Stock Market Correlations and the Business Sentiments: Evidence from the US and Germany

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Abstract

We analyse the correlations between the US and German stock markets and study the influences of the US and German business sentiments on the correlations. On the whole, high US business sentiment increases the correlations, while low US business sentiment decreases the correlations. However, the German business sentiment has virtually no influence on the correlations. The correlations are joint positive-type asymmetric, although the asymmetry is not statistically significant. Both the asymmetry in the correlations and the influences of the business sentiments on the correlations had structural breaks caused by the advent of the Euro and the recent financial crisis.

Keywords: *business sentiment, correlation, asymmetry, structural break*

JEL Classification: G10

Introduction

With the development of globalization, the relationship among markets is becoming increasingly important, including the correlations between different stock markets (see, e.g., Li and Zou, 2008). It is well known that the US and the European Union play very important roles in global economic affairs. Germany is the largest economy in European Union, and its GDP accounted for more than one-fifth of the whole European Union's GDP in 2013. Germany is also the most populous country in the European Union. Hence, the German economy deeply

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influences the entire Eurozone. Therefore, we choose the US and German stock markets for our investigation.

In this paper, we mainly address two problems. First, we detect the asymmetry in the correlations between the US and German stock markets. Suppose that the US and German stock markets simultaneously receive news, such as policy resulting in a decline in the stock markets. The US is a typical market-based country (Lee, 2012; Levine, 2002), and the US stock market will react to the news. However, Germany is a bank-based country (Lee, 2012; Levine, 2002), which is more clear in the early years. The effect of the news may be principally absorbed by the banks and not by the stock market. If so, the news will affect the correlations mainly through the US stock market. However, there is another possibility. In recent years, Germany has become more market-based than ever, and the two economies are more closely connected. In this situation, the simultaneously received news will affect the correlations through the two markets. If this occurs, for good news, the government will typically leave things as they are. For bad news, the government may make interventions. Hence, the effects of the good news on the correlations overwhelm the bad news of the same magnitude, which is called "joint-positive asymmetry" (Li, 2011).[1] In this paper, the data will uncover the truth.

Second, we examine how business sentiments in the US and Germany affect the correlations between the US and German stock markets. Business sentiment is a leading economic indicator (Entorf, Gross and Steiner, 2012) that can affect investors' behaviours and further influence the performances of the stock markets. The US is the most economically influential country in the world, while the German economy is a small open economy. As Nikkinen and Sahlström (2004) stated, the US macroeconomic news announcements are valuable sources of information on German stock markets, while domestic news releases in Germany seem to be unimportant. Hence, we insist that the US business sentiment has a more important influence on the correlations between the US and German stock markets, even dominating the correlations, while German business sentiment has little impact on the correlations. High business sentiment can trigger investors' enthusiasm for stocks. Therefore, high US business sentiment will promote the two markets to be more bullish, leading to a rise in the correlations. In the low US business sentiment situation, the government may not just stay out of the market, and German banks may absorb most of the bad information for its bank-based financial system. Thus, the connection between the two stock

[1] If the effects of the bad news on the correlations overwhelm the good news of the same magnitude, it is joint-negative asymmetric. If the effects of the bad news on the correlations are equal to the good news of the same magnitude, it is symmetric (Li, 2011).

markets in the different countries will be weaker. Hence, the consequence of low US business sentiment results in a decline in the correlations.

The influences of business sentiments on the correlations between the US and German stock markets can also be interpreted as below. Arguably, high business sentiment often corresponds to a bullish stock market, while low business sentiment is often consistent with a bearish stock market. Noise traders or retail traders are prone to be more active in bullish stock markets than in bearish ones (Baker and Stein, 2004; Corredor, Ferrer and Santamaria, 2015); on the contrary, institutional investors or informed traders tend to be more active in bearish markets than in bullish ones (see, Shleifer and Vishny, 2003; Yu and Yuan, 2011; Corredor, Ferrer and Santamaria, 2015). As stated by Kumar and Lee (2006) and Kumar, Page and Spalt (2013), retail trades can increase stock co-movements, but institutional trading attenuates stock co-movements. Therefore, we hold that high business sentiment increases the correlations between the two stock markets, while low business sentiment decreases the correlations between the two stock markets. Previous studies suggest that the major US macroeconomic news had cross border impacts on both European equity returns and volatilities (Harju and Hussain, 2011). Furthermore, the US market is the most important producer of information (Eun and Shim, 1989; Ng, 2000; Theodossiou and Lee, 1993), which is also related to the asymmetry in the correlations. Therefore, the US business sentiment has more influence on the correlations than the German business sentiment, and it even dominates the correlations.

The launch of the Euro makes the stock markets in the European Union more closely linked (Cappiello, Engle and Sheppard, 2006), which may cause a structural break in the relationship between business sentiments and the correlations. As described in Gao and Zhang (2016)'s paper, the 2008 – 2010 financial crisis had numerous effects on the economy and could have caused a structural break in the relationships among the assets. Hence, in this paper, we also check whether there are structural breaks in the relationship between the two stock markets and the business sentiment caused by the introduction of the Euro and the outbreak of the recent financial crisis, respectively.

The topic that we discuss is very important for investors. As is known, correlations between the US and German stock markets play important roles when investors construct their portfolios containing the US and German stocks. Ignoring the asymmetry in the correlations will overestimate/underestimate the correlations which directly affect the benefits of diversification. Since business sentiment is a leading economic indicator (Entorf, Gross and Steiner, 2012), by understanding the influence of business sentiment on the correlations, investors can adjust the portfolio in time according to the relationship between business

sentiments and the correlations. Capturing the differences in the influences of the US and German business sentiments on the correlations, investors can pay more attention to the business sentiment that has a bigger impact on the correlations.

Our contributions are as follows. First, we probe the asymmetry in the correlations between the US and German stock markets. The correlations between stock markets have been widely analysed (e.g., Cappiello, Engle and Sheppard, 2006; Hwang et al., 2013). The asymmetry in the correlations between different assets has also been explored (e.g., Gao and Zhang, 2016; Li, Zhang and Gao, 2015). However, the asymmetry in the correlations between the US and German stock markets receives less attention. Although, Cappiello, Engle and Sheppard (2006) investigate the asymmetry in the correlations between the US and German stock markets, they utilized data spanning from January 8, 1987 until February 7, 2002, which did not include the most recent ten years. In this paper, we employ a method different from Cappiello, Engle and Sheppard's (2006) to examine the asymmetry in the correlations between the US and German stock markets. Our data cover the most recent ten years. This paper adds a new study on the asymmetry in the correlations.

Second, our most important contribution is that we explore the influences of business sentiments on the correlations between the US and German stock markets. The influence of the macroeconomic factors on the stock market has been studied by many scholars (e.g., Kurov and Stan, 2017; McQueen and Roley, 1993, etc.). The relationship between business sentiment and the stock market has also been studied. Abberger (2007) analyses whether the extensive use of business tendency survey results are helpful for forecasting quarter-on-quarter growth rates of GDP. Entorf, Gross and Steiner (2012) examine the reactions of DAX returns to the announcements of business sentiment indicators. Vermeulen (2014) studies the valuation of business sentiments. Using the high-dimensional Granger Causality approach, Wilms, Gelper and Croux (2016) investigate the predictive power of the business and bank sentiment of firms. However, little literature has addressed how business sentiments affect the correlations between stock markets. The literature concerning the cross-country study on this topic is almost non-existent. Our paper fills this gap.

Third, we discuss the influences of the introduction of the Euro and the outbreak of the 2008 – 2010 financial crisis on the relationships among the stock markets and business sentiments. In particular, we investigate whether there are structural breaks in the relationships among the stock markets and business sentiments. Some papers have tested the structural break caused by the launch of Euro or the outbreak of the 2008 – 2010 financial crisis. For instance, Ehrmann and Fratzscher (2005) verify that there is indeed a clear structural break for the

spillover across the US and Euro area money markets of many of the macroeconomic variables around the advent of European Economic and Monetary Union (EMU). Kearney and Potì (2006) find that a structural break in the correlations between the five largest Eurozone stock market indices is caused by the official adoption of the Euro. Kontonikas, MacDonald and Saggu (2013) find that an important structural shift took place during the financial crisis, which changed the stock markets' responses to Federal Funds rate shocks. Jung and Maderitsch (2014) study the structural break in volatility spillovers between international financial markets caused by the 2008 – 2010 financial crisis. However, few papers simultaneously detect structural breaks in the asymmetry in the US-German stock market correlations and the influences of business sentiments on the correlations caused by the advent of the Euro and the 2008 – 2010 financial crisis, respectively. Our work settles these problems. To the best of our knowledge, we are the first to discuss these questions.

Our work relates to that of Bedowska-Sojka (2013). She studied the reaction of the German and French stock markets to the releases of macroeconomic fundamentals including business sentiments that emanated from Germany and the US. However, he did not check the influences of the business sentiments on the correlations between the cross-country stock markets. He documents that the reaction of the German stock market to the US macroeconomic surprises is stronger than to the German ones. This may help us understand the influences of the US and German business sentiments on the correlations between the US and German stock markets.

The rest of this paper is organized as follows. Section 1 presents the data and methodology. Section 2 provides an empirical analysis, and last section concludes.

1. Data and Methodology

1.1. Data

We choose monthly data from the US S&P 500 Index and the German DAX index. We employ the Institute for Supply Management (ISM) PMI (Purchasing Managers' Index) to measure the US business sentiment and the IFO (Information und Forschung) Business Climate Index for Germany to measure German business sentiment. All of the data are available from the Wind database. The database only provides monthly data for the ISM index and the IFO index. Therefore, in the paper, we use monthly data. Since the IFO index data are only from January 1991, our period covers January 1991 to December 2014. We should

note that the IFO index provided for the European Union's quarterly data is too small, which is why we do not investigate the correlations between the US and European Union stock markets.

The ISM index is constructed from a survey of more than 300 purchasing and supply executives from across the country. The survey is conducted every month and covers new orders, production, employment, the timeliness of supplier deliveries and inventories in their companies, comparing the current month to the previous one. The index is compiled based on the survey. A value of 50 of the index can be regarded as a benchmark. An index above or below 50 implies that the economy is in an expansion or contraction, respectively. The IFO index is very similar to the ISM index, but 100 is chosen as a benchmark. Veredas (2006) believes that the ISM index is the most forward-looking measure available for the market since it is based on expectations. Laakkonen and Lanne (2009) suggest utilizing the ISM index and IFO index as the measures of the US and German business cycles, respectively. Hence, we implement the two indexes to measure the business sentiment in each respective country.

1.2. Methodology

The model that we employ is enlightened by Li (2011). We first fit the following ARMA(*m*, *n*) models:

$$r_{it} = c_i + \sum_{j=1}^{m} \phi_{ij} r_{i,t-j} + z_{it} + \sum_{k=1}^{n} K_{ik} z_{i,t-k}, (i = 1,2) \quad (Z_t \mid \Omega_t) \sim N[0, H_t] \qquad (1)$$

In (1), $r_{it}(i = 1,2)$ are the logarithm returns of the US stock prices and German stock prices at time *t*, respectively, $Z_t = [z_{1t}, z_{2t}]$, Ω_{t-1} is the information set. H_t can be expressed as

$$H_t = D_t R_t D_t \qquad (2)$$

In formula (2), $D_t = diag(h^{1/2}_{1t}, h^{1/2}_{2t})$, $h_{it}(i = 1,2)$ are the elements on the main diagonal of the matrix H_t, and $R_t = (diag(Q_t))^{-1} Q_t (diag(Q_t))^{-1}$ is the conditional correlation coefficient matrix of series $\{\varepsilon_{1t}\}$ and series $\{\varepsilon_{2t}\}$. $\varepsilon_{it}(i = 1,2)$ are defined as $\varepsilon_{it} = \frac{z_{it}}{h_{it}^{1/2}}(i = 1,2)$. We choose the orders (*m* and *n*) of the ARMA(*m*, *n*) models to make ε_{1t} and ε_{2t} as close to i.i.d. as possible, and estimate the GARCH(1,1) models for the conditional variance $h_{it}, (i = 1,2)$:

$$h_{it} = \omega_i + \delta_i \varepsilon^2_{i,t-1} + \theta_i h_{i,t-1}, (i = 1,2) \qquad (3)$$

Everything above is from the standard DCC model Engle and Sheppard (2001). We now consider how the business sentiments influence the correlations between the US and German stock markets. Enlightened by Li (2011), we assume that Q_t follows the form:

$$Q_t = (\overline{Q} - A'\overline{Q}A - B'\overline{Q}B) + A'e_{t-1}e'_{t-1}A + B'Q_{t-1}B + \eta_U \Delta\xi_{U,t-1} + \eta_G \Delta\xi_{G,t-1} \quad (4)$$

where $\overline{Q} = \begin{pmatrix} 1 & \overline{\rho_{12}} \\ \overline{\rho_{12}} & 1 \end{pmatrix}$, $A = \begin{pmatrix} \alpha_1 & 0 \\ 0 & \alpha_2 \end{pmatrix}$ $B = \begin{pmatrix} \beta_1 & 0 \\ 0 & \beta_2 \end{pmatrix}$, $e_t = \begin{pmatrix} \varepsilon_{1t} + \gamma_1 \\ \varepsilon_{2t} + \gamma_2 \end{pmatrix}$, $\Delta\xi_{U,t} = \xi_{U,t} - \xi_{U,t-1}$, $\Delta\xi_{G,t} = \xi_{G,t} - \xi_{G,t-1}$, and $\xi_{U,t}$ is ISM index at time *t*, $\xi_{G,t}$ is IFO index at time *t*. $\overline{Q}$ is unconditional correlation coefficient matrix. *A* and *B* describe the time-varying characteristics of the correlations. $\overline{Q}$, *A* and *B* have the same implications in the models described in Engle and Sheppard (2001) and Li (2011). If $\Delta\xi_{U,t} > 0$, this implies that the US business sentiment at time *t* is higher than at time $t-1$; if $\Delta\xi_{U,t} < 0$, the US business sentiment is lower than before; if $\Delta\xi_{U,t} = 0$, the US business sentiment is stable. $\xi_{G,t}$ has a similar economy implication. $\alpha_1(\geq 0)$, $\alpha_2(\geq 0)$, $\beta_1(\geq 0)$, $\beta_2(\geq 0)$, γ_1, γ_2, η_U and η_G are the parameters needing to be estimated. The difference of the series $\{\xi_{U,t}\}$ and $\{\xi_{G,t}\}$ can avoid the effect of different benchmarks to some extent. The parameters in (4) must satisfy $1-\alpha_1^2-\beta_1^2 > 0$, $1-\alpha_2^2-\beta_2^2 > 0$ and $1-\alpha_1\alpha_2-\beta_1\beta_2 > 0$. Formula (4) means that when $\gamma_1 = \gamma_2 = 0$, (4) is the standard DCC model with no asymmetry in the study by Engle and Sheppard (2001); when $\varepsilon_i > 0(\varepsilon_i < 0), i = 1,2$, joint positive-type (negative-type) asymmetry;[2] when γ_1 and γ_2 take different signs, the asymmetry type could be joint-positive or joint-negative depending on the values of $|\gamma_i|$, $|\alpha_i|$ and $|\beta_i|$ $(i = 1,2)$.

The element $\rho_{12,t}$ in matrix R_t is the correlations coefficient between series $\{\varepsilon_{1t}\}$ and series $\{\varepsilon_{2t}\}$.Since the correlations coefficient must lies in the interval [–1, 1], we must rescale the correlation coefficient as the following equation, because $e_{t-1}e'_{t-1}$ is not constrained to have elements between –1 and 1 (Pelletier, 2006).

$$\rho_{12,t} = \frac{q_{12,t}}{(q_{11,t}q_{22,t})^{1/2}} \quad (5)$$

where $q_{12,t}, q_{11,t}, q_{22,t}$ are the elements of matrix Q_t.

[2] This means that joint positive-type (negative-type) news ($\varepsilon_i > 0(\varepsilon_i < 0),\ i = 1,2$) yields a greater impact on the correlation than join negative-type (positive-type) news ($\varepsilon_i < 0(\varepsilon_i > 0),\ i = 1,2$) of the same magnitude, which is termed "joint positive-type (negative-type) asymmetry".

Similar to Li (2011), if $\eta_U < 0$, high US business sentiment will increase the correlations; if $\eta_U > 0$, low US business sentiment will increase the correlations; if $\eta_U = 0$, the correlations are independent of the US business sentiment. The implication of η_G is similar with η_U.

We use the two-stage procedure proposed by Engle and Sheppard (2001) to obtain the estimates of the model.

2. Empirical Analysis

2.1. Estimates of the Model

From Table 1 in the appendix, we can see that all the series are stationary, indicating that the ARMA model is appropriate.

Table 1 shows the estimates of the model. In the table, all of the Ljung-Box statistics are not significant, denoting that ε_{it} constitutes white noise and that our models fit the series very well. All estimates of the GARCH parameters are significant at least at the 10% level. $\hat{\delta}_1 + \hat{\theta}_1 > \hat{\delta}_2 + \hat{\theta}_2$ ($\hat{\delta}_i + \hat{\theta}_i < 1, (i = 1, 2)$). Hence, the US stock return series is more persistent than the German stock-return series with respect to volatility.

According to the estimates of the DCC parameters, α_1 and β_2 are significant at the 1% level, and α_2 and β_1 are not significant. $\hat{\alpha}_1^2 + \hat{\alpha}_2^2$, $\hat{\alpha}_1\hat{\alpha}_2 + \hat{\beta}_1\hat{\beta}_2$ and $\hat{\beta}_1^2 + \hat{\beta}_2^2$ ($\hat{\alpha}_i, \hat{\beta}_i, i = 1, 2$ are the estimates of $\alpha_i, \beta_i, i = 1, 2$, respectively) are significantly less than 1, which indicates a low degree of persistence in the correlations.

2.2. Asymmetry Type in the Correlations and the Influences of the Business Sentiments on the Correlations

From Table 1, $\hat{\gamma}_1$ and $\hat{\gamma}_2$ (the estimates of γ_1 and γ_2) are positive, but while $\hat{\gamma}_1$ is significant at the 1% level, $\hat{\gamma}_2$ is not significant. This suggests that the correlation is joint positive-type asymmetric, but the asymmetry is not statistically significant. Hence, in our whole sample, good news from the US stock market has more influence on the correlations than bad news from the US stock market of the same magnitude; good news and bad news from German stock market have no significantly asymmetric effects on the correlations. This can be interpreted by the different financial systems of the two countries and by the related the literature that the US market is the most important producer of information (Eun and Shim, 1989; Ng, 2000; Theodossiou and Lee, 1993).

We are most interested in the estimates of η_U and η_G. In Table 1, $\hat{\eta}_U$ (the estimate of η_U) is positive and significant at the 1% level, which suggests that when the US business sentiment is high, the correlations will be stronger. However, $\hat{\eta}_G$ (the estimate of η_G) is not significant. Therefore, the German business sentiment has virtually no influence on the correlations. Considering $\hat{\eta}_U$ and $\hat{\eta}_G$ together, we can conclude that the US business sentiment dominates the correlations to a very high extent.[3]

This can be explained as follows. First, the US is the most economically influential country in the world, while the German economy is a small open economy.

Second, the US financial system is typically market-based, while Germany's is typically bank-based. The release of business sentiment is a kind of macroeconomic news. Moreover, we find support in the related literature that the reaction of German stock market to the US macroeconomic surprises is stronger than to the German ones (Bedowska-Sojka, 2013).

Table 1

Estimates of the Model

GARCH model parameters									
ω_1	δ_1	θ_1	ω_2	δ_2	θ_2				
0.4796*	0.1554***	0.8219***	3.5474*	0.1488**	0.7575***				
DCC model (with exogenous variables) parameters									
α_1	β_1	γ_1	α_2	β_2	γ_2	η_U	η_G	LLF	LRT
0.2620***	0.1227E-05	1.1858***	0.1110	0.8089***	1.8840	0.0811***	–0.8196E-03	–1584.915	7.1100**
$\bar{\rho}_{12} = 0.7092$									
$Q_1 = 7.8554$									
$Q_{11} = 8.7290$									
$Q_2 = 16.153$									
$Q_{22} = 10.243$									

Note: *** means that the coefficient is significant at the 1% level. ** means that the coefficient is significant at the 5% level. * means that the coefficient is significant at the 10% level. LLF is the likelihood value. LRT denotes the likelihood ratio test statistic testing the joint null $\gamma_1 = \gamma_2 = 0$. Q_1, Q_{11}, Q_2 and Q_{22} are Ljung-Box statistics for ε_{1t}, ε_{1t}^2, ε_{2t} and ε_{2t}^2 at 20 lags, respectively. We should note that all of the Ljung-Box statistics are not significant up to 20 lags. We cannot list all of the Ljung-Box statistics due to limited space.

Source: Own research.

[3] We should note that although we reject the standard DCC model according to the LRT in Table 1, the same conclusion can be derived by employing the standard DCC model. The results can be provided on request.

Table 2

Estimated Results of the Model with the Possible Structural Breaks in γ_1 and γ_2

Panel A: Influences of the introduction of the Euro and the outbreak of the 2008 – 2010 financial crisis on γ_1 and γ_2											
α_1	β_1	$\gamma_{1,\,pre\text{-}euro}$	$\gamma_{1,\,euro\text{-}crisis}$	$\gamma_{1,\,post\text{-}crisis}$	α_2	β_2	$\gamma_{2,\,pre\text{-}euro}$	$\gamma_{2,\,euro\text{-}crisis}$	$\gamma_{2,\,post\text{-}crisis}$	η_U	η_G
0.3482***	0.1485E-07	0.7197*	–0.5566	2.0219***	0.1518***	0.6746***	1.6073	0.3147	2.2105**	0.0877***	–0.3742E-02
LLF: –1570.848											
Panel B: Test Results											
(1) H_0: $\gamma_{1,\,pre\text{-}euro} = \gamma_{1,\,euro\text{-}crisis} = \gamma_{1,\,post\text{-}crisis}$, $\gamma_{2,\,pre\text{-}euro} = \gamma_{2,\,euro\text{-}crisis} = \gamma_{2,\,post\text{-}crisis}$; H_1: $\gamma_{1,\,pre\text{-}euro} \neq \gamma_{1,\,euro\text{-}crisis}$, $\gamma_{1,\,euro\text{-}crisis} = \gamma_{1,\,post\text{-}crisis}$, $\gamma_{2,\,pre\text{-}euro} \neq \gamma_{2,\,euro\text{-}crisis}$, $\gamma_{2,\,euro\text{-}crisis} = \gamma_{2,\,post\text{-}crisis}$. $LRT_{euro} = 9.7820^{***}$											
(2) H_0: $\gamma_{1,\,pre\text{-}euro} = \gamma_{1,\,euro\text{-}crisis} = \gamma_{1,\,post\text{-}crisis}$, $\gamma_{2,\,pre\text{-}euro} = \gamma_{2,\,euro\text{-}crisis} = \gamma_{2,\,post\text{-}crisis}$; H_1: $\gamma_{1,\,pre\text{-}euro} = \gamma_{1,\,euro\text{-}crisis}$, $\gamma_{1,\,euro\text{-}crisis} \neq \gamma_{1,\,post\text{-}crisis}$, $\gamma_{2,\,pre\text{-}euro} = \gamma_{2,\,euro\text{-}crisis}$, $\gamma_{2,\,euro\text{-}crisis} \neq \gamma_{2,\,post\text{-}crisis}$. $LRT_{crisis} = 14.7820^{***}$											
(3) H_0: $\gamma_{1,\,pre\text{-}euro} = \gamma_{1,\,euro\text{-}crisis}$, $\gamma_{1,\,euro\text{-}crisis} \neq \gamma_{1,\,post\text{-}crisis}$, $\gamma_{2,\,pre\text{-}euro} = \gamma_{2,\,euro\text{-}crisis}$, $\gamma_{2,\,euro\text{-}crisis} \neq \gamma_{2,\,post\text{-}crisis}$; H_1: $\gamma_{1,\,pre\text{-}euro} \neq \gamma_{1,\,euro\text{-}crisis}$, $\gamma_{1,\,euro\text{-}crisis} \neq \gamma_{1,\,post\text{-}crisis}$, $\gamma_{2,\,pre\text{-}euro} \neq \gamma_{2,\,euro\text{-}crisis}$, $\gamma_{2,\,euro\text{-}crisis} \neq \gamma_{2,\,post\text{-}crisis}$. $LRT_{two\text{-}breaks} = 16.4880^{***}$											

Note: *** means that the coefficient is significant at the 1% level. ** means that the coefficient is significant at the 5% level. * means that the coefficient is significant at the 10% level. LLF is the likelihood value. In panel B, LRT denotes the likelihood ratio test statistic.

Source: Own research.

Table 3

Estimated Results of the Model with the Possible Structural Breaks in η_U and η_G

Panel A: Influences of the introduction of the Euro and the outbreak of the 2008 – 2010 financial crisis on η_U and η_G											
α_1	β_1	γ_1	α_2	β_2	γ_2	$\eta_{U,\,pre\text{-}euro}$	$\eta_{U,\,euro\text{-}crisis}$	$\eta_{U,\,post\text{-}crisis}$	$\eta_{G,\,pre\text{-}euro}$	$\eta_{G,\,euro\text{-}crisis}$	$\eta_{G,\,post\text{-}crisis}$
0.2009**	0.1687E-08	1.22396**	0.2123***	0.6561***	1.1547**	0.1019**	0.0530	0.0697***	–0.1000	–0.0246	0.0566
LLF: –1572.217											
Panel B: Test Results											
(1) H_0: $\eta_{U,\,pre\text{-}euro} = \eta_{U,\,euro\text{-}crisis} = \eta_{U,\,post\text{-}crisis}$, $\eta_{G,\,pre\text{-}euro} = \eta_{G,\,euro\text{-}crisis} = \eta_{G,\,post\text{-}crisis}$; H_1: $\eta_{U,\,pre\text{-}euro} \neq \eta_{U,\,euro\text{-}crisis}$, $\eta_{U,\,euro\text{-}crisis} = \eta_{U,\,post\text{-}crisis}$, $\eta_{G,\,pre\text{-}euro} \neq \eta_{G,\,euro\text{-}crisis}$, $\eta_{G,\,euro\text{-}crisis} = \eta_{G,\,post\text{-}crisis}$. $LRT_{euro} = 10.3560^{***}$											
(2) H_0: $\eta_{U,\,pre\text{-}euro} = \eta_{U,\,euro\text{-}crisis} = \eta_{U,\,post\text{-}crisis}$, $\eta_{G,\,pre\text{-}euro} = \eta_{G,\,euro\text{-}crisis} = \eta_{G,\,post\text{-}crisis}$; H_1: $\eta_{U,\,pre\text{-}euro} = \eta_{U,\,euro\text{-}crisis}$, $\eta_{U,\,euro\text{-}crisis} \neq \eta_{U,\,post\text{-}crisis}$, $\eta_{G,\,pre\text{-}euro} = \eta_{G,\,euro\text{-}crisis}$, $\eta_{G,\,euro\text{-}crisis} \neq \eta_{G,\,post\text{-}crisis}$. $LRT_{crisis} = 9.7720^{***}$											
(3) H_0: $\eta_{U,\,pre\text{-}euro} \neq \eta_{U,\,euro\text{-}crisis}$, $\eta_{U,\,euro\text{-}crisis} = \eta_{U,\,post\text{-}crisis}$, $\eta_{G,\,pre\text{-}euro} \neq \eta_{G,\,euro\text{-}crisis}$, $\eta_{G,\,euro\text{-}crisis} = \eta_{G,\,post\text{-}crisis}$; H_1: $\eta_{U,\,pre\text{-}euro} \neq \eta_{U,\,euro\text{-}crisis}$, $\eta_{U,\,euro\text{-}crisis} \neq \eta_{U,\,post\text{-}crisis}$, $\eta_{G,\,pre\text{-}euro} \neq \eta_{G,\,euro\text{-}crisis}$, $\eta_{G,\,euro\text{-}crisis} \neq \eta_{G,\,post\text{-}crisis}$. $LRT_{two\text{-}breaks} = 18.1760^{***}$											

Note: *** means that the coefficient is significant at the 1% level. ** means that the coefficient is significant at the 5% level. * means that the coefficient is significant at the 10% level. LLF is the likelihood value. In panel B, LRT denotes the likelihood ratio test statistic.

Source: Own research.

2.3. Testing the Structural Breaks in the Relationship

The introduction of the Euro has had a deep influence on Germany and the entire Eurozone. The recent financial crisis also had a heavy impact on the world economy. Thus, we discuss whether the introduction of the Euro and the outbreak of the 2008 – 2010 financial crisis changed the relationship among the US and German business sentiments and the US and German stock markets. We choose the date January 1, 1999, as one possible structural break date. In September 2008, Lehman Brothers collapsed, which was the onset of the global financial crisis (Aït-Sahalia et al., 2012; Ivashina and Scharfstein, 2010). Therefore, September 2008 is taken as another possible structural break date.[4] The estimated results of the model with the possible structural breaks are presented in Table 2 and Table 3.

Table 2 reports the results testing the possible structural breaks in the asymmetry in the correlations. In Panel B of Table 2, both the value of the LRT_{crisis} (testing the null hypothesis without breaks in the asymmetry in the correlations against the alternative hypothesis with one break caused by the outbreak of the financial crisis) statistic and the value of the LRT_{euro} (testing the null hypothesis without breaks in the asymmetry in the correlations against the alternative hypothesis with one break caused by the introduction of the Euro) statistic are significant at the 1% level. Since the value of the LRT_{crisis} statistic is greater than the value of the LRT_{euro} statistic, there is at least one structural break in the asymmetry in the correlations caused by outbreak of the 2008 – 2010 financial crisis. The value of the $LRT_{two\text{-}breaks}$ (testing the null hypothesis with one break on the asymmetry in the correlations caused by the outbreak of the 2008 – 2010 financial crisis against the alternative hypothesis with two breaks caused by the launch of the Euro and the outbreak of the financial crisis) statistic is significant at the 1% level. Based on the above analysis, both the introduction of the Euro and the outbreak of the recent financial crisis result in structural breaks in the asymmetry in the correlations between the US and German stock markets.

In Panel A of Table 2, we report all the estimates with two structural breaks in the asymmetry in the correlations between the US and German stock markets. $\hat{\gamma}_{1,\,pre\text{-}euro}$ and $\hat{\gamma}_{2,\,pre\text{-}euro}$ are positive.

However, $\hat{\gamma}_{1,\,pre\text{-}euro}$ is significant at the 10% level, and $\hat{\gamma}_{2,\,pre\text{-}euro}$ is not significant. This indicates that before the introduction of the Euro, the correlations are not significantly joint asymmetric, and only the US stock market has a positively asymmetric weak impact on the correlations. This finding means that before the

[4] We appreciate the anonymous referee's insightful suggestion.

launch of the Euro, the US stock market had a greater impact on the correlations than German stock market. However, the connection between the two stock markets is not strong enough to make the impact of the US stock market on the correlations occur at a more significant level.

Both $\hat{\gamma}_{1,euro\text{-}crisis}$ and $\hat{\gamma}_{2,euro\text{-}crisis}$ are not significant. Therefore, from the introduction of the Euro to the outbreak of the recent financial crisis, the correlations are symmetric. This is explained by the fact that the advent of the Euro links the German stock market more closely to other Eurozone stock markets, which indirectly decreases the impacts of the US and German stock markets on the correlations.

Both $\hat{\gamma}_{1,post\text{-}crisis}$ and $\hat{\gamma}_{2,post\text{-}crisis}$ are positive. $\hat{\gamma}_{1,post\text{-}crisis}$ is significant at the 1% level. $\hat{\gamma}_{2,post\text{-}crisis}$ is significant at the 5% level, related to Germany adopting a more market-based financial system. Thus, since the outbreak of the 2008 – 2010 financial crisis, the asymmetry is joint positive-type asymmetric. In other words, joint positive-type news ($\varepsilon_i > 0,\ i = 1,\ 2$) produces a greater impact on the correlations than joint negative-type news ($\varepsilon_i < 0,\ i = 1,\ 2$) of the same magnitude. This can be explained as follows. The recent financial crisis had deep impacts on both the US and European economies. Hence, the US and Germany implemented all kinds of measures to improve the economy. When the two stock markets received joint positive-type news, the governments stood by the market. However, when the two stock markets received joint negative-type news, the governments may intervene to reduce the influence of negative news. Therefore, the impact of joint positive-type news on the correlations overwhelms the joint negative-type news of the same magnitude.

The most interesting thing is whether the advent of the Euro and the recent financial crisis cause structural breaks in the influences of the US and German business sentiments on the correlations between the US and German stock markets. Table 3 reports the results that test for possible structural breaks in the influences of the US and German business sentiments on the correlations. In Panel B of Table 3, both the value of the LRT_{euro} (testing the null hypothesis without breaks in the influences of business sentiments on the correlations against the alternative hypothesis with one break caused by the launch of the Euro) statistic and the value of the LRT_{crisis} (testing the null hypothesis without breaks in the influences of business sentiments on the correlations against the alternative hypothesis with one break caused by the outbreak of the 2008 – 2010 financial crisis) statistic are significant at the 1% level. The value of the LRT_{euro} statistic is greater than the value of the LRT_{crisis} statistic. Therefore, there is at least one break in the influences of business sentiments on the correlations caused by the advent of the Euro. The value of the $LTR_{two\text{-}breaks}$ (testing the null hypothesis with

one break on the influences of business sentiments on the correlations caused by the introduction of Euro against the alternative hypothesis with one break caused by the launch of the Euro against the alternative hypothesis with two breaks caused by the launch of the Euro and the outbreak of the financial crisis, respectively) statistic is significant at the 1% level. Hence, either the introduction of the Euro or the outbreak of the recent financial crisis caused a structural break in the impacts of business sentiments on the correlations between the US and German stock markets.

In Panel A of Table 3, $\hat{\eta}_G$ is uniformly not significant over the three periods, indicating that German business sentiment has little influence on the correlations. This supports our conjecture that due to a bank-based financial system and the relatively small economic influential power, German business sentiment has little impact on the correlations. The finding here provides evidence for the viewpoint that domestic macroeconomic news releases in Germany seem to be unimportant for German stock markets (Nikkinen and Sahlström, 2004).

Prior to the launch of the Euro, $\eta_{U,pre\text{-}euro}$ is positive and significant at the 5% level. Therefore, during this period, the US business sentiment has positive impacts on the correlations. Hence, high US business sentiment results in an increase in the correlations, while low US business sentiment leads to a decline in the correlations. This is due to the following reasons. High business sentiment stimulates the demand for stocks, and the government welcomes it, which increases the correlations. Moreover, low business sentiment depresses the demand for stocks, and the government may intervene. This weakens the links between the cross-country stock markets, resulting in a decline in the correlations.

During the period from the introduction of the Euro to the outbreak of the 2008 – 2010 financial crisis, $\eta_{U,euro\text{-}crisis}$ is not significant. We insist that it is related to the fact that the launch of the Euro makes countries in the European Union link more tightly than ever, and during the period, the European Union economy experienced a fast and steady growth. These facts may intensify the expectations of good European Union economic prospects and lessen the relative influential power of the US business sentiment on the correlations.

After the recent financial crisis, $\eta_{U,post\text{-}crisis}$ is positive and significant at the level of 1%. The US business sentiment has positive effects on the correlations once again, which is related to the outbreak of the 2008 – 2010 financial crisis. The financial crisis originated in the US and quickly spread to the European Union. The financial crisis heavily destroyed the European Union economy.

This highlights the importance of the US economy. It abates the influential power of German business sentiment and enhances the impact of US business sentiment. Therefore, the US business sentiment dominates the correlations.

High US business sentiment provides the world with a good prospect for the world economy, helping to boost the stock markets, which results in a rise in the correlations between the US and German stock markets. However, due to governments' interventions in low US business sentiment situations, low US business sentiment leads to a decline in the correlations between the US and German stock markets.

2.4. Graphical Representation of the Asymmetry in the Correlation Since the 2008 – 2010 Financial Crisis

Since the 2008 – 2010 financial crisis, the correlations between the US and German stock markets are significantly joint positive-type asymmetric. We employ graphs to vividly present the asymmetry type of the correlations after the outbreak of the recent financial crisis, which is enlightened by Kroner and Ng (1998) and Li (2011).

In particular, we take the stock shocks (i.e., ε_{it}) as "good/bad news" and investigate the impact of such news on the correlations using the graph "news impact surface". Focusing on the asymmetric impact of "ε_{1t}" and "ε_{2t}" on the correlations, we set both exogenous variables as 0. Hence, for our model, the correlation news impact surface is:

$$f(\varepsilon_1,\varepsilon_2)=\frac{\tilde{C}_{12}+\alpha_1\alpha_2(\varepsilon_1+\gamma_{1,post\text{-}crisis})(\varepsilon_2+\gamma_{2,post\text{-}crisis})+\beta_1\beta_2\bar{\rho}_{12}}{\sqrt{[\tilde{C}_{11}+\alpha_1^2(\varepsilon_1+\gamma_{1,post\text{-}crisis})^2+\beta_1^2][\tilde{C}_{22}+\alpha_2^2(\varepsilon_2+\gamma_{2,post\text{-}crisis})^2+\beta_2^2]}} \quad (6)$$

where $\tilde{C}_{12}=\bar{\rho}_{12}(1-\alpha_1\alpha_2-\beta_1\beta_2)$, $\tilde{C}_{11}=1-\alpha_1^2-\beta_1^2$, and $\tilde{C}_{22}=1-\alpha_2^2-\beta_2^2$. $\alpha_i(i=1,2)$, $\beta_i(i=1,2)$ and $\gamma_{i,post\text{-}crisis}(i=1,2)$ are the parameter estimates in Table 2. For convenience, we utilize the following formula to express the correlation news impact surface:

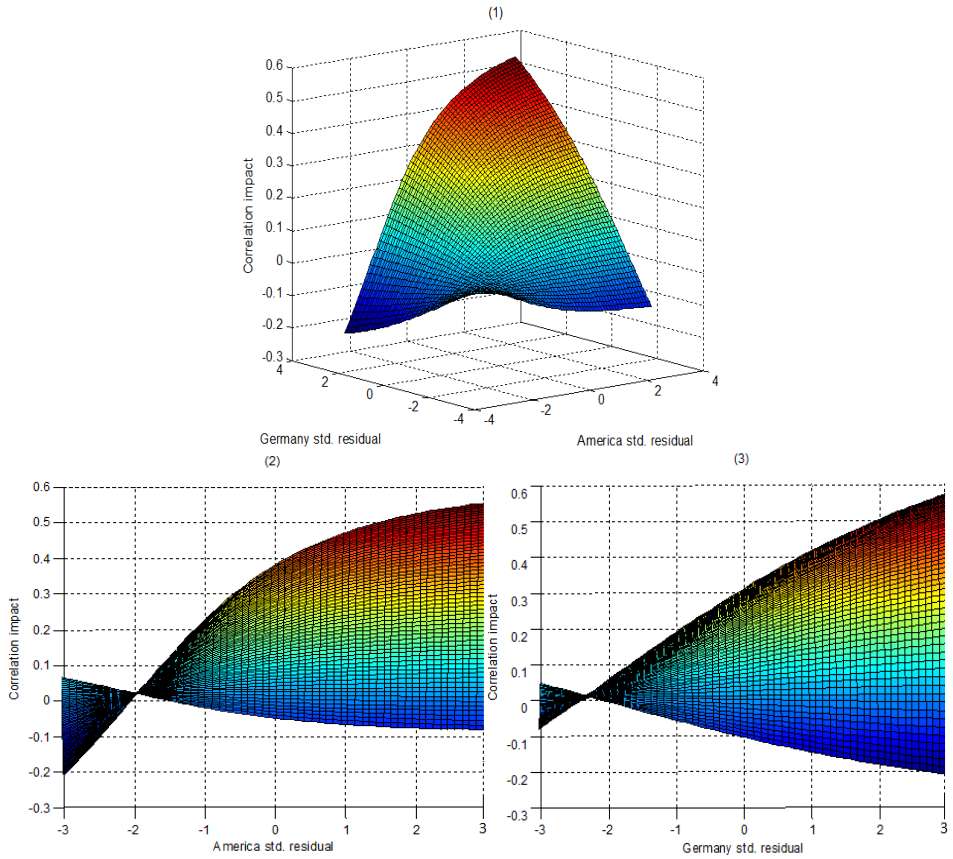
$$f(\varepsilon_1,\varepsilon_2)=\frac{\alpha_1\alpha_2(\varepsilon_1+\gamma_1)(\varepsilon_2+\gamma_2)}{\sqrt{[\tilde{C}_{11}+\alpha_1^2(\varepsilon_1+\gamma_1)^2+\beta_1^2][\tilde{C}_{22}+\alpha_2^2(\varepsilon_2+\gamma_2)^2+\beta_2^2]}} \quad (7)$$

Formulas (6) and (7) only have a different vertical location in a three-dimensional plot, but they have the same shape. We evaluate the surface in the domain $[-3,3]\times[-3,3]$.

Figure 1 is the news impact surface for the correlations between the US and German stock markets with three different views. In Panels (2) and (3), we can find that the joint positive-type asymmetry in the correlations is very apparent.

Figure 1

The News Impact Surface for the Correlations between the US and German Stock Markets with three Different Views



Source: Own research.

The centre of the surface is located at the point $(-2.0219, -2.2105)$, which is away from the origin $(0,0)$, resulting in a greater surface value for joint positive than joint negative standardized residuals of equal magnitudes. This suggests that after the outbreak of the recent financial crisis, the correlations between the US and German stock markets have a larger response to joint good news (in the "+, +" standardized-residual quadrant) than joint bad news (in the "–, –" standardized-residual quadrant). More specifically, we consider two extreme scenarios. One is that joint positive shocks $\varepsilon_1 = \varepsilon_2 = 3$ hit the US and German stock markets. The other scenario is that for joint negative shocks, $\varepsilon_1 = \varepsilon_2 = -3$. According to formula (7), $f(3,3) = 0.5507$ and $f(-3,-3) = 0.0411$. The latter is less than one-thirteenth of the former.

This implies that after the 2008 – 2010 financial crisis, the correlations between the US and German stock markets decline when joint bad news hits the markets. The diversification sought by investing in the US and German stock markets is likely high.

Conclusions

This paper discusses the asymmetry in the correlations between the US and German stock markets and the influences of the US and German business sentiments on the correlations. On the whole, the correlations between the US and German stock markets are joint positive-type asymmetric, but the asymmetry is not statistically significant. News from the US stock market has a positively asymmetric impact on the correlations. The asymmetric impact on the correlations caused by the German stock market is not significant. US business sentiment has a positive impact on the correlation. When US business sentiment increases, the correlations increase. Likewise, a decreasing US business sentiment decreases the correlations. However, the German business sentiment has almost no influence on the correlations.

The asymmetry in the correlations mainly caused by the US stock market relates to the viewpoint that the US market is the most important producer of information (Eun and Shim, 1989; Ng, 2000; Theodossiou and Lee, 1993). Different impacts of the US and German business sentiments on the correlations support the related literature that major US macroeconomic news had a cross-border impact on both European equity returns and volatilities (Harju and Hussain, 2011) and that the reaction of the German stock market to the US macroeconomic surprises is stronger than to the German ones (Bedowska-Sojka, 2013).

Both the advents of the Euro and the 2008 – 2010 financial crisis changed the asymmetric type in the correlations between the US and German stock markets. Before the launch of the Euro, the asymmetry in the correlations between the US and German stock markets was mainly dominated by the US stock market. After the introduction of the Euro, before the outbreak of the recent financial crisis, the correlations are symmetric, implying that the advent of the Euro tightens the European Union countries and decreases the influence of the US stock markets on the correlations. Since the outbreak of the Euro, the correlations between the US and German stock markets become joint positive-type asymmetric due to the interconnection of the economy and Germany's increasing market-based financial system.

Two structural breaks caused by the introduction of the Euro and the outbreak of the financial crisis also exist in the influences of business sentiments on the

correlations. Although the influences of German business sentiment on the correlations are not consistently significant, the influences of the US business sentiment on the correlations are significant, except in the period between the launch of the Euro and the outbreak of the 2008 – 2010 financial crisis. The European Union quickly develops and experiences a fast and steady economic growth, which makes the influences of US business sentiment insignificant.

Our research is very important for investors and policymakers. For example, investors should consider the asymmetry type in the correlations, constructing their portfolio containing US and German stocks. Since business sentiment is a leading economic indicator (Entorf, Gross and Steiner, 2012), our findings can help investors adjust their portfolio and help policymakers to estimate the consequence of the policy.

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Appendix

Table 1 reports the results of the stationary test for all the series. From the table, we can see that all the series are significant at the level of 1%.

Table 1

The Results of the Stationary Test for All the Series

	r_1	r_2	$\Delta\xi_U$	$\Delta\xi_G$
ADF test statistic	–16.0390***	–16.1908***	–15.6883***	–5.4292***

Note: ADF test is Augmented Dickey-Fuller test; $r_i\,(i=1,2)$ are the logarithm return series of the US stock prices and German stock prices respectively; $\Delta\xi_U$ denotes the difference series of the US business sentiment; $\Delta\xi_G$ denotes the difference series of the Germany business sentiment; *** indicates significant at the level of 1%.

Source: Own research.