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The volatility spillover from the market to disaggregated industry stocks: the case for the US and UK

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Abstract

This article empirically investigates the volatility spillover of stock returns from the market to disaggregated industry sectors. Seventeen sectors from the US and UK stock markets are estimated by the GARCH technique based on daily data from 1973 to 2008. The key findings are two-fold. In the UK, whilst some industries are more sensitive to market volatility in a bear market than others, these disaggregated sectors are broadly affected in a similar way in a bull market. The volatility of foreign markets seems to have more impact than the domestic markets on some key industries in the US, suggesting the international integration for these sectors.

Keywords: Volatility of stock returns; Market returns; Disaggregated industry stocks; GARCH

JEL classification: G1, C1

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1. Introduction

This article empirically investigates volatility spillovers of stock returns from the market to disaggregated industry sectors[1]. Seventeen disaggregated industry sectors from the US and UK stock markets are estimated by the GARCH technique, respectively with the daily data from 1973 to 2008. We aim to establish the relative exposure to market risk across industries. We have recently observed an extremely volatile stock market in the leading economies since the onset of the financial crisis in August 2007. At the same time, a significant variation was evident in the volatility of stock returns among different industries. In turbulent stock markets, the study provides important implications for portfolio diversification.

There has been surprisingly little research conducted on volatility structure at the level of a particular industry. Campbell et al (2001) and Catão and Timmerman (2003) investigate the time path of volatility at an industry level, and Roll (1992) and Heston and Rouwenhorst (1994) decompose world market volatility into industry and country specific effects. However, none has addressed the spillover of market volatility into individual sectors.

Section 2 is for the theoretical model specification, and the empirical analysis is found in Section 3.

2. Theoretical model specification

The excess return of industry *i* in period *t* is denoted as R_{it}, which are measured as an excess return over the Treasury bill rate. Based on the capital asset pricing model (CAPM), we specify the following industry returns (Campbell et al 2001):

[1] Aggregate volatility is one of the components of the return of an individual stock. Volatility at industry level is also an important component of individual stock returns. Campbell et al (2001) studied idiosyncratic volatility of individual shares, and found that if firms are in the same industry, any shift derived from the market tends to exert broadly the same impact on the firms. The evidence supports our focus on the volatility at an industry level in this paper.

$$R_{it} = \beta_i R_{mt} + e_{it} \quad (1)$$

β_i denotes the sensitivity of industry i to the market return, R_{mt} is the excess market return, and e_{it} is the industry-specific residual. The weight of industry i in the total market is denoted by w_{it},

$$R_{mt} = \sum_{i=1}^{k} w_{it} R_{it} \quad (2)$$

where k is the number of industries, which constitutes the market. The weighted sums of the different betas are equal to unity:

$$\sum_{i=1}^{k} w_{it} \beta_i = 1 \quad (3)$$

We assume that the components of an industry's excess return are orthogonal to each other (Campbell et al 2001). This permits us to generate a variance (V) decomposition, where all covariance terms are zero.

$$V(R_{it}) = \beta_i^2 V(R_{mt}) + V(e_{it}) \quad (4)$$

For empirical purposes, we modify the model (1) by taking lagged industry and market returns, hence

$$R_{it} = \alpha_i + \sum_{j=1}^{p} \delta_{ij} R_{i,t-j} + \sum_{j=1}^{p} \theta_{ij} R_{m,t-j} + \xi_{it} \quad (5)$$

and the restriction of (3) is now relaxed, i.e. $\sum_{i=1}^{k} w_i \theta_i \neq 1$. R_{mt} takes an autoregressive form

$$R_{mt} = \lambda + \sum_{i=1}^{p} \psi_i R_{m,t-i} + u_{mt} \quad (6)$$

The variance of residual in (5) follows the conditional variance given by

$$V(\xi_{it}) = h_{it}^2 = \varphi_i + \mu_i \xi_{i,t-1}^2 + \gamma_i h_{it-1}^2 + \tau_i u_{mt-1}^2 + \varepsilon_{it} \quad (7)$$

The model (7) is equivalent to the GARCH model, and is used for estimation, where we can measure the extent of volatility spillover from the market to individual industries.

We also carry out some variation of the model (7). It is probable that the spillover effect may not be the same when the market is in turbulence, and also when that turbulence is either in an upward or downward direction. Hence, we examine the asymmetric effect on spillovers according to the direction of market returns, as specified:

$$V(\xi_{it}) = h_{it}^2 = \varphi_i + \mu_i \xi_{i,t-1}^2 + \gamma_i h_{it-1}^2 + \tau_i u_{mt-1}^2 + \tau_i^- d^{-*} u_{mt-1}^2 + \varepsilon_{it} \quad (8)$$

$$V(\xi_{it}) = h_{it}^2 = \varphi_i + \mu_i \xi_{i,t-1}^2 + \gamma_i h_{it-1}^2 + \tau_i u_{mt-1}^2 + \tau_i^+ d^{+*} \tau_i u_{mt-1}^2 + \varepsilon_{it} \quad (9)$$

d^- and d^+ are the dummies, when market returns exceed the negative and positive 2 standard deviations (s.d.) over the sample period, respectively. We also see the international spillover effect by specifying the ARCH term for the foreign market.

$$V(\xi_{it}) = h_{it}^2 = \varphi_i + \mu_i \xi_{i,t-1}^2 + \gamma_i h_{it-1}^2 + \tau_i u_{mt-1}^2 + \tau_i^f u_{fmt-1}^2 + \varepsilon_{it} \quad (10)$$

where *f* = UK and US markets in the US and UK models respectively. Note that the UK market enters in the US model with the time period of *t,* instead of *t-1* due to the time lag[2].

3. Empirical results

The daily price indices of Datastream are used to derive the stock returns. The market is disaggregated into seventeen sectors: automobiles, banks, real estate, financial services, food & beverage, health care, industrial goods & services (*ind*), insurance, raw materials (*mat*), media, oil & gas, personal & household goods, retail, technology (*tech*), telecommunications, travel & leisure and utilities. The sample period starts from 2nd January 1973 and lasts until 31st December 2008, except for technology and utilities in the UK, which starts 4th November 1981 and 8th December 1986 respectively.

The GARCH is conducted by using (quasi) maximum likelihood. Given the tendency of stock returns to be leptokurtic, the Generalized Error Distribution is considered. Two lags are used for all cases for the mean equations (5), since it mostly avoids up to the 20th order serial correlation by Ljung-Box portmanteau statistics in the standardized squared residuals.

[2] The US markets opens five hours later than the UK market.

Based on the robust standard errors due to Bollerslev and Wooldridge (1992), the coefficients are mostly significant at the 1% level[3].

[Table 1 and Table 2 are around here]

Table 1 corresponds with equation (7). The size of the coefficients on the market ARCH term (τ_i) reveals that *travel* in the US and *auto, food* and *insurance* in the UK are more sensitive to the market than other sectors. *banks*, *estate* and *utilities* are statistically insignificant in the US, and these sectors also have a lower exposure to market volatility in the UK. The banking sector appears to maintain a position as the market maker in the Anglo-Saxon stock markets.

In Table 2a with a negative asymmetry, the positive significant coefficients on τ_i^- imply that volatility increases when the market is depressed. The effect of a negative asymmetry seems to be stronger in the US than in the UK judging from the statistical evidence. Given the relatively large size of the coefficients, *auto, financial* and *tech* in the US, and *bank* and *tech* in the UK are vulnerable to market risk with a sharp fall in market returns.

The empirical results of the positive asymmetry are found in Table 2b. A significant negative coefficient on τ_i^+ suggests that the volatility declines during a bull market. The UK market is well determined with all the coefficients of τ_i^+ (except for *tech*) being highly significant at the 1% level, and there is less sizable differences among disaggregated sectors. It is interesting to compare this with the negative asymmetry, where about a half of the sectors have an insignificant coefficient on τ_i^-.

[Table 3 is around here]

Table 3 presents the volatility spillovers from a foreign market. It is surprising to find that the UK market has more impact than the domestic market on the US industries, since we find

[3]The serial correlation tests and standard errors are available on request from the author.

$\tau_i < \tau_i^f$ for 12 cases. In the UK market, *banks, mat, oil, tech, telecom* and *utilities* are more affected by the US market than by their own market.

To conclude, the key empirical findings are two-fold. Firstly, in the UK, some industries seems to be more exposed to market risk than others during a bear market, whereas a bull market appears to contribute to reducing the volatility of returns for most of these industries broadly in a similar way. The number of stocks needed to achieve a given level of diversification should be increased at an industry level when the market is moving downwards. Secondly, the empirical result does not appear to support the leading role of the US market, since the volatility of spillovers from the UK market is not trivial for some US industries, suggesting a level of international integration of these industry stocks[4]. Further research would be useful for other leading and emerging economies.

[4] The time lag between the US and UK markets may also contribute to this result.

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Table 1 GARCH model

	USA			UK		
	μ_i	γ_i	τ_i	μ_i	γ_i	τ_i
auto	0.042	0.932	0.030	0.053	0.925	0.060
banks	0.086	0.915	-0.002§	0.072	0.904	0.028
estate	0.068	0.932	0.000§	0.095	0.898	0.006
financial	0.058	0.930	0.013*	0.095	0.881	0.026
food	0.052	0.932	0.007	0.054	0.877	0.056
health	0.054	0.926	0.008	0.050	0.887	0.047
ind	0.032	0.934	0.033	0.060	0.905	0.040
insurance	0.061	0.909	0.021	0.069	0.886	0.060
mat	0.054	0.929	0.013**	0.099	0.883	0.011
media	0.049	0.937	0.016	0.074	0.897	0.033
oil	0.051	0.938	0.011	0.055	0.924	0.022
personal	0.053	0.920	0.016	0.071	0.875	0.039
retail	0.042	0.938	0.023	0.076	0.902	0.031
tech	0.044	0.946	0.014	0.216	0.807	0.010§
telecom	0.055	0.935	0.007**	0.068	0.918	0.023
travel	0.058	0.905	0.061	0.065	0.907	0.042
utilities	0.096	0.897	0.000§	0.066	0.894	0.019

The coefficients are significant at the 1% level, except ** at the 5%, * at the 10% and § insignificant.

Table 2a GARCH model with negative asymmetry

	US				UK			
	μ_i	γ_i	τ_i	τ_i^-	μ_i	γ_i	τ_i	τ_i^-
auto	0.042	0.930	0.014*	0.057	0.053	0.925	0.050	0.031§
banks	0.084	0.914	-0.005**	0.022	0.070	0.906	0.013§	0.052
estate	0.065	0.934	-0.005**	0.014**	0.095	0.898	0.007*	-0.001§
financial	0.059	0.929	-0.007§	0.065	0.094	0.881	0.023	0.012§
food	0.051	0.935	-0.003§	0.029	0.054	0.879	0.046	0.036
health	0.056	0.926	-0.002§	0.032	0.051	0.888	0.034	0.039
ind	0.034	0.931	0.024	0.033	0.060	0.906	0.033	0.019§
insurance	0.060	0.908	0.013**	0.040	0.068	0.886	0.051	0.036§
mat	0.054	0.927	0.006§	0.035	0.099	0.884	0.005§	0.021*
media	0.050	0.936	0.006§	0.032	0.073	0.899	0.022	0.044
oil	0.050	0.938	0.002§	0.031	0.054	0.925	0.012*	0.032**
personal	0.054	0.920	0.005§	0.034	0.072	0.874	0.034	0.015§
retail	0.042	0.938	0.015**	0.026**	0.076	0.903	0.024	0.018§
tech	0.047	0.943	-0.006§	0.055	0.210	0.809	0.002§	0.061**
telecom	0.055	0.933	-0.001§	0.035	0.069	0.919	0.012§	0.029§
travel	0.058	0.908	0.027	0.093	0.065	0.908	0.033	0.025
utilities	0.095	0.895	-0.004	0.023	0.064	0.899	0.007§	0.028*

The coefficients are significant at the 1% level, except ** at the 5%, * at the 10% and § insignificant.

Table 2b GARCH model with positive asymmetry

	US				UK			
	μ_i	γ_i	τ_i	τ_i^+	μ_i	γ_i	τ_i	τ_i^+
auto	0.042	0.932	0.038	-0.035**	0.052	0.926	0.075	-0.066
banks	0.084	0.917	0.001§	-0.013**	0.069	0.907	0.044	-0.071
estate	0.065	0.934	0.004§	-0.011*	0.092	0.902	0.011	-0.022
financial	0.056	0.932	0.031	-0.076	0.093	0.883	0.032	-0.033
food	0.050	0.935	0.013	-0.024	0.050	0.882	0.069	-0.058
health	0.050	0.930	0.018	-0.033	0.046	0.893	0.060	-0.053
ind	0.033	0.933	0.041	-0.037	0.056	0.907	0.059	-0.066
insurance	0.058	0.913	0.028	-0.030	0.068	0.889	0.071	-0.054
mat	0.053	0.929	0.022	-0.032	0.097	0.885	0.017	-0.029
media	0.049	0.936	0.026	-0.044	0.071	0.901	0.045	-0.053
oil	0.049	0.938	0.021	-0.032	0.054	0.924	0.036	-0.051
personal	0.050	0.923	0.025	-0.033	0.068	0.880	0.054	-0.058
retail	0.042	0.938	0.035	-0.048	0.074	0.904	0.046	-0.061
tech	0.044	0.946	0.023	-0.038	0.209	0.812	0.021§	-0.031§
telecom	0.056	0.933	0.017	-0.039	0.063	0.923	0.045	-0.077
travel	0.055	0.907	0.073	-0.042	0.061	0.915	0.053	-0.075
utilities	0.093	0.901	0.003§	-0.012**	0.061	0.898	0.034	-0.049

The coefficients are significant at the 1% level, except ** at the 5%, * at the 10% and § insignificant.

Table 3 GARCH model with foreign market

	US				UK			
	μ_i	γ_i	τ_i	τ_i^{uk}	μ_i	γ_i	τ_i	τ_i^{us}
auto	0.049	0.883	0.032	0.040	0.054	0.920	0.046	0.024
banks	0.086	0.912	-0.002§	0.001§	0.073	0.890	0.019	0.036
estate	0.067	0.930	-0.007	0.013	0.092	0.901	0.006§	0.001§
financial	0.070	0.909	-0.002§	0.026	0.095	0.882	0.015	0.010
food	0.056	0.928	0.003§	0.005	0.061	0.858	0.041	0.029
health	0.064	0.909	0.001§	0.011	0.050	0.873	0.036	0.029
ind	0.040	0.903	0.026	0.022	0.059	0.908	0.026	0.012
insurance	0.068	0.888	0.012	0.020	0.066	0.884	0.050	0.021
mat	0.062	0.895	0.011§	0.028	0.101	0.881	0.001§	0.012
media	0.061	0.890	0.011*	0.044	0.071	0.894	0.024	0.021
oil	0.052	0.934	0.010**	0.003§	0.055	0.914	0.015	0.023
personal	0.058	0.910	0.008**	0.010	0.075	0.866	0.027	0.022
retail	0.046	0.931	0.013**	0.013	0.078	0.903	0.015**	0.015
tech	0.050	0.939	0.004§	0.011	0.216	0.794	-0.016*	0.053
telecom	0.059	0.923	0.011	0.002§	0.073	0.907	0.008§	0.027
travel	0.058	0.902	0.015	0.047	0.063	0.910	0.030	0.011
utilities	0.101	0.889	0.000§	0.002§	0.074	0.872	0.010§	0.016

The coefficients are significant at the 1% level, except ** at the 5%, * at the 10% and § insignificant.