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Stock Market Interdependence during the Iraq War

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Abstract

This paper aims to show how consolidated and innovative methodologies can be employed to assess the financial impact of a global shock. Particularly, we consider the Iraq War in 2003 and its impact on the market indexes of five of the most capitalised stock markets in the world, U.S., U.K., France, Germany and Italy. After using an event study methodology to assess the direct impact of War events on the five selected markets, we extensively analyse the correlation between these markets. Since cross-market correlation coefficients are conditional on market volatility, tests for market interdependence based on these coefficients are inaccurate due to heteroskedasticity. Therefore, during crises when markets are more volatile, like during the Iraq War, estimates of correlation coefficients tend to increase and be biased upward. We correct for the bias as proposed by Forbes and Rigobon (2002) and estimate the time-varying correlation index using the Kalman filter methodology. Our research objective is to verify whether during the conflict the correlation among markets varied significantly. We find that correlation increases between Italy, U.K. and France whereas it decreases between these markets and both U.S. and Germany. We explain this behaviour building up a Country-specific exposure index considering jointly the direct involvement in the War and the economic linkages with Iraq, measured in terms of oil imports.

JEL: G14, G15, G22.
Key words: stock market interdependence, Event Analysis, Iraq War.

1. Introduction

On 12 September 2002 U.S. President George W. Bush warns world leaders gathered at a U.N. General Assembly session that the Iraq regime of Saddam Hussein poses "a grave and gathering danger" to peace, and urges world leaders to "move deliberately and decisively to hold Iraq to account". In the same month, British Prime Minister Tony Blair publishes a dossier on Iraq's military capability. A half-year later, on 20 March 2003, the Iraq War commences; Bush delivers a live television address shortly after explosions rocked Baghdad, signalling the start of the US-led campaign to depose Iraqi leader Saddam Hussein.

During these six months, the international community is split. The U.S.A. and the U.K., on one side, take military action, and Germany and France on the others, call for a diplomatic solution to the crisis. Seldom in recent diplomatic history have the words of ally nations been so in contention on such a crucial issue. It is therefore important to investigate the stock markets reactions from belligerent and war-averse Countries to "War news". To this extent, we examine through an event study methodology the effects of War's key events on the market indexes of the U.S. and the European greatest economies (i.e. Germany, France, Britain, and Italy). We find that four events are significant on more than one market. The first event, U.S. President Statement addressing the United Nations warning of Iraqi threat (12 September 2003), shows a negative return on a one-day basis. A negative effect is registered even for Blix' report on Iraq's failing to disarm (27 January 2003). Then, U.S. ultimatum, and consequent joint French-Russian-German statement of disagreement, on 17 March 2003, causes a significantly positive index on an aggregate five-market level. At a single Country level, the French market reacts particularly well to this "news". Finally, a positive return is related to the entry of the Coalition Forces in central Baghdad on 7 April 2003.

The first and the last of these significant events, i.e. U.S. President Statement on 12 September 2002 and Coalition entry in central Baghdad on 7 April 2003, are then used to identify the turmoil period related to the War. During this period the mean index variance of the five markets is indeed greater than 2%. The identification of this turbulent period yields the starting point for

the subsequent analysis of the effect of the War on correlation coefficients. More precisely, this article explores the changes that occurred in the cross-market stock return correlation during the War. The aim is to analyse the interdependence of prices and price volatility across markets, and so to investigate if the degree of comovements across stock markets changed during the unstable period connected to the War. It has indeed already been established that, in the last two decades, integration of financial markets within a rapidly expanding global financial system has increased the extent of volatility linkages. Stock markets are strongly linked in the sense that they have developed dynamic second moment interactions. In other words, markets are linked in that news originated in one market affects the volatility of the other market, positively or negatively.

In this regard, we test for statistically significant changes in unconditional correlation coefficients between the "stable" period (prior and subsequent to the War) and the turbulent conflict period. We interpret the results from two perspectives; from one side the Countries economic relationships with Iraq, and from the other side their position toward the War. The literature agrees on the importance of trade links for crisis transmissions (Moser, 2003). To this extent, economic links are typically proxied by the Foreign Direct Investments. Unfortunately, this kind of data is not available in this case due to the embargo imposed on Iraq in 1990 from the U.N. Security Council. Hence, we opt for relating the economic relationships with Iraq to data on oil imports from Iraq. We motivate this choice highlighting that Iraq's economy is dominated by the oil sector, which has traditionally provided more than 95 percent of foreign exchange earnings, and possibly as much as 79 percent of Iraqi GDP. Referring to the oil imports from Iraq during the past five years, we can partition the sample in low-importer, i.e. U.K. and Germany, and high-importer, i.e. France, U.S.A., and Italy. Gathering together remarks concerning economic relationships with Iraq, and their position toward the War, we can reach our concluding interpretation. Thus, we identify a set of three Countries (i.e. U.K., Italy, and France) that significantly increased their interdependence. Conversely, all these Countries decreased significantly their correlations with Germany, and finally even the correlation between U.K. and U.S.A. showed a significant decline.

The rest of the paper is organised as follows. Section 2 presents a brief survey of the literature, highlighting various approaches to analyse market comovements. Section 3 describes the basic features of the five analysed stock markets and indexes. The main events relevant to the Iraq War are analysed in Section 4, along with the study of the change in correlation coefficients during the War. In Section 5, we relate for each Country the stock market evidence to its economic relationships with Iraq, and its position toward the War. Concluding comments appear in Section 6.

2. Literature review

The issue of interdependence across national stock markets has attracted considerable empirical research. It has long been recognized that stock market interdependence varies over time. In particular, the empirical literature suggest that the free flow of capital, facilitated by increased deregulation of international capital markets, combined with improvements in electronic coordination across world market, has led to increased market interdependence (Roll, 1989; Longin and Solnik, 1995; Billio and Pelizzon, 2003; Karolyi, 2003)[1]. Referring to changes in the degree of market interdependence, a number of studies attempted to measure the effects of crisis on the interdependence between markets. Among other methodologies, the two most adopted are the analysis of cross-market correlation coefficients and the GARCH frameworks (Hon, Strauss, and Yong, 2004).

King and Wadhwani (1990) utilize first the analysis of cross-market correlation coefficients to test for interdependence across stock markets. They find a significant increase in correlation coefficient between U.S.A., U.K., and Japan stock markets after the U.S. market crash in 1987. Despite the range of Countries and time periods investigated, following studies based on this approach reach the same general conclusion that there is a significant increase in cross-market correlation after a shock. Forbes and Rigobon (2002) point out that heteroskedasticity biases this kind of tests since correlation coefficients are conditional on market volatility. Hence, when markets are more volatile, estimated correlation coefficients tend to be biased upward, and tests are

[1] Following this stream of studies, we observe the correlation coefficient from 1996 to 2003 using the Kalman filter approach (see Section 4) over the stock market indexes of U.S.A., U.K., France, Germany, and Italy.

traditionally apt to find evidence of contagion. Nevertheless, Yoon (2005) indicates that the contagion can even be biased downward under heteroskedasticity.

Other studies have also explored volatility spillovers, defined as market interdependences in terms of conditional second moments of the distributions of returns. This approach typically employs a Generalized AutoRegressive Conditionally Heteroskedastic (GARCH) framework to examine the transmission mechanism of the conditional first and second moments in common stock prices across international stock markets. In a seminal paper, Hamao, Masulis, and Ng (1990) proposed this procedure to examine the short-run interdependence of prices and price volatility across U.S., U.K. and Japan stock markets around the 1987 U.S. stock market crisis. Using a MA(1)-GARCH(1,1)-M model, they found significant spillovers in conditional variances across the markets after the crash.

3. Data and markets

To describe the basic features of major international stock exchanges, Table 1 reports some descriptive statistics for the ten biggest stock markets in terms of capitalization. Among them, we study those of the Countries (U.S.A. and U.K.) that formed the Coalition in the Iraq War, and those of the Countries that publicly opposed the military solution (France and Germany). Additionally, the Italian Stock Exchange is examined. According to the World Federation of Exchanges, these five markets sum a capitalization that represents approximately 60% of the capitalization of all the world's stock exchanges.

Daily data are collected from DATASTREAM for the period from 17/10/1994 (DATASTREAM base date for MIB 30) to 31/07/2003. Indexes are in terms of local currency. Continuously compounded returns (denoted by x_t) are calculated as the difference in natural logarithms of the closing index (denoted by p_t) value for two consecutive trading days, i.e. $x_t = ln(p_t) - ln(p_{t-1})$. Following previous studies, the market index for each Country is assigned the value of the preceding day whenever a holiday exists. The indexes adopted are market value (shares outstanding times stock price) arithmetic weighted and narrow based.

Table 1

The 10 biggest stock markets in the world by market capitalization

Stock Exchange	Country	Market capitalization (US$ m)[1]	Number of companies
NYSE	United States	9,015,271	1,894
Tokyo	Japan	2,069,299	2,119
NASDAQ	United States	1,994,494	3,268
London	United Kingdom	1,800,658	1,890
Euronext	France, Netherlands, Belgium, Portugal	1,538,654	1,114
Deutsche Börse	Germany	686,014	715
Toronto	Canada	570,223	1,252
Swiss Exchange	Switzerland	547,020	258
Milan	Italy	477,075	288
Hong Kong	Hong Kong	463,055	968

For the New York Stock Exchange, we used the S&P 500 (Standard and Poor's 500 Composite Index). Firms in this index are selected primarily to be representative of the U.S. economy. For the London Stock Exchange we employed the FTSE 100 (Financial Times Stock Exchange 100 Index) that consists of the largest 100 U.K. companies ranked by market value. CAC 40 (Compagnie des Agents de Change 40 Index) is the index adopted for the Paris Stock Exchange. It is based on 40

[1] Market capitalization in millions of US dollars and number of domestic companies with shares listed on that market at the end of 2002. Data exclude investment funds, and include common and preferred shares, as well as shares without voting rights. The dotted markets are those analysed in this paper. Data sources: World Federation of Exchanges.

stocks selected on the base of market capitalization and liquidity. For the Frankfurt Exchange, we used DAX 30 (Deutscher Aktienindex 30) that is a performance index (adjusted for dividends payments) calculated from XETRA prices. The index sample of the DAX 30 is selected according to criteria of turnover, market capitalization, and branch representativeness for the German economy. Finally, MIB 30 (Mercato Italiano di Borsa 30) is a capitalization-weighted index of the 30 top Italian companies (in terms of capitalization and liquidity) traded on the Milan Stock Exchange.

4. Methodology

Events analysis of the Iraq War

Table 2 shows the timeline of the most important events related to the Iraq War. The analysis begins on 12 September 2002, with the first statement at the United Nations General Assembly referring to the danger represented by the Iraqi regime. The second event is the unanimous adoption by the U.N. Security Council of the resolution on the return of weapons inspectors to Iraq. U.N. inspectors' reports are associated with the third and the forth event. On 17 March 2003, U.S. ultimatum and consequent French-Russian-German statement of disapproval identify the fifth event. In the end, the last three events are directly related to the War, that commences on 20 March 2003 (sixth event) and finishes officially on 1 May 2003 (eighth event), even if the US-led Coalition forces enter Baghdad on 7 April (seventh event).

Fig. 1 charts the stock market indexes performance during and after the War. At a first glance, different patterns in market indexes performance are identifiable. The index showing the best performance is the U.S. S&P 500, that increases more then 10% in approximately one-year time since. Conversely, German DAX 30 shows the worse "path" after the forth event (Blix' report on Iraq's failing to disarm), and then recoup in the post-war over the British FTSE 100 and the Italian MIB 30. French CAC 40 performance is similar to FTSE 100 and MIB 30 up to Blix report on Iraq failing to disarm (forth event, 27 January 2003), and then it worsens during the War.

Table 2

Timeline of events relevant to the Iraq War

1	12 September 2002	**U.S. President Bush's Statement to the United Nations General Assembly.** Bush warns that the Iraqi regime of Saddam Hussein poses "a grave and gathering danger" to peace, and urges world leaders to "move deliberately and decisively to hold Iraq to account".
2	8 November 2002	**U.N. Security Council adoption of the Resolution 1441.** The U.N. Security Council adopts unanimously the resolution on the return of inspectors to Iraq, recognizing the threat Iraq's non-compliance with Council resolutions and proliferation of weapons of mass destruction and long-range missiles poses to international security.
3	9 January 2003	**U.N. inspectors report finding no chemical weapons in Iraq.** Dr. Hans Blix, the United Nations chief weapons inspector, brief to the Security Council: "We have now been there for some two months and been covering the Country in ever wider sweeps and we haven't found any smoking guns".
4	27 January 2003	**Blix report.** Dr. Hans Blix states unequivocally that Saddam Hussein had failed to disarm, greatly strengthening the American and British case for war.
5	17 March 2003	**U.S. ultimatum without the support of France, Germany, and Russia.** The U.S. President announces an ultimatum with a short deadline for war; change in terror alert from elevated to high (explicitly related to the prospect of war). Joint French-Russian-German statement on Iraq: "The use of force can only be a last resort. We solemnly appeal to all members of the Security Council to do everything they can to hold to the peaceful route."
6	20 March 2003	**Beginning of the War.** The War commences, President Bush delivers a live television address shortly after explosions rocked Baghdad at 05H34 local time (02H34 GMT), signalling the start of the US-led campaign to topple Iraqi leader Saddam Hussein.
7	7 April 2003	**Coalition forces in central Baghdad.** American tanks and armoured vehicles enter the centre of the Iraqi capital, raiding President Saddam Hussein's main palace and attacking several other sites.
8	1 May 2003	**U.S. President Bush declares "major combat operations in Iraq have ended".**

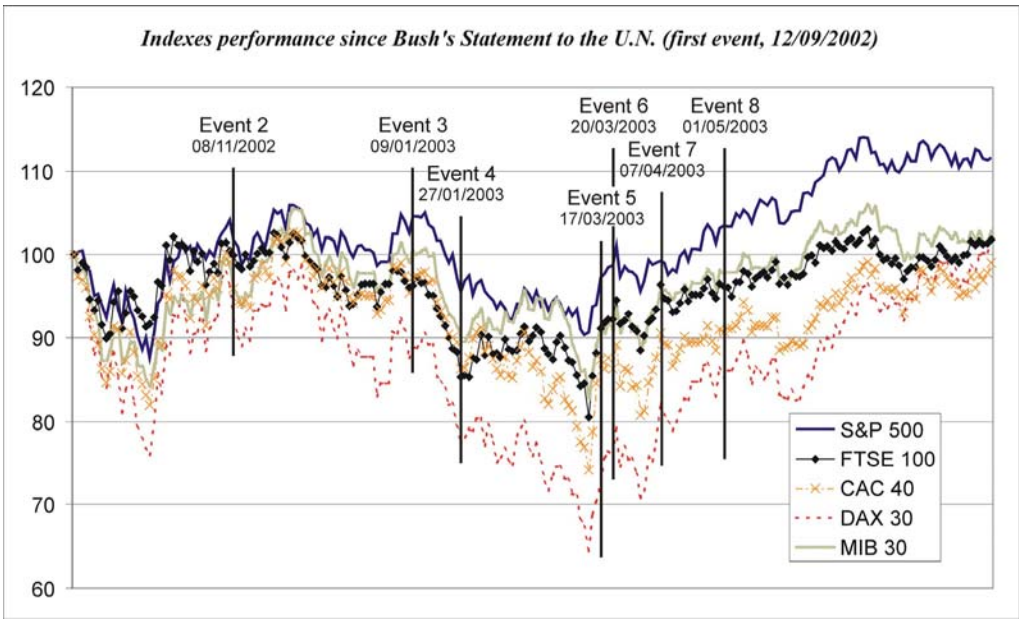

Fig. 1. Performance of the stock market indexes

We apply the event analysis methodology examining the continuous returns around the eight event identified as relevant to the Iraq War in Table 2. The analysis is carried out by considering both a one-day event period, and a two-day event period (the event day and the day before), while the estimation period is 300 days. Five statistical tests are used to check if the returns are significantly different from zero. The first test (FJFR) is the standard parametric test introduced by Fama, Fisher, Jensen, and Roll (1969). It relies on the assumption that the sample observations (returns) are independent drawings from an underlying normally distributed population. The return metric divided by its standard error (the estimate of its standard deviation) will be t-distributed. The second test (B-W) is the crude dependence adjustment test introduced by Brown and Warner (1980) in order to overcome the cross-sectional dependence problem. In the case of a single index analysis, the B-W test will lead to the same result as the FFJR test. The Patell standardized test suggested by Patell (1976) surmounts the heteroskedasticity problem. Next, the last two tests, the generalized sign test and the rank test, are non-parametric tests elaborated to overcome the potential lack of normality in return distributions. The sign test (Cowan 1992) compares the number of positive sign returns over the estimation period with that over the event period. The rank test (Corrado 1989) involves placing in order all the returns, over both the estimation and the event period, and testing whether the actual rank of event day returns is significantly above or below zero.

Table 3 and Table 4 report the result of the event analysis with reference to the five indexes considered both aggregately, and separately. The first event, Bush's statement to the U.N. General Assembly on 12 September 2002, shows a negative return when the indexes are examined together (-3.53% on a one-day basis). The negative return is less significant when the indexes are considered separately, especially on the U.S., U.K., and Italian markets. If we consider a two-day event period, even the second event, the adoption of the Resolution 1441, has a negative impact on the aggregate index (-4.03%). Analysing this event on a single market level, the negative effect is statistically significant (-4.65%, statistically significant at 5%) only on the DAX 30. While Blix' 'no smoking guns' report (third event) does not appear to have a significant impact on the markets, the report on Iraq failing to disarm (fourth event) has a negative aggregate impact (-2.61% on one-day basis, and -4.32% on a two-day basis). The fifth event, that splits the Countries analysed in this study, shows a positive index on aggregate level (+3.13% one-day, +6.26% two-day). At a single Country level, the CAC 40 two-day return shows the highest value of return found in this

study, +10.29%. Therefore, the French market reacted particularly well at the U.S. ultimatum, and at the joint French-Russian-German search for a 'peaceful route'. Three days later, the War commences with the US-led Coalition forces entering in Iraq (sixth event), but the markets do not react significantly. In contrast, they show an aggregate positive return when the Coalition forces enter Baghdad (seventh event), +2.92% one-day, and +4.24% two-day. At a Country level, DAX 30 and FTSE 100 are the only indexes to show a statistically positive return with reference to this event. Finally, the eighth event, the official announcement of the end of the conflict, does not present any effect on the analysed indexes[1].

Table 3

Event analysis for the aggregate index with a one-day and two-day event period[2]

Event date			Return	Std Dev	FFJR		B-W		Patell		Sign		Rank	
1	12/09/2002	1-day	-3.64%	1.82%	-4.47	***	-2.28	**	-4.45	***	-2.04	**	-3.61	***
		2-days	-2.05%	2.58%	-1.78	*	-0.91		-1.86	*	-0.35		-0.92	
2	08/11/2002	1-day	-1.43%	1.99%	-1.60		-0.81		-1.56		-2.06	**	-2.14	**
		2-days	-4.09%	2.82%	-3.25	***	-1.65	*	-3.17	***	-2.91	***	-3.55	***
3	09/01/2003	1-day	1.36%	1.91%	1.59		0.81		1.62		2.55	**	2.33	**
		2-days	-0.50%	2.71%	-0.41		-0.21		-0.31		0.41		-0.07	
4	27/01/2003	1-day	-2.64%	1.92%	-3.08	***	-1.55		-3.13	***	-1.93	*	-3.08	***
		2-days	-4.39%	2.72%	-3.61	***	-1.82	*	-3.67	***	-2.73	***	-3.67	***
5	17/03/2003	1-day	3.22%	2.00%	3.60	***	1.82	*	3.74	***	2.60	**	3.41	***
		2-days	6.40%	2.83%	5.06	***	2.56	**	5.13	***	3.67	***	4.44	***
6	20/03/2003	1-day	-0.60%	2.03%	-0.66		-0.33		-0.63		-0.14		-0.58	
		2-days	0.54%	2.86%	0.42		0.21		0.45		1.72	*	1.04	
7	07/04/2003	1-day	2.94%	2.07%	3.18	***	1.61		3.02	***	2.54	**	2.83	***
		2-days	4.27%	2.93%	3.26	***	1.65	*	3.05	***	3.59	***	3.38	***
8	01/05/2003	1-day	-0.25%	2.08%	-0.27		-0.13		-0.31		0.75		-0.07	
		2-days	0.04%	2.94%	0.03		0.02		-0.04		1.06		0.45	

[1] Extending the event period on a three-day basis, the significance levels do not change except for the fifth event, that is the event showing the biggest impact on stock market indexes (i.e. the highest market returns in absolute value). The date of this event identifies the official U.S. ultimatum and consequent French-Russian-German statement of disapproval, but even in the previous days the position of the Countries was explicit and there were symptoms of the ultimatum without the support by France, Russia, and Germany. Therefore, even if the 'news' was made official in the fifth event's date, it could be incorporated from the markets in the previous days. This hypothesis is tested by extending the event period to a three-day window. The result of this analysis (not reported in the table) shows a significant positive return for every index (1% significance level except 5% for S&P 500). Interestingly, the returns are largely positive both for belligerent and war-averse Countries. Our interpretation of this evidence is that the event is seen by markets as an "exit" from uncertainty. Up to this event, the indexes level was indeed steadily decreasing since the U.N. inspectors' report finding no chemical weapons (fourth event). The fall reached a minimum three weekdays before the fifth event (12 March 2003) and then the indexes began rising, as the uncertainty concerning the War began vanishing.

[2] The estimation period is 300 days and the event period is indicated in the third column (one or two-day). The null (alternative) hypothesis for each test states that the return given the event is (not) equal to zero. FJFR is the standard parametric tests introduced by Fama, Fisher, Jensen, and Roll (1969); B-W is the crude dependence adjustment test introduced by Brown and Warner (1980); Patell is the standardized test suggested by Patell (1976); the sign test and the rank test are non-parametric tests introduced by Cowan (1992), and Corrado (1989) respectively. *** 1% significance level; ** 5% significance level, * 10% significance level.

Table 4

Event analysis for the five market indexes[1]

	Event		U.S.A. (S&P 500)			U.K. (FTSE 100)			France (CAC 40)			Germany (DAX 30)			Italy (MIB 30)		
			return	FFJR	Rank	return	FFJR	Rank	return	FFJR	Rank	return	FFJR	Rank	return	FFJR	Rank
1	12/09/02	1-day	-2.51%	*		-3.03%	*		-4.68%	**	*	-4.65%	**		-3.36%	*	
		2-days	-2.52%			-2.19%			-1.77%			-2.11%			-1.65%		
2	08/11/02	1-day	-0.88%			-1.15%			-1.74%			-2.46%			-0.92%		
		2-days	-3.19%			-1.70%			-4.93%		*	-6.89%	**	**	-3.75%		
3	09/01/03	1-day	1.92%			0.23%			1.86%			1.48%			1.31%		
		2-days	0.50%			-0.59%			-0.28%			-2.44%			0.33%		
4	27/01/03	1-day	-1.63%			-3.47%	**		-3.61%	*		-2.76%			-1.75%		
		2-days	-4.60%	**	**	-3.98%	*		-4.28%			-6.14%	*	*	-2.94%		
5	17/03/03	1-day	3.48%	**		3.29%	*		3.29%			3.43%			2.60%		
		2-days	3.65%			6.53%	***	**	10.29%	***	**	5.49%		*	6.02%	**	**
6	20/03/03	1-day	0.19%			3.29%			-1.52%			-0.40%			-1.25%		
		2-days	1.06%			0.49%			0.00%			0.78%			0.36%		
7	07/04/03	1-day	0.12%			3.13%	*		3.39%			5.67%	**	*	2.40%		
		2-days	0.40%			4.28%	*	*	5.14%		*	8.90%	**	**	2.64%		
8	01/05/03	1-day	-0.07%			-1.17%			0.00%			0.00%			0.00%		
		2-days	-0.17%			-1.22%			0.44%			1.13%			0.05%		

[1] The Patell test yields the same significance levels of the FFJR test.

Analysis of correlation coefficients

To investigate the effects of the War, we partition the sample into a turbulent period (higher volatility, *h*) and stable period (lower volatility, *l*). The stable period is made of two sub-periods; the pre-war sub-period covers from 1 January 2002 to the first War event (12 September 2002, U.S. President Bush' Statement to the U.N. General Assembly), while the post-war sub-period begins on the seventh War event (7 April 2003, entry of the Coalition Forces in central Baghdad), and ends on 31 July 2003. The turmoil period is between these two sub-periods and identifies the period with a mean variance of the five indexes greater then 2%, as shown in Fig. 2[1].

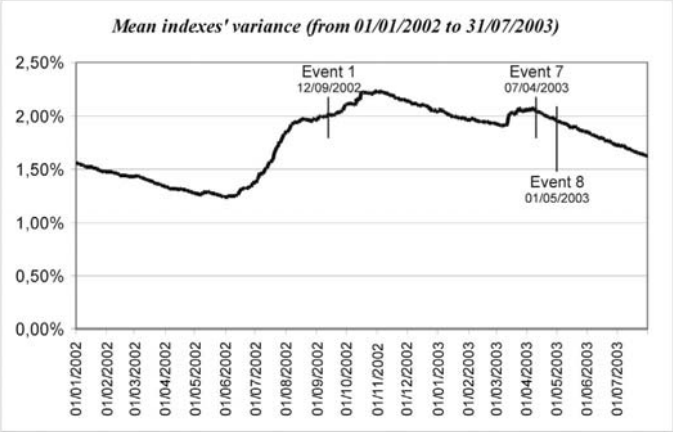

Fig. 2. The mean variance of the indexes from 01/01/2002 to 31/07/2003

Naming *x* and *y* the index returns, we assume the relation

$$y_t = \alpha + \beta \cdot x_t + \varepsilon_t . \tag{1}$$

We then estimate the variance-covariance matrices for each pair of Countries during the stable period, and the turbulent period. The first and simplest method proposed by the literature is the rolling regression that bases the estimate on only the most recent portion of the data. As each new observation is acquired another observation may be removed so that, at any instant, the estimator comprises only *n* points. On this basis, the parameters are estimated by using the Ordinary Least Square (OLS) method. The model can thus be written as in Equation (2):

$$Y_t = \beta_t X_t + u_t . \tag{2}$$

Consequently, Equation (3) expresses the estimation of the parameter:

$$\beta_t = \frac{\sum_{j=t-T+1}^{t} X_j Y_j}{\sum_{j=t-T+1}^{t} X_j^2} . \tag{3}$$

A wide variety of techniques for shaping the memory of the recursive least square algorithm may be devised. However, it is well established that volatility is a stochastic process with a non-negligible degree of persistence. To this extent, a better theoretical basis from which to develop the algorithms is provided by the Kalman filter, that we adopt in this study. The elaboration of the recur-

[1] The mean variance of the indexes exceeds 2,00% on 06/09/2002, four weekdays before the first event. Then it definitely return to be less than 2,00% on 23/04/2003, that is between the seventh and the eighth event. We chose to terminate the turmoil period with the seventh event because it has a significant effect on the indexes, while the eighth event is irrelevant (see Table 3 andTAble 4). However, we carried out all the tests on correlation considering both the seventh and the eighth war event as end date of the turbulent period, and the results were qualitatively similar.

sive least-square model which is required in order to achieve the generality of the Kalman filter is the addition of a process which describes the variation of the parameter vector β of Equation (2). Such a process might be described by a state equation that describes the time variance of the parameter β:

$$\beta_t = \beta_{t-1} + w_t, \tag{4}$$

where w_t is the innovation term, with zero mean and constant variance.

The classic version of Kalman filter requires the homoskedastic assumption on the errors u_t, in this case the estimation parameter can be written as in Equation (5):

$$\beta_t = \frac{\sum_{j=1}^{t} \phi_j X_j Y_j}{\sum_{j=1}^{t} \phi_j X_j^2}. \tag{5}$$

Equation (5) is the minimum-variance estimator if the series of ϕ_j is selected as in Equation (6):

$$\begin{aligned} \phi_1 &= 1 \\ \phi_{j+1} &= \phi_j + K \sum_{h=1}^{j} \phi_h X_h^2, \end{aligned} \tag{6}$$

where K is the ratio between the expected squared change in β and the residual variance of returns[1].

Next, we calculate the correlation coefficients for each set of Countries and periods:

$$\rho = \frac{\sigma_{xy}}{\sigma_x \sigma_y}. \tag{7}$$

Tests for contagion based on cross-market correlation coefficients are biased and inaccurate due to heteroskedasticity. Cross-market correlation coefficients are indeed conditional on market volatility. Therefore, during crises when markets are more volatile, like during the Iraq War, estimates of correlation coefficients tend to increase and be biased upward. If correlation coefficients are not adjusted for this bias, it is impossible to deduce if an increase in the conditional correlation represents an increase in the unconditional correlation or simply an increase in market volatility. According to Forbes and Rigobon (2002) we distinguish between the unconditional correlation coefficients, defined as above, and the conditional correlation coefficients. The conditional correlation can be written as:

$$\rho^* = \rho \sqrt{\frac{1+\delta}{1+\delta\rho^2}}, \tag{8}$$

where ρ^* is the conditional correlation coefficient, ρ is the unconditional correlation coefficient, and δ is the relative increase in the variance of x and y:

$$\delta \equiv \frac{\sigma^h}{\sigma^l} - 1, \tag{9}$$

where σ^h and σ^l are the mean of the variance of x and y during, respectively, the more (h) and the less (l) volatile period.

Equation (8) shows that the estimated correlation coefficient is increasing in δ. Therefore during periods of high volatility, the estimated conditional correlation will be greater than the unconditional correlation. Hence, heteroskedasticity in market returns can cause estimate of cross-market correlation coefficients to be biased upward during a turmoil period. Even if the unconditional correlation coefficient remains constant during a stable period and volatile period, the condi-

[1] To our knowledge, besides Kalman filter and rolling regression, the literature proposes other two major approaches to estimate the variance-covariance matrices: option-implied volatility and GARCH.

tional correlation coefficient will be greater during the more volatile period. Solving Equation (8) for the unconditional correlation coefficient yields

$$\rho = \frac{\rho^*}{\sqrt{1+\delta\left[1-\left(\rho^*\right)^2\right]}}. \quad (10)$$

Table 5 reports the unconditional and conditional correlation coefficient for each couple of Countries. As previously stated, the turbulent period begins on the first War event and ends on the seventh War event; the stable period is made of sub-period prior to the War from 1 January 2001, and a post-war sub-period up to 31 July 2003[1]. The changes in mean correlation coefficients appear statistically significant in seven cases. A significant decrease from the stable to the turbulent period is found between the German market and the rest of the markets except the American. U.S.A. and Britain also show a significant decrease in correlation. On the other hand, U.K., France, and Italy increase each other their correlation.

Fig. 3 synthesises graphically the results shown in Table 5. We can identify a set of three Countries, i.e. U.K., France, and Italy, increasing their correlation during the volatile period. The other two Countries, U.S.A. and especially Germany, appear to reduce their correlation with the sample of markets.

Table 5

Mean correlation coefficients between pair of indexes[2]

		U.S.A.	U.K.	France	Germany	Italy
U.S.A. S&P 500	ρ_{stable}	100.00%	46.37%	51.16%	62.65%	51.61%
	$\rho_{turmoil}$	100.00%	46.43%	55.95%	68.67%	54.98%
	$\rho^*_{turmoil}$	100.00%	41.84%	50.95%	63.62%	51.13%
	t-test		-			
U.K. FTSE 100	ρ_{stable}		100.00%	86.27%	76.10%	80.49%
	$\rho_{turmoil}$		100.00%	90.06%	76.79%	84.88%
	$\rho^*_{turmoil}$		100.00%	87.48%	72.17%	82.10%
	t-test			+	-	+
France CAC 40	ρ_{stable}			100.00%	85.47%	89.51%
	$\rho_{turmoil}$			100.00%	85.99%	91.94%
	$\rho^*_{turmoil}$			100.00%	82.58%	90.16%
	t-test				-	+
Germany DAX 30	ρ_{stable}				100.00%	83.61%
	$\rho_{turmoil}$				100.00%	85.87%
	$\rho^*_{turmoil}$				100.00%	83.04%
	t-test					-
Italy MIB 30	ρ_{stable}					100.00%
	$\rho_{turmoil}$					100.00%
	$\rho^*_{turmoil}$					100.00%
	t-test					

[1] We performed the analysis considering both the seventh and the eighth event as end date of the turmoil period. The findings were qualitatively similar. We even repeated the investigation considering a stable period starting from 01/01/2001; in this case the results showed a shift towards an increase in market correlations due to the lower level of market correlation during 2001 with respect to 2002. This evidence is consistent with the increasing markets integration within a rapidly expanding global financial system. Even the latter analysis considered the end of the turbulent period fixed both to the seventh and the eighth event. Finally, we validated the result with a two-days return analysis, finding similar results. We then replicated all these tests considering for the Italian Exchange, the open based MIBTEL instead of the narrow based MIB 30. In this case, we found the same results in terms of statistical significance of the changes in correlation coefficients, just the acceptance level of the decrease in the correlation coefficient between Italy and Germany decreases from 1% to 5%.

[2] The turmoil period covers from the first War event (12/09/2002) to the seventh event (07/04/2003). The stable period is from 01/01/2002 to the first War event, and from the seventh event to 31/07/2003. ρstable indicates the mean conditional correlation coefficients in the stable period; ρturmoil is the mean conditional correlation coefficients in the turmoil period; ρ*turmoil is the mean unconditional correlation coefficients in the turmoil. The two-sample t-test is used for testing equality of means between ρstable and ρ*turmoil.

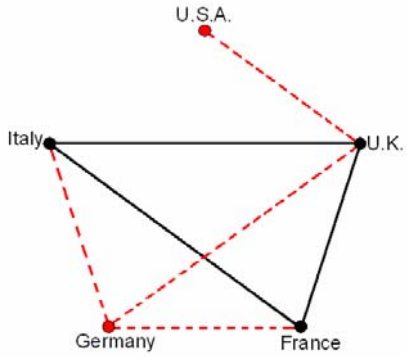

Fig. 3. Changes in unconditional correlation coefficients.

Solid (dashed) lines indicate a statistically significant increase (decrease) in correlation from the stable to the turmoil period.

5. Results

The typical starting point in the analysis of relationships among Countries relies on the study of Foreign Direct Investments (FDI). FDI have indeed emerged as the most important source of international flows of productive resources, so that the study of FDI is important for obtaining a complete picture of the extent and sources of international linkages. Symmetrical FDIs are indeed found to be the most stable guarantor of low conflict between Countries (Rosecrance and Thompson, 2003). Unfortunately, research methodologies based on FDI are not applicable in our case due to the embargo imposed on Iraq in 1990. The U.N. Security Council's economic sanctions on Iraq were implemented following the Country's invasion of neighbouring Kuwait and have continued due to Iraqi refusal to grant U.N. weapons inspectors unfettered access to weapons facilities. Thereby, Iraq's economy has been largely isolated from the international market for the past decade with consequences in all sectors, and no FDI are registered in Iraq during this period. Instead, under the U.N.'s "oil-for-food" programme, Iraq has been permitted to sell an unlimited amount of oil in exchange for humanitarian goods[1]. Iraq's economy is actually dominated by the oil sector, which has traditionally provided more than 95 percent of foreign exchange earnings, and possibly as much as 79 percent of GDP[2].

Iraq has a huge development potential, and its vast oil reserves are expected to act as the Country's primary engine of economic recovery[3]. Hence, we assume the quantity of oil imported from Iraq by one Country as a proxy of its economic relationship with Iraq. Using data from EIA and DATASTREAM, Table 6 reports, for each analysed Country, the importance of oil imports from Iraq relative to both total oil imported, and GDP. We can identify two Countries with low (or

[1] On 6 August 1990 the U.N. imposed economic sanctions on Iraq, including a full trade embargo barring all imports from and exports to Iraq, excepting only medical supplies, foodstuffs, and other items of humanitarian need (U.N. Resolution 661, 1990). Subsequent Security Council resolutions have offered to modify the embargo terms, but the Iraqi government declined the reworked terms. As the humanitarian crisis continued to grow in the six years after the Gulf War, the U.N. and the Government of Iraq concluded on 20 May 1996 the Memorandum of Understanding that codified the practical arrangements for the implementation of the "oil-for-food" agreement (authorized under U.N. Resolution 986, 1995). According to the agreement, Iraq could sell up to $1 billion of oil every 90 days with the understanding that revenue would be used to purchase humanitarian goods. The Security Council called the program, "a temporary measure to provide for the humanitarian needs of the Iraqi people". The ceiling on oil sales was lifted on 17 December 1999, allowing the Iraqis to export unlimited quantities of oil and ideally spend more of the resulting revenue on humanitarian needs as well as the repair of infrastructure destroyed during the Gulf War (U.N. Resolution 1284, 1999).

[2] According to the Energy Information Administration, a statistical agency of the U.S. Department of Energy, in 2002 Iraq GDP at purchasing power parity rates amounted to 15.5 US$ billions, and Iraq total exports revenues to 13.0 US$ billions, while Iraq oil export revenues were estimated to be 12.3 US$ billions. Additionally, Iraq possesses 11 percent of the world's proven oil reserves, second only to those of Saudi Arabia.

[3] See the Business Guide for Iraq by the U.S. Department of Commerce, revised on 8 September 2003.

null) oil imports from Iraq: U.K. and Germany. Thanks to its oil fields in the North Sea, the United Kingdom is a net exporter of crude oil and oil products (the U.K. produces approximately half of Europe's oil). Germany imported from Iraq just 0.28% of its total oil imports during the last five years. Conversely, from 1998 to 2002, Italy, U.S.A., and France imported from Iraq respectively 4.96%, 5.20%, and 5.74% of their total oil imports. If we analyse for each Country the oil imports from Iraq relative to its GDP, we can draw similar conclusions[1]. We can finally partition the sample with reference to oil imports from Iraq in low-importer, i.e. U.K. and Germany, and high-importer, i.e. France, U.S.A., and Italy.

Table 6

Oil Imports from Iraq (mean values for 1998-2002)[2]

	Oil Imports(1,000 Barrels per Day)			GDP (US$ bn)	oil from Iraq (US$) over GDP (US$ m)
	total	From Iraq	%		
U.S.A.	11,284	587	5.20	9,682	440
U.K.		Oil exporter		1,464	Oil exporter
France	2,247	129	5.74	1,495	591
Germany	3,041	8	0.28	2,096	22
Italy	2,178	108	4.96	1,446	539
OECD	23,860	1,340	5.62	25,361	393

Referring to their attitude concerning the Iraq War, we can clearly distinguish the position of the U.S.A. and the U.K. in favour, and that of France and Germany in opposition. The United States, allied with the United Kingdom, led the Coalition that entered Iraq on the 23 April 2003 without U.N. support. On the other side, France and Germany were among nations on the Security Council that opposed the War[3]. Finally, Italy's position was intermediate as it supported U.S.-led action, but it remained a non-belligerent Country and did not participate directly in military operations.

It is now possible to synthesize in Fig. 4 the observations about market comovements during the Iraq War (Section 4) in a framework that considers for each Country its "belligerency" in the Iraq War context, and its economic relationships with Iraq (as defined earlier in this section referring to oil imports). The horizontal axis locates each Country with reference to the weight of oil imports from Iraq relative to their total oil imports. As a net oil exporter, the U.K. does not show any linkage with Iraq. Germany's oil imports from Iraq are scarce (see Table 6). On the other hand, Iraq has represented for the last five years a significant source of oil for Italy, U.S.A., and France (it weighed up to about 5% of their total oil imports). Therefore, if the sample classification based on economic relationship with Iraq is gathered along with that based on "belligerency", we

[1] It is important to highlight, however, that all the data here exposed refer to the last five years, and thus they do not take into account possible future evolutions in oil market. In the next decade, for instance, the United Kingdom might lose its position of net oil importer due to the decreasing extent of its remaining oil reserves.

[2] For each Country, and for OECD (Organisation for Economic Co-operation and Development), total oil imports and oil imports from Iraq are expressed in thousands barrels per day. The percentage refers to the part of total oil imported from Iraq out of the total oil imported by each Country. No data are reported for U.K. that is a net exporter of crude oil. The Gross Domestic Product (GDP) is estimated using the Purchasing Power Parity method (PPT), which eliminates differences in price levels between Countries. The last column reports for each Country the ratio between the cost of oil imported from Iraq, and its GDP (US$ over millions US$). The cost of oil imported from Iraq is determined, for each Country and for each year, as the product between the amount of oil imported from Iraq and the crude oil domestic first purchase price (yearly mean). The analysed period begins with 1998, in which Iraq exports towards OECD Countries exceeds 1 million barrel per day. The total oil imports column refers to the total gross oil imports for single Country, while it refers to total net oil imports for OECD. Oil imports from Iraq are gross values. OECD values referring to oil imports exclude data for Slovakia (not available). All data are mean value over the period of 1998 - 2002, except GDP for OCED that covers from 1998 to 2001 (2002 not available). Data sources: Energy Information Administration (EIA, http://eia.doe.gov), a statistical agency of the U.S. Department of Energy, for oil data; DATASTREAM for GDP data.

[3] Excerpt from the Joint French-Russian-German statement on Iraq, 17 March 2003: "The use of force can only be a last resort. We solemnly appeal to all members of the Security Council to do everything they can to hold to the peaceful route which was proposed by the Security Council and supported by the overwhelming majority within the international community."

can elaborate a measure of "Iraq Exposure". We can thus identify three different levels of Iraq Exposure (IE), defined taking into account each Country's "economic relationships" and "Belligerency" in Iraq. First, Germany has a low level of IE; it is indeed averse to the War, and it does not have a relevant economic relationship with Iraq. Second, we can identify a set of three Countries, i.e. U.K., Italy, and France, characterised by an intermediate level of IE. France is exposed to Iraq through the economic dimension (oil imports from Iraq); Britain through the belligerency dimension; and Italy is exposed to both but at an "intermediate" level. On the other hand, the U.S.A. is fully exposed to Iraq (i.e. high IE) as it imports oil from Iraq, and led the military campaign as well. These three sets of Countries reveal indeed three different levels of Iraq Exposure; in other words, they lie on three different isoquants with reference to IE.

Relating these isoquants to the changes occurred to correlation the coefficients between markets from the stable to the unstable period (see Fig. 3), we could finally interpret the market comovements during the Iraq War. The Countries with an intermediate IE, i.e. U.K., Italy, and France, increased significantly their interdependence during the turmoil period. Conversely, all these Countries decreased significantly their correlations with Germany, and finally even the correlation between U.K. and U.S.A. showed a significant decline (see Fig. 4).

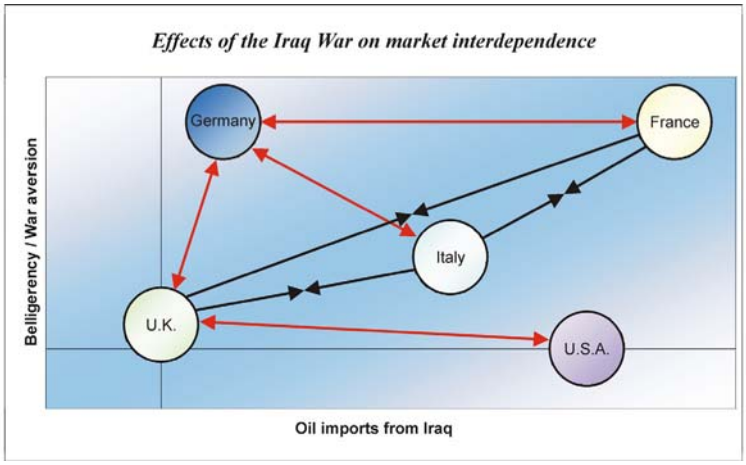

Fig. 4. Effects of the Iraq War on market interdependence[1]

6. Conclusions

In this paper we aim to show how consolidated and innovative methodologies can be employed to assess the financial impact of shocks. Specifically, we consider the recent Iraq War and its impact on the market indexes of five financial markets among the world most capitalised, U.S., U.K., France, Germany and Italy. The first part of the empirical analysis is an introductory event study aiming to analyse the impact on market performances of the main Iraq War milestones, such as the U.S. ultimatum, the beginning and the end of the War. We show that there exist differences between U.S. and U.K., taking military action, and France and Germany, openly against the conflict. The second part of the paper analyses the correlation between the five financial markets. In particular, we estimate the time-varying correlation index using the Kalman filter methodology. Our research objective is to verify whether during the conflict the correlation varied significantly. After taking into account heteroskedasticity, we find that correlation increases between Italy, U.K. and France whereas it decreases between these financial markets and both U.S. and Germany.

[1] Abscissa-axis locates each Country with reference to the weight of oil imports from Iraq relative to their total oil imports (this axis is out of scale for clarity). Ordinate-axis values each Country's belligerency, with the leader of the Coalition (U.S.A.) referred to as zero-point, followed by its main ally (U.K.). Convergent (divergent) arrows indicate an increase (decrease) in correlation coefficients during the turbulent period connected to the Iraq War.

We explain this behaviour considering two different factors affecting the impact of the War on market indexes. The first is the official position and military exposure related to the War. In this case, as remarked above, U.K. and U.S. have the higher War exposure whereas Germany and France have the lowest. Italy's position is not such clear-cut since it did not participate directly to the military campaign but offered logistic support. The second factor affecting the Countries' exposure to Iraq is the economic interest in Iraq; we measure this factor considering the oil imports from Iraq to the five Countries considered. In this regard, U.S. and France have the highest importation degrees, with Iraq oil representing more than 5% of their total oil imports. Conversely, U.K. and Germany oil imports from Iraq are irrelevant. Italy is again in an intermediate position. Considering jointly the two variables, we build up a qualitative overall impact variable. It follows that Germany is the Country least affected by the War, whereas U.S. is the most affected. U.K., France and Italy show an intermediate level of "Iraq Exposure". Thus, the overall impact seems to explain the correlation pattern.

Future developments of this work will address on one hand the use of further statistical tools to support the correlation analysis and, on the others, the problem of constructing a quantitative overall impact index that could be employed analysing the financial effects of previous conflicts, as well as other kinds of stock markets shocks.

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