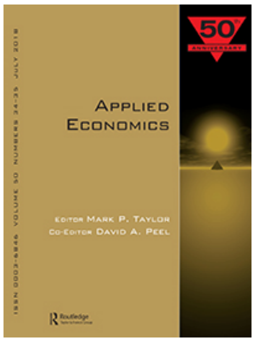

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ABSTRACT

In this article, we examine herding in three developed stock markets testing for the impact of investors' 'fear' on herding estimations. To this end, we employ daily data of all listed stocks from USA, UK and Germany from January 2004 to July 2014. We examine herd behaviour applying the cross-sectional dispersion approach. Moreover, we investigate the asymmetric herding behaviour under different market states and sub-periods. The stock markets under examination provide comparable implied volatility indices which are used as a proxy for fear. As a result, apart from the standard herding estimations within and across markets, we also augment the benchmark model with the fear indicator. Our empirical results document the statistically significant impact of fear on herding estimations. Moreover, there is evidence of cross market herding as well as evidence of herding in the UK during specific sub-periods.

KEYWORDS

Herding; cross-sectional dispersion of returns; implied volatility index; fear

JEL CLASSIFICATION

G12; G15

I. Introduction

The successive crises witnessed in the financial markets in recent decades highlight the increasing influence of investors' sentiment on market efficiency. Among the most interesting topics that attract international research interest is the examination of herd behaviour that refers to correlated trading stemming from mutual imitation of action (Bikhchandani, Hirshleifer, and Welch 1992; Welch 2000; Hirshleifer and Teoh 2003).

Although investors' sentiment cannot be easily and accurately measured, recent studies have focused on its impact on herding in the stock market employing the CBOE implied volatility index (VIX) as a proxy for US investors' sentiment (Philippas et al. 2013; Chiang et al. 2013; Economou et al. 2015). The CBOE VIX index was introduced in 1993 and expresses the expected future market volatility over the next 30 calendar days, based on the S&P500 options. Higher CBOE VIX levels indicate increased uncertainty in the market and the index is considered to be the investors' sentiment barometer, usually reported as the 'investor fear gauge' (Whaley 2000; Whaley 2009). The CBOE VIX index has been widely acknowledged internationally due to its superior explanatory power compared to historical volatility (Siriopoulos and Fassas 2009). As a result, relative comparable implied volatility indices were constructed, based on the CBOE VIX methodology for UK (VFTSE), Germany (VDAX NEW), France (CAC 40 Volatility Index), Belgium (BEL 20 Volatility Index), Greece (KEPE GRIV), etc.

In this article, we examine the impact of investors' fear on herding estimations, as it is captured by the respective implied volatility indices. To this end, we employ daily data of all listed stocks, active or dead, from three developed stock markets, i.e. USA, UK and Germany, from January 2004 to July 2014. The sample consists of the world's largest stock market (US) as well as the two largest European stock markets (UK and German). Our motivation lies in the hypothesis that herding can be more pronounced when fear prevails the market. In order to test for this hypothesis, we examine herd behaviour applying the cross-sectional dispersion approach in the same spirit with Chang, Cheng, and Khorana (2000), augmenting the benchmark model with the fear indicator. The stock markets under examination provide comparable implied volatility indices to capture investors' sentiment and fear, which are all constructed based on the new CBOE VIX methodology.

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Our empirical results document the statistically significant impact of fear on herding estimations. Moreover, there is evidence of herding in the UK during the global financial crisis period (2007–2009) and during the sub period January 2004 to 20 November 2007, as well as evidence of cross market herding.

This article contributes to the existing herding literature conducting a thorough examination of herding in three developed stock markets under different market states and for different sub-periods, also introducing the fear indicator in the traditional Chang, Cheng, and Khorana (2000) model. We provide new evidence regarding cross market, as well as individual market, herding taking into consideration the impact of investors' fear. Our findings provide useful insight for investors and regulators, especially during crisis periods, and can be useful in asset allocation and hedging.

The rest of the article is structured as follows: Section II provides a brief literature review on herding behaviour and stock market volatility, Section III presents the data and the methodology employed to examine herd behaviour, Section IV reports and discusses the empirical results, while Section V concludes the study.

II. Literature review: herding and volatility

Herd behaviour has been examined in many different contexts in the financial markets[1] i.e. in the international stock markets (Christie and Huang 1995; Chang, Cheng, and Khorana 2000; Hwang and Salmon 2004; Tan et al. 2008; Chiang, Li, and Tan 2010; Economou, Kostakis, and Philippas 2011) and exchange groups (Andrikopoulos, Hoefer, and Kallinterakis 2014; Economou et al. 2015), in the bond market (Galariotis et al. 2016), in the real estate market (Philippas et al. 2013), in the foreign exchange market (Kaltwasser 2010), in the commodities market (Gleason, Lee, and Mathur 2003; Philippas 2014), in the ETFs market (Gleason, Mathur, and Peterson 2004) etc. Another strand of literature also examines the fund managers' correlated transactions and their portfolios' holdings, since herding is also profound in institutional investors' investment decisions (Lakonishok, Shleifer, and Vishny 1992; Wermers 1999; Sias 2004).

Herding can be either intentional when it reflects information or reputation/career related payoffs, or spurious when it reflects trading homogeneity based on the same informational, educational and regulatory background as well as characteristic trading, i.e. following trading strategies based on particular asset characteristics (e.g. size, volume, performance, etc.) (Gavriilidis, Kallinterakis, and Leite Ferreira 2013; Holmes, Kallinterakis, and Leite Ferreira 2013). Herding is expected to be more pronounced during periods of extreme market conditions which are characterized by increased uncertainty and significant market fluctuations. Under market stress, when fear and panic prevail the market, individual investors, retail or institutional, are more likely to follow the market consensus i.e. the herd (Christie and Huang 1995), exposing market participants to additional risks that are difficult to eliminate through portfolio diversification or hedging strategies.

Herding has been examined both in developed and emerging markets providing mixed evidence depending mostly on the time period under examination and the employed methodological approach. The context of emerging markets generally facilitates herd behaviour due to the market participants' characteristics and incentives compared to their more experienced peers in developed stock markets. Moreover, information asymmetries, lack of transparency and information disclosure, low trading volume, inadequate regulatory framework, etc. may promote and facilitate herding behaviour (Kallinterakis and Kratunova 2007).

Several studies provide evidence of herding in developed stock markets, also testing for the sensitivity of herding estimations to different market states relative to market performance and volume. Even though herding is expected to be more pronounced during down market periods (Chang, Cheng, and Khorana 2000; Demirer, Kutan, and Chen 2010; Chiang and Zheng 2010; Chen 2013; Philippas et al. 2013; Mobarek, Mollah, and Keasey 2014), there is also evidence of significant asymmetric herding behaviour during up-market periods (Tan et al. 2008; Economou, Kostakis, and Philippas 2011; Economou et al. 2015). With reference to trading volume, literature also provides mixed results documenting both up-volume (Tan et al. 2008; Economou, Kostakis, and Philippas 2011) and down-volume (Mobarek, Mollah, and Keasey 2014; Economou et al. 2015) herding asymmetries.

Moreover, there has been an established relationship between herding and increased market volatility

[1]Spyrou (2013) provides a comprehensive review of the recent herding literature summarizing theory and empirical results of more than two decades.

(Gleason, Mathur, and Peterson 2004). Tan et al. (2008) have reported an asymmetric herding behaviour for the A-share Shanghai market on days with high volatility, while recent studies also employ the implied volatility index (VIX) to test for the impact of the US investors' sentiment on the US (Philippas et al. 2013) or other international stock markets (Chiang et al. 2013; Economou et al. 2015). The rationale is that the CBOE VIX index reflects the uncertainty of the sophisticated derivatives' market participants for the short-term expected market volatility i.e. the investors' fear regarding the short term expected performance of the underlying market. When fear prevails the market herding is more likely to occur, as indicated by the empirical results of Philippas et al. (2013) for the US REITs market. On the other hand, Economou et al. (2015) indicate that herding is more pronounced in the Euronext markets on down-VIX days, consistent to their finding of herding asymmetries during up domestic market and S&P500 performance, while Chiang et al. (2013) also report a reduction in herding activity on rising VIX days for the Pacific-Basin region stock markets. These results should be further examined though using the respective domestic market implied volatility index in order to examine the domestic investors' sentiment impact on herding estimations employing indices based on the same methodological approach as the CBOE VIX index.

Finally, there are several recent studies (Chiang and Zheng 2010; Economou, Kostakis, and Philippas 2011; Chiang et al. 2013; Balcilar, Demirer, and Hammoudeh 2013; Mobarek, Mollah, and Keasey 2014; Economou et al. 2015) that also focus on cross market herding and herding that can be attributed to other markets' dynamics due to its implications for international diversification, contagion and market destabilization. Overall, there is evidence of cross-market herding i.e. herding towards other markets that should be further analysed especially during periods of market stress during which such a coordinated herding behaviour could have a negative impact for investors' portfolios and market efficiency.

III. Data and methodology

In order to examine herd behaviour we employ the well-known cross-sectional dispersion approach based on the seminal work of Christie and Huang (1995) and Chang, Cheng, and Khorana (2000). They argue that the cross-sectional dispersion of the individual assets' returns is a simple but intuitive measure of herding that tends to decrease in the presence of herd behaviour and it is calculated as follows:

$$CSAD_t = \frac{\sum_{j=1}^{N} \left| R_{i,t} - _{m,t} \right|}{N} \tag{1}$$

where $R_{i,t}$ is the equity i's percentage log differenced return on day t, $R_{m,t}$ is the market's return on day t that is calculated as the equally weighted average return of the individual equities on day t and finally N is the number of all listed equities in the market under examination on day t.

Based on rational asset pricing models we would expect an increase in the cross-sectional dispersion measure under extreme market conditions due to the individual assets' different sensitivity to the market returns. However, Christie and Huang (1995) argue that investors are more likely to ignore their own beliefs/information and follow the market consensus during periods of extreme market returns. As a result, their correlated investment decisions will end up in reduced cross-sectional dispersion during periods of market stress, that are usually characterized by negative returns and high market volume and volatility (Economou, Kostakis, and Philippas 2011).

Chang, Cheng, and Khorana (2000) proposed a non linear model (CCK) that captures the relationship of the CSAD measure with the market return as follows:

$$CSAD_{m,t} = a + \gamma_1 \left| R_{m,t} \right| + \gamma_2 R_{m,t}^2 + \varepsilon_t \tag{2}$$

A negative and statistically significant γ_2 coefficient provides evidence of herding behaviour, i.e. the cross-sectional dispersion of returns increases (if γ_1 coefficient is positive and statistically significant) but at a decreasing rate. This is enough to document herding behaviour.

However, herding may display an asymmetric behaviour during up and down market periods. Following Chiang and Zheng (2010), Chiang, Li, and Tan (2010) and Economou, Kostakis, and Philippas (2011), we test for herding asymmetric behaviour employing a single equation model using a dummy variable as follows:

$$CSAD_{m,t} = a + \gamma_1 D^{up}|R_{m,t}| + \gamma_2(1 - D^{up})|R_{m,t}| + \gamma_3 D^{up} R^2_{m,t} + \gamma_4(1 - D^{up})R^2_{m,t} + \varepsilon_t \quad (3)$$

where D^{up} is a dummy variable that takes the value 1 on days with positive market returns and the value 0 otherwise. Empirical evidence on the up/down market herding asymmetry is rather mixed with empirical studies supporting more pronounced herding during either down market periods or up market periods depending on the market and the period under examination.

Especially during crisis periods when fear prevails, the market herding may be even more pronounced. In line with Philippas et al. (2013) that documented a negative relationship between CBOE VIX implied volatility index and US REIT returns' cross-sectional dispersion, we test for the impact of 'fear' on herding estimations in the markets under examination using the following augmented CCK (2000) model:

$$CSAD_{m,t} = a + \gamma_1|R_{m,t}| + \gamma_2 R^2_{m,t} + \gamma_3 VIX_{m,t} + \varepsilon_t \quad (4)$$

where $VIX_{m,t}$ is the daily return of the implied volatility index of market m. A negative and statistically significant coefficient γ_3 would confirm our research hypothesis of increased herding during periods of increased uncertainty and fear. It should be mentioned that we employ the implied volatility indices that are calculated based on the official CBOE VIX methodology, hence we provide comparable results that reflect the impact of domestic investors' sentiment on herding estimations.

Moreover, we test for cross market herding, in the same spirit with Chiang and Zheng (2010), Balcilar, Demirer, and Hammoudeh (2013), Lee, Chen, and Hsieh (2013) and Economou et al. (2015), by augmenting the benchmark CCK (2000) model with the cross-sectional absolute deviation of the individual stock returns and the squared market return for each of the other two markets k (where k ≠ m) of our sample as follows:

$$CSAD_{m,t} = a + \gamma_1|R_{m,t}| + \gamma_2 R^2_{m,t} + \gamma_3 CSAD_{k,t} + \gamma_4 R^2_{k,t} + \varepsilon_t \quad (5)$$

We expect coefficient γ_3 to be positive and statistically significant indicating CSAD positive co-movement and γ_4 to be negative and statistically significant, i.e. investors in market m herd towards market k during periods of extreme market returns in market k.

Finally, taking into consideration the significant spill-over effects of the US investor sentiment on international stock markets (Bathia, Bredin, and Nitzsche 2016), we also test for the impact of the fear index of market k on market m herding estimation as follows:

$$CSAD_{m,t} = a + \gamma_1|R_{m,t}| + \gamma_2 R^2_{m,t} + \gamma_3 VIX_{k,t} + \varepsilon_t \quad (6)$$

According to our research hypothesis a negative and statistically significant coefficient γ_3 indicates that investors' decision to herd is affected by investors' sentiment in other stock markets.

In order to examine herding we employ daily closing prices for all equities in the US (NYSE and NASDAQ), the UK (London Stock Exchange) and the German (Frankfurt Stock Exchange) stock markets and their respective implied volatility indices derived from the Thomson-Reuters DataStream database from January 2004 to July 2014. We construct a survivor bias free dataset that consists of both active and dead stocks for every market. The number of active stocks that displayed trading activity[2] on day t ranged between 3,098 and 3,661 for the US, 1,277 and 1,912 for the UK and 522 and 830 for the German stock market.

Table 1 presents the descriptive statistics for each market's CSAD, market return and the implied volatility indices returns. We calculate the percentage log differenced returns as $R_{i,t} = 100\times(\log(P_{i,t})-\log(P_{i,t-1}))$ and our sample consists of more than 2,500 daily observations. Table 2 reports all the cross-market correlations of the individual markets' CSAD, market returns and the implied volatility indices' returns. Overall, the correlations are higher between the US and the UK market (regarding CSAD), as well as between the UK and the German market (regarding market returns and implied volatility).

[2]We did not include in our sample stocks that did not display trading activity on day t, since their zero returns would provide biased empirical results in favour of herding. We employ all active stocks that actually displayed trading activity on day t.

Table 1. Descriptive statistics.

Panel A: Cross-sectional average deviation of returns and equally weighted market returns						
	USA		UK		Germany	
	CSAD	R_m	CSAD	R_m	CSAD	R_m
Mean	0.8002	0.0043	0.7018	−0.0234	1.0990	−0.0190
Median	0.7104	0.0477	0.6567	0.0129	1.0405	0.0114
Maximum	3.0958	3.9676	2.1067	0.7953	3.6946	3.0675
Minimum	0.4383	−4.7603	0.3051	−1.8750	0.6103	−2.2911
Std. Dev.	0.3002	0.5910	0.2118	0.2426	0.2856	0.2877
Observations	2,567		2,610		2,659	

Panel B: Implied volatility indices returns			
	USA	UK	
	CBOE VIX	VFTSE	VDAX
Mean	−0.0517	−0.0293	−0.0203
Median	−0.2787	−0.1976	−0.1776
Maximum	21.5414	16.1414	13.2749
Minimum	−15.2259	−11.6345	−9.1929
Std. Dev.	2.9196	2.7184	2.3345
Observations	2,567	2,610	2,659

This table reports the descriptive statistics of the daily cross-sectional absolute deviation (CSAD) of individual stock returns, the relative equally weighted market returns (R_m) (Panel A) and the implied volatility indices (Panel B) for the US, UK and German stock markets during the period January 2004–July 2014.

Table 2. Cross-market correlations.

	USA	UK	Germany
Panel A: Correlations of CSAD			
USA	1.0000		
UK	0.7649	1.0000	
Germany	0.6511	0.7211	1.0000
Panel B: Correlations of market portfolio returns			
USA	1.0000		
UK	0.4308	1.0000	
Germany	0.4908	0.7509	1.0000
Panel C: Correlations of implied volatility indices' returns			
UK	0.4714	1.0000	
Germany	0.5171	0.7984	1.0000

This table reports the cross-market correlations of the daily cross-sectional absolute deviation (CSAD) of individual stock returns (Panel A), the respective equally weighted market returns (R_m) (Panel B) and the implied volatility indices (Panel C) for the US, UK and German stock markets during the period January 2004–July 2014.

IV. Empirical results

Table 3 reports the first set of our empirical results that examine the existence of herding in the three markets under examination employing the standard CCK (2000) model using Newey and West (1987) consistent estimators. According to the empirical results there is no evidence of herding in the UK and the German stock markets since coefficient γ_3 does not display a statistically significant result,[3] while we find a positive and statistically significant coefficient γ_3 for the US market instead of a negative value that would confirm herding. Previous literature also fails to document herding in the German (Mobarek, Mollah, and Keasey 2014) and the US markets (Christie and Huang 1995; Chang, Cheng, and Khorana 2000; Chiang and Zheng 2010) employing the cross-sectional dispersion approach.[4] Moreover, Table 4 reports the estimates of herding during up and down market periods testing for asymmetries in herding estimations. However, the results do not display any evidence of herding towards the market return for up or down market days.

The next set of empirical results (Table 5) takes into consideration the impact of 'fear' on our herding estimations. In this case, even though there is no evidence of herding towards the market return for the US, the UK and the German markets, there is clear evidence of herding towards the 'fear' indicator, displaying a negative

[3]Chiang and Zheng (2010) have documented evidence of herding for the UK and the German stock markets. However, these results are derived using industry and market price indices from 25 April 1989 to 24/ April 2009, instead of the individual equity returns for the whole market.

[4]Belhoula and Naoui (2011) have documented herding in the US for the period 1 February 1987–12 November 2009, using a small sample of 25 Dow Jones Industrial Average Index stocks, which cannot be considered to be representative of the whole US market though.

Table 3. Estimates of the standard CCK (2000) model.

	Constant	$\lvert R_{m,t}\rvert$	$R^2_{m,t}$	R^2 adj.
USA	0.6303 (56.82)***	0.3929 (7.90)***	0.0441 (2.47)**	51.93%
UK	0.5603 (83.68)***	0.9034 (16.50)***	−0.0489 (−1.11)	55.55%
Germany	0.9428 (81.78)***	0.8058 (14.88)***	0.0114 (0.44)	37.82%

This table presents the estimated coefficients for the CCK (2000) model:
$CSAD_{m,t} = a + \gamma_1 \lvert R_{m,t}\rvert + \gamma_2 R^2_{m,t} + \varepsilon_t$, where $CSAD_{m,t}$ is the cross-sectional absolute deviation of returns and $R_{m,t}$ is the market return. Daily data from January 2004 to July 2014. t-Statistics are given in parentheses using Newey and West (1987) standard errors. *** and ** represent statistical significance at the 1% and 5% level, respectively.

Table 4. Estimates of the CCK (2000) model during up and down periods of the market.

	Constant	$D^{up}\lvert R_{m,t}\rvert$	$(1-D^{up})\lvert R_{m,t}\rvert$	$D^{up} R^2_{m,t}$	$(1-D^{up})R^2_{m,t}$	R^2 adj.
USA	0.6353 (59.20)***	0.3550 (5.91)***	0.3762 (8.17)***	0.0955 (2.96)***	0.0319 (2.07)**	52.81%
UK	0.5748 (85.13)***	0.6196 (8.09)***	0.7674 (13.98)***	0.9846 (5.55)***	0.0249 (0.53)	57.85%
Germany	0.9358 (80.24)***	0.9316 (12.70)***	0.7751 (12.83)***	0.0239 (0.50)	−0.0075 (−0.17)	38.53%
Wald tests for equality of herding coefficients						
			USA	UK	Germany	
γ_1-γ_2 Chi-square, H_0: $\gamma_1 = \gamma_2$			−0.0212 [0.34]	−0.1478 [4.53]**	0.1564 [5.19]**	
γ_3-γ_4 Chi-square, H_0: $\gamma_3 = \gamma_4$			0.0636 [4.90]**	0.9597 [34.84]***	0.0314 [0.17]	

This table presents the estimated coefficients for the CCK (2000) model during up and down periods of the market: $CSAD_{m,t} = a + \gamma_1 D^{up}\lvert R_{m,t}\rvert + \gamma_2(1-D^{up})\lvert R_{m,t}\rvert + \gamma_3 D^{up} R^2_{m,t} + \gamma_4(1-D^{up})R^2_{m,t} + \varepsilon_t$, where $CSAD_{m,t}$ is the cross-sectional absolute deviation of returns, $R_{m,t}$ is the market return and D^{up} is a dummy variable that takes the value 1 on days with positive market returns and the value 0 otherwise. Daily data from January 2004 to July 2014. t-Statistics are given in parentheses using Newey and West (1987) standard errors. *** and ** represent statistical significance at the 1% and 5% level, respectively. Panel B reports chi-square statistics and the Wald tests for the null hypotheses $\gamma_1 = \gamma_2$ and $\gamma_3 = \gamma_4$.

Table 5. Estimates of herding behaviour incorporating the 'fear' factor.

	Constant	$\lvert R_{m,t}\rvert$	$R^2_{m,t}$	$VIX_{m,t}$	R^2 adj.
USA	0.6265 (56.44)***	0.3999 (8.12)***	0.0452 (2.64)***	−0.0097 (−4.95)***	52.78%
UK	0.5563 (82.96)***	0.9202 (16.98)***	−0.0323 (−0.77)	−0.0078 (−6.02)***	56.46%
Germany	0.9362 (80.60)***	0.8400 (14.89)***	0.0097 (0.43)	−0.0107 (−4.96)***	38.50%

This table presents the estimated coefficients for the augmented CCK (2000) model using the 'fear' factor: $CSAD_{m,t} = a + \gamma_1 \lvert R_{m,t}\rvert + \gamma_2 R^2_{m,t} + \gamma_3 VIX_{m,t} + \varepsilon_t$, where $CSAD_{m,t}$ is the cross-sectional absolute deviation of returns, $R_{m,t}$ is the market return and
$VIX_{m,t}$ is the return of the implied volatility index for each market m. Daily data from January 2004 to July 2014. t-Statistics are given in parentheses using Newey and West (1987) standard errors. *** represent statistical significance at the 1% level.

and statistically significant coefficient γ_4 i.e. an increase in the implied volatility indices is negatively related to CSAD, consistent to our research hypothesis.

Moreover, we test for the impact of the global financial crisis. Table 6 reports the re-estimated results for the period 2007–2009 indicating evidence of herding only in the UK stock market, which however is not related to an asymmetric herding behaviour during up and down days.[5] There is no evidence of herding in US and Germany during the crisis period. In fact, coefficient γ_2 is not statistically significant. This finding is consistent with the predictions of rational asset pricing models.

Apart from the crisis period, there might be other structural breaks that would be necessary to analyse. In order to endogenously identify sub-periods of interest, we employ the Quandt-Andrews breakpoint test and

Table 6. Estimates of the standard CCK (2000) model during the global financial crisis period (2007–2009).

	Constant	$\lvert R_{m,t}\rvert$	$R^2_{m,t}$	R^2 adj.
USA	0.7490 (25.65)***	0.5463 (9.35)***	−0.0085 (−0.50)	55.48%
UK	0.6218 (35.22)***	1.0523 (12.76)***	−0.1299 (−2.69)***	58.28%
Germany	1.0554 (49.18)***	0.8455 (10.13)***	−0.0147 (−0.43)	48.96%

This table presents the estimated coefficients for the CCK (2000) model:
$CSAD_{m,t} = a + \gamma_1 \lvert R_{m,t}\rvert + \gamma_2 R^2_{m,t} + \varepsilon_t$, where $CSAD_{m,t}$ is the cross-sectional absolute deviation of returns and $R_{m,t}$ is the market. Daily data from January 2004 to July 2014. t-Statistics are given in parentheses using Newey and West (1987) standard errors. *** represent statistical significance at the 1% level.

[5]The results for the asymmetric herding behaviour during the global financial crisis are not reported in the article for the interest of brevity and are available upon request.

Table 7. Estimates of the standard CCK (2000) model for two sub-periods.

Panel A. 1st sub-period	Constant	$\|R_{m,t}\|$	$R^2_{m,t}$	R^2 adj.
USA	0.6420 (42.91)***	0.5595 (9.97)***	0.0017 (0.09)	58.10%
UK	0.4909 (97.02)***	0.7166 (18.59)***	−0.0912 (−2.27)**	66.47%
Germany	0.8307 (109.60)***	0.4990 (10.12)***	0.0732 (2.46)**	44.25%
Panel B. 2nd sub-period	Constant	$\|R_{m,t}\|$	$R^2_{m,t}$	R^2 adj.
USA	0.6164 (79.89)***	0.1902 (5.68)***	0.0465 (2.37)**	56.71%
UK	0.6245 (87.48)***	0.8280 (13.67)***	0.0025 (0.06)	57.90%
Germany	1.0427 (78.26)***	0.7405 (12.86)***	0.0444 (1.76)*	40.73%

This table presents the estimated coefficients for the CCK (2000) model: $CSAD_{m,t} = a + \gamma_1 |R_{m,t}| + \gamma_2 R^2_{m,t} + \varepsilon_t$, where $CSAD_{m,t}$ is the cross-sectional absolute deviation of returns and $R_{m,t}$ is the market return. The sample consists of daily data for the two sub-periods that were endogenously defined using the Quandt-Andrews breakpoint test. The structural breaks are 4 February 2010 for the US market, 20 November 2007 for the UK market and 29 October 2007 for the German market. t-Statistics are given in parentheses using Newey and West (1987) standard errors. ***, ** and * represent statistical significance at the 1%, 5%, and 10% level, respectively. Panel A reports the results for the first sub-period and Panel B the results for the second sub-period.

we define structural breaks for each market, i.e. 4 February 2010 for the US market, 20 November 2007 for the UK market and 29 October 2007 for the German market. Table 7 presents the empirical results for the two sub-periods under examination which indicate the existence of herding only during the first sub-period for the UK. There is no evidence of herding for the rest sub-periods for any market.

Finally, Tables 8–10 report the cross market herding results for US, UK and Germany respectively. Panel A in each Table reports the estimates of the cross market herding of market m relative to the other two markets, while Panel B presents the herding estimations for market m taking into consideration the impact of the 'fear' indicator of each one of the other two markets. Overall, the empirical results for the US, the UK and the German markets confirm our research hypothesis regarding the cross market herding estimations, having important implications for international diversification and market destabilization.

As far as the estimations for the US market are concerned (Table 8, Panel A), the CSAD of the US, the UK and the German markets exhibit a positive and statistically significant relationship as expected. At the same time, coefficient γ_4 is negative and statistically significant but only at the 10% statistical significance level. Moreover, it seems that the 'fear' indicators of the other two markets do not affect herding estimations for the US market (Table 8, Panel B).[6] In the remaining estimations for the UK and the German stock markets, we include the one lagged CSAD, market return and VIX return for the US market since they do not operate simultaneously. Table 9 reports the results for the UK market. In this case there is also evidence of cross market herding (Panel A), especially with the US market. Coefficient γ_3 is positive and statistically significant in all cases, while coefficient γ_4 displays negative statistically significant results. In this case, the 'fear' indicators of the other two markets display negative and statistically significant impact (Panel B). The results reported in Table 10 for the German market are quite similar, displaying more intense relationships of the expected signs with the UK market.

Table 8. Estimates of cross market herding for the US market.

Panel A: Cross market herding		
Constant	0.1112 (2.47)**	0.2058 (4.19)***
$\|R_{US,t}\|$	0.2189 (9.84)***	0.2749 (7.79)***
$R^2_{US,t}$	0.0327 (2.47)**	0.0398 (2.18)**
$CSAD_{UK,t}$	0.8600 (11.95)***	-
$R^2_{UK,t}$	−0.1966 (−1.85)*	-
$CSAD_{GER,t}$	-	0.4354 (9.13)***
$R^2_{GER,t}$	-	−0.0769 (−1.66)*
R^2 adj.	71.81%	63.20%
Panel B: Estimates of herding behaviour incorporating the 'fear' factor of other markets		
Constant	0.6289 (56.17)***	0.6295 (56.24)***
$\|R_{US,t}\|$	0.3997 (7.94)***	0.3927 (7.84)***
$R^2_{US,t}$	0.0424 (2.37)**	0.0447 (2.51)**
$VFTSE_t$	−0.0028 (−0.97)	-
$VDAX_t$	-	−0.0053 (−1.65)*
R^2 adj.	52.35%	52.18%

This table presents the cross market herding estimations. Panel A reports the estimated coefficients of the model: $CSAD_{m,t} = a + \gamma_1 |R_{m,t}| + \gamma_2 R^2_{m,t} + \gamma_3 CSAD_{k,t} + \gamma_4 R^2_{k,t} + \varepsilon_t$, while Panel B reports the estimated coefficients of the model: $CSAD_{m,t} = a + \gamma_1 |R_{m,t}| + \gamma_2 R^2_{m,t} + \gamma_3 VIX_{k,t} + \varepsilon_t$, where $CSAD_{m,t}$ is the cross-sectional absolute deviation of returns, $R_{m,t}$ is the market return and $VIX_{m,t}$ is the implied volatility index for each market m. $CSAD_{k,t}$ and $R^2_{k,t}$ stand for cross-sectional absolute deviation of returns and the market return, respectively, in each of the two other markets. Daily data from January 2004 to July 2014. t-Statistics are given in parentheses using Newey and West (1987) standard errors. ***, ** and * represent statistical significance at the 1%, 5%, and 10% level, respectively.

[6]Coefficient γ_3 is negative and statistically significant only for the UK implied volatility index at the 10% statistical significance level.

Table 10. Estimates of cross market herding for the German market.

Panel A: Cross market herding		
Constant	0.5875 (24.20)***	0.3984 (15.48)***
$\lvert R_{GER,t}\rvert$	0.6326 (16.79)***	0.4837 (12.57)***
$R^2_{GER,t}$	−0.0176 (−0.86)	0.0742 (2.15)**
$CSAD_{US,t-1}$	0.4952 (16.87)***	-
$R^2_{US,t-1}$	−0.0173 (−2.25)**	-
$CSAD_{UK,t}$	-	0.8862 (22.13)***
$R^2_{UK,t}$	-	−0.3878 (−5.64)***
R^2 adj.	58.81%	62.37%
Panel B: Estimates of herding behaviour incorporating the 'fear' factor of other markets		
Constant	0.9404 (80.08)***	0.9315 (81.11)***
$\lvert R_{GER,t}\rvert$	0.8148 (14.58)***	0.8544 (15.41)***
$R^2_{GER,t}$	0.0079 (0.30)	0.0069 (0.30)
CBOE VIX_{t-1}	−0.0030 (−1.84)*	-
$VFTSE_t$	-	−0.0108 (−6.25)***
R^2 adj.	38.75%	39.59%

This table presents the cross market herding estimations. Panel A reports the estimated coefficients of the model: $CSAD_{m,t} = a + \gamma_1 \lvert R_{m,t}\rvert + \gamma_2 R^2_{m,t} + \gamma_3 CSAD_{k,t} + \gamma_4 R^2_{k,t} + \varepsilon_t$, while Panel B reports the estimated coefficients of the model: $CSAD_{m,t} = a + \gamma_1 \lvert R_{m,t}\rvert + \gamma_2 R^2_{m,t} + \gamma_3 VIX_{k,t} + \varepsilon_t$, where $CSAD_{m,t}$ is the cross-sectional absolute deviation of returns, $R_{m,t}$ is the market return and $VIX_{m,t}$ is the implied volatility index for each market m. $CSAD_{k,t}$ and $R^2_{k,t}$ stand for cross-sectional absolute deviation of returns and the market return respectively in each of the two other markets. Daily data from January 2004 to July 2014. t-Statistics are given in parentheses using Newey and West (1987) standard errors. ***, ** and * represent statistical significance at the 1%, 5%, and 10% level, respectively.

Table 9. Estimates of cross market herding for the UK market.

Panel A: Cross market herding		
Constant	0.2873 (17.82)***	0.1994 (8.15)***
$\lvert R_{UK,t}\rvert$	0.6142 (24.47)***	0.6288 (17.99)***
$R^2_{UK,t}$	0.0083 (0.35)	0.0157 (0.31)
$CSAD_{US,t-1}$	0.4007 (19.27)***	-
$R^2_{US,t-1}$	−0.0168 (−3.68)***	-
$CSAD_{GER,t}$	-	0.3719 (15.09)***
$R^2_{GER,t}$	-	−0.0804 (−1.76)*
R^2 adj.	77.92%	72.59%
Panel B: Estimates of herding behaviour incorporating the 'fear' factor of other markets		
Constant	0.5602 (80.69)***	0.5585 (82.47)***
$\lvert R_{UK,t}\rvert$	0.8956 (16.15)***	0.9064 (16.78)***
$R^2_{UK,t}$	−0.0365 (−0.85)	−0.0251 (−0.59)
CBOE VIX_{t-1}	−0.0037 (−3.41)***	-
$VDAX_t$	-	−0.0079 (−5.12)***
R^2 adj.	55.77%	56.25%

This table presents the cross market herding estimations. Panel A reports the estimated coefficients of the model: $CSAD_{m,t} = a + \gamma_1 \lvert R_{m,t}\rvert + \gamma_2 R^2_{m,t} + \gamma_3 CSAD_{k,t} + \gamma_4 R^2_{k,t} + \varepsilon_t$, while Panel B reports the estimated coefficients of the model: $CSAD_{m,t} = a + \gamma_1 \lvert R_{m,t}\rvert + \gamma_2 R^2_{m,t} + \gamma_3 VIX_{k,t} + \varepsilon_t$, where $CSAD_{m,t}$ is the cross-sectional absolute deviation of returns, $R_{m,t}$ is the market return and $VIX_{m,t}$ is the implied volatility index for each market m. $CSAD_{k,t}$ and $R^2_{k,t}$ stand for cross-sectional absolute deviation of returns and the market return respectively in each of the two other markets. Daily data from January 2004 to July 2014. t-Statistics are given in parentheses using Newey and West (1987) standard errors. *** and * represent statistical significance at the 1% and 10% level, respectively.

V. Conclusion

In this article, we examine herding behaviour in three developed stock markets taking into consideration the impact of investors' sentiment as it is captured by the respective implied volatility indices. The empirical results for the period January 2004–July 2014 do not indicate the presence of herding in the three markets under examination. However, our empirical results document the existence of herding towards the 'fear' indicator, rather than the market return in USA, UK and Germany.

When testing for different sub-periods, i.e. the global financial crisis and the endogenously defined sub-periods based on the structural breaks, we document herding in the UK market during the global financial crisis period (2007–2009), as well as during the sub-period January 2004–20 November 2007.

Finally, the empirical results indicate the existence of cross market herding for the US, the UK and the German market. The results also document that herding estimations can also be affected by other markets' investors' sentiment displaying more pronounced relationships between the two European markets.

These findings provide useful insight both for investors and regulators. Cross market herding eliminates international diversification benefits, exposing market participants to risk that cannot be easily hedged. Moreover, the documented impact of investors' cross market sentiment facilitates crisis transmission and market contagion. The impact of investors' sentiment on cross market herding should be further analysed in order to better understand market psychology and asset pricing anomalies.

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