Received: 29 March 2013; Accepted: 07 October 2013.
DOI: 10.2298/PAN1403275K
Original scientific paper

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A version of this paper was presented at the 11th Annual Meeting of the European Economics and Finance Society which took place in Istanbul, June 2012. The authors are grateful to the participants for their helpful comments. The authors would also like to thank the two anonymous referees and the Editor for their helpful comments and suggestions that have significantly improved this paper. This work was carried out at the Faculty of Economics, University of Athens, Greece, and supported by Special Account Research Grant 11105.

Contagion Effects of the Global Financial Crisis in US and European Real Economy Sectors

Summary: This paper empirically investigates the contagion effects of the Global Financial Crisis (2007-2009) from the financial sector to the real economy by examining nine sectors of US and developed European region. We provide a regional analysis by testing stock market contagion on the aggregate level and the sector level, on the global level and the domestic/regional level. Results show evidence of global contagion in US and developed European aggregate stock market indices and all US sector indices, implying the limited benefits of portfolio diversification. On the other hand, most of the European regional sectors seem to be immune to the adverse effects of the crisis. Finally, all non-financial sectors of both geographical areas seem to be unaffected by their domestic financial systems. These findings have important implications for policy makers, investors and international organizations.

Key words: Global financial crisis, Financial contagion, Real economy sectors, USA, Europe.

JEL: G15, F30.

On 9th August 2007 the large French bank BNP Paribas temporarily halted redemptions for three of its funds that held assets backed by US subprime mortgage debt. Since then, many unanticipated and tumultuous economic events, as well as their global scale and magnitude, contributed to characterize the US subprime as the beginning of a "Global Financial Crisis" (GFC, hereafter). The GFC of 2007-2009 affected both financial activities and macroeconomic conditions around the globe that are difficult to be explained by pointing to "fundamentals". "Contagion" became the catchword for such phenomena and is now widely being used to describe the spread of financial disturbances from one country to others. The literature on financial contagion literally exploded since the thought-provoking paper by Kristin J. Forbes and Roberto Rigobon (2002) started circulating in the late 1990s. They define contagion as "a significant increase in cross-market linkages after a shock to one country (or group of countries)", otherwise, a continued market correlation at high levels is considered to be "no contagion, only interdependence".

There is a large body of literature on financial contagion during several crises occurred within the last three decades (see Dimitris Kenourgios, Aristeidis Samitas, and Nikos Paltalidis 2011; Dimitrios Dimitriou, Kenourgios, and Theodore Simos 2013; Kuan-Min Wang and Hung-Cheng Lai 2013, for a survey). This literature has focused mainly on contagion effects across stock markets in different countries, based on aggregate data. This paper empirically investigates the contagion effects of

the GFC, using non-aggregate data and focuses on the transmission of shocks from financial sector stock indices to nine non-financial sector stock indices, and thus the "real economy" of two major geographical areas, namely US and developed Europe.

Prior works that analyze non-aggregate stock market indices of different countries are still rare (see the following section for a literature review). Our study extends the existing literature and provides an analysis of the relationship among financial contagion and the real economy at a regional level rather than individual country level, since no attention has been paid to the dynamics of contagion from a regional perspective. The analysis of stock prices grouped into regional sector indices will shed light on the impact of the global crisis on the real economy of regions, since regional sector indices are indicators of the economic activities of a region. We select sectors of the US and developed European region due to the significant impact of these economies on the rest of the world. Together they account for over 25% of world domestic product. Furthermore, the US-developed Europe bilateral economic relationship can influence the economic conditions in other countries. Therefore, this is an interesting pair to examine the existence of financial contagion by testing various channels, that is: (i) contagion of aggregate equity market indices; (ii) contagion of the financial sector across US and developed European region; (iii) contagion of the financial sector and the real economy across US and developed Europe; (iv) contagion of the financial sector and the real economy within US and developed Europe. The empirical results can be summarized as follows. The GFC can be characterized by: (a) contagion of aggregate US and developed European equity indices; (b) contagion of financial sector only for US, while the developed Europe show evidence of immunity; (c) contagion of US real economy sectors, while most of the sectors in developed European region seem to be unaffected from the GFC. Finally, all non-financial sectors of US and developed European region seem to be unaffected by their domestic financial systems.

Many interesting aspects emerged from our empirical analysis. Firstly, the US stock market and real economy sectors are severely affected by the crisis. Due to the fact that the US is the source of the GFC, many investors may consider that the bad news concern only the US and so the other markets would be safer. On the other hand, most of the sectors of developed European region seem to be immune to the adverse effects of the crisis. This implies that markets with great exposure via trade or financial linkages were not necessarily hit hardest by the crisis, mainly due to their fundamental strengths and quality of institutions. These results are useful for investors in order to diversify their assets and reduce the costs of future financial crises. Also, an assessment of the breadth of a financial crisis can also assist US and European policy makers in effectively designing stimulus packages to reduce the possibility of a future infection of multiple sectors.

The rest of the paper is structured as follows. Section 1 reviews the prior literature. Section 2 introduces the methodology framework to test contagion, the crisis period identification, the channels of contagion and the hypotheses to be tested. Section 3 presents the dataset and preliminary analysis. Section 4 produces the estimation results and robustness tests. Finally, Section 5 summarizes the findings and concludes.

1. Literature Review

The existing literature that analyzes contagion during several crises using aggregate stock market indices is vast. The Asian crisis contagion clearly receives the highest share of attention in the literature (see for example Reuven Glick and Andrew K. Rose 1999; Forbes and Rigobon 2002; Geert Bekaert, Campbell R. Harvey, and Angela Ng 2005; Brian H. Boyer, Timoni Kumagai, and Kathy Yuan 2006; Thomas Chiang, Bang N. Jeon, and Huimin Li 2007; Essahbi Essaadi, Jamel Jouini, and Wajih Khallouli 2009; Mardi Dungey, George Milunovich, and Susan Thorp 2010; Kenourgios, Samitas, and Paltalidis 2011; Kenourgios, Dimitrios Asteriou, and Samitas 2013). On the other hand, there is limited empirical evidence on the contagious effects of the Russian default in 1998 (Gaston R. Gelos and Ratna Sahay 2001; Dungey et al. 2007) and the Argentinean crisis of 1999-2001 (Melisso Boschi 2005; Kenourgios and Puja Padhi 2012) in global financial markets.

Recently, a large number of studies provide evidence on contagion of the US subprime crisis and the GFC in advanced and emerging stock markets (Riadh Aloui, Mohamed S. Ben Aïssa, and Duc Khuong Nguyen 2011; Lalith P. Samarakoon 2011; Manolis N. Syllignakis and Georgios P. Kouretas 2011; Kenourgios and Padhi 2012; Dimitriou, Kenourgios, and Simos 2013; Dimitriou and Simos 2013). Another strand of the literature confirms contagion of the GFC on credit default swap (CDS) markets (Michael Dooley and Michael Hutchison 2009; Ping Wang and Tomoe Moore 2012), bond markets (Francis A. Longstaff 2010) and other asset classes, such as exchange rates, real estate, commodities and energy (Kam Fong Chan et al. 2011; Feng Guo, Carl R. Chen, and Ying Sophie Huang 2011; John Beirne and Jana Gieck 2012). On the other hand, the investigation of the effects of the EMU sovereign-debt crisis on stock markets (Samitas and Ioannis Tsakalos 2013), bond markets (Michael G. Arghyrou and Alexandros Kontonikas 2012; Silvo Dajcman 2013; Dionisis Philippas and Costas Siriopoulos 2013) and CDS markets (Alesia Kalbaska and Mateusz Gatkowski 2012; Beirne and Marcel Fratzscher 2013) is growing fast.

However, few of the existing studies investigate the contagion effects of the GFC based on non-aggregate data. A recent example of this literature is Dirk G. Baur's (2012) study that examines the transmission of shocks from the financial sector to real economy sectors in 25 major developed and emerging stock markets. His results demonstrate that no country and sector was immune to the adverse effects of the crisis limiting the effectiveness of portfolio diversification. However, he provides clear evidence that some sectors in particular Healthcare, Telecommunications and Technology were less severely affected by the crisis.

Another example is the work of Bekaert et al. (2011) that analyzes the equity market transmission of the 2007-2009 GFC to country-industry equity portfolios in 55 countries. They find evidence of contagion from US markets and from the global financial sector, but the effects are economically small. On the other hand, there has been substantial contagion from domestic equity markets to individual domestic equity portfolios, while its severity inversely related to the quality of fundamentals and policies of each country. They also confirm that investors focus substantially more on country-specific characteristics during a crisis. Paulo Horta, Carlos Mendes, and Isabel Vieira (2010) analyze four European aggregate stock markets, financial sector

and industrial sector during the GFC and find contagion for all markets and sectors. Finally, Kate Phylaktis and Lichuan Xia (2004) investigate portfolio diversification among various real economy sectors within a CAPM perspective during the period from 1990 until 2004 and provide mixed evidence for contagion.

2. Methodology Framework

According to a market model proposed by Bekaert, Harvey, and Ng (2005), contagion from one market to another is estimated as follows:

$$r_{market,i,t} = a + br_{world,t} + e_{market,i,t} \tag{1}$$

$$e_{market,i,t} = c_0 + c_1 e_{market^*,t} + c_2 e_{market^*,t} D_{crisis} + \eta_{i,t} \tag{2}$$

where $r_{market,i}$ is the return stock index of market i, $r_{world,i}$ is the return of a global equity portfolio, and e_{market} is the estimated residuals from the first equation. A second-pass regression utilizes e_{market} from Equation (1) to determine the impact of unexpected shocks from the crisis-market (e_{market}*) on the unexpected return component ($e_{market,i}$) in market i. The dummy variable D_{crisis} is equal to unity if there is a crisis and zero otherwise. The parameter c_1 is an indicator of interdependence and the parameter c_2 measures the contagion effects. Contagion exists if c_2 is positive and statistically significant.

However, the above specification is sensitive to the specification of the first-pass regression. Moreover, controlling the Equation (1) by adding financial and macroeconomic variables that may change during the crisis period can lead to an estimate of "unexpected" shocks which is not truly unexpected. Specifically, if the first-pass regression employs regressors that contain unexpected information the supposedly unexpected component in the second-pass regression leads to biased estimates of contagion. Another issue is the fact that the coefficients estimated with Equation (2) do not show a change in the impact of the systematic component $r_{world,i}$. Thus, the model given in Equations (1) and (2) provides changes in the co-movement of the filtered or idiosyncratic shocks.

In order to alleviate the first-pass regression sensitivity to "unexpected" shocks and test world and domestic contagion, we apply the following model:

$$\begin{aligned} r_{S,i,t} &= a + b_1 r_{fin.,world,t} + b_2 r_{fin.,world,t} D_{crisis,t} + e_{S,i,t} \\ h_{S,i,t} &= \pi + ae^2_{S,i,t-1} + \beta e^2_{S,i,t-1} I(e_{S,i,t-1} < 0) + \gamma h_{S,i,t-1} \\ e_{S,i,t} &= (h_{S,i,t})^{0.5} k_{S,i,t} \\ K_{S,i} &\sim N(0,1) \end{aligned} \tag{3}$$

where $r_{fin.,world,t}$ is the return of the global financial sector portfolio, while the subscript S denotes the sector under examination for each market. The model is also used to analyze contagion across aggregate stock market indices. In this case S represents the sum of all sectors and is substituted by *market*. We assume that the GFC was triggered by a crisis in the financial sector. This model estimates a change

in the transmission mechanism of systematic shocks in a crisis period compared to a non-crisis period. The dummy variable D_{crisis} is equal to unity if there is a crisis and zero otherwise. If the coefficient estimate of b_2 is positive and statistically different from zero, there is evidence of contagion. This type of contagion can be termed "systematic contagion" in contrast to "idiosyncratic contagion" as estimated by Equations (1) and (2). The model is estimated within an asymmetric GARCH (1,1) framework of Lawrence R. Glosten, Ravi Jagannathan, and David E. Runkle (1993), since equity returns exhibit conditional heteroskedasticity.

In order to specify the length of the GFC, we define a relatively long crisis period which includes all major financial and economic news events representing the GFC, i.e. the bankruptcy of Lehman Brothers (15th September 2008). To obtain a relative long period of crisis we use timelines provided by official sources, such as the Federal Reserve Bank of St. Louis (2009) and the Bank for International Settlements - BIS (2009), which separate the crisis period in four phases. Phase 1 is described as "initial financial turmoil" and spans from 1st August 2007 to 15th September 2008. Phase 2 is defined as "sharp financial market deterioration" (16th September 2008 until 31st December 2008), phase 3 is described as "macroeconomic deterioration" (1st January 2009 until 31st March 2009) and phase 4 as "stabilization and tentative signs of recovery" (from 1st April onwards to the end of our sample). According to above crisis specification, we use a crisis period that spans from 1st August 2007 until 31st March 2009.

This length of the crisis period has been used by several studies so far (see: Dooley and Hutchison 2009; Bekaert et al. 2011). However, all studies on contagion, which determine the crisis length either *ad-hoc* based on major economic and financial events (Forbes and Rigobon 2002) or endogenously (Boyer, Kumagai, and Yuan 2006), are to some degree arbitrary, because they all depend on a correct definition of the crisis period. As Baur (2012, p. 2682) argues, "…even studies that avoid discretion in the definition of the crisis period use discretion in the choice of the econometric model to estimate the location of the crisis period in time".

Then we test four alternative channels of contagion: aggregate stock market contagion, financial sector contagion and real economy (non-financial sector) contagion spread through the global financial system or the domestic financial system. To differentiate between global and domestic contagion, Equation (3) is augmented as follows:

$$r_{S,i,t} = a + b_1 r_{fin.,world,t} + b_2 r_{fin.,world,t} D_{crisis,t} + c_1 r_{fin.,i,t} + c_2 r_{fin.,i,t} D_{crisis,t} + e_{S,i,t}. \quad (4)$$

The equation can be used to estimate changes in the return co-movement of a specific sector S with the global financial system ($r_{fin.,world}$) or with the domestic/regional financial system ($r_{fin.,i}$). Following the testing framework of Baur (2012), the tests and hypotheses are given below.

Test 1 - Aggregate equity market contagion: *An increased co-movement of a stock market index* i *and world stock index in crisis period compared to stable period.* This test empirically investigates the aggregate equity market index contagion across markets (i = US, developed Europe), and assumes that the source of contagion is the world stock market index.

Test 2 - Global financial sector contagion: *An increased co-movement of a financial sector stock index i and world financial sector stock index in crisis period compared to stable period.* This test investigates contagion of the US and developed European financial sectors from the world financial sector.

Test 3 - Financial contagion of real economy sector on a global level: *An increased co-movement of a non-financial sector stock index i and world financial sector index in crisis period compared to stable period.* This test investigates contagion of the US and developed European non-financial sectors from the world financial sector.

Test 4 - Financial contagion of real economy sector on a domestic level: *An increased co-movement of a non-financial sector stock index i and domestic financial sector stock index in crisis period compared to stable period.* This test examines contagion across sectors within US and developed European region and can be used as a local or domestic test of contagion. It assumes that the financial sector of a region is infected by the GFC and spreads it to other non-financial sectors.

The null hypothesis (H_0) and alternative hypothesis (H_1) for Tests 1-3 are the following:

$$H_0 : b_2 \leq 0 \text{ (no evidence of contagion)}$$
$$H_1 : b_2 > 0 \text{ (evidence of contagion).}$$

The null and alternative hypotheses for Test 4 are given by:

$$H_0 : c_2 \leq 0 \text{ (no evidence of contagion)}$$
$$H_1 : c_2 > 0 \text{ (evidence of contagion).}$$

Furthermore the above framework allows an analysis of the homogeneity of the contagion effects across markets and sectors. If the propagation of shocks is homogeneous, investors act similarly (e.g., sell stocks simultaneously due either to margin calls or to panic preferring safer assets), and there is *investors-induced contagion*. In contrast, when investors observe a change in fundamentals (e.g., firms' higher cost of capital due to more risk-averse banks and investors) and act accordingly, there is *fundamental-induced contagion*. In this study, we assume that investor-induced contagion leads to a relatively homogeneous change in the level of co-movement across markets and sectors, whereas fundamentals-based contagion is expected to lead to a more heterogeneous form of contagion.

3. Data and Preliminary Analysis

The data comprises daily MSCI aggregate stock indices of World, US, developed Europe and ten sector stock indices of the geographical areas of US and developed Europe (Financial, Energy, Materials, Industrials, Consumer Goods, Consumer Services, Healthcare, Information Technology, Telecommunications and Utilities). All MSCI stock indices are denominated in USD (the results using indices denominated on domestic currency are similar and available upon request). The developed European region includes the following countries: Austria, Belgium, Denmark, Finland,

France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom. The data extracted from Thomson Financial (Datastream) covers the period from 1st January 2004 to 31st December 2009, giving a total of 1825 observations. For each MSCI index, the continuously compounded return was estimated as $r_t = 100[\log(p_t) - \log(p_{t-1})]$, where p_t is the price on day t.

Summary statistics for US and developed European aggregate stock indices' returns are displayed in Table 1. Panel A reports summary statistics for the full sample period and show significant differences in mean returns, standard deviations, skewness, kurtosis and autocorrelation (Ljung-Box statistics) across the two aggregate market indices. Panel B presents the summary statistics for the crisis period identified using key economic and financial events of the GFC as described in methodology framework section. Comparing the two periods, we can perceive that all stock returns show significant changes in mean returns, standard deviations, skewness and kurtosis.

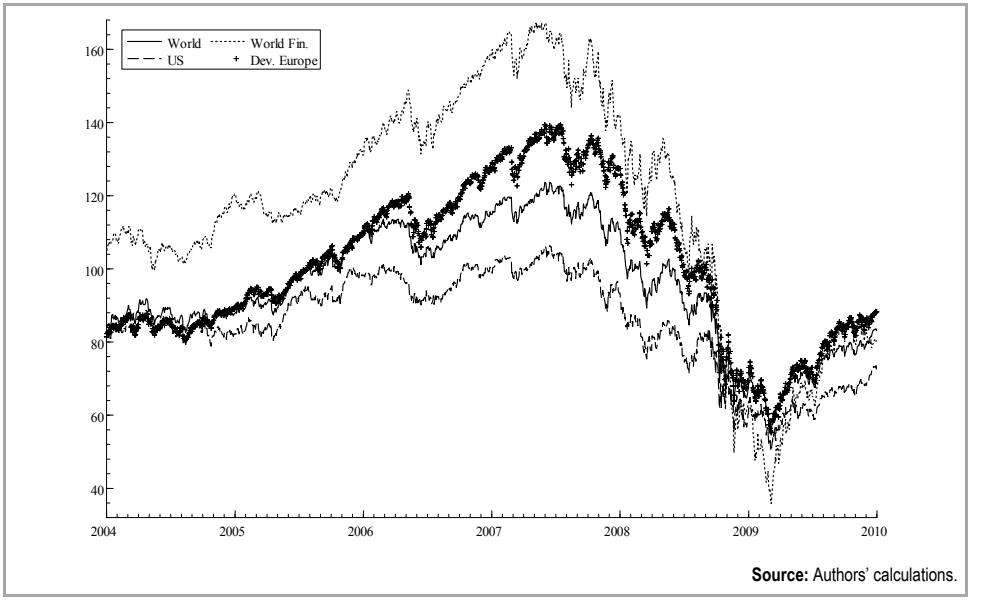
Table 1 Descriptive Statistics for Aggregate Stock Market Indices

	Mean	Std. dev.	Min.	Max.	Skewness	Kurtosis	N	J-Berra	Ljung Box	p-value
Panel A: Full sample period (2004-2009)										
Dev. Europe	0.0086	1.2694	-7.9177	9.5723	-0.1000	11.7422	1825	5824.499	36.693	0.000
US	0.0048	1.4196	-9.1461	10.448	-0.1400	11.2946	1825	5248.141	93.167	0.000
Panel B: Crisis period (2007-2009)										
Dev. Europe	-0.1762	2.0247	-7.9177	9.5724	0.1371	6.7274	434	252.6007	29.252	0.004
US	-0.1306	2.3582	-9.1461	10.4484	0.0519	5.8991	434	152.1809	39.300	0.000

Note: The table presents descriptive statistics of the daily aggregate stock market returns for US and developed Europe during stable and crisis periods.

Source: Authors' calculations.

Figure 1 illustrates the evolution of World, US, World Financial and Developed European stock indices over time. The figure shows strong co-movement among all equity market indices and significant declines in the levels during 2008, especially at the time of Lehman Brothers collapse (15th September 2008). Since all equity returns exhibit ARCH and asymmetric effects (results not presented here), the asymmetric GARCH process (GJR-GARCH) adopted in this paper is an appropriate specification.



Source: Authors' calculations.

Figure 1 Equity Market Indices Behavior over Time

4. Empirical Results and Robustness Tests

This section presents the estimation results of the econometric model specified in Equations (3) and (4) and discusses the implications for the hypotheses presented in Section 2. Tables 2 and 3 present the results for the 4 tests of contagion. Not surprisingly, Table 2 - Panel A indicates that both aggregate equity indices are integrated with world equity market, since they have positive and statistically significant (b_1) coefficient. The equity markets of US and developed Europe are among the largest in terms of capitalization and their large interdependence with the world equity index is an expected outcome. Moreover, they indicate evidence of contagion since (b_2) coefficients are positive and statistically significant. It is interesting to mention that both stock indices show evidence of contagion, although US was the source of the GFC. This could be explained by the strong financial and economic ties among these two geographical areas. These findings are in line with the individual stock market analysis' results of Baur (2012). The results also show that the coefficient governing contagion (b_2) varies significantly across the two areas. This heterogeneity of the contagion effect suggests a fundamentals-based contagion. This type of contagion occurs when investors observe a change in fundamentals and act accordingly.

Panel B of Table 2 presents the results of global financial sector contagion. The interdependence of both financial sector indices with the world financial index is present, while contagion effects exist only among US and the world financial sector. The contagion coefficient (b_2) is negative and statistically insignificant for the developed European financial index, suggesting the immunity of the European financial sector from the world financial sector. This finding is not in line with the results of Baur (2012), who provides evidence on contagion for all European countries' financial sectors included in his sample. According to Bekaert et al. (2011), the explana-

tion of this finding could be that developed markets with great exposure via trade or financial linkages were not necessarily hit hardest by the financial crisis, mainly due to their fundamental strengths and quality of financial institutions. However, the fact that there is no evidence of contagion in the European financial sector does not mean that some of the financial sectors of the countries were not affected by the crisis. The findings merely imply that the regional financial sector index did not suffer from an increased co-movement with a falling portfolio of world financial stocks. Further analysis of the decreasing co-movement of the European financial sector index with the world financial portfolio shows that the co-movement with the world portfolio of financial stocks decreased because the value of the world financial index deteriorated by more than the regional financial stock portfolio in that period.

Table 2 Contagion of US and Developed European Aggregate and Financial Stock Indices - Estimation Results

Panel A: Aggregate equity market contagion

Model: $r_{aggr.,i,t} = a + b_1 r_{aggr.,world,t} + b_2\, r_{aggr.,\ world,\ t} D_{crisis,t} + e_{aggr.,i,t}$

	a	b_1	b_2	Contagion
Dev. Europe	0.0244**	0.8494***	0.0865***	**C**
US	-0.0180	1.1256***	0.0459*	**C**

Panel B: Global financial sector contagion

Model: $r_{fin.,i,t} = a + b_1\, r_{fin.,world,t} + b_2\, r_{fin.,i,t} D_{crisis,t} + e_{fin.,i,t}$

Dev. Europe	5.38E-06	0.9765***	-0.0068	-
US	-0.0034	0.6434***	0.4280***	**C**

Notes: C denotes contagion during the crisis period if the dummy coefficient b_2 is positive and statistically significant; - denotes no evidence of contagion; ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Source: Authors' calculations.

Table 3 displays the results associated with Hypotheses 3 and 4, thus testing the existence of contagion among the world financial sector/domestic financial sector and the sectors representing the real economy in each area. For Test 3, we assume that the global financial system has a direct impact on US and developed Europe non-financial firms. This is because firms are directly affected by the GFC since lend and borrow globally. In order to control for an increased co-movement of the financial sector with the domestic financial sector, we use Equation (4) which includes the domestic financial sector returns in normal and crisis periods as control variables. All US real economy sectors are infected by the GFC, since the coefficients b_2 are positive and statistically significant. On the other hand, developed European sectors exhibit no evidence of contagion, except two sectors: Consumer Services and Healthcare. Almost the same findings are provided by Baur (2012) for the US sectors and the two infected European sectors. Since all other sectors in this region seem to be immune, this suggests that they are prone to portfolio diversification. These results demonstrate that US firms are more exposed to the global financial system than developed European firms. Panel B contains the coefficient estimates measuring the crisis specific change in the level of co-movement of the "local" financial stock index and the non-financial sector indices of the two areas. A positive and statistically significant coefficient estimate c_2 implies contagion. The results show no cases of contagion for all sectors of both regions, supporting the findings of Baur (2012).

Table 3 Contagion of US and Developed European Real Economy Sectors - Estimation Results

Model: $r_{S,i,t} = a + b_1 r_{fin.,world,t} + b_2 r_{fin.,world,t} D_{crisis,t} + c_1 r_{fin.,i,t} + c_2 r_{fin.,i,t} D_{crisis,t} + e_{S,i,t}$

Panel A: Financial contagion of real economy sector on a global level

	Energy	Materials	Industrials	Cons. goods	Cons. services	Healthcare	Telecom	Info-tech	Utilities
Dev. Europe	-	-	-	-	C_g***	C_g***	-	-	-
US	C_g***	C_g***	C_g***	C_g***	C_g***	C_g***	C_g***	C_g***	C_g***

Panel B: Financial contagion of real economy sector on a domestic level

Dev. Europe	-	-	-	-	-	-	-	-	-
US	-	-	-	-	-	-	-	-	-

Notes: C_g denotes global financial contagion of real economy during the crisis period if the b_2 coefficient is positive and statistically significant; C_d denotes domestic financial contagion of real economy during the GFC if c_2 is positive and statistically significant; - denotes no evidence of contagion; ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Source: Authors' calculations.

Finally, in order to check the robustness of our results, the sensitivity of the crisis period definition and the full period sample is analyzed by three ways as presented in Table 4 (Panels A, B and C). The main results corresponding to the crisis period of 2007-2009 are also presented.

Table 4 Summary of Results and Robustness Tests

	Aggregate equity market contagion			Global financial sector contagion			Global financial contagion of real economy sector			Domestic financial contagion of real economy sector		
Panel A: Variations of full sample period with fixed crisis start												
Sample period:	'04-'09	'04-'10	'06-'09	'04-'09	'04-'10	'06-'09	'04-'09	'04-'10	'06- '09	'04-'09	'04-'10	'06-'09
Dev. Europe	C	C	-	-	-	-	2	2	1	0	0	0
US	C	C	C	C	C	C	9	9	8	0	0	0
Panel B: Fixed crisis start and variations of the crisis period length												
Crisis period:	Aug. '07-Mar. '09	Aug. '07-Sep. '08	Aug. '07-Dec. '08	Aug. '07-Mar. '09	Aug. '07-Sep. '08	Aug. '07-Dec. '08	Aug. '07-Mar. '09	Aug. '07-Sep. '08	Aug. '07-Dec. '08	Aug. '07-Mar. '09	Aug. '07-Sep. '08	Aug. '07-Dec. '08
Dev. Europe	C	C	C	-	C	-	2	2	2	0	1	0
US	C	C	C	C	C	C	9	8	9	0	0	0
Panel C: Fixed crisis period length and variations of the crisis start												
Crisis period:	Aug. '07-Mar. '09	Sep. '08-Mar. '09	Jan. '09-Mar. '09	Aug. '07-Mar. '09	Sep. '08-Mar. '09	Jan. '09-Mar. '09	Aug. '07-Mar. '09	Sep. '08-Mar. '09	Jan. '09-Mar. '09	Aug. '07-Mar. '09	Sep. '08-Mar. '09	Jan. '09-Mar. '09
Dev. Europe	C	C	C	-	-	-	2	2	1	1	1	0
US	C	C	C	C	C	C	9	9	9	0	0	0

Notes: This table summarizes the test results of different types of contagion during the crisis period (August 2007-March 2009), while presents the robustness tests' results by varying the full sample period, the crisis period length and the crisis starting date; C denotes contagion and the numbers in Panels A, B and C display the number of real economy sectors affected by the crisis; - denotes no evidence of contagion.

Source: Authors' calculations.

Firstly, we change the sample period into two different horizons: (1) 2004-2010 (the sample extended beyond 2009 and spans until the end of 2010) and (2) 2006-2009 (the sample starts from 2006), while the crisis period remains the same, i.e. 2007-2009 for all cases. The results from the GJR-GARCH model presented in Panel A are almost similar with those of the period 2004-2009. Secondly, we fix the crisis start date at August 2007 and the length of the crisis is increasing until: (i) 15th September 2008 (the collapse of Lehman Brothers) and (ii) 31st December 2008 (end

of phase 2 - "initial financial turmoil" according to the official timelines). The coefficients indicating contagion change only slightly. Thirdly, we fix the crisis length (until end of March 2009) and the crisis starts at: (a) 15th September 2008 and (b) 1st January 2009 (the beginning of phase 3 - "macroeconomic deterioration" according to the official timelines). Again, the results of this sensitivity analysis are almost the same. Overall, these results indicate that changes due to sample period selection and crisis period definition are rather small and economically insignificant.

5. Concluding Remarks

This paper empirically investigates the contagion effects of the GFC from the financial sector to real economy using an asymmetric GJR-GARCH (1,1) model and a dataset of aggregate and sector stock indices of US and developed Europe during the period 2004-2009. We test for contagion across stock markets on the aggregate level and the sector level, on the global level and the domestic/regional level. Results imply that the contagion hypothesis holds for US and developed European aggregate stock markets, while financial sector contagion is evident only for US financial sector stocks.

In line with Baur (2012), the evidence for contagion of the sectors representing the real economy is mixed. Specifically, contagion effects from the global financial portfolio are present for all US real economy sectors, implying the diminished benefits of international portfolio diversification. On the other hand, the developed European region exhibit evidence of contagion only for Consumers Services and Healthcare sectors. Moreover, our results show no evidence of domestic financial contagion of real economy sectors for both geographical areas.

Our findings have important implications for investors, policy makers and international organizations, such as International Monetary Fund (IMF), with regard to the linkages among the markets and their real economy sectors during the GFC. In particular, investors may benefit from the different vulnerability of the markets and real economy sectors, since holding a portfolio with equities from diverse sectors is less subject to systematic risk. From policymakers and international organizations' perspective, this study provides useful information about the directions for possible future policy decisions in order to protect countries and investors from future financial crises. Future research may investigate the dynamics of contagion across different phases of the GFC.

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