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Measuring the Impact of Stock Exchange Rules on Volatility and Error Transmission – The Case of European Cross-Listed Equities

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Abstract: This paper investigates the relationship between spillover effects and stock market regulations for a sample of cross-listed European firms. Using LaPorta et al.'s (1998) stock exchange regulatory classification we identify firms that have cross-listed on foreign exchanges with either tougher, weaker or similar accounting disclosure, bankruptcy and shareholder protection rules. We then use the GARCH approach suggested by Karolyi (1995) and Engle and Kroner (1995) to estimate volatility and error transmission for our sample of cross-listed equities, taking into account regulatory differences between exchanges. Our results show how differences in stock exchange rules can influence spillovers between foreign cross-listed equities and the respective market indices. Accounting disclosure rules also seem to have less of an effect on cross-listed share volatility transmission than do differences in shareholder and bankruptcy protection rules.

Key words: croos-listings, equities, error transmission, Siamese twin equities, spillover effects

JEL Classification: G15

Introduction

This paper examines the integration process for cross-listed equities in Europe. A primary focus of this study is to relate the volatility spillover effects for cross-listings across markets with different regulatory structures. In particular, the paper investigates the relationship between spillover effects and stock market regulatory structures for cross-listed European firms. Using La Porta et al.'s (1998) stock exchange regulatory classification (that distinguishes between differences in capital

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market accounting disclosure requirements, and shareholder and creditor protection rules) we identify firms that have cross-listed on exchanges with tougher, weaker or similar regulatory features compared with the home market. Using data on cross-listings from the UK, and French markets we construct portfolios of the foreign listed companies based on the aforementioned regulatory conditions[1]. After having identified the differences in the regulatory features associated with the cross-listing we then construct portfolios of the foreign (cross-listed) equities according to different regulatory environments and examine the performance of these portfolios with the relevant market indices (FTSE100, and CAC40) to investigate volatility spillover effects.

In his seminal study Karolyi (1995) examines volatility spillover effects between the United States (S & P 500) and Canada (TSE 300)[2], and demonstrates that such spillovers on the portfolios of 'inter-listed' versus 'non-inter-listed' stocks are distinctly different. That is, the magnitude and persistence of S&P 500 shocks are greater for subsequent returns of 'inter-listed' stocks than 'non-inter-listed' stocks. Likewise, Eun and Jang (1997) find statistical evidence that there are dynamic interactions among the prices of those stocks that are 'cross-listed' on the three major stock markets of the world, i.e. New York, London, and Tokyo. Based on these findings, it is suggested that investment barriers relating to restrictions on the free flow of capital, tax considerations, foreign-ownership restrictions and differences in accounting standards and disclosure practices may be important for understanding the dynamics of co-movements in stock prices around the world. Such factors might also dampen the cross-market impact of large stock-price movements. The intention of the present study is based on these inferences, and we develop a model to analyse whether similar barriers influence the market transmission mechanism for European cross-listed stocks.

The starting point for the current study is the extension of the above-mentioned literature to the European security market. In particular, the multivariate GARCH-BEKK model introduced by Karolyi (1995) is extended to control for regulatory differences between exchanges that may act as investment barriers to the transmission mechanism. Multivariate GARCH models are commonly used to investigate such transmission patterns (e.g. Theodossiou and Lee, 1993; Kanas, 1998), and the GARCH-BEKK model has been suggested as an approach that offers greater flexibility for modelling these dynamic effects[3]. The latter approach allows for the measurement of the magnitude and persistence on a portfolio's own lagged returns.

The main finding of this paper is that we find that spillover effects are important both within and across European markets for cross-listed companies. In addition, different regulatory environments have a significant impact on volatility spillovers. Our study extends current understanding about the determinants and intentions

underlying transmission patterns by introducing regulatory investment barriers into the modelling framework. In this way it may be seen as a contribution to the debate on the effects of volatility spillovers in circumstances where the dynamics of market integration may be better understood. Our analysis of transmission patterns amongst cross-listed European equities shows what seems to be an effect of barrier restrictions on market integration. That is, regulatory differences between markets appear to have an impact on volatility spillover effects for European cross-listed shares. This is an important contribution to the debate given the view, prevalent amongst some capital market regulators, that harmonisation of regulatory standards will reduce barriers and therefore spillover effects across markets (Stulz (1981, 1999)).

Secondly, this paper also of importance as it provides an empirical link between research in finance and accounting. It investigates the effects on accounting standards, and shareholder and creditor protection legislation on the volatility spillover effects of cross-listed equities (within Europe).

Literature Overview and Study Objective

Volatility clustering characterises the transmission of news from one market to another. Among others, Bennett and Kelleher (1988), Von Furstenberg and Jeon (1989), Hamao, Masulis and Ng (1990), King and Wadhwani (1990), Schwert (1990), Susmel and Engle (1990), Neumark, Tinsley, and Tosini (1991), Becker, Finnerty, and Tucker (1992), Fratzscher (2001), Hardouvelis et al. (2002), Bekaert et al. (2003) demonstrate this type of transmission of news. In their various analyses, they report that the transmission of volatility between markets is also time-varying, that lagged spillovers of price changes and price volatility exist between major stock markets, and that, when volatility is high, price changes in major stock markets tend to become highly correlated.

Fratzscher (2001) examines the integration of European markets between January 1986 and June 2000 using a GARCH methodology. The results suggest that the financial liberalisation process in Europe has increased the degree of stock market integration, most notably in the EMU participating countries. Hardouvelis et al. (2002) considered the implications of EMU and the introduction of Euro estimating a conditional asset pricing model. Their results suggest that the reduction of currency risk following the introduction of the single currency is extremely important in enhancing stock market integration principally through a reduction in the volatility of European equity premia. Bekaert et al. (2003) find that more than 30% of the conditional mean variance in European returns is attributed to shocks from the US. In terms of contagion effects, there is intra-European contagion but no evidence of excess correlation between Europe and the US.

This type of correlation may be caused because volatility spillovers that emanate from more efficient markets and that are transmitted to less efficient markets are simply contagious. One possibility is that such patterns of spillovers lead regulators to impose rules on markets in a more pervasive way in order to remove inefficiencies. This in turn breaks down the regulatory restrictions that act as barriers to capital market integration. There is some evidence that relates volatility spillovers to barriers on structural differences between markets.

For instance, Kanas (1998) shows that spillovers across markets with diverse structures are different to those with similar structures. While Kanas (1998) focuses on London, Paris, and Frankfurt, other studies (e.g. Hamao et al. (1990), Theodossiou and Lee (1993)) focus on the major stock markets (US, Canada, Japan, UK, and Germany). For example, Hamao et al. (1990), Koutmos and Booth (1995), and Susmel and Engle (1994) focus on spillovers across New York and London, and Theodossiou and Lee (1993) examine spillovers across US, Japan, Canada and Germany. In addition to the above, Hamao et al. (1990) find the existence of spillovers from the USA and UK markets to Japan. Koutmos and Booth (1995) find that the transmission of volatility is asymmetric and is more pronounced when news is bad and coming from either market. Other evidence from Susmel and Engle (1994) find that volatility transmission is short and small between New York and London, in contrast to Teodossiou and Lee (1993) who note that the US capital market is the major 'exporter' of volatility to other financial markets.

The research design of each of the above studies involves the use of GARCH models to examine transmission patterns. GARCH models with conditional correlation are developed extensively in the finance literature to model spillover effects. As research reveals, volatility spillovers from the US capital markets could lead the rest of the world (Eun and Shim, 1989) and also correlation between markets could increase over time (Koch and Koch, 1991; Von Furstenberg and Jeon, 1989). In particular, Eun and Shim (1989) study the change in daily stock returns across nine stock markets using a VAR approach adjusting for non-synchronous stock price trading hours in different markets. As already mentioned, these authors found that the US market is by far the most influential vis-B-vis other markets. On the other hand, Von Furstenberg and Jeon (1989) investigate the relationships between change in daily stock price returns in Japan, Germany, the UK, and the USA markets over the period 1986 to 1988. They find an increase in the correlation between the above markets especially after the October crash in 1987. Studies that have used the GARCH modelling framework in the past, however, have typically not used specifications that control for the impact of regulatory barriers (such as different stock market rules) on equity market interrelationships, the main focus of the current study.

If one examines the correlation of equities returns alone, one cannot reach conclusions with regard the impact of regulatory barriers on market integration. As Karolyi (1995) has pointed out, barrier restrictions have an impact on interdependencies and this need to be taken into account using GARCH models in order to be able to draw correct inferences on such spillover relationships. Such interdependencies may be related to the ongoing debate on capital market standards, and the impact of 'cross-listing' on the quality of market standards. The debate on market interdependence and its relation to different regulatory standards is also of particular importance in Europe where there have been regulatory moves to foster market integration[4].

In this respect, an analysis of volatility spillovers between cross-listed equities between exchanges with different regulatory structures may help to inform us more about the market integration process. Huddart et al. (1998), for instance, suggests that market exchanges lower their disclosure standards in order to attract more listed foreign firms and this reduces the market integration process as this competition results to 'a race to the top' for admission of firms to other stock exchanges. In general, it is assumed in the literature (Saudagaran and Biddle, 1992) that stringent disclosure requirements reduce access to foreign exchanges (and investment in capital markets). Baker (1992) finds that the most important investment barriers are the costs faced by companies and the level of disclosure requirements. Potential relaxation 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. Higher standards, however, may result in stock exchanges attracting higher quality corporations because of the stricter environment (e.g. Cheung and Lee, 1995).

While there have been regulatory initiatives aimed at harmonising European stock market rules, substantial differences still remain between markets. Adhikari and Tondkar (1995) note that European exchanges set their requirements with a 'lower bound' without any 'higher bound' when they accept new financial corporations. For instance, in France, Germany, the Netherlands, and Sweden companies surpass the requirements demanded by the stock exchanges providing additional voluntary disclosures that are important for shareholders and investors (e.g. Meek and Gray, 1989). Differences in accounting disclosure requirements and protection of shareholders and creditors may impact on the financial regulation on capital markets. For example, La Porta et al. (1998) document a variety of regulatory differences relating to investor protection rules and accounting disclosure regulations across EU markets.

An important question with regard to cross-listings relates to the influence, if any, of various regulations and institutional rules on price volatility. Empirical evidence (Karolyi, 1995) suggests that because stock markets are characterised by different

structures, the potential investment barriers that arise may affect volatility spillovers (information transfers) between markets. For example, tax considerations, as cited by Stiglitz (1989) and Summers (undated) may influence stock price volatility changes that cannot be fully explained by 'fundamental' factors alone.

Given that regulations are believed to have an impact on stock price volatility this paper examines how such investment barriers (arising from accounting disclosure standards, creditor and shareholder protection rules) may impact on both stock price and trading noise changes in Europe. As far as we are aware the available empirical evidence simply confirms the interrelationship between stock prices and volatilities without taking into account regulatory barriers. Most of this literature has examined the interrelatedness of major exchanges in the US, Europe and Asia (Eun and Shim (1989), and Koch and Koch (1991)). When significant spillover effects are found these are explained by different structural and regulatory features associated with the respective markets but these specific features are (as far as we are aware) never tested for. We therefore do not know what impact different regulatory features have on such spillover effects. This paper aims to address these issues by examining the influence that regulatory structures have on volatility transmission for cross-listed European equities.

The Data

Sample Selection

This paper focuses on 'cross-listed' equities in Europe[5]. Sample selection requires that we obtain information on European cross-listed equities in order to construct portfolios so that we can test for spillover effects between markets. This means that data has to be obtained on firms that have cross-listings and we collect information on their home and foreign equity performance over the period 1987 to 1998.

In order to identify European companies with 'inter-listings' we first wrote to the European stock exchanges asking for information on companies that were listed on their exchanges and quoted on other European markets. Based on the responses, we selected stock price information for firms with multiple quotations that were available on 'Datastream' during the period 1987 to 1998. In order to avoid the survivorship bias in data collection, firms involved in de-listings, bankruptcies, mergers and acquisitions were also included in the sample.

To be included in the sample, firms that experienced bankruptcies, de-listings and mergers or acquisitions had to meet the following criteria:

The merger/acquisition announcement had to be identified by the FT-EXTEL database over the period of January 1987 to December 1998. 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 databases. The exact effective date of consummation of the merger 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 date of consummation arrangement for the remaining 19 acquisitions is found in DATASTREAM, however without a back-filling process. Thus, a 'back-filling' process is 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 above, the stock price of acquired and acquiring equities of companies that traded in the same stock exchange are averaged together in order to examine them as one equity during the period 1987 through 1998. This procedure improves the way in which we examine high-frequency return equities over a long-term period, because mergers/acquisitions are treated as special cases in the data sample. This approach helps us to specify these returns so as to avoid overestimation or underestimation of stock price volatility distributions in the constructed equity portfolios used in the spillover analysis.

We also deal with equity de-listings from 1987 to 1998 by using the electronic news retrieval services LEXIS, FT-EXTEL, and DATASTREAM. Based on stock price data availability on DATASTREAM, we identify equity prices prior to a delisting. DATASTREAM provides evidence that many de-listings involve suspensions before proceeding to bankruptcy. While many of these companies' equities are in financial distress, most of them continue to trade before delisting. A company with different types of equities that list on a certain stock exchange might experience de-listing in a certain type of security (e.g. ordinary shares) with 'normal' performance in other types of listed securities (e.g. A and B shares). In this case, there are survivorship bias effects that may be caused by the performance of non-survived equities (e.g. ordinary shares).

So as to avoid this bias, non-survived equities are included in our sample. In addition to identifying survivorship bias brought about by M & A and de-listings we also take account of a variety of other factors that can influence volatility and spillover effects. Such factors include identifying the following: unsuccessful mergers, de-mergers (e.g. BAT Industries demerged into BAT PLC and Allied Zurich), Siamese twin equities (e.g. Royal Dutch / Shell), change of name equities (e.g. from Sanofi to Elf Sanofi), subsidiaries that trade separately from the holding equity (e.g. AEG), integration of equities to other equities (e.g. Siemens Nixdorf to Siemens), and different types of equities that belong to the same company (e.g. 'A' and 'B' shares). In all cases equities are identified in a similar fashion as with the mergers and acquisitions or de-listing cases as mentioned above. To recap, the sample that is used is based on 'cross-listing' data, and checked to account for all the

above possible survivorship biases that might arise in the sample in order for us to construct the appropriate portfolios.

To determine how much the categories of equities above contribute to variations in stock price volatility transmission between equities, only the average return of these groups are added into the constructed equity portfolios. In addition, the data is transformed into Euros by using the European Central Bank (ECB) exchange rates at the end of 1998 or beginning of 1999. In addition trading holidays as identified by Datastream are excluded so we have a continuous data series[6]. After following the aforementioned data selection procedure we arrive at a sample of 210 firms that have 168 foreign cross-listings across different European markets as shown in Table 1.

Data Description

Table 1 shows our sample of 'cross-listed' equities in European stock markets. The current study covers 'cross-listed' equities from 14 European stock exchanges. These are: Vienna, Brussels, Copenhagen, Helsinki, Paris, Frankfurt+ (comprising Berlin, Düsseldorf, 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 + foreign) across the 14 European stock markets is 448; 280 are home equities and 168 are foreign equities. The current study concentrates on the foreign equities that are listed in Paris, and London+[7].

Table 1: Within sample-inter-listing of stock prices

Home Markets	Firms	Equities	Paris	London+[a]	Total
Austria	6	7	1	2	3
Belgium	7	8	6	5	11
Denmark	7	9	0	2	2
Finland	4	7	1	4	5
France	32	34	0	15	15
Germany	26	56	14	20	34
Netherlands	26	30	12	13	25
Italy	12	14	7	7	14
Norway	6	11	1	7	8
Spain	20	23	4	7	11

Sweden	13	20	3	8	11
UK	40	45	18	0	18
Switzerland	7	11	3	4	7
Ireland	4	5	0	4	4
Total	210	280	70	98	168

[a]London+ comprises London, and XSQ. The sample includes ordinary shares, 'A' shares, 'B' shares, registered shares, but not Redeemable shares (regarded as a preference share and therefore as non-equity share). Out of the 280 home listings, 22 have been delisted. In addition, 31 home equity listings involve mergers.
This table presents the number of foreign listings within the stock exchanges of London+ and Paris. The variable Home Markets indicates the number of European cross-listed equities that used in this study. The variables Firms and Equities are referred to the number of European firms and equities that used in the whole study. The variables Paris, London+ and Total are referred to the number of foreign cross-listings from the respective home markets. The number of foreign cross-listed equities is reported for the stock exchanges of London+ and Paris.

The number of foreign listings varies within the stock exchanges; there are 98 foreign listings in London+. There is also a large number of foreign listing in Paris (70). There are a large number of home 'cross-listings' in the Netherlands and France; 30 in the former and 34 in the latter.

All the above mentioned 210 'home' market 'cross-listings' comprise 159 firms that belong to the General Industry Sector[8], five firms that operate in the consumer goods, recreation and services sectors, ten firms that are utilities (e.g. telecommunications) and 36 firms are financial and/or investment companies[9].

Methodology

As noted already the main aim of this paper is to investigate volatility spillovers relating to cross-listed companies in Europe and this requires us to model the interrelatedness of returns between markets. In order to do this we follow Karolyi (1995), Karolyi and Stulz (1996) and Eun and Shim (1989) and construct portfolios for the home and foreign equity of cross-listed companies in European exchanges. Rather than examining volatility spillovers across all markets we narrow the focus by using La Porta et al.'s (1998) broad legal classification to examine the influence of regulatory differences on information transmission across the main European capital markets.

La Porta et al. (1998) notes that European countries impose different legal rules on their stock markets with respect to investor protection in the context of accounting disclosure rules, and creditor/shareholder protection rules. They suggest that the legal status of countries also affects the decisions of where companies may seek a foreign listing. For example, over a hundred European companies have obtained a public cross-listing in the United Kingdom whereas few European firms seek Italian listings. Thus, legal rules appear to affect the decision of companies to cross-list. La Porta et al. (1998) identify four broad types of legal structure governing European exchanges: English, French, Germanic, and Scandinavian. The UK and Dublin stock exchanges are governed by English law which is a common law made by judges and incorporated into legislature; French, German, and Scandinavian laws, in contrast, is based on a civil law tradition dating back to Roman times.

Table 2: Accounting disclosure standards' differences

	Foreign Markets	
	London+	Paris
Home Market		
UK		LOW
Belgium	HIGH	HIGH
France	HIGH	
Italy	HIGH	HIGH
Netherlands	HIGH	HIGH
Spain	HIGH	HIGH
Austria	HIGH	HIGH
Germany	HIGH	HIGH
Switzerland	HIGH	HIGH
Denmark	HIGH	HIGH
Finland	HIGH	LOW
Norway	HIGH	LOW
Sweden	LOW	LOW

The table presents La Porta et al. (1998) regulatory classification index. Data on regulatory classification were obtained from La Porta et al. findings for European home equities that traded on foreign markets of London+ and Paris in December 1998. For each stock eligible for dual listing, we identify the difference in accounting disclosure rules between the home and

foreign (London+ or Paris) markets. 'High' refers to where the foreign cross-listing is located in a market with more onerous accounting disclosure rules, compared to the home listings. 'Low' refers to less onerous regulatory environments and the 'Same' refers to exchanges that have similar accounting disclosure rules. La Porta et al 1998 pp. 1125, construct this index by examining and rating a minimum of three companies in each country using 1990 annual reports studying the inclusion or omission of 90 items. These items fall into seven categories (general information, income statements, balance sheets, funds flow statement, accounting standards, stock data, and special items). The companies represent a cross section of various industry groups; industrial companies represent 70 percent, and financial companies represent the remaining 30 percent).In order to distinguish between more specific regulatory differences between European exchanges we use the regulatory classification provided in La Porta et al. (1998) to distinguish between different levels of regulation relating to accounting standards, creditor and shareholder protection. These are then used to identify firms that have obtained foreign cross-listings in markets with tougher, laxer or similar regulatory environments compared with the home listing. These are shown in Tables II-IV. Table II shows differences in accounting standards between home and foreign markets. For instance, a French company that has a foreign listing in London and Frankfurt has to comply with higher (tougher) accounting disclosure requirements in the former, but lower (laxer) requirements in the latter, compared with home rules. Similarly, Table III shows differences for creditor protection rules covering bankruptcy and Table IV shareholder protection rules.

Table 3: Creditor bankruptcy protection rules' differences

	Foreign Markets	
	London+	Paris
Home Market		
UK		HIGH
Ireland	HIGH	HIGH
Belgium	HIGH	HIGH
France	LOW	
Italy	HIGH	HIGH
Netherlands	HIGH	HIGH
Spain	HIGH	HIGH
Austria	HIGH	HIGH
Germany	HIGH	HIGH
Switzerland	HIGH	HIGH
Denmark	HIGH	HIGH
Finland	HIGH	HIGH

Norway	HIGH	HIGH
Sweden	HIGH	HIGH

The table presents La Porta et al. (1998) regulatory creditor rights index. Data on creditor rights index were obtained from La Porta et al. findings for European home equities that traded on foreign markets of London+ and Paris in December 1998. For each stock eligible for dual listing, we identify the difference in creditor rights between the home and foreign (London+ or Paris) markets. 'High' refers to where the foreign cross-listing is located in a market with more onerous creditor rights, compared to the home listings. 'Low' refers to less onerous regulatory environments and the 'Same' refers to exchanges that have similar creditor rights. The index is formed by adding when (1) the country imposes restrictions, such as creditors' consent or minimum dividends to file for reorganisation; (2) secured creditors are able to gain possession of their security once the reorganisation petition has been approved (no automatic stay); (3) secured creditors are ranked first in the distribution of the proceeds that result from the disposition of the assets of a bankrupt firm; and (4) the debtor does not retain the administration of its property pending the resolution of the reorganisation. The index ranges from zero to four (La Porta et al., 1998).

Table 4: Shareholder protection rules' differences

	Foreign Markets	
	London+	Paris
Home Market		
UK		HIGH
Ireland	LOW	LOW
Belgium	LOW	LOW
France	LOW	
Italy	LOW	LOW
Netherlands	LOW	LOW
Spain	LOW	LOW
Austria	LOW	LOW
Germany	LOW	LOW
Switzerland	LOW	LOW
Denmark	LOW	LOW
Finland	LOW	LOW
Norway	LOW	LOW

Sweden	LOW	HIGH

The table presents La Porta et al. (1998) ownership concentration index. Data on ownership concentration index were obtained from La Porta et al. findings for European home equities that traded on foreign markets of London+ and Paris in December 1998. For each stock eligible for dual listing, we identify the difference in ownership concentration between the home and foreign (London+ or Paris) markets. 'High' refers to where the foreign cross-listing is located in a market with more onerous ownership concentration, compared to the home listings. 'Low' refers to less onerous regulatory environments and the 'Same' refers to exchanges that have similar ownership concentration. La Porta et al. (1998) use ownership concentration in 10 largest private firms as an index of investor protection: The index is constructed using the average percentage of common shares owned by the three largest shareholders in the 10 largest non-financial, privately owned domestic firms in a given country. A firm is considered privately owned if the state is not a known shareholder. It is often efficient to have some ownership concentration in companies since large shareholders might monitor managers and thus increase the value of a firm. Concentration of ownership is an adaptation to poor legal protection. Countries that for some reason have heavily concentrated ownership and small stock markets might have little use for good accounting standards, and so fail to develop them. Good accounting standards and shareholder protection measures are associated with a lower concentration of ownership, indicating that concentration is indeed a response to poor investor protection (La Porta et al., 1998).

For each foreign market shown in Tables 2 to 4 we construct portfolios according to whether the regulatory requirements are higher, lower or the same as for the home listing. For example, from Table II for foreign listings on the London market we construct one portfolio for those equities exposed to higher disclosure requirements and another for those exposed to lower requirements (e.g. Sweden). For Frankfurt, three portfolios are constructed, one comprises cross-listing firms from Belgium and Austria that are exposed to higher accounting disclosure rules, another for UK, French, Dutch, Spanish, Swiss and Scandinavian companies that are faced by lower disclosure rules, and finally a third portfolio for cross-listed Italian and Danish firms that face similar requirements. We do the same for shareholder and creditor rules as shown in Tables 3 and 4. All in all, this provides us with groups of foreign equity portfolios for cross-listed companies exposed to varying regulatory environments. After constructing these portfolios we examine volatility spillovers between these separate portfolios and the respective market indices (FTSE100 in London, and CAC40 in Paris) to examine whether cross-listing on exchanges with lower or higher regulatory requirements has any influence on the magnitude and persistence of spillover effects.

Modeling Volatility and Error Transmission

Using the approach suggested by Karolyi (1995) and Engle and Kroner (1995) volatility and error transmission of cross-listed equities are estimated. Time-series daily returns are for the 12-year period from 1987 to 1998. Autoregressive conditional heteroskedastic (ARCH) type models have traditionally been used to investigate information transfer (volatility spillovers) between equities and stock exchanges. Engle (1982) notes that it is reasonable for stock return variances to be conditional on current information and following this assumption, Bollerslev (1986, 1987), Engle, Lilien, and Robins (1987) use models to account for second moments of errors in their investigations of spillover effects. Examining the descriptive validity of these models, French, Schwert, and Stambaugh (1987) find that the extended generalised autoregressive conditional heteroskedastic-in-mean (GARCH-M) model provides a good representation for the behaviour of US daily stock returns[10]. Engle and Kozicki (1993) note it is quite possible for two stock markets to be dependent through their second moments, and furthermore, additional evidence by Engle and Susmel (1993) suggest that stock markets are linked through their second moments. Overall, this suggests that volatility spillovers should be investigated using ARCH type models that take account of second moments.

Among GARCH models, multivariate GARCH approaches are the most widely used in time-varying (second moments) 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, Ng, and Rothschild (1990), and the GARCH-BEKK of Engle and Kroner (1995). The GARCH-BEKK model represents a successful attempt to overcome the various technical difficulties associated with previous approaches, such as the fact that the definite Ht matrix may not always be positive (a restriction imposed in the previous empirical studies). Previous approaches impose the restriction for the estimated variance to be greater than zero when 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 matrix.

Underlying these theoretical developments, the multivariate GARCH-BEKK [Engle and Kroner (1995)] model is written as:

$$r_t = \alpha + \sum_{p=1}^{n} \Phi_p r_{t-n} + e_t, e_t \left| \Omega_{t-1} \sim N(0, H_t) \right. \tag{1.1a}$$

where, r_t is the return series, e_t is the error term of return equation, and α is the constant term in the above return equation, 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.

To avoid the problems of dealing with normal distributions[11], the first moment of errors e_t is represented by a martingale process, as shown in equation (1.1b). It is assumed that e_t in equation (1.1a) follows a process of $E(\varepsilon_t)$.

$$E(\varepsilon_t) = E(r_t - \mu_t) \tag{1.1b}$$

where, μ_t is the long-term drift coefficient and

$$H_{t+1} = CC' + B' H_t B + A' \varepsilon_t * \varepsilon_t' A \tag{1.2a}$$

In the variance equation (1.2a) of the GARCH-BEKK model the squared innovation series are smoothed with an n-period moving average technique. This is written as:

$$\tilde{\varepsilon}_t^2 = \frac{1}{n}(\varepsilon_t^2 + \varepsilon_{t-1}^2 + \ldots + \varepsilon_{t-n+1}^2) \tag{1.2b}$$

The above outlines the main features of the GARCH-BEKK modelling approach that will be used to investigate volatility spillovers for our sample of cross-listed companies.

Spillovers, Foreign Equity Cross-Listings and the Regulatory Environment

This section reports the findings of our analysis considering spillover effects between foreign equity cross-listings and the respective markets indices. In particular we focus our analysis on the London+ and Paris exchanges[12].

Tables 5 and 6 present our spillover results for cross-listed companies on the London+ and Paris exchanges. In London+ we find that differences in shareholder protection rules and accounting standards influence spillover effects, whereas in Paris both creditor and shareholder protection rules are important. (Differences in bankruptcy protection and accounting disclosure rules for the cross-listed firm in London+ and Paris have no significant impact and so are not reported).

Table 5: Spillovers between Cross-Listed Foreign Equities on the London+ and FTSE100

Panel A: London foreign equity portfolios with the FTSE100: 5/1/87-321/12/98	Shareholder protection rules
Volatility Transmission from FTSE100 to Low	0.02 (0.00)
Volatility persistence	
Low FTSE100	0.95 0.59
Log-Likelihood	25401.39
Panel B: London foreign equity portfolios with the FTSE100: 5/1/87-31/12/98	Disclosure of accounting standards
Volatility Transmission from FTSE100 to High	0.03 (0.00)
Error Transmission from FTSE100 to High	-0.06 (0.02)
Volatility persistence	
High FTSE100	0.98 0.59
Log-Likelihood	24943.41

This table represents the spillover effects between UK equity cross-listings and the FTSE100 stock index with respect to different regulatory environments. Only statistically significant results are reported.

Also, it reports the results of volatility persistence, which measures the persistence of stock price news from the previous day to the next day in the same portfolio of stock price returns. '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.

Table 6: Spillovers between Cross-Listed Foreign Equities on the Paris and the CAC40

Panel A: Paris foreign equity portfolios with the CAC40: 10/7/87-31/12/98	Creditor protection rules
Volatility Transmission from High to CAC40	0.03 (0.00)
Volatility persistence	
High CAC40	0.93 0.91
Log-Likelihood	22136.83
Panel B: Paris foreign equity portfolios with the CAC40: 21/4/89-31/12/98	Shareholder protection rules
Volatility Transmission from High to Low	0.03 (0.00)
Error Transmission from High to Low	-0.01 (0.00)
Error Transmission from Low to CAC40	0.06 (0.01)
Volatility persistence	
High Low CAC40	0.034 0.93 0.43
Log-Likelihood	32211.50

This table represents the spillover effects between French equity cross-listings and the CAC40 stock index with respect to different regulatory environments. Only statistically significant results are reported. Also, it reports the results of volatility persistence, which measures the persistence of stock price news from the previous day to the next day in the same portfolio of stock price returns. '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.

Panel A of table 5 reports the results with respect to different shareholder protection rules. This suggests that differences in shareholder protection rules between exchanges have a significant impact on volatility transmission from the FTSE100 stock index to the 'Low' portfolio, although the magnitude of spillovers is small (0.02).

Table 5 (panel B) shows the effects for cross-listed equities with exposure to different accounting disclosure standards. To reiterate, here we consider portfolios of foreign cross-listed companies based on exchanges identifying differences in accounting requirements compared to the home market. Overall, the table shows that volatility is transmitted from the FTSE100 to 'High' (0.03) although the spillover is small in magnitude. This means that companies that have foreign listings on the London stock exchange (where accounting disclosure rules are more onerous than for their home listing) are only slightly influenced by the FTSE100 index.

The coefficient for the FTSE100 to 'High' error transmission estimate is double in magnitude compared to returns volatility transmission. This means that both changes in stock prices and noise significantly contribute to information transfers from the FTSE100 index to the 'High' portfolio of cross-listed equities. We also find evidence that the magnitude and persistence of volatility transfer from the FTSE100 index to 'High' portfolio differs compared with the error transfer. In particular, the persistence of trading noise in FTSE100 equities contributes insignificantly to information transfer to the 'High' portfolio.

Table 6 (panel A) reports the results in Paris stock exchange and shows that the volatility spillover from cross-listed equities (that have listings where creditor bankruptcy protection rules are more onerous) to the CAC40 stock index is significant in magnitude (0.03), although small. This suggests that cross-listed equities whose home listings are on environments with less onerous creditor bankruptcy protection rules transmit volatility to the domestic stock price index in the Paris stock exchange. Panel B of Table 6 shows that there are significant volatility and error transmission effects, when we take into account differences in shareholder protection rules between the foreign markets and the Paris stock exchange. Volatility and error spillovers in Paris market suggest that the foreign listings on markets with less onerous shareholder protection rules influence the cross-listed foreign equities that coming from markets with lax rules. The volatility spillover coefficient from 'High' to 'Low' (0.03) is greater in magnitude and persistence than the error coefficient from 'High' to 'Low' (-0.01). So changes in stock prices of 'High' portfolio of cross-listed equities contribute significantly to information transfers and persistence to 'Low' portfolio of cross-listed equities.

The spillover coefficient from 'Low' portfolio of foreign cross-listed equities to the CAC40 stock index is equal to 0.06. This is greater in magnitude and persistence to the spillover coefficient from 'High' to 'Low' portfolio. This means that changes in trading noise for foreign cross-listed equities, whose home stocks are listed on exchanges with tougher shareholder protection rules, influences the CAC40 stock index in a stronger manner than compared with error spillovers from the 'High' to 'Low' portfolios of foreign cross-listed equities.

To sum up, volatility and error spillovers in London stock exchange appear to be influenced by differences in accounting standards and shareholder protection rules between markets. In particular, volatility spillovers flow from the FTSE100 stock index to foreign cross-listed equities that coming from regulatory environments with both less and more onerous accounting and shareholder protection rules. In contrast, in Paris stock exchange volatility spillover effects move to the opposite direction, from cross-listed equities to the stock index where variations in bankruptcy and shareholder protection rules (between markets) are considered.

Conclusion

This paper examines the short-term dynamics of volatility and error transmission for cross-listed equities traded on European stock markets for the period 1987 to 1998. The methodology has been designed to specifically account for differences in regulations between exchanges and the assumption that these may influence spillovers between markets. In particular, we use La Porta et al.'s (1998) classification of regulatory conditions so as to facilitate the analyses of the magnitude and persistence of volatility spillovers for cross-listed equities within and between markets.

In particular, we examine the influence of differences in stock exchange disclosure requirements and shareholder and creditor protection rules on volatility spillovers for the foreign listings of companies quoted on the London+, and Paris exchanges. The paper shows that the impact of differences in accounting standards, and shareholder and creditor protection rules on spillovers is distinctly different across exchanges. Differences in accounting disclosure rules across markets also appear to have less of an effect on cross-listed share volatility transmission than do differences in shareholder and bankruptcy protection rules. In particular, we found that changes in trading noise may have an impact on the transmission of news from FTSE100 to 'High' portfolio of cross-listed equities (equities that listed on stock exchanges with more onerous accounting disclosure standards). This transmission found to be equal to 0.06 in magnitude with a negative persistence. This means that changes in trading noise may not persist for a long time when news is transmitted from FTSE100 to 'High' portfolio of equities. Overall, our paper suggests that investment barriers relating to the above mentioned regulations are important for understanding the dynamics of spillover patterns in stock prices within Europe.

NOTES

[1] For instance companies from Belgium, Netherlands, Spain, Austria, Germany, and Denmark that have a cross-listing on the Paris exchange are (according to LaPorta et al.) listing on an exchange with higher accounting standards. A UK, Finland, Norway and Swedish firm listing in Paris is listing on an exchange with lower accounting standards than the home market.

[2] S & P is the Standard and Poor 500 share index on the New York and TSE300 is the Toronto Stock Exchange 300 index.

[3] See Engle and Kroner (1995) for a discussion of GARCH-BEKK model advantages over previous GARCH models. In addition, Eitman and Stoneheill (1989) support that listing requirements for foreign firms on the London exchange are fairly liberal, as disclosure requirements, accounting costs and the respective fees are fairly modest compared to the US market.

[4] See Tondkar et al. (1990) regarding the implementation of three European Union Directives on Admission requirements, Listing and Interim reporting requests aimed at harmony. The EU's Financial Services Action Plan announced in 1999 a current ongoing initiative aimed at fostering integration in many financial services throughout Europe including capital markets.

[5] Portugal, Greece, and Luxembourg are excluded because of unavailability of data.

[6] Trading dates around the October 1987 crash, namely the 16th, 19th-21st October are excluded from the sample.

[7] We look only at these two foreign stock markets, as the number of foreign listings is larger in comparison to the other stock exchange foreign listings.

[8] The General Industry sector contains Chemicals, Printing and Publishing, Oil, Gas and Related Services, Miscellaneous, Food Producer, Engineering, Beverages, Metal Producers, Metal Products Manufacturers, Machinery and Equipment, Drugs, Cosmetics, Health Care, Automative, Diversified Paper, Construction, Book, Materials, Tobacco, Metal Producers, Apparel, Electrical, Retailers, Textiles.

[9] Financial companies include banks, investment banks, and investment trusts. In terms of the sample size in most cases the home and foreign issues of cross-listed companies account for around 8 percent of total issues in the respective markets. We also undertake a one way ANOVA (analysis of variance) to test for differences in the market capitalisation of the respective stock market indices and the market capitalisation of the sample. These were not significant different at the 5% level suggesting that the data is a representative sample.

[10] Bollerslev, Chou, and Kroner (1992) provide a summary of ARCH-type models.

[11] This is important for smoothing the series for calculating the conditional volatility of returns in the data sample. In this way, we transform the non-linear GARCH-BEKK model into a stochastic model.

[12] Where Frankfurt+ refers to Berlin, Dusseldolf, Stuttgart, Munich, Xet, and Frankfurt and London+ includes London and XSQ.

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