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Financial contagion and the real economy

Dirk G. Baur *

UTS Business School - Finance, University of Technology, Sydney, Australia
Centre for Applied Macroeconomic Analysis (CAMA), Australian National University, Canberra, Australia

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ABSTRACT

This paper studies the spread of the Global Financial Crisis of 2007–2009 from the financial sector to the real economy by examining ten sectors in 25 major developed and emerging stock markets. The analysis tests different channels of financial contagion across countries and sectors and finds that the crisis led to an increased co-movement of returns among financial sector stocks across countries and between financial sector stocks and real economy stocks. The results demonstrate that no country and sector was immune to the adverse effects of the crisis limiting the effectiveness of portfolio diversification. However, there is clear evidence that some sectors in particular Healthcare, Telecommunications and Technology were less severely affected by the crisis.

1. Introduction

The Global Financial Crisis of 2007–2009 has been linked to the Great Depression of 1929 due to the joint deterioration of stock markets and macroeconomic variables such as industrial production and world trade. The global scale of the recent crisis also distinguishes it from previous financial crisis with a more regional focus such as the Asian financial crisis in 1997 or the Mexican crisis in 1994. While the simultaneous drop in stock prices and macroeconomic conditions has been described and analyzed (e.g. see Eichengreen and O'Rourke, 2009), there is no global and comprehensive study of the transmission of shocks from stocks of the financial sector to stocks representing non-financial sectors and thus "real economy" stocks such as Industrials, Consumer Goods, Utilities or Technology. Such a study is important as it can provide information about investor behavior in times of turmoil and thus how a crisis spreads. For example, do investors sell stocks of specific sectors and countries or do they sell stocks across all sectors and countries? The latter would lead to a reduced effectiveness of diversification while the former would maintain the benefits of diversification. An assessment of the breadth of a financial crisis can also assist governments in effectively designing stimulus packages to reduce the costs of an infection of multiple sectors in an economy.

Most of the existing literature on contagion analyzes aggregate stock market indices (e.g. see Baig and Goldfajn, 1999; Forbes and Rigobon, 2002; Bae et al., 2003; Baur and Schulze, 2005; Bekaert et al., 2005; Boyer et al., 2006; Chandar et al., 2009; Markwat et al., 2009 and Dungey et al., 2010 among others). Studies that test for contagion based on non-aggregate data are rare. Phylaktis and Xia (2004) analyze contagion of sectors within an asset pricing perspective for the period from 1990 to 2004 and find mixed evidence for contagion. They see this as evidence that diversification is beneficial despite the existence of contagion and financial crises. Horta et al. (2010) analyze the Global Financial Crisis (GFC in the following) for four European aggregate stock markets and two sectors (financial and industrial) with copulas and find contagion for all markets and sectors.

We extend the existing studies in two major ways. First, we use a large sample of countries and sectors to obtain detailed information about the specific impact of the crisis in developed and emerging countries and second, we test various channels of financial contagion, that is, (i) contagion of the financial sector across countries, (ii) contagion of the financial sector and the real economy across countries and (iii) contagion of the financial sector and the real economy within a country. In addition, we propose a novel crisis identification approach by using both key financial and economic news events and estimates of excess volatility.

* Address: UTS Business School - Finance, University of Technology, Sydney, Australia. Tel.: +61 2 9514 7784; fax: +61 2 9514 7722.

E-mail address: dirk.baur@uts.edu.au

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The empirical results can be summarized as follows. The GFC can be characterized by (i) contagion of aggregate stock market indices, (ii) contagion of financial sector stocks across countries and (iii) contagion of real economy sectors such as Oil and Gas, Basic Materials and Industrials. Some sectors (Healthcare, Telecommunications and Technology) are less affected by the repercussions of the GFC. Finally, while some countries' aggregate stock markets were more severely affected than others, there was no country or sector which proved immune to the effects of the crisis. The null hypothesis of "no contagion" is generally rejected in around 70% of all cases. Since the number of potential incidences of contagion among disaggregated indices exceeds tests based on aggregate stock market indices by a factor of 10[1] the evidence of contagion is both more detailed and robust.

A systematic analysis of variations in the start date of the crisis with a fixed crisis period length and of variations in the crisis period length with a fixed start date of the crisis further illustrates the robustness of the results.

The remainder of the paper is structured as follows. Section 2 introduces the testing framework including a description of the regression model to test contagion, the crisis period identification, the channels of contagion and the hypotheses to be tested. Section 3 produces the empirical analysis including descriptive statistics and estimation results. Finally, Section 4 summarizes the findings and concludes.

2. Testing framework

2.1. Econometric models

In this section we first present a basic econometric model to estimate contagion in financial markets and discuss the importance of the definition of the crisis period. We distinguish between *crisis period* definition which includes the beginning of a crisis and its duration and *crisis type* definition which confines the outbreak of a crisis to a certain sector, i.e. a crisis originating in the financial sector or in the real sector. We assume that the GFC was triggered by a crisis in the financial sector.

In a market model framework related to a model proposed by Bekaert et al. (2005) contagion from one market to another is estimated as follows:

$$R_{M,i,t} = a + bR_{W,t} + e_{M,i,t} \tag{1}$$

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

where R is the return of a representative stock market index M of country i regressed on a constant and the return of a global equity portfolio denoted by W. A second-pass regression utilizes the estimated residual e_M from Eq. (1) to determine the impact of unexpected shocks from crisis-originating country $M^*(e_{M*})$ on the unexpected return component ($e_{M,i}$) in country i. The distribution of the error terms are specified below. The dummy variable D_{crisis} is equal to one if there is a crisis and zero otherwise. The parameter c_1 measures the spillover of shocks from one country to another in normal periods, and parameter c_2 measures the contribution of the crisis period to the spillover. If c_2 is positive (negative), there is an increased (decreased) transmission of unexpected shocks from country j to country i in the crisis period compared to normal periods. Such a scenario constitutes contagion. Unfortunately, the model given in Eqs. (1) and (2) and thus the incidences of contagion are sensitive to the specification of the first-pass regression both with one regressor and multiple regressors. Moreover, controlling in the first-pass regression for financial and macroeconomic variables that also change in the crisis period can lead to an estimate of "unexpected" shocks which is not truly unexpected. For example, if a crisis leads a central bank to change monetary policy or the government to change existing regulation thereby changing the cost of capital, the unexpected component of these regime changes becomes "expected" if the variables are included in the first-pass regression to control for action that is related to the crisis. In other words, 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 Eq. (2) do not show a change in the impact of the systematic component R_W. Many models used in the literature assume that this systematic component does not change in the crisis period (e.g. see Forbes and Rigobon, 2002 and Bekaert et al., 2005 among others). The model thus provides changes in the co-movement of the filtered or idiosyncratic shocks.

Since we are interested in the change of co-movement including changes in the systematic co-movement in normal and crisis periods, we use an alternative model given by Eq. (3) as follows:

$$R_{M,i,t} = a + b_1 R_{W,t} + b_2 R_{W,t} D_t + e_{i,t} \tag{3}$$

where R_M is the aggregate stock index return of country i, R_W is the aggregate return of a world stock portfolio and D is a dummy variable which is equal to one for the crisis period and zero otherwise. The error term is given by e. Eq. (3) is based on the assumption that contagion exists if the system proxied by a global portfolio of stocks is infected and has an increased influence on the portfolio of stocks comprising either the entire market or a sector of a specific country. Eq. (3) can be rewritten to estimate contagion across sectors where sectors are denoted as S:

$$R_{S,i,t} = a + b_1 R_{S,W,t} + b_2 R_{S,W,t} D_t + e_{S,i,t} \tag{4}$$

The models given by Eqs. (3) and (4) estimate a change in the transmission mechanism of systematic shocks in a crisis period compared to a non-crisis period. If the coefficient estimate of b_2 is positive and statistically different from zero there is evidence of contagion.[2] If the coefficient is negative, the co-movement decreased in the crisis period and there is no contagion.

If Eq. (3) is augmented by regressors that capture the influence of a potential crisis trigger market in normal periods and crisis periods, the following equation is obtained:

$$R_{M,i,t} = a + b_1 R_{W,t} + b_2 R_{W,t} D_t + c_1 R_{M^*,t} + c_2 R_{M^*,t} D_t + e_{i,t} \tag{5}$$

where the subscript M^* denotes the market which triggers the crisis. If Eq. (1) contains the world return R_W and the interaction term with the dummy variable D as in Eq. (3), the coefficient estimates of c_1 and c_2 of Eq. (5) are equal to the coefficient estimates of c_1 and c_2 in Eq. (2). However, the coefficient estimates in Eq. (5) estimating the normal and crisis-specific impact of the world return are influenced by the correlation with the potential trigger market M^*. On the other hand, Eq. (2) will not provide any clear evidence of contagion due to the filtering of returns which eliminates most of the return co-movements observed in crisis periods. The different coefficient estimates obtained in a model based on Eq. (3) and a model which uses pre-filtered returns in a two-stage framework are discussed in the empirical section.

Since all models presented above utilize a dummy variable to determine the impact of shocks on other markets' or sectors' shocks in a crisis period, the incidences of contagion will be sensitive to the specification of the dummy variable. The start date and

[1] For a sample size of $N = 25$ countries and $M = 10$ sectors, a simple cross-country contagion study can detect a maximum of $N - 1 = 24$ cases of contagion while a sector-specific analysis can detect a maximum of $(N - 1) \times M = 240$ cases of contagion.

[2] This type of contagion may be termed "systematic contagion" in contrast to "idiosyncratic contagion" as estimated by Eq. (2).

the duration of the crisis period have a direct impact on the coefficient estimate of b_2 (Eq. (3)) which indicates whether the comovement of returns has increased or decreased.

The next section addresses these issues explicitly.

2.2. Crisis identification

The length and breadth of the Global Financial Crisis compared to previous financial crises potentially exacerbates problems related to the identification of the crisis period and the crisis source. Dungey et al., 2005 note that tests of contagion are normally sensitive to the definition of the crisis period and often rely on anecdotal evidence. Many empirical studies also need to make an assumption regarding the source of the crisis, i.e. the country that triggered the crisis (Baur and Fry, 2009 propose a methodology to test such an assumption). The Asian financial crisis of 1997 and 1998 is a good example to illustrate the difficulties to identify the crisis source and the exact crisis start and end date. Baig and Goldfajn (1999), Forbes and Rigobon (2002), Boyer et al. (2006) and Rodriguez (2007) use different crisis periods or source countries (Thailand or Hong Kong). Not surprisingly, they report different results. While Baig and Goldfajn (1999) and Forbes and Rigobon (2002) use ad-hoc definitions of the crisis period, Boyer et al. (2006) and Rodriguez (2007) use a regime-switching model to identify the crisis period endogenously. Both studies assume the existence of two regimes (''stable'' and ''volatile'') where the ''volatile'' regime defines the crisis period. This approach avoids discretion in the identification of the crisis period but lacks the modeling flexibility, especially the integration of economic and financial events in the crisis identification, of the method employed by the former studies. Finally, it is important to note that the crisis lengths obtained with the endogenous methodology substantially exceed the ad-hoc approach.[3]

We combine both methodologies in the following way. Firstly, we define a relatively long crisis period which includes all major financial and economic news events representing the GFC. Secondly, we use volatility estimates of the potential source of the crisis to identify regimes of excess volatility. This methodology yields different crisis period start and end dates depending on the definition of the source of the crisis and the threshold that defines ''excess'' volatility. Thirdly, we identify the time window which is common to both methodologies. In a final step, the model which provides the coefficient estimates to test for contagion is estimated for all crisis periods identified and the sensitivity of the results is assessed and discussed.

It is important to note that all studies of contagion are arbitrary to some degree as they all depend on a correct definition of the crisis period. 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.

To obtain a long crisis period which encompasses all major financial and economic events that represent the GFC we use timelines provided by the Federal Reserve Board of St. Louis (2009), Guillen (2009) of the Lauder Institute at Wharton and the Bank for International Settlements (BIS, 2009) among others. The BIS study separates the timeline in four phases from the third quarter in 2007 until the end of 2009. Phase 1 spans a period from Q3 in 2007 until mid-September 2008 and is described as ''initial financial turmoil''. Phase 2 (mid-September 2008 until late 2008) is defined as ''sharp financial market deterioration'', phase 3 is a phase of macroeconomic deterioration (until Q1 2009) and phase 4 is described as ''stabilization and tentative signs of recovery'' including a financial market ''rally'' (from Q2 2009 onwards). According to the studies cited above, the crisis can be defined from August 2007 until March 2009 covering the first three phases. This crisis start is justified by one main event in August 2007, i.e. the deterioration of liquidity in the money market following negative announcements by the investment banks Bear Stearns and BNP Paribas (see also Taylor and Williams, 2008) and leading to substantial central bank intervention. The month that marks the end of this crisis period can be characterized by the absence of negative news events and a stock market rally.

The next step uses estimates of excess volatility to identify the start date and end date of the GFC. We assume that the GFC originated in the financial sector and use the volatility of global (world) financial sector returns as a crisis indicator. We use four different thresholds to define excess volatility and determine two regimes, a low volatility or stable regime and a high volatility or crisis regime. The thresholds are given by the 95%, 99%, 99.5% and 99.9% quantiles based on the pre-crisis distribution of return volatility. Fig. 1 presents the conditional volatility estimates of the world financial sector stock index for weekly returns for the period from 1979 to 2009.[4] The conditional volatility is estimated with an asymmetric (Glosten et al., 1993) GARCH model. The resulting period in which the volatility of world financial stock returns continuously exceeds the thresholds and thus defines a crisis regime is from July 2008 until June 2009 for the 95% quantile, from October 2008 until May 2009 for the 99% quantile, from October 2008 until April 2009 for the 99.5% quantile and from November 2008 until March 2009 for the 99.9% quantile.[5] These estimates of a crisis regime are all located within the crisis period based on economic and financial news events identified above. The dummy variable D_t as defined in Section 2.1 is set equal to one if t is part of the crisis period and zero otherwise. The sensitivity of the estimation results with respect to the specification of the dummy variable D_t is systematically analyzed in Section 2.3 below.

Fig. 2 presents volatility estimates of three different index returns (world aggregate stock index, world financial sector stock index and US financial sector stock index) for a sub-sample period from 2007 until 2009. The graph shows that the volatility of the global financial sector index returns increased steadily from 2007 and peaked on November 25, 2008. In contrast, the volatility of the US financial sector peaked 2 months later while the world aggregate index displays a similar pattern of volatility as the global financial sector index. This analysis helps to identify the core of the crisis period and also shows how the crisis, investors' risk aversion and uncertainty in the market, evolved through time.

This section described the problems of an adequate crisis period identification and proposed a combined approach. The identification issue is further analyzed by a systematic variation of the crisis start date with a fixed crisis period window and a systematic variation of the crisis period window with a fixed crisis start date in Section 3.

2.3. Benchmark model and hypotheses

Following the description of econometric models and issues regarding the identification of the crisis period in Sections 2.1 and 2.2, respectively, this section specifies a benchmark model and various tests of contagion based on the model's coefficient estimates.

[3] The crisis period length for the Asian crisis spans 20 trading days in Forbes and Rigobon (2002) compared to several months in Rodriguez (2007).

[4] The indices are total market indices obtained from Datastream.

[5] The choice of the thresholds is arbitrary but necessary to define high or ''excess'' volatility regimes. In addition, this methodology provides full information about how the regimes were obtained in contrast to studies that estimate regime-switching models. The crisis periods based on US financial sector returns and aggregate world index return volatility are similar.

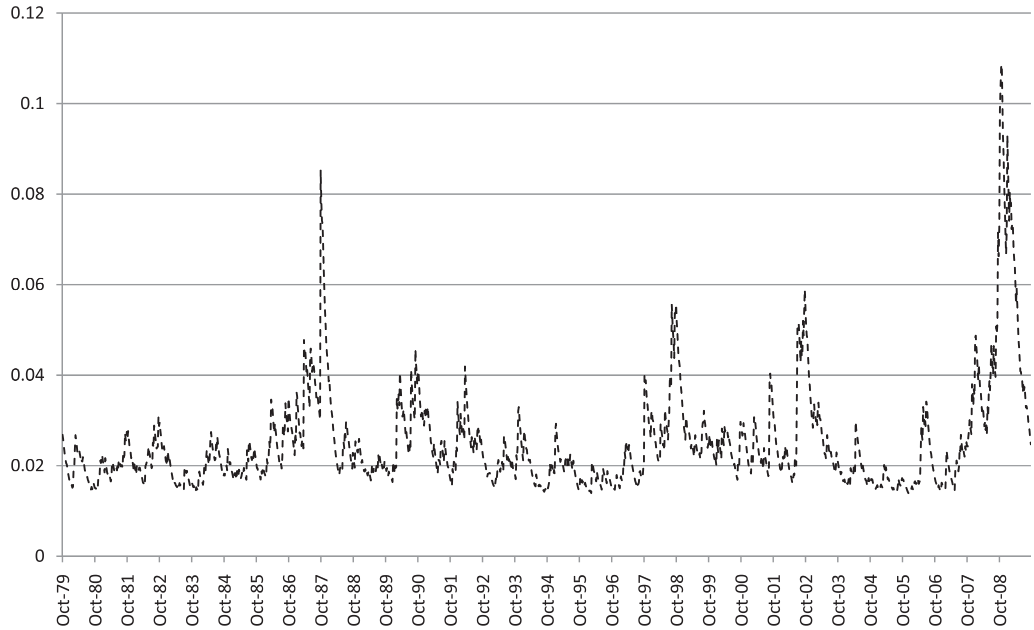

Fig. 1. Conditional volatility: World financial sector. The graph presents conditional volatility estimates (asymmetric GJR-GARCH(1,1)) of the aggregate world financial sector stock index. Regimes of extreme (excess) volatility can be identified around October 1987, September 1998, October 2002 and October 2008.

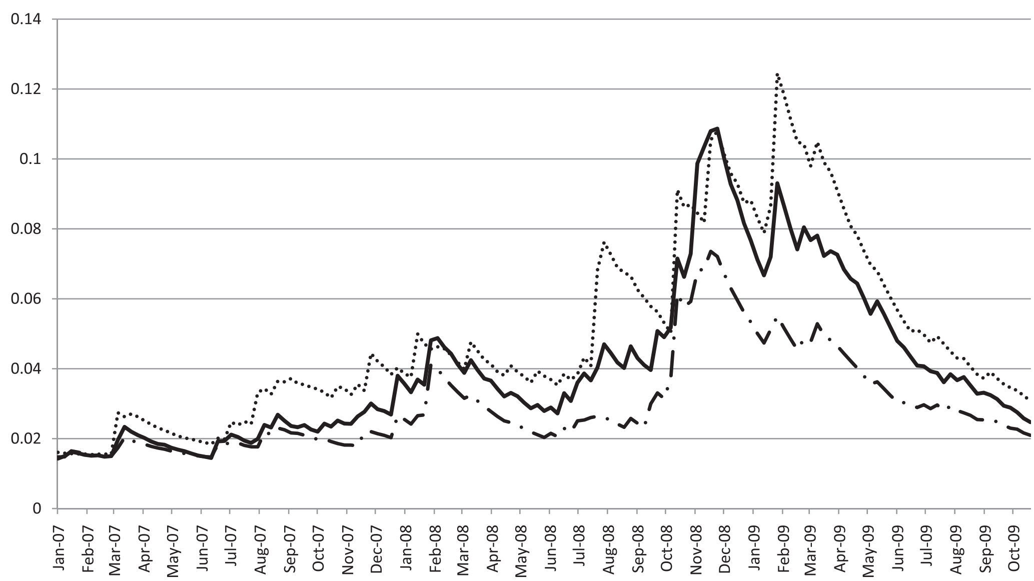

Fig. 2. Conditional volatility in Global Financial Crisis. The graph shows the volatility (asymmetric GJR-GARCH(1,1)) of the world index return (dashed-dotted line),world financial sector return (straight line) and US financial sector return (dashed line).

The econometric model is specified as follows:

$$R_{S,i,t} = a + b_1 R_{FIN,W,t} + b_2 R_{FIN,W,t} D_t + e_{S,i,t} \tag{6a}$$

$$h_{S,i,t} = \pi + \alpha e^2_{S,i,t-1} + \beta e^2_{S,i,t-1} I(e_{S,i,t-1} < 0) + \gamma h_{S,i,t-1} \tag{6b}$$

$$e_{S,i,t} = (h_{S,i,t})^{0.5} z_{S,i,t} \tag{6c}$$

$$Z_{S,i} \sim N(0,1) \tag{6d}$$

The system of Eq. (6) estimates the degree of co-movement of a sector-portfolio (S) with a global financial sector portfolio (*FIN, W*) in normal and crisis times. The parameter b_1 captures the degree of co-movement in normal times and the parameter b_2 measures the change in the degree of co-movement in the crisis period defined by the dummy variable D which is equal to one if t is part of the crisis period and zero otherwise. The global or system-wide portfolio of financial stocks is exclusively composed of financial stocks to analyze the spreading of the crisis from the financial sector to the real economy, i.e. shares of firms that represent the real economy. The subscript S denotes the sector which can assume *FIN* for the financial sector or other, non-financial, sectors. 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 M.

Since equity returns exhibit conditional heteroscedasticity, the model is estimated within a GARCH framework. In addition, we account for the asymmetric impact of positive and negative shocks on the conditional volatility in equity markets by specifying the error term as an asymmetric GARCH process a la Glosten et al. (1993).

The model given by Eq. (6) is used to test four alternative types 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, Eq. (6) is augmented as follows:

$$R_{S,i,t} = a + b_1 R_{FIN,W,t} + b_2 R_{FIN,W,t} D_t + c_1 R_{FIN,i,t} + c_2 R_{FIN,i,t} D_t + e_{S,i,t} \tag{7a}$$

The equation can be used to estimate changes in the return co-movement of a specific sector S with the global financial system ($R_{FIN,W}$) or with the domestic financial system ($R_{FIN,i}$). The tests and hypotheses are given below.

Test 1 (contagion of aggregate stock market):

Increased co-movement of a country's stock market and world portfolio of stocks in crisis period compared to tranquil period.

Test 2 (contagion of financial sector):

Increased co-movement of a country's financial sector stocks and world portfolio of financial sector stocks in crisis period compared to tranquil period.

Test 3 (global financial contagion of real economy sector):

Increased co-movement of a country's non-financial sector stocks and world portfolio of financial sector stocks in crisis period compared to tranquil period.

Test 4 (domestic financial contagion of real economy sector):

Increased co-movement of a country's non-financial sector stocks and domestic portfolio of financial sector stocks in crisis period compared to tranquil period.

The null hypothesis (H_0) and alternative hypothesis (H_1) for tests 1–3 are given by

H_0: $b_2 \leqslant 0$ (no contagion)
H_1: $b_2 > 0$ (contagion).

For test 4 the null and alternative hypotheses are represented by

H_0: $c_2 \leqslant 0$ (no contagion)
H_1: $c_2 > 0$ (contagion).

Test 1 entails an assessment of aggregate stock market index contagion across countries, tests 2–3 analyse the existence of sector-specific cross-country contagion and test 4 examines contagion across sectors within a country. Tests 1–3 can be further characterized as global tests of contagion while test 4 can be interpreted as a local or domestic test of contagion.

The testing framework also allows an analysis of the homogeneity of the contagion effects across countries and sectors. If the propagation of shocks is homogeneous, there is evidence that investors pool sectors or markets and act similarly. It is clear that contagion in stock markets is linked to investor behavior. If investors sell stocks simultaneously, it is possible that this leads to an increased co-movement of the respective stocks establishing contagion. However, it is not clear what drives such investor behavior. Is contagion across sectors investor-induced or fundamentals-induced (see Boyer et al., 2006)? If investors sell all stocks in their portfolios as a reaction to a crash in financial sector stocks, either because they are forced to due to margin calls or because they panic and prefer safer assets such as government bonds, there is investor-induced contagion. In contrast, fundamentals-based contagion occurs if investors observe a change in fundamentals and act accordingly. For example, if firms face financing problems and a higher cost of capital due to more risk-averse banks and investors, non-financial (real economy) sector stocks will fall in response to a crisis in the financial sector. Another example focuses on the demand side (consumers) as opposed to the supply side (firms) of an economy. If consumers suffer financial losses due to investments in the financial sector, face tougher borrowing constraints or general uncertainty related to a potential crisis, they will spend less than in normal periods adversely affecting the real economy through a lower aggregate demand. Finally, if consumers anticipate a spillover of the crisis from the financial sector to the real sector and spend less, the infection can be self-fulfilling. The latter would lead to an immediate contagion while the former would most likely occur with a certain lag.

We assume that investor-induced contagion leads to a relatively homogeneous change in the level of co-movement across countries and sectors whereas fundamentals-based contagion is expected to lead to a more heterogeneous picture of contagion. Both assumptions are analyzed in the empirical section.

3. Empirical analysis

This section introduces the data which is used for the empirical analysis and the econometric estimation.

3.1. Data

The data comprises weekly prices (Tuesday to Tuesday closing prices) of aggregate stock indices and sector stock indices for 25 countries and ten sectors denominated in local currency. The local currency denomination is used to analyze the transmission of a crisis in the financial sector to the real sector from a local economy or local investor perspective. The data is obtained from Thomson Financial (Datastream). The analysis entertains weekly data to avoid a bias due to non-synchronous trading across countries. The data cover a 30-year period from October 23, 1979 until October 20, 2009 leading to a sample size of 1565 weekly observations.

Table 1 reports summary statistics of aggregate stock market (Datastream total market) indices' weekly returns for all 25 countries. The statistics are based on the entire sample period and show significant differences in mean returns, standard deviations, skewness, kurtosis and autocorrelation (Ljung-Box statistics) across the returns.

Table 2 presents the summary statistics for the crisis period identified using key economic and financial events of the GFC as described in the "Crisis identification" section above. The statistics are reported for a 86 week period from July 2007 to March 2009.

Fig. 3 presents the cross-sectional average of the mean return for a 12-week period through time from August 2007 until March 2009. The time-series plot of cross-sectional averages of weekly mean returns illustrates the evolution of the crisis and shows that there is a global minimum located around the first week of August 2008. The average weekly cross-sectional return for a 12-week period starting in August 2008 is −3.37%. The time-series can be interpreted as the average return of an equally-weighted portfolio comprising all stocks over a 12-week investment horizon. The periods of negative average returns overlaps with periods of increased volatility as reported in Fig. 2.

In the following we present graphs illustrating the movement of aggregate and disaggregate stock indices for a selection of countries and sectors. The presentation aims to provide preliminary evidence for the existence of cross-country contagion and cross-sector contagion as given by the hypotheses above.

Fig. 4 illustrates the evolution of the world and the US aggregate stock indices and the respective financial sector indices. The figure

Table 1
Descriptive statistics. The table presents descriptive statistics of the weekly aggregate stock market returns for each of the 25 countries in the sample for the period 1979–2009.

	Full period								
	Mean	Std. dev.	Min.	Max.	Skewness	Kurtosis	Ljung Box (12)	*p*-Value	*N*
Australia	0.0016	0.0266	−0.3545	0.1035	−1.8751	25.7277	18.6742	0.0967	1565
Brazil	0.0016	0.0282	−0.1860	0.2184	−0.2615	12.7587	72.1077	0.0000	797
Canada	0.0015	0.0223	−0.2352	0.1157	−1.2847	14.9162	17.1407	0.1444	1565
Chile	0.0021	0.0220	−0.1225	0.1202	0.1455	7.0377	57.2018	0.0000	1059
China	0.0011	0.0389	−0.2819	0.2672	−0.3611	12.8664	59.1077	0.0000	847
France	0.0016	0.0275	−0.1875	0.1575	−0.7027	7.8340	16.6723	0.1623	1565
Germany	0.0012	0.0256	−0.1730	0.1182	−0.9722	8.0050	12.9354	0.3738	1565
Hong Kong	0.0022	0.0410	−0.3669	0.1830	−1.1138	11.4397	22.1451	0.0359	1565
Indonesia	0.0008	0.0360	−0.2864	0.2521	−0.1056	12.8892	60.4858	0.0000	1016
India	0.0020	0.0376	−0.3641	0.3488	−0.4796	17.1808	61.9932	0.0000	1027
Italy	0.0019	0.0336	−0.2345	0.1953	−0.2666	7.1872	34.0048	0.0007	1565
Japan	0.0006	0.0273	−0.1920	0.1511	−0.4379	7.5267	20.6231	0.0562	1565
Mexico	0.0035	0.0327	−0.1851	0.3323	0.9459	14.9793	50.0532	0.0000	1137
NZ	0.0005	0.0204	−0.1760	0.1700	0.2772	14.6387	30.8588	0.0021	1137
Norway	0.0017	0.0352	−0.3043	0.2380	−0.9043	13.2051	47.1404	0.0000	1552
Russia	0.0022	0.0467	−0.3697	0.3294	−0.5610	16.1299	74.4592	0.0000	800
South Africa	0.0029	0.0321	−0.2248	0.1426	−0.8053	8.1725	24.3789	0.0181	1565
South Korea	0.0009	0.0374	−0.1826	0.1828	0.1307	6.5673	18.7985	0.0935	1151
Spain	0.0010	0.0244	−0.1889	0.1789	−0.7715	11.1279	34.7422	0.0005	1178
Sweden	0.0020	0.0320	−0.1602	0.2081	−0.3384	7.0135	31.0345	0.0019	1450
Switzerland	0.0015	0.0226	−0.1918	0.1372	−1.2050	12.3232	22.7937	0.0295	1562
Taiwan	0.0005	0.0403	−0.2346	0.1914	−0.4080	6.8901	27.7058	0.0061	1150
Thailand	0.0012	0.0399	−0.2241	0.3041	0.1612	9.4972	17.4775	0.1325	1188
UK	0.0016	0.0229	−0.2484	0.1683	−1.0707	15.5226	19.7490	0.0720	1565
US	0.0016	0.0239	−0.2709	0.1230	−1.3770	16.7807	39.0135	0.0001	1565

Table 2
Descriptive statistics – crisis period. The table presents descriptive statistics of the weekly aggregate stock market returns for each of the 25 countries in the sample for the 86 week crisis period from August 2007 until March 2009.

	Full crisis period							
	Mean	Std. dev.	Min	Max	Skewness	Kurtosis	Ljung Box (12)	*p*-Value
Australia	−0.0060	0.0400	−0.1402	0.1030	−0.4208	4.8203	2.5488	0.6359
Brazil	−0.0040	0.0489	−0.1771	0.1824	−0.2101	6.1818	5.6099	0.2302
Canada	−0.0052	0.0384	−0.1748	0.0963	−0.8792	6.4950	1.8564	0.7621
Chile	−0.0030	0.0309	−0.1225	0.0825	−0.5841	4.7713	3.4835	0.4804
China	−0.0049	0.0745	−0.2177	0.1855	−0.4986	3.5779	2.7612	0.5985
France	−0.0084	0.0385	−0.1050	0.1575	0.5348	5.8328	3.2287	0.5203
Germany	−0.0074	0.0349	−0.1107	0.1014	−0.4603	3.9047	5.7602	0.2178
Hong Kong	−0.0072	0.0540	−0.1638	0.1292	−0.2307	3.4227	3.7319	0.4435
Indonesia	−0.0057	0.0653	−0.2864	0.2304	−0.6304	7.6764	8.1138	0.0875
India	−0.0052	0.0644	−0.2428	0.1495	−0.7833	4.4458	8.6001	0.0719
Italy	−0.0103	0.0427	−0.1406	0.1953	0.9059	8.7384	5.0455	0.2827
Japan	−0.0089	0.0460	−0.1920	0.1511	−0.2867	5.9906	8.4306	0.0770
Mexico	−0.0049	0.0378	−0.1479	0.1211	−0.2911	5.4874	7.1260	0.1294
NZ	−0.0060	0.0231	−0.0795	0.0517	−0.3850	3.8805	1.4858	0.8292
Norway	−0.0086	0.0581	−0.1742	0.2380	0.2527	6.4181	6.8413	0.1445
Russia	−0.0118	0.0819	−0.3353	0.3122	−0.4163	7.5823	21.4638	0.0003
South Africa	−0.0035	0.0428	−0.1369	0.1426	−0.1892	4.8833	11.1164	0.0253
South Korea	−0.0052	0.0473	−0.1608	0.1372	−0.1862	4.1264	5.8523	0.2105
Spain	−0.0083	0.0407	−0.1724	0.1789	0.1934	9.1339	4.9017	0.2975
Sweden	−0.0083	0.0474	−0.1418	0.2081	0.8078	7.1354	4.8608	0.3019
Switzerland	−0.0067	0.0350	−0.1080	0.1372	0.4361	5.4706	3.0126	0.5557
Taiwan	−0.0067	0.0465	−0.1144	0.1315	0.0473	3.1077	3.5239	0.4743
Thailand	−0.0081	0.0472	−0.1929	0.1527	−0.2388	5.9555	1.5043	0.8259
UK	−0.0059	0.0385	−0.0861	0.1683	0.7525	6.4299	1.4835	0.8296
US	−0.0067	0.0375	−0.1637	0.0748	−1.0484	6.2074	0.8869	0.9264

shows that there is strong co-movement of all four indices particularly at the end of the sample period.

Fig. 5 presents the levels of aggregate stock indices for Germany, Japan, the UK and the US. The graph shows significant co-movement among all four stock indices and significant declines in the levels at the end of the sample period. Fig. 6 illustrates the performance of the financial sector stock indices for the same group of countries.

Fig. 7 presents the evolution of four sectors (Basic Materials, Consumer Goods, Financials and Industrials) of the world stock price index. The figure demonstrates that all sectors were affected by the Global Financial Crisis with Consumer Goods the least affected.

The graphical analysis of the indices shows that aggregate stock market indices and sectors decreased simultaneously during the financial crisis. While some graphs indicate that the degree of co-movement and thus the impact of the GFC varied across countries and sectors, it is not straightforward to determine significant changes in the degree of co-movement and thus the existence of contagion. The next section uses an econometric model to analyze changes in the transmission of shocks across countries and sectors.

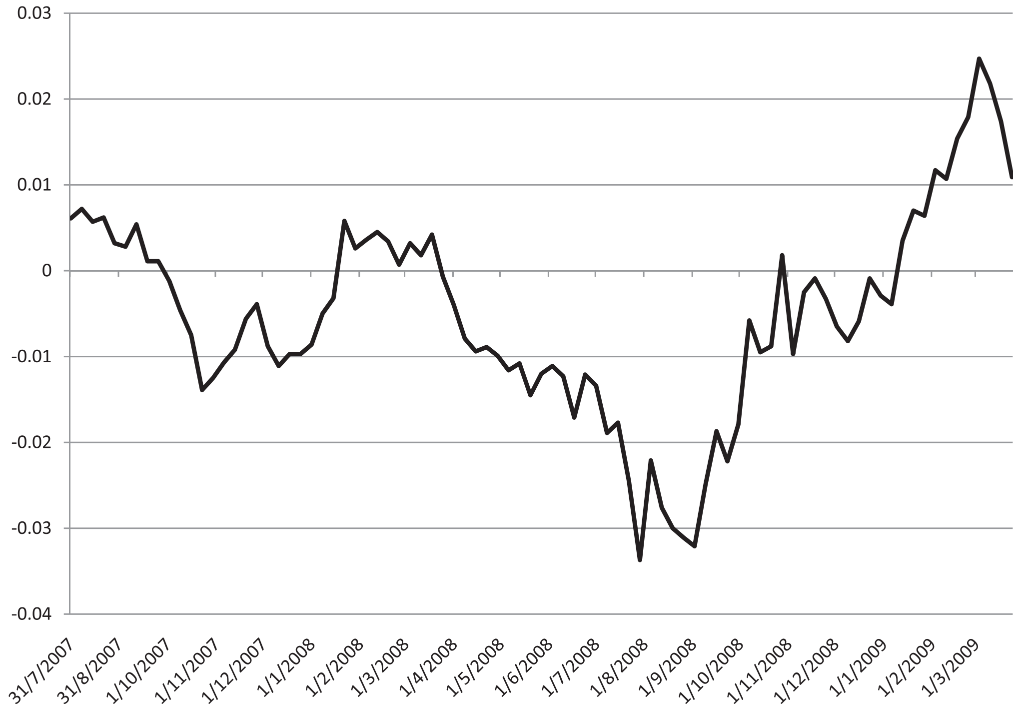

Fig. 3. Rolling window cross-sectional average for rolling crisis period start date and 12 week duration. The graph shows the time-varying severity of the financial crisis measured as the mean return over a 12-week period for an equally-weighted portfolio comprising 25 stock markets.

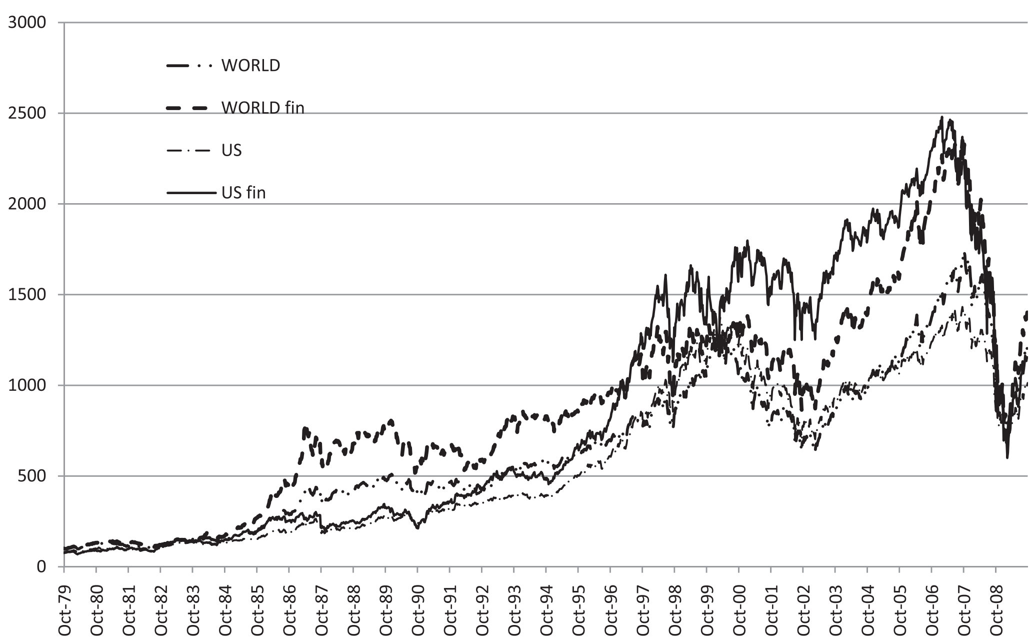

Fig. 4. Stock market indices 1979–2009: World stock index, World financial sector index, US stock index, US financial sector index. The graph shows that the four indices exhibit increased co-movement in 2008 compared to the pre-crisis period from 2003 to 2007.

3.2. Estimation results

This section presents the estimation results of the econometric model specified in Eq. (6) and discusses the implications for the hypotheses derived from the model and formulated in Section 2. The section is structured accordingly. The results presented below are based on the crisis period identification based on major financial and economic events during the GFC as described in above. The crisis period is identified for the period July 2007 to March 2009. This crisis period is used as a benchmark and systematically changed as part of a robustness analysis and an assessment of the evolution of the GFC.

Table 3 displays the estimation results of the regression model testing for aggregate stock market contagion. The table shows the coefficient estimates with the country tabulated in the first column, the constant (second column), the normal-period influence of the world portfolio (third column) and the crisis-specific influence or co-movement of a world portfolio of stocks and each of

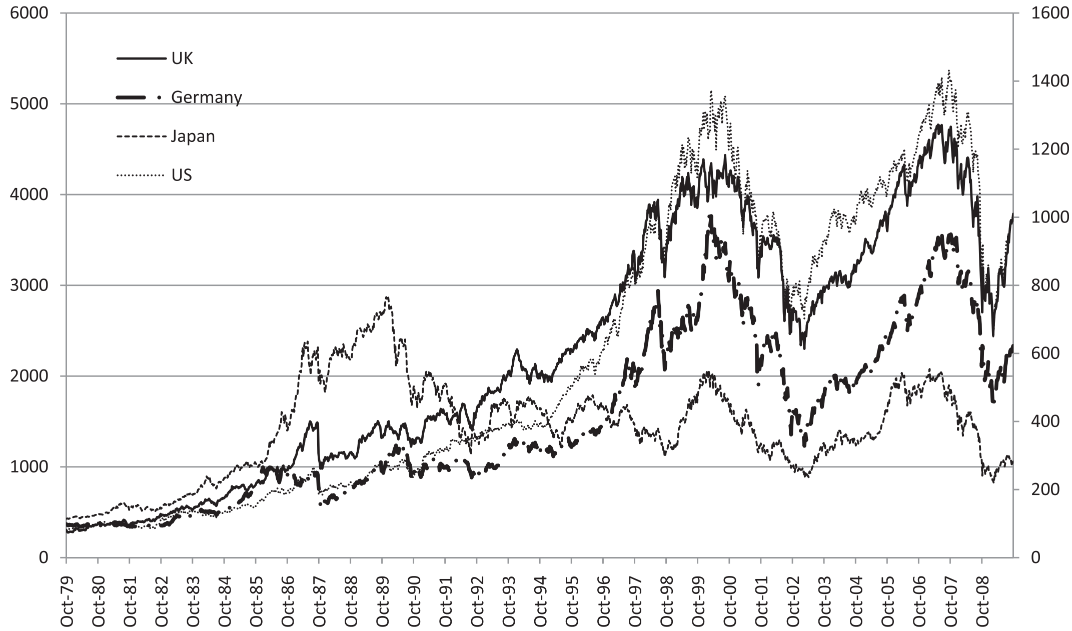

Fig. 5. Aggregate stock market indices 1979–2009: Germany, Japan, UK, US.

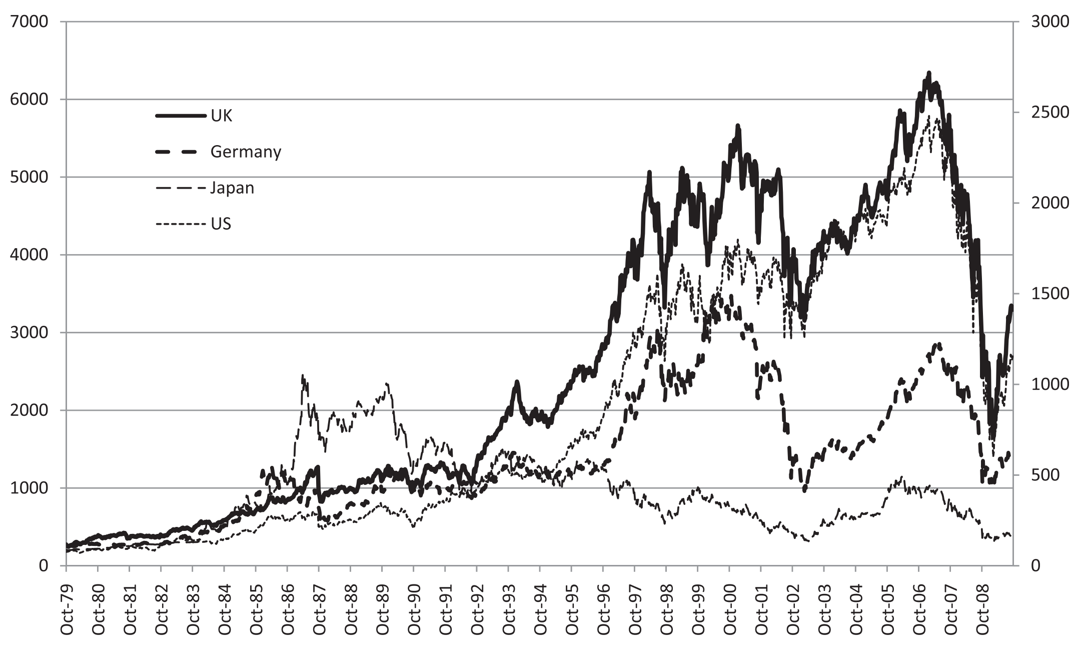

Fig. 6. Financial sector stock indices – selected countries: Germany, Japan, UK, US.

the 25 countries in the sample. The coefficient estimates for the crisis-specific influence shows that 18 out of 25 countries exhibit an increased co-movement with the world portfolio. This means that there is aggregate stock market contagion in most countries. Countries that are not affected by an increased co-movement with the world portfolio are Brazil, Germany, Mexico, Spain, Sweden, Thailand and the US. The fact that there is no evidence of contagion in the aggregate stock market does not mean that these countries were not affected by the crisis. The findings merely imply that these countries did not suffer from an increased co-movement with a falling portfolio of world stocks. Hence, hypothesis 1 cannot be rejected for 7 out of 25 countries. Further analysis of the decreasing co-movement of Germany and the US with the aggregate portfolio illustrates that the co-movement with the world portfolio of stocks decreased because the value of the world stock portfolio deteriorated by more than the German and the US aggregate stock portfolios in that period.

The results also show that the coefficient governing contagion (b_2) varies significantly across the entire sample of countries. In contrast, there is a remarkable homogeneity of coefficient estimates for some countries. For example, Australia, Chile and South Korea all display values of around 0.15, Hong Kong, Indonesia and India values around 0.65 and Russia and South Africa values around 0.25. This homogeneity of the contagion effect for groups of comparable countries suggests a similar reaction of investors to the financial crisis.

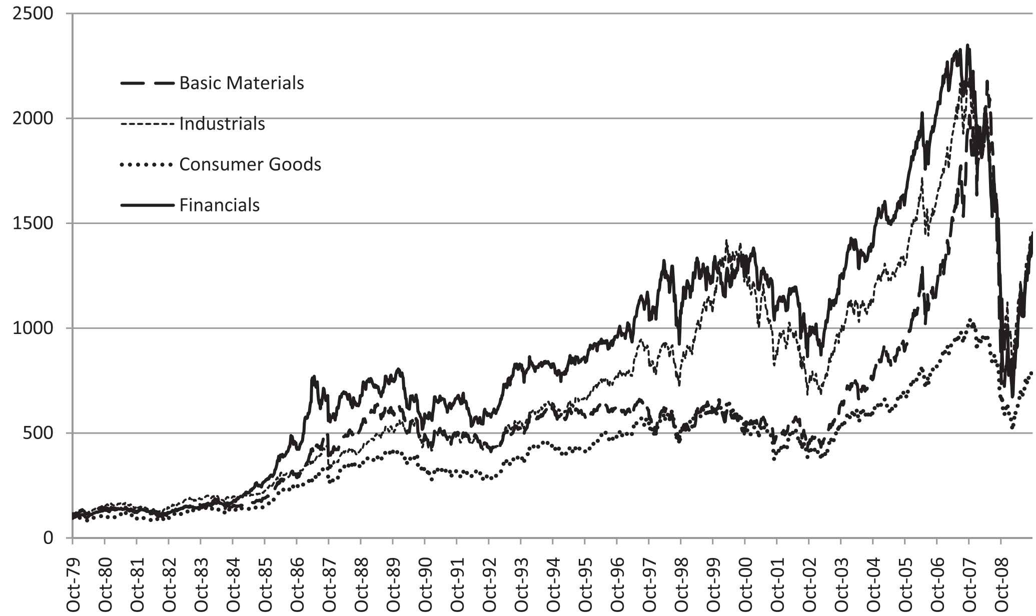

Fig. 7. World sector stock indices: Basic Materials, Industrials, Consumer Goods, Financials.

Table 4 presents the estimation results of the model testing for an increased co-movement of financial sector stocks of a country with a world portfolio of financial stocks. The table shows that 19 out of 25 countries exhibit an increased co-movement and thus contagion (hypothesis 2 can be rejected). The countries for which hypothesis 2 cannot be rejected are Japan, Mexico, New Zealand, South Africa, South Korea and Thailand. However, most of these countries display a high level of interdependence with the systematic component in general (for example, Japan has a normal level of interdependence of 1.03 and Russia a coefficient of 0.88). This is consistent with the Forbes and Rigobon (2002) result that interdependence does not imply contagion.

India stands out as an example of a country whose financial market is only moderately linked to the global financial sector in normal times (0.3650) but highly linked in the crisis period (1.1593). The degree of co-movement in the crisis period can be

Table 3
Estimation results – global aggregate stock market contagion. The table shows the estimation results of a model testing for aggregate stock market contagion.

	Coefficient			
	a	b_1	b_2	Contagion
Australia	0.0008**	0.5888***	0.1441***	C
Brazil	0.0021***	1.0043***	−0.0263	
Canada	0.0005*	0.7311***	0.0710**	C
Chile	0.0021***	0.3718***	0.1589***	C
China	0.0023**	0.7832***	0.5997***	C
France	0.0003	0.7740***	0.1228***	C
Germany	0.0003	0.7222***	−0.1022***	
Hong Kong	0.0021***	0.4996***	0.6677***	C
Indonesia	0.0016*	0.5901***	0.6855***	C
India	0.0032***	0.5271***	0.6414***	C
Italy	0.0001	0.7573***	0.1988***	C
Japan	−0.0005	0.8470***	0.1144***	C
Mexico	0.0028***	0.8388***	−0.0093	
NZ	0.0005	0.3559***	0.0538*	C
Norway	0.0013**	0.7248***	0.5385***	C
Russia	0.0044***	1.0839***	0.2572**	C
South Africa	0.0021***	0.6387***	0.2453***	C
South Korea	0.0003	0.7829***	0.1692**	C
Spain	0.0006	0.8008***	0.0052	
Sweden	0.0009*	0.8971***	0.0477	
Switzerland	0.0009**	0.5341***	0.1916***	C
Taiwan	−0.0001	0.8295***	0.0282	
Thailand	0.0014	0.6985***	0.1898**	C
UK	0.0002	0.7171***	0.1330***	C
US	−0.0002	0.9439***	−0.1189***	

Note: Coefficient estimates of asymmetric GARCH model are not reported.
Model: $R_{aggr,i,t} = a + b_1\ R_{aggr,W,t} + b_2 R_{aggr,W,t}\ D_t + e_{aggr,i,t}$.
*** Denote statistical significance 1%.
** Denote statistical significance 5%.
* Denote statistical significance 10%.

Table 4
Estimation results – global financial sector contagion. The table shows the estimation results of a model testing for cross-country financial sector contagion.

	Coefficient			
	a	b_1	b_2	Contagion
Australia	0.0011**	0.4136***	0.2219***	C
Brazil	0.0024**	0.6411***	0.1946***	C
Canada	0.0011***	0.4849***	0.2021***	C
Chile	0.0020***	0.2258***	0.1777***	C
China	0.0029*	0.6103***	0.2752***	C
France	0.0009*	0.5849***	0.4449***	C
Germany	0.0010**	0.6379***	0.2245***	C
Hong Kong	0.0017***	0.4698***	0.3024***	C
Indonesia	0.0002	0.4962***	0.3615***	C
India	0.0046***	0.3650***	0.7943***	C
Italy	0.0008	0.6248***	0.2383***	C
Japan	−0.0011**	1.0333***	−0.0021	
Mexico	0.0035***	0.5266***	−0.0663	
NZ	−0.0001	0.3384***	−0.1330***	
Norway	0.0015**	0.5109***	0.4910***	C
Russia	0.0064***	0.8814***	0.2038*	C
South Africa	0.0025***	0.4895***	0.0519	
South Korea	−0.0004	0.6717***	0.0177	
Spain	0.0007	0.6937***	0.1846***	C
Sweden	0.0008	0.7559***	0.0832**	C
Switzerland	0.0006	0.4896***	0.5676***	C
Taiwan	−0.0007	0.6318***	0.1942**	C
Thailand	0.0012	0.4639***	0.0609	
UK	0.0005	0.6385***	0.3951***	C
US	0.0001	0.8092***	0.2113***	C

Note: Coefficient estimates of asymmetric GARCH model are not reported.
Model: $R_{FIN,i,t} = a + b_1\ R_{FIN,W,t} + b_2\ R_{\ FIN,W,t}\ D_t + e_{\ FIN,i,t}$.
*** Denote statistical significance 1%.
** Denote statistical significance 5%.
* Denote statistical significance 10%.

Table 5
Estimation results – global financial contagion of real economy. The table shows the estimation results of a model testing for non-financial sector contagion (contagion from global financial sector).

	Oil and Gas	Basic Materials	Industrials	Consumer goods	Healthcare	Consumer services	Telecom.	Utilities	Technology
Australia	C***	C***	C***					C*	
Brazil									
Canada		C***							
Chile									
China									
France	C***	C***	C***	C***		C***		C***	C***
Germany			C***	C**				C***	
Hong Kong									
Indonesia									
India									
Italy	C**	C***	C***	C***	C***				C***
Japan									
Mexico		C**	C*						
NZ								C*	
Norway		C***				C*		C***	
Russia				C***					
South Africa	C***	C**	C***				C***	C***	
South Korea	C*	C***		C**		C***	C***		
Spain		C***			C***			C*	
Sweden	C**								
Switzerland		C***	C***	C*	C**			C*	C***
Taiwan									
Thailand								C**	
UK	C***	C***	C***			C**		C***	C***
US	C***	C***	C***	C**	C***		C***	C***	C***

C denotes contagion if b_2 is positive.
Model: $R_{S,i,t} = a + b_1\ R_{FIN,W,t} + b_2\ R_{FIN,W,t}\ D_t + c_1\ R_{FIN,i,t} + c_2\ R_{FIN,i,t}\ D_t + e_{S,i,t}$.
*** Denote statistical significance 1%.
** Denote statistical significance 5%.
* Denote statistical significance 10%.

calculated by adding up the coefficient estimates b_1 and b_2. This finding points to the possibility that contagion is non-linear (see Rodriguez, 2007) and can be characterized by jumps, e.g. there is a low degree of interdependence in normal times and a very high degree of interdependence compared to other countries in the crisis period.

In addition, there is a considerable homogeneity in the coefficient estimates across the entire sample and a strong similarity

Table 6
Estimation results – domestic financial contagion of real economy. The table shows the estimation results of a model testing for non-financial sector contagion (contagion from domestic financial sector).

	Oil and Gas	Basic Materials	Industrials	Consumer goods	Healthcare	Consumer services	Telecom.	Utilities	Technology
Australia									C***
Brazil	C*	C***	C***			C***			
Canada							C***		
Chile	C***	C***	C***	C**	C***	C***	C***	C***	
China	C***	C***	C***	C**		C***	C***	C***	
France									
Germany									
Hong Kong	C*	C***		C***		C***			C***
Indonesia	C***	C***	C***	C***	C**	C***	C*	C**	
India	C***	C***	C***					C***	
Italy									
Japan		C***	C***	C***					C**
Mexico									
NZ	C*	C**		C*	C***	C***		C***	
Norway				C***	C**	C**			
Russia	C***	C***	C***		C*	C***		C***	
South Africa						C**			
South Korea	C*								
Spain	C**								
Sweden		C***	C*		C**				
Switzerland							C**		
Taiwan	C*			C***		C***			
Thailand	C***	C***	C***	C***	C**	C*			
UK									
US									

C denotes contagion if c_2 is positive.
Model: $R_{S,i,t} = a + b_1\ R_{FIN,W,t} + b_2\ R_{FIN,W,t}\ D_t + c_1\ R_{FIN,i,t} + c_2\ R_{FIN,i,t}\ D_t + e_{S,i,t}$.
*** Denote statistical significance 1%.
** Denote statistical significance 5%.
* Denote statistical significance 10%.

in the contagion effect for a group of 11 countries which exhibit a contagion coefficient (b_2) around 0.2.

Table 5 displays the results associated with hypothesis 3 testing the existence of contagion among the world financial sector and the sectors representing the real economy in each country. This test assumes that the global financial system has a direct impact on non-financial firms, i.e. firms lend and borrow globally and are thus directly affected by a Global Financial Crisis. In order to control for an increased co-movement of the financial sector with the domestic financial sector, we use Eq. (10) which includes the domestic financial sector returns in normal and crisis periods as control variables.

Table 5 contains the coefficient estimates measuring the crisis-specific change in the level of co-movement of global financial stocks and local non-financial sector stocks. A positive and statistically significant coefficient estimate of the crisis-specific coefficient implies contagion. The table shows that there are 63 cases of contagion. Since ten sectors (except the local financial sector) in 25 countries can be infected, this represents an infection rate of 28%.

The lowest number of contagion incidences is presented by emerging markets (many countries show no incidence of contagion). In contrast, most developed markets display relatively high incidences of contagion across sectors. The US has the highest number with eight (out of 9) sectors infected followed by France with seven sectors infected. The sectors most affected are Basic Materials (12) and Utilities (11) while the least affected sectors are Telecommunications (3), Consumer Services (4) and Healthcare (4). The results demonstrate that developed countries' firms are more exposed to the global financial system than emerging market firms.

Table 6 shows the estimation results for a test of hypothesis 4. We use the same augmented model as for hypothesis 3 but focus on the coefficient estimates which quantify the crisis-specific co-movement of the local financial sector and the real economy. The test assumes that the domestic financial sector is infected by the crisis and spreads it to other domestic, non-financial, sectors.

The table shows that there are 73 cases of contagion, most of them in emerging markets. Many developed markets exhibit no case of contagion including Germany, the UK and the US. The countries with the highest number of contagion incidences are Chile (8), Indonesia (8) and China (7).

The sectors most affected are Oil and Gas (12), Basic Materials (11) and Consumer Services (11) and the sectors least affected are Technology (5), Telecommunications (5) and Utilities (6).

The coefficient estimates displayed in Tables 5 and 6 illustrate that there is increased return co-movement of the real economy sectors and the global financial sector in developed markets and increased co-movement in returns of the sectors representing the real economy and the local financial system. These changes in co-movement could also be labeled global financial contagion and domestic financial contagion, respectively.

Table 7 summarizes the four tests of contagion.

The fact that there is stronger evidence for contagion in the financial sector compared to the non-financial sector for most countries suggests that the financial sector is, in fact, the epicenter of the Global Financial Crisis. There are only six countries that do not exhibit an increased co-movement of the domestic financial sector with the global financial sector. Three of these countries display an increased but statistically insignificant level of co-movement (interdependence) and the remaining three countries exhibit a decreased level of co-movement (Japan, Mexico, New Zealand) with only one statistically significant negative change (New Zealand).

Table 7

Contagion – summary of results. This table summarizes the test results of four different types of contagion. Columns 2 and 3 indicate whether the country was affected by aggregate and financial sector contagion (C denotes contagion) and columns 4 and 5 display the number of real economy sectors affected by the crisis.

	Aggregate stock market contagion	Financial sector contagion	Global financial contagion of real economy	Domestic financial contagion of real economy
Australia	C	C	4	1
Brazil		C	0	4
Canada	C	C	1	1
Chile	C	C	0	8
China	C	C	0	7
France	C	C	7	0
Germany		C	3	0
Hong Kong	C	C	0	5
Indonesia	C	C	0	8
India	C	C	0	4
Italy	C	C	6	0
Japan	C		0	4
Mexico			2	0
NZ	C		1	6
Norway	C	C	3	3
Russia	C	C	1	6
South Africa	C		5	1
South Korea	C		5	1
Spain		C	3	1
Sweden		C	1	3
Switzerland	C	C	6	1
Taiwan		C	0	3
Thailand	C		1	6
UK	C	C	6	0
US		C	8	0

3.3. Specification issues

This section addresses various specification issues focussing on the robustness of the contagion results with respect to different crisis periods.

The specification of the crisis period is based on an economic and a statistical approach. The former defines the crisis period using major financial and economic events and the latter identifies the crisis period according to states of excess volatility. The results reported are primarily based on the economic approach which defines a relatively long period from August 2007 until March 2009 but encompasses all states of excess volatility as identified with the statistical approach. The statistical approach illustrates that the coefficient estimates and goodness of fit measures change only slightly for alternative crisis periods based on different threshold, i.e. varying degrees of excess volatility. If excess volatility is defined as volatility exceeding the 95% quantile, the average (cross-sectional) coefficient estimates of b_1 and b_2 are around 0.6 and 0.21 compared to 0.57 and 0.23, respectively, for the original crisis period and the cross-country financial sector contagion test (see Table 4). The estimate of b_1 is stable across all thresholds (95%, 99%, 99.5%, 99.9% quantiles) and the estimate of b_2 only changes for the 99.9% quantile and yields average values of 0.27. The fact that the evidence for contagion becomes stronger for the 99.9% quantile is not surprising given that the crisis period is relatively short and volatility extremely high.

The sensitivity of the crisis period definition is further analyzed systematically in two dimensions. First, by varying the crisis start date and fixing the crisis length and second, by fixing the crisis start date and varying the crisis length. If the crisis start date is increasing in weekly intervals starting from July 2008 and the crisis period length is fixed at 3 months, the average model fit for each country measured by the Log-likelihood in the GARCH specification and R squared in the OLS case is largest for start dates in July 2008 up to September 2008 and steadily declines thereafter as the start date is approaching the end of 2008. If the crisis start date is fixed at July 2008 and the crisis period length is varied from 3 months to 12 months in weekly intervals, the best model fit is obtained for shorter crisis periods and the values are slowly decaying for increasing lengths of the crisis period. The average coefficient estimates change only slightly and generally in an economically insignificant way. The outcome of this sensitivity analysis demonstrates that the estimation results depend on the crisis period definition and illustrates that shorter crisis periods in high volatility states lead to slightly larger estimates of contagion than longer crisis periods. This outcome is expected and shows that a longer crisis period as employed in this study yields more conservative estimates of contagion. However, it is important to add that the changes are rather small and insignificant in economic and financial terms.

The cross-sectional averages of the model fit measures and the coefficients are relatively stable. For example, the average R squared is estimated at 0.30 for the model testing cross-country aggregate stock market contagion (Table 3) and 0.24 for the model assessing cross-country financial sector contagion (Table 4) and both averages change by less than 0.01 across all crisis period alternatives.[6]

The definition of the crisis period implicitly determines the stable period as the rest of the sample period. The longer that period is the more likely it contains structural breaks that potentially bias the co-movement in the stable period. Therefore we analyze the sensitivity of the contagion results with respect to changes in the length of the pre-crisis (“stable”) period. The results are robust to all pre-crisis period specifications between 7 years (2000–2007) and 28 years (1979–2007) but change substantially for pre-crisis periods of less than 7 years. The evolution of stock prices over the entire 30-year sample period shows that the period between 2000 and 2010 is rather volatile compared to the period from 1990 to 2000 and from 1980−1990. Relatively short pre-crisis estimation periods can thus not be used as stable regimes and yield biased results.

Finally, we also estimated a simple regime-switching model with two regimes and find very similar qualitative results. For example, estimates of the aggregate stock market contagion for the US yield a stable-regime beta of 1.01 and a crisis-regime beta of 0.758 compared to the estimates reported in Table 3 where the corresponding coefficient estimates are 0.944 and 0.825 (0.944 − 0.119 = 0.825), respectively.

If the returns are filtered in a first-stage as described by Eqs. (1) and (2) the evidence for contagion changes significantly. The filtering and the elimination of the system-wide or systematic component lead to lower incidences of contagion. For example, there is evidence for global contagion across the financial sector in 19 out of 25 cases in the model based on Eq. (6) while this number drops to 10 out of 25 in a model based on Eqs. (1) and (2). Not unexpectedly, the filtering leads to weaker evidence of contagion than the model based on systematic contagion. The two-stage approach provides strong evidence for a decreased co-movement of the filtered returns in the crisis period compared to the normal period. This finding is consistent with an increased role of the systematic component in the crisis period reported above. The two-stage approach described by Eqs. (1) and (2) assumes that the exposure to systematic or system-wide shocks is constant and does not change in the crisis period. If this assumption is relaxed and Eq. (1) augmented with an interaction term allowing an increased impact of systematic shocks, the results change dramatically. The evidence for contagion of the financial sectors across countries drops to one. This explains that most of the observed changes in co-movement during the GFC are systematic in nature.

4. Concluding remarks

This paper studied the spread of the financial crisis of 2007–2009 from the financial sector to the “real economy”. The analysis comprises tests of stock market contagion on the aggregate level and the sector level, on the global level and the domestic level. The results show that the Global Financial Crisis can be characterized by strong contagion effects among aggregate stock markets and among financial sector stocks. In contrast, the evidence for contagion of the sectors representing the real economy such as Consumer Goods, Industrials, Telecommunications and Technology is mixed. The findings illustrate that the crisis of 2007–2009 is truly global in the sense that no region or specific group of countries, i.e. emerging or developed markets has been immune to the shocks associated with the crisis. In addition, the strong evidence for contagion of the financial sector demonstrates the importance of this sector in the crisis. The weaker evidence for contagion of the real economy sector especially for Healthcare, Telecommunications and Technology implies that investors distinguished between sectors and thus maintained the effectiveness of diversification.

The paper contributes to the literature by modeling and estimating financial and real economy cross-country and within-country contagion. The study thus provides important information about the role of the financial sector in spreading the crisis to other countries and sectors and can assist policy makers and investors to reduce the costs of a financial crisis in the future. The study also uses a novel approach to identify the crisis period in combination with an extensive sensitivity analysis. In addition, the disaggregated analysis of contagion increases the number of potential incidences of contagion and provides a more detailed and robust picture of contagion.

Future research could investigate the impact of regulatory measures and government stimulus packages on the probability of an infection of the real economy and the severity of a crisis.

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[6] The R squared is based on the estimates obtained with the asymmetric GARCH model via maximum-likelihood estimation. We report average R squared values as this measure can be interpreted in absolute terms.

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