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THE FINANCIAL CONTAGION EFFECT OF THE SUBPRIME CRISIS ON SELECTED DEVELOPED MARKETS

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Abstract

The purpose of this empirical study is to explore and compare the effects of subprime crisis on some of developed markets (e.g. France, Germany, the United Kingdom and Japan).

The VECM model and Johansen's cointegration approach (1988) have been used to verify the existence of potential short and long run relationships between the United States market, where the subprime crisis has been triggered, and the other markets.

The results indicated that all the markets are cointegrated in the long run and there is long run equilibrium. Dynamic interactions between the developed markets and the US increased during the subprime crisis.

Our results shed light on financial contagion as the element that dramatically spreads the shock to the whole financial system as well as other financial markets. This contagion is a top priority for investors, financial regulators and international organizations whose goal is to improve the global financial regulation system and make it more resistant to shocks.

Keywords: *financial contagion effect; subprime crisis; developed markets, VECM.*

JEL Classification: G15

1. Introduction

Initiated in September 2008 by the bankruptcy of Lehman Brothers, the global financial crisis spread rapidly to almost all emerging and advanced economies by contagion effect. Financial contagion refers to "the spread of market disturbances – mostly on the downside – from one country to the other, a process observed through co-movements in exchange rates, stock prices, sovereign spreads, and capital flows". [Dornbusch *et al.*, 2000] Trade links, competitive devaluations, and financial links are the most fundamental causes of financial contagion. Trade links in goods and services and exposure to a common creditor can explain earlier crises clusters, not only the debt crisis of the early 1980s and 1990s, but also the observed historical pattern of contagion. [Kaminsky & Reinhart, 2000] Any major trading partner of a country in which a financial crisis has induced a sharp current depreciation could then experience declining asset prices and large capital outflows or could become the target of a speculative attack as investors anticipate a decline in exports to the crisis country and hence a deterioration in the trade account. Also known as a currency war, Competitive devaluation is when multiple countries compete against one another to gain a competitive advantage by having low exchange rates for their currency. "Devaluation in a country hit by a crisis reduces the export competitiveness of the countries with which it competes in third markets, putting pressure on the currencies of other countries; especially when those currencies do not float freely." [Dornbusch *et al.*, 2000] This action causes countries to act irrationally due to fear and doubt. "If market participants expect that a currency crisis will lead to a game of competitive devaluation, they will naturally sell their holdings of securities of other countries, curtail their lending, or refuse to roll over short-term loans to borrowers in those countries." [Dornbusch *et al.*, 2000] Financial links come from financial globalization since countries try to be more economically integrated with global financial markets. Allen and Gale (2000) and Lagunoff and Schreft (2001) analyse financial contagion as a result of linkages among financial intermediaries. The former explained a small liquidity preference shock in one region can spread by contagion throughout the economy and the possibility of contagion depends strongly on the completeness of the structure of interregional claims. The latter explained interrelated portfolios and payment commitments forge financial linkages among agents and thus make two related types of the financial crisis can occur in response.

The crisis had severe, long-lasting consequences for the US which entered a deep recession, with nearly 9 million jobs lost during 2008 and 2009, roughly 6% of the workforce. The number of jobs did not return to the December 2007 pre-crisis peak until May 2014 [U.S Bureau of Labour Statistics, 2018]. Household net worth declined by nearly $13 trillion (20%) from its Q2 2007 pre-crisis peak, recovering by Q4 2012 [US Board of Governors of the Federal Reserve System, 2018]. Housing prices fell nearly 30% on average and the US stock market fell approximately 50% by early 2009, with stocks regaining their December 2007 level during September 2012 [S&P Dow Jones Indices LLC]. One estimate of lost output and income from the crisis comes to "at least 40% of 2007 gross domestic product" [Simon, 2013].

Financial crisis has hit the European Union in early 2008 and had non-negligible repercussions due to substantial purchases of subprime securities by European banks and financial institutions. Those repercussions occurred in two stages. In the first one, the EU has faced the economic recession, following the global economic downturn. In this stage, the macroeconomic indicators have modified significantly both at EU level and in the individual countries: the real GDP dropped, the unemployment rate of the euro area increased, budget deficits exceeded the limit of 3% of GDP and public debts exceeded 60% of the GDP. In the second one, the EU has faced the sovereign debt crisis that firstly began in Greece [Yurtsever, 2011]. Due to the global financial shock, in late 2009, a number of countries announced increases in deficit/GDP ratios, among these Greece announcing a deficit forecast of 12.7% of GDP for 2009. From this point on, the sovereign debt crisis enhanced. Consequently, Greece was shut out of the bond market in May 2010. In 2011, GDP shrunk by a further 6.8%, leaving total economic output now 16% below the pre-crisis peak in 2011. Greece's economy declined further in 2012, by an estimated 4.4%. In this year, this country entered its 5th year of recession. Also, Spain and Cyprus sought official funding in 2012. Germany's industrial output was down 2.4 per cent in May, the fastest rate for a decade. Orders have fallen for six months in a row, the worst run since the early 1990s. The German Chamber of Industry and Commerce warned of up to 200,000 job losses in coming months. German retails sales fell 1.4 per cent in June more than any expectations. The German economy declined by 0.5 per cent in the second quarter. France too saw a decline in its economy in the second quarter by 0.3 per cent to fell into recession in the first quarter of 2009. The economy of the United Kingdom has also been hit by the credit crisis. The economic output increased by just 0.2 per cent in the second quarter 2008, the joint-slowest pace since 2001. The mortgage approvals fell by a record of nearly 70 per cent. Growth in the British economy was at zero, the worst since the second quarter of 1992. The current slowdown has ended 16 years of continuous economic growth, the longest period of economic expansion in Britain since the 19th century. Unemployment increased by 32,500 in August 2008 to reach 904,900. Between May and July, joblessness rose by 81,000 to reach 1.72 million, the largest increase since 1999.

Our empirical research deals with the process of contagion in selected capital markets during 2005 to 2015. We examine the existence of a contagion effect from the USA to four developed markets (France, Germany, the United Kingdom and Japan) which will be measured by increased linkages between these markets. The values of stock market indexes provide the most concise information about the situation in the different capitals markets. In the aggregate equity market indexes, the contagion effect from the US can explain a large portion of the variance in stock returns in such markets. So we verify if the interdependencies of these markets with the US are important and sensitive during the period of crisis.

This paper is thus organized as follow: we present in first a literature review. Next we present our data sources and we introduce our methodology, after, we present and we discuss our empirical results, we present in the end our conclusion.

2. *Literature Review*

Without a doubt, financial market contagion is an issue of enormous interest in the finance literature. The first empirical study on financial contagion was given by King and Wadhwani (1990). This study defined the contagion as significant increase in correlation between asset returns during the stock market crash of October 1987. Using correlation analysis, Lee and Kim (1993) found evidence of contagion in the global stock markets after the 1987 US stock market crash.

Baig and Goldfajn (1998) investigated the contagion effect from the Asian crisis. They consider the presence of contagion between equity and currency markets during the Asian currency crisis on Thailand, Malaysia, Indonesia, South Korea and the

Philippines. During the Asian crisis too, Kaminsky and Schmukler (1999) concluded that movements were triggered by local and neighbouring countries and that news about agreements with international organizations and credit rating agencies have the most weight.

Baig and Goldfajn (2000) examined whether there was contagion during the Russian crisis with regard to Brazil and concluded that contagion occurred and that the mechanism of propagation was the debt securities market. They also noted the sudden halt in capital flows to Brazil and Russia.

Ang and Bekaert (2001) and Longin and Solnik (2001) showed that cross-correlations of international equity markets are higher during periods of volatility, which is true for major events such as financial crises. One year later, Sola *et al.* (2002) tested the contagion effects during the emerging market currency crises and have found evidence of contagion from the South Korean crisis to Thailand but not to Brazil. However, with Forbes and Rigobon (2002), Pearson's correlation coefficients were conditional on market volatility, and therefore, their increase in turbulent periods does not necessarily indicate that contagion existed. In the presence of heteroscedasticity, for instance, linear correlation between markets may increase after a crisis, even when there is no increment in the underlying links, thus leading to biased conclusions.

Rigobon (2003) tests contagion during Mexican, Asian and Russian crises. For the Mexican crisis, the mechanism for the transmission of crises remained relatively constant, providing evidence of interdependence. At the same time, evidence of a structural breakdown existed for the Russian crisis and particularly for the Asian crisis. Caporale *et al.* (2003) also conclude that there was evidence of contagion during the Asian crisis. In 2003 too, Bae *et al.* noted that contagion was more serious in Latin America than in Asia; contagion from Latin America to other regions was more important than that in Asia; the United States was not contaminated by the Asian crisis; and contagion is predictable and subject to prior information. However, Khalid and Kawai (2003) did not find any evidence to strongly support contagion.

Fernandez-Izquierdo and Lafuente (2004)'s empirical results tended to support the contagion hypothesis, i.e., significant leverage effects are the result of negative shocks within the market itself and foreign negative shocks. Alper and Yilmaz (2004) presented an empirical analysis of real stock return volatility contagion on the Istanbul Stock Exchange (ISE) from emerging markets and produced evidence of a volatility contagion from financial centres, particularly on the aftermath of the Asian crisis to the ISE.

Collins and Gavron (2005) studied 44 events of contagion in 42 countries and find that the Brazilian and Argentinean crisis generated most of the contagion events. However, Bekaert *et al.* (2005) produced no evidence that the Mexican crisis caused contagion. Boschi (2005) too was unable to provide evidence of contagion between Argentina and Brazil, Venezuela, Uruguay, Mexico and Russia. Trivedi and Zimmer (2005) suggested that, of the 18 analysed countries, only Croatia and Romania exhibited significant evidence of contagion. Testing the contagion effect between Hong Kong, the ten emerging nations and the G7 countries Corsetti *et al.* (2005) suggested that five of the seventeen countries showed symptoms of contagion.

Cappiello *et al.* (2006) also concluded that, during periods of financial turmoil, equity market volatilities show important linkages and conditional equity correlations among regional groups increase dramatically. In the same year, Khalid and Rajaguru (2006) note that linkages and/or interdependence amongst financial markets increase because of a financial crisis and Hu (2006) found that, although it is not possible to assess how two markets are related in volatile periods using simple correlation coefficients, as they only measure the level of dependence, with copula models it is possible to study both the level and the structure of dependence.

Chiang *et al.* (2007) revealed the contagion effect in Asian markets and have identified two phases (contagion and herding behaviour of correlation) of correlation amongst these markets. Sovereign credit rating agencies have played a vital role in shaping the structure of dynamic correlation in the Asian markets.

Lucey and Voronkova (2008) found that in the long run the Russian equity market remained isolated from the influence of several developed international markets as well as the equity markets of Hungary, the Czech Republic and Poland, before and after the 1998 crisis.

Horta *et al.* (2008) assess whether capital markets of developed countries reflect the effects of financial contagion from the US subprime crisis and, in such case, if the intensity of contagion differs across countries. The results suggest that markets in Canada, Japan, Italy, France and the United Kingdom display significant levels of contagion, which are less relevant in Germany. Canada appears to be the country where the highest intensity of contagion is observed.

Meric *et al.* (2008) show that during the GFC, integration has increased between the US stock market and the European and Australian developed stock markets and that the US stock returns led European and Australian stock returns with a high level of statistical significance.

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Abd Majid and Hj Kassim (2009) noted that emerging stock markets in Indonesia and Malaysia tend to show a greater degree of integration or increased co-movements with US stock market during the a crisis period. However, in the early stages of GFC (from January 2007 to the summer of 2008), it shows that emerging markets are isolated and differentiated from developments in the US.

Huyghebaert and Wang (2010) revealed that the relationships among East Asian stock markets were time-varying while stock market interactions were limited before the Asian financial crisis started. Longstaff (2010) presents strong recent evidence of contagion in the financial markets. His results support the hypothesis that financial contagion was propagated primarily through liquidity and risk-premium channels rather than through a correlated information channel.

Syllignakis and Kouretas (2011) provided evidence that the stock markets of the Central and Eastern European countries were partially integrated with the developed stock markets of the US and Germany. Moreover, there were strong contagion effects among the US, German, Russian and Central and Eastern European (CEE) stock markets. Aloui *et al.* (2011) found evidence of strong co-movement between the BRIC markets and the US market during the crisis period. The magnitude of contagion effects is more in the cases of Brazil and Russia compared to emerging markets, like China and India. In 2011 too, Kenourgios et al confirmed the contagion effects of five different financial crises during 1997–2002 on BRIC, US and U.K. stock markets, while the emerging stock markets have greater financial contagion effects. Their study was, however, unlikely to cover the global financial crisis of 2008. Chudik and Fratzscher (2011) study twenty-six economies (defining the Euro area as a single economy and excluding China) and found that the tightening of financial conditions was the key transmission channel in advanced economies, whereas the real side of the economy was the main channel in emerging economies. Another conclusion of their paper is that Europe suffered a greater effect than other advanced economies from the decline in risk appetite. Coudert *et al.* (2011) found that contagion spread from one to other neighbouring emerging countries' foreign exchange markets during a global crisis. The empirical results are inconclusive.

Graham *et al.* (2012) revealed a low degree of co-movement between the US and the 22 individual emerging markets and that the degree of stock market integration was changing over time. Lin (2012) revealed that the Asian emerging markets have strong co-movement between exchange rates and stock prices during crisis periods.

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Gharsellaoui (2013) showed that the Tunisian financial market does not seem to be very influenced by the subprime crisis and explained this result by the intrinsic characteristics of the Tunisian market, an underdeveloped market and elemental thing that can make him more or less immune to that crisis. Employing a multivariate GARCH model for four major, international equity markets, namely the USA, EMU, China and Japan Dimitriou and Simos (2013) provided empirical evidence of contagion in all markets with the US market through various channels, which have not been discussed in other related studies. Specifically, Japanese and EMU markets have been directly affected from the crisis. However, while China's equity market has been mainly unaffected by the US subprime crisis, it has been affected indirectly through Japan. Moreover, the Japanese equity market exhibits positive and significant spillovers effects with China and EMU, revealing an indirect volatility transmission channel of US subprime crisis.

Mollah *et al.* (2014) demonstrated the existence of contagion in the financial markets during the global crisis. However, the crisis originated in the US and its effects escalated immediately to the other global markets. In the same year and in their comprehensive study of 58 countries, Morales and Andreosso-O'Callaghan (2014) documented that there are no significant contagion effects derived from the US stock markets, either at world level and or at a regional level. Moreover, there was a spillover effect of the US subprime crisis on selected markets rather than contagion to most of the countries. Dungey and Gajurel (2014) provided strong evidence of contagion effects on both emerging as well as on advanced equity markets. For financial sector indices, however, the results are slightly different. Particularly in the case of advanced markets, there is a weak indication of contagion in the aggregate indices. However, Bekaert *et al.* (2014) recognized the small effect of contagion from the US market to the global financial sector during the crisis, and it did not spread extensively across countries and sectors. Further, they found that the countries suffering from high unemployment, great political risk and a huge deficit in both the government budget and current account balance experienced a high magnitude of contagion.

Horta *et al.* (2014) investigated contagion effects of both USA financial crisis and European sovereign debt crisis in the stock markets of Belgium, France, Greece, Japan, Netherlands, Portugal and the UK. The authors first assessed these markets' efficiency and subsequently using copula models to investigate their dependence structures. The results suggested that there was significant contagion from both crises, with the former displaying more prominent effects.

Bae and Zhang (2015) exposed that stock market integration was evident only in emerging countries in the financial crises of 1997 and 2008. Syriopoulos *et al.* (2015) on BRICS economies also confirmed the evidence for volatility and shock spillover between India, Russia, Brazil and the US stock markets and business sectors during the 2008 financial crisis. Daugherty and Jithendranathan (2015) concluded that the European markets received more information flows from USA markets and that integration increased with the financial crisis but not with the European debt crisis.

Using cointegration and Granger causality tests to examine contagion risk associated to the subprime crisis, Boubaker *et al.* (2016) found evidence of contagion in both developed (Canada, France, Germany, Japan, UK), and emerging markets (Brazil, Russia, China, Malaysia and Singapore). The study of Yarovaya and Lau (2016) indicated that the Chinese stock market is the most attractive option for UK investors.

Jiang *et al.* (2017) noted that the correlation of stock markets between the US, Britain, Germany, Japan and Hong Kong increases markedly after the crisis, while it exhibits a reverse trend with the Chinese stock market. Olbry's and Majewska (2017) found that the correlation between USA-S&P500 and France-CAC, and UK-FTSE and Germany DAX markets increased during the 2008 crisis period compared to the pre-crisis period. Turk *et al.* (2017) found that during the GFC period, 27 European countries were subject to a contagion effect due to integration with the United States and there was no decoupling. One year after, Sosa Castro *et al.* (2018) analysed the contagion effect among the stock markets of the BRIC+M block (Brazil, Russia, India, China plus Mexico). The contagion effect is proved through increases on dependence parameters during crisis periods. Empirical results show strong evidence of time-varying dependence among those markets and an increasing dependence relation during the global financial crisis period.

Mohti *et al.* (2019) assesses contagion from the USA subprime financial crisis on a large set of frontier stock markets. Copula models were used to investigate the structure of dependence between frontier markets and the USA, before and after the occurrence of the crisis. Statistically significant evidence of contagion could only be found in the European region, with the markets of Croatia and Romania being affected. The remaining European markets in our sample and the others, located in America, Middle East, Africa, and Asia, appear to have been isolated from the subprime crisis impact. Gulzar *et al.* (2019) examined the financial cointegration and spillover effect of the global financial crisis to emerging Asian financial markets

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(India, China, Pakistan, Malaysia, Russia and Korea). The analysis used daily stock returns, divided into three time periods: pre-, during and post-crisis from 1 July 2005 to 30 June 2015. Applying the Johansen and Juselius cointegration test, the vector error correction model (VECM) and the G.A.R.C.H.-B.E.K.K. model for an examination of integration and conditional volatility, authors found long-term cointegration between the US market and emerging stock markets, and the level of cointegration increased after the crisis period. The VECM and impulse response function reveal that a shock in the US financial market has a short-term impact on the returns of emerging financial markets. Past shocks and volatility have more effect on the selected stock markets during all time periods. The Korea Composite Stock Price Index and the Bombay stock exchange (B.S.E.) are the only stock markets that have cross-market news and volatility spillover effects during the crisis period. After the crisis period, news effects are positive on the B.S.E. and the Russian Trading System and have a negative effect on the Kuala Lumpur Stock Exchange and the Shanghai Stock Exchange.

3. ***Methodology***

We investigate the correlations between the daily returns of the USA stock index and four developed financial markets returns and we study if the co-movements between the USA and other stock markets are statistically significant. It is clear that when we analyse linkages among international stock markets, it is of interest to determine if there are any common forces driving the long-run movement of the data series or if each individual stock index is driven solely by its own fundamentals; this relationship can be captured by cointegration analysis. We start to use the cointegration test to measure the relationships between different markets. The idea behind this cointegration is that multivariate time series are integrated.

3.1. **Cointegration approach**

Testing cointegration among stock markets is a test of the level of arbitrage activity in the long run. If markets are not cointegrated, this implies that there is no arbitrage activity to bring the market together in the long run, and hence, the investors can potentially obtain long-run gains through portfolio diversification. If the cointegration is found, this means even if a set of variables are non-stationary, they never drift apart in the long run.

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So when cointegration exists, the variables are cointegrated and the Error Correction Term (ECT) has to be included in the VAR. The model becomes a VECM which can be seen as a restricted VAR. The variance decomposition and impulses analysis must be constructed on the ECMs. If there is no cointegration, then the analyses will be based on the regression of first differences of the variables by utilizing a standard VAR framework.

The notion of cointegration makes it possible to demonstrate stable long-term relationships between stationary series. This concept reproduces the existence of a long-term equilibrium and the error term at time *t* can be interpreted as a distance to the period *t* with respect to this equilibrium. The cointegration relation is an equilibrium relation between series in a balanced growth regime but shocks can affect this short-term relationship in order to have temporary effects. The problem consists therefore in determining if the series are cointegrated and then to estimate the short- and long-term relationships between the variables. It is clear that when the number of series is greater than 2, then it is possible to obtain integrated series of different order which are cointegrated. In general, let N be the number of series, there may exist N-1 linearly independent cointegrating vectors and thus N-1 cointegration relations which govern the joint evolution of the variables. When the number of variables exceeds 2, the Engel and Granger approach becomes insufficient because it considers only a cointegration relation. We use in this case the VAR approach developed by Johansen to carry out the cointegration tests and to construct a VECM with several equations. Using multivariate cointegration approach and VECM, we investigated the dynamic linkages among the US market and four developed markets (countries are: France, Germany, the UK, and Japan). Prior to estimating VAR model specified above, we start our analysis by testing for stationarity using both the Augmented Dickey Fuller (ADF) Unit Root test and the Phillips-Perron (PP) Unit Root test. The Unit Root tests are conducted in first, to examine the stationary property of each series.

3.2. **The VAR model**

To examine how American financial market had affected the all of the other developed markets during and post the global financial crisis and to demonstrate how the spillovers of a crisis are transmitted within the markets, we explore the relationships of these markets within a VAR framework.

The application of the VAR model proposed by Forbes and Rigobon (2002) allows us to directly examine whether links between markets in times of crisis, differ from those in periods of calm.

Our VAR models can be written as:

$$R\_FR_t = c_1 + \sum_{i=1}^{p} \alpha_{1,i}.R\_FR_{t-i} + \sum_{j=0}^{p} \beta_{1,j}.R\_US_{t-j} + \varepsilon_{1,t} \quad (1)$$

$$R\_GE_t = c_2 + \sum_{i=1}^{q} \alpha_{2,i}.R\_GE_{t-i} + \sum_{j=0}^{q} \beta_{2,j}.R\_US_{t-j} + \varepsilon_{2,t} \quad (2)$$

$$R\_UK_t = c_3 + \sum_{i=1}^{r} \alpha_{3,i}.R\_UK_{t-i} + \sum_{j=0}^{r} \beta_{3,j}.R\_US_{t-j} + \varepsilon_{3,t} \quad (3)$$

$$R\_JP_t = c_4 + \sum_{i=1}^{s} \alpha_{4,i}.R\_JP_{t-i} + \sum_{j=0}^{s} \beta_{4,j}.R\_US_{t-j} + \varepsilon_{4,t} \quad (4)$$

Before running the Johansen test, the selection of lag length and the identification of deterministic components should be done first. To select the optimal lag length, two methods are generally applied. One way is a likelihood ratio test, and the other is the information criteria, such Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC). The best model is the one that maximize LR, or minimize the information criteria. Compared with the LR ratio test, the information criteria method is more powerful.

To test whether the variables are cointegrated or not, one of the well-known tests is the Johansen trace test. The Johansen test is used to test for the existence of cointegration and is based on the estimation of the ECM by the maximum likelihood, under various assumptions about the trend or intercepting parameters, and the number k of cointegrating vectors, and then conducting likelihood ratio tests.

3.3. **The Johansen tests**

The Johansen tests are called the maximum Eigen value test and the trace test. The Johansen tests are likelihood-ratio tests.

The Johansen cointegration proposed two test statistics through the VAR model that are used to identify the number of cointegrating vectors, namely, the trace test statistic and the maximum Eigen value test statistic. So there are two tests: The

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maximum Eigen value test, and the trace test. For both test statistics, the initial Johansen test is a test of the null hypothesis of no cointegration against the alternative of cointegration.

These test statistics can be constructed as:

$$\lambda_{trace}(r) = -T.\sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i^2) \tag{5}$$

$$\lambda_{\max}(r, r+1) = -T.\ln(1-\hat{\lambda}_{r+1}^2) \tag{6}$$

where are the Eigen values obtained the λ_{trace} tests the null that there are at most *r* cointegrating vectors, against the alternative that the number of cointegrating vectors is greater than *r* and the $\lambda_{\max}$ tests the null that the number of cointegrating vectors is r, against the alternative of r + 1. Critical values for the λ_{trace} and $\lambda_{\max}$ statistics are provided by MacKinnon-Haug-Michelis of MacKinnon *et al.* (1999).

If the cointegration relation exists between our series, the VECM will be used to identify the equilibrium or a long-run relationship among the variables, and can also improve longer term forecasting. Johansen (1988)'s cointegration test will be used to investigate the long-run relationship between the variables. Besides, the causal nexus between United States and selected developed stock markets will be investigated by estimating the following VECM Johansen (1988) and Johansen and Juselius (1990).

3.4. **Vector Error Correction Model: VECM**

The estimation of the VECM yields insight into short- and long-run linkages between our different markets. This model is useful for determining short term dynamics between variables by restricting long-run behaviour of variables. It restricts long run relationships through their cointegrating relations and ECT which represented the deviation from long run equilibrium.

In a VECM, short-term causal effects are indicated by changes in other differenced explanatory variables. The long-term relationship is implied by the level of disequilibrium in the cointegration relationship. That is, the lagged ECT.

If the cointegration relation exists between ours series, so the corresponding VECM form with the cointegration rank could be constructed as:

$$\Delta R\_FR_t = c_1 + \phi_1.R\_FR_{t-1} + \gamma_1.R\_US_{t-1} + \sum_{i=1}^{p} \alpha_{1,i}.\Delta R\_FR_{t-i} + \sum_{j=0}^{p} \beta_{1,j}.\Delta R\_US_{t-j} + \lambda_1 ECT_{t-1} + \varepsilon_{1,t} \quad (7)$$

$$\Delta R\_GE_t = c_2 + \phi_2.R\_GE_{t-1} + \gamma_2.R\_US_{t-1} + \sum_{i=1}^{q} \alpha_{2,i}.\Delta R\_GE_{t-i} + \sum_{j=0}^{q} \beta_{2,j}.\Delta R\_US_{t-j} + \lambda_2 ECT_{t-1} + \varepsilon_{2,t} \quad (8)$$

$$\Delta R\_UK_t = c_3 + \phi_3.R\_UK_{t-1} + \gamma_3.R\_US_{t-1} + \sum_{i=1}^{r} \alpha_{3,i}.\Delta R\_UK_{t-i} + \sum_{j=0}^{r} \beta_{3,j}.\Delta R\_US_{t-j} + \lambda_3 ECT_{t-1} + \varepsilon_{3,t} \quad (9)$$

$$\Delta R\_JP_t = c_4 + \phi_4.R\_JP_{t-1} + \gamma_4.R\_US_{t-1} + \sum_{i=1}^{s} \alpha_{4,i}.\Delta R\_JP_{t-i} + \sum_{j=0}^{s} \beta_{4,j}.\Delta R\_US_{t-j} + \lambda_4 ECT_{t-1} + \varepsilon_{4,t} \quad (10)$$

Since we deal with the stock market cointegration, it is of special interest to know how one market responds to innovations in a complex system. The cointegration test measures the relationships between different markets in the long-run while the other two tests (variance decomposition and impulses analysis) are utilized to examine the short-run aspects. Thus and in order to show the interactions between the equations, variance decompositions analysis would be applied. We generally just regard variance decomposition as a confirmation of impulse responses

3.5. **Impulse Response Function**

For dealing with dynamic systems, impulse response analysis has now become a common tool. Impulse response functions allow tracing out the direct and the indirect effect of an exogenous shock, or an impulse, in one variable to the system over time. This function investigates the time horizon of variables and their response for any sudden shock in any variable in the model with time which passes.

An impulse response function traces both direct and indirect effects of a shock to one variable on current and future values of all of the endogenous variables in the VAR model.

3.6. **Variance Decomposition Test**

Sometimes there are sudden shocks that affect variables. Thus we use in this case variance decomposition analysis to analyse the error in the evaluation process that is resulted from other variables in the VECM model. Therefore, we used this test in our study in order to assess to what extent shocks to developed markets (French–German–The UK–Japanese) are explained by the US market. Meaning, it

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tends to show the percentage of forecast error variance for each of the selected index that may be attribute to its own shocks and to fluctuations in S&P500 index.

4. ***Empirical Results***

In the first step we investigate the data of developed markets (France, Germany, the UK and Japan).

Table 1. Data Description

Database (data description)		**Period (daily data)**
R_US:	Return of S&P 500 Index of the US market	
R_FR:	Return of CAC 40 Index of the French market	From **April 01, 2005**
R_GE:	Return of DAX Index of the German market	to **December 31, 2015**
R_UK	Return of FTSE 100 Index of the UK market	
R_JP:	Return of Nikkei 225 Index of the Japan market	(2805 observations)

Table 2. Descriptive Statistics

	R_US	R_FR	R_GE	R_UK	R_JP
Mean	-0.000142	7.54E-05	-0.000204	1.81E-05	-9.14E-05
Median	-0.000658	-0.000261	-0.000762	0.000000	-0.000364
Maximum	0.099324	0.099346	0.077167	0.097073	0.128749
Minimum	-0.103782	-0.100527	-0.102350	-0.089574	-0.123962
Std. Dev.	0.012619	0.014535	0.013982	0.011986	0.015470
Skewness	0.576406	0.135387	0.163972	0.332503	0.778702
Kurtosis	14.05593	8.903404	8.835084	11.33959	11.74920
Jarque-Bera	14441.38	4081.683	3991.954	8180.191	9230.089
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	-0.397770	0.211528	-0.572555	0.050903	-0.256494
Sum Sq. Dev.	0.446542	0.592426	0.548202	0.402804	0.671041
Observations	2805	2805	2805	2805	2805

We use daily data for the following series and we generate returns for S&P 500 index of the US market, for the CAC 40 index of the French market, for the DAX

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index of the German market, for FTSE 100 index of the UK market, and for Nikkei 225 index of the Japan market. The daily series returns are calculated by taking the natural logarithm of daily prices of each index from April 01, 2005 to December 31, 2015 (Table 1).

We then analyse the summary of descriptive statistics of the variable, so Table 2 presents the results where sample, means, standard deviation, skewness and kurtosis, and the Jacque-Bera statistic and p-values have been reported.

We also report in the following table the descriptive statistics of daily return of all indexes.

The results indicate that over the sample period, all the series evidence such as the skewness and the kurtosis are significant. The Jarque–Bera tests show that all five series depart from normality.

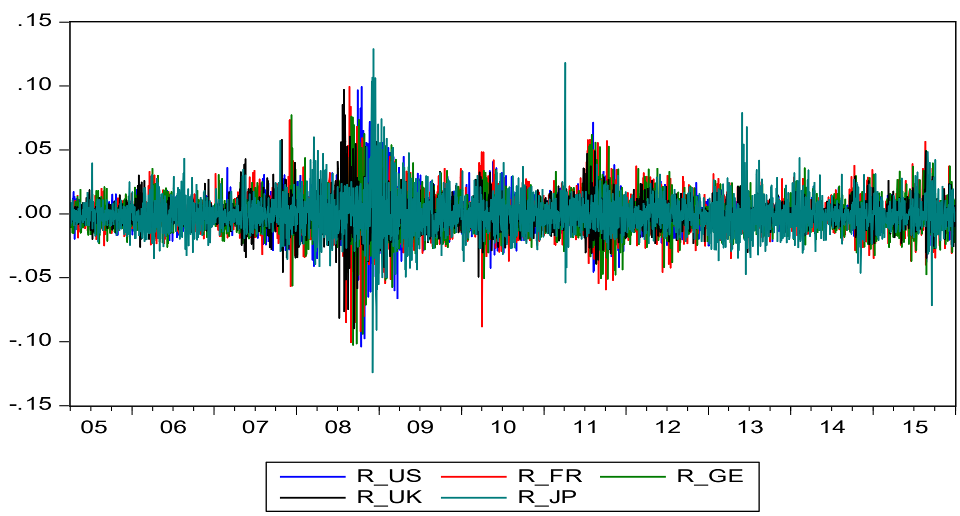

Fig. 1. Single Graph of Indexes Returns (April 01, 2005 - December 31, 2015)

We observe in one Figure and separately the distributions of daily returns of all indexes (Fig. 2 and Fig. 3).

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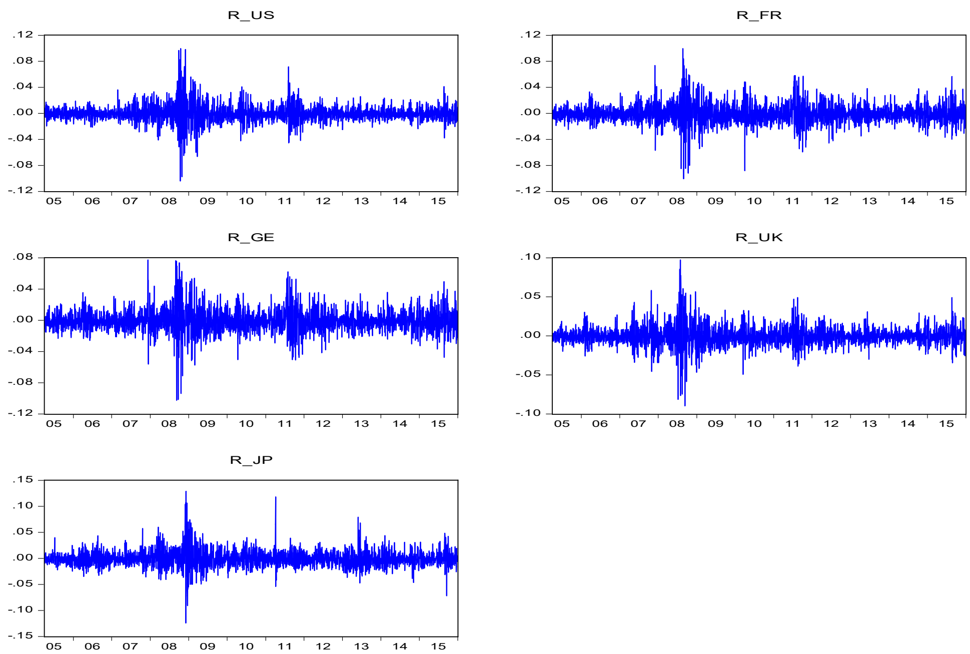

Fig. 2. Multiple Graphs of Indexes Returns (April 01, 2005 - December 31, 2015)

Prior to identifying the possibility of long-term relations of our series, we present the stationarity results for all the variables, based upon the Augmented Dickey–Fuller unit root test as well as the Phillips–Perron test, which corrects any possible presence of autocorrelation in the standard ADF test, in a non-parametric way.

We have applied the ADF and PP unit root tests to examine the integrating properties of the variables.

The results of the two tests reported in Table 3 reveal that all series appear to have the absence of unit root in their levels, while they are also stationary in their first differences form. Thus, we conclude that all variables are integrated at the level, i.e. I(0).

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Table 3. Unit root tests results

		R_US	R_FR	R_GE	R_UK	R_JP
Augmented Dickey–Fuller	Level	-57.33157* (0.0001)	-33.49702* (0.0000)	-51.65105* (0.0001)	-54.02786* (0.0001)	-53.49795* (0.0001)
	Δ	-93.18763* (0.0001)	-23.54484* (0.0000)	-19.20442* (0.0000)	-20.43169* (0.0000)	-20.88665* (0.0000)
Phillips–Perron	Level	-57.54819* (0.0001)	-53.76839* (0.0001)	-51.66568* (0.0001)	-54.19887* (0.0001)	-53.50634* (0.0001)
	Δ	-645.1136* (0.0001)	-549.4632* (0.0001)	-820.8641* (0.0001)	-648.2722* (0.0001)	-994.5288* (0.0001)

Δ is the first difference term. The optimal lag length stands for the lag level that maximizes the Schwarz Information Criteria (SIC). P-values are in parentheses.*indicates significance at the 1% level.

The results of stationarity tests confirm that return of all indexes are stationary and don't seem to follow a random walk. They do interact with each other and have stationary equilibrium relationship which assures that the indexes never drift too far apart. This is presuming that all series are co integrated in same order and it exist a cointegration relationship between ours series. The Johansen cointegration technique is used in this study to detect the presence of cointegration among the variables studied. The results of cointegration were reported in Table 5.

Thus to examine how financial crisis had affected the all of the markets, and to demonstrate how the spillovers of a crisis are transmitted within markets we explore the relationships of these markets within VAR framework. We can also consider the estimation of a VECM model. To do this, the number of delay p of the model VAR (p) must be first determined using the information criterion.

The significance of the model coefficients (i.e. interactions between the variables) is affected in our work by many factors such as the lag length selected and the number of variables included in the appropriate lag lengths and that are determined by the information criteria, such AIC (Akaike Information Criterion), LR (sequential modified LR test statistic), FPE (Final Prediction Error), HQ

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(Hannan Quinn information criterion) and SIC (Swhartz Information Criterion). However, it is worth mentioning that the VAR estimation output indicates that the model has relatively good statistical properties.

Table 4. Choice of Optimal Lag

VAR Lag Order Selection Criteria (max lag 13)
Sample: 04/01/2005 12/31/2015
Included observations: 2795

	Max (LR)	Min (FPE)	Min (AIC)	Min (SIC)	Min (HQ)
R_FR = *f*(R_US)	8	8	8	0	3
R_GE = *f*(R_US)	10	10	10	0	2
R_UK = *f*(R_US)	11	5	5	0	2
R_JP = *f*(R_US)	12	12	12	0	2

LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SIC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The results presented in Table 4, LR, FPE and AIC suggest VAR models with different lag length, the appropriate lag length is 8 for the French market, 10 for the German market, 5 for the UK market, and 12 for the Japanese market.

The Johansen (1988)'s setup permits the test of hypotheses about the long-run equilibrium between the variables. The results of cointegration were reported in Table 5.

The Johansen (1988)'s test can detect the presence of cointegrations among the variables studied; this test is based on the calculation of the trace statistic and maximum Eigen value. Returning to the Table 5, the trace statistics are very high with an almost zero probability. Trace and maximum Eigen value indicate the presence of cointegrating between the variables of the 4 models at 5% significant level.

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Table 5. Johansen Cointegration Test

Unrestricted Cointegration Rank Test (Trace)					
	Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob.****
R_FR = *f*(R_US)	None *	0.112665	659.6401	15.49471	0.0001
	At most 1 *	0.109872	325.4275	3.841466	0.0000
R_GE = *f*(R_US)	None *	0.084326	470.6678	15.49471	0.0001
	At most 1 *	0.077217	224.5296	3.841466	0.0000
R_UK = *f*(R_US)	None *	0.163809	958.3953	15.49471	0.0001
	At most 1 *	0.150841	457.6606	3.841466	0.0000
R_JP = *f*(R_US)	None *	0.081553	405.5202	15.49471	0.0001
	At most 1 *	0.058398	168.0018	3.841466	0.0000

Trace test indicates 2 cointegrating eqn (s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

This implies that there is a well-defined long-run equilibrium relationship among the major stock markets, which suggests the stock market indexes move together and have high correlation in the long-run. The cointegration relationships between stocks markets imply that there is a common force, such as arbitrage activity which brings the stock markets together in the long run. We therefore deduce the existence of cointegrations relationship and we pass from VAR model to the VECM model.

Let we remember that if the variables are cointegrated, the ECT has to be included in the VAR. The model becomes a VECM which can be seen as a restricted VAR. But if the variables are not cointegrated, the variables have first to be differenced in times and have a VAR in difference.

In addition, having found two statistically significant cointegration tests, this specification corresponds to the results from the maximum Eigen value test which only founded 2 significant cointegrating vectors.

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The cointegration relationship exists between our series, so we proceed to our investigation by estimating a VECM model for each set of variables to report the corresponding equation of each VECM associated with the particular stock price index presented in the above equations (1-4).

Table 6.1. VECM Estimation Results of France

	ΔR_FR				**Cointegrating Eq:**	
Regressors	**Coefficients**	**t-ratio**			**Coefficients**	**t-ratio**
ΔR_FR(-1)	-0.798802	-26.1581*		*R_FR(-1)*	1.000000	
ΔR_FR(-2)	-0.714494	-21.6621*		*R_US(-1)*	-2.854769	-17.8846*
ΔR_FR(-3)	-0.665493	-19.6590*		*Constant*	-0.000484	
ΔR_FR(-4)	-0.512793	-15.1298*				
ΔR_FR(-5)	-0.461276	-14.1331*				
ΔR_FR(-6)	-0.337392	-11.2957*		*ECT*	-0.099790	-3.8312*
ΔR_FR(-7)	-0.185101	-7.19590*				
ΔR_FR(-8)	-0.089703	-4.69324*		R^2	0.459968	
				F	139.1845*	
ΔR_US(-1)	-0.295380	-4.21348*				
ΔR_US(-2)	-0.267698	-4.10940*				
ΔR_US(-3)	-0.264750	-4.41886*				
ΔR_US(-4)	-0.226183	-4.15318*				
ΔR_US(-5)	-0.158836	-3.26391*				
ΔR_US(-6)	-0.041731	-0.99255				
ΔR_US(-7)	-0.006159	-0.18401				
ΔR_US(-8)	-0.018470	-0.80588				
Constant	2.45E-06	0.00850				

* and ** denote the significance at 1% and 5% levels, respectively; DW indicates Durbin-Watson statistic.

Table 6.2. VECM Estimation Results of Germany

	ΔR_GE				Cointegrating Eq:	
Regressors	**Coefficients**	**t-ratio**			**Coefficients**	**t-ratio**
ΔR_GE(-1)	-0.555613	-12.5797*		*R_GE(-1)*	1.000000	
ΔR_ GE(-2)	-0.536267	-12.2461*		*R_US(-1)*	-1.645075	-14.0131*
ΔR_ GE(-3)	-0.511517	-11.8834*		*Constant*	-4.76E-05	
ΔR_GE(-4)	-0.427253	-10.2029*				
ΔR_GE(-5)	-0.397145	-9.91481*				
ΔR_GE(-6)	-0.346576	-9.18685*		*ECT*	-0.365422	-8.38428*
ΔR_GE(-7)	-0.277250	-7.93039*				
ΔR_GE(-8)	-0.202629	-6.53186*		R^2	0.465719	
ΔR_GE(-9)	-0.178679	-6.92283*		F	115.0612*	
ΔR_GE(-10)	-0.067981	-3.55359*				
ΔR_US(-1)	-0.509200	-7.34811*				
ΔR_US(-2)	-0.423568	-6.37898*				
ΔR_US(-3)	-0.340977	-5.38341*				
ΔR_US(-4)	-0.279740	-4.69434*				
ΔR_US(-5)	-0.199570	-3.60242*				
ΔR_US(-6)	-0.184869	-3.64556*				
ΔR_US(-7)	-0.144871	-3.17922*				
ΔR_US(-8)	-0.088504	-2.24752**				
ΔR_US(-9)	-0.079346	-2.52857**				
ΔR_US(-10)	-0.052369	-2.43107**				
Constant	1.46E-06	0.00539				

* and ** denote the significance at 1% and 5% levels, respectively. DW indicates Durbin-Watson statistic.

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Table 6.3. VECM Estimation Results of the UK

	ΔR_UK			Cointegrating Eq:	
Regressors	**Coefficients**	**t-ratio**		**Coefficients**	**t-ratio**
ΔR_UK(-1)	-0.435514	-13.5006*	*R_UK(-1)*	1.000000	
ΔR_UK(-2)	-0.386462	-12.3101*	*R_US(-1)*	-2.854769	-15.0578*
ΔR_UK(-3)	-0.323636	-11.2102*	*Constant*	0.000150	
ΔR_UK(-4)	-0.155798	-6.19740*			
ΔR_UK(-5)	-0.089360	-4.75894*			
			ECT	-0.484665	-3.8312*
ΔR_US(-1)	0.518830	14.0967*			
ΔR_US(-2)	0.418955	12.1262*	R^2	0.468788	
ΔR_US(-3)	0.300170	9.60448*	F	223.5900*	
ΔR_US(-4)	0.197312	7.64487*			
ΔR_US(-5)	0.097715	5.37571*			
Constant	1.94E-06	0.00822			

The results in the Tables (Table 6.1, Table 6.2, Table 6.3 and Table 6.4) above presented the adjustment's coefficients, for the set of series used in our investigation. The ECT results in our markets are found statistically significant with the anticipated negatives signs (-0.099790, -0.365422, -0.484665, -0.663715). The adjustment's coefficients associated with the stock price index are negative and statistically significant. This is sufficient to confirm the presence of a stable long-run relationship between indexes and this confirms the finding in Johansen cointegration tests presented previously, which has suggested a bi-directional long run relationship between indexes.

We then import empirical results of impulse response functions, and variance decompositions analysis. Usually, there are two methods to widen our investigation and study the effects of shocks to the return of indexes. We compute variance decompositions and impulse-response functions, which serve as tools for evaluating the dynamic interactions and strength of causal relations among variables in the system.

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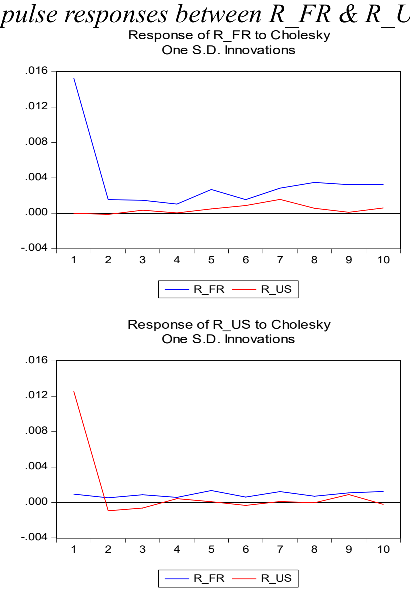
Table 6.4. VECM Estimation Results of Japan

	ΔR_JP				**Cointegrating Eq:**	
Regressors	**Coefficients**	**t-ratio**			**Coefficients**	**t-ratio**
ΔR_JP(-1)	-0.332991	-6.54899*		*R_JP(-1)*	1.000000	
ΔR_ JP(-2)	-0.306292	-6.13924*		*R_US(-1)*	-1.406760	-11.8928*
ΔR_ JP(-3)	-0.312920	-6.44143*		*Constant*	-0.000128	
ΔR_JP(-4)	-0.326640	-6.92902*				
ΔR_JP(-5)	-0.288324	-6.33643*				
ΔR_JP(-6)	-0.280429	-6.42165*		*ECT*	-0.663715	-12.7147*
ΔR_JP(-7)	-0.229161	-5.53396*				
ΔR_JP(-8)	-0.203144	-5.24771*		R^2	0.505495	
ΔR_JP(-9)	-0.158896	-4.51366*		F	113.0990*	
ΔR_JP(-10)	-0.104895	-3.37391*				
ΔR_JP(-11)	-0.042471	-1.63084				
ΔR_JP(-12)	-0.043923	- 2.34530**				
ΔR_US(-1)	-0.866400	-11.8860*				
ΔR_US(-2)	-0.809879	-11.2311*				
ΔR_US(-3)	-0.760912	-10.7443*				
ΔR_US(-4)	-0.717823	-10.4479*				
ΔR_US(-5)	-0.628989	-9.48005*				
ΔR_US(-6)	-0.523764	-8.31323*				
ΔR_US(-7)	-0.405471	-6.85726*				
ΔR_US(-8)	-0.317320	-5.82046*				
ΔR_US(-9)	-0.276635	-5.62266*				
ΔR_US(-10)	-0.194250	-4.53760*				
ΔR_US(-11)	-0.116199	-3.39239*				
ΔR_US(-12)	-0.004833	-0.20591				
Constant	-1.22E-05	-0.04140				

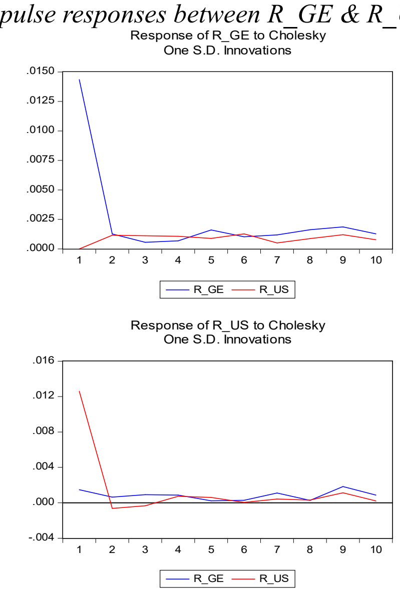
* and ** denote the significance at 1% and 5% levels, respectively. DW indicates Durbin-Watson statistic.

Fig. 3. Impulse Response Functions

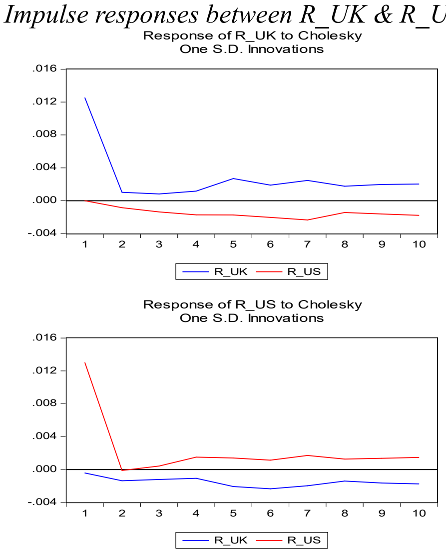
Impulse responses between R_FR & R_US



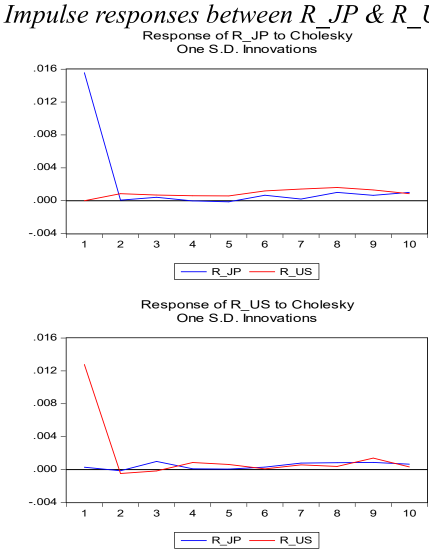
Impulse responses between R_GE & R_US



Impulse responses between R_UK & R_US



Impulse responses between R_JP & R_US



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The figures above present the impulse response functions. This function which can produce the time path of dependent variable, in the system of equation developed within the VECM framework, to shocks from all the explanatory variables.

Table 7. Variance Decompositions

Variance decompositions between R_FR & R_US

Period	S.E.	R_FR	R_US
Variance Decomposition of R_FR:			
1	0.015261	100.0000	0.000000
2	0.015339	99.99278	0.007220
3	0.015413	99.94307	0.056927
4	0.015447	99.94261	0.057389
5	0.015687	99.84839	0.151609
6	0.015787	99.54825	0.451749
7	0.016116	98.62287	1.377133
8	0.016498	98.56896	1.431044
9	0.016812	98.61807	1.381926
10	0.017131	98.54964	1.450360
Variance Decomposition of R_US:			
Period	S.E.	R_FR	R_US
1	0.012582	0.565413	99.43459
2	0.012628	0.733012	99.26699
3	0.012674	1.205554	98.79445
4	0.012695	1.406273	98.59373
5	0.012766	2.500521	97.49948
6	0.012785	2.720122	97.27988
7	0.012844	3.609484	96.39052
8	0.012863	3.896895	96.10311
9	0.012940	4.548362	95.45164
10	0.013001	5.412448	94.58755

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Variance decompositions between R_GE & R_US

Variance Decomposition of R_GE:			
Period	S.E.	R_GE	R_US
1	0.014353	100.0000	0.000000
2	0.014456	99.35830	0.641696
3	0.014509	98.77616	1.223841
4	0.014564	98.25070	1.749298
5	0.014680	97.90918	2.090821
6	0.014771	97.18621	2.813788
7	0.014827	97.09203	2.907970
8	0.014942	96.79371	3.206294
9	0.015106	96.23245	3.767548
10	0.015179	96.01069	3.989311

Variance Decomposition of R_US:			
Period	S.E.	R_GE	R_US
1	0.012680	1.351154	98.64885
2	0.012712	1.599193	98.40081
3	0.012749	2.106646	97.89335
4	0.012800	2.553310	97.44669
5	0.012817	2.577891	97.42211
6	0.012820	2.624247	97.37575
7	0.012875	3.343132	96.65687
8	0.012882	3.384254	96.61575
9	0.013060	5.258103	94.74190
10	0.013090	5.670529	94.32947

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Variance decompositions between R_UK & R_US

Variance Decomposition of R_UK:			
Period	S.E.	R_UK	R_US
1	0.012516	100.0000	0.000000
2	0.012587	99.54419	0.455812
3	0.012687	98.40368	1.596316
4	0.012855	96.67262	3.327382
5	0.013246	95.17588	4.824123
6	0.013534	93.13572	6.864276
7	0.013954	90.73715	9.262851
8	0.014138	89.95442	10.04558
9	0.014367	89.01701	10.98299
10	0.014619	87.90769	12.09231

Variance Decomposition of R_US:			
Period	S.E.	R_UK	R_US
1	0.013009	0.103650	99.89635
2	0.013080	1.174930	98.82507
3	0.013142	2.009781	97.99022
4	0.013271	2.607396	97.39260
5	0.013504	4.851990	95.14801
6	0.013753	7.567135	92.43287
7	0.013999	9.275278	90.72472
8	0.014127	10.08662	89.91338
9	0.014286	11.16712	88.83288
10	0.014467	12.33437	87.66563

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Variance decompositions between R_JP & R_US

Variance Decomposition of R_JP:

Period	S.E.	R_JP	R_US
1	0.015563	100.0000	0.000000
2	0.015587	99.69588	0.304124
3	0.015608	99.49958	0.500417
4	0.015620	99.34657	0.653428
5	0.015632	99.20503	0.794971
6	0.015692	98.62831	1.371685
7	0.015757	97.83169	2.168312
8	0.015872	96.82904	3.170956
9	0.015941	96.17347	3.826532
10	0.015996	95.91301	4.086992

Variance Decomposition of R_US:

Period	S.E.	R_JP	R_US
1	0.012778	0.050616	99.94938
2	0.012788	0.063399	99.93660
3	0.012827	0.653207	99.34679
4	0.012856	0.656607	99.34339
5	0.012871	0.657051	99.34295
6	0.012875	0.712694	99.28731
7	0.012912	1.086845	98.91316
8	0.012944	1.500057	98.49994
9	0.013049	1.928323	98.07168
10	0.013070	2.179016	97.82098

While impulse response functions trace the responses of all endogenous variables to innovations in one endogenous variable, variance decompositions indicate the relative importance of each random innovation in affecting the variables in the system. Thus, variance decompositions determine the proportion of the variance of the forecast error for any variable in the system that is explained by

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innovations in other endogenous variable by breaking down the forecast error variance for each variable into its components.

The tables above presented the results of the variance decomposition. They have showed that there are significant roles played by the Subprime crisis in most of markets accounting for the fluctuations in the return indexes.

Variance decomposition gives the proportions of the movement in dependent variables that are due to their "own" shocks, versus shocks to the other variables. The results of variance decomposition over a period of 10 years' time horizon are presented in Table 7. The results indicate that 94.58755% of the variation in the forecast error for variability return in the French market is explained by the effect of subprime crises, while 87.66563% of the variation in the forecast error for variability return in the UK is explained by the effect of Subprime crises. 94.32947% of the variation in the forecast error for variability return in the German market is explained by the effect of subprime crises and 97.82098% of the variation in the forecast error for variability return in the Japanese markets was explained by the effect of subprime crises. Thus we conclude the existence of the strong link between the variability prices and the subprime crises which affects directly the developed markets.

5. ***Summary and Conclusion***

"Like a pretty girl: difficult to define, but recognizable when seen [Kindleberger & Laffargue, 1982], financial crisis had a powerful impact upon the whole world economies. Our main objective was to study its impact on some developed countries via the contagion effect.

Our results concluded that the subprime financial crisis had seriously affected these countries. Considering daily data from April 2005 to December 2015, we found that financial stress was equally transmitted from the US market to the French, German, the UK, and Japanese markets. The analysis clearly showed that there are long-run relationships between the developed markets and the US market during the sample period.

Using approach of cointegration of Johansen (1988) and the estimation a VECM which provides an insight in the short and long run linkages in our system of return markets we can clearly see that all the markets are cointegrated in the long run and there are long run equilibriums. So, the subprime crisis in the US return markets has a significant influence on the whole of the cointegration patterns

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of our sample. We also observed that the dynamic interactions between the developed markets and the US have increased during the subprime crisis.

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