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THE IMPACT OF REGULATORY STANDARDS, INTEREST RATES AND TRADING VOLUME ON VOLATILITY TRANSMISSION BETWEEN CROSS-LISTED EUROPEAN EQUITIES

ABSTRACT

This paper investigates the relationship between volatility transmission and stock market regulatory structures, interest rates and trading volume for European securities which are cross-listed on stock exchanges of higher, lower or similar regulatory standards compared to their home stock markets. The empirical results suggested that the regulatory environment has a significant impact on volatility spillovers and the level of interest rates and trading volume have a positive impact on the magnitude and persistence of these volatility spillovers. These findings have potentially important implications for both regulators and investors who are concerned with the effectiveness of legislation aiming to harmonise the European stock markets and the effects of volatility transmission on investment positions across European stock markets.

Key Words: GARCH, volatility transmission, regulatory differences, trading volume, interest rates

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INTRODUCTION

During the last two decades the international capital markets have experienced the abolishment of investment barriers as well as substantial deregulation and harmonisation which led to increasing free flow of capital across stock markets. However, this also led to the transmission of volatility shocks across stock markets[1]. Volatility transmission has received considerable attention since a number of stock market crises made clear that the interdependence between stock markets can have a devastating effect upon investment portfolios and the stability of financial system. Identifying, therefore, the degree of dependence between stock markets and the factors that determine the magnitude of volatility transmission can have important implications for both investors and regulators.

The aim of this study is to examine the impact of different stock market regulatory structures (i.e., accounting standards, shareholder and creditor protection legislation) taking into account the impact of interest rates and trading volume on volatility transmission patterns of cross-listed European equities. The starting point is the use of the multivariate GARCH-BEKK model[2] introduced by Karolyi (1995) controlling for regulatory differences (High, Low or similar standards) between stock exchanges that may act as investment barriers to the transmission mechanism. The La Porta et al. (1998) stock exchange regulatory classification, which distinguishes between different accounting disclosure requirements and shareholder and creditor protection rules, is adopted to identify equities listed in the UK, German, Swiss, and French stock markets which are also cross-listed on stock exchanges of higher, lower or similar regulatory standards[3] compared to their home stock exchange. Portfolios of these cross-listed equities are then constructed and their performance is compared to the associated stock market index. For that reason, the FTSE100, DAX100, SBC100 and CAC40 indices are used for UK, German, Swiss and French equities, respectively, in order to investigate volatility spillover effects with the home stock market general index and between different cross-listed portfolios accounting for different regulatory standards amongst the European countries.

1 This reaction of one stock market to changes in other stock markets can be either unilateral, which is a partly integrated phenomenon, or bilateral, which is a fully integrated market phenomenon.
2 Multivariate GARCH models have been used for some time to investigate transmission patterns (see for example Theodossiou and Lee (1993) and Engle and Kroner (1995)).
3 According to La Porta et al. (1998), firms from Belgium, Netherlands, Spain, Austria, Germany, and Denmark that have a cross-listing on the Paris exchange are listed on a stock exchange with higher accounting standards than their home stock exchange while the opposite is true for firms from UK, Finland, Norway and Sweden.

The empirical results provided evidence that volatility spillovers are significant for cross-listed stocks in major European stock markets and that there seems to be an effect of investment restrictions and interest rates and trading volume on stock exchange integration since regulatory differences between stock exchanges and the explanatory variables of interest rate and trading volume appear to have an impact on volatility spillovers between European cross-listed shares. These findings are important given the view that the harmonisation of regulatory standards will reduce barriers and therefore volatility spillover effects across stock markets (Stulz 1981, 1999).

LITERATURE REVIEW

Large firms and international conglomerates have for some time sought to expand their investor bases, typically in export countries, in order to have access to new capital markets, which naturally led to an increasing number of cross-listing of stocks. Huddart et al. (1998) suggested that stock exchanges which lower their disclosure standards in order to attract more listed foreign firms could slow down the integration process as this would result to competition for admission of firms to other stock exchanges. Additionally, Baker (1992) found that the most important entry barriers are the costs faced by companies and the level of disclosure requirements. Potential relaxation, therefore, of these standards may result in stock exchanges gaining poorer quality listings as the benefits of a foreign listing may not outweigh the cost of compliance with the disclosure and other standards. Raising the standards, on the other hand, may result in stock exchanges attracting higher quality corporations because of the stricter environment (Cheung and Lee 1995).

Despite changes in European legislation, differences in accounting disclosure requirements and protection of shareholders and creditors that may have a substantial impact on the financial regulation still remain between the European stock exchanges. La Porta et al. (1998), for example, documented a variety of regulatory differences relating to investor protection rules and accounting disclosure regulations across EU markets. For example, in France, Germany, the Netherlands, and Sweden companies provide voluntary disclosures, additional to the requirements demanded by the stock exchanges, which are important for shareholders and investors.

Volatility spillovers have been studied in a number of papers. Kanas (1998) investigated the stock exchanges in London, Paris, and Frankfurt using a multivariate E-GARCH model and found that volatility spillovers across stock exchanges with different structures differ in magnitude to those with similar structures. In an international study, Hamao, Masulis, and Ng (1990) provided evidence in support to the volatility spillover effects from the US and UK to Japan, while Susmel and Engle (1994) found that volatility transmission between the US and UK stock markets is short living and of small size. The later contrasts the findings by Theodossiou and Lee (1993) who argued that the US capital market is a major exporter of volatility to other financial markets; also argued by Eun and Shim (1989).

Engle and Mezrich (1996) argued that the factors that may influence volatility spillovers might include market liquidity and the level of interest rates. Indeed, Chan et al. (1995) investigated the effects of market liquidity on volatility spillovers, using the trading volume as a proxy, and found that the magnitude and persistence of volatility spillovers are not very pronounced in stock markets with high liquidity. Recently Ng (2000) used data from Pacific-Basin stock markets and found that changes in the trading volume increases volatility persistence. Similar conclusions were also reached by Gallo and Pacini (2000) and Lamoureux and Lastrapes (1990) for the US stock market. In addition to market liquidity, the impact of interest rates on stock price volatility and market integration has also been investigated. For example, Bhoocha-oom and Stansell (1990) found that there is a substantial degree of interest rate harmonisation and financial market integration between Hong Kong, Singapore and the US while Elyasiani and Mansur (1998) found shifts in volatility according to changes in the monetary policy regime in the US.

Given the changes in the European stock markets' regulatory landscape one would expect that volatility spillovers would be less pronounced because of the fewer regulatory discrepancies between European stock exchanges. It would, therefore, be important to examine the role of regulatory differences and investigate the interest rates and trading volume as factors that may help to explain volatility transmission patterns between European stock markets.

SAMPLE SELECTION AND DATA DESCRIPTION

Information regarding cross-listed European equities was obtained directly from European stock exchanges. Equity prices were then collected from Datastream for those equities that were cross-listed during the period 1987 to 2006. In order to avoid survivorship bias in data collection, firms involved in de-listings, bankruptcies and mergers and acquisitions were also included in the sample. However, cross-listings had to meet the following criteria. The merger or acquisition announcement had to be identified by the FT-EXTEL database over the period of January 1987 to December 2006. The gap between the announcement and consummation day during the acquisition process is determined by finding the 'effective date' in Mergers and Acquisitions magazine, Reuters and Datastream. The exact effective date of consummation of the merger or acquisition is determined for 81 out of 100 acquisitions and the effect scheme of capital change arrangements for the 81, added automatically by Datastream. The effective dates of consummation for the remaining 19 acquisitions were found in Datastream. A 'back-filling' process was added in the acquired company's equity upon its de-listing date and backward to add the effective scheme of capital offer arrangements (similar to Datastream). In any given case, the stock price of acquired and acquiring equities of companies that traded in the same stock exchange were averaged together in order to examine them as one equity during the period 1987 through 2006. This procedure improved the way equity returns were examined over a long-term period because mergers and acquisitions were treated as special cases in the data sample. To deal with equity de-listings the electronic news retrieval services LEXIS, FT-EXTEL, and Datastream were used. Based on the availability of equity prices in Datastream, equities prior to a delisting were identified. To determine how much the categories of equities above contribute to variations in stock price volatility transmission between equities, only the average daily return of these groups were added to the constructed equity portfolios. The equity prices were also converted in Euros while bank holidays were also excluded in order to create a continuous time series. Finally, trading dates around the October 1987 crash (i.e., 16th, 19th-21st October) and that on 11th September of 2001 were also excluded from the sample.

Table 1 contains information of the sample of the cross-listed European equities from 14 European stock exchanges. These are: Vienna, Brussels, Copenhagen, Helsinki, Paris, Frankfurt+ (comprising Berlin, Dusseldorf, Stuttgart, Munich, XET (XETRA stock index), and Frankfurt), Amsterdam, Milan, Oslo, Madrid, Stockholm, London+ (comprising London, and XSQ (international stock exchange), Zurich, and Dublin. The total number of cross-listed equities, home and foreign cross-listed equities[4], is 689; 280

4 Home portfolios were made up by domestic firms listed in these markets that have a foreign cross-listing while foreign portfolios were made up by cross-listed foreign equities in the respective markets.

are home equities and 409 are foreign equities. The current study concentrates on all the home equities of companies with cross-listings in 14 stock exchanges and their foreign equities listed in Frankfurt+, Paris, London+, and Zurich as their number of foreign listings is larger in comparison to the other stock exchange foreign listings.

Noticeable is that the number of foreign listings significantly varies within the stock exchanges; there are 178 European foreign listings in Frankfurt+ and 98 foreign listings in London+. There are also a large number of foreign listings in Paris (70) and Zurich (63). The number of foreign listings in Frankfurt+ is larger than the number of the home market cross-listings (56). It is also indicated that there are a total number of 45 cross-listings in the UK home market.

Table 1: Number of cross-listed equities

Markets	Firms	Equities	Paris	Frankfurt+	London+	Zurich	Total
Austria	6	7	1	8	2	0	11
Belgium	7	8	6	4	5	2	17
Denmark	7	9	0	5	2	2	9
Finland	4	7	1	3	4	0	8
France	32	34	0	31	15	7	53
Germany	26	56	14	0	20	28	62
Netherlands	26	30	12	30	13	17	72
Italy	12	14	7	12	7	0	26
Norway	6	11	1	6	7	0	14
Spain	20	23	4	19	7	1	31
Sweden	13	20	3	13	8	0	24
UK	40	45	18	33	0	6	57
Switzerland	7	11	3	10	4	0	17
Ireland	4	5	0	4	4	0	8
Total	210	280	70	178	98	63	409

Notes: Frankfurt+ comprises Berlin, Dusseldolf, Stuttgart, Munich, Xet, and Frankfurt. London+ comprises London, and XSQ. The sample includes ordinary shares, 'A' shares, 'B' shares, registered shares, but not redeemable shares (regarded as preference shares and therefore as non-equities). The column Total contains the number of foreign cross-listed equities that comes from the 14 home markets (Austria, Belgium, Denmark, Finland, France, Germany, Netherlands, Italy, Norway, Spain, Sweden, UK, Switzerland, and Ireland) to Paris, Frankfurt+, London+ and Zurich.

An examination of Table 2 which contains various descriptive statistics for the home and foreign stock equity reveals a number of data features. The mean returns for both the home and foreign portfolios were close to zero and standard deviation was rather low. Skewness was negative but very low for most home portfolios returns and for some of the foreign portfolios returns. Additionally, the return distributions of both home and foreign portfolios were fat tailed, with the exception of the Italian home portfolio returns.

The fatness of tails being more pronounced in the returns distributions in Amsterdam and Brussels and Paris and Switzerland for home and foreign portfolios, respectively.

Table 2: Descriptive statistics for cross-listed equities

	Mean (%)	Standard deviation (%)	Skewness	Kurtosis
Panel A: Home portfolios of equities				
Amsterdam	0.000	0.008	-0.34	14.36
Brussels	0.000	0.009	-0.30	13.94
Copenhagen	0.000	0.011	-0.28	6.33
Frankfurt+	0.000	0.012	-0.31	6.40
Helsinki	0.001	0.015	0.00	2.85
Ireland	0.001	0.011	-0.27	6.55
London+	0.000	0.010	-0.12	4.63
Madrid	0.000	0.013	-0.03	3.83
Milan	0.000	0.015	0.10	1.09
Oslo	0.000	0.016	-0.34	3.48
Paris	0.000	0.011	-0.44	6.00
Stockholm	0.000	0.013	-0.30	6.10
Swiss	0.000	0.012	-0.40	7.88
Vienna	0.000	0.013	-0.34	8.93
Panel B: Foreign portfolios of equities				
Frankfurt+	0.000	0.009	0.07	9.88
London+	0.000	0.020	-0.24	11.03
Paris	0.000	0.020	1.47	58.90
Swiss	0.000	0.020	-0.35	27.47

Notes: This table contains the average descriptive statistics for home portfolios of equities in the 14th countries and also the foreign portfolios of equities in the countries of Germany, UK, France and Switzerland. (i) Kurtosis is larger than 3 in all the portfolios of cross-listed equities except for the Milan and Helsinki which means that the tails of the distribution are thicker than the normal. (ii) Skewness provides useful information about the symmetry of the probability distribution. In most of the cases is negative with exception the Helsinki and Milan home portfolios of equities and the German and Paris foreign portfolios of equities.

Table 3 contains descriptive statistics for the daily returns of stock market indices, the trading volume of cross-listed companies and the interest rates in Germany, UK, France, and Switzerland. Noticeable is that the stock market indices exhibit excess kurtosis and negative skewness which is indicative of non-normality in the returns distributions. Kurtosis is negative for the long term interest rates but skewness is very low. However, trading volume has significant kurtosis and positive skewness especially in the returns distribution of the Swiss stock market.

Table 4 shows simple ARCH tests for one period lagged autocorrelation portfolios. Panel A contains the results for the constructed home portfolios and panel B contains the results for foreign portfolios. The estimated results indicate that ARCH effects are significant at the 99% significance level in all the 14 home and 4 foreign portfolios of equities. This suggests that a GARCH modelling framework would be appropriate for investigating daily return behaviour for cross-listed companies.

Table 3: Descriptive statistics for stock indices, foreign equity trading volumes and interest rates

	Mean (%)	Standard deviation (%)	Skewness	Kurtosis
	Panel A: Stock market indices			
Germany	0.001	0.011	-1.15	14.64
UK	0.000	0.010	-1.36	20.62
France	0.000	0.012	-0.48	6.52
Switzerland	0.000	0.010	-1.55	18.12
	Panel B: Foreign equity trading volume			
Germany	N/A	N/A	N/A	N/A
UK	224.44	291.44	2.40	6.95
France	4.62	6.86	9.79	172.25
Switzerland	50.74	609.72	16.59	289.90
	Panel C: Long -term interest rates			
Germany	6.74	1.25	0.16	-0.54
UK	8.63	1.53	-0.33	-0.13
France	7.71	1.68	-0.40	-0.91
Switzerland	4.76	1.13	0.27	-0.87

Notes: (i) Germany contains Frankfurt, Berliner, Dusseldorf, Stuttgart, Munich, and XET equities. UK contains London and XSQ equities. (ii) The long-term interest rates were collected from Datastream from the start of 1987 to the end of 2006. The starting date of the stock markets indices varies amongst countries. For example, the starting date for France is 9/7/87 while for Germany, Switzerland and UK are 30/12/87, 1/4/87 and 1/1/87 respectively. N/A means not available.

Table 4: ARCH Test Effects Results

Panel A: Home portfolios of equities	chi-squared
Amsterdam	83.26
Brussels	55.30
Copenhagen	106.07
Ireland	97.04
Frankfurt+	294.16
Helsinki	79.33
Madrid	66.36
Milan	71.84
Oslo	173.02
Paris	100.93
Stockholm	160.24
Zurich	442.37
London+	162.58
Vienna	106.52
Panel B: Foreign portfolios of equities	
Frankfurt+	73.48
Paris	5.21
Zurich	552.35
London+	317.87

Note: Critical level of the chi-square is 3.84. This table contains the ARCH test results in order to check the appropriateness of data to deal with a GARCH modeling approach. All the results are statistically significant at the 99% level.

METHODOLOGY

Using the approach suggested by Karolyi (1995) and Engle and Kroner (1995), volatility and error transmission[5] of cross-listed equities were estimated. ARCH type models have traditionally been used to investigate volatility spillovers between equities and stock exchanges. Bollerslev (1986, 1987) and Engle, Lilien, and Robins (1987) used ARCH type models to account for second moments of errors in their investigations of volatility spillover effects. Examining the descriptive ability of these models, French, Schwert, Stambaugh (1987) found that the extended Generalised Autoregressive Conditional Heteroskedastic-in-Mean (GARCH-M) model provides a good representation for the behaviour of US daily stock returns, while Engle and Susmel (1993) suggested that stock markets are linked through their second moments. Overall, these finding suggested that volatility spillovers can be investigated using ARCH type models that take account of second moments. Among the GARCH models family, multivariate GARCH approaches are the most widely used in time-varying covariance studies. Such approaches include the Vector (VEC) of Bollerslev, Engle, and Wooldridge (1988), the Constant Correlation (CCORR) of Bollerslev (1990), the Factor ARCH (FARCH) of Engle et al. (1990), and the GARCH-BEKK of Engle and Kroner (1995).

The GARCH-BEKK model represents an attempt to overcome the various technical difficulties associated with previous approaches, such as the fact that the definite H_t variance matrix may not always be positive (a restriction imposed in the previous empirical approaches). Previous approaches impose the restriction for the estimated variance to be greater than zero when volatility spillovers are examined. In contrast, the GARCH-BEKK parameterisation is specified in such a manner that no restrictions are required to ensure a positive definite H_t variance matrix.

The multivariate GARCH-BEKK model is written as (Berndt et al. 1974, Engle and Kroner 1995):

$$r_t = \alpha + \sum_{p=1}^{n} \Phi_p r_{t-n} + e_t, e_t \mid \Omega_{t-1} \sim N(0, H_t) \tag{1}$$

5 Error transmission is the transmission of noise between markets and it refers to the unexplained part of the GARCH-BEKK model.

where, r_t is the series of returns, e_t is the error term of return equation, a is the constant term, Φ_p is the matrix of coefficients with the p lagged values of r_t, Ω_{t-1} is the matrix of conditional past information that includes the p lagged values of r_t, and H_t is the matrix of volatility. To avoid the problems of dealing with non normal distributions[6], the first moment of errors e_t is represented by a martingale process, as shown in Equation (2). It is assumed that e_t in equation (1) follows a process of $E(\varepsilon_t)$, where

$$E(\varepsilon_t) = E(r_t - \mu_t) \tag{2}$$

where μ_t is the long-term drift coefficient, and the volatility matrix H_t can also be written as

$$H_{t+1} = CC' + \mathrm{B}' H_t B + A' \varepsilon_t * \varepsilon_t' \mathrm{A} \tag{3}$$

where C is the matrix of constant coefficients, C' is the transposed matrix of the constant coefficients, B is the matrix of the coefficients of volatility, B' is the transposed matrix of the coefficients of volatility, A is the matrix of the coefficients of the error term, A' is the transposed matrix of the coefficients of the error term, ε_t is the matrix of error terms and ε_t' is the matrix of transposed error terms

Equation (1) can be further expanded to consider the effects of interest rates and trading volume on spillover effects:

$$r_t = \alpha + \sum_{p=1}^{n} \Phi_p r_{t-n} + z_{1t} + z_{2t} + e_t, e_t \mid \Omega_{t-1} \sim N(0, H_t) \tag{4}$$

where, r_t is the series of returns, z_{1t} represents the actual data series for interest rate, z_{2t} represents the actual data series for trading volume, Φ_p is the matrix of coefficients with the p lagged values of r_t and Ω_{t-1} is the matrix of conditional past information that includes the p lagged values of r_t. Error terms are then extracted from Equation (4) in order to be used in Equation (2) to measure the impact of interest rates and trading

6 This is important for smoothing the series for calculating the conditional volatility of returns.

volume on the magnitude and persistence of volatility spillovers between different equity portfolios.

The above specified GARCH-BEKK model will be used to investigate volatility spillovers for the sample of cross-listed companies. The same modelling approach will also be used to investigate relationships between the returns of foreign cross-listed shares (according to different regulatory environments for varying disclosure rules and investor protection regulations) and with the domestic stock indices.

EMPIRICAL RESULTS

While a substantial amount of the literature examines the impact of interest rates and trading volume on equity returns (see for example Lamoureux and Lastrapes 1990, Elyasiani and Mansur 1998) no studies have examined how such factors affect volatility between stock markets. In that respect two factors, interest rates (z_1) and portfolio trading volume (z_2) were also included in the first equation of the GARCH-BEKK model in order to examine whether these factors influence volatility spillover estimates through the residuals which coming from the return equation. The same approach was also used as this that has been described just above to consider the volatility spillover effects relating to foreign cross-listed equities which are listed to various foreign regulatory environments in comparison to the home markets.

Table 5 (panel A to C) compares the estimates of volatility spillover effects from the foreign cross-listed equities on the Frankfurt stock exchange with the DAX100 stock index which are considered in the GARCH-BEKK model including and excluding the variable of interest rates. The results are reported in terms of different accounting regimes, creditor bankruptcy and shareholder protection rules. The focus was kept on this stock market because the German interest rate follows an independent distribution in comparison to the stock price changes of the other European interest rates (Karfakis and Moschos 1990).

Table 5: Impact of interest rates on volatility spillovers between German cross-listed European equities

	With interest rates	Without interest rates
Panel A: German foreign equity portfolios with the DAX100: Disclosure of accounting standards -period: 27/9/1988-31/12/2006	**'Low' 'High' 'Same' DAX100**	**'Low' 'High' 'Same' DAX100**
Volatility transmission from 'Low' to 'High'	0.09 (0.04)	0.11 (0.04)
Volatility transmission from 'High' to 'Low'	0.08 (0.03)	
Volatility transmission from 'Same' to 'High'	0.14 (0.07)	
Volatility transmission from DAX100 to 'Low'	-0.12 (0.04)	
Volatility transmission from 'High' to DAX100	-0.14 (0.03)	
Volatility transmission from 'Low' to DAX100	0.13 (0.02)	
Volatility transmission from DAX100 to 'High'	N/A	0.26 (0.06)
Error transmission from 'Low' to 'High'	-0.04 (0.01)	-0.02 (0.01)
Error transmission from 'High' to 'Low'	-0.05 (0.02)	0.06 (0.02)
Error transmission from 'Same' to 'High'	-0.06 (0.03)	
Error transmission from 'High' to 'Same'	0.05 (0.03)	
Error transmission from DAX100 to 'Low'	0.10 (0.02)	0.12 (0.03)
Error transmission from 'High' to DAX100	0.08 (0.02)	
Error transmission from DAX100 to 'High'	N/A	0.25 (0.02)
Volatility persistence		
'Low'	0.74	0.71
'High'	0.56	0.81
'Same'	0.88	0.90
DAX100	0.86	0.35
Log-Likelihood	44253.57	44195.29
Panel B: German foreign equity portfolios with the DAX100: Creditor bankruptcy protection rules-period: 27/9/1988-31/12/2006	**'High' 'Low' 'Same' DAX100**	
Volatility transmission from 'High' to 'Same'	-0.20 (0.09)	
Volatility transmission from 'High' to DAX100	0.33 (0.16)	
Error transmission from DAX100 to 'Low'	0.12 (0.04)	0.11 (0.04)
Error transmission from DAX100 to 'Same'	0.11 (0.04)	0.13 (0.03)
Error transmission from 'Low' to DAX100	N.A	0.05 (0.02)
Volatility persistence		
'High'	-0.47	0.87
'Low'	0.86	0.13
'Same'	0.37	0.56
DAX100	0.97	0.51
Log-likelihood	42642.12	42560.39

Note: (i) 'High' refers to where the foreign cross-listing is located in a market with more onerous regulatory requirements in the context of accounting rules, creditor bankruptcy and shareholder protection rules. 'Low' refers to less onerous regulatory environments and the 'Same' refers to exchanges that have similar rules. (ii) only statistically significant results are reported, (iii) N/A means not available, (iv) standard errors are given in brackets.

Table 5: Impact of interest rates on volatility spillovers between German cross-listed European equities (continued)

	With interest rates	Without interest rates
Panel C: German foreign equity portfolios with the DAX100: Shareholder protection rules-period: 27/9/1988-31/12/2006	**'High' 'Low' DAX100**	
Volatility transmission from 'High' to DAX100	0.10 (0.01)	0.075 (0.00)
Volatility transmission from 'Low' to 'High'	N.A	0.04 (0.01)
Volatility transmission from 'High' to 'Low'	N.A	-0.02 (0.00)
Volatility transmission from DAX100 to 'High'	N.A	-0.11 (0.018)
Error transmission from 'High' to 'Low'	0.02 (0.01)	0.057 (0.00)
Error transmission from DAX100 to 'High'	0.08 (0.03)	0.19 (0.02)
Error Transmission from DAX100 to 'Low'	0.03 (0.02)	0.05 (0.01)
Error transmission from 'Low' to DAX100	N/A	0.03 (0.00)
Volatility persistence		
'High'	0.68	0.65
'Low'	0.92	0.91
DAX100	0.79	0.98
Log-likelihood	34135.02	33125.15

Note: (i) 'High' refers to where the foreign cross-listing is located in a market with more onerous regulatory requirements in the context of accounting rules, creditor bankruptcy and shareholder protection rules. 'Low' refers to less onerous regulatory environments and the 'Same' refers to exchanges that have similar rules. (ii) only statistically significant results are reported, (iii) N/A means not available, (iv) standard errors are given in brackets.

Comparing the two columns of the volatility spillover effects, it can be seen that the inclusion of interest rates results in a more dynamic volatility spillover effects' environment. For example, in panel A the volatility and error transmissions between the portfolio of High, Low, Same and the stock index of DAX 100 variables considering the impact of interest rates is evidenced for the case of High to Low (0.08) volatility transmission but not for the same variables without the impact of interest rates in the econometric GARCH-BEKK model. There is greater interrelationship in the volatilities of the various portfolios (i.e., 'High', 'Low' and 'Same' and with the stock index) in the GARCH-BEKK interest rate model. In total, there are 12 cases of volatility spillovers according to the results of panel A and only 6 when the impact of interest rates is not considered. In general, while interest rates add to the dynamics of the volatility spillover effects their magnitude found to be relatively low. The second part of 1990s was characterised by declining interest rates and this may help to explain the modest magnitude of these volatility spillovers.

The effect of both trading volume and interest rates together on volatility transmission was also examined by including these variables in the GARCH-BEKK model[7]. Table 6 reports the volatility spillover coefficients for cross-listed equity portfolios that were found to be statistically significant for the London, Paris, and Zurich stock exchanges. In general, it was found that the inclusion of the trading volume variable to the cross-listed foreign equities has little impact on volatility spillovers especially in the London stock market. For instance, the error transmission coefficient from the FTSE100 to the 'High' (accounting standards) portfolio has fallen from –0.06 (in the model that excludes interest rates and trading volume[8]) to -0.05. Other interactions remained the same.

Table 6: Impact of interest rate and trading volume on volatility spillovers between cross-listed European equities

Panel A: London foreign equity portfolios with the FTSE100: Disclosure of accounting standards-Period: 5/1/1987-31/12/2006	**'High' FTSE100**
Volatility transmission from FTSE100 to 'High'	0.03 (0.00)
Error transmission from FTSE100 to 'High'	-0.05 (0.01)
Volatility persistence	
'High'	0.97
FTSE100	0.70
Log-Likelihood	24920.20
Panel B: Paris foreign equity portfolios with the CAC40: Creditor bankruptcy protection rules-period: 10/7/1987-31/12/2006	**'High' CAC40**
Volatility transmission from CAC40 to 'High'	-0.02 (0.00)
Volatility transmission from 'High' to CAC40	0.07 (0.02)
Error transmission from CAC40 to 'High'	0.87 (0.01)
Volatility persistence	
'High'	0.92
CAC40	0.85
Log-Likelihood	22059.07
Panel C: Zurich foreign equity portfolios with the SBC100: Shareholder protection rules-period: 28/3/1990-31/12/2006	**'Low' 'High' SBC100**
Volatility transmission from SBC100 to 'High'	0.14 (0.06)
Volatility transmission from 'High' to SBC100	0.04 (0.02)
Error transmission from 'Low' to SBC100	0.07 (0.02)
Volatility persistence	
'Low'	0.91
'High'	0.85
SBC100	0.90
Log-Likelihood	27682.97

Note: (i) 'High' refers to where the foreign cross-listing is located in a market with more onerous regulatory requirements in the context of accounting rules, creditor bankruptcy and shareholder protection rules. 'Low' refers to less onerous regulatory environments and the 'Same' refers to exchanges that have similar rules. (ii) only statistically significant results are reported. (iii) standard errors are given in brackets.

7 We do not use trading volume data for the expected stock indices as the impact of trading volume of stock price indices on spillovers between markets tends always to be significant. In contrast, we expect cross-listed equities to have thin trading volume on the foreign market, and thus we do not know if changes in trading volume for the foreign sample of cross-listed equities has a significant impact on volatility spillovers or not.

8 The results are not reported but are available under request.

In Paris stock market the volatility spillover dynamics has increased in terms of magnitude (the volatility transmission coefficient from 'High' to CAC40 has increased from 0.03 to 0.07) while various directions of the other volatility spillover interactions emerged. Finally, the results for the foreign cross-listed equity portfolios in the Zurich stock market suggested that volatility spillover effects were reduced when their trading volume was taken into account. While the results may appear *ad hoc*, taken together they do suggest that both economic news, represented by interest rates, and market news, represented by trading volumes, can influence the volatility transmission patterns between portfolios and stock market indices.

This paper found that there are strong interactions between portfolios of foreign equities, classified according to the three regulatory factors to 'High', 'Low' and 'Same' when these compared to the home stock markets for specific cross-listed equities, and the stock indexes. Specifically, it was found that 'High' and 'Low' regulatory differences for cross-listed portfolios of equities play a key role compared to the same portfolio of cross-listed equities. The results indicate that regulators should try to harmonize accounting standard differences between stock markets in order to reduce market volatility. If markets become more integrated, regulators and investors will gain from a common stock market which will be less volatile and less prone to crashes.

CONCLUSIONS

This paper investigates the relationship between volatility spillover effects and different stock market regulatory structures, interest rates and trading volume for cross-listed European equities over the period 1987 to 2006.

The main findings are two. First, a multivariate GARCH-BEKK model provides a useful modelling framework to examine the mechanism of volatility spillovers between European stock markets with different regulatory structures. The magnitude and persistence of volatility spillovers is found to be significant here, however, this depends on how the cross-market (portfolio) dynamics in the conditional volatilities of the respective stock markets (portfolios) are modelled. We believe that our spillovers are true as the GARCH-BEKK model is the most representable for this kind of analysis.

Second, the impact of differences in accounting standards and shareholder and creditor protection rules on volatility spillovers between foreign cross-listed equities and stock market indices are noticeably different when we account for the impact of interest rates and trading volume. This suggests that investment barriers and other explanatory variables of stock market dependencies may be related to the above mentioned regulations for understanding the dynamics of volatility spillover patterns in stock prices within Europe.

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