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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, while 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 international integration for these sectors.

Key words: volatility of stock returns; market returns; disaggregated industry stocks; GARCH

JEL classification: G1; C1

1. Introduction

This article empirically investigates volatility spillovers of stock returns from the market to disaggregated industry sectors. Seventeen disaggregated industry sectors from the US and UK stock markets are estimated by the GARCH technique with the daily data from 1973 to 2008. We aim to establish the relative exposure to market risk across industries. 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. This supports our focus on the volatility at an industry level in this paper.

The contribution of this study is largely two-fold. One is the practical implications for investors and the other is to the finance literature. We recently

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observed an extremely volatile stock market in the leading economies since the onset of the financial crisis in August 2007. At the same time, significant variation was evident in the volatility of stock returns among different industries. Non-cyclical industries, e.g., gas and oil industries, were relatively unscathed by the crisis—in other words, the spillovers from the market shock were weak—whereas cyclical industries, e.g., the automobile industries, were heavily exposed to the market risk.

The volatility measures investment risk, and the greater the likely variability in securities returns, the greater the risk that an investor is expected to bear in holding particular securities. The potential variation in volatility and risk across disaggregated industries affects portfolio diversification requirements. Hence, in turbulent stock markets, the investigation of volatility spillovers at an industry level provides important practical 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. In this respect, this article contributes to the finance literature.

This paper is organized as follows. Section 2 specifies the theoretical model, and Section 3 presents the empirical analysis. Section 4 concludes.

2. Theoretical Model Specification

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

$$R_{it} = \beta_i R_{mt} + e_{it} , \tag{1}$$

where 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 w_{it}, so that we may write:

$$R_{mt} = \sum_{i=1}^{k} w_{it} R_{it} , \tag{2}$$

where k is the number of industries that together constitute the market. The weighted sums of the different betas are equal to unity:

$$\sum_{i=1}^{k} w_{it} \beta_i = 1 . \tag{3}$$

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:

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

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

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

and the restriction of (3) is now relaxed, i.e., $\sum_{i=1}^{k} w_i \theta_1 \neq 1$. R_{mt} takes an autoregressive form:

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

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

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

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.[1]

We also consider variations of (7). It is probable that the spillover effect may not be the same when the market is turbulent and when that turbulence is upward or downward. Hence, we examine the asymmetric effect on spillovers according to the direction of market returns, specified as:

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

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

where d^- and d^+ indicate when market returns exceed the negative and positive 2 standard deviations over the sample period, respectively.[2] We also see the international spillover effect by specifying the ARCH term for the foreign market:

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

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.[3]

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 and beverage, health care, industrial goods and services (*ind*), insurance, raw materials *(mat*), media, oil and gas, personal and household goods, retail, technology (*tech*), telecommunications, travel and leisure, and utilities. The sample period starts on January 2, 1973, and lasts until December 31, 2008, except for technology and utilities in the UK, which starts November 4, 1981, and lasts until December 8, 1986.

The GARCH model is fit by using quasi-maximum likelihood. Given the tendency of stock returns to be leptokurtic, we consider the generalized error distribution. 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. Based on robust standard errors due to Bollerslev and Wooldridge (1992), the coefficients are mostly significant at the 1% level.[4]

Table 1. GARCH Model

Industry	US			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***

Notes: ***, **, and * denote significant at 1%, 5%, and 10% levels, respectively.

Table 2a. GARCH Model with Negative Asymmetry

Industry	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*

Notes: ***, **, and * denote significant at 1%, 5%, and 10% levels, respectively.

Table 2b. GARCH Model with Positive Asymmetry

Industry	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***

Notes: ***, **, and * denote significant at 1%, 5%, and 10% levels, respectively.

Table 1 corresponds to equation (7). The size of the coefficients of 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. The revenues of some industries are quite cyclical. These industries do well in the expansion period of the business cycle, but perform poorly in the contraction phase, fluctuating with the business cycle. Correspondingly, their stock returns can be sensitive to the market. The finding of high sensitivity in the automobile and travel industries are quite plausible, in this respect.

In contrast, *banks*, *estate*, and *utilities* are statistically insignificant in the US, and these sectors also have a lower exposure to market volatility in the UK. In countries with highly developed financial systems, we argue that bank portfolios have high exposure, directly or indirectly, to the real estate sector. Therefore, changes in the value of real estate can have a potentially significant impact on the default risk of banks and on their profitability. In the recent subprime crisis, this was especially critical, when bank losses increased dramatically in line with the declining value of the real estate, placing the entire financial system at risk of collapse. Hence, rather than responding to the market, banks may be responding to the estate industry, and the banking sector appears to maintain a position as the market maker in the US and UK stock markets. The *utilities* industry is often viewed as relatively low in risk because the industry is, in general, a mature industry operating in a predictable environment with relatively little change. This is consistent with our finding that it is less vulnerable to the market in both countries.

In the results of the model with negative asymmetry (Table 2a), the positive significant coefficients on τ_i^- imply that volatility increases when the market is depressed. The effect of 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. With respect to the technology industry in both economies, this sector exposes investors to a higher uncertainty of returns than the market average during a bear market. This may arise from the unique character of each industry as it changes rapidly and unpredictably due to the inherent uncertainty of their new products and new markets.

In the results of the model with positive asymmetry (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*) highly significant at the 1% level, and there are 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 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 $\tau_i < \tau_i^f$ for 12 of the 17 industries. In the UK market, *banks*, *mat*, *oil*, *tech*, *telecom*, and *utilities* are more affected by the US market than by their own market.

Table 3. GARCH Model with Foreign Market

Industry	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***

Notes: ***, **, and * denote significant at 1%, 5%, and 10% levels, respectively.

4. Conclusion

Industry risk relates to uncertainties caused by particular features of the industry sector in which a company operates. These risks can vary dramatically across different industries. This paper investigated the sensitivity of disaggregated industry to the market volatility for the US and UK.

The key empirical findings are broadly three-fold. First, we find that cyclical industries are more vulnerable to market volatilities than non-cyclical industries. Second, in the UK, some industries seem 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 and in a similar way. The implication is that 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. Third, the empirical results do not appear to support a leading role for the US market, since the volatility of spillovers from the UK market are not trivial for some US industries, suggesting a level of international integration of these industry stocks[5] and, at the same time, a diminishing effect of international portfolio diversification. This finding suggests choosing industries that are not much affected by foreign market portfolio. Further research would be useful for other leading and emerging economies.

Notes

1. The multivariate GARCH model with $p = q = 1$ was tested. We found that the lagged market variance is mostly insignificant, and the overall number of significant coefficients is less than that with the univariate GARCH model. This implies that the volatility at the industry level is sensitive to the market ARCH term, but less so to the persistence of market volatility. We, hence, adhere to the univariate GARCH model (7), which specifies the market ARCH term without the lagged market volatility.
2. EGARCH and TGARCH techniques, which account for asymmetry, were also tried. However, the asymmetry effect was not well-determined in terms of statistical significance. As in this paper, by computing the negative and positive two standard deviations of returns, the effect is well-determined. Note that one standard deviation was found to perform poorly; this seems to imply that the data perform well with a certain degree of negative or positive returns, rather than with their marginal levels.
3. The US markets opens five hours later than the UK market.
4. The serial correlation tests and standard errors are available upon request from the author.
5. The time lag between the US and UK markets may also contribute to this result.

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