En Büyük Küresel Finansal Kriz: Amerika'dan mı Yayıldı Yoksa Sadece bir Karşılıklı Bağımlılık mı?

Received/Geliş: 20/05/2017
Accepted/Kabul: 16/10/2017

Doğuş EMİN*

Öz

Bu çalışma 2008 Mortgage krizininin Türkiye'nin de içinde bulunduğu gelişmekte olan Avrupa ülkelerine Amerika ile olan güçlü bağlardan dolayı mı etki ettiğini yoksa krizin dinamiklerinden kaynaklanan sebepler ile mi bulaştığını incelemektedir. Bu amaç ile çalışmada kriz ve kriz öncesi dönemlerin dinamik korelasyonları karşılaştırılarak 2008 Mortgage krizininin Amerika'dan bulaşma şeklinde yayılıp yayılmadığı test edilmektedir. Sonuçlar gelişmekte olan Avrupa ülkelerine krizin her ne kadar bulaşma şeklinde yayıldığını gösterse de borsaların birbirlerine normal gündeki güçlü bağımlılıklarından dolayı da bulaştığını göstermiştir. Sonuçlar aynı zamanda metodoloji üzerine de bazı implikasyonları ortaya koymuştur. Buna göre bulaşmanın tespit edilmesinde ekonometrik tanımlamalar ve kriz dönemlerinin belirlenmesi önemli ve anlamlı rol oynamaktadır.

Anahtar Kelimeler: Krizlerin Bulaşması, Borsaların Bağımlılığı, Dinamik Korelasyon
Jel Kodları: E61, F30, G01, G02, G15

The Greatest Global Financial Crisis: Contagion from the United States or Only Interdependence?

Abstract

Comparing tranquil and shock periods' dynamic conditional correlations; this study tests presence of "contagion effect" from the US to the group of countries that includes Turkey too -emerging European countries- during the latest global financial crisis (2008 Mortgage Crisis). The results reveal that although the contagion effect was observed for some of the emerging European countries, the crises did propagate to the rest of the emerging European countries due to strong normal day interdependence. The results reveal some key implications regarding methodological issues too as the conclusion regarding the presence of the contagion is highly dependent on econometric specifications and sample period diversifications.

Keywords: Contagion, Interdependence, Dynamic Conditional Correlation
JEL Codes: E61, F30, G01, G02, G15

*Yrd. Doç., Ankara Sosyal Bilimler Üniversitesi, Siyasal Bilgiler Fakültesi, İşletme Bölümü, Tel: 0312 596 4690, E-mail: dogus.emin@asbu.edu.tr.
ORCID ID: orcid.org/0000-0002-4980-171X

Introduction

The global financial crisis which had started as a subprime mortgage crisis in 2007 in the US caused large scars in the economies of most of the countries all around the world and heavy losses in the stock markets of those countries. Emerging Europe was one of the regions that were heavily affected from that locally started crisis. Amongst those countries, Hungary was the most heavily affected one and could not stop the depreciation of its currency against Euro and had to ask 16.5 billion Dollars loan from the IMF and 5 billion Euros from the European Central Bank to ease its economy (Syllignakis and Kouretas, 2011). During that period, GDP growth rate of the Czech Republic decreased to 2.5% in 2008 and -4.1% in 2009. Poland was more resistant to the crisis compared to the Czech Republic and Hungary but it still experienced a remarkable decrease on the GDP growth rate and could succeed rather lower growth rates compared to the previous years; a 5% increase in 2008 and a 1.7% increase in 2009 (Terazi and Senel, 2011). The global financial crisis hit Turkey strongly too and caused a sharp decrease on total market capitalization of the Istanbul Stock Exchange from US $288 billion at the end of 2007 to US $118 billion at the end of 2008 (Rawdanowicz, 2010) while the Russian stock market lost 60 per cent of its value in one year (Eichengreen, 2010).

Forbes and Rigobon (2002) suggest that the correlation coefficient method is the most direct method while investigating the existence of contagion. According to that, the authors claim that any significant increase in stock market correlations due to the effect of the financial crisis is a solid evidence of the existence of contagion. However, the authors state that this approach has one big shortcoming since the increase on the correlation coefficients may occur due to increased volatility of stock returns during the crisis times and thus this may lead to false or spurious conclusion. For that reason, Forbes and Rigobon (2002) develop an adjusted correlation coefficient to fix the heteroscedasticity problem which erroneously leads to accept the existence of contagion. On the other hand, some scholars point out the shortcomings of the model of Forbes and Rigobon (2002). Baur (2003, p.406), for instance, argues that results of the Forbes and Rigobon (2002) model can be misleading when "(i) correlations are time varying and not constant; (ii) heteroscedasticity is a source of contagion; and (iii) the crisis period is too short, i.e. the test does not have enough power to detect contagion". Amongst

others, Engle and Sheppard (2001) introduce a multivariate dynamic correlation model that, unlike heteroscedasticity correction technique, is free from a priori restrictions that briefly mentioned above and deals with heteroscedasticity problems of data.

In this paper, by using the model that is introduced by Engle and Sheppard (2001), we investigate whether there is a significant increase in cross-market correlations during the latest financial crisis. Therefore, our empirical analysis attempts to examine the changes in dynamic conditional correlations between the US market and emerging European markets before and after the crisis. We aim thus to investigate whether the greatest global financial crisis is the result of a contagion effect from the United States or whether it is the inevitable consequence of strong interdependences of countries with the US.

By employing the dynamic conditional correlation model with both overlapping and non-overlapping data and distinguishing between 'contagion from the United States' and 'interdependence with the United States', we believe, we significantly contribute to the literature.

International Financial Contagion And The Financial Crisis Of 2007-2009

International Financial Contagion

Forbes and Rigobon (2002) believe that contagion should be defined in a straightforward and narrow way. For this purpose, the authors suggest the term 'shift contagion' to explain the propagation of financial shocks; and they associate it with investor's behaviour which is unrelated to economic or trade based links. According to this, instead of economic fundamentals, contagion is triggered with the herd behaviour of investors. For instance, if investors or agents who are panicked "withdraw their funds from other countries following a crisis in one country" (Naoui et al., 2010, p.85) that causes a contagion. The authors prefer to quantify and define this phenomenon as "a significant increase in cross-market linkages after a shock to one country (or group of countries)" (Forbes and Rigobon, 2002, p.2223). This definition dictates that if two markets already show a high degree of co-movement during tranquil times, even if those markets are still highly correlated after a shock to one market, this may not constitute a contagion. Therefore, if the co-movement between two markets does not significantly increase but continues to have

high level of market correlation, this suggests strong linkages between two markets that exist in all states of the economy; whilst only a significantly increased cross-market co-movement after a shock constitutes a contagion.

The Financial Crisis of 2007-2009

The subprime mortgage crisis of 2007 that originated in the US mortgage market has become one of the most destructive global financial crises in history. The crisis was triggered by easy loans to people who had low credit scores and eventually the default of those mortgages in the United States of America. Until 2007, the whole system was working fine since initial interest rates were low and borrowers who were struggling with their payments were re-mortgaging their estates to pay for their loans. Meanwhile those loans were being resold to the interested investors to create another investment opportunity. However, when the prices of real estates started to decrease and interest rates started to increase; re-mortgaging opportunities disappeared and borrowers with low credit scores started to have difficulties with paying their loans. After the defaults started to pop up, the financial bubble that was created with high real estate prices and the subprime mortgage market burst. The subprime crisis contaminated the structured-credit market too. It caused a credit crunch for both individuals and financial institutions and finally led to a dramatic decline in liquidity of debt securities in almost every market (Longstaff, 2010). The crisis spilled over quickly and dramatically to other markets in the US due to confidence loss of markets to the financial sector after "the collapse or forced merger/bailouts of Bear Stearns, AIG, Fannie Mae, Freddie Mac, Lehman Brothers, IndyMac Bank, Merrill Lynch, Wachovia, Washington Mutual, and many others" (Longstaff, 2010, p.436). Although the Treasury and the Federal Reserve intervened to stop contagion and spillovers to other markets and sectors by providing liquidity and financial guarantees to the market, that intervention even strengthened the concerns about the long term performance of the US economy. Due to those fundamental problems, the decline had started in the US stock market in late 2007 and "during the most turbulent episode of the meltdown that lasted for about 6 months from September 2008 to early March 2009, the U.S. stock market plummeted by 43%, the emerging markets by 50%, and frontier markets by 60%" (Samarakoon, 2011, p.727). Therefore, although the financial crisis had started locally in the United States, in 2008 it spilled over and became a global financial crisis in almost every country and every sector.

Data And Methodology

Data

We construct our dataset with daily closing price observations of the main stock indices from the stock markets of emerging European countries: the PX of Prague Stock Exchange (the Czech Republic); the BUX of Budapest Stock Exchange (Hungary); the WIG20 of Warsaw Stock Exchange (Poland); the RTS Index of Russian Trading System Stock Exchange (Russia); and the XU100 of Istanbul Stock Exchange (Turkey). To represent the US market, we prefer to use the S&P 500 Index since it includes 500 leading companies from leading industries, and covers over (according to Standard & Poor's Financial Services) 75% of the market's total value in the US.

Our sample period covers the period of January 1, 2005 to March 31, 2009 and it is divided into two sub-periods as the pre-crisis period and crisis period so as to be able to examine the possible changes in co-movement relations. Naoui et al. (2010) suppose that the explosion of the subprime bubble occurred on August 1, 2007 when the US stock markets began to show sharp declines approximately around that date. Therefore, we construct the pre-crisis period such that it covers a period of two and a half years prior to that date. We choose March 31, 2009 as the end of the crisis since the "S&P 500 index rebounded well from its lowest value by the end of March" (Manda, 2010, p.10).

Forbes and Rigobon (2002) suggest using overlapping data (the comparison of the cross-market correlations of the crisis period with the full sample period) while investigating the presence of the contagion. Dungey et al. (2005), on the other hand, claim that overlapping data may cause a bias in results as the length of pre-crisis period directly affects the estimation of full period correlations and suggest using a non-overlapping data (the comparison of the cross-market correlations of the pre-crisis period with the crisis period). In this paper, we conduct the analyses with both overlapping and non-overlapping data.

Our major concern related to daily data is the differences in time zones. Since the US stock markets open and close after the European stock markets, the shocks originated from the US may affect the markets in Europe when they open the day after. To deal with this issue, by following Forbes and Rigobon (2002), we calculate the index returns as a two-day rolling average,

where we calculate daily stock market returns by taking the first difference of the natural log of the daily closing prices [1]:

$$R_{i,t} = \ln(I_{i,t}) - \ln(I_{i,t-1}) \qquad (1)$$

where, $I_{i,t}$ is the index price of the i-th country at time t, $I_{i,t-1}$ is the index price of the i-th country at time $t-1$, and $R_{i,t}$ is the corresponding rate of return on index.

As Brooks (2008, p.292) clearly states "if one wishes to use hypothesis tests, either singly or jointly, to examine the statistical significance of the coefficients, then it is essential that all of the components in the model are stationary". Therefore, to test the presence of unit roots in data series, we apply both the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test.

[1] While some stocks do not pay dividends at all, by paying a significant amount of money as dividends some stocks may significantly increase their total returns. However, since we are only interested in the price returns of the stocks (to be able investigate the return co-movements with international markets), we ignore dividends.

Table 1: Unit Root Tests Results for Pre-crisis Period, Crisis Period and Full-period BUX- Budapest Stock Exchange, Hungary; PX- Prague Stock Exchange, the Czech Republic; RTS- Russian Trading System Stock Exchange, Russia; SP500- Standard and Poor's 500, the US; WIG20- Warsaw Stock Exchange, Poland; and XU100- Istanbul Stock Exchange, Turkey.

	ADF	***PP***
	Pre-crisis	
BUX	-23.40361*	-23.39814*
PX	-23.64323*	-23.54204*
RTS	-23.99119*	-24.00886*
S&P 500	-27.33156*	-27.72923*
WIG20	-24.94810*	-24.94636*
XU100	-24.69798*	-24.66760*
	Crisis	
BUX	-16.73544*	-18.44992*
PX	-18.85750*	-18.85750*
RTS	-18.09192*	-18.08589*
S&P 500	-18.48974*	-25.20358*
WIG20	-20.07450*	-20.06760*
XU100	-19.69314*	-19.69443*
	Full-period	
BUX	-27.28878*	-27.33301*
PX	-24.98039*	-24.92116*
RTS	-22.98360*	-22.87481*
S&P 500	-17.41417*	-29.35586*
WIG20	-21.16525*	-25.97090*
XU100	-26.07120*	-26.06259*

The null hypothesis for the ADF and PP tests is the presence of a unit root. The critical values for the ADF and PP test statistics are: -3.4398 for the pre-crisis period; -3.4451 for the crisis period; -3.4392 for the post-crisis period at the 1% significance level. * denotes the rejection of the null hypothesis at 1% level.

Methodology

The Dynamic Conditional Correlation model of Engle and Sheppard (2001) is composed of two steps: the estimation of a univariate GARCH model and the estimation of a bivariate Dynamic Conditional Correlation model.

The model is defined as:

$$r_{i,t}|F_{t-1} \sim N(0, H_t) \qquad (2)$$

where $r_{i,t}$ are the normally distributed return series with zero mean; F_{t-1} is the information set available at $t-1$, H_t is a positive definite conditional variance-covariance matrix.

$\boldsymbol{H_t}$ can be decomposed as follows;

$$H_t = D_t R_t D_t \qquad (3)$$

$\boldsymbol{D_t}$ is a 2×2 diagonal matrix of time-varying standard deviations from the first step univariate GARCH model estimation with $\sqrt{\sigma_{it}^2}$ on the i^{th} diagonal. Specifically, D_t can be expressed as follows:

$$D_t = \begin{bmatrix} \sqrt{\sigma_{11,t}^2} & 0 \\ 0 & \sqrt{\sigma_{22,t}^2} \end{bmatrix} \qquad (4)$$

$\boldsymbol{\sigma_{it}^2}$ can be calculated by the univariate GARCH model as follows:

$$\sigma_{it}^2 = \omega_0 + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \qquad (5)$$

where σ_t^2 is the conditional variance of returns on stock at time t; ω_0 is the constant term; ε_{t-1} is the news about volatility from the previous period; σ_{t-1}^2 is the last period's estimated conditional variance; and α and β are ARCH and GARCH effects respectively. (To ensure the non-negativity of the conditional variance σ_t^2, the following conditions should be present: $\alpha \geq 0$, $\beta \geq 0$, and $\alpha + \beta < 1$.)

$\boldsymbol{R_t}$ is the time-varying correlation matrix of the standardized residuals ε_t $(\varepsilon_t = D_t^{-1} r_t \sim N(0, R_t))$:

$$R_t = \begin{bmatrix} 1 & \rho_{12,t} \\ \rho_{21.t} & 1 \end{bmatrix} \qquad (6)$$

where the correlation estimator is $\rho_{12,t} = \frac{q_{12,t}}{\sqrt{q_{1,t} q_{2,t}}}$.

The elements in R_t can be calculated by using the following framework:

$$R_t = \left(diag(Q_t)\right)^{-1} Q_t \left(diag(Q_t)\right)^{-1} \qquad (7)$$

where, Q_t, is the proposed dynamic correlation structure.

$\boldsymbol{Q_t}$ can be expressed as:

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha\varepsilon_{t-1}\varepsilon'_{t-1} + \beta Q_{t-1} \qquad (8)$$

where ε_t is the standardized residual matrix from the first stage estimation, and $\bar{Q}$ is the 2×2 unconditional correlation matrix of the standardized residuals ($\bar{Q} = E[\varepsilon_t \varepsilon'_t]$). The parameters α and β capture the effects of previous shocks and previous dynamic conditional correlations on current dynamic conditional correlations.

Estimation of the Model

The log-likelihood function of the model as follows:

$$L(\theta) = -\frac{1}{2}\sum_{t=1}^{T}(nlog(2\pi) + \log|H_t| + r'_t H_t^{-1} r_t)$$

$$= -\frac{1}{2}\sum_{t=1}^{T}(nlog(2\pi) + \log|D_t R_t D_t| + r'_t D_t^{-1} R_t^{-1} D_t^{-1} r_t)$$

$$= -\frac{1}{2}\sum_{t=1}^{T}(nlog(2\pi) + 2\log|D_t| + \log|R_t| + \varepsilon'_t R_t^{-1}\varepsilon_t) \qquad (9)$$

where $\varepsilon_t \sim N(0, R_t)$ are the residuals standardized on the basis of their conditional standard deviations.

Using the quasi-likelihood function, the first step parameters can be estimated maximizing the following function:

$$L_1(\emptyset|r_t) = -\frac{1}{2}\sum_{t=1}^{T}\left(nlog(2\pi) + \sum_{t=1}^{n}\left(log(\sigma_{it}^2) + \frac{r_{it}^2}{\sigma_{it}^2}\right)\right) \qquad (10)$$

and the second step parameters can be estimated maximizing the following function:

$$L_2\left(\varphi\middle|\widehat{\emptyset}, r_t\right) = -\frac{1}{2}\sum_{t=1}^{T}(\log|R_t| + \varepsilon'_t R_t^{-1}\varepsilon_t - \varepsilon'_t\varepsilon_t) \qquad (11)$$

Finally the *Fisher z* transformation technique is used to test whether the increases on the dynamic conditional correlations are significant:

$$H_0: \rho_c \leq \rho_t$$

$$H_1: \rho_c > \rho_t$$

where ρ_c is the adjusted correlation coefficient during the crisis period, and ρ_t is the adjusted correlation coefficient during the tranquil period.

Empirical Results

Before we proceed to examine the adjusted correlation coefficients with the Engle and Sheppard (2001) technique, in the first step we briefly investigate the presence of contagion with simple correlation coefficients.

Table 2: Unadjusted Correlation Coefficients
This table reports cross-market correlation coefficients (unadjusted) for the stock markets of the US and 5 emerging European countries for the crisis period and the full sample period. "C" indicates that the crisis correlation coefficient is greater than the full sample period correlation coefficient and therefore contagion occurred. "N" indicates that the full sample period correlation coefficient is larger than or equal to the crisis correlation coefficient and therefore no contagion occurred.

	Full-period	*Crisis*	*Contagion?*
Czech Republic	0.30659	0.34290	**C**
Hungary	0.35691	0.39017	**C**
Poland	0.33225	0.36430	**C**
Russia	0.22396	0.35777	**C**
Turkey	0.31262	0.38071	**C**

Table 2 presents the unadjusted correlation coefficients that are computed with the overlapping data (comparison of the full period, i.e. pre-crisis period and crisis period, with the crisis period). A comparison of the correlation coefficients shows that the crisis has increased the correlations between the US stock market and the stock markets of emerging European countries. During the full sample period (January 1, 2005 to March 31, 2009), the correlation coefficients of emerging European markets with the American market vary between 0.224 and 0.357. During the crisis period, however, we note a considerable increase on the correlations of all sample countries (between 0.258 and 0.390). Therefore, the comparison of simple (unadjusted) correlation coefficients confirms the presence of contagion during the global financial crisis of 2007-2009.

Next, to investigate the presence of the contagion effect, we examine the estimated results of the dynamic correlation framework of five pair-wise models (USA-Czech Republic, USA-Hungary, USA-Poland, USA-Russia, and USA-Turkey) for overlapping data (the tranquil period is specified as the

full sample period) and non-overlapping (the tranquil period is specified as the pre-crisis period).

Table 3 presents the dynamic conditional correlations between the stock markets of emerging European countries and the US stock market for the pre-crisis, crisis, and full sample periods. By comparing those correlation estimates, we intend to examine the presence of the contagion effect of the subprime mortgage crisis on the stock markets of emerging European countries. As it is clearly seen, a drastic increase in the conditional correlations between national stock markets and the US market is common for all emerging European countries during the crisis period. Therefore, both full period and crisis period dynamic conditional correlation estimations are larger than the pre-crisis period estimations for all sample countries. According to this, it is fair to say that the subprime mortgage crisis has caused sharp increases in the correlation levels of all sample stock markets with the origin country of the crisis, i.e. the US.

Table 3: Dynamic Conditional Correlation Estimations
This table reports the period averages of the daily conditional correlation estimates between stock markets of emerging Europe and the US, based on the Dynamic Conditional Correlation model of Engle and Sheppard (2001).

Period	*BUX*	*PX*	*RTS*	*WIG20*	*XU100*
Pre-crisis	0.13393	0.20024	0.15479	0.25242	0.20820
Crisis	0.32155	0.30378	0.22593	0.33738	0.36647
Full Period	0.23117	0.23604	0.17192	0.29552	0.26904

BUX- Budapest Stock Exchange, Hungary; PX- Prague Stock Exchange, the Czech Republic; RTS- Russian Trading System Stock Exchange, Russia; Warsaw Stock Exchange, Poland; and XU100- Istanbul Stock Exchange, Turkey.

According to Table 3, obvious increases in dynamic conditional correlations for the pairs of 'the USA - the Czech Republic', 'the USA – Hungary', 'the USA – Poland', 'the USA – Russia', and 'the USA – Turkey' confirm the presence of contagion from the US to all emerging European countries. However, by following Forbes and Rigobon (2002) and Kazi et al. (2011) we apply a Fisher's z-test to investigate whether the differences in estimated time varying correlation coefficients between both the pre-crisis

period and the crisis period; and the crisis period and the full sample period are significant enough to confirm the existence of the contagion.

The results of the Fisher's z-test are reported in Table 4 and Table 5. According to the Table 4, the test statistics fail to reject null of no contagion since *increases* on the correlation coefficients *are not* significant enough to confirm the presence of contagion for overlapping data. Therefore, the Fisher's z-tests show us that the cross market correlation coefficients during the crisis period are not significantly greater than the full sample period for any of the sample countries. As a result of these findings, by using dynamic conditional correlations we are not able to confirm the existence of a contagion effect of the subprime mortgage crisis on any of the emerging European countries.

Table 4: Dynamic Conditional Correlation Coefficients with Overlapping Data and Test Statistics

This table reports unconditional (adjusted) cross-market correlation coefficients for the stock markets of 5 emerging European countries with the US stock market. Test statistics are for examining whether the cross-market correlation coefficient during the crisis (high volatility) period is not significantly greater than during the tranquil (full sample) period. "C" indicates that the test statistic is greater than the critical value and therefore contagion occurred (rejection of null of no contagion). "N" indicates that the test statistic is less than or equal to the critical value and therefore no contagion occurred (failure to reject the null of no contagion).

	Tranquil	***Crisis***	***Test Statistic***	***Contagion?***
Czech Republic	0.23604	0.30378	1.421378	**N**
Hungary	0.23117	0.32155	0.457481	**N**
Poland	0.29552	0.33738	-0.71615	**N**
Russia	0.17192	0.22593	1.146075	**N**
Turkey	0.26904	0.36647	-0.30725	**N**

***Statistical significance at 1% level. **Statistical significance at 5% level. *Statistical significance at 10% level

As Table 3 shows the period averages of dynamic conditional correlations between the US and all of the sample countries during the crisis period are larger than those during the pre-crisis period (non-overlapping data). Therefore, by only looking at the changes (increase) on the correlation

coefficients, it is possible to say that contagion effects are observed for all five emerging European market if non-overlapping data is used for the model. However, we still need to test whether the increases on correlations are significant enough to confirm the presence of contagion as we did for overlapping data analysis.

Table 5 presents the test statistics for non-overlapping data. According to that, examination of the test statistics shows that the stock index returns of the Hungary and Turkey experience *significant* increases in adjusted correlation during the crisis period. On the other hand, increases on the correlation coefficients of the Czech Republic, Poland and Russia are *not significant* to confirm the contagion effect of the subprime mortgage crisis. Therefore, although the overlapping data fails to reject the null of no contagion for all sample countries, by using non-overlapping data, we confirm the existence of the contagion effect of the subprime mortgage crisis from the US to Hungary and Turkey.

Table 5: Dynamic Conditional Correlation Coefficients with Non-overlapping Data and Test Statistics

This table reports unconditional (adjusted) cross-market correlation coefficients for the stock markets of 5 emerging European countries with the US stock market. The test statistics are for examining if the cross-market correlation coefficient during the crisis (high volatility) period is not significantly greater than the pre-crisis (low volatility) period. "C" indicates that the test statistic is greater than the critical value and therefore contagion occurred (rejection of null of no contagion). "N" indicates that the test statistic is less than or equal to the critical value and therefore no contagion occurred (failure to reject the null of no contagion).

	Pre-crisis	***Crisis***	***Test Statistic***	***Contagion?***
Czech Republic	0.20024	0.30378	1.6195	**N**
Hungary	0.13393	0.32155	2.4007**	**C**
Poland	0.25242	0.33738	1.0085	**N**
Russia	0.15479	0.22593	1.1612	**N**
Turkey	0.20820	0.36647	1.7440*	**C**

***Statistical significance at 1% level.

**Statistical significance at 5% level. *Statistical significance at 10% level

Conclusion

In this paper we have followed Forbes and Rigobon (2002, p.2223) and defined the contagion as "a significant increase in cross-market linkages after a shock to one country (or group of countries)". Therefore, to test whether the subprime mortgage crisis spilled over contagiously to the emerging European countries, we have examined the cross-market correlation coefficients between the daily returns of the US stock market and the emerging European stock markets. To investigate whether there were significant increases in the cross-market correlations of emerging European countries with the US during the subprime mortgage crisis, we used the Dynamic Conditional Correlation model that is developed by Engle and Sheppard (2001). Furthermore, as Dungey et al. (2005) claim that overlapping data (the comparison of the cross-market correlations of the crisis period with the full sample period) may cause a bias in results as the length of pre-crisis period directly affects the estimation of full period correlations, we conducted our tests by using both overlapping data as Forbes and Rigobon (2002) suggest and non-overlapping data (the comparison of the cross-market correlations of the pre-crisis period with the crisis period) as Dungey et al. (2005) suggest.

Before we estimated the adjusted cross-market correlations and the dynamic conditional correlations, we simply examined the simple cross-market correlations and confirmed the presence of contagion for all sample countries since the cross-market correlations between the US stock market and the emerging European stock markets considerably increase due to the impact of the crisis. Next, to investigate the presence of the contagion effect, we estimated dynamic correlation framework of five pair-wise models (USA-Czech Republic, USA-Hungary, USA-Poland, USA-Russia, and USA-Turkey) for overlapping data (the tranquil period is specified as the full sample period) and non-overlapping (the tranquil period is specified as the pre-crisis period). After we corrected the bias that occurs due to high volatilities of the stock markets during the crisis period, our findings have shown a totally different picture. The findings of Dynamic Conditional Correlation model with overlapping data failed to reject the null of no contagion for all sample countries as *increases* on the correlation coefficients *are not* significant enough to confirm the presence of contagion for overlapping data. Therefore, the Fisher's z-tests show us that the cross market correlation coefficients during the crisis period are not significantly greater than the full sample period

for any of the sample countries. Non-overlapping data, however, has revealed more moderate results since the Dynamic Conditional Correlation model of Engle and Sheppard (2001) has proven the existence of a contagion effect for Hungary and Turkey. According to that, examination of the test statistics shows that the stock index returns of the Hungary and Turkey experience *significant* increases in adjusted correlation during the crisis period. On the other hand, increases on the correlation coefficients of the Czech Republic, Poland and Russia are *not significant* to confirm the contagion effect of the subprime mortgage crisis.

Although, in this paper, we have proved that although the contagion effect is observed for some emerging European countries, the crises do propagate to emerging European countries due to strong normal day interdependence too, the results have revealed some key implications regarding methodological issues. First of all, we have clearly proven that a high volatility during a crisis period leads to the false rejection of the null of no contagion. The correction of that bias has clearly shown that the subprime mortgage crisis did not actually increase the interdependence of all emerging European countries with the US stock market. However, by using both overlapping and non-overlapping data we have also shown that the construction of the hypothesis directly affects the result of the test regarding the presence of contagion. Accordingly, if one constructs the hypothesis by using overlapping data (crisis period correlations should be higher than full sample period correlations) this may possibly lead to the failure of rejecting the null of no contagion. On the other hand, examining the presence of contagion by using non-overlapping data and comparing the correlations of the pre-crisis period with the correlations of the crisis period provides for a stronger chance to reject the null of no contagion.

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