the second-moment correlations and covariances. In this study, to overcome such problems involved in modelling spillover effects, a multivariate DCC-GARCH model of (Engle 2002) is used. Engle's (2002) model has many advantages over other models, for example, unlike constant correlations, dynamic

conditional correlations (DCC) allow the detection of possible changes in conditional correlations over time, which is very important since stock returns are negative during turbulent periods and positive during tranquil periods. In addition, the model estimates the correlation coefficients of the standardized residuals and accounts for heteroscedasticity directly (Chiang et al 2007). Moreover, the multivariate setting of dynamic correlations overcomes problems of omitted variables such as fundamentals and risk perceptions and endogeneity (Kenourgios et al., 2013).

The estimation of Engle's (2002) DCC-GARCH model comprises two steps: first, the estimation of the univariate GARCH model for the stock returns and second, the estimation of the conditional correlations that vary over time. The DDC model of Engle (2002) can be expressed as

$$H_t = D_t R_t D_t \tag{1}$$

where $H_t$ is the conditional covariance matrix that is decomposed into conditional standard deviations, $D_t = diag(h_{1,1,t}^{1/2},.....,h_{N,N,t}^{1/2})$ in which $h_{i,i,t}$ is any univariate GARCH process and $R_t$ is the time dependent conditional correlations matrix, which defined as:

$$R_t = diag(q_{11,t}^{-1/2},....,q_{NN,t}^{-1/2})Q_t(q_{11,t}^{-1/2},.....,q_{NN,t}^{-1/2}) \tag{2}$$

where $Q_t$ is a symmetrical positive definite matrix that defines the dynamic correlation structure as:

$$Q_t = (1-a-b)\overline{Q} + au_{t-1}u_{t-1}^{'} + bQ_{t-1} \tag{3}$$

where $u_t$ is a vector of the standardised residuals, $\overline{Q}$ is an unconditional variance matrix of $u_t$, and 'a' and 'b' are non-negative one-period lagged autoregressive and

correlation coefficients satisfying a+b<1. Therefore, the conditional correlation between the two stock returns (1 and 2) can be expressed as

$$\rho_{12,t} = \frac{(1-a-b)\bar{q}_{12} + au_{1,t-1}u_{2,t-1} + b_{12,t-1}}{\sqrt{\left[(1-a-b)\bar{q}_{11} + u_{1,t-1}^2 + bq_{11,t-1}\right]\left[(1-a-b)\bar{q}_{22} + au_{2,t-1}^2 + bq_{22,t-1}\right]}} \quad (4)$$

Where $\rho_{12}$ is the element on the 1th line, and 2th column of the matrix $Q_t$. The quasi-maximum likelihood method (QMLE) is used to estimate the parameters. Distribution used is the Student's *t*-distribution.

## 3.2 Crisis Identification

Crisis identification plays a significant role in identifying the increased correlation that has resulted from contagion or market interdependencies, and, for this reason, the researchers have been considering different techniques. Two approaches are commonly used in the literature: econometric approach in determining the break date endogenously and economic approach. (see Kenourgios et al., 2013). In recent years, event studies have also been used in identifying crises: for detail discussion on this method see Baur, (2012). In our study, we follow the economic approach in identifying the beginning of the crisis.

### 3.2.1 GFC identification

In the literature, there is no precise date for when the GFC started. In choosing the start date, the timelines of the Federal Reserve Bank of St. Louis were reviewed. Accordingly, 4 July 2007 is considered to be the starting date for the first part of thesis, since on this day the Federal Bank of St. Louis announced that Standard and Poor's placed 612 securities backed by subprime residential mortgages on a credit watch. For the second part of the study, we consider 9 August 2007, since on this is

the date that the Bank for International Settlement (BIS) and the Federal Reserve Bank of St. Louis (2009) officially announced the start of the GFC.

### 3.2.2 ESDC identification

The ESDC start date is exogenously chosen as 19 October 2009, in line with the Guardian's interactive timeline of the Eurozone crisis. On this day, the newly elected Greek Prime Minister, George Papandreou, disclosed that the public deficit was actually twice what was initial estimated and noted that the deficit would reach 12% of GDP. The impact of this news was quickly reflected in other counties' markets. For example, on the same date, the FTSE 100 fell by 200 points.

# Chapter 4

# SPILLOVER EFFECTS OF THE GLOBAL FINANCIAL CRISIS ON THE SELECTED EMERGING AND DEVELOPED STOCK MARKETS

## 4.1 Introduction

The global financial crisis led to a dramatic loss of confidence on the part of international investors, a dramatic decline in international trade, and ultimately slowed down economic growth across the advanced and developing economies. Indeed, the cost and severity of the crisis were much more severe in countries that had strong financial and trade linkages with the USA, and those that had fragile economies that depended on external debt to achieve growth. It is worth remembering that in order to overcome the turmoil, some countries enacted policies such as providing financial assistance to the firms that were affected by the crisis or making available low or no rate funds to businesses and individuals. For example, the Federal Reserve Bank (FED) launched a programme known as the unconventional monetary policy or quantitative easing (QE), whereby the FED increased the money supply and provided cheap or no interest rate loans to businesses and corporations. This no interest rate or low rate policy, however, led to a large inflow of capital into emerging economies, since investors believed that these markets provided an attractive rate. Equally, the EU launched a similar programme to increase the inflation rate and reduce unemployment, both with the aim of boosting economic growth. However, recently there has been high uncertainty and high volatility in the emerging markets, since investors are expecting the FED to end

QE, which has already led to a greater outflow from these economies and resulted in the loss value of domestic currency against the US dollar, increasing their borrowing cost. For example, according to the Exchange Fund Trade (EFI) announcements, in 2015 alone $12 bill capital has been withdrawn from emerging markets. There are some analysts who believe that the FED may not increase the interest rate since the US is highly in debt and so paying the debt will be a major problem. At the moment, the total US outstanding debt is estimated to be above $12 trillion.

Usually, investing in international markets is associated with risk, especially investing in emerging markets as there is the risk of political instability, exchange rate, corruption, copyright problems, and, above all, they depend on advanced economies to sell their products. Nevertheless, emerging markets are thought to have certain attractive features such as higher rates of return and lower correlation with developed markets, which provides an opportunity for asset allocation. Therefore, the extent to which these emerging markets were affected during the GFC period and whether they still enjoy lower correlation with developed markets remain central questions from the investor's perspective.

The existing literature on the GFC came to a general consensus that the US financial crisis rapidly spread worldwide through the financial markets, although it affected the emerging markets most in late 2008 and 2009, while the developed markets that were highly integrated with the crisis originating country felt the impacts immediately. Regarding the degree of influence of the crisis on the emerging stock markets, the empirical findings point to two major yet conflicting conclusions: first, the emerging markets have experienced significant structural changes in the dynamic

correlation behaviour of their stock markets with the US leading to long-term impacts of the crisis on their economies. Second, the most significant influence is seen from 2009 and the dynamic stock market correlations weakened afterwords, allowing for new investment opportunities in these markets.

Within the context of the above, this part of the thesis will attempt to investigate the extent to which the BRIC-T plus three CEE and EU3 have been affected by the GFC. Did these emerging markets directly feel the impacts from the crisis originating country, the USA, or indirectly through the EU markets? Were the impacts felt by the BRIC-T plus the CEE countries more severe when compared to those experienced by the EU3 markets? The answers to these questions are important for at least three reasons. First, identifying whether the conditional correlation behaviour changed temporarily or permanently would help in understanding whether the GFC led to structural changes in the relationship between the US financial market and the markets of the BRIC-T plus CEE and the developed EU3 countries. Second, correlation behaviour among different stock markets assists international investors and portfolio fund managers with their decisions regarding asset allocation. This is because the benefits of asset diversification can only be achieved by investing in stock markets that have weak correlation with each other. Third, understanding the extent to which the dynamic correlation behaviour among these financial markets has changed following the crisis will help to provide a clear indication for regulators concerning whether the monetary and fiscal policies need to be revised. Fourth, the analysis of dynamic correlation is also important in understanding the transmission mechanism whether it real linkages or investors induced contagion which is important for policy implication.

## 4.2 Economic Outlook of BRIC-T plus three CEE

BRIC-T plus three CEE are emerging economies that registered as fast growth and received great attention from international investors in their rapid growing financial markets. The international monetary Fund and the world bank in their 2014 report reveals that five of these economies ranked among the top 20 countries in the world measured by purchasing power parity (PPP) adjusted nominal gross domestic product (GDP).These countries are China (ranked 2), Brazil (7), India (9), Russia (10) and Turkey(18). It is also worth noting that the BRICS including South Africa accounts for almost 15% of the global GDP. Therefore, these countries are deemed to be at a similar stage of newly advanced economic developed.

Table 1 panel A-I show macroeconomic indicators and financial position for BRIC-T plus three CEEs starting from year 2004 to 2013. Penal A and B show nominal GDP and annual GDP growth, as it can be seen from the table in general there is high economic growth with almost all of the BRIC-T plus three CEE, among these countries BRIC-T being fastest growing and lowest being three CEE economies. However, all of them are aboserved to be adversely affeted from the GFC easpecially in 2008 & 2009 and the three CEE economies continue to experience negative growth during ESDC (most effected being Chezh Republics). Looking at unemployment and inflation in panel C and D , China and India have the lowest unemployment rate as compared to other emerging countries in our sample. In general, unemeployment and inflation rates are moderate in these economies. Comparing trade interdependence among BRIC-T plus three CEE economies in panel E through G , the one most dependent on trade are three CEE countries and at the same time more dependent on high income economies ( EU and US) to sell their

products. Among the BRIC-T, the most dependent on trade for its growth and on high income economies to is China. It is also worth noting that starting from the GFC period (2007 to 2008) until 2014 there is a decline in exports to high income economies. Finally panel H and I report portfolio equity inflows and foreign direct investments as it can be seen from the table 1 with the exception of China and Turkey all other emerging economies experienced negative portfolio equity inflow during GFC (2007 and 2008). In addition to this among BRIC-T plus three CEE, Czech Republic, Hungary and Russia continue to experience negative portfolio inflow especially during ESDC period. Considering the FDI in general China received the highest followed by Brazil while to CEE the lowest inflows. Economies have the lowest and the highest being China followed by Brazil. Panel I also shows that during the GFC period there was a decline in FDI in all the BRIC-T plus three CEE economies.

Table 1: Macroeconomic Outlook and Financial Position of BRIC-T plus three CEE

| Panel A | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GDP (miilion US$) | | | | | | | | |
| Years | Brazil | Russia | India | China | Turkey | Czech | Hungary | Poland |
| 2004 | 6.6964 | 5.91 | 7.216 | 1.942 | 392,2 | 119,0 | 103,2 | 253,5 |
| 2005 | 8.9211 | 7.64 | 8.342 | 2.269 | 483,0 | 136,0 | 111,9 | 304,4 |
| 2006 | 1.1078 | 9.899 | 9.491 | 2.73 | 530,9 | 155,2 | 114,2 | 343,2 |
| 2007 | 1.396 | 1.3 | 1.239 | 3.52 | 647,2 | 188,8 | 138,6 | 428,7 |
| 2008 | 1.6946 | 1.661 | 1.224 | 4.558 | 730,3 | 235,2 | 156,6 | 530,1 |
| 2009 | 1.6646 | 1.223 | 1.365 | 5.059 | 614,6 | 205,7 | 129,4 | 436,4 |
| 2010 | 2.2094 | 1.525 | 1.708 | 6.04 | 731,2 | 207,0 | 129,6 | 476,6 |
| 2011 | 2.6152 | 1.905 | 1.836 | 7.492 | 774,8 | 227,3 | 139,4 | 524,3 |
| 2012 | 2.4132 | 2.016 | 1.832 | 8.462 | 788,9 | 206,8 | 126,8 | 496,2 |
| 2013 | 2.3921 | 2.079 | 1.862 | 9.491 | 823,2 | 208,8 | 133,4 | 526,0 |
| 2014 | 2.3461 | 1.861 | 2.067 | 10.36 | 799,5 | 205,5 | 137,1 | 548,0 |
| Panel B | | | | | | | | |
| Annual GDP growth % | | | | | | | | |
| Years | Brazil | Russia | India | China | Turkey | Czech | Hungary | Poland |
| 2004 | 5.66 | 7.18 | 7.92 | 10.08 | 9.36 | 4.95 | 4.79 | 5.14 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2005 | 3.15 | 6.38 | 9.28 | 11.35 | 8.4 | 6.44 | 4.26 | 3.55 |
| 2006 | 4 | 8.15 | 9.26 | 12.69 | 6.89 | 6.88 | 3.96 | 6.2 |
| 2007 | 6.01 | 8.54 | 9.8 | 14.19 | 4.67 | 5.53 | 0.51 | 7.16 |
| 2008 | 5.02 | 5.25 | 3.89 | 9.62 | 0.66 | 2.71 | 0.88 | 3.87 |
| 2009 | -0.24 | -7.82 | 8.48 | 9.23 | -4.83 | -4.84 | -6.55 | 2.62 |
| 2010 | 7.57 | 4.5 | 10.26 | 10.63 | 9.16 | 2.3 | 0.79 | 3.71 |
| 2011 | 3.92 | 4.26 | 6.64 | 9.48 | 8.77 | 1.96 | 1.81 | 4.77 |
| 2012 | 1.76 | 3.41 | 5.08 | 7.75 | 2.13 | -0.81 | -1.48 | 1.82 |
| 2013 | 2.74 | 1.34 | 6.9 | 7.68 | 4.19 | -0.7 | 1.53 | 1.71 |
| 2014 | 0.14 | 0.64 | 7.42 | 7.35 | 2.87 | 1.99 | 3.64 | 3.37 |
| Panel C | | | | | | | | |
| Unemployment total (% of total labor force) | | | | | | | | |
| Years | Brazil | Russia | India | China | Turkey | Hungary | Czech | Poland |
| 2004 | BRA | RUS | IND | CHN | TUR | HUN | CZE | POL |
| 2005 | 8.9 | 7.8 | 3.9 | 4.3 | 10.8 | 6.1 | 8.3 | 19 |
| 2006 | 9.3 | 7.1 | 4.4 | 4.1 | 10.6 | 7.2 | 7.9 | 17.7 |
| 2007 | 8.4 | 7.1 | 4.3 | 4 | 10.2 | 7.5 | 7.1 | 13.8 |
| 2008 | 8.1 | 6 | 3.7 | 3.8 | 10.3 | 7.4 | 5.3 | 9.6 |
| 2009 | 7.1 | 6.2 | 4.1 | 4.4 | 11 | 7.8 | 4.4 | 7.1 |
| 2010 | 8.3 | 8.3 | 3.9 | 4.4 | 14 | 10 | 6.7 | 8.2 |
| 2011 | 7.9 | 7.3 | 3.5 | 4.2 | 11.9 | 11.2 | 7.3 | 9.6 |
| 2012 | 6.7 | 6.5 | 3.5 | 4.3 | 9.8 | 10.9 | 6.7 | 9.6 |
| 2013 | 6.1 | 5.5 | 3.6 | 4.5 | 9.2 | 10.9 | 7 | 10.1 |
| 2014 | 5.9 | 5.6 | 3.6 | 4.6 | 10 | 10.2 | 6.9 | 10.4 |
| Panel D | | | | | | | | |
| Inflation, consumer prices (annual %) | | | | | | | | |
| Years | Brazil | Russia | India | China | Turkey | Czech | Hungary | Poland |
| 2004 | 6.599 | 10.861 | 3.767 | 3.884 | 10.58 | 2.827 | 6.78 | 3.577 |
| 2005 | 6.867 | 12.683 | 4.246 | 1.822 | 10.14 | 1.846 | 3.551 | 2.107 |
| 2006 | 4.184 | 9.679 | 6.146 | 1.463 | 9.597 | 2.528 | 3.878 | 1.115 |
| 2007 | 3.637 | 9.007 | 6.37 | 4.75 | 8.756 | 2.927 | 7.935 | 2.388 |
| 2008 | 5.663 | 14.108 | 8.352 | 5.864 | 10.44 | 6.351 | 6.066 | 4.349 |
| 2009 | 4.886 | 11.654 | 10.877 | -0.703 | 6.251 | 1.045 | 4.209 | 3.826 |
| 2010 | 5.038 | 6.858 | 11.992 | 3.315 | 8.566 | 1.409 | 4.881 | 2.707 |
| 2011 | 6.636 | 8.435 | 8.858 | 5.411 | 6.472 | 1.936 | 3.957 | 4.258 |
| 2012 | 5.402 | 5.068 | 9.312 | 2.652 | 8.892 | 3.299 | 5.706 | 3.557 |
| 2013 | 6.202 | 6.763 | 10.908 | 2.631 | 7.493 | 1.435 | 1.726 | 1.034 |
| 2014 | 6.332 | 7.826 | 6.353 | 1.993 | 8.855 | 0.337 | -0.24 | 0.107 |
| Panel E | | | | | | | | |
| Trade (% of GDP) | | | | | | | | |
| Years | Brazil | Russia | India | China | Turkey | Czech | Hungary | Poland |
| 2004 | 29.67 | 56.58 | 36.86 | 59.45 | 49.74 | 114.05 | 124 | 71.82 |
| 2005 | 27.07 | 56.71 | 41.31 | 62.9 | 47.21 | 122.28 | 128.6 | 70.79 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2006 | 26.04 | 54.73 | 45.3 | 64.77 | 50.25 | 127.84 | 150.4 | 78.3 |
| 2007 | 25.32 | 51.71 | 44.88 | 62.28 | 49.81 | 130.66 | 156.5 | 80.95 |
| 2008 | 27.28 | 53.38 | 52.27 | 56.8 | 52.25 | 124.56 | 159.6 | 81.51 |
| 2009 | 22.14 | 48.44 | 45.48 | 43.59 | 47.74 | 113.74 | 146.1 | 75.91 |
| 2010 | 22.51 | 50.36 | 48.31 | 49.33 | 47.97 | 129.25 | 159.9 | 82.76 |
| 2011 | 23.71 | 52 | 55.02 | 48.83 | 56.62 | 139.29 | 168.9 | 88.03 |
| 2012 | 25.27 | 51.89 | 55.55 | 45.71 | 57.75 | 148.1 | 168 | 90.31 |
| 2013 | 26.38 | 51.29 | 53.28 | 43.9 | 57.81 | 148.69 | 169.9 | 90.3 |
| 2014 | 25.79 | .. | 49.56 | 41.53 | 59.85 | 160.39 | .. | .. |
| Panel F | | | | | | | | |
| Merchandise exports to high-income economies (% of total merchandise exports) | | | | | | | | |
| Years | Brazil | Russia | India | China | Turkey | Czech | Hungary | Poland |
| 2004 | 70.003 | 69.842 | 69.761 | 85.693 | 74.35 | 94.127 | 90.88 | 90.122 |
| 2005 | 70.337 | 68.85 | 69.941 | 84.995 | 71.6 | 93.506 | 87.43 | 89.406 |
| 2006 | 70.379 | 70.562 | 68.136 | 83.024 | 71.28 | 93.18 | 85.67 | 88.882 |
| 2007 | 72.047 | 66.631 | 65.523 | 81.56 | 69.56 | 92.745 | 84.81 | 88.172 |
| 2008 | 67.939 | 67.343 | 66.506 | 79.208 | 67.43 | 92.235 | 83.89 | 87.98 |
| 2009 | 62.511 | 56.923 | 66.149 | 78.084 | 62.23 | 92.341 | 84.86 | 88.969 |
| 2010 | 61.045 | 62.472 | 64.24 | 77.023 | 62.41 | 92.031 | 83.67 | 88.941 |
| 2011 | 60.659 | 57.526 | 63.634 | 75.986 | 62.64 | 92.053 | 82.36 | 88.482 |
| 2012 | 59.447 | 64.6 | 64.8 | 75.35 | 58.72 | 91.212 | 82.12 | 87.538 |
| 2013 | 58.569 | 67.194 | 61.641 | 74.531 | 58.51 | 90.686 | 82.31 | 87.275 |
| 2014 | 59.345 | 66.051 | 61.233 | 73.328 | 60.65 | 91.297 | 82.79 | 88.342 |
| Panel G | | | | | | | | |
| Merchandise imports from high-income economies (% of total merchandise imports) | | | | | | | | |
| Years | Brazil | Russia | India | China | Turkey | Czech | Hungary | Poland |
| 2004 | 73.735 | 66.813 | 52.84 | 75.527 | 75.21 | 87.526 | 88.75 | 86.556 |
| 2005 | 72.783 | 64.161 | 51.325 | 73.085 | 72.74 | 87.819 | 85.31 | 90.451 |
| 2006 | 70.985 | 67.073 | 60.716 | 71.44 | 70.26 | 91.756 | 84.89 | 89.312 |
| 2007 | 68.788 | 62.939 | 63.179 | 70.051 | 69.66 | 90.471 | 84.09 | 88.539 |
| 2008 | 66.943 | 63.438 | 63.306 | 69.239 | 68.77 | 89.65 | 84.26 | 88.61 |
| 2009 | 69.191 | 63.011 | 62.011 | 69.477 | 69.28 | 89.163 | 83.64 | 88.562 |
| 2010 | 66.99 | 59.56 | 62.977 | 67.585 | 66.18 | 86.55 | 82.56 | 88.547 |
| 2011 | 64.836 | 47.839 | 62.064 | 66.81 | 64.02 | 85.679 | 82.88 | 88.304 |
| 2012 | 64.237 | 59.223 | 62.229 | 65.461 | 63.72 | 87.003 | 83.78 | 88.26 |
| 2013 | 63.38 | 59.349 | 61.783 | 66.176 | 64.02 | 87.401 | 83.7 | 88.023 |
| 2014 | 61.914 | 58.741 | 57.972 | 66.537 | 62.58 | 86.502 | 84.72 | 86.038 |
| Panel H | | | | | | | | |
| Portfolio equity, net inflows (million US$) | | | | | | | | |
| Years | Brazil | Russia | India | China | Turkey | Czech | Hungary | Poland |
| 2004 | 2,080 | 269 | 9,053 | 10,923 | 1,427 | 737 | 1,490 | 1,660 |
| 2005 | 6,451 | -163 | 12,151 | 20,569 | 5,669 | -1,540 | -16 | 1,333 |
| 2006 | 7,715 | 723 | 9,509 | 42,861 | 1,939 | 268 | 911 | -2,128 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2007 | 26,213 | 1,839 | 32.862 | 18,478 | 5,138 | -268 | -5,009 | -470 |
| 2008 | -7,565 | -1,538 | -15,030 | 8,464 | 7,160 | -1,124 | -197 | 564 |
| 2009 | 37,071 | 3,762 | 24,688 | 29,116 | 2,827 | -310 | 665 | 1,579 |
| 2010 | 37,670 | -4,885 | 30,442 | 313,570 | 3,468 | -231 | -325 | 7,531 |
| 2011 | 7,174 | -9,795 | -4,048 | 5,308 | -985 | -17 | 177 | 3,078 |
| 2012 | 5,599 | 1,162 | 2,280 | 29,902 | 627 | -148 | 746 | 3,613 |
| 2013 | 11,636 | -7,625 | 19,891 | 32,594 | 842 | 106 | 25 | 2,583 |
| 2014 | 11,773 | -1,288 | 12,369 | NA | 255 | 270 | -341 | NA |
| Panel I | | | | | | | | |
| Foreign direct investment (million US$) | | | | | | | | |
| Years | Brazil | Russia | India | China | Turkey | Czech | Hungary | Poland |
| 2004 | 181,656 | 15,444 | 57,712 | 6,.210 | 2,785 | 4,977 | 4,281 | 12,716 |
| 2005 | 15,459 | 15,508 | 72,694 | 111,210 | 10,031 | 1,160 | 8,505 | 11,051 |
| 2006 | 19,378 | 37,594 | 20,029 | 133,272 | 20,185 | 5,521 | 1,867 | 21,518 |
| 2007 | 44,579 | 55,873 | 25,227 | 169,389 | 22,047 | 1,060 | 7,063 | 25,573 |
| 2008 | 50,716 | 74,782 | 43,406 | 186,797 | 19,851 | 8,815 | 7,501 | 15,031 |
| 2009 | 31,480 | 36,583 | 35,581 | 167,070 | 8,585 | 5,271 | -2,967 | 14,388 |
| 2010 | 53,344 | 43,167 | 27,396 | 272,986 | 90,990 | 1,016 | -2,093 | 18,145 |
| 2011 | 71,538 | 55,083 | 36,498 | 3.31,591 | 16,176 | 4,188 | 1,050 | 18,485 |
| 2012 | 76,110 | 50,587 | 23,995 | 2.95,625 | 13,282 | 9,433 | 1,063 | 7,189 |
| 2013 | 80,842 | 69,218 | 28,153 | 347,849 | 12,457 | 7,357 | -4,112 | 0,120 |
| 2014 | 96,851 | 20,957 | 34,410 | NA | 12,550 | 4,870 | 8,525 | NA |

Source: World Development Bank.

## 4.3 Literature Review of the Global Financial Crisis

### 4.3.1 Emerging and developed stock markets during the global financial crisis

The empirical results concerning the US financial crisis are mixed, with some researchers noting a spillover effect while others did not. For instance, Valls and Chulia (2012) examine the volatility transmission and conditional correlations behaviour between the US and one mature and ten emerging stock markets located in Asia. They find that the US financial crisis has barely changed the volatility transmission pattern and that the conditional correlations depend on the level of development of each country, with the developing ones being the least affected. Beirne et al. (2008) study the volatility spillovers from mature to emerging market

economies by adopting the GARCH-BEKK model of returns during 1996-2008, and confirm the presence of spillovers in several emerging market economies from mature markets, although only during turbulent episodes. Samarakoon (2011) examines the propagation of return shocks between the USA, emerging and frontier markets during the US financial crisis and, overall, determines that except for Latin America, no evidence of contagion can be seen in Europe, Asia, Africa and the Middle East supporting the interdependence of foreign markets with the USA. In line with this finding, Morales and Callaghan (2014) argued that there is no contagion shock to the worldwide markets. Similarly, Zhou et al. (2012) noted that Chinese market is less affected from the global spillover effects.

However, Frank and Hesse (2009), who examine the conditional correlations and volatility spillovers between money and equity markets to emerging markets during the GFC, argue that even those emerging countries with strong financial and macroeconomic conditions have been seriously affected by the financial turmoil in late 2008, which ultimately penetrated into their real sectors. Furthermore, Cheung, Fung and Tsai (2010) investigate the effects of the sub-prime mortgage crisis among global stock markets using VECM and report that the crisis triggered a strong worldwide spillover effect in both developed and emerging markets that is consistent with the contagion theory. Dungey and Gajurel (2014) also supported the view that the GFC caused contagion shock to both developed and emerging equity markets.

There are also researcher that examine the impacts of GFC on the equity market loss For example Bartram & Bodnar (2009) noted that global equity market at the beginning of August 2007 was more than $51 trillion whereas by the end of February

2009 the equity market value declined to more than $22 trillion registering loss of $29 trillion or 56% reduction in its original value and this destruction was estimated to be 50% of the total world output. A reasonable number of studies have been conducted that examine the spillover and volatility transmission that resulted from the GFC, particularly from other developed economies such as, the UK, Germany, France, and Japan to emerging markets (Lupu and Lupu, 2009; Dajčman and Alenka, 2011).

### 4.3.2 BRIC stock markets and the global financial crisis

Considering the recent rapid economic and financial developments in the BRIC countries, several researchers have investigated the impacts of the GFC on those countries. For example, Alou et al. (2011) utilised copulas functions to observe the high level of interdependences between the BRICs plus South Africa and the USA. Dimitriou et al. (2013) examined the contagion effect of the GFC on BRIC and South Africa within the FIAPARCH-DCC framework and suggested the absence of a pattern of contagion for all the BRIC markets. On the other hand, the findings of Zhang et al. (2013) indicated that the 2008 financial crisis permanently changed the dynamic correlations in most BRIC plus the South African and European stock markets, thus imposing a long-term impact on these countries. Chiang et al. (2013) studied the spillover effects of the US crisis on the BRIC plus Vietnam using an autoregressive conditional jump intensity model and determined the highest spillover effects in Russia and Vietnam. Grigoryev, R. (2010) study the interdependences between the BRIC and developed stock markets by incorparting the impacts of oil price. There are also researchers that examine both bond and stock markets of BRICS countries For examples see Bianconi et al. (2013).

## 4.4 Data and Descriptive Statistics

In an attempt to investigate and compare the spillover effects of the global financial crisis on the three developed European and the BRIC-T stock markets, we use the weekly stock market indices for each country from 3 January 2001 to 13 November 2013, that is Wednesday to Wednesday, in order to minimise the cross-country differences and the end-of-week effects. The developed stock markets are represented by the FTSE100 index of the UK, the DAX index of Germany, and the CAC40 index of France. The emerging market indices are the BOVESPA for Brazil, the MICEX index for Russia, the CNX index for India, the SSE Composite index for China, the BIST National 100 for Turkey, the CZPXIDX for the Czech Republic, the BUXINDX for Hungary, and the POLWIGI for Poland. The S&P500 index is used to represent the US market. We also incorporated the EUROSTOXX50 stock price index, representing 50 blue chip corporations from 12 Eurozone countries, which will be referred to as the EU index within the remainder of the thesis. The purpose of using the EU index is to measure and compare the spillover effects from the European markets on the BRIC-T plus three CEE markets with those from the crisis originating country. The stock price indices are all denominated in the US dollar, and all of the stock market index data was obtained from Thomson Reuters Datastream.

The stock price indices for the developed markets for the whole sample period are displayed in Figure 1. In 2003, all the indices were at their lowest level, which could reflect the influences of the Brazilian crisis and the dot com crisis that lasted from 2002 until 2003. From the beginning of 2004, all of the indices started trending upward at a slow pace, which then exhibited a relatively sharper increase between 2006 and 2007 before reaching a peak in 2008. The high levels of stock prices before

mid-2007 seem to indicate the sub-mortgage crisis in 2007 and the collapse of Lehman Brothers in 2008. However, after 2009, the EU index and the other indexes for France, Germany and the UK are lower, although they exhibit volatile behaviour until 2013. However, the USA market after 2009 appears to be relatively more stable, showing recovery with a sharp upward increase until the end of the sample.

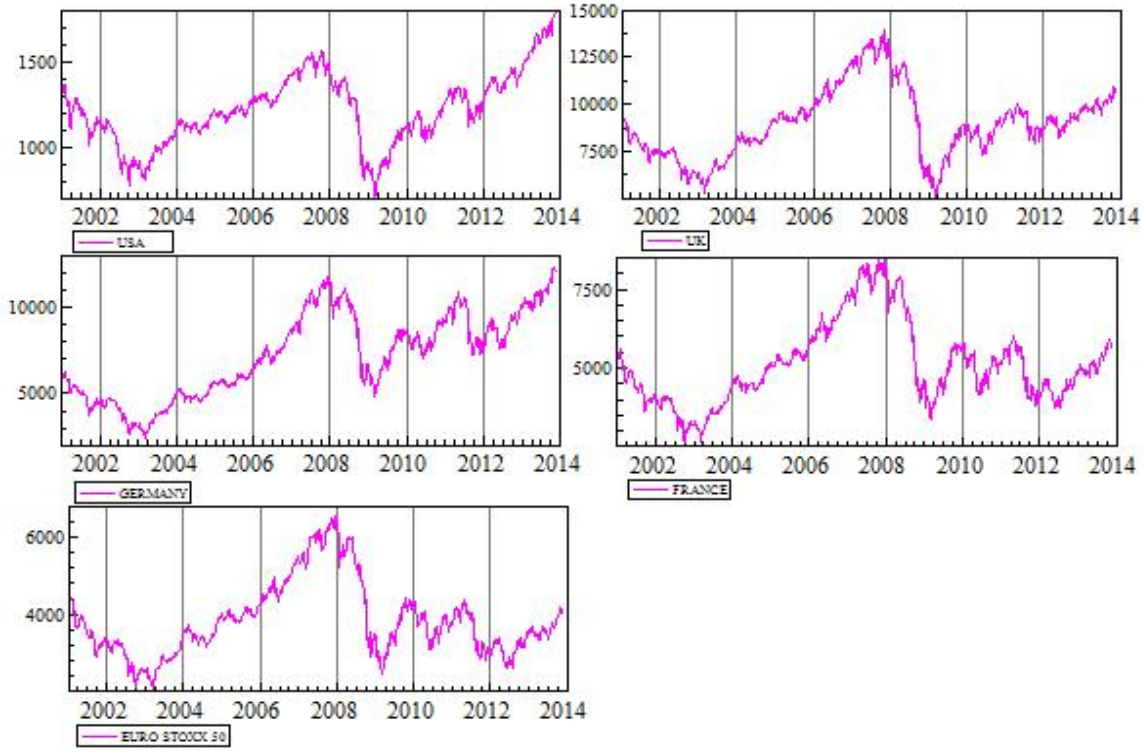



Figure 1 : Weekly stock indices for the USA, U.K, Germany, France, and the EU Index for the whole sample period of 3 January 2001 – 13 November 2013.

Figure 2, shows the stock market indices for the BRIC-T plus CEE emerging markets. All of the series exhibit similar patterns: a strong upward trend until 2008 and a sharp fall around 2009 reaching the lowest point, after which they all exhibit a relatively volatile behaviour, except for China. After 2009, the Chinese stock prices stay at lower levels when compared to those of Brazil, India and Turkey, Russia and the three CEE.

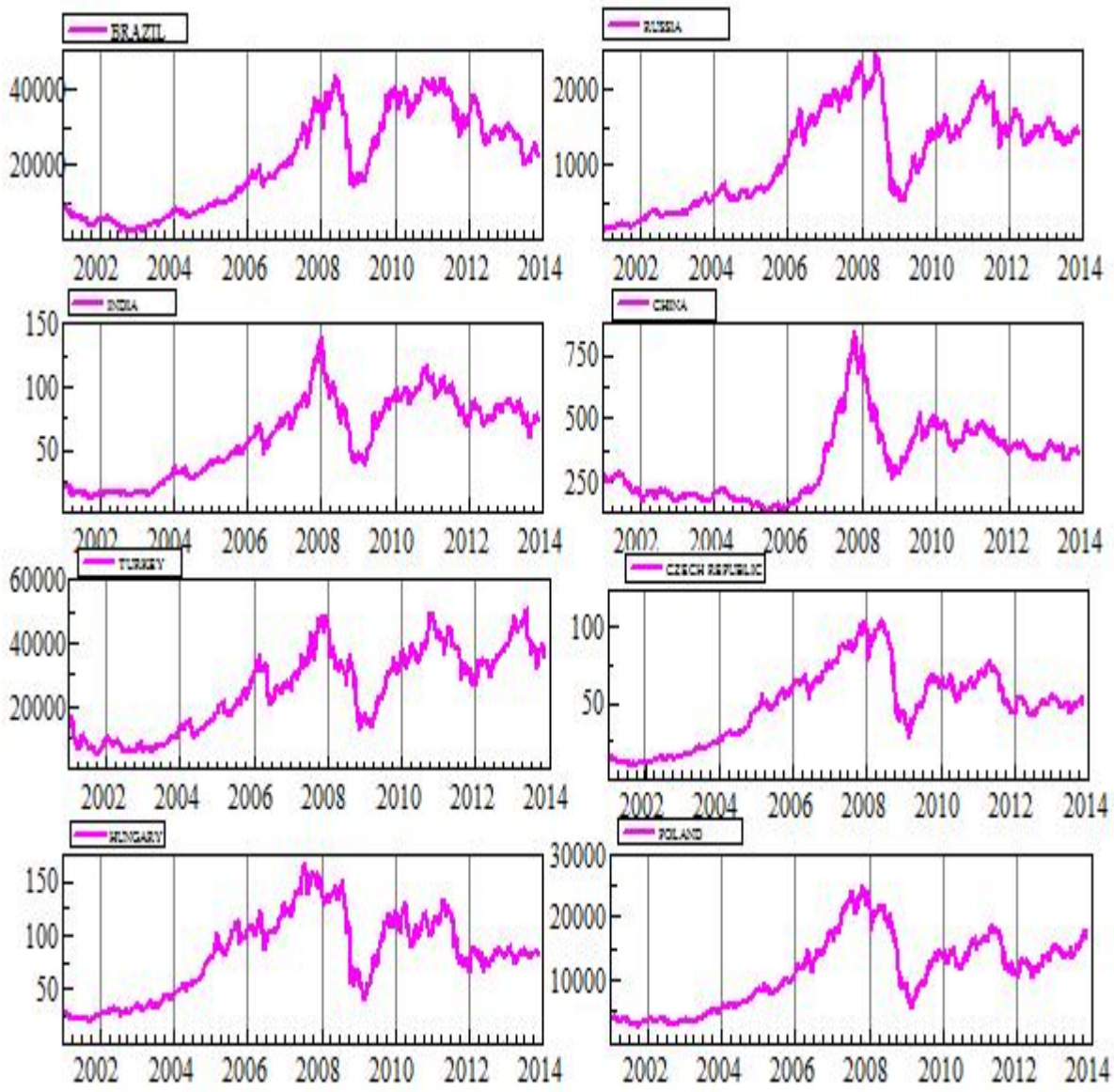



Figure 2: Weekly stock indices of Brazil, Russia, India, China, Turkey and the three CEE markets (Czech Republic, Hungary and Poland) for 3 January 2001 – 13 November 2013.

Figure 3 shows the stock market returns for the developed markets. High volatility is observed for all the indices between the period of 2002-2004 and 2008-2012. However, the S&P500 return series seems to be relatively less volatile during 2011 and 2012 when compared to those in the other markets.

Figure 4 illustrates the stock returns for the BRIC-T plus the three CEE emerging markets. High volatility is observed during the period between 2002-2004 in Brazil, China and Turkey. However, all of the emerging markets exhibited much higher volatility, especially during the 2008-2010 period. After 2010 (or considering the ESDC period), some of these markets still exhibited high volatility, especially China, Hungary and Poland.

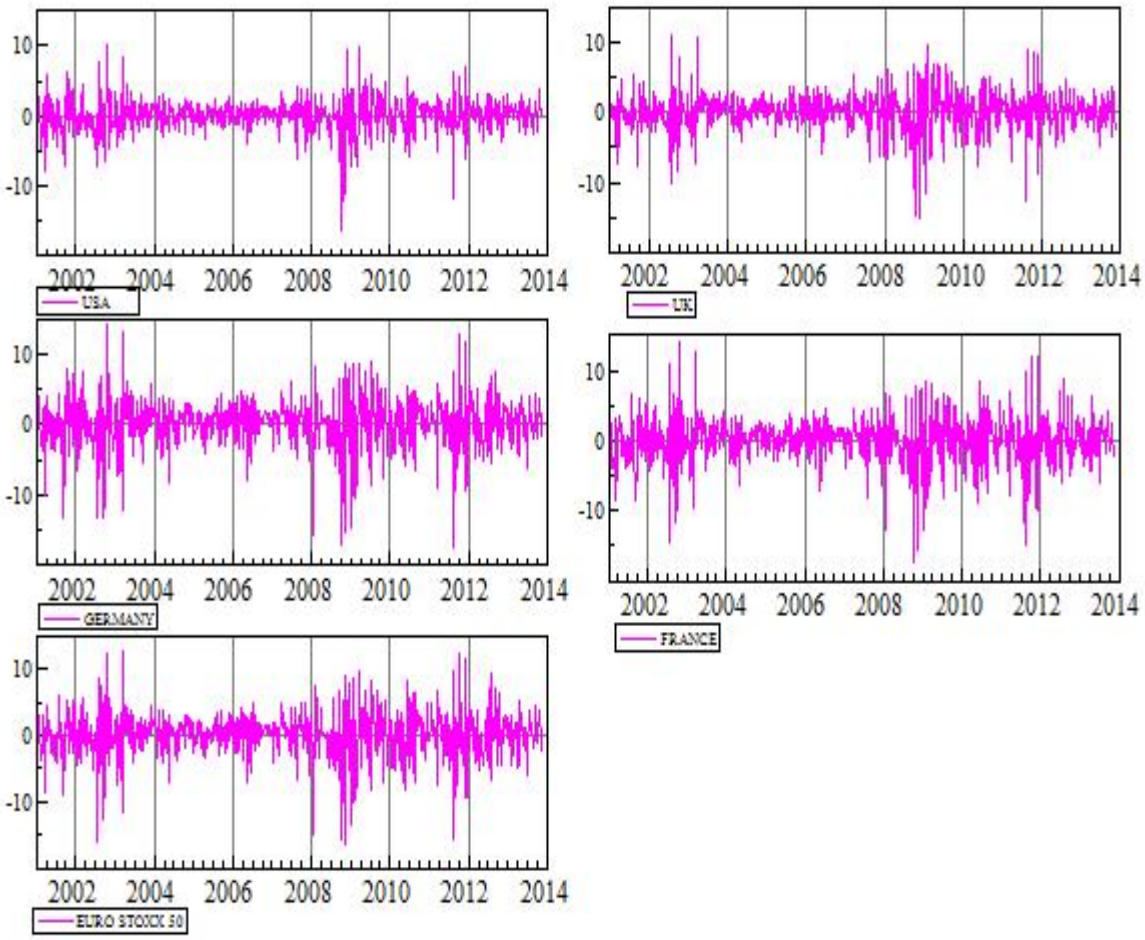



Figure 3: Stock returns for the USA, the U.K, Germany, France and the EU index for the whole sample period (3 January 2001 – 13 November 2013).

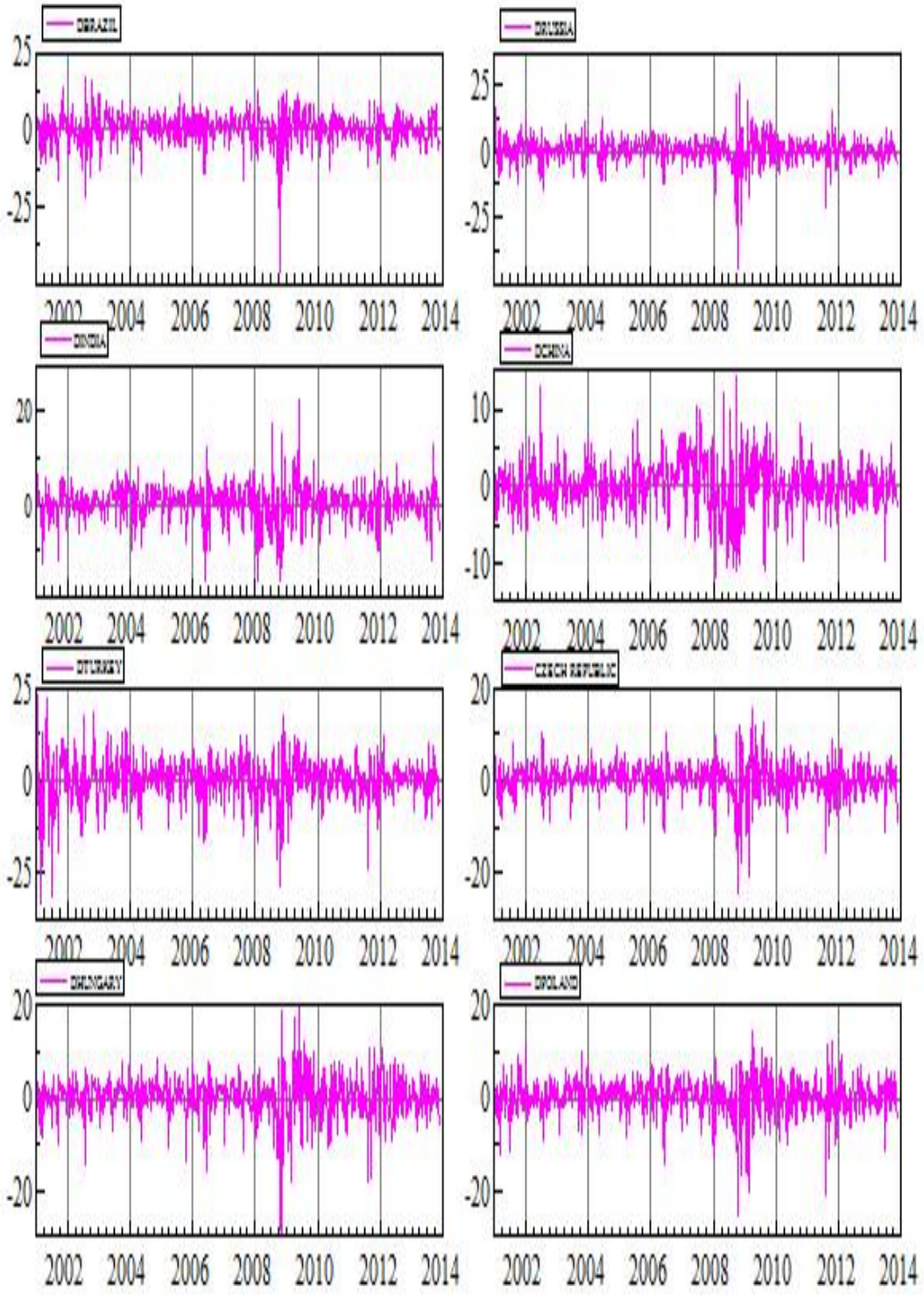



Figure 4: Stock returns for Brazil, Russia, India, China, Turkey and three CEE markets (Czech Republic, Hungary and Poland) for the whole sample period (3 January 2001 – 13 November 2013).

### 4.4.1 Summary descriptive statistics

Table 2 Panels A-C report the statistical properties of the weekly return series for the full sample, the pre-crisis, and the crisis and post-crisis periods, respectively. It can be observed from Panel 'A' that all of the emerging markets have higher standard deviations over the full sample, save for China, than the developed markets, showing that these markets are relatively more risk: Turkey with a standard deviation of 6.37 is the riskiest country, Russia the second with 5.32, and Brazil the next with 5.32. All of the return mean values are positive over the full sample, with the highest return being for Russia with 0.334, followed by the Czech Republic and Poland with an average of 0.206 and 0.204, respectively. A comparison of the pre-crisis and the crisis/post-crisis periods shows increases in the standard deviations of all the series. For the crisis/post-crisis period, Russia's 6.35 standard deviation is the highest, the second riskiest country is Hungary (5.93), while Turkey (5.77) ranks as the third. Again, China records the lowest standard deviation of all, except for the UK and the USA, during both the pre-crisis and crisis/post-crisis periods. In general, the return means over the crisis/post-crisis period have become negative, except for the US and Germany, indicating the effect of the crisis. As expected, all of the return series have negative skewness and high kurtosis, reflecting the stylised characteristics of the financial series. The Ljung-Box Q statistics and the Q statistics on standardised squared residuals at the lag (10) indicate the presence of ARCH effects, which is also confirmed by the significant ARCH tests. The ADF test results at lag (5) reject the null value of unit root of the return series.

Table 2: Descriptive statistics

| Table 2 Panel A for full sample period (03/01/2001-13/11/2013) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | USA | UK | GERMANY | FRANCE | EU | BRAZIL | RUSSIA | INDIA | CHINA | TURKEY | CZE[A] | HUNGARY | POLAND |
| Mean | 0.041 | 0.022 | 0.102 | 0.008 | -0.012 | 0.144 | 0.334 | 0.193 | 0.041 | 0.14 | 0.206 | 0.167 | 0.204 |
| Std. Dev. | 2.506 | 2.981 | 3.823 | 3.645 | 3.714 | 5.319 | 5.46 | 4.156 | 3.43 | 6.375 | 4.0543 | 4.867 | 4.375 |
| Skewness | -0.647 | -0.61 | -0.77 | -0.537 | -0.614 | -1.392 | -1.204 | -0.32 | -0.035 | -0.926 | -1.014 | -1.045 | -1.006 |
| Kurtosis | 7.936 | 6.248 | 6.082 | 5.7 | 5.691 | 11.912 | 14.811 | 5.758 | 4.258 | 6.675 | 7.8507 | 8.502 | 6.9198 |
| Jarque-Bera | 728.19 | 336.7 | 333.56 | 236.22 | 244.73 | 2437.86 | 4063 | 224.23 | 44.4 | 473.63 | 772.87 | 968.85 | 542.84 |
| P-Value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ARCH(5) | 13.80** | 27.09** | 15.89** | 19.39** | 19.20** | 5.611** | 27.07** | 12.82** | 15.05** | 14.89** | 37.675 | 37.531 | 20.216 |
| P-Value | [0.000] | [0.000] | [0.00] | [0.00] | [0.00] | [0.00] | [0.000] | [0.000] | [0.000] | [0.00] | [0.00]** | [0.00]** | [0.000]** |
| Q(10) | 27.75** | 33.24** | 28.77** | 37.35** | 37.20** | 33.69** | 66.89** | 46.87** | 28.82** | 30.67** | 70.494 | 59.264 | 80.5499 |
| P-Value | [0.001] | [0.000] | [0.001] | [0.000] | [0.003] | [0.000] | [0.000] | [0.000] | [0.001] | [0.000] | [0.000]** | [0.000]** | [0.000]** |
| Q2(10) | 137.88** | 284.63** | 157.56** | 181.93** | 193.93** | 43.032** | 236.483** | 121.71** | 230.19** | 181.41** | 449.1 | 361.9 | 288.4 |
| P-Value | [0.000 | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000]** | [0.000]** | [0.000]** |
| ADF Test (5)lag | 14.52*** | 14.88*** | -13.76*** | -14.02*** | -13.82*** | -12.68*** | -13.76*** | 12.61*** | -12.63*** | 13.10*** | -12.352*** | -13.751*** | -12.784*** |
| Table 2 - Panel B | | | | | | | | | | | | | |
| Descriptive statistics for crisis & post-crisis period weekly (04/07/2007-13/11/2013) | | | | | | | | | | | | | |
| | USA | UK | GERMANY | FRANCE | EU | BRAZIL | RUSSIA | INDIA | CHINA | TURKEY | CZK | HUNGARY | POLAND |
| Mean | 0.046 | -0.071 | 0.0296 | -0.114 | -0.126 | -0.078 | -0.118 | -0.066 | -0.116 | -0.024 | -0.18 | -0.204 | -0.1104 |
| Std. Dev. | 2.801 | 3.509 | 4.186 | 4.146 | 4.24 | 5.561 | 6.365 | 4.679 | 3.793 | 5.772 | 4.883 | 5.938 | 5.163 |
| Skewness | -1.04 | -0.694 | -0.842 | -0.547 | -0.532 | -1.953 | -1.365 | 0.058 | -0.174 | -1.158 | -0.8914 | -0.7991 | -0.9478 |
| Kurtosis | 8.121 | 5.118 | 5.663 | 4.678 | 4.629 | 16.58 | 14.928 | 5.499 | 4.187 | 7.048 | 6.542 | 6.865 | 6.062 |
| Jarque-Bera | 423.13 | 88.82 | 137.41 | 55.52 | 52.41 | 2763.69 | 2071.47 | 86.61 | 21.21 | 300.98 | 217.51 | 242.07 | 179.45 |
| P-Value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ARCH(5) | 5.633** | 12.76** | 8.544** | 8.075** | 9.035** | 2.97* | 13.39** | 5.414** | 9.533** | 15.93** | 19.216 | 18.95 | 10.482 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| p-value | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.012] | [0.000] | [0.000] | [0.00] | [0.000] | [0.00]** | [0.000]** | [0.000]** |
| Q(10) | 15.218 | 16.818 | 25.11** | 20.99* | 22.25* | 37.69** | 61.80** | 26.34** | 19.82* | 29.41** | 45.48 | 47.8 | 61.78 |
| p-value | [0.124] | [0.078] | [0.005] | [0.021] | [0.013] | [0.000] | [0.000] | [0.003] | [0.030] | [0.001] | [0.000]** | [0.000]** | [0.000]** |
| Q2(10) | 57.78** | 128.36** | 81.06** | 68.96** | 83.32** | 19.67* | 118.33** | 51.32** | 133.50** | 122.20** | 207.33 | 166.8 | 135.4 |
| p-value | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.032] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000]** | [0.000]** | [0.000]** |
| ADF Test lag(5) | -10.56*** | - 10.60*** | - 9.98*** | - 10.2*** | - 9.99*** | - 9.46*** | - 8.86*** | - 8.61*** | - 9.10*** | - 9.36*** | -8.60*** | -9.584*** | -8.94*** |

Table 2- Panel C

Descriptive statistics for pre-crisis period weekly (03/01/2001-27/06/2007)

| | USA | UK | GERMANY | FRANCE | EU | BRAZIL | RUSSIA | INDIA | CHINA | TURKEY | CZK | HUNGARY | POLAND |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 0.032 | 0.106 | 0.16 | 0.1168 | 0.087 | 0.348 | 0.769 | 0.437 | 0.215 | 0.267 | 0.573 | 0.5193 | 0.503 |
| Std. Dev. | 2.186 | 2.352 | 3.43 | 3.0763 | 3.1161 | 5.071 | 4.366 | 3.558 | 3 | 6.9 | 2.987 | 3.485 | 3.413 |
| Skewness | 0.217 | -0.058 | -0.606 | -0.361 | -0.657 | -0.634 | -0.181 | -0.984 | 0.343 | -0.809 | -0.577 | -1.182 | -0.639 |
| Kurtosis | 5.824 | 6.815 | 6.238 | 7.0333 | 7.1668 | 4.786 | 4.079 | 5.4 | 3.622 | 6.26 | 5.096 | 6.143 | 4.9 |
| Jarque-Bera | 115 | 205.19 | 168.42 | 236.48 | 268.87 | 67.68 | 18.27 | 135.79 | 12.08 | 186.58 | 80.64 | 218 | 74.13 |
| p-value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.002 | 0 | 0 | 0 | 0 |
| ARCH(5) | 11.110** | 13.35** | 10.68** | 18.301** | 13.319** | 5.882** | 1.851 | 7.159** | 2.269* | 4.336** | 6.359 | 2.376 | 1.71 |
| p-value | [0.000] | [0.000] | [0.00] | [0.000] | [0.000] | [0.000] | [0.102] | [0.000] | [0.047] | [0.00] | [0.00]** | [0.038]* | [0.131] |
| Q(10) | 26.051** | 30.793** | 15.07 | 35.620** | 31.28** | 21.33* | 11.686 | 28.17** | 20.29* | 17.215 | 28.85 | 18.014 | 29.65 |
| p-value | [0.003] | [0.000] | [0.129] | 0.000] | [0.0006] | [0.018] | [0.306] | [0.001] | [0.026] | [0.069] | [0.090] | [0.586] | [0.075] |
| Q2(10) | 106.93*** | 96.05** | 92.00** | 145.17** | 124.35** | 66.392** | 17.242 | 55.700** | 20.193* | 95.953** | 42.146 | 17.69 | 21.02 |
| p-value | [0.00] | [0.00] | [0.00] | [0.00] | [0.000] | [0.000] | [0.0691] | [0.000] | [0.027] | [0.000] | [0.002]** | [0.607] | [0.398] |
| ADF Test lag(5) | - 9.53*** | - 9.98*** | - 9.12*** | - 9.02*** | - 9.07*** | - 8.4*** | - 10.62*** | - 9.6*** | - 8.41*** | - 9.25*** | -8.830*** | -9.865*** | -9.020*** |

Note: Q(20) and $Q^2$(20) are the Ljung-Box statistics for serial correlation in standardised return and squared standardised return series at lag 20. ***,**, * indicate the rejection of the null hypotheses of no autocorrelation, normality and homoscedasticity at 1%, 5% and 10% levels of significance, respectively. The test of ADF indicates rejecetion of the null hypotheses at 1% . $CZE^A$=CZECH REPUBLIC.

### 4.4.2 Unconditional correlations of BRIC-T and CEE with the US

Table 3 presents the unconditional correlations of the return series between the USA and BRIC-T plus the CEE markets for the full sample and for the split data as well as the changes in the correlations over the two sub-periods. A comparison of the correlations over the pre-crisis and crisis/post-crisis sub-samples between the USA and the developed countries shows that the correlations were also high for the pre-crisis sub-sample and that there were no notable changes over the post-crisis period. However, the unconditional correlations for the BRIC-T plus CEE countries over the full sample vary between 0.44-0.61, except for China which is as low as 0.196, whereas the highest correlation was found for Brazil and followed by Poland. On the other hand, the correlations for the pre-crisis sample vary between 0.412-0.230 with an exception of China, which was only 0.082, and again the highest value was recorded for Brazil followed by Poland. When we consider the changes in the correlations between the two sub-samples, as observed in the last column, the correlations between BRIC-T plus the CEE markets and the US stock markets have increased significantly, ranging between 71.2% and 281.8%. However, these changes are negative for the developed countries, except for the UK, indicating a weakening of the relationship by 8.9% for Germany and 6.4% for France, while for the UK the correlations increased by 3.3%.

Table 3: Unconditional correlations of BRIC-T plus three CEEs with the USA

| Names of the Country | Full sample (03/01/2001-12/11/2013) | Pre-crisis (03/01/2001-26/06/2007) | Crisis/Post-crisis 4/07/2007-12/11/2013) | Changes |
|---|---|---|---|---|
| UK | 0.782 | 0.693 | 0.716 | 0.033 |
| Germany | 0.785 | 0.764 | 0.696 | -0.089 |
| France | 0.785 | 0.734 | 0.687 | -0.064 |
| Brazil | 0.611 | 0.412 | 0.705 | 0.712 |
| Russia | 0.506 | 0.230 | 0.650 | 1.822 |
| India | 0.439 | 0.264 | 0.629 | 1.379 |
| China | 0.196 | 0.082 | 0.313 | 2.818 |
| Turkey | 0.486 | 0.322 | 0.664 | 1.060 |
| Czech Republic | 0.559 | 0.338 | 0.675 | 0.996 |
| Hungary | 0.556 | 0.319 | 0.676 | 1.116 |
| Poland | 0.590 | 0.401 | 0.694 | 0.727 |

Note: changes are obtained using the formula (Post-crisis-pre-crisis)/pre-crisis

### 4.4.3 Unconditional correlations of BRIC-T and CEE with the EU markets

Table 4 illustrates the unconditional correlations across the three EU and BRIC-T plus the CEE markets. Considering the unconditional correlations for the full sample, it is observed that the CEE markets have a higher correlation than the BRIC-Turkey markets, with the highest being for the Czech Republic (0.72), followed by Poland (0.70). Comparing the pre-crisis and crisis/post-crisis sub-samples, the unconditional correlations are observed to be higher for the CEE markets. The reasons why there is higher correlation between the CEE markets and the EU is because these countries are regionally located and so have higher integration in terms of trade and finance. Regarding the changes from the pre-crisis to the crisis/post-crisis period, it is observed that China has the highest with 172.9%, followed by Turkey with 156.5%. In addition, lower changes are observed for the CEE markets, with Czech Republic being the lowest (69.9) and then Poland (75%).

Table 4: Unconditional correlation of BRIC-T returns with the EU index return

| Name of the country | Full sample (03/01/2001-12/11/2013) | Pre-crisis (03/01/2001-26/06/2007) | Crisis/Post-crisis 4/07/2007-12/11/2013) | Changes |
|---|---|---|---|---|
| Brazil | 0.613 | 0.421 | 0.748 | 0.777 |
| Russia | 0.589 | 0.311 | 0.731 | 1.347 |
| India | 0.500 | 0.320 | 0.601 | 0.878 |
| China | 0.232 | 0.112 | 0.308 | 1.729 |
| Turkey | 0.498 | 0.312 | 0.800 | 1.565 |
| Czech Republic | 0.724 | 0.491 | 0.835 | 0.699 |
| Hungary | 0.676 | 0.433 | 0.787 | 0.814 |
| Poland | 0.702 | 0.466 | 0.819 | 0.758 |

Note: changes are obtained using the formula (Post-crisis-pre-crisis)/pre-crisis

## 4.5 Empirical Results

The following sections will present the first and the second step DDC estimation results for the dynamic co-movements across the US, EU and the emerging markets (BRIC-T plus CEE markets) for the two sub-samples in the pre-crisis period of 3 January 2001 to 27 June 2007 and the crisis and post-crisis period from 4 July 2007 to 12 November 2013. The splitting of the sample period will allow us to compare the dynamic correlations over the two sub-periods and to observe any discernible changes, if any, in the behaviour of the dynamic correlations.

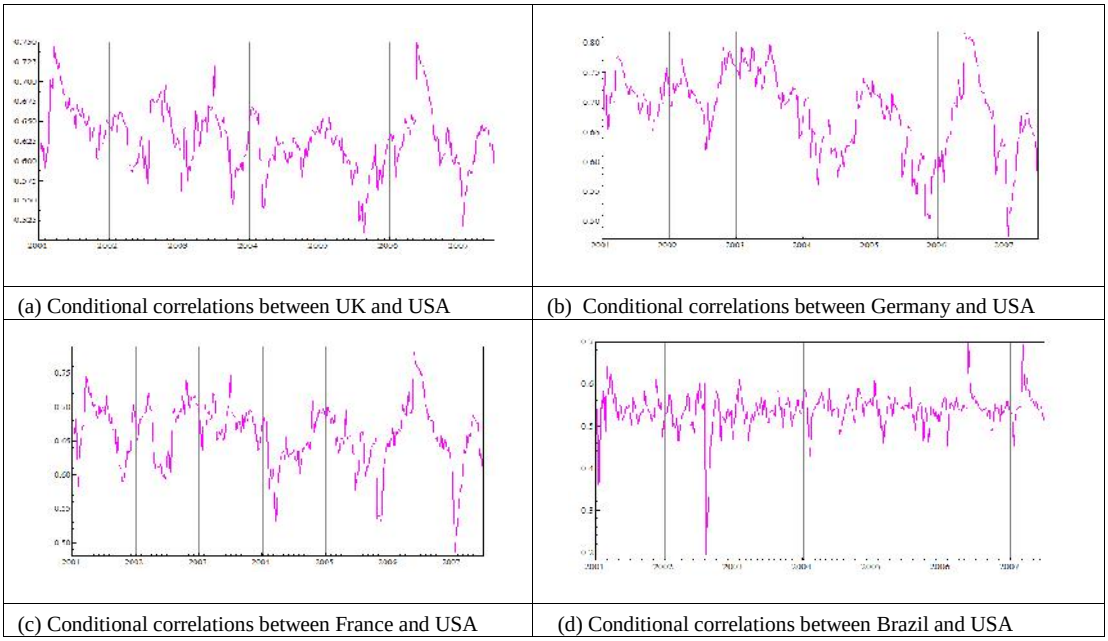
In all cases, the Hoskins (1980) multivariate portmanteau statistics reported for each model confirms the adequacy of the estimated models. The estimated autoregressive and correlation coefficients of the multivariate DCC models also meet the condition that $(a + b) < 1$ and are non-negative.

### 4.5.1 Pre-GFC period conditional correlations of BRIC-T and CEE with the US market

The empirical results for the dynamic co-movements between BRIC-T plus the CEE emerging markets and EU3 with the USA for the first sub-sample are presented in Table 5. For the US market, the conditional mean equation is filtered using an AR (1) model, while the conditional variance equation is an asymmetric EGARCH (1,1) model and is significant at least at the 5% level. According to the first step estimation results, most of the coefficients are highly significant, with high GARCH coefficients close to 1 indicating the persistence of any shock on the volatilities. The asymmetric effect has only been observed for Germany and France. Regarding the multivariate DCC equation, the estimates of the '*b*' parameter and the dynamic correlations are highly significant in all cases. Among the emerging markets, the highest correlation is recorded for Brazil with a value of 0.53, while Poland ranks as the second with a value of 0.44. The insignificant multivariate Q statistics and squared Q statistics indicate the adequacy of the estimated models. However, the test for India and China indicates some correlation left on the mean model.

Figure 5, Panels A-K show the dynamic correlations across the USA, EU3 and BRIC-T emerging markets for the pre-crisis period. As observed from Panels (a), (b) and (c), the dynamic correlations across the US, UK, Germany and French stock markets are rather volatile and high, averaging over 65% over the sub-sample; for France, Germany, and the UK the coefficients of the dynamic interrelationship range between 63-70%, 65-78%, and 60-70%, respectively. The correlations are the strongest at the beginning of 2001, which might be a reflection of the internet bubble, and between 2006 and 2007 just prior to the financial crisis. However, in contrast,

the conditional correlations among the USA and BRIC-T plus the CEE markets are observed to be, in general, rather low throughout the entire period, except that of Brazil, which ranged between 50-60%. Among the emerging markets, China is seen to be the most stable market with the lowest correlation and, thus, appears to be the best alternative financial market for foreign investment prior to the crisis period. The Russian market is also relatively stable, with a low correlation coefficient ranging around 0.25-0.30. During 2001-2003, a sharp increase in correlation is observed in most of the emerging markets, especially for Poland and Hungary, reaching as high as 65%. In general, the Indian, Turkish, Polish and Hungarian markets appear to have interdependences around 35% over this sub-period, which also exhibits increasing volatility of correlations after 2004. The reason why China has lower correlation could be due to less willingness on the part of the Chinese government to open up its financial market to international investors (for instance, China requires international investors to employ only local people after one year of operation).

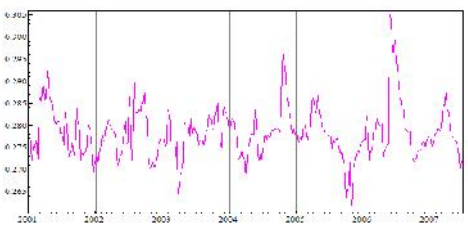


(a) Conditional correlations between UK and USA

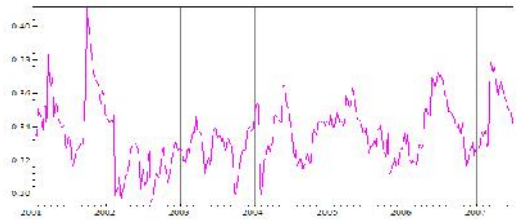
(b) Conditional correlations between Germany and USA

(c) Conditional correlations between France and USA

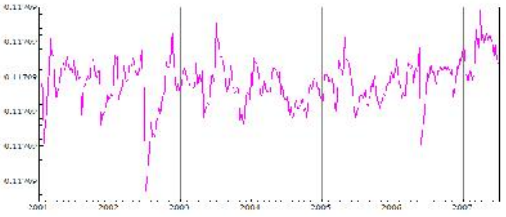
(d) Conditional correlations between Brazil and USA



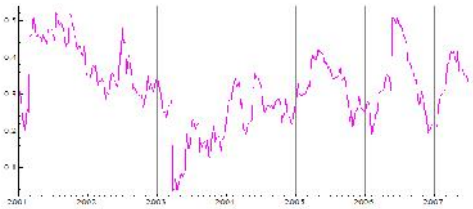
(e) Conditional correlations between Russia and USA



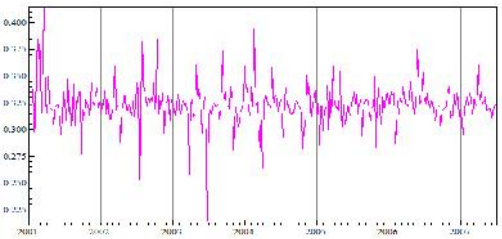
(f) Conditional correlations between India and USA



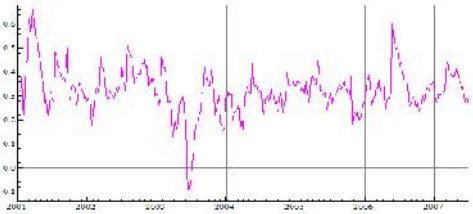
(g) Conditional correlation between China and USA



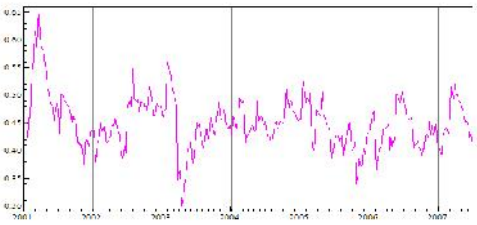
(h) Conditional correlations between Turkey and USA



(i) Conditional correlations between Czech Republic and USA



(j) Conditional correlations between Hungary and USA



(k) Conditional correlations between Poland and USA

Figure 5: Dynamic conditional correlations between the BRIC-T plus three CEE emerging markets and EU3 with the USA for pre-crisis period.

Table 5: DCC estimation results using an EGARCH(1,1) model for the US (pre-crisis sample period of 3 January 2001–27 June 2007)

| Model | UK AR(1)-GARCH(1,1) | Germany GJR(1,1) | France GJR(1,1) | Brazil ARMA(1,1)-GARCH(1,1) | Russia ARMA(1,1)-GARCH | India AR(1)-GARCH(1,1) | China GARCH(1,1) | Turkey GARCH(1,1) | Czech Republic GARCH(1,1) | Hungary GARCH(1,1) | Poland GARCH(1,1) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean equation | | | | | | | | | | | |
| μ | 0.241** | 0.258* | 0.175 | 0.651** | 0.742*** | 0.5449** | 0.075 | 0.549 | 0.721426*** | 0.554637*** | 0.576866*** |
| | (0.097) | (0.153) | (0.127) | (0.260) | (0.236) | (0.236) | (0.163) | (0.333) | (0.15095) | (0.18866) | (0.18603) |
| $a_1$ | -0.112* | | | -0.669*** | 0.285*** | 0.135** | | | | | |
| | (0.067) | | | (0.137) | (0.076) | (0.064) | | | | | |
| $a_2$ | | | | 0.741*** | -0.265*** | | | | | | |
| | | | | (0.125) | (0.104) | | | | | | |
| Variance equation | | | | | | | | | | | |
| ω | 0.643* | 0.599** | 0.551** | 1.444* | 2.999 | 1.802*** | 0.861** | 1.151 | 2.588721** | 4.115351** | 1.964214** |
| | (0.383) | (0.238) | (0.259) | (0.784) | (1.837) | (1.037) | (0.382) | (0.882) | (1.0331) | (1.6942) | (0.90059) |
| α | 0.283** | -0.015 | 0.016 | 0.112*** | 0.0806** | 0.2176* | 0.157*** | 0.064** | 0.309361** | 0.093544 | 0.079922 |
| | (0.131) | (0.050) | (0.070) | (0.044) | (0.041) | (0.121) | (0.050) | (0.030) | (0.13348) | (0.062308) | (0.054832) |
| β | 0.613*** | 0.842*** | 0.786*** | 0.829*** | 0.755*** | 0.649*** | 0.757*** | 0.903*** | 0.421477** | 0.569945*** | 0.751644*** |
| | (0.158) | (0.050) | (0.073) | (0.052) | (0.110) | (0.156) | (0.060) | (0.042) | (0.17243) | (0.13876) | (0.080162) |
| γ | | 0.201*** | 0.236** | | | | | | | | |
| | | (0.076) | (0.105) | | | | | | | | |
| Multivariate DCC equations | | | | | | | | | | | |
| a | 0.0359 | 0.0473 | 0.0142 | 0.033 | 0.011 | 0.007 | 0.000 | 0.035 | 0.00 | 0.061831* | 0.006991 |
| | (0.031) | (0.030) | (0.036) | (0.034) | (0.032) | (0.014) | (0001) | (0.023) | (18.00) | (0.033692) | (0.029411) |
| b | 0.832*** | 0.8681*** | 0.832*** | 0.422*** | 0.732*** | 0.935*** | 0.829*** | 0.906*** | 0.810136*** | 0.730174*** | 0.837933*** |
| | (0.080) | (0.065) | (0.135) | (0.173) | (0.118) | (0.088) | (0.167) | (0.052) | (0.29462) | (0.12264) | (0.14619) |
| ρ | 0.621*** | 0.697*** | 0.680*** | 0.534*** | 0.2518*** | 0.338*** | 0.137*** | 0.306*** | 0.319009*** | 0.279993*** | 0.445487*** |
| | (0.037) | (0.04) | (0.029) | (0.042) | (0.057) | (0.059) | (0.054) | (0.073) | (0.05056) | (0.066361) | (0.040812) |
| df | | 9.456*** | 12.24*** | 10.564*** | 8.740*** | | | 11.240*** | | | |
| | | (2.37) | (3.72 ) | (3.28) | (2.34) | | | (3.200) | | | |
| Diagnostic checking | | | | | | | | | | | |
| Log-likelihood | -1320.71 | -1404.83 | -1373.24 | -1625.11 | -1631.59 | -1554.14 | -1517.36 | -1751.8 | -1492.19 | -1538.27 | -1531.18 |
| MQ(20) | 79.12 | 93.803 | 89.57 | 81.759 | 72.574 | 125.98 | 105.03 | 77.952 | 72.7717 | 73.2132 | 87.3104 |
| | [0.475] | [0.122] | [0.195] | [0.363] | [0.652] | [0.00] | [0.026] | [0.512] | [0.6757065] | [0.6622889] | [0.2444997] |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $MQ^2(20)$ | 57.66 | 58.286 | 57.424 | 59.291 | 43.89 | 58.01 | 56.65 | 69.15 | 69.3626 | 45.2129 | 54.443 |
| | [0.959] | [0.953] | [0.961] | [0.943] | [0.991] | [0.956] | [0.967] | [0.752] | [0.7469572] | [0.9989177] | [0.9804748] |

Note: The numbers given in ( ) are standard errors while the numbers given in [ ] are the p-values. ***, **, * statistical significance at 1%, 5%, 10% respectively.

Table 6 : DCC estimations using EGARCH(1,1) models for the EUROSTOXX50

| Model | Brazil GJR(1;1) | Russia ARMA(1:1)-GARCH | India AR(1)-GARCH | China ARMA(1;1)-GARCH(1;1) | Turkey GARCH(1;1) | Czech Republic GARCH(1;1) | Hungary GARCH(1;1) | Poland GARCH(1;1) |
|---|---|---|---|---|---|---|---|---|
| Mean equation | | | | | | | | |
| μ | 0.538332** | 0.742901*** | 0.544978** | 1.022267 | 0.549753 | 0.721426*** | 0.554637*** | 0.576866*** |
| | (0.24941) | (0.23696) | (0.23285) | (5.8409) | (0.33368) | 0.15095 | 0.18866 | 0.18603 |
| $a_1$ | | 0.285641*** | 0.135010** | 0.994066*** | | | | |
| | | (0.076285) | (0.064548) | (0.039698) | | | | |
| $a_2$ | | -0.265519*** | | -0.966580*** | | | | |
| | | (0.10477) | | (0.051543) | | | | |
| Variance equation | | | | | | | | |
| ω | 1.619348* | 2.999478 | 1.802751* | 1.283457** | 1.151512 | 2.588721** | 4.115351** | 1.964214** |
| | (0.93492) | (1.8371) | (1.0375) | (0.62933) | (0.88208) | 1.0331 | 1.6942 | 0.90059 |
| $\alpha^1$ | 0.014466 | 0.080605** | 0.217665* | 0.170817*** | 0.064447** | 0.309361** | 0.093544 | 0.079922 |
| | (0.037697) | (0.041863) | (0.12159) | (0.064234) | 0.030879 | 0.13348 | 0.062308 | 0.054832 |
| β | 0.845472*** | 0.755957*** | 0.649539*** | 0.692971*** | 0.064447** | 0.421477** | 0.569945*** | 0.751644*** |
| | (0.053578) | (0.11012) | (0.15656) | (0.089977) | (0.030879) | 0.17243 | 0.13876 | 0.080162 |
| γ | 0.124740** | | | | | | | |
| | (0.064926) | | | | | | | |
| Multivariate DCC equations | | | | | | | | |
| a | 0.019638* | 0.024362** | 0.020162* | 0.00002 | 0.025587** | 0.016361 | 0.040514 | 0.026058 |
| | (0.010669) | (0.010442) | (0.012027) | (0.00008) | (0.010832) | (0.01534) | (0.027045) | (0.017593) |
| b | 0.980352*** | 0.975628*** | 0.979828*** | 0.842840** | 0.974403*** | 0.96188*** | 0.872429*** | 0.935372*** |
| | (0.013246) | (0.011879) | (0.015620) | (0.41425) | (0.014175) | (0.016466) | (0.13235) | (0.02203) |
| ρ | 0.328988*** | 0.162815** | 0.103192 | 0.114787** | 0.211264** | 0.516528*** | 0.446529*** | 0.548766*** |
| | (0.080612) | (0.083126) | (0.13086) | (0.055303) | (0.10215) | (0.061522) | (0.065114) | (0.06052) |
| df | 10.859044*** | | 7.972296*** | | 8.583812*** | 8.703164*** | 6.389355*** | 7.524326*** |
| | (3.2323) | | (1.8966) | | (1.7692) | (1.9764) | (1.0696) | (1.5198) |
| Diagnostic checking | | | | | | | | |
| Log-likelihood | -1757.66 | -1753.34 | -1679.55 | 1697.6 | -1876.44 | -1579.78 | -1638.01 | -1624.8 |
| MQ | 92.4198 | 68.1935 | 99.6846 | 84.6384 | 87.3670 | 66.8033 | 44.6035 | 72.2793 |
| | (0.1617460) | (0.7783741) | (0.0579105) | (0.2842817) | (0.2683598) | [0.8343531] | [0.2478979] | [0.6904670] |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $MQ^2$ | 106.266 | 68.3805 | 60.2432 | 99.4511 | 87.4370 | 81.7801 | 59.2765 | 75.909 |
| | (0.0183983) | (0.7734777) | (0.9321690) | (0.0511759) | (0.2177038) | [0.3627588] | [0.9434824] | [0.5459365] |

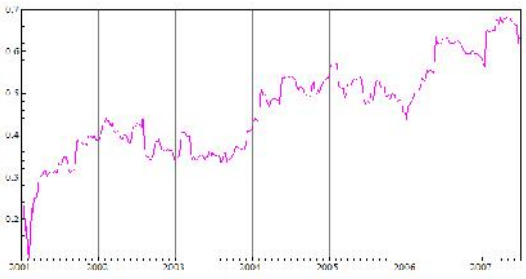
Note: The numbers given in ( ) are standard errors while the numbers given in [ ] are the p-values. ***, **, * statistical significance at 1%, 5%, 10% respectively.

### 4.5.2 Pre-GFC period conditional correlations of BRIC-T and CEE with the EU markets

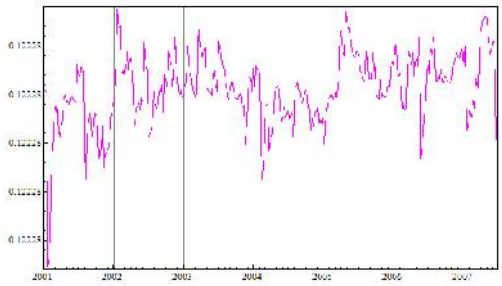
Table 6 shows the dynamic co-movements between the EU index and the emerging markets (BRICS plus CEE markets) for the first sub-sample. The EU index is modelled using EGARCH (1,1) model where the asymmetric coefficient, the GARCH and the ARCH coefficients are significant at 5% level of significance. The GARCH model is found to be suitable for almost all of the emerging markets, except for the Brazilian stock market, which is modelled with GJR. The coefficients of GARCH and ARCH are mostly significant at 1% level. In other words, a significant ARCH coefficient means that the previous day`s information on returns reflects in today's volatility, whereas significant GARCH means the previous day's return volatility reflects on today's volatility. The significance of the two coefficients means the stock return volatility is influenced by its own shock. Considering the Brazilian market, the asymmetric coefficient is statistically significant at 5% meaning that negative news persists more than positive news. The derived multivariate DCC equations between the EU and the emerging markets, all satisfy the condition $a+b<1$ and is non-negative. The multivariate portmanteau statistics reported as multivariate Q(20) and $Q^2(20)$ are based on Hoskins (1980) testing serial correlation in the mean and variance equations, respectively. The results confirm the successful elimination of serial correlation on the mean and variance equations for almost all of the markets.

Figure 6 A-H shows the dynamic conditional correlation between the EU Index and BRIC-T plus the CEE markets. In general, the dynamic correlations with the EU are higher than with the USA, and among the emerging markets the CEE have higher

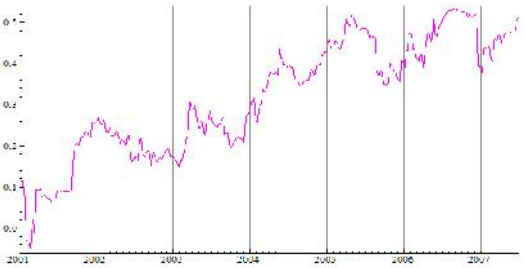
dynamic correlations, varying between 40% and 80%. A gradual increase in the conditional correlations during the period 2001-2007 is observed in Brazil from 20% to 65% and in Indian from 10% to 50%. In addition, with Czech Republic and Polish markets experienced a sharp increase in correlations starting from 2004. Finally, the lowest average correlation is observed with Russia and China with 12% and 16 %, respectively.



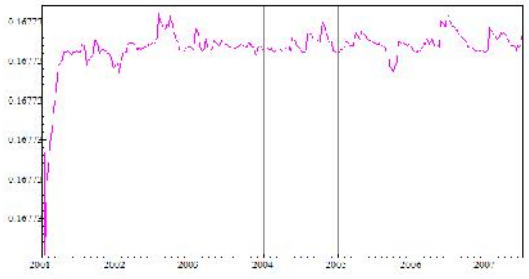
(a) Conditional correlations between Brazil and EU



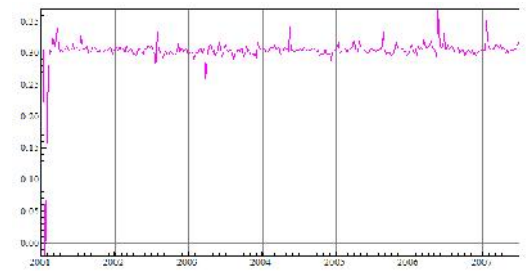
(b) Conditional correlations between Russia and EU



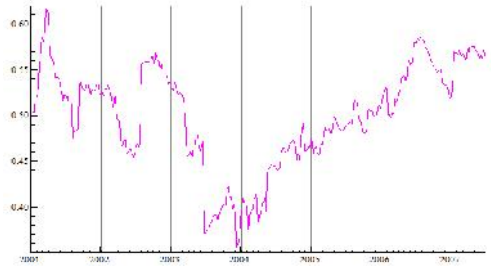
(c) Conditional correlations between India and EU



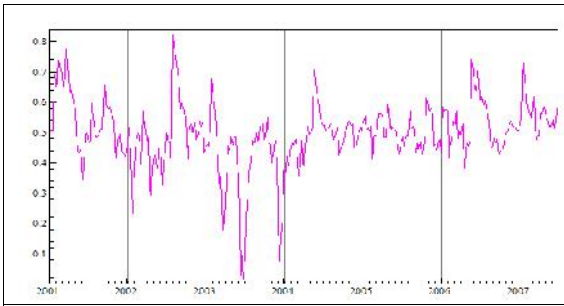
(d) Conditional correlations between China and EU



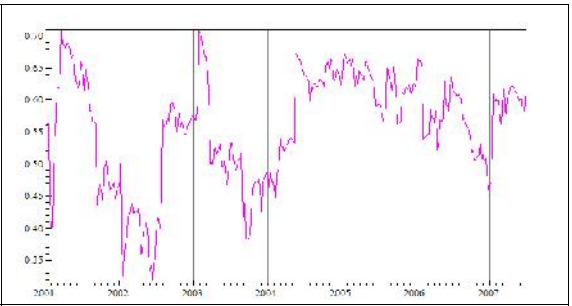
(e) Conditional correlations between Turkey and EU



(f) Conditional correlations between Czech Republic and EU



(g) Conditional correlations between Hungary and EU



(h) Conditional correlations between Poland and EU

Figure 6: Conditional correlations between the BRIC-T plus the CEE emerging markets and the EU for pre-crisis period.

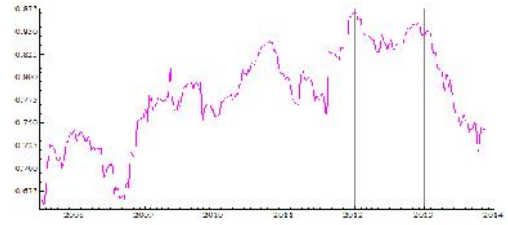
### 4.5.3 Crisis and post-crisis period conditional correlations BRIC-T and CEE with the US market

The DCC estimation results regarding the dynamic correlations among the US and the three European markets and the BRIC-T plus the CEE emerging markets over the crisis and post-crisis period (covering 4 July 2007–13 November 2013) are presented in Table 7. In the conditional variance equations, the asymmetric behaviour of the market returns is modelled by EGARCH (1,1) in the case of three European markets. For the emerging markets, the asymmetric behaviour is detected for Brazil, India, Czech Republic and Poland, which is GJR (1,1) modelled. In general, all of the coefficients are highly significant and the GARCH coefficients are very close to 1, indicating the persistence of any shock to volatility. The coefficients of the asymmetric effects (γ) are all negative and highly significant for the three EU markets, suggesting that negative shock volatilities have more impact than positive ones. Regarding the second stage estimation results, all of the parameters are highly significant at the 1% significance level. It is worth noting here that the dynamic correlations for Brazil have increased by 26% from the pre-crisis period, reaching 0.67. Russia appears to be the second most risky country, with an approximate correlation estimate of 0.60, while Turkey ranks as the third with an estimate of 0.56.

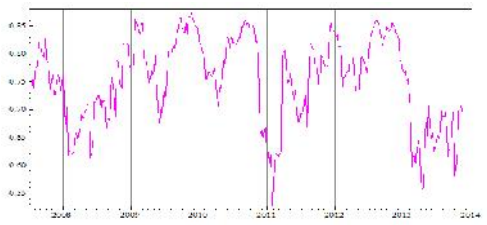
For the European markets, the range of increase in dynamic correlations is merely between 3.6% -12.5% as from the pre-crisis period, the highest being France and the lowest estimate observed for Germany. The diagnostic statistics reported at the end of the table indicate that the estimates are reliable and only the mean equation for Brazil has serial correlation based on Q statistics.

Figure 7 Panels A-K show the conditional correlations across the EU3, the BRIC-T plus CEE markets and the US markets for the second sub-sample period. Starting from mid-2007, Germany and France exhibited similar and very high correlation spillovers, reaching as high as 85% by the end of 2009, which remained at these levels until the beginning of 2013, except for a shot of calming from the end of 2010 until the third quarter of 2011. This might be interpreted as the relief in the markets due to the precautionary economic measures announced by the European Central Bank (ECB) and the IMF to provide the necessary support to save the Euro. However, regarding the conditional correlations across the UK and the US markets, the peak is observed in 2012, which reached 87.5%. For BRIC-T plus the CEE markets, the co-movements of stock returns across the crisis-originating country are rather low during the pre-crisis period (see Figure 3), while these markets have become highly interdependent as from 2007 until the end 2012. For example, in the case of Brazil, the conditional correlations have become highly volatile and increased significantly from about 55-60% to 85% by the end of 2010. A sharp decline is noticed from the first quarter to third quarter of 2011, but starting from the third quarter of 2011 it increased significantly until mid-2012. Considering the CEE markets, a shape increase starting from 2009 until the end of 2012 is noticed, reaching as high as 80% with Hungary, 75% with the Czech Republic, and 70%

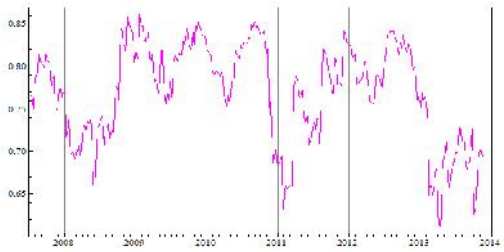
Poland. Similarly, for the EU3, during 2011, those markets experienced calming due to the measures taken by the ECB and IMF. In the case of China, despite its relatively closed financial sector, the conditional correlation has increased by more than double, especially over the period from mid-2007 to 2011. After 2011, although volatility has decreased, the correlations remained at high levels of around 35%. Likewise, for India the dynamic correlations significantly increased, reaching as high as 70% from the end of 2008 until 2011. Similarly, the Russian and the Turkish stock markets have been affected by the end of 2008. However, the dynamic correlations of the Russian and the US markets are highly volatile over the second sub-sample as compared to the other BRIC-T markets, except for Brazil. In other words, the Brazilian and Russian markets have been observed to be the most volatile markets and are highly influenced from the US market, with correlations reaching as high as 80%. On the other hand, the Chinese market seems to be the least affected by the turmoil. Although Turkey is an open market with no restrictions on foreign investors, the second least affected markets is observed to be the Turkish market, with dynamic correlations fluctuating around 52-57% over 2008 to 2013.



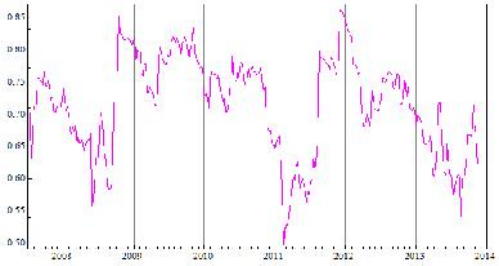
(a) Conditional correlations between UK and USA



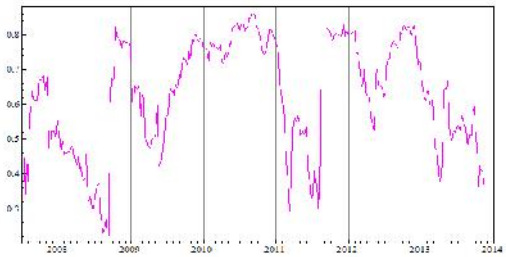
(b) Conditional correlations between Germany and USA



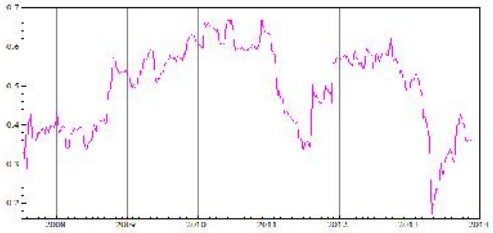
(c) Conditional correlations between France and USA



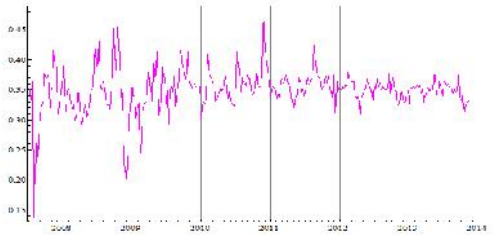
(d) Conditional correlations between Brazil and USA



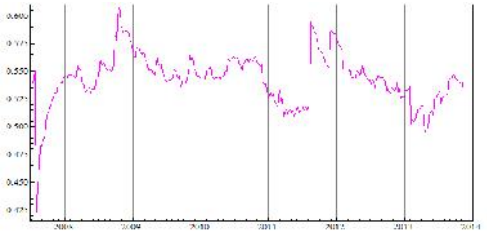
(e) Conditional correlations between Russia and USA



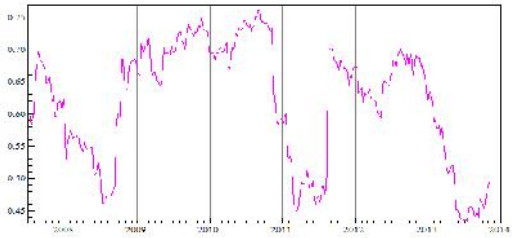
(f) Conditional correlations between India and US



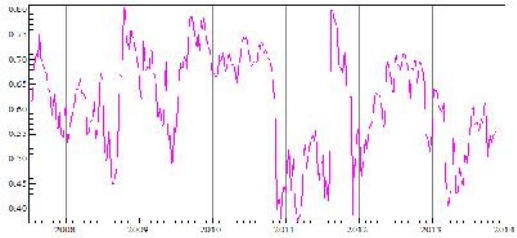
(g) Conditional correlations between China and USA



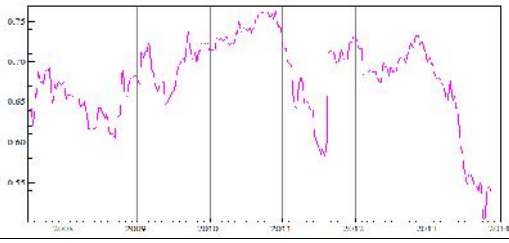
(h) Conditional correlations between Turkey and USA



(i) Conditional correlations between Czech Republic and USA



(j) Conditional correlations between Hungary and USA



(k) Conditional correlation between Poland and USA

Figure 7: Conditional correlations between the BRIC-T Emerging Markets and the EU3 with the US for the crisis and post-crisis period.

Table 7: DCC estimations using EGARCH(1,1) models for the US (crisis and post-crisis period of 4 July 2007 – 13 November 2013 )

| | UK EGARCH(1,1) | Germany EGARCH(1,1) | France EGARCH(1,1) | Brazil GJR(1,1) | Russia GARCH(1,1) | India ARMA(1,1)-GJR | China GARCH (1,1) | Turkey ARMA(1,1)-GARCH | Czech republic EGARCH(1,1) | Hungary EGARCH(1,1) | Poland EGARCH(1,1) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean equation | | | | | | | | | | | |
| μ | -1.180 | -0.191 | -0.282 | -0.298 | 0.319 | -0.228 | -0.113 | 0.159 | -0.13268 | -0.0075 | -0.16995 |
| | (0.146) | (0.196) | (0.189) | (0.241) | (0.251) | (0.267) | (0.174) | (0.304) | 0.20214) | 0.22529) | 0.19556) |
| $a_1$ | | | | | | 0.623*** | | 0.660*** | | | |
| | | | | | | (0.196) | | (0.179) | | | |
| $a_2$ | | | | | | -0.529*** | | -0.614*** | | | |
| | | | | | | (0.197) | | (0.16989) | | | |
| Variance equation | | | | | | | | | | | |
| ω | 2.385*** | 2.792*** | 2.763*** | 0.748 | 3.567 | 0.142 | 0.102 | 0.1630 | 2.984098*** | 1.065242 | 3.122928*** |
| | (0.284) | (0.230) | (0.201) | (0.555) | (2.457) | (0.216) | (0.137) | (1.074) | 0.2102) | 0.62953) | 0.24036) |
| α | -0.406* | -0.393*** | -0.226 | 0.0298 | 0.2453** | -0.014 | 0.051* | 0.080*** | -0.13247 | 0.176261*** | -0.20587 |
| | ((0.230) | (0.130) | (0.255) | (0.054) | (0.126) | (0.043) | (0.029) | (0.031) | 0.36312) | 0.065032) | 0.34919) |
| β | 0.945*** | 0.921*** | 0.903*** | 0.835*** | 0.652*** | 0.942*** | 0.937*** | 0.865*** | 0.911384*** | 0.800224*** | 0.931162*** |
| | (0.039) | (0.031) | (0.056) | (0.069) | (0.150) | (0.054) | (0.036) | (0.037) | 0.044345) | 0.057917) | 0.033317) |
| $\Theta^1$ | -0.309*** | -0.385*** | -0.327** | | | | | | -0.20499** | | -0.25574** |
| | (0.077) | (0.093) | (0.000) | | | | | | 0.10221) | | 0.12111) |
| $\Theta^2$ | 0.258** | 0.124 | 0.154** | | | | | | 0.217071** | | 0.228058** |
| | (0.114) | (0.078) | (0.041) | | | | | | 0.091911) | | 0.099362) |
| γ | | | | 0.239*** | | 0.138* ** | | | | | |
| | | | | (0.121) | | (0.045) | | | | | |
| Multivariate DCC Equations | | | | | | | | | | | |
| a | 0.023** | 0.076** | 0.054** | 0.034** | 0.094*** | 0.026** | 0.027 | 0.021 | 0.03387 | 0.063132 | 0.020449 |
| | (0.011) | (0.038) | (0.023) | (0.017) | (0.032) | (0.013) | (0.032) | (0.022) | (0.028095) | (0.042544) | (0.015903) |
| b | 0.976*** | 0.866*** | 0.885*** | 0.948*** | 0.885*** | 0.966** | 0.654*** | 0.917*** | 0.950661*** | 0.855149*** | 0.973929*** |
| | (0.012) | (0.071) | (0.041) | (0.051) | (0.046) | (0.014) | (0.179) | (0.047) | (0.077571) | (0.090063) | (0.028013) |
| ρ | 0.666*** | 0.752*** | 0.765*** | 0.669*** | 0.597*** | 0.429*** | 0.349*** | 0.560*** | 0.586159*** | 0.608636*** | 0.640509*** |
| | (0.078) | (0.046) | (0.032) | (0.118) | (0.133) | (0.196) | (0.050) | (0.049) | (0.16279) | (0.060322) | (0.10414) |
| df | 10.42*** | 8.229*** | 10.90*** | 12.74*** | 7.142*** | 11.25*** | 11.62*** | 7.05*** | 8.737408*** | 8.92506*** | 12.1332*** |
| | (3.29) | (1.790) | (3.65) | (4.72) | (1.52) | (3.47) | (3.56) | (1.57) | (1.9728) | (2.3041) | (4.3132) |

| Diagnostic checking | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Log-likelihood | -1432.38 | -1506.99 | -1507.42 | -1623.42 | 1010.56 | 1642.54 | - 1613.66 | -1695.65 | -1626.23 | -1702.26 | -1628.31 |
| MQ | 80.681 | 77.22 | 77.49 | 105.76 | 73.50 | 83.43 | 91.75 | 91.74 | 78.5524 | 88.9079 | 92.4091 |
| | [0.457] | [0.567] | [0.558] | [0.019] | [0.682] | [0.316] | [0.173] | [0.136] | [0.5248481] | [0.2321039] | [0.1619350] |
| MQ2 | 87.24 | 81.969 | 84.33 | 98.64 | 83.97 | 92.65 | 69.40 | 77.36 | 83.6038 | 120.483 | 59.9498 |
| | [0.221] | [0.357] | [0.292] | [0.077] | [0.301] | [0.123] | [0.745] | [0.4989] | [0.3115549] | [0.0014481] | [0.9357598] |

Note: The numbers given in ( ) are standard errors. ***, **, and * indicate the univariate and multivariate coefficients are statistically significant at 1%, 5%, and 10%, respectively

Table 8:DCC estimations using EGARCH(1,1) models for the EU (crisis and post-crisis period)

| Model | Brazil ARMA(1,1) GJR(1,1) | Russia ARMA(1,1) GJR (1,1) | India ARMA(1,1) GJR(1,1) | China GARCH(1,1) | Turkey ARMA(1,1) GJR(1,1) | Czech republic EGARCH(1,1) | Hungary EGARCH(1,1) | Poland EGARCH(1,1) |
|---|---|---|---|---|---|---|---|---|
| Mean Equation | | | | | | | | |
| μ | 0.777 | 0.319 | -0.228 | -0.113 | -0.273 | -0.13268 | -0.0075 | -0.16995 |
| | (0.570) | (0.251) | (0.267) | (0.174) | (0.469) | 0.20214 | 0.22529 | 0.19556 |
| $a_1$ | 0.801** | | 0.623*** | | 0.889*** | | | |
| | (0.332) | | (0.196) | | (0.116) | | | |
| $a_2$ | -0.7792** | | -0.529*** | | -0.835*** | | | |
| | (0.333) | | (0.197) | | (0.148) | | | |
| Variance equation | | | | | | | | |
| ω | 0.777 | 3.567 | 0.1425 | (0.103) | 1.245* | 2.984098*** | 1.065242 | 3.122928*** |
| | (0.570) | (2.457) | (0.216) | 0.137 | (0.754) | 0.2102 | 0.62953 | 0.24036 |
| α | 0.025 | 0.245** | -0.014 | 0.051* | -0.068** | -0.13247 | 0.176261*** | -0.20587 |
| | (0.063) | (0.126) | (0.043) | (0.029) | (0.033) | 0.36312 | 0.065032 | 0.34919 |
| β | 0.829** | 0.652*** | 0.942*** | 0.937*** | 0.923*** | 0.911384*** | 0.800224*** | 0.931162*** |
| | (0.072) | (0.150) | (0.054) | (0.036) | (0.047) | 0.044345 | 0.057917 | 0.033317 |
| $\Theta^1$ | | | | | | -0.20499** | | -0.25574** |
| | | | | | | 0.10221 | | 0.12111 |
| $\Theta^2$ | | | | | | 0.217071** | | 0.228058** |
| | | | | | | 0.091911 | | 0.099362 |
| γ | 0.267** | | 0.138*** | | 0.182*** | | | |
| | (0.132) | | (0.045) | | (0.063) | | | |
| Multivariate DCC Equations | | | | | | | | |
| a | 0.094*** | 0.117*** | 0.036** | 0.000 | 0.094** | 0.11185** | 0.034839** | 0.018109** |
| | (0.033) | (0.042) | (0.015) | (0.005) | (0.046) | (0.049098) | (0.016942) | (0.009065) |
| b | 0.8561*** | 0.805*** | 0.942*** | 0.838*** | 0.817*** | 0.702313*** | 0.955882*** | 0.981881*** |
| | (0.062) | (0.080) | (0.019) | (0.312) | (0.074) | (0.17494) | (0.020862) | (0.009647) |
| ρ | 0.695*** | 0.698*** | 0.537*** | 0.340*** | 0.622*** | 0.790035*** | 0.703861*** | 0.696452*** |
| | (0.056) | (0.059) | (0.095) | (0.055) | (0.071) | (0.032479) | (0.10492) | (0.14137) |
| df | 13.531*** | 7.934*** | 14.958*** | | 7.238*** | | | |
| | (5.23) | (1.87) | (6.06) | | (1.59) | | | |

| Diagnostic checking | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Log-likelihood | -1776.25 | -1786.39 | -1789.11 | -1776.56 | -1833.8 | -1696.33 | -1792.07 | -1708.77 |
| MQ | 90.00 | 78.89 | 86.07 | 95.89 | 82.12 | 77.7396 | 79.068 | 97.5237 |
| | [0.166] | [0.514] | [0.24] | [0.108] | [0.352] | [0.5507471] | [0.5084495] | [0.0889433] |
| MQ2 | 87.27 | 74.00 | 79.45 | 57.70 | 43.84 | 65.5479 | 69.5139 | 44.7918 |
| | [0.221] | [0.607] | [0.430] | [0.958] | [0.999] | [0.8416910] | [0.7427531] | [0.9990824] |

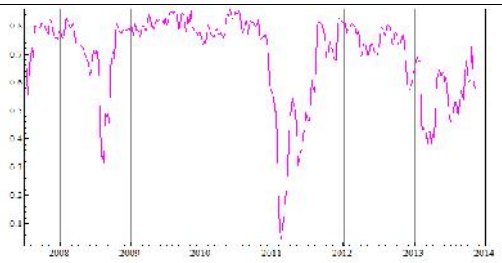
Note: The numbers given in ( ) are standard errors. ***, **, and * indicate the univariate and multivariate coefficients are statistically significant at 1%, 5%, and 10%, respectively

### 4.5.4 Crisis and post-crisis period conditional correlations of BRIC-T and CEE with the EU markets

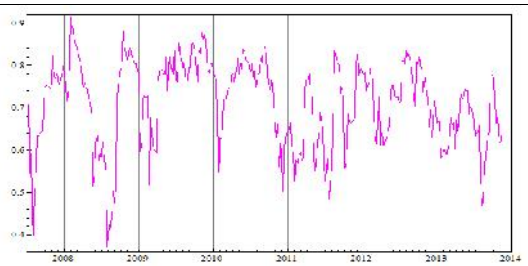
Table 8 presents the empirical results for the dynamic correlations between the European and the BRIC-T plus the CEE markets for the second sub-sample period. The conditional variance equation for the EU index returns is an EGARCH (1,1) model. The estimates for the dynamic conditional correlations have significantly increased for all the countries compared with those for the pre-crisis period. These results suggest higher interdependences across the BRIC-T and the EU markets as compared with the USA, which is an indication that the regional factor is very important in explaining the correlation spillovers and volatility transmission. Interestingly, although the CEE markets have a higher level of correlation with the EU index, the changes in average dynamic correlations among BRIC-Turkey and UE index are greater. The reason for this is because the CEE countries already had higher correlations before the crisis.

Figure 8 Panels A-H presents the conditional correlations between the EU index and BRIC-T plus the CEE markets for the second sub-sample, which have remarkably increased as compared to the pre-crisis period. After mid-2008, the estimated value for the Czech Republic, Hungary and Poland reaches as high as 85% and remains at high levels until the end of 2012, with the exception of the Czech Republic, which stays high until the end of sample period. The co-movements of the Chinese market with the EU markets in general stayed at 34% throughout the period, which is lower than those with the US market. In the case of India, the interdependences reach as high as 70% over 2008-2010, which are again recorded to be much higher than those with the USA. Similar to the correlation pattern in Brazil, the weakening of the

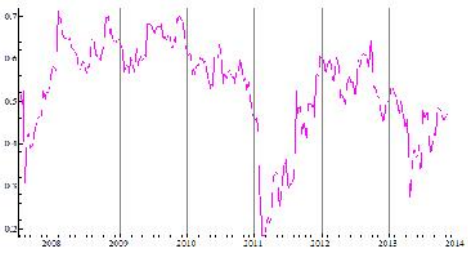
interdependences in 2011 is not permanent and reverts back to a level of around 0.6 until 2013, after which it starts declining although remains volatile. The highest conditional correlation is observed between Russia and the EU, reaching as high as 80% (in early 2008) and showing high volatility until 2013. Similarly, the Turkish financial market also seems to be highly interrelated with the European markets after the crisis period; the estimated rho value for Turkey significantly increased and stayed above 60% until 2013. In general, the conditional correlation between India, Russia and Turkey shows higher and increased volatility with the EU than with the USA market. In other words, these countries are highly affected by the US financial crisis through the European markets rather than directly from the US financial market. Moreover, our findings also suggest that the European and the BRIC-T financial markets remain highly interdependent even after 2009, which may be interpreted as a repercussion of the global financial crisis.



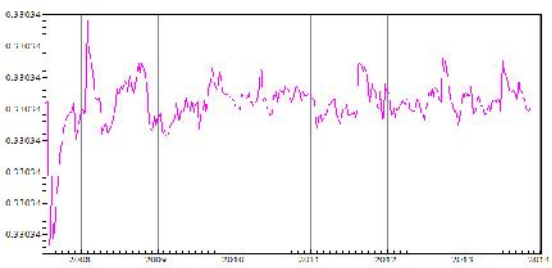
(a) Conditional correlations between Brazil and EU



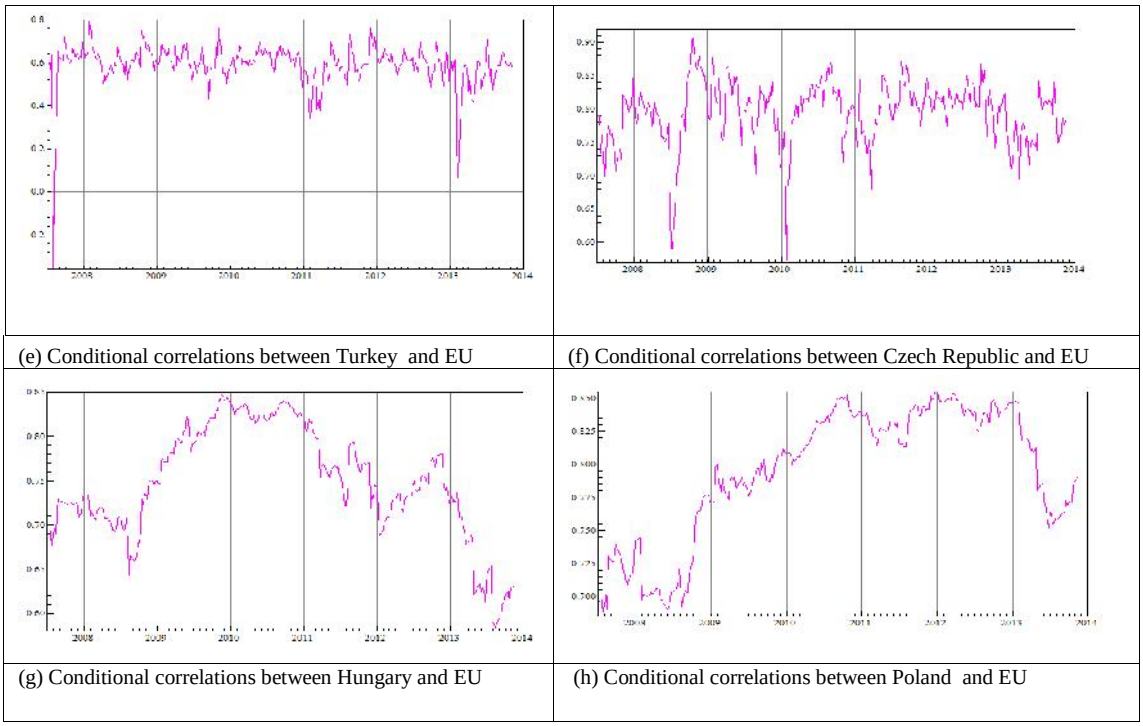
(b) Conditional correlations between Russia and EU



(c) Conditional correlations between India and EU



(d) Conditional correlations between China and EU



(e) Conditional correlations between Turkey and EU

(f) Conditional correlations between Czech Republic and EU

(g) Conditional correlations between Hungary and EU

(h) Conditional correlations between Poland and EU

Figure 8: Conditional correlations between the BRIC-T plus the CEE emerging markets and the EU for the crisis and post-crisis period.

## 4.6 Average Dynamic Conditional Correlations with the USA and EU

Comparing the correlation between the developed markets and developing economies with the originating crisis country for the stable period. In table 9, it is observed that mature markets have much higher correlation with the US, with the highest being for Germany (0.697) and followed by France (0.68). Furthermore, considering the correlation between BRIC plus the CEE markets with US market during the pre-crisis period, generally the correlations are low, with the lowest being China (0.137) and highest being Brazil (0534) followed by Poland (0.4454) and the Czech Republic (0.31909). In Column 2 Panel (a), it is observed that the correlations for the emerging markets have substantially increased. For example, Brazil and Poland reached 67% and 64%m respectively. However, with the mature markets the

correlations have not increased much and indeed stayed almost as during the pre-crisis period. Regarding the change in Column 3 Panel (a), we notice the highest increase for the emerging economies with China (154%) followed by Russia (137%) and the lowest being for Brazil (25%) and India (26.9%). Interestingly, the increase in correlation in the EU3 is subnational low, for example the highest change being with France (12.5) and followed by Germany (7.89%) and the lowest increase being for the UK (7.24%). Table 9 Panel (b) shows the correlations between emerging BRIC-T plus the CEE markets with the EU for the pre-crisis and crisis/post periods. In general, the correlations are much higher for the CEE markets than for the BRICS, with the highest being for Poland (0.54) and followed by the Czech Republic (0.516) and the lowest being with India (0.10) and China (0.11). Considering the correlation during the crisis/post-crisis period, again the CEE markets retain a higher level of correlation with the EU, with the Czech Republic being the highest (79%) followed by Hungary (70%). In addition, the level of correlation with BRIC has also increased, with Russia and Brazil being an equally high 69%. Considering the changes in Column 3 Panel (b), it is observed that the BRIC have a much more significant increase in correlation than the CEE markets, with the highest increase being for India (420%) followed by Russia (328%), while the lowest increase being for Poland (26.71%).

Table 9: Estimated average dynamic conditional correlations

| | Pre-GFC pried | | GFC/Post period | | % changes |
|---|---|---|---|---|---|
| | Coefficient | s.e | Coefficient | s.e | |
| Panel A DCC with USA markets | | | | | |
| UK | 0.621*** | (0.037) | 0.666*** | (0.078) | 7.25 |
| Germany | 0.697*** | (0.04) | 0.752*** | (0.046) | 7.89 |
| France | 0.68*** | (0.029) | 0.765*** | (0.032) | 12.50 |
| Brazil | 0.534*** | (0.042) | 0.669*** | (0.118) | 25.28 |
| Russia | 0.2518*** | (0.057) | 0.597*** | (0.133) | 137.09 |
| India | 0.338*** | (0.059) | 0.429*** | (0.196) | 26.92 |
| China | 0.137*** | (0.054) | 0.349*** | (0.05) | 154.74 |
| Turkey | 0.306*** | (0.073) | 0.56*** | (0.049) | 83.01 |
| Czech Republic | 0.319*** | (0.051) | 0.586*** | (0.163) | 83.74 |
| Hungary | 0.280*** | (0.066) | 0.609*** | (0.060) | 117.38 |
| Poland | 0.445*** | (0.041) | 0.641*** | (0.104) | 43.78 |
| Panel B DCC with EU index markets | | | | | |
| Brazil | 0.329*** | (0.081) | 0.695*** | (0.056) | 111.25 |
| Russia | 0.163*** | (0.083) | 0.698*** | (0.059) | 328.71 |
| India | 0.103*** | (0.131) | 0.537*** | (0.095) | 420.39 |
| China | 0.115*** | (0.055) | 0.340*** | (0.055) | 196.20 |
| Turkey | 0.211*** | (0.102) | 0.622*** | (0.071) | 194.42 |
| Czech Republic | 0.517*** | (0.062) | 0.790*** | (0.032) | 52.95 |
| Hungary | 0.447*** | (0.065) | 0.704*** | (0.105) | 57.63 |
| Poland | 0.549*** | (0.061) | 0.696*** | (0.141) | 26.91 |

Note: the numbers given in ( ) are standard errors. ***, **, * indicate the significance levels at 1%, 5%, and 10%, respectively.

## 4.7 Robustness checks

By changing the starting date of the crisis we have confirmed that our main findings do not change. In order to check the robustness of the estimations we consider the starting of the crisis as 1 December 2007 instead of July 4. It is worth remembering that according to the National Bureau of Economic Research, the beginning date of the financial crisis was December 1, 2007. Moreover, some studies also consider starting date of GFC in line with this date, see for example Zhang et al. (2013).

## 4.8 Conclusion

We attempted to investigate whether the dynamic correlation behaviour of the BRIC plus Turkey (BRIC-T), the USA, and the three developed EU countries (the U.K, Germany and France) are different, leading to temporary or long-term effects of the recent financial crisis, and whether the EU countries have played a greater role in the transmission of the effects of the GFC to the BRIC-T markets than the direct influences from the crisis originating market. We have included Turkey with the BRIC in our study, since it is a fast growing MENA country as compared to its neighbouring developing countries and has a very rapidly growing equity market (Istanbul stock exchange), which has recently become an important financial market attracting foreign investors both from European and GCC countries. We included the CEE markets (Czech Republic, Hungary, and Poland) in the emerging markets group for three reasons. First, these markets are among the biggest emerging markets in the EU and, since they joined the EU in 2004, they have received a considerable amount of portfolio investment. Second, empirical studies of the GFC have documented that the most affected emerging economies are the Eastern European emerging economies (see Claessens et al. 2010); therefore, including those countries in our study will provide more meaningful results. Third, given that the advanced EU markets have experienced the most impacts of the GFC, including some of the CEE markets, their inclusion allows us to capture the regional spillover. In addition, the CEE countries highly depend on the developed EU markets for investment and for exporting their products.

The sample period is divided into the pre-crisis and crisis and post-crisis periods in order to capture the structural changes, if any, in the dynamic linkages across the

markets. The empirical results indicate that, first of all, the structure of the transmission mechanism and the impact of the GFC on the developed and the BRIC-T countries are quite different. The BRIC-T markets have been more highly affected by the global financial crisis as compared to the developed EU3 countries. All of the mature markets that are highly integrated with the US market evidenced high dynamic correlations throughout the whole sample period, while the emerging BRIC-T markets exhibited very low dynamic correlations in their stock markets before the crisis, which significantly increased for the crisis/post-crisis sub-period and remained persistent and volatile until 2013. Second, the EU index has a more significant and greater volatility impact on BRIC-Turkey as compared to the crisis-originating country, the USA. However, the three CEE markets felt the impact more from the USA. This is because the correlation between the three CEE countries and the EU index was already high even before the GFC period. Third, the emerging market economies have not been affected as immediately as the EU countries, although the effects have been more long-lasting but not permanent, starting to decrease from 2013. Fourth, we have noted that the dynamic evolution of the CEE markets has considerably increased and became more volatile from 2009 until the end of the sample, although they experienced a short calming during in the third quarter of 2011 due to ECB and IMF intervention before starting to increase again. Therefore, the impacts of the ESDC were stronger on the CEE markets than on BRIC-Turkey. This renders it necessary to investigate the extent to which the ESDC affected those markets.

# Chapter 5

# SPILLOVER EFFECTS OF GIPSI AND EU3 ON THE THREE CEE MARKETS DURING THE GFC AND ESDC PERIODS

## 5.1 Introduction

One of the worst consequences of the GFC was the outbreak of the ESDC in late 2009, which was expected and was not surprising considering the strong ties between the crisis originating country, the USA, and the EU. Certainly, the GFC energized numerous researchers to investigate the impacts on other countries, especially research that examines the spillover effects through stock markets. Empirical studies that analyse the spillover effects of the ESDC mostly concentrate on the bond market and/or credit defaults swap (CDS), while studies that use the stock markets are more rare. Given that the European Union is one of largest world economies and has strong economic and political ties with several developed and developing economies, it deserves greater attention. In addition, there have been no studies that compare the spillover effects of these two crises and whether the GFC had a much more severe impact than the ESDC or vice versa. Therefore, the second part of this thesis will study the extent to which the European emerging economies felt the impacts. Did the CEE suffer more during the GFC or the EDSC period? In order to answer to this question, the spillover effects from the most affected European stock market, the GIPSI, are analysed. Furthermore, we also included the impacts from the three largest European economies (UK, Germany, and France; referred to as EU3) to

understand whether the spillover effects are much more significant from the crisis borne countries or from the largest economies with strong financial and trade ties with the CEE markets.

Understanding how conditional correlation changes within the region between the GIPSI and EU3 with the three CEE countries during the GFC and EDSC periods is crucial and should be of great interest to individual investors, institutional and corporate investors, financial managers, and policy makers. In the following paragraph, four points in relation to the possible economic consequences of the effects of the crises are addressed. First, is there a weak correlation between the EU developed markets (GIPSI and EU3 countries) and the three CEE markets? Asset allocation (i.e., investing in multiple assets to reduce risk) would require weak correlation among the assets. So, can the three CEE markets provide the benefits of portfolio diversification during times of turmoil in mature markets? Previous empirical results have suggested that emerging markets have weak correlations and high returns compared to mature markets (Bekaert and Harvey 1997). Second, in addition to the free movement of labour and capital within the member states, the emerging European markets enjoy strong trade and financial linkages with the advanced EU countries; however, these connections leave the emerging markets' economies very vulnerable during times of turmoil. For example, in the first quarter of 2014, the domestic bank of the Czech Republic owed $52,605 million to the EU3 and $20,284 million to GIPSI, while the banks in Hungary and Poland owed $21,128 million and $96,940 million to the EU3 and $22,737 million and $60,342 million to GIPSI, respectively. In its reports, the International Bank for Settlement also showed that the domestic bank in the Czech Republic owed $189,348 million to advanced

European countries while Hungary and Poland owed a total of $84,176 million and $295,459 million, respectively. Access to the credit market is very important for domestic firms, since the decision to enlarge their capacity and boost investment depends on the availability of funds to facilitate borrowing without constraint. At the same time, households may also require credit to purchase a house or a car and to make decisions about future consumption. However, domestic banks may have limited available funds from advanced European banks, which may affect local firms' stock prices and so require the study of correlation changes. Moreover, advanced economies may also have a considerable amount invested in direct and portfolio investments, which again necessitates the investigation of changes in stock return correlations. Third, how did the dynamics of conditional correlations change before and during the GFC and ESDC? Are there temporary or enduring changes? Fourth, is the level of conditional correlation higher with the EU3 relative to the GIPSI countries or is there an association between a country's economic development and its conditional correlation with the stock index returns of these countries?

## 5.2 Literature Review on the ESDC

### 5.2.1 Spillover effects from government and CDS markets

Numerous studies have investigated the spillover effects of shocks resulting from the Eurozone sovereign debt crisis using the bond market or CDS (Kalbasakaa and Gatkowskib 2012; Bruyckere et al. 2013; Kohonen 2014; Puig et al. 2014; Gorea and Rade 2014; Avinoa and Cotter 2014; Alter and Andreas 2014; Drenovak et al. 2014; Sensoy et al. 2013). It is worth remembering that most of these studies have concentrated on the effects within the European countries. For example, Kalbasakaa

and Atkowskib (2012) found that within the GIPSI countries, the CDS markets of Spain and Ireland had a greater impact on the European CDS, whereas the CDS market of the UK did not cause great distress in the Eurozone and was also immune from shocks. In addition, they found Portugal to be the most risky country among the GIPSI and noted that, overall, contagion is only observed from the core EU rather than from the GIPSI countries. Avinoa and Cotter (2014) examined whether there is an association between the sovereign and CDS spreads for the period 2004-2013. Their results were in favour and noted that, for Portugal and Spain, the sovereign CDS spread had a greater impact during the GFC and Eurozone crisis, but for Germany and Sweden the bank CDS spread had a greater impact throughout the study. In line with these studies, Sensoy et al. (2013) used the DCC model to study the spillover effects from the European countries to Turkey. In their findings, they documented an increase in CDS correlations during the Eurozone crisis. There are also studies that examine the impact of credit rating changes on financial markets (Alsakka and Gwilym 2011; Cavallo et al. 2013; Afonso et al. 2012).

### 5.2.2 Spillover effects to banking sectors

The European crisis has also energised some researchers to investigate the spillover effects to banking stock returns. For example, Tamakoshi and Hamori (2013) explored whether the Greek sovereign debt crisis had any impact on five major financial institutions in Europe. They provided evidence that the stock returns of all the five financial institutions under study were highly affected by the Greek debt crisis. Mink and Haan (2013) examined whether news about the bailout and other news on Greece could lead to financial contagion in 48 European banking stock returns. Interestingly, they noted that news on the bailout had a significant effect on the European bank returns, whereas other news only had an effect on the Greek local

banks. In line with this, Arnold (2012) also found substantial spillover effects from GIPSI banks to other market.

### 5.2.3 Spillover effects through the stock markets

The stock markets are the main channel for transmitting shocks from one country to another. However, only relatively few studies have examined the impacts of the ESDC from the most affected countries. Dajcman (2013) noted contagion during the Greek debt crisis from the Irish, Italian and Spanish stock markets to the stock markets of France and Germany. Furthermore, Harmann (2014) examined contagion effect from developed European countries to eight European emerging economics. In their findings, they observed an increase in correlation during the sovereign debt crisis. Acatrinei et al. (2013) found that contagion effects from Germany had an impact on the Romanian stock market. Ahmed et al. (2013) examined volatility and conditional correlation spillovers from the Eurozone crisis countries to emerging BRIICKS (Brazil, Russian, India, Indonesia, China, South Korea). They found the existence of interdependence with all the emerging markets before and after the crisis. However, regarding the financial contagion shock, they found different results for different countries; for the emerging BRICS (Brazil, Russia, India, China and South Africa), the markets were found to suffer from contagion shock, but not so for Indonesia and South Korea.

## 5.3 Data and Descriptive Statistics

The thesis makes use of daily data in local currency from 3 May 2004 to 22 November 2013 (2495 days) for a total of eleven (11) stock price indices. Of these indices, three are emerging CEE indices: the CZPXIDX for the Czech Republic, the BUXINDX for Hungary, and the POLWIGI for Poland. The GIPSI indices are as

follows: the ATHEX for Greece, the ISEQUIT for Ireland, the PSI20 for Portugal, the IBEX35I for Spain, and the FTSEMIB for Italy. Finally, the EU3 stock price indices are the DAX30 for Germany, the CAC40 for France, and the FTSE100 for the UK. The starting date was chosen as immediately after the three CEE countries joined the European Union in order to avoid structural changes in the dynamic relationships. Moreover, the data is divided into three sub-samples: pre-crisis period (3 May 2004 to 8 August 2007) (853 observations), GFC period (9 August 2007 to 16 October 2009) (572 observations), and ESDC/post period (19 October 2009 to 22 November 2013) (1070 observations).

Figure 9 illustrates the stock price indexes for the GIPSI and emerging CEE markets starting from 3 May 2004 to 22 November 2013. An upward trend in all the markets is noticed starting from 2004, reaching the highest level during the third quarter of 2008. However, after the third quarter of 2008, a sharp decline is observed in all markets, and by the first quarter of 2009 the CEE markets were at their lowest level. Interestingly, the crisis hit GIPSI countries' stock prices show almost the same trend and pattern. For example, after the first quarter of 2009, a tendency of upward trend is noticed until the end of 2009. But again, from the beginning of 2010, these markets started to decline, reaching their lowest level during the first quarter of 2012. For the Irish stock market, the lowest level is observed during the first quarter of 2009, unlike the other GIPSI markets, which showed the lowest levels during the first quarter of 2012. After 2013, gradual increases in the stock price of all the GIPSI markets are noticed and this continued until the end of the sample period. In the case of the emerging European (CEE) countries, the stock prices show almost the same pattern and trend with each other. For instance, a sudden decline in the fourth quarter

of 2011 is observed in all three of the CEE markets and continues to be low for the Czech Republic and Hungary until the end of the sample, while for Poland the stock market started to rise.

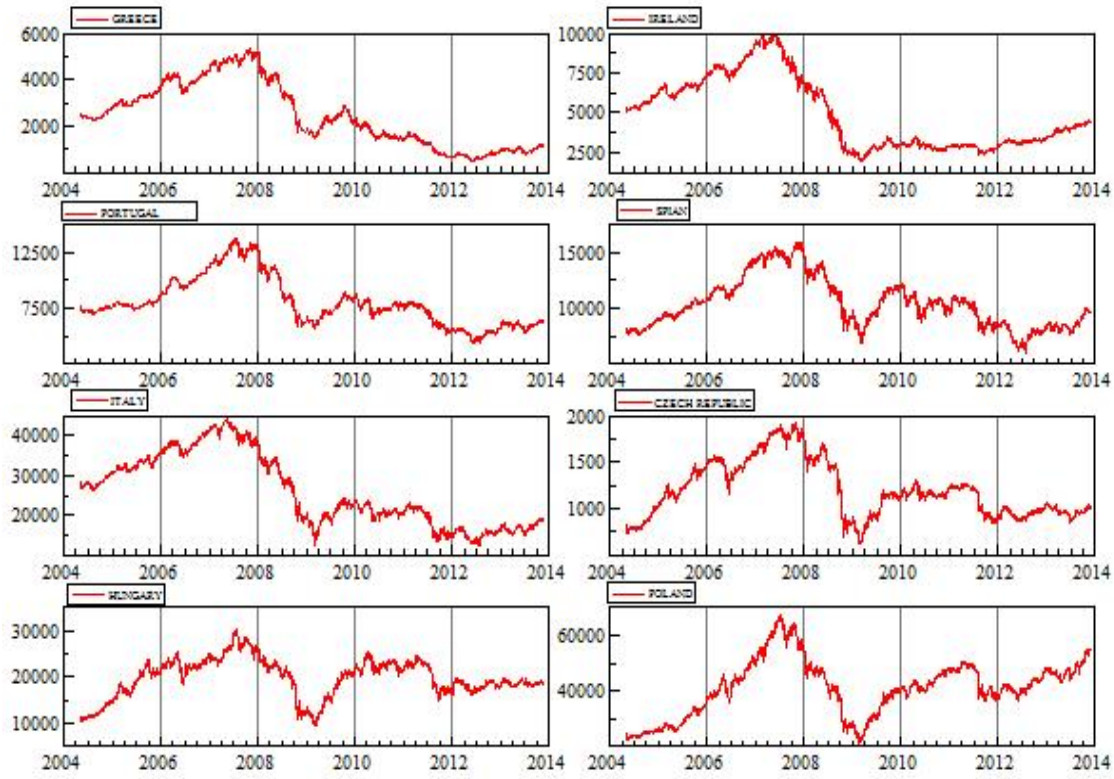



Figure 9: Daily stock price indexes for GIPSI and three CEE countries.

Figure 10 shows the stock returns for GIPSI and the emerging CEE markets starting from 3 May 2004 to 22 November 2013. The highest volatility is noticed with all returns during the GFC period, especially in the third quarter of 2008. Among the GIPSI, the Greek stock market remained the most volatile market throughout the period, especially in the beginning 2010 and starting from the third quarter of 2011 to mid-2013. For the rest of the GIPSI markets, a high volatility is noticed in mid-2010 and from the third quarter of 2011 to the third quarter of 2012. After this period, the markets started to experience calming down, with the exception of the Portuguese

market, which continued to be volatile even after 2013. Considering the three CEE markets, the returns were volatile in mid-2010 and became extremely volatile from the third to the fourth quarter of 2011. After this period, the returns for the Czech Republic and Hungarian market tended to be stable until the end of the period, although for Poland the return remained volatile until the end of 2013.

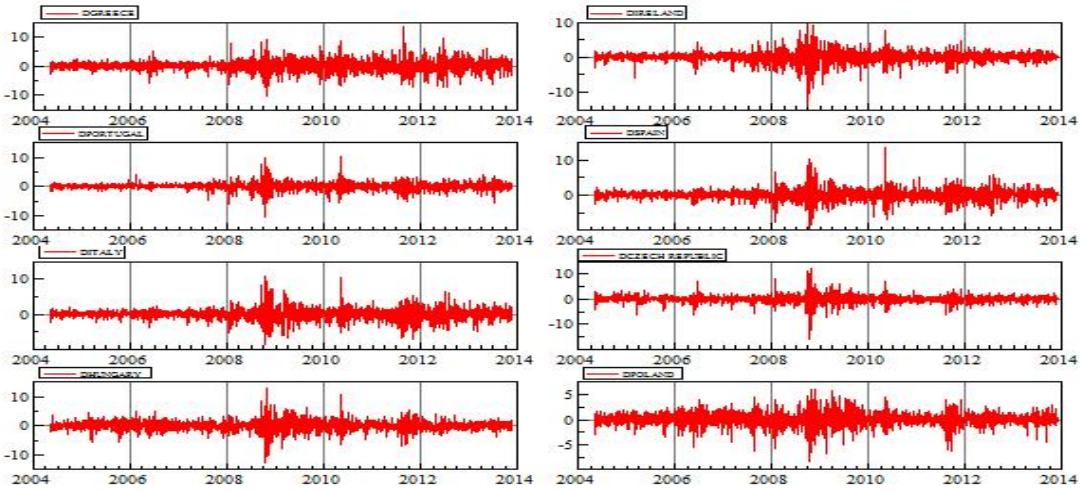



Figure 10: Daily stock price indexes for GIPSI and three CEE countries.

### 5.3.1 Statistical properties

Table 10 below at Panels A and B shows a summary of the descriptive statistics for the whole sample period from 3 May 2004 to 22 November 2013, and for the ESDC period from 19 October 2009 to 22 November 2013. In the case of the whole sample period, the GIPSI had negative returns, except for Spain. The Greek market recorded the highest negative return (-3.02%) and is the country with the highest standard deviation (1.85), reflecting the highest risk. The highest positive return is observed in Germany (3.37%), followed closely by Poland with 3.29%.

Notably, almost all of the GIPSI markets show higher volatility than the EU3. Among the emerging markets, Hungary is the most risky market, with a standard deviation reaching 1.67. Table 9 Panel A also shows that almost all the returns are negatively skewed, except those for those of Spain, Germany, and France. Compared to the crisis period in Panel B, the GIPSI markets retain negative returns (except for Ireland), while the German and Polish markets still rank as the highest in terms of positive returns. Considering the volatility, the GIPSI still demonstrate higher risk, with Greece having the most risky market, while within the emerging markets, Hungary remains as the most risky market. Furthermore, the markets of Spain, France, Portugal, and Hungary are positively skewed, while the remaining markets show negative skewness. The Augmented Dickey–Fuller (ADF) tests on the return series reject the null hypothesis that the series have unit roots. All daily returns were calculated as log differences using daily closing prices. Kurtosis in Table 9 is high for all markets above five, reflecting the stylised characteristics of the financial series. The Jarque-Bera test statistics reveal with high significance that the distributions of the return series are not normal distributions. The Ljung-Box Q statistics on the return series and on the standardised squared return series at the lag (20) suggest that there is serial correlation for the whole sample and for the crisis period. Lastly, the tests on the return series reveal the presence of autoregressive conditional heteroskedasticity (ARCH) effects, meaning that the ARCH and GARCH models should be considered in modelling.

Table 10: Descriptive statistics of daily returns

| Countries | Mean | Std. Dev. | Skewness | Kurtosis | J-Bera | ARCH(5) | Q(20) | $Q^2(20)$ | ADF |
|---|---|---|---|---|---|---|---|---|---|
| Panel A: Full sample (May 03, 2004 to Nov 22, 2013) | | | | | | | | | |
| GRC | -0.0302 | 1.8532 | -0.0150 | 6.93 | 1608*** | 45.9*** | 51.21*** | 985*** | - 28.5*** |
| IRL | -0.0070 | 1.5436 | -0.5928 | 10.84 | 6535*** | 117.1*** | 62.60*** | 2690*** | - 29.6*** |
| PRT | -0.0068 | 1.2115 | -0.1200 | 11.96 | 8361*** | 73.8*** | 48.72*** | 1448*** | -29.3*** |
| ESP | 0.0068 | 1.5131 | 0.1451 | 10.18 | 5371*** | 75.3*** | 42.81*** | 1340*** | - 31.2*** |
| ITA | -0.0163 | 1.5513 | -0.0642 | 8.67 | 3346*** | 93.0*** | 61.78*** | 2055*** | - 30.9*** |
| UK | 0.0160 | 1.2114 | -0.1552 | 11.80 | 8062*** | 149.5*** | 69.80*** | 3012*** | -32.7*** |
| DEU | 0.0337 | 1.3819 | 0.0355 | 10.25 | 5463*** | 88.4*** | 45.82*** | 2071*** | - 32.6*** |
| FRA | 0.0060 | 1.4427 | 0.0568 | 10.04 | 5160**** | 103.4*** | 60.78*** | 2078*** | - 32.5*** |
| CZE | 0.0089 | 1.5395 | -0.5487 | 17.47 | 2189*** | 143.8*** | 78.18*** | 3034*** | -30.7*** |
| HUN | 0.0207 | 1.6702 | -0.0901 | 9.74 | 4732*** | 79.8*** | 82.64*** | 2067*** | - 30.0*** |
| POL | 0.0329 | 1.2980 | -0.4871 | 6.75 | 1563*** | 73.5*** | 33.30** | 1284*** | - 27.9*** |
| Panel B: Eurozone crisis-post period (Oct 19, 2009 to Nov 22, 2013) | | | | | | | | | |
| GRC | -0.086 | 2.229 | 0.230 | 5.205 | 226*** | 5.03*** | 37.5** | 108.6*** | - 19.0*** |
| IRL | 0.025 | 1.282 | -0.255 | 6.109 | 442*** | 20.60*** | 24.8 | 335.3*** | - 20.8*** |
| PRT | -0.031 | 1.317 | 0.073 | 7.411 | 867*** | 14.19*** | 32.7** | 231*** | - 20.1*** |
| ESP | -0.020 | 1.644 | 0.369 | 8.302 | 1277*** | 24.20*** | 37.2** | 179.8*** | - 20.3*** |
| ITA | -0.024 | 1.701 | -0.068 | 5.630 | 309*** | 17.08*** | 22.1 | 293.8*** | - 19.9*** |
| UK | 0.022 | 1.039 | -0.193 | 5.138 | 210*** | 22.57*** | 16.8 | 429.5*** | - 19.9*** |
| DEU | 0.043 | 1.302 | -0.225 | 5.580 | 305*** | 32.78*** | 30.87 | 791.9*** | - 19.8*** |
| FRA | 0.009 | 1.418 | 0.027 | 6.330 | 494*** | 17.20*** | 20.4 | 285.9*** | - 20.0*** |
| CZE | -0.012 | 1.182 | -0.290 | 6.514 | 565*** | 24.13*** | 27.1 | 446.7*** | - 20.2*** |
| HUN | -0.014 | 1.453 | 0.127 | 7.489 | 901*** | 13.16*** | 33.2** | 176.1*** | -20.4*** |
| POL | 0.030 | 1.093 | -0.617 | 6.798 | 711*** | 25.35*** | 32.6** | 468.4*** | - 19.5*** |

Note: Q(20) and $Q^2(20)$ are the Ljung-Box statistics for serial correlation in standardised return and squared standardised return series at lag 20. ***,**, * indicate the rejection of the null hypotheses of no autocorrelation, normality and homoscedasticity at 1%, 5% and 10% levels of significance, respectively.

### 5.3.2 Unconditional correlations

Table 11 Panels A and B show the unconditional correlation matrix between the GIPSI and the EU3 with the three CEE emerging economies for the whole sample and for the crisis/post period. As expected, higher unconditional correlations are evident during the ESDC crisis/post period in Panel B, as is the case for all countries except Greece. In Panel B, compared to the Czech Republic and Hungary, the unconditional correlations among the stock returns are the highest between Poland and all the other countries. In general, Greece and Ireland have the lower unconditional correlations with the three CEE emerging markets as compared to other GIPSI and EU3.

Table 11 : Unconditional correlation matrix

| | CZE | HUN | POL |
|---|---|---|---|
| Panel A: Full sample (May 03, 2004 to Nov 22, 2013) | | | |
| GRC | 0.507 | 0.391 | 0.478 |
| IRL | 0.538 | 0.491 | 0.549 |
| PRT | 0.572 | 0.501 | 0.542 |
| ESP | 0.590 | 0.549 | 0.588 |
| ITA | 0.596 | 0.552 | 0.589 |
| UK | 0.611 | 0.559 | 0.619 |
| DEU | 0.577 | 0.556 | 0.623 |
| FRA | 0.614 | 0.582 | 0.628 |
| Panel B: Eurozone crisis-post period (Oct 19, 2009 to Nov 22, 2013) | | | |
| GRC | 0.423 | 0.314 | 0.377 |
| IRL | 0.559 | 0.547 | 0.586 |
| PRT | 0.570 | 0.515 | 0.562 |
| ESP | 0.589 | 0.564 | 0.594 |
| ITA | 0.606 | 0.568 | 0.629 |
| UK | 0.584 | 0.568 | 0.652 |
| DEU | 0.607 | 0.583 | 0.691 |
| FRA | 0.634 | 0.603 | 0.675 |

Author's estimation

## 5.4 Empirical Results

In this section, we study the spillovers from the GIPSI and EU3 into the CEE markets by dividing the whole sample into three periods: pre-crisis period (3 May 3 2004 to 8 August 2007), GFC period (9 Aug 2007 to 16 October 2009) and EU debt crisis/post (19 October 2009 to November 2013). By dividing the sample into three, we are able to compare the impact of the ESDC and GFC periods and whether there were spillover effects as compared to pre-crisis period. The following three sections present estimations of the conditional mean and variance for each market as well as the multivariate DCC equation. Furthermore, we carried out the Hosking (1980) multivariate portmanteau test at lag (20) to check for the serial correlation in the

mean and variance equations. The results in most cases reveal the successful elimination of serial correlation in the mean and variance.

### 5.4.1 Pre-GFC period

Table 12 Panels A-D presents the estimations for the pre-crisis period; that is, the mean and variance for each market as well as the second estimations, which are the generated DCC. The GJR (1,1) model is found to be suitable in modelling almost all developed markets, except for the Portuguese market where GARCH(1,1) is used. In the case of emerging markets, GARCH (1,1) is found to be appropriate in modelling. The coefficients of GJR, GARCH and ARCH are statistically significant at 5% or better for almost all the markets. Considering the second estimations between each CEE market with the developed markets (GIPSI and EU), the condition that $a+b<1$ is satisfied and non-negative. The results also reveal that in most of the cases the 'a' and 'b' coefficients are statistically significant, meaning that there is market interdependence among the pair. For example, in Panel B the estimated DCC between the Czech Republic and developed markets shows that b coefficients are highly significant at 1% with all markets and, in most of the cases, the a coefficients are also significant. The same is true between Hungary and the developed markets in Panel C and between Poland and the developed markets in Panel D. In addition, the test on serial correlation reveals that the model is free of correlation in most all of the countries.

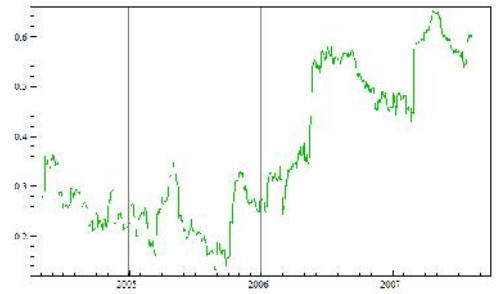
Table 12: Dynamic co-movements during the pre-crisis period (3 May 2004 to 8 Aug 2007)

| Mean | Greece GJR(1,1) | Ireland GJR(1,1) | Portugal GARCH(1,1) | Spain GJR(1,1) | Italy GJR(1,1) | UK GJR(1,1) | Germany GJR(1,1) | France GJR(1,1) | CZE GARCH(1,1) | Hungary GARCH(1,1) | Poland GARCH(1,1) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Panel A. Conditional mean and variance equations for each market | | | | | | | | | | | |
| μ | 0.082*** | 0.0814*** | 0.155*** | 0.081*** | 0.045** | 0.032 | 0.068** | 0.033 | 0.133*** | 0.155*** | 0.117*** |
| | (0.029) | (0.025) | (0.040) | (0.023) | (0.022) | (0.021) | (0.029) | (0.026) | (0.032) | (0.040) | (0.033) |
| ω | 0.080** | 0.067** | 0.065** | 0.098*** | 0.042*** | 0.035*** | 0.0662** | 0.049*** | 0.061** | 0.0655** | 0.0189** |
| | (0.034) | (0.030) | (0.028) | (0.025) | (0.012) | (0.012) | (0.031) | (0.015) | (0.024) | (0.028) | (0.010) |
| α | -0.004 | -0.041 | 0.084** | -0.0227 | 0.081*** | 0.0381* | -0.0349 | 0.0722*** | 0.122*** | 0.084*** | 0.057*** |
| | (0.021) | (0.035) | (0.022) | (0.049) | (0.022) | (0.021) | (0.023) | (0.017) | (0.035) | (0.022) | (0.016) |
| β | 0.830*** | 0.804*** | 0.877*** | 0.710*** | 0.863*** | 0.845*** | 0.847*** | 0.888*** | 0.828*** | 0.877*** | 0.926*** |
| | (0.056) | (0.060) | (0.030) | (0.070) | (0.036) | (0.048) | (0.061) | (0.035) | (0.036) | (0.030) | (0.017) |
| γ | 0.144*** | 0.277** | | 0.292*** | 0.255*** | 0.222*** | 0.195*** | 0.216*** | | | |
| | (0.056) | (0.114) | | (0.091) | (0.061) | (0.046) | (0.059) | (0.043) | | | |
| Panel B. Multivariate DCC equations (CZE with each mature market) | | | | | | | | | | | |
| | Greece | Ireland | Portugal | Spain | Italy | UK | Germany | France | | | |
| a | 0.016 | 0.039** | 0.010* | 0.016*** | 0.025 | 0.012** | 0.021 | 0.032** | | | |
| | (0.020) | (0.019) | (0.006) | (0.008) | (0.018) | (0.005) | (0.018) | (0.016) | | | |
| b | 0.979*** | 0.920*** | 0.986*** | 0.967*** | 0.955*** | 0.984*** | 0.962*** | 0.940*** | | | |
| | (0.038) | (0.057) | (0.013) | (0.020) | (0.040) | (0.012) | (0.044) | (0.040) | | | |
| ρ | 0.428*** | 0.271*** | 0.246** | 0.430*** | 0.359*** | 0.436*** | 0.370*** | 0.393*** | | | |
| | (0.150) | (0.067) | (0.115) | (0.052) | (0.059) | (0.166) | (0.064) | (0.057) | | | |
| df | | 5.808*** | 5.457** | | 7.665*** | | 7.05*** | 8.208*** | | | |
| | | (0.61) | (0.53) | | (1.07) | | (0.98) | (1.29) | | | |
| Diagnostic checking | | | | | | | | | | | |
| Log-likelihood | -2228.8 | -2071.0 | -1808.2 | -2072.4 | -1980.0 | -1934.4 | -2161.6 | -2085.1 | | | |
| MQ | 88.1 | 43.3 | 49.8 | 88.7 | 107.6 | 111.2 | 86.8 | 101.4 | | | |
| | [0.2506] | [0.3313] | [0.1370] | [0.2361] | [0.2215] | [0.0119] | [0.2821] | [0.0536] | | | |
| $MQ^2$ | 56.13 | 24.35 | 55.94 | 66.82 | 39.42 | 64.47 | 75.96 | 79.33 | | | |
| | [0.970] | [0.957] | [0.972] | [0.812] | [0.406] | [0.864] | [0.544] | [0.436] | | | |

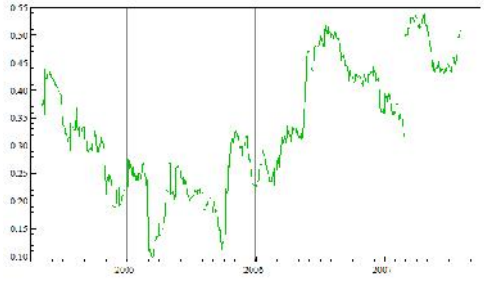
| Panel C. Multivariate DCC equation (HUN with each mature market) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Greece | IRL | PRT | ESP | ITA | UK | DEU | FRA | | | |
| a | 0.100*** | 0.0747 | 0.022** | 0.045** | 0.0441 | 0.072 | 0.031 | 0.056 | | | |
| | (0.036) | (0.050) | (0.010) | (0.023) | (0.033) | (0.057) | (0.040) | (0.048) | | | |
| b | 0.2548 | 0.6681*** | 0.9674*** | 0.752*** | 0.868*** | 0.472 | 0.9381*** | 0.841*** | | | |
| | (0.177) | (0.354) | (0.020) | (0.128) | (0.155) | (0.819) | (0.119) | (0.214) | | | |
| ρ | 0.356*** | 0.310*** | 0.230** | 0.359*** | 0.333*** | 0.377*** | 0.3642*** | 0.390*** | | | |
| | (0.035) | (0.042) | (0.094) | (0.037) | (0.045) | (0.033) | (0.057) | (0.044) | | | |
| df | | | 7.425*** | 8.67*** | 11.00*** | | 11.36*** | | | | |
| | | | (1.09) | (1.42) | (2.24) | | (2.52) | | | | |
| Diagnostic checking | | | | | | | | | | | |
| Log-likelihood | -2450 | -2360 | -2043 | -2265 | -2222 | -2160 | -2399 | -2330 | | | |
| MQ | 88 | 91 | 94 | 79 | 92 | 218 | 87 | 99 | | | |
| | [0.257] | [0.194] | [0.135] | [0.499] | [0.162] | [0.185] | [0.275] | [0.069] | | | |
| $MQ^2$ | 95.8 | 124.7 | 104.7 | 81.0 | 89.5 | 79.9 | 96.3 | 87.8 | | | |
| | [0.1883] | [0.2348] | [0.123] | [0.3849] | [0.1756] | [0.4190] | [0.078] | [0.209] | | | |
| Panel D. Multivariate DCC equation (Poland with each mature market) | | | | | | | | | | | |
| | Greece | IRL | PRT | ESP | ITA | UK | DEU | FRA | | | |
| a | 0.150*** | 0.0141 | 0.0274 | 0.057** | 0.074*** | 0.0691** | 0.066** | 0.0687*** | | | |
| | (0.051) | (0.009) | (0.027) | (0.025) | (0.027) | (0.029) | (0.026) | (0.025) | | | |
| b | 0.006 | 0.983*** | 0.788*** | 0.686*** | 0.725*** | 0.706*** | 0.779*** | 0.737*** | | | |
| | (0.118) | (0.018) | (0.238) | (0.085) | (0.058) | (0.058) | (0.092) | (0.068) | | | |
| ρ | 0.376*** | 0.353** | 0.268*** | 0.407*** | 0.393*** | 0.467*** | 0.417*** | 0.44*** | | | |
| | (0.034) | (0.140) | (0.037) | (0.035) | (0.039) | (0.032) | (0.039) | (0.034) | | | |
| df | 12.07*** | 6.7*** | 7.38*** | 8.52*** | 9.20*** | 12.75*** | 9.66*** | 13.30*** | | | |
| | (3.01) | (0.93) | (1.12) | (1.43) | (1.75) | (3.29) | (2.04) | (3.59) | | | |
| Diagnostic checking | | | | | | | | | | | |
| Log-likelihood | -2235 | -2107 | -1854 | -2054 | -2004 | -1919 | -2186 | -2106 | | | |
| MQ | 79.5 | 91.1 | 98.0 | 79.9 | 80.0 | 96.2 | 80.2 | 96.1 | | | |
| | [0.495] | [0.186] | [0.083] | [0.483] | [0.480] | [0.105] | [0.471] | [0.105] | | | |
| $MQ^2$ | 111.2 | 134.0 | 98.7 | 93.3 | 72.1 | 79.9 | 94.7 | 92.9 | | | |
| | [0.1180] | [0.2584] | [0.0567] | [0.1143] | [0.6660] | [0.419] | [0.0957] | [0.1193] | | | |

Note: The numbers given in ( ) are standard error while the numbers given in [] are the p-value. ***, **, * statistical significance at 1%, 5%, 10%, respectively.

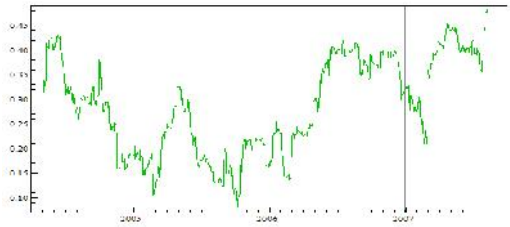
Figure 11-13 presents the evolutions of the dynamic conditional correlations across the developed markets (GIPSI and EU3) and the CEE markets. Figure 11 shows the dynamic correlation between the Czech Republic and the developed markets. We observed the correlation starting to gradually decline until the third quarter of 2005 and then a sharp increase was seen until the end of the sample period. In addition, the correlation has fluctuated a lot and at the end of the sample reached almost 65% with almost all the markets, except with Greece where its highest was around 45%. Regarding the dynamic correlation between Hungary and the developed markets in Figure 12, an increase in correlation starting from 2005 is noticed with Portugal, Italy and Germany. However, with the rest of the developed markets, the correlation has been very volatile and varies between 45% and 55%. Lastly, in terms of the dynamic correlation between Poland and the developed markets in Figure 13, it is observed that the correlation has been extremely volatile throughout the sample with almost all the markets, except the Greece market where correlation fluctuated. Among the CEE markets, Poland shows a higher level of correlation as compared to the Czech Republic and Hungary.



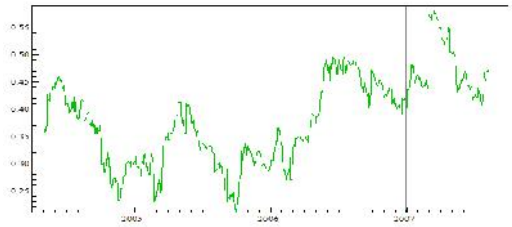

Greece



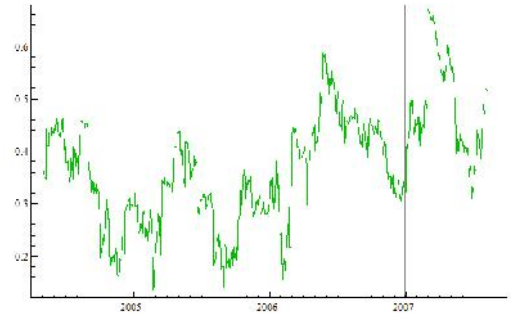
Ireland



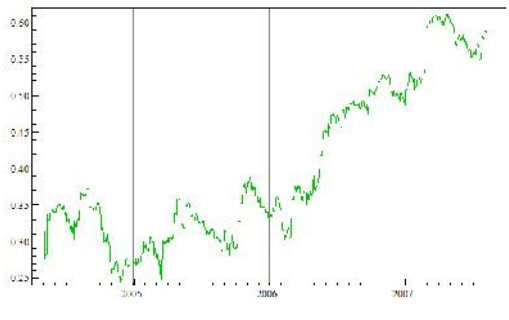
Portugal



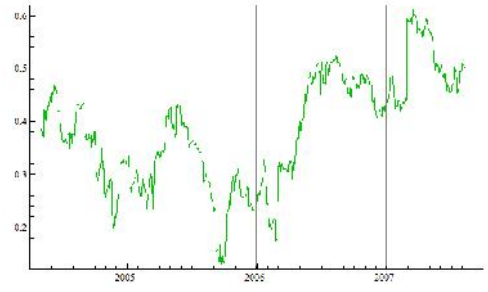
Spain



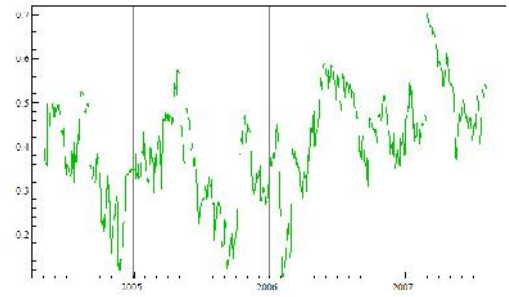

Italy



UK




Germany



France

Figure 11: Pre-crisis period conditional correlations between mature markets and the Czech Republic.

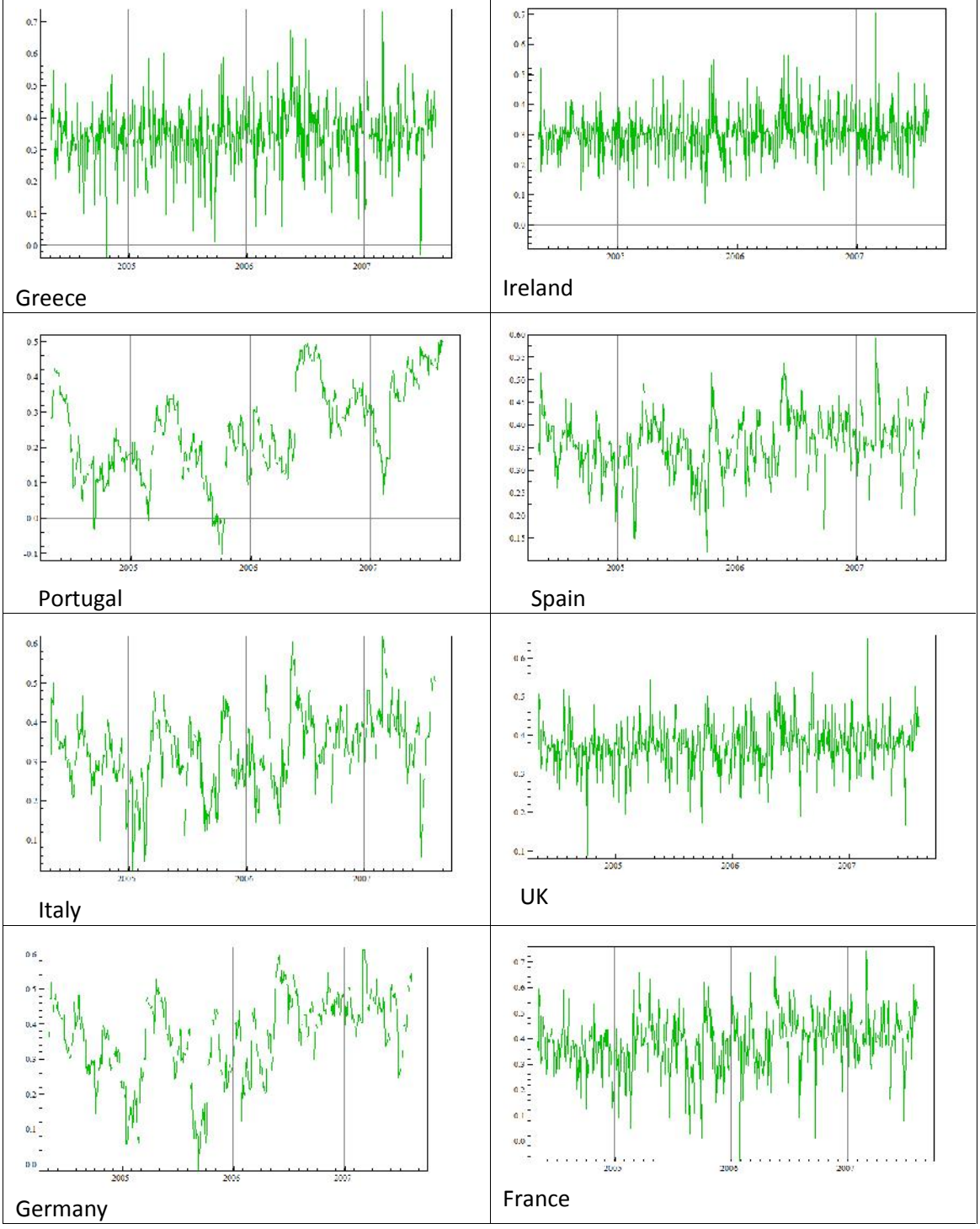
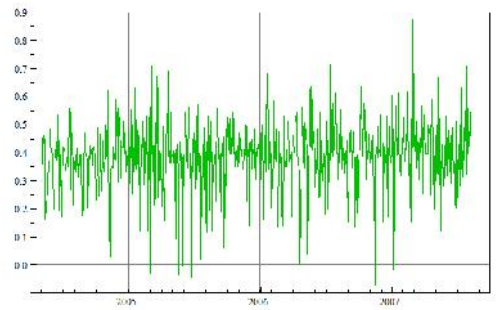
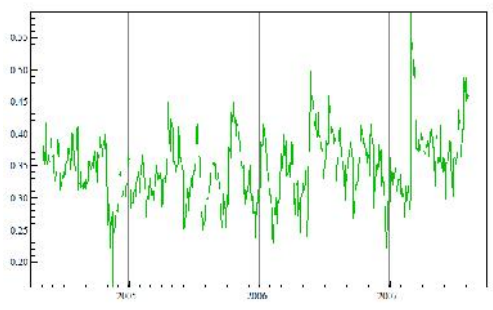


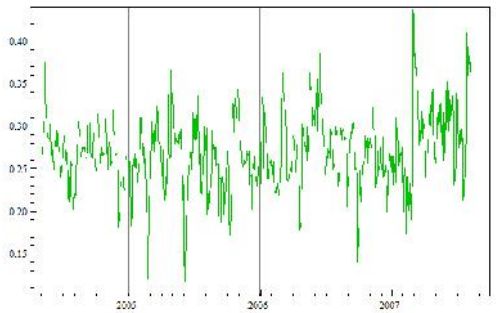

Figure 12: pre-crisis period conditional correlations between mature markets and Hungary



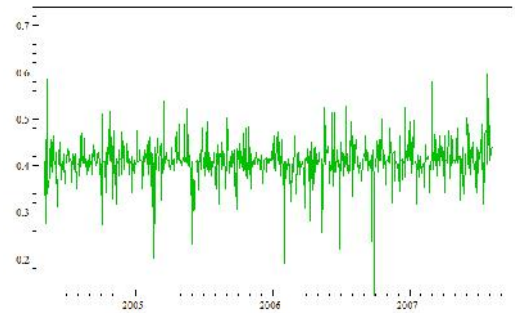
Greece



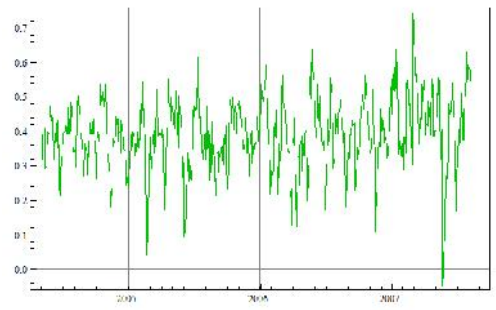
Ireland



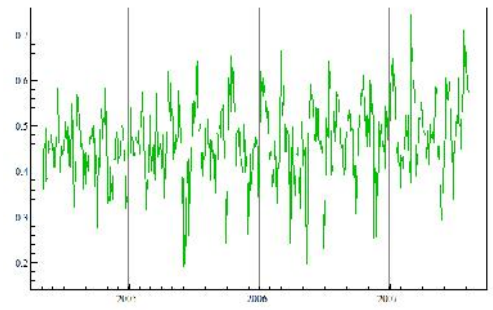
Portugal



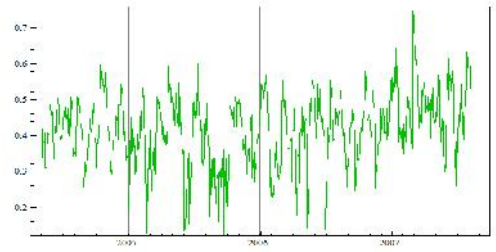
Spain



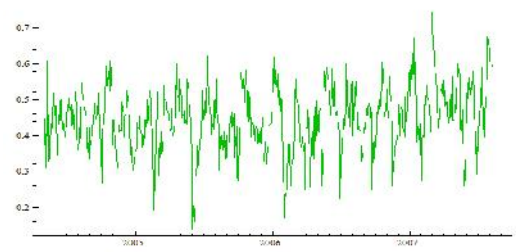
Italy



UK



Germany



France

Figure 13: pre crisis period conditional correlations between mature markets and Poland.

### 5.4.2 Global financial crisis period

Table 13 Panels A-D shows estimations for the GFC/period, which includes conditional mean and variance for each market in Panel A and the DCC process between each CEE market with the developed markets in Panels B-D. All of the developed and emerging economies are modelled using GJR (1,1) and the coefficients of the asymmetric effects (γ) are all negative and highly significant for all markets, indicating that negative shock volatilities have more impact than positive ones. The coefficients of ARCH and GARCH are all highly statistically significant at 5% or better. In other words, a statistically significant ARCH coefficient means the previous day‘s information on returns reflects in today’s volatility, whereas significant GARCH means the previous day‘s returns volatility reflects on today’s volatility. The significance of the two coefficients means the stock return volatility is influenced by its own shock. Moreover, for the derived multivariate DCC equation, the condition $a+b<1$ is satisfied and non-negative. For example, in Panel B (between the Czech Republic and the developed markets), Panel C (between Hungary and the developed markets) and Panel D (between Poland and the developed markets) the estimated coefficients for ‘b’ between the CEE markets and the developed markets are significant at 1%, indicating the markets interdependence and compared to the pre-crisis period, these coefficients have increased which can be interpreted as an increase in volatilities because of the GFC. Finally, the multivariate portmanteau statistics reported as multivariate Q(20) and $Q^2(20)$ are due to the Hosking (1980) test and testing serial correlation in mean and variance equations, respectively. The results in Panels B, C and D confirm the adequacy of the estimated models.

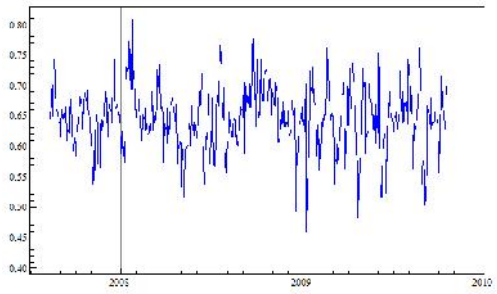
Table 13: Dynamic co-movements during the GFC period (9 Aug 9 2007- 16 Oct 2009)

| | Greece GJR(1,1) | Ireland GJR(1,1) | Portugal GJR(1,1) | Spain GJR(1,1) | Italy GJR(1,1) | UK GJR(1,1) | Germany GJR(1,1) | France GJR(1,1) | CEZ GJR(1,1) | Hungary GJR(1,1) | Poland GJR(1,1) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Panel A. Conditional mean and variance equations for each market | | | | | | | | | | | |
| μ | 0.013849 | -0.1347 | -0.02583 | -0.0397 | 0.099514* | -0.03705 | -0.03761 | -0.06419 | -0.02076 | -0.07908 | -0.09286 |
| | 0.073917 | 0.086064 | 0.049681 | 0.060616 | 0.060034 | 0.059211 | 0.054737 | 0.059516 | 0.067435 | 0.062104 | 0.069369 |
| ω | 0.085125 | 0.11707 | 0.1046** | 0.0656** | 0.0422* | 0.0761** | 0.039617 | 0.0707** | 0.118*** | 0.029679 | 0.095022 |
| | 0.05482 | 0.074989 | 0.037267 | 0.032741 | 0.022407 | 0.031991 | 0.021522 | 0.031656 | 0.058247 | 0.02597 | 0.075531 |
| α | 0.082915 | 0.056096* | 0.028786 | -0.02153 | 0.010766 | 0.0366** | -0.02288 | -0.02275 | 0.104*** | 0.067*** | 0.025508 |
| | 0.028698 | 0.029143 | 0.025984 | 0.020489 | 0.019295 | 0.016039 | 0.020078 | 0.019993 | 0.028012 | 0.020838 | 0.017428 |
| β | 0.843498 | 0.8853*** | 0.8050*** | 0.8972*** | 0.8992*** | 0.905*** | 0.907*** | 0.895*** | 0.815*** | 0.874*** | 0.8998** |
| | 0.025302 | 0.034746 | 0.042682 | 0.021482 | 0.017472 | 0.022684 | 0.016418 | 0.020443 | 0.032823 | 0.021029 | 0.03638 |
| γ | 0.11938 | 0.07694** | 0.2378*** | 0.2148*** | 0.159087*** | 0.210568*** | 0.217422 | 0.224958*** | 0.124047** | 0.131115*** | 0.092915*** |
| | 0.050791 | 0.038375 | 0.07315 | 0.056653 | 0.043135 | 0.048536 | 0.056609 | 0.064456 | 0.061878 | 0.046412 | 0.047723 |
| Panel B. Multivariate DCC equations (CEZ with each mature market) | | | | | | | | | | | |
| | GRC | IRL | PRT | ESP | ITA | UK | DEU | FRA | | | |
| a | 0.050224** | 0.027331*** | 0.008321 | 0.011142 | 0.025615 | 0.00751 | 0.052836 | 0.009722 | | | |
| | 0.022929 | 0.016103 | 0.012571 | 0.011356 | 0.022557 | 0.008893 | 0.040887 | 0.010998 | | | |
| b | 0.880819*** | 0.000 | 0.9419*** | 0.946813*** | 0.872124*** | 0.959877*** | 0.538603 | 0.956269*** | | | |
| | 0.049803 | 0.40392 | 0.02918 | 0.025226 | 0.092986 | 0.026693 | 0.43789 | 0.054791 | | | |
| ρ | 0.619795*** | 0.543745*** | 0.584069*** | 0.598634*** | 0.622063*** | 0.615938*** | 0.602661*** | 0.609765*** | | | |
| | 0.041734 | 0.028466 | 0.029615 | 0.028424 | 0.027464 | 0.027673 | 0.025607 | 0.029132 | | | |
| df | 7.229157*** | | 8.795055*** | 13.41628*** | 10.693025*** | 9.97527*** | 8.061334*** | 10.202349*** | | | |
| | 1.4078 | | 1.9143 | 4.4806 | 2.9421 | 2.5466 | 1.7081 | 2.5823 | | | |
| Diagnostic checking | | | | | | | | | | | |
| Log-likelihood | -2168.03 | -2338.34 | -2013.76 | -2135.5 | -2129.87 | -2094.26 | -2113.02 | -2142.69 | | | |
| MQ | 80.8924 | 97.6459 | 84.3803 | 96.4158 | 85.7869 | 97.3634 | 110.981 | 107.582 | | | |
| | [0.4510633] | [0.0875884] | [0.3472828] | [0.1020034] | [0.3087722] | [0.1907466] | [0.1125183] | [0.1215822] | | | |
| $MQ^2$ | 85.8785 | 104.428 | 86.9126 | 92.474 | 92.4286 | 74.1162 | 67.8243 | 78.336 | | | |
| | [0.2534447] | [0.2245696] | [0.2293479] | [0.1257576] | [0.1264303] | [0.6035849] | [0.7878811] | [0.4680172] | | | |
| Panel C. Multivariate DCC equation (HUN with each mature market) | | | | | | | | | | | |

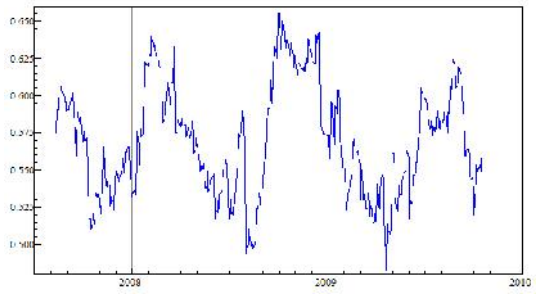
| | GRC | IRL | PRT | ESP | ITA | UK | DEU | FRA | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| a | 0.030291 | 0.019366 | 0.013608 | 0.009079 | 0.041126* | 0.035853** | 0.059783* | 0.037307 | | | |
| | 0.019353 | 0.016652 | 0.009885 | 0.014303 | 0.023401 | 0.016967 | 0.030781 | 0.022694 | | | |
| b | 0.888391*** | 0.938741*** | 0.953161*** | 0.93817*** | 0.86285*** | 0.921963*** | 0.825849*** | 0.909162*** | | | |
| | 0.080843*** | 0.064624 | 0.022227 | 0.035453 | 0.066319 | 0.031625 | 0.078415 | 0.051036 | | | |
| ρ | 0.519323*** | 0.502293*** | 0.543335*** | 0.585371*** | 0.612686*** | 0.590614*** | 0.602182*** | 0.612856*** | | | |
| | 0.041852 | 0.047827 | 0.040245 | 0.029875 | 0.033038 | 0.046564 | 0.03565 | 0.039839 | | | |
| df | 9.691624 | 11.982331*** | 10.569668*** | 11.360466*** | 10.606424*** | 9.953383*** | 8.848664*** | 10.246852*** | | | |
| | 2.4103 | 3.5136 | 2.8774 | 3.3284 | 3.0693 | 2.3959 | 2.0949 | 2.5823 | | | |
| Diagnostic checking | | | | | | | | | | | |
| Log-likelihood | -2245.08 | -2368.74 | -2056.38 | -2163.32 | -2157.47 | -2131.75 | -2136.83 | -2164.32 | | | |
| MQ | 98.5223 | 97.3555 | 84.5497 | 100.317 | 100.783 | 108.688 | 105.396 | 104.245 | | | |
| | [0.2783490] | [0.1908357] | [0.3425271] | [0.3618907] | [0.2581218] | [0.2181400] | [0.1301176] | [0.4356956] | | | |
| $MQ^2$ | 76.9087 | 65.1477 | 58.264 | 57.9611 | 73.7835 | 71.8442 | 62.4686 | 70.4116 | | | |
| | [0.5136879] | [0.8502452] | [0.9537886] | [0.9565807] | [0.6141746] | [0.6746141] | [0.9002265] | [0.7172201] | | | |
| Panel D. Multivariate DCC equation (Poland with each mature market) | | | | | | | | | | | |
| | GRC | IRL | PRT | ESP | ITA | UK | DEU | FRA | | | |
| a | 0.083699** | 0.01929* | 0.047929 | 0.019653 | 0.020895 | 0.037753 | 0.004942 | 0.005074 | | | |
| | 0.035555 | 0.011172 | 0.036179 | 0.015965 | 0.022659 | 0.034848 | 0.027462 | 0.013244 | | | |
| b | 0.534502*** | 0.946133*** | 0.579045*** | 0.928206*** | 0.857497*** | 0.906769*** | 0.883351*** | 0.953879*** | | | |
| | 0.16856 | 0.018157 | 0.13453 | 0.047388 | 0.052446 | 0.11207 | 0.21422 | 0.047422 | | | |
| ρ | 0.645894*** | 0.572617*** | 0.600374*** | 0.649325*** | 0.648992*** | 0.652707*** | 0.65522*** | 0.655697*** | | | |
| | 0.026977 | 0.040239 | 0.030839 | 0.029048 | 0.026395 | 0.037274 | 0.023632 | 0.024935 | | | |
| df | 8.437414*** | 11.020921*** | 7.479353*** | 10.270028*** | 8.312546*** | 8.012491*** | | 7.964076*** | | | |
| | 1.8671 | 3.1467 | 1.2839 | 2.5382 | 1.7397 | 1.5376 | | 1.5024 | | | |
| Diagnostic checking | | | | | | | | | | | |
| Log-likelihood | -2107.9 | -2272.53 | -1959.97 | -2059.06 | -2068.62 | -2027.94 | -2077.66 | -2067.08 | | | |
| MQ | 96.6457 | 92.0967 | 84.3697 | 104.756 | 94.317 | 97.1048 | 96.4671 | 100.191 | | | |
| | [0.0991762] | [0.1675038] | [0.3475803] | [0.0331181] | [0.1308030] | [0.0937163] | [0.1013671] | [0.0629463] | | | |
| $MQ^2$ | 92.8353 | 83.9564 | 85.3001 | 62.1367 | 73.2824 | 78.4916 | 62.6335 | 77.9695 | | | |
| | [0.1205041] | [0.3021073] | [0.2675702] | [0.9055328] | [0.6300254] | [0.4630879] | [0.8975195] | [0.4796751] | | | |

Note: The numbers given in ( ) are standard errors while the numbers given in [] are the p-value. ***, **, * statistical significance at 1%, 5%, 10%, respectively.

Figure 14-16 present the evolutions of the dynamic conditional correlations between the developed markets and the CEE markets during the GFC. The dynamic correlations have significantly increased during this period with all countries, the highest ranging from 0.65-0.85. For example, in Figure 14 (between the Czech Republic and the developed markets), the dynamic correlation reaches almost 65% during 2008 to 2009. Considering the dynamic correlation between Hungary and the developed markets in Figure 15, a sharp increase is again noticed during the crisis period, reaching almost 80%, and the lowest increase being with Ireland at around 57%. Finally, in the dynamic correlation with Poland in Figure 16 it is observed that the correlation has been fluctuating, reaching almost 85% during 2008 and 2009. Comparing the correlation level between the three CEE markets, Poland has the higher level of correlation with the developed markets. Compared to the pre-crisis period, however, all of the correlations between the CEE countries and the developed markets have substantially increased.



Greece



Ireland

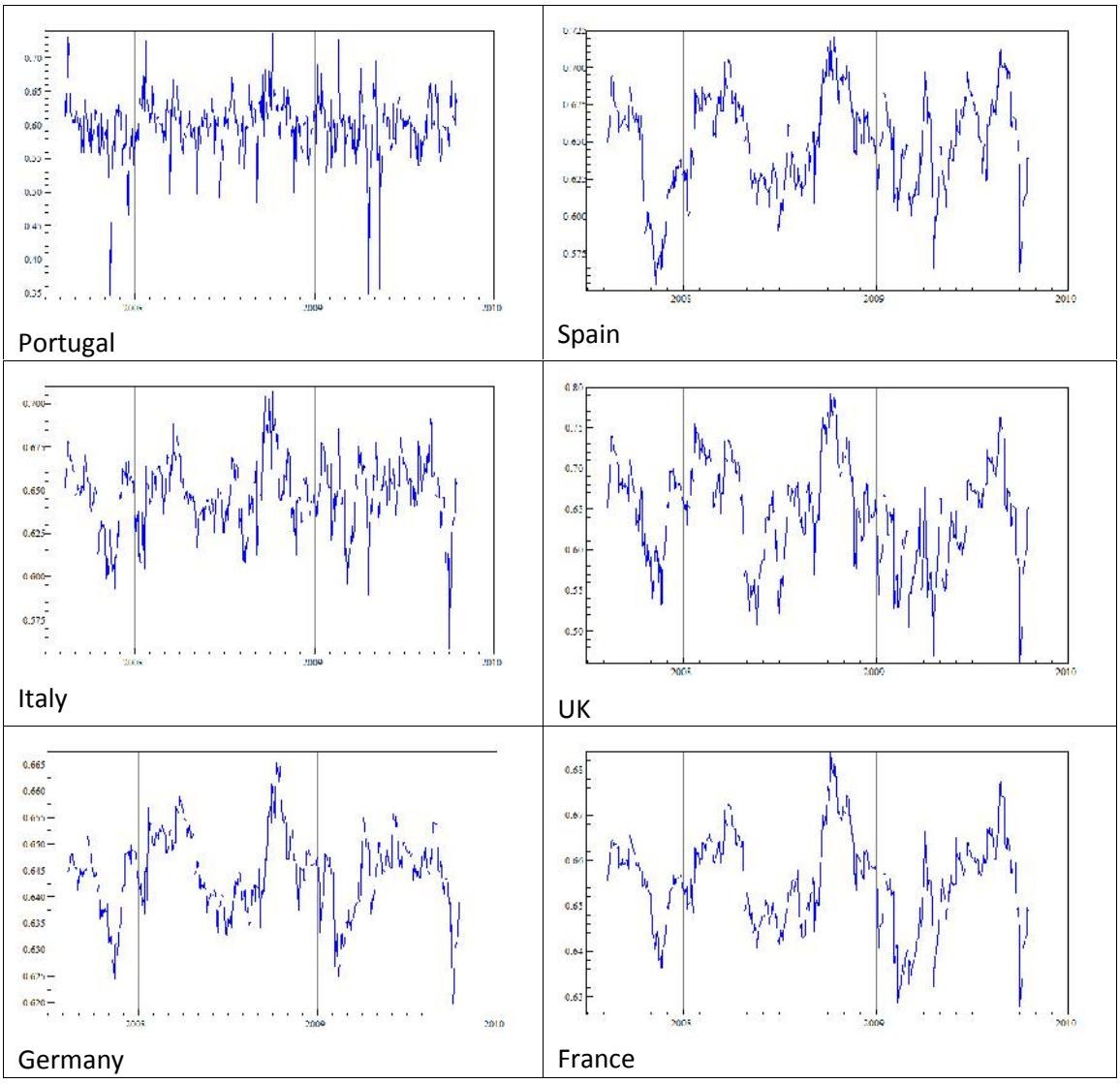
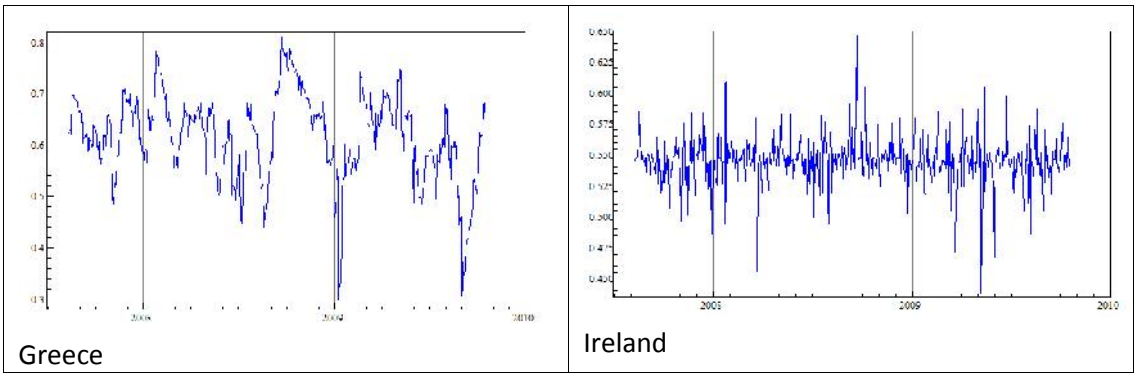



Figure 14: GFC-period conditional correlations between mature markets and the Czech Republic.



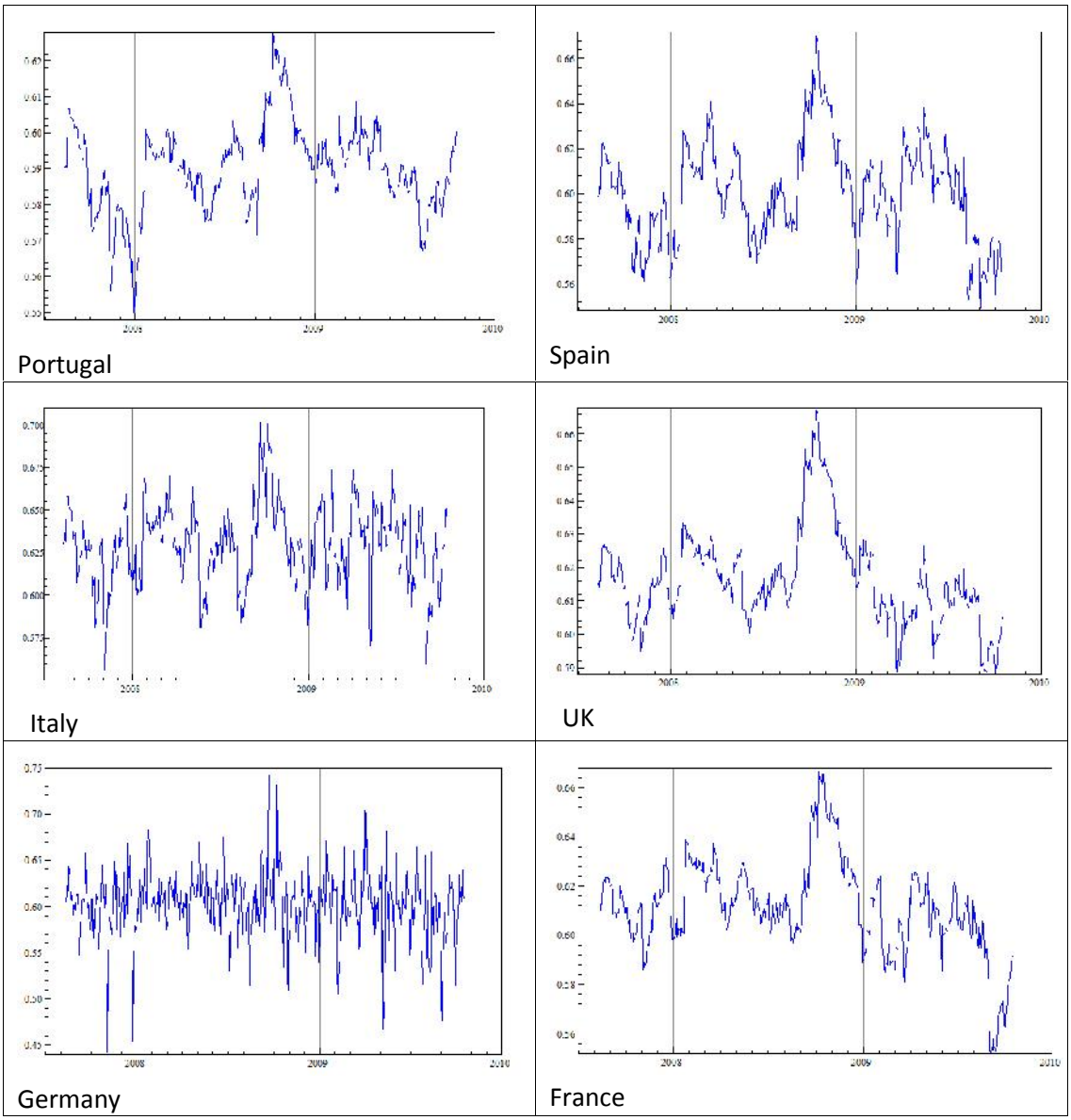



Figure 15: GFC-period conditional correlations between mature markets and Hungary.

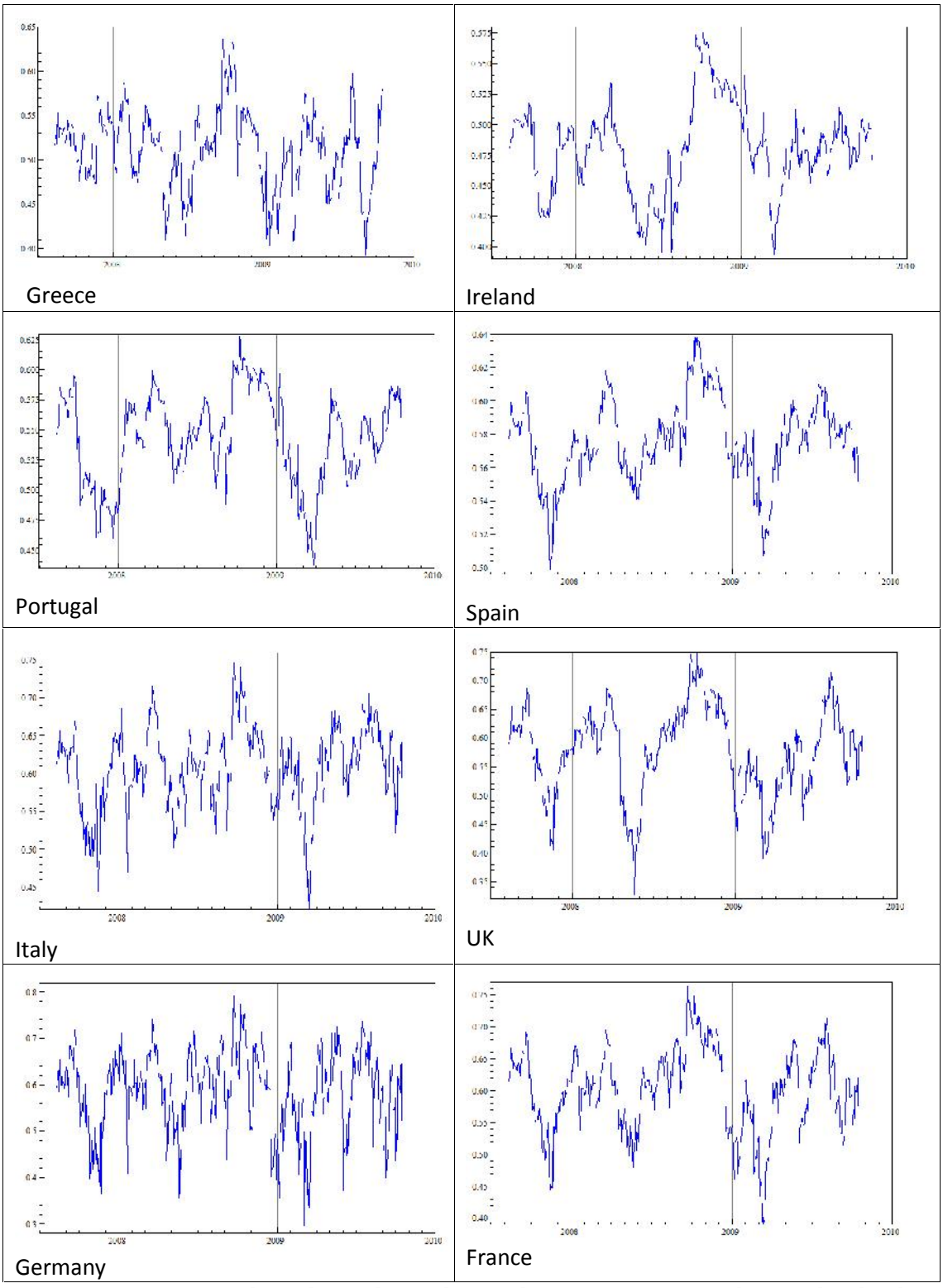



Figure 15: GFC period conditional correlations between mature markets and Poland.

### 5.4.3 ESDC post-crisis

Table 14 Panels A-D show the stock market co-movement during the ESDC crisis/post period (19 October 2009 to 22 November 2013). In the first step, the univariate for each market's estimated ACI criteria is used in choosing the best and most appropriate model. These models are presented in Table 14. The Glosten-Jagannathan-Runkle (GJR) model is suggested for Greece, Germany, France, and the UK and, as expected, the asymmetric coefficients are statistically significant, meaning that negative news affects market volatility more than positive news. For the remaining markets, the EGARCH model is used (with the exception of the Hungarian market). The asymmetric coefficients for all the markets are highly statistically significant. The GARCH coefficients for all countries are statistically significant at 1%. In other words, all the markets are affected by their past shock (news) and volatility is affected by its own shock. Nevertheless, the results confirmed that the condition that $a + b < 1$ is met. Table 3 Panels B-D shows the estimated DCC equations between all the mature markets with the three CEE emerging markets. As can be seen in each panel, the generated parameters for a and b are highly significant with almost all markets, except between the Czech Republic and Ireland in Penal B as well as in Penal C between Hungary and Spain where a parameter is not significant. In addition, the estimated Student's t-distributions between the three CEE countries and the mature markets are highly significant. The Hosking (1980) multivariate portmanteau test is carried out at lag (20) to check for serial correlation in the mean and variance equations, which indicate that the estimated models do not suffer from misspecification.

Table 14: Estimation results from GARCH-DCC models using daily returns during the EU debt crisis 19/10/2009-22/11/2013.

| | GRC ARMA(1,1)-GJR(1,1) | IRL ARMA (1,1)-EGARCH(1,1) | PRT EGARCH (1,1) | ESP ARMA (1,1)-EGARCH(1,1) | ITA ARMA (1,1)-EGARCH(1,1) | UK AR(1)-GJR(1,1) | DEU ARMA (1,1) GJR(1,1) | FRA ARMA(1,1) GJR(1,1) | CEZ EGARCH (1,1) | HUN ARMA(1,1) GARCH(1,) | POL EGARCH(1,1) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Panel A. Conditional mean and variance equations for each market | | | | | | | | | | | |
| μ | -0.053 | 0.03 | -0.008 | -0.048 | 0.048 | 0.006 | 0.041 | 0.004 | 0.004 | -0.028 | 0.033* |
| | -0.069 | 0.033 | -0.034 | -0.053 | 0.045 | 0.027 | 0.033 | 0.034 | 0.118 | -0.022 | 1.652 |
| $a_1$ | -0.49*** | -0.922*** | | -0.906*** | -0.944*** | | -0.928*** | -0.743*** | | -0.966*** | |
| | -0.15 | -0.033 | | -0.036 | -0.013 | | -0.02 | -0.213 | | -0.009 | |
| $a_2$ | 0.552*** | 0.934*** | | 0.947*** | 0.974*** | | 0.96*** | 0.71*** | | 0.98*** | |
| | 0.143 | 0.038 | | 0.025 | 0.013 | | 0.026 | 0.248 | | 0.007 | |
| ω | 0.248*** | 0.382*** | 0.379*** | 0.915*** | 0.986*** | 0.028*** | 0.028 | 0.060** | 0.237 | 0.016* | 0.051 |
| | 0.094 | 0.161 | 0.144 | 0.233 | 0.169 | 0.011 | 0.026 | 0.031 | 0.149 | 0.009 | 0.209 |
| α | 0.038** | 0.555 | -0.521*** | -0.15 | -0.11 | -0.04*** | -0.021* | -0.024** | -0.594*** | 0.107*** | -0.593*** |
| | 0.019 | 0.791 | -0.131 | 0.333 | -0.545 | -0.013 | -0.012 | -0.013 | -0.158 | 0.045 | -0.096 |
| β | 0.885*** | 0.948*** | 0.967*** | 0.973*** | 0.969*** | 0.925*** | 0.922*** | 0.867*** | 0.970*** | 0.878*** | 0.984*** |
| | 0.026 | 0.024 | 0.012 | 0.016 | 0.025 | 0.029 | 0.056 | 0.057 | 0.015 | 0.023 | 0.005 |
| $\Theta^1$ | | -0.073* | -0.198*** | -0.168*** | -0.134*** | | | | -0.142** | | -0.248*** |
| | | -0.044 | -0.049 | -0.058 | -0.064 | | | | -0.067 | | -0.059 |
| $\Theta^2$ | | 0.147*** | 0.238*** | 0.124*** | 0.10*** | | | | 0.284*** | | 0.166*** |
| | | 0.057 | 0.059 | 0.04 | 0.036 | | | | 0.06 | | 0.046 |
| γ | 0.054* | | | | | 0.174*** | 0.156** | 0.264*** | | | |
| | 0.031 | | | | | 0.041 | 0.074 | 0.093 | | | |
| Panel B. Multivariate DCC equations (CEZ with each mature market) | | | | | | | | | | | |
| | GRC | IRL | PRT | ESP | ITA | UK | DEU | FRA | | | |
| a | 0.01** | 0.02 | 0.03* | 0.04* | 0.07*** | 0.06** | 0.05** | 0.06*** | | | |
| | 0.007 | 0.013 | 0.021 | 0.026 | 0.025 | 0.031 | 0.027 | 0.025 | | | |
| b | 0.97*** | 0.89*** | 0.72*** | 0.70*** | 0.68*** | 0.71*** | 0.53** | 0.67*** | | | |
| | 0.008 | 0.083 | 0.171 | 0.119 | 0.09 | 0.219 | 0.215 | 0.146 | | | |
| ρ | 0.383*** | 0.511*** | 0.50*** | 0.571*** | 0.547*** | 0.529*** | 0.565*** | 0.578*** | | | |
| | 0.03 | 0.061 | 0.039 | 0.042 | 0.057 | 0.037 | 0.034 | 0.033 | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| df | 8.41*** | 9.90*** | 11*** | 9.63* | 9.79*** | 11.9*** | 9.50*** | 10.9*** | | | |
| | 1.26 | 1.68 | 2.15 | 1.47 | 1.53 | 2.41 | 1.51 | 1.93 | | | |
| Diagnostic checking | | | | | | | | | | | |
| Log-likelihood | 3809.3 | 3073.0 | 3121.9 | 3291.6 | 3332.3 | 2831.7 | 2995.0 | 3087.4 | | | |
| MQ | 88.5 | 88.4 | 84.0 | 111.3 | 109.6 | 93.6 | 104.0 | 129.8 | | | |
| | [0.194] | [0.1967] | [0.358] | [0.0079] | [0.0105] | [0.141] | [0.026] | [0.000] | | | |
| $MQ^2$ | 87.8 | 83.5 | 97.9 | 91.2 | 101.6 | 79.0 | 93.7 | 88.8 | | | |
| | [0.209] | [0.315] | 0.063] | [0.1464] | [0.037] | [0.448] | [0.10861] | [0.1891] | | | |
| Panel C. Multivariate DCC equation (HUN with each mature market) | | | | | | | | | | | |
| | GRC | IRL | PRT | ESP | ITA | UK | DEU | FRA | | | |
| a | 0.07** | 0.013* | 0.02** | 0.016 | 0.009*** | 0.019** | 0.017** | 0.018** | | | |
| | 0.04 | 0.007 | 0.011 | 0.016 | 0.004 | 0.009 | 0.009 | 0.009 | | | |
| b | 0.0 | 0.98*** | 0.93*** | 0.96*** | 0.99*** | 0.95*** | 0.95*** | 0.95*** | | | |
| | 0.341 | 0.012 | 0.029 | 0.042 | 0.005 | 0.017 | 0.027 | 0.021 | | | |
| ρ | 0.267*** | 0.427*** | 0.45*** | 0.496*** | 0.460*** | 0.498*** | 0.514*** | 0.523*** | | | |
| | 0.051 | 0.027 | 0.025 | 0.022 | 0.025 | 0.024 | 0.021 | 0.022 | | | |
| df | 8.23*** | 9.27*** | 10.2*** | 8.92*** | 9.24*** | 8.66*** | 7.35*** | 8.76*** | | | |
| | 1.26 | 1.53 | 1.95 | 1.38 | 1.53 | 1.38 | 1.03 | 1.38 | | | |
| Diagnostic checking | | | | | | | | | | | |
| Log-likelihood | 4074 | 3318 | 3380 | 3547 | 3591 | 3063 | 3240 | 3352 | | | |
| MQ | 217 | 210 | 220 | 213 | 204 | 202 | 202 | 208 | | | |
| | [0.14] | [0.263] | [0.15] | [0.220] | [0.3679] | [0.44] | [0.406] | [0.306] | | | |
| $MQ^2$ | 173 | 219 | 157 | 190 | 185 | 191 | 177 | 196 | | | |
| | [0.89] | [0.142] | [0.98] | [0.647] | [0.736] | [0.63] | [0.860] | [0.521] | | | |
| Panel D. Multivariate DCC equation (Poland with each mature market) | | | | | | | | | | | |
| | GRC | IRL | PRT | ESP | ITA | UK | DEU | FRA | | | |
| a | 0.01** | 0.019*** | 0.02** | 0.021*** | 0.016*** | 0.03*** | 0.012* | 0.01*** | | | |
| | 0.005 | 0.007 | 0.011 | 0.007 | 0.006 | 0.013 | 0.007 | 0.008 | | | |
| b | 0.98*** | 0.977*** | 0.95*** | 0.967*** | 0.972*** | 0.93*** | 0.97*** | 0.96*** | | | |
| | 0.007 | 0.009 | 0.021 | 0.01 | 0.008 | 0.025 | 0.015 | 0.02 | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ρ | 0.310** | 0.430** | 0.492** | 0.564*** | 0.540*** | 0.589*** | 0.619*** | 0.608*** | | | |
| | 0.08 | 0.11 | 0.05 | 0.05 | 0.54 | 0.043 | 0.048 | 0.038 | | | |
| df | 7.53*** | 8.712*** | 9.37*** | 8.74*** | 8.659*** | 8.83*** | 7.04*** | 8.19*** | | | |
| | 1.05 | 1.28 | 1.55 | 1.36 | 1.37 | 1.37 | 0.9 | 1.17 | | | |
| Diagnostic checking | | | | | | | | | | | |
| Log-likelihood | 3700. | 2918.0 | 2990. | 3154 | 3191. | 2636. | 2787 | 2916. | | | |
| MQ | 90.2 | 86.5 | 82.5 | 85.6 | 89.0 | 84.2 | 79.8 | 84.6 | | | |
| | [0.163] | [0.238] | [0.4] | [0.25] | [0.185] | [0.35] | [0.42] | [0.284] | | | |
| $MQ^2$ | 69.9 | 70.7 | 87.1 | 88.4 | 73.9 | 89.8 | 85.8 | 94.0 | | | |
| | [0.73] | [0.710] | [0.226] | [0.197] | [0.609] | [0.10] | [0.25] | 0.17] | | | |

Note: The numbers given in ( ) are standard errors. ***, **, and * indicate the univariate and multivariate coefficients are statistically significant at 1%, 5%, and 10%, respectively

Figure 17-19, show the dynamic conditional correlations between the three CEE countries and the GIPSI and EU3 during the EU crisis/post period (19 October 2009 - 22 November 2013). A temporary increase in the conditional correlations is particularly noticeable during the downgrading of the GIPSI markets by Moody's and S&P during the second quarter of 2010 and in the third quarter of 2011. For example, in all of the CEE stock markets a sudden increase is observed during these periods. Figure 12 the average dynamic correlations between the Czech Republic and all the mature markets are rather volatile. For instance, the correlations between Spain and the Czech Republic varied between 10% and 80%. In addition, the average of the conditional correlations with GIPSI is around 50%, while with the EU3 it is around 60%. Figure 18, which presents the pairwise conditional correlations with Hungary, almost all the markets (except Greece) peaked as high as 65%, while with Spain and Portugal peaked at 60%. Finally, Figure 19 with Poland, among the GIPSI the highest conditional correlation is observed at 75% with the stock markets of Italy, Portugal, and Spain, while the lowest is with Ireland at about 17%. With the EU3, the correlations vary between 70-75%. Comparing the three CEE conditional correlations with GIPSI and EU3, Poland's stock market shows the highest average level of conditional correlations with 62% during and after the EU crisis period. This indicates that the level of development of the CEE country matters for higher than average correlations. It is worth noting that the conditional correlations as shown in Figure 17-19 begin falling from 2012 until the end of the sample, 22 November 2013. From the fall in the conditional correlations across the markets after 2013 it is evident that the impact of the Eurozone debt crisis was temporary.

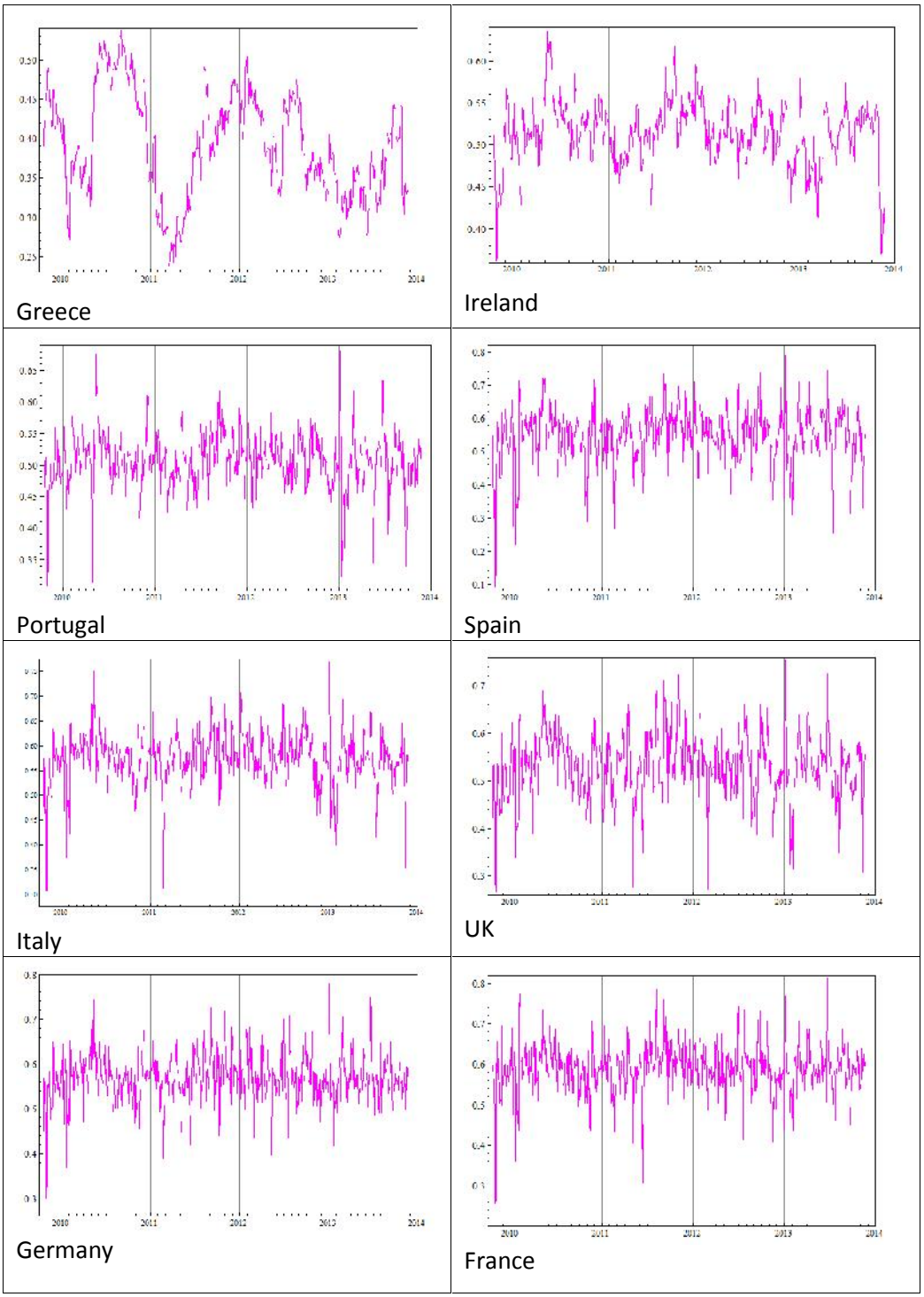
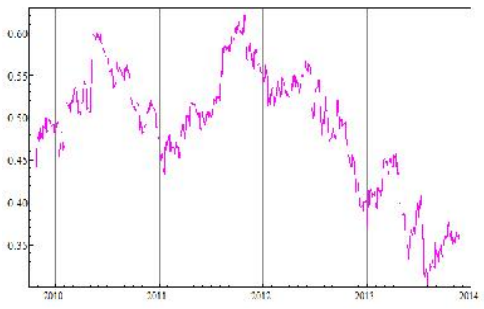
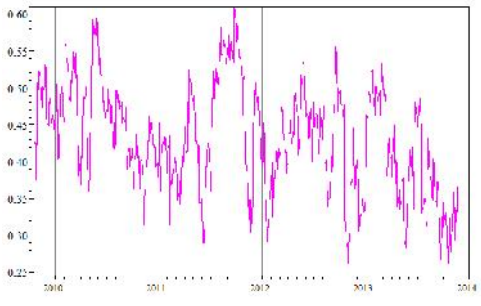



Figure 16: ESDC period conditional correlations between mature markets and the Czech Republic.

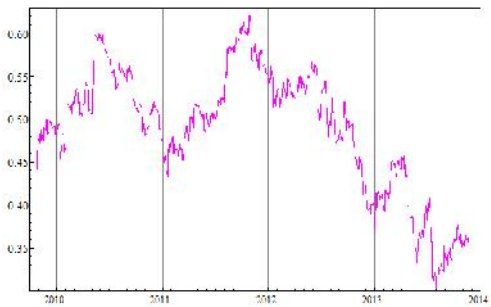
Greece



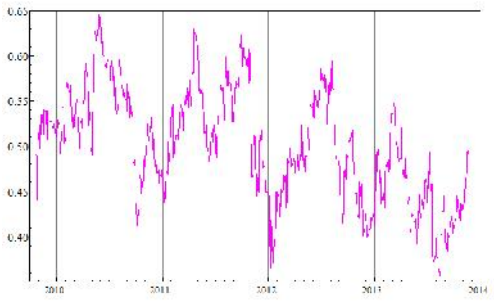
Ireland



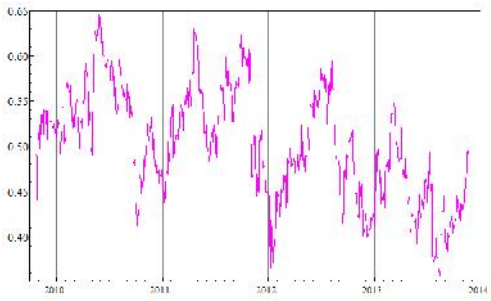
Portugal



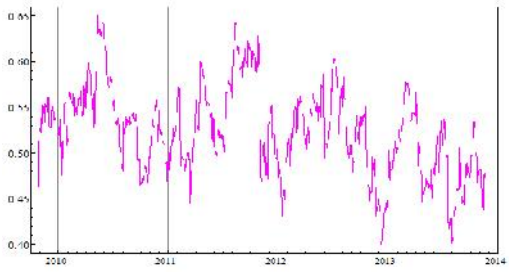
Spain



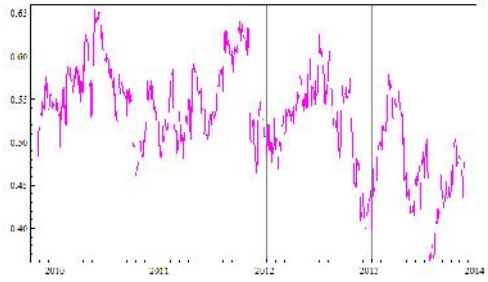
Italy



UK

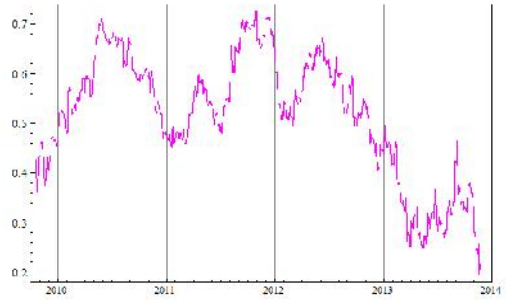


Germany

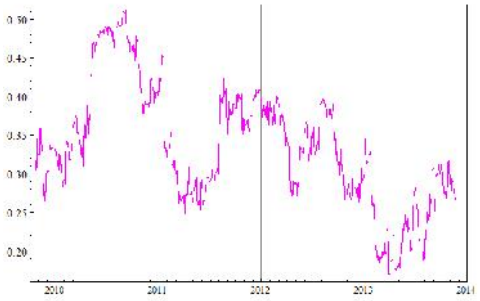


France

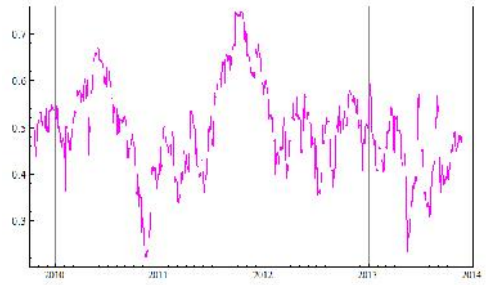
Figure 17: ESDC period conditional correlations between mature markets and Hungary.



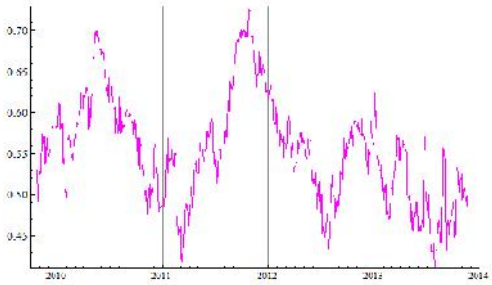
Greece



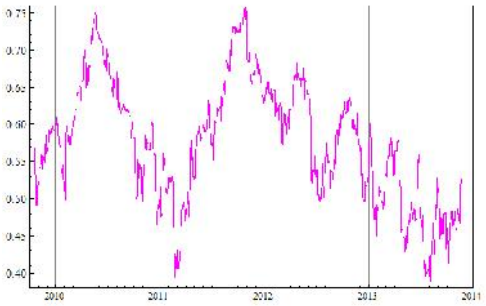
Ireland



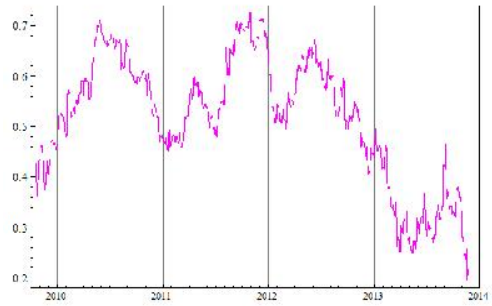
Portugal



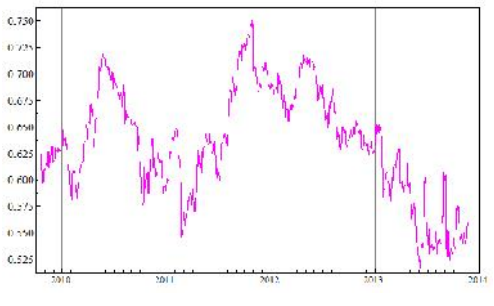
Spain



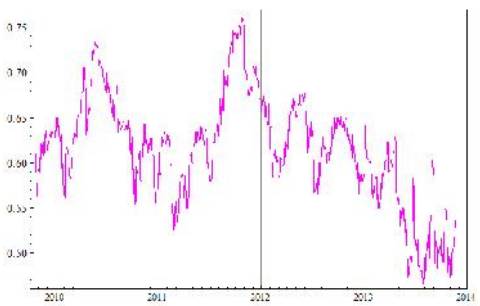
Italy



UK



Germany



France

Figure 18: ESDC period conditional correlations between mature markets and Poland.

### 5.4.4 Average conditional correlations during the four periods

Table 15 shows the average conditional correlation coefficients for four periods: pre-crisis (3 May 2004 to 8 August 2007), GFC (9 August 2007 to 16 October 2009), pre-EU crisis (3 May 3 2004 to 16 October 2009), and during the EU crisis/post period (19 October 2009 to 22 November 2013). From the above table, we observed that the correlations between the CEE markets and the developed markets during the pre-crisis period are considerably lower than during the other periods. Among the developed markets, the EU3 have higher correlations with Hungary and Poland, whereas Greece and Spain show a higher level of correlation with the Czech Republic. Considering the GFC period, we noticed that the correlations have substantially increased with the developed markets. The highest increase is noticed between the three CEE markets with Portugal, for example with the Czech Republic there was an increase of 137%, Hungary 135%, and Poland 123%. In addition, a significant increase in correlation is observed between the Czech Republic and Ireland where it increased by 100%, and between Italy and Hungary by 83.4%, and between Greece and Poland by 71%. Regarding the ESDC period, it is observed that, as compared to the pre-crisis period, the correlations have increased significantly with almost all the market except with Greece, which experienced a decline of 10% with Czech Republic, 25% with Hungary and 17% with Poland. The highest increase is noticed with Portugal, where the correlations increased by 105% with the Czech Republic, 84% with Hungary, and 83% with Poland. Comparing the increases in correlation during the GFC and ESDC periods, it is observed during the GFC that the correlations increased much more and the increase was with all the markets. Among

the CEE markets, the Polish market had the higher level of correlation with the developed markets especially, during the GFC and ESDC.

Finally, the last column shows changes during the different crisis periods. The highest increases in co-movements have been observed between the stock returns of the Czech Republic with Ireland (46.4%), Portugal (about 31%) and Spain (about 21%) - classified within the group of GIPSI countries. However, among the EU3, only Germany's stock market correlations hit the highest increase in Poland (19.5%) and the Czech Republic (about 16.5%). Portugal had almost the same increase in spillover effects on the Hungarian and Polish markets, being about 22%. Furthermore, the average dynamic conditional correlation between Poland and Germany reaches the highest value during the EU crisis/post-crisis period, with about 62%. In addition to the weakened co-movements during and after the EU debt crisis across Greece and all the CEE markets, the Italian market also experienced a negative change with Hungary by 3.28%. These results suggest that the Czech Republic had the most spillover effects from Ireland, Portugal and Spain, followed by Italy and Germany, with the highest increases in average correlations across markets. In this respect, Hungary and Poland are the markets that have been the least affected by the ESDC. Second, the spillover effects are transmitted through the GIPSI countries (except Greece) to the Czech Republic and through Portugal to Hungary and Poland. However, among the EU3, it has mainly been Germany that has been instrumental in transmitting the shocks to the three CEE countries. It can also be observed that the level of conditional correlation between the three CEE countries and the advanced economies (GIPSI+EU3) depends on the countries'

levels of economic development. For example, Germany, France, and the UK exhibit a higher correlation with the three CEE countries.

Table 15: Estimated average dynamic conditional correlations

| | | Pre-crisis | | Pre-EU crisis | | GFC | | During and after EU crisis | | Changes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Coeff. | s.e. | Coeff. | s.e. | Coeff. | s.e. | Coeff. | s.e. | $A^1$ | $B^2$ | $C^3$ |
| CZE | | | | | | | | | | | | |
| | GRC | 0.428*** | 0.15 | 0.481*** | 0.06 | 0.619*** | 0.04 | 0.383*** | 0.03 | 44.7 | -10.6 | -20.4 |
| | IRL | 0.271*** | 0.07 | 0.34*** | 0.12 | 0.54*** | 0.03 | 0.511*** | 0.061 | 100.4 | 88.3 | 46.4 |
| | PRT | 0.246** | 0.12 | 0.38*** | 0.07 | 0.584*** | 0.03 | 0.506*** | 0.039 | 137. | 105.7 | 30.9 |
| | ESP | 0.430*** | 0.05 | 0.472*** | 0.05 | 0.598*** | 0.03 | 0.571*** | 0.042 | 39.1 | 32.7 | 21.0 |
| | ITA | 0.359*** | 0.06 | 0.488*** | 0.04 | 0.622*** | 0.03 | 0.547*** | 0.057 | 72.9 | 52.0 | 12.2 |
| | UK | 0.436*** | 0.17 | 0.509*** | 0.05 | 0.615*** | 0.03 | 0.529*** | 0.037 | 41.2 | 21.2 | 4.0 |
| | DEU | 0.370*** | 0.06 | 0.486*** | 0.05 | 0.602*** | 0.03 | 0.565*** | 0.034 | 62.7 | 52.5 | 16.5 |
| | FRA | 0.393*** | 0.06 | 0.506*** | 0.05 | 0.609*** | 0.03 | 0.578*** | 0.033 | 54.9 | 46.9 | 14.2 |
| HUN | | | | | | | | | | | | |
| | GRC | 0.356*** | 0.04 | 0.414*** | 0.04 | 0.519*** | 0.04 | 0.267*** | 0.051 | 45.6 | -25.1 | -35.4 |
| | IRL | 0.310*** | 0.04 | 0.380*** | 0.03 | 0.502*** | 0.05 | 0.427*** | 0.027 | 61.5 | 37.3 | 12.5 |
| | PRT | 0.230** | 0.09 | 0.350*** | 0.09 | 0.543*** | 0.04 | 0.425*** | 0.025 | 135.3 | 84.1 | 21.6 |
| | ESP | 0.359*** | 0.04 | 0.472*** | 0.05 | 0.585*** | 0.03 | 0.496*** | 0.022 | 62.9 | 38.0 | 5.1 |
| | ITA | 0.333*** | 0.05 | 0.476*** | 0.05 | 0.612*** | 0.03 | 0.460*** | 0.025 | 83.9 | 38.1 | -3.3 |
| | UK | 0.377*** | 0.03 | 0.476*** | 0.04 | 0.590*** | 0.05 | 0.498*** | 0.024 | 56.6 | 32.1 | 4.7 |
| | DEU | 0.3642*** | 0.06 | 0.486*** | 0.05 | 0.602*** | 0.04 | 0.514*** | 0.021 | 65.3 | 41.1 | 5.7 |
| | FRA | 0.390*** | 0.04 | 0.499*** | 0.04 | 0.612*** | 0.04 | 0.523*** | 0.022 | 57.1 | 34.1 | 4.9 |
| POL | | | | | | | | | | | | |
| | GRC | 0.376*** | 0.03 | 0.458*** | 0.08 | 0.645*** | 0.03 | 0.310** | 0.08 | 71.7 | -17.6 | -32.5 |
| | IRL | 0.353** | 0.14 | 0.422*** | 0.06 | 0.572*** | 0.04 | 0.430** | 0.11 | 62.1 | 21.7 | 2.1 |
| | PRT | 0.268*** | 0.04 | 0.402*** | 0.09 | 0.600*** | 0.03 | 0.492** | 0.05 | 123.6 | 83.3 | 22.4 |
| | ESP | 0.407*** | 0.04 | 0.516*** | 0.06 | 0.649*** | 0.03 | 0.564*** | 0.05 | 59.5 | 38.5 | 9.3 |
| | ITA | 0.393*** | 0.04 | 0.523*** | 0.03 | 0.648*** | 0.03 | 0.540*** | 0.54 | 65.0 | 37.3 | 3.3 |
| | UK | 0.467*** | 0.03 | 0.552*** | 0.03 | 0.652*** | 0.04 | 0.589*** | 0.043 | 39.6 | 25.9 | 6.8 |
| | DEU | 0.417*** | 0.04 | 0.518*** | 0.06 | 0.655*** | 0.02 | 0.619*** | 0.048 | 57.1 | 48.4 | 19.5 |
| | FRA | 0.44*** | 0.03 | 0.553** | 0.03 | 0.655*** | 0.02 | 0.608*** | 0.038 | 46.6 | 35.9 | 9.9 |

Note: the numbers given in ( ) are standard errors, ***, **, * indicate the significance levels at 1%, 5%, and 10%, respectively. Changes are obtained using the formula (Post-crisis-pre-crisis)/pre-crisis multiplying by 100. $A^1$ = (GFC-Pre-crisis)/Pre-crisis , $B^2$ =( EU crisis-Pre-crisis)/pre-crisis, $C^3$= (EU- crisis-Pre EU-crisis)/ Pre EU-crisis.

## 5.5 Conclusion

Several European equity markets experienced a sharp decline during the GFC and ESDC periods, especially GIPSI (Greece, Ireland, Portugal, Spain, and Italy), which all have balance of payments problems. Since the Eurozone countries are highly integrated with each other, it is expected that if there is any shock in one member

state it will spread to others. Therefore, in this part we investigated the impacts of these two crises on the stock markets of the three emerging CEE countries (the Czech Republic, Hungary, and Poland). The EU3 were included to help understand whether the spillover effects are greater from hard-hit crisis counties or from the EU3, which have considerable investment and trade ties with the CEE markets.

The empirical results of this section are several. First, we observe a substantial spillover effect into the CEE markets during the GFC and ESDC. However, comparing these two crises, the GFC had much more of an affect and the impact was from all of the developed markets, with Portugal being the most contagious. In addition, during the ESDC period, we did not observe spillover effects from Greece. Second, the analysis of the dynamic correlations indicated that all of the CEE markets have been, on average, highly correlated with the finance-led growth markets of GIPSI and the EU3 during the whole sample period, meaning that market interdependence existed before and during the EU crisis. This interdependence is due to the high trade and banking sector relationships of the CEE countries with the developed EU countries. However, the degree of the spillover effects of the EU crisis differs among the stock markets of the CEE countries. For instance, during the second sub-period, the highest increase in dynamic correlations was observed across the Czech Republic, and Ireland, Portugal and Spain among the GIPSI. Also, during this period the highest average conditional correlations were observed across the Czech Republic and GIPSI (except Greece). On the other hand, among the three emerging countries, the stock market of Poland showed the highest levels of average dynamic correlations with the EU3 as compared to those of the other two emerging countries. Third, the evaluation dynamic conditional correlation significantly increased during the GFC and stayed almost the same during the EDSC.

Furthermore, the evaluation became more volatile and fluctuated significantly during the two crises. Fourth, the EU3 have a higher level of average correlations than the GIPSI, while among the GIPSI, Spain and Italy have higher average correlations with the three CEE markets. Fifth, out of all the markets, Portugal was the most contagious (highest spillover effect) during both the GFC and ESDC to all of the three CEE countries. Among the CEE markets, the most effected market is the Czech Republic.

# Chapter 6

# CONCLUDING REMARKS AND POLICY RECOMMENDATIONS

## 6.1 Concluding Remarks

This thesis investigates the interrelationships and spillover effects into fast growing emerging and developed markets using two data sets (in two parts). The multivariate GARCH-DCC model of Engle (2002) was employed in studying the volatility spillovers and to capture the time-variability of the conditional correlations. In the first part, we examine the spillover effects from the global financial crisis into BRIC-T (Brazil, Russia, India, China and Turkey) and three Central and Eastern European emerging economies (Czech Republic, Hungary, and Poland; hereafter CEE) as well as into the three largest European markets (UK, Germany, and France; referred to as EU3). The spillover effects of the Eurozone into the emerging BRIC-T plus CEE is also examined to account for indirect transmission and to capture the regional effects, which is important given the strong trade and financial ties between the Eurozone and these emerging markets. The EUROSTOXX50 (EU index) stock price index is taken as the proxy for the Eurozone as whole. This index contains 50 blue chip companies operating in 12 developed European economies. In addition, since the stock market operating hours among the developed and emerging economies are different, weekly stock market indices from Wednesday to Wednesday for the period from 3 January 2001 to 13 November 2013 are considered in order to minimise the cross-country differences and to account for end-of-week effect. All of the stock

price indexes are in US dollars, since changing to a common currency would allow use to control for the impact of inflation among countries. We have split the sample period into two periods: pre-crisis period (3 January 2001 to 27 July 2007) with 339 observations and GFC/post period (4 July 2007 to 13 November 2013) with 333 observations. In choosing the splitting date, data from the Federal Bank of St. Luis (2009) was reviewed.

The findings are several and can be summarised as follows. The empirical results suggest that the EU3 stock markets are less affected as compared to the emerging markets because there was already higher market interdependence between the EU3 and the USA prior to the crisis. Second, the emerging markets have not been as immediately affected as the EU3 countries, although the effects have been more long-lasting but not permanent, falling as from 2013. Third, the EU index has significant and greater volatility impact on BRIC-Turkey as compared to the crisis-originating country, the USA. However, the three CEE markets felt impacts more from the USA, since the correlation between the three CEE economies and the EU index was already high even before the GFC period. Fourth, we have noted that the dynamic evolutions for the CEE markets have considerably increased and become more volatile from 2009 until the end of the sample, although they experienced a short calming in the third quarter of 2011 due to ECB and IMF intervention, before starting to increase again. Therefore, the impacts of the European sovereign debt crisis (ESDC) were stronger on the CEE markets than on BRIC-Turkey.

Consequently, the second part of the thesis investigates the extent to which the three CEE markets have been affected by the GIPSI (Greece, Ireland, Portugal, Spain and

Italy) and by the EU3. We include the EU3 in order to understand whether the spillover effects are greater with crisis borne countries or with the EU3, which have more trade and financial ties with the three CEE countries. It is worth mentioning that the GFC resulted in the ESDC, which broke out in 2009. Accordingly, the second part of the thesis examines the impacts of the ESDC and compares it to the GFC period. Daily data in local currency from 3 May 2004 to 22 November 2013 is used by splitting it into three sub-samples: pre-crisis (stable) period, GFC period and ESDC/post period. The findings are several. First, we observe a substantial spillover effect into the CEE markets during both the GFC and ESDC. However, comparing these two crises, the GFC had much more of an effect and the impact was from all of the developed markets, with Portugal being the most contagious. In addition, during the ESDC period, we did not observe spillover effect from Greece. Second, the analysis of the dynamic correlations indicates that all of the CEE markets have been, on average, highly correlated with the finance-led growth markets of GIPSI and EU3 during the whole sample period, meaning that market interdependence existed before and during the EU crisis. This interdependence is due to the high trade and banking sector relationships of the CEE countries with the developed EU countries. However, the degree of the spillover effects of the EU crisis differs among the stock markets of the CEE countries. For instance, during the second sub-period, the highest increase in dynamic correlations had been observed across the Czech Republic, and Ireland, Portugal and Spain among the GIPSI. Also, during this period, the highest average conditional correlations have been observed across the Czech Republic and GIPSI (except Greece). On the other hand, among the three emerging countries, the stock market of Poland has shown the highest levels of average dynamic correlations with the EU3 as compared to those of the other two emerging countries. Third, the

evaluation dynamic conditional correlations significantly increased during the GFC and stayed almost the same during the EDSC. Furthermore, the evaluation became more volatile and fluctuated significantly during the two crises. Fourth, the EU3 have a higher level of average correlations than with GIPSI, while among the GIPSI, Spain and Italy have higher than average correlations with the three CEE markets. Fifth, out of all the markets, Portugal remains the most contagious (highest spillover effect) during both the GFC and ESDC periods to all three of the CEE countries. Among the CEE markets, the most effected market is the Czech Republic.

## 6.2 Policy Recommendations

The findings of this thesis have important implications for policy makers and investors. First, from the policy point of view, the results reveal that the stock markets of the developed and emerging markets are highly integrated, which means that market interdependence exists before and after the crisis. This not surprising given the strong trade and financial linkages among those economies, and so making individual policy changes is ineffective in the spread of the crises. These findings support the arguments of Pesaran and Pick (2007) that if the spread of crisis is due to market interdependence (fundamental-based contagion), policy intervention is less effective in avoiding the crisis. On the other hand, the authors noted that if the interdependence is due to shift or pure contagion, then policy intervention is effective in curbing the crisis. Therefore, this study recommends that policy makers, especially in emerging economies, should consider two important issues: first, they should work toward establishing and promoting trade and investment with each other and/or with other developing economies. This could be one way to reduce the adverse effects from another shock from the developed economies. Understanding the need to

cooperate with each other, BRIC are forming a new development bank (NDB) to finance projects and to meet other investments as needed. Beside this, they have also increased their bilateral trade and cross investments. Second, since the cause is due to real linkages i.e. interdependence, policy implication would be to improve the fundamentals as proposed by Forbes and Rigobon, (2001). There are also some important issue that policy makers especially in emerging economies should pay attention this include encourage privatization of state companies, education system, fighting corruption. Moreover, the rich literature on economies has stressed that a high reserve ratio and lower debt ratio play a significant role in reducing external shock and, therefore, emerging economies should also take these variables into account. The reason why China is able to reduce the impacts as compared to the other emerging economies is because they have a higher level of reserve ratio and lower debt ratio, although recently China has experienced rapid outflow from its stock markets and so panic is spreading on its two biggest stock exchange. In addition, many other emerging economies, including Brazil, Russia, Turkey, Poland, and Hungary, are witnessing greater uncertainty in their stock exchanges, which supports our finding that the impacts were much more significant on the emerging markets than on the developed markets.

From the investors' perspective, the level of correlations among stock markets is very important for fund managers, portfolio managers and individual investors who would like to benefit by investing in multiple markets and at the same time reduce risk. However, our results reveal that the global financial crisis and the European sovereign debt crisis reduced the benefit of portfolio diversification across the examined markets.

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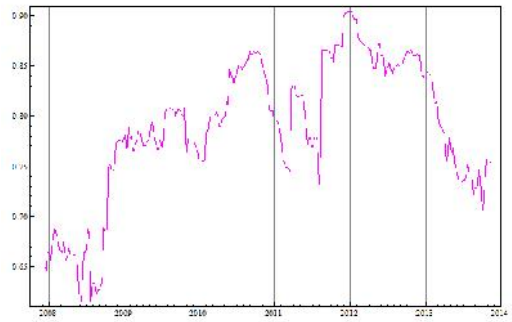
# APPENDIX

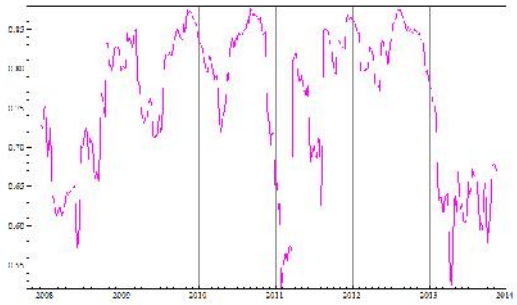
## APPENDIX A: Robustness for BRIC-T plus three CEEs

| DCC estimation results Pre-crisis with US | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Model | UK | Germany | France | Brazil | Russia | India | China | Turkey | Czech Republic | Hungary | Poland |
| Mean equation | GARCH(1,1 | GARCH(1,1 | GARCH(1,1 | GARCH(1,1 | GARCH(1,1 | GARCH(1,1 | GARCH(1,1 | GARCH(1,1 | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) |
| μ | 0.235252** | 0.377993** | 0.283347** | 0.620346** | 0.832622*** | 0.607883 | 0.094488 | 0.592205 | 0.733603*** | 0.497644** | 0.526835*** |
| | 0.10208 | 0.15788 | 0.12328 | 0.25751 | 0.23054 | 0.20595 | 0.16274 | 0.32571 | 0.15227 | 0.1834 | 0.18007 |
| Variance equation | | | | | | | | | | | |
| ω | 0.737917** | 0.293718 | 0.543197 | 1.882536* | 2.680705*** | 2.098796* | 0.695753** | 1.334124 | 2.721317*** | 4.126586*** | 2.082413** |
| | 0.43743 | 0.60165 | 0.45508 | 1.0267 | 0.93928 | 1.177 | 0.31605 | 0.91144 | 1.0487 | 1.6081 | 0.92206 |
| α | 0.327901** | 0.108486 | 0.236535 | 0.097797** | 0.118813*** | 0.222834* | 0.151806*** | 0.066161** | 0.277692** | 0.086134 | 0.07097 |
| | 0.13448 | 0.128 | 0.1313 | 0.043617 | 0.040602 | 0.12571 | 0.04694 | 0.030122 | 0.12606 | 0.057101 | 0.05125 |
| β | 0.576233*** | 0.867199*** | 0.720677*** | 0.830709*** | 0.727017*** | 0.627318*** | 0.785926*** | 0.898774*** | 0.431961** | 0.577464*** | 0.750631*** |
| | 0.16357 | 0.17362 | 0.14199 | 0.054479 | 0.064318 | 0.16191 | 0.054226 | 0.041554 | 0.1726 | 0.12765 | 0.082614 |
| Multivariate DCC equations | | | | | | | | | | | |
| a | 0.051611* | 0.054437** | 0.047444* | 0.042502 | 0.055 | 0.025 | 0.013 | 0.022967 | 0.0118 | 0.024307 | 0.00866 |
| | 0.02738 | 0.026145 | 0.026464 | 0.035381 | 0.002 | 0.051 | 0.019 | 0.019648 | 0.000159 | 0.01587 | 0.022262 |
| b | 0.824249*** | 0.865889*** | 0.840838*** | 0.411062* | 0.700372 | 0.290392 | 0.113719 | 0.930829*** | 0.479998 | 0.927749*** | 0.894018*** |
| | 0.075986 | 0.038585 | 0.059697 | 0.23137 | 2.0691 | 0.80458 | 0.65468 | 0.055229 | 1.9207 | 0.047156 | 0.072497 |
| ρ | 0.652731*** | 0.717432*** | 0.698772*** | 0.570925*** | 0.27162*** | 0.32756*** | 0.11859*** | 0.315403*** | 0.336898*** | 0.298529*** | 0.435814*** |
| | 0.036082 | 0.035804 | 0.03349 | 0.039687 | 0.052441 | 0.047444 | 0.050184 | 0.074507 | 0.04778 | 0.076842 | 0.044978 |
| df | 10.196426*** | 7.382196*** | 9.207865*** | 7.251765*** | 7.602554*** | 8.7243*** | 18.229944*** | 8.114263*** | 8.627394*** | 6.430187*** | 8.64627*** |

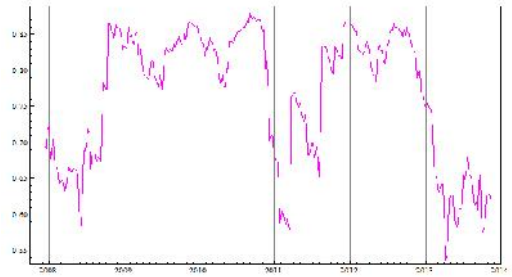
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2.7084 | 1.4539 | 2.2756 | 1.5124 | 1.6561 | 1.968 | 8.4713 | 1.6584 | 1.8293 | 1.0063 | 1.9302 |
| Diagnostic checking | | | | | | | | | | | |
| Log-likelihood | -1422.96 | -1509.66 | -1481.78 | -1746.53 | -1745.43 | -1666.82 | -1650.87 | -1886.78 | -1602.24 | -1657.35 | -1644.26 |
| MQ(20) | 78.6137 | 95.0672 | 93.0121 | 83.5357 | 72.5744 | 133.252 | 115.44 | 88.6062 | 82.5578 | 80.0429 | 96.427 |
| | [0.5228948] | [0.1198738] | [0.1515656] | [0.3714369] | [0.7099052] | [0.0001740] | [0.0058474] | [0.2389491] | [0.4002522] | [0.4776214] | [0.1018649] |
| MQ2(20) | 106.536 | 91.7508 | 85.7699 | 78.892 | 45.6641 | 59.8386 | 65.3244 | 71.7187 | 71.7675 | 55.8676 | 58.8907 |
| | [0.0176175] | [0.1367920] | [0.2560608] | [0.4504566] | [0.9987129] | [0.9370850] | [0.8465031] | [0.6784268] | [0.6769457] | [0.9725437] | [0.9475908] |



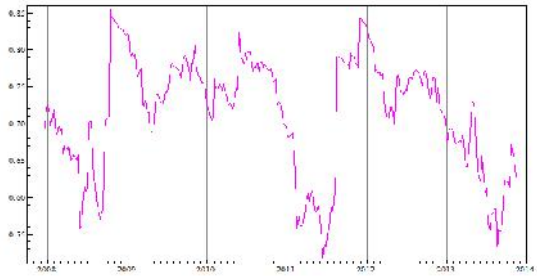
UK



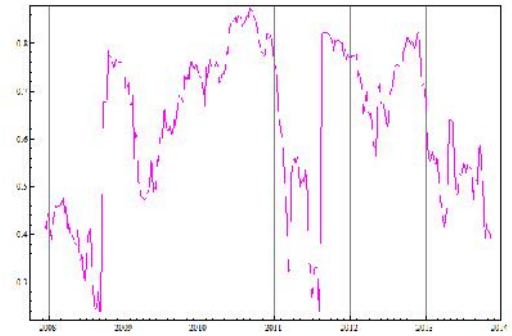
Germany



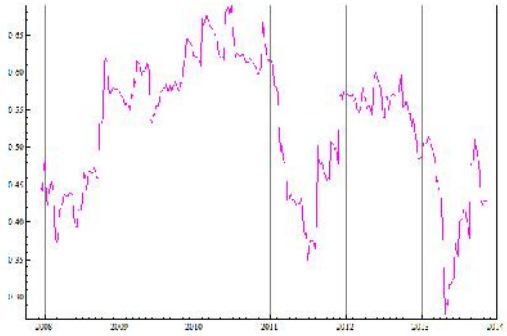
France



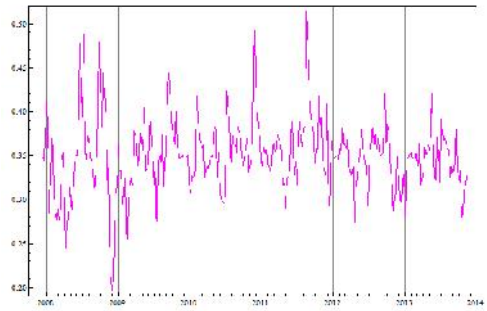
Brazil



Russia



India



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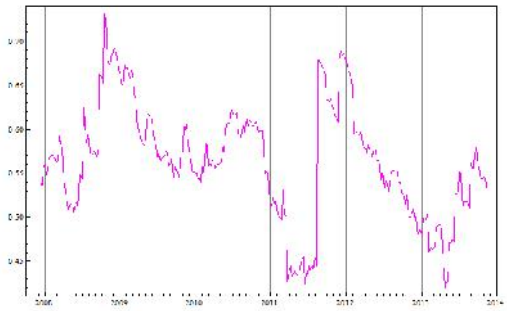
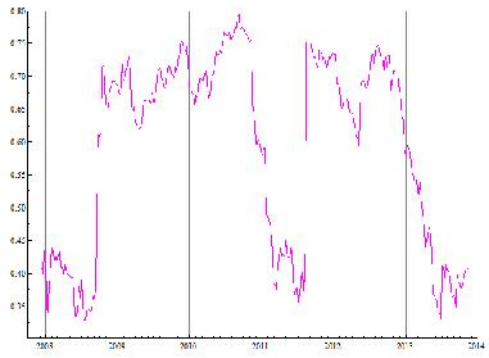
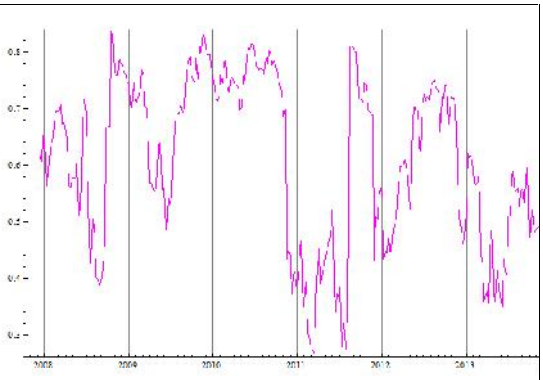


Turkey



Czech Republic



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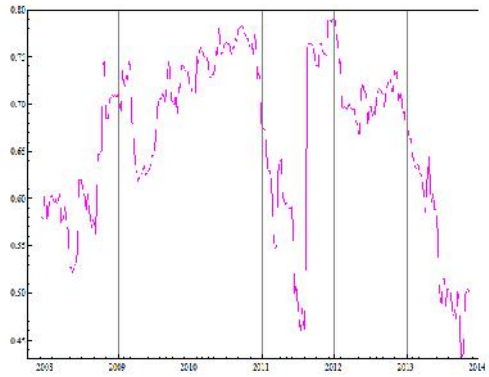
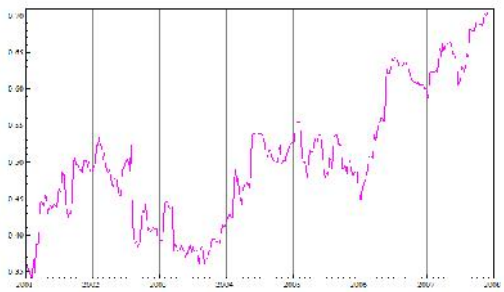


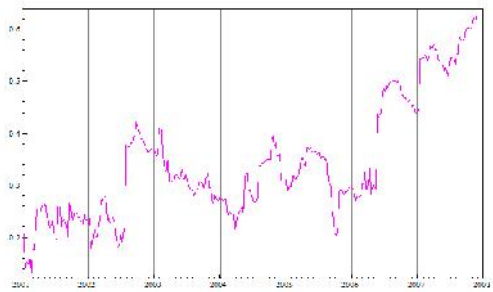
Poland

Conditional correlation between the BRIC-T Emerging Markets and the EU3 with the US for the crisis and post-crisis period.

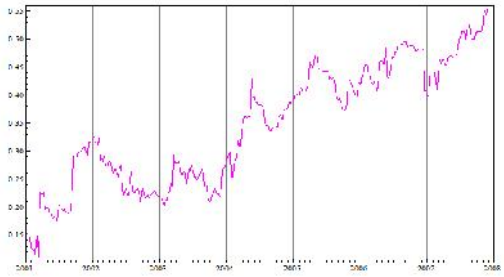
| DCC estimation results Pre-crisis with EU | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Brazil | Russia | India | China | Turkey | Czech Republic | Hungary | Poland |
| | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) |
| Model | | | | | | | | |
| Mean equation | | | | | | | | |
| μ | 0.620346** | 0.832622*** | 0.607883 | 0.094488 | 0.592205 | 0.733603*** | 0.497644** | 0.526835*** |
| | 0.25751 | 0.23054 | 0.20595 | 0.16274 | 0.32571 | 0.15227 | 0.1834 | 0.18007 |
| Variance equation | | | | | | | | |
| ω | 1.882536* | 2.680705*** | 2.098796* | 0.695753** | 1.334124 | 2.721317*** | 4.126586*** | 2.082413** |
| | 1.0267 | 0.93928 | 1.177 | 0.31605 | 0.91144 | 1.0487 | 1.6081 | 0.92206 |
| α | 0.097797** | 0.118813*** | 0.222834* | 0.151806*** | 0.066161** | 0.277692** | 0.086134 | 0.07097 |
| | 0.043617 | 0.040602 | 0.12571 | 0.04694 | 0.030122 | 0.12606 | 0.057101 | 0.05125 |
| β | 0.830709*** | 0.727017*** | 0.627318*** | 0.785926*** | 0.898774*** | 0.431961** | 0.577464*** | 0.750631*** |
| | 0.054479 | 0.064318 | 0.16191 | 0.054226 | 0.041554 | 0.1726 | 0.12765 | 0.082614 |
| Multivariate DCC equations | | | | | | | | |
| a | 0.018715** | 0.020603** | 0.016793** | 0 | 0.027163*** | 0.024605* | 0.037733 | 0.03117* |
| | 0.0078023 | 0.0088865 | 0.007887 | -9 | 0.010217 | 0.01311 | 0.025004 | 0.016389 |
| b | 0.981275*** | 0.979387*** | 0.983197*** | 0.82734** | 0.972827*** | 0.965357*** | 0.892542*** | 0.931035*** |
| | 0.0090286 | 0.010927 | 0.010493 | 0.38747 | 0.01257 | 0.014194 | 0.094084 | 0.021472 |
| ρ | 0.357148*** | 0.207641** | 0.151286 | 0.118289** | 0.198666* | 0.533934*** | 0.453679*** | 0.576949*** |
| | 0.058013 | 0.08448 | 0.094165 | 0.055175 | 0.11401 | 0.11827 | 0.066519 | 0.063914 |
| df | 7.029787*** | 6.757077*** | 6.894567*** | | 7.21277*** | 7.370311*** | 5.773585*** | 7.065452*** |
| | 1.3936 | 1.4322 | 1.3653 | | 1.3283 | 1.4321 | 0.87542 | 1.3639 |
| Diagnostic checking | | | | | | | | |
| Log-likelihood | -1871.94 | -1849.41 | -1772.68 | -1778.05 | -1994.74 | -1685.59 | -1750.85 | -1733.71 |
| MQ(20) | 83.778 | 89.9722 | 106.937 | 230.226 | 95.049 | 82.1491 | 99.8995 | 84.2149 |
| | [0.364434] | [0.20896] | [0.023846] | [0.07021] | [0.12013] | [0.41253] | [0.06543] | [0.351954] |
| MQ2(20) | 154.976 | 59.8206 | 53.2824 | 222.132 | 77.7372 | 77.621 | 54.7472 | 64.8108 |
| | [0.00005] | [0.937295] | [0.98543] | [0.11502] | [0.48709] | [0.49081] | [0.978957] | [0.85723] |



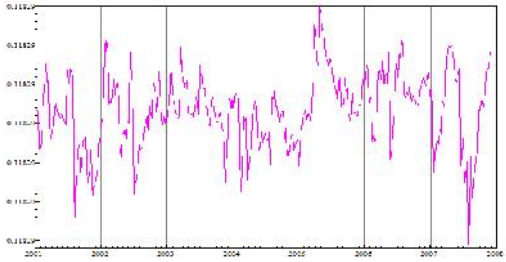
Brazil



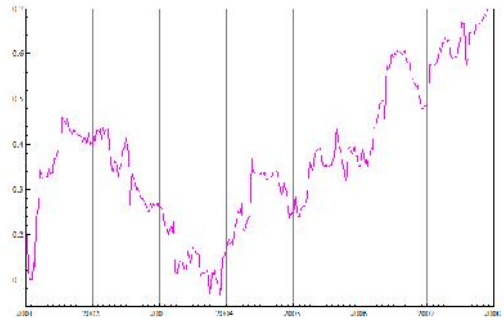
Russia



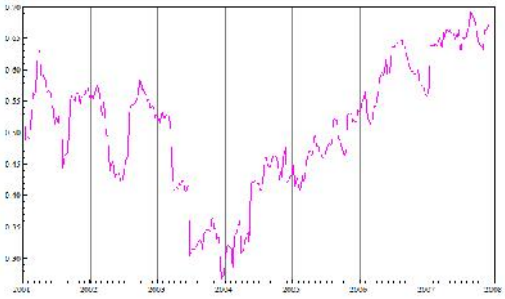
India



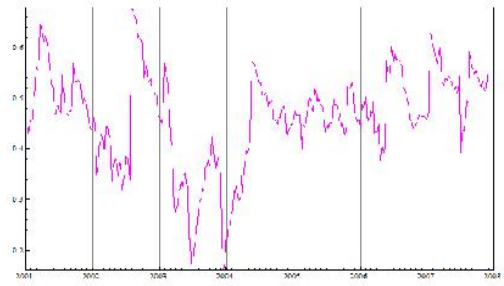
China



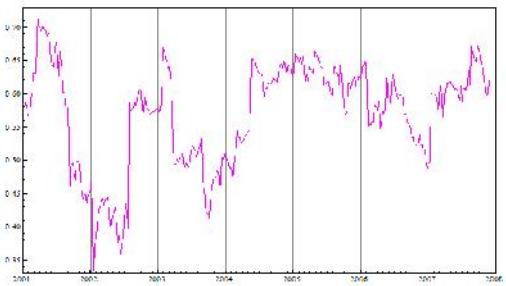
Turkey



Czech Republic



Hungary

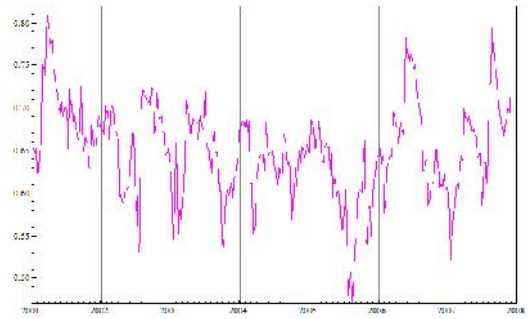


Poland

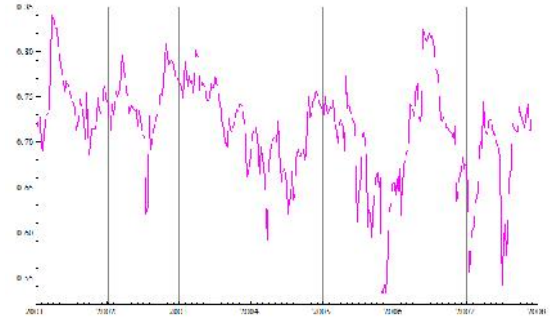
Conditional correlations between the BRIC-T plus the CEE emerging markets and the EU for pre-crisis period

| DCC estimation results Crisis/post period with the US | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Model | UK | Germany | France | Brazil | Russia | India | China | Turkey | Czech Republic | Hungary | Poland |
| Mean equation | GARCH(1,1 | GARCH(1,1 | GARCH(1,1 | GARCH(1,1 | GARCH(1,1 | GARCH(1,1 | GARCH(1,1 | GARCH(1,1 | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) |
| μ | 0.06237 | 0.159755 | 0.2007 | -0.04475 | 0.31252 | -0.05173 | -0.16785 | 0.163722 | -0.00463 | 0.044927 | 0.140309 |
| | 0.14447 | 0.19065 | 1.413925 | 0.21166 | 0.34812 | 0.21585 | 0.17895 | 0.27665 | 0.21109 | 0.23663 | 0.22202 |
| Variance equation | | | | | | | | | | | |
| ω | 0.893408 | 1.33734* | 0.7117** | 1.334026 | 2.905062 | 0.330684 | 0.13886 | 1.635873 | 2.102006 | 1.051415 | 2.02639 |
| | 0.70789 | 0.76588 | 0.174967 | 0.82403 | 3.8546 | 0.2732 | 0.21427 | 1.0914 | 1.2906 | 0.64337 | 1.5445 |
| α | 0.193374* | 0.168688** | 0.174967** | 0.27065** | 0.211947 | 0.103152*** | 0.057871 | 0.079943** | 0.183578*** | 0.183493*** | 0.236131 |
| | 0.10368 | 0.073194 | 0.068884 | 0.11042 | 0.23456 | 0.03885 | 0.047623 | 0.032763 | 0.088797 | 0.065457 | 0.14562 |
| β | 0.733417*** | 0.757786*** | 0.748582*** | 0.71726*** | 0.699175*** | 0.884575*** | 0.927185*** | 0.864804*** | 0.723197*** | 0.796547*** | 0.701009*** |
| | 0.13477 | 0.082945 | 0.077217 | 0.051297 | 0.29683 | 0.036869 | 0.060692 | 0.038847 | 0.11396 | 0.055303 | 0.15121 |
| Multivariate DCC equations | | | | | | | | | | | |
| a | 0.03317** | 0.066893 | 0.055231** | 0.044209** | 0.074891** | 0.028068** | 0.046573 | 0.027803 | 0.046338 | 0.084704*** | 0.03605** |
| | 0.014833 | 0.045876 | 0.025121 | 0.022454 | 0.029436 | 0.014489 | 0.055561 | 0.020344 | 0.017734 | 0.039067 | 0.015562 |
| b | 0.965133*** | 0.912087*** | 0.932881*** | 0.922634*** | 0.920024*** | 0.962386*** | 0.551894*** | 0.926475*** | 0.947825*** | 0.872245*** | 0.953507*** |
| | 0.015971 | 0.093977 | 0.03913 | 0.075585 | 0.034782 | 0.013331 | 0.19539 | 0.039328 | 0.021338 | 0.06664 | 0.022172 |
| ρ | 0.650691*** | 0.727575*** | 0.695831*** | 0.696383*** | 0.420519** | 0.447145*** | 0.346955*** | 0.539221*** | 0.408654*** | 0.619671*** | 0.580092*** |
| | 0.090179 | 0.18928 | 0.18459 | 0.082825 | 0.20899 | 0.17213 | 0.049481 | 0.061299 | 0.22217 | 0.084048 | 0.12459 |
| df | 8.787434*** | 6.197386*** | 7.497934*** | 10.042603*** | 6.594657*** | 7.848563*** | 8.922663*** | 5.681791*** | 6.761331*** | 6.902058*** | 7.739074*** |
| | 3.1729 | 1.2146 | 2.1947 | 3.3892 | 1.3942 | 1.8846 | 2.4142 | 1.0268 | 1.2805 | 1.4483 | 1.9709 |
| Diagnostic checking | | | | | | | | | | | |
| Log-likelihood | -1338.36 | -1413.9 | -1417.67 | -1513.58 | -1546.63 | -1539.88 | -1504.21 | -1577.97 | -1517.28 | -1581.43 | -1524.13 |
| MQ(20) | 82.6939 | 74.7757 | 78.8956 | 99.1271 | 64.2569 | 83.0592 | 79.6343 | 90.9671 | 71.4221 | 87.4425 | 91.2392 |
| | [0.3961913] | [0.6440619] | [0.5139262] | [0.0724451] | [0.9003357] | [0.3853707] | [0.4905058] | [0.1887647] | [0.7424122] | [0.2665101] | [0.1834812] |

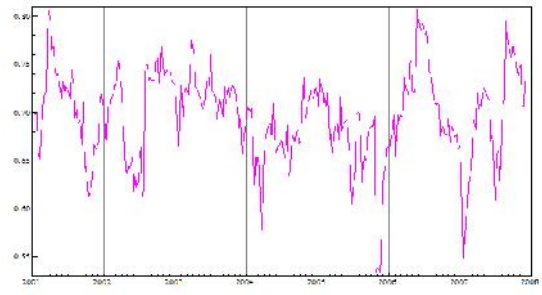
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MQ2(20) | [0.4222550] | 62.3837 | 70.6803 | 94.9901 | 85.2641 | 66.3566 | 65.7502 | 81.9836 | 198.838 | 128.018 | 71.8743 |
| | 201.255 | [0.9016] | [0.7093] | [0.09259] | [0.2684] | [0.8235] | [0.8372] | [0.3568] | [0.4698] | [0.0003] | [0.6736970] |



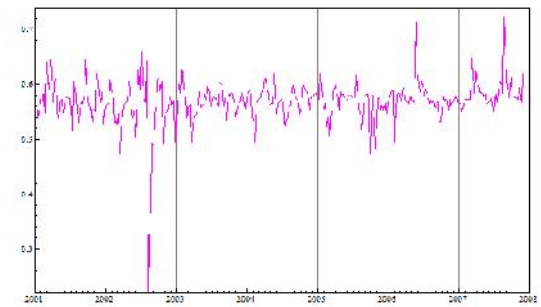
UK



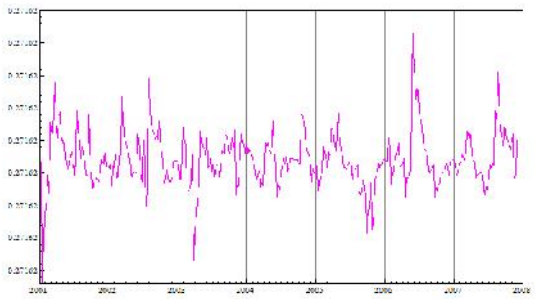
Germany



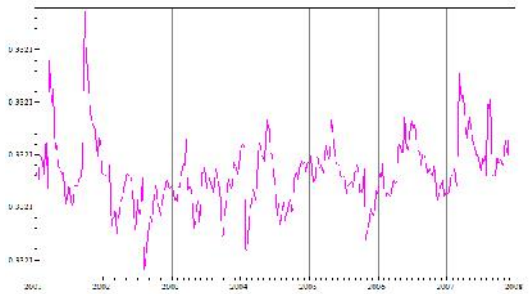
France



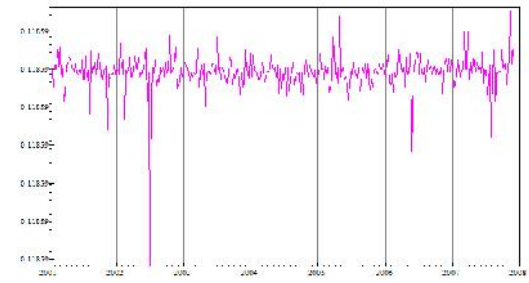
Brazil



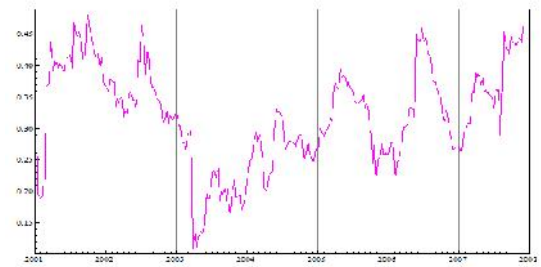
Russia



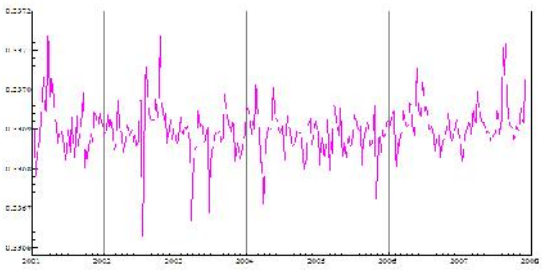
India



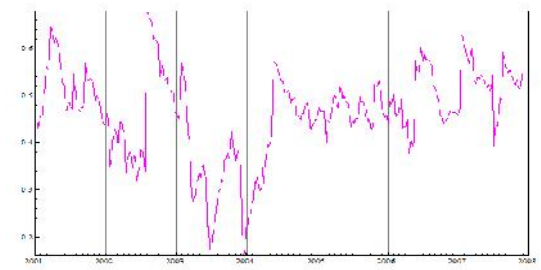
China



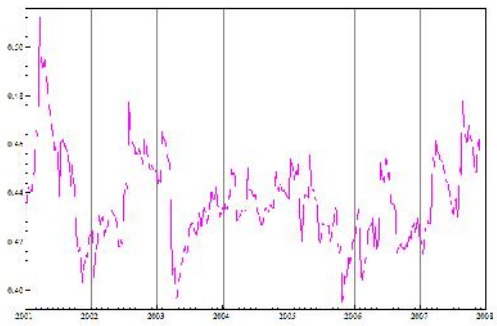
Turkey



Czech Republic



Hungary



Poland

Dynamic conditional correlations between the BRIC-T plus The CEE emerging markets and EU3 with the USA for pre-crisis period.

| DCC estimation results crisis/post period with EU | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Model | Brazil | Russia | India | China | Turkey | Czech Republic | Hungary | Poland |
| Mean equation | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) | GARCH(1,1) |
| μ | -0.04475 | 0.31252 | -0.05173 | -0.16785 | 0.163722 | -0.00463 | 0.044927 | 0.140309 |
| | 0.21166 | 0.34812 | 0.21585 | 0.17895 | 0.27665 | 0.21109 | 0.23663 | 0.22202 |
| Variance equation | | | | | | | | |
| ω | 1.334026 | 2.905062 | 0.330684 | 0.13886 | 1.635873 | 2.102006 | 1.051415 | 2.02639 |
| | 0.82403 | 3.8546 | 0.2732 | 0.21427 | 1.0914 | 1.2906 | 0.64337 | 1.5445 |
| α | 0.27065** | 0.211947 | 0.103152*** | 0.057871 | 0.079943** | 0.183578*** | 0.183493*** | 0.236131 |
| | 0.11042 | 0.23456 | 0.03885 | 0.047623 | 0.032763 | 0.088797 | 0.065457 | 0.14562 |
| β | 0.71726*** | 0.699175*** | 0.884575*** | 0.927185*** | 0.864804*** | 0.723197*** | 0.796547*** | 0.701009*** |
| | 0.051297 | 0.29683 | 0.036869 | 0.060692 | 0.038847 | 0.11396 | 0.055303 | 0.15121 |
| Multivariate DCC equations | | | | | | | | |
| | | | | | | | | |
| a | 0.873106*** | 0.732572*** | 0.952721*** | 0.755174 | 0.706351*** | 0.427044 | 0.957062*** | 0 |
| | 0.044442 | 0.080578 | 0.016242 | 0.41173 | 0.14468 | 0.72035 | 0.021231 | 0.42562 |
| b | 0.088607*** | 0.125793*** | 0.031225** | 2E-07 | 0.160299*** | 0.131871 | 0.027374*** | 0.059772 |
| | 0.026912 | 0.043132 | 0.012699 | 948 | 0.060333 | 0.098459 | 0.015133 | 0.045979 |
| ρ | 0.714466*** | 0.716829*** | 0.560359*** | 0.385934*** | 0.624995*** | 0.816301*** | 0.765028*** | 0.831946*** |
| | 0.063416 | 0.041143 | 0.077024 | 0.043322 | 0.058566 | 0.020677 | 0.060087 | 0.017232 |
| df | 11.418115*** | 7.63321*** | 12.028052*** | | 6.255457*** | 8.069824*** | 7.431168*** | 7.157087*** |
| | 4.2022 | 1.9222 | 4.3594 | | 1.4577 | 1.8452 | 1.7962 | 1.682 |
| | | | | | | | | |
| Diagnostic checking | | | | | | | | |
| Log-likelihood | -1669.39 | -1684.1 | 1690.66 | -1663.18 | -1719.63 | -1583.08 | -1680.36 | -1598.59 |
| MQ(20) | 87.2468 | 80.8177 | 83.0923 | 89.0297 | 78.2895 | 78.0674 | 81.5976 | 82.9555 |
| | [0.271320] | [0.45335] | [0.384395] | [0.22937] | [0.53325] | [0.54029] | [0.42931] | [0.38842] |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MQ2(20) | 77.5764 | 80.4883 | 71.006 | 73.6762 | 62.9895 | 57.2984 | 68.393 | 41.4851 |
| | [0.492238] | [0.40117] | [0.69979] | [0.61758] | [0.8915] | [0.96224] | [0.77314] | [0.99977] |

| Estimated Average conditional correlation | | | | | |
|---|---|---|---|---|---|
| | GFC/Post period | | Pre-GFC pried | | % changes |
| | Coeff | S.e | Coeff | S.e | |
| Panel B DCC with US index markets | | | | | |
| UK | 0.650691*** | 0.090179 | 0.652731*** | 0.036082 | -0.31253 |
| Germany | 0.727575*** | 0.18928 | 0.717432*** | 0.035804 | 1.413793 |
| France | 0.695831*** | 0.18459 | 0.698772*** | 0.03349 | -0.42088 |
| Brazil | 0.696383*** | 0.082825 | 0.570925*** | 0.039687 | 21.97452 |
| Russia | 0.420519** | 0.20899 | 0.27162*** | 0.052441 | 54.81886 |
| India | 0.447145*** | 0.17213 | 0.32756*** | 0.047444 | 36.50782 |
| China | 0.346955*** | 0.049481 | 0.11859*** | 0.050184 | 192.5668 |
| Turkey | 0.539221*** | 0.061299 | 0.315403*** | 0.074507 | 70.96255 |
| Czech Republic | 0.408654*** | 0.22217 | 0.336898*** | 0.04778 | 21.29903 |
| Hungary | 0.619671*** | 0.084048 | 0.298529*** | 0.076842 | 107.5748 |
| Poland | 0.580092*** | 0.12459 | 0.435814*** | 0.044978 | 33.10541 |
| Panel B DCC with EU index markets | | | | | |
| Brazil | 0.714466*** | 0.063416 | 0.357148*** | 0.058013 | 100.0476 |
| Russia | 0.716829*** | 0.041143 | 0.207641** | 0.08448 | 245.2252 |
| India | 0.560359*** | 0.077024 | 0.151286 | 0.094165 | 270.3971 |
| China | 0.385934*** | 0.043322 | 0.118289** | 0.055175 | 226.2636 |
| Turkey | 0.624995*** | 0.058566 | 0.198666* | 0.11401 | 214.5959 |
| Czech Republic | 0.816301*** | 0.020677 | 0.533934*** | 0.11827 | 52.88425 |
| Hungary | 0.765028*** | 0.060087 | 0.453679*** | 0.066519 | 68.6276 |
| Poland | 0.831946*** | 0.017232 | 0.576949*** | 0.063914 | 44.19749 |