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Bond market investor herding: Evidence from the European financial crisis

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ABSTRACT

During the recent financial crisis, numerous EU officials, market participants and the media suggested that irrational herding was a key factor for the financial turmoil and the soaring yield spreads. In this paper we test for evidence of herd behavior in European government bond prices and, overall, we find no evidence of investor herding either before or after the EU crisis. We do find, however, in an original contribution to the bond market literature, strong evidence that during the EU crisis period, macroeconomic information announcements induced bond market investor herding; a finding that confirms the notion of 'spurious' herding proposed by Bikhchandani and Sharma (2001) for bond markets. Further tests reinforce this finding and also indicate the existence of herding spill-over effects.

1. Introduction

In early 2010 Greece ran into a serious fiscal crisis. In order to deal with the crisis, a European Union/International Monetary Fund (EU/IMF) bailout package of 110 billion euro along with a series of fiscal austerity measures was agreed upon. During the same period, Credit Rating Agencies downgraded Greece's rating to BB+ and their view on Portugal, while international equity and bond markets experienced a period of significant volatility with sharp price decreases in many capital markets. A major fear at the time was that the financial turmoil in Greece would spill over to other countries with similar problems. Indeed, not long after the Greek package, a further 85 billion euro aid package was agreed for Ireland (November 2010) and a 78 billion euro aid package was agreed for Portugal (May 2011), by European governments. The bond market turmoil and the sharp drop in bond prices during this period is clearly evidenced in Fig. 1 where the 10-year benchmark government bond yields for Greece, Portugal, Ireland, Spain, and Italy are presented. For example, bond yields rose from approximately 5% in 2009 to approximately 30% by 2012 for Greece, and from 5% in 2009 to approximately 10% to 15% by 2012 for Ireland and Portugal; the yields for Spain and Italy also increased significantly during the same period.

During the financial crisis, many EU officials, market participants and the media proclaimed that herd behavior[1] on the part of investors was (to some extent) responsible for the escalation of the crisis and the spillover of volatility from the countries that received financial packages from other countries. Consider, for instance, Olli Rehn, the European Union Economic and Monetary Affairs Commissioner, who argued during the agreement of the Irish aid-package that "*There's plenty of herd behavior in the market*"[2]; the European Commission President Jose Manuel Barroso who claimed that "*The current sovereign crisis has now become systemic in nature, and is driven not only by budgetary fundamentals, but also by the mispricing of credit risk by investors and short-term herding behavior in the markets*"[3]; or the Swedish Finance Minister Anders Borg who pointed out, during May 2010, that "*We now see herd behavior in the markets that are really pack behavior, wolfpack behavior*".[4]

Although the above statements, among many more, focus on the irrationality of herding behavior, Devenow and Welch (1996) argue that herding can be approached from three points of view: the irrational view focuses on investor psychology and implies that individuals unconsciously mimic each other; the near-rational view asserts that investors use heuristic rules in order to obtain information easily; the rational view holds that herd behavior can be caused as a response to imperfect information, reputation and compensation issues. Furthermore, Bikhchandani and Sharma (2001) make a distinction between 'spurious' herding which is motivated by changes in fundamentals, and

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[1] Herding in financial markets can be defined as the economic agents' behavioral convergence. For instance, a group of individuals may ignore their own beliefs, imitate each other and act in the same direction. Lakonishok et al. (1992) define fund manager herding as trading the same assets at the same time as other managers do.

[2] See: Bloomberg, article by Neuger, J., and Kennedy, S., November 29, 2010 (www.bloombeg.com/news/2010-11-29/ireland-s-eu-financial-rescue-fails-to-stem-contagion-as-spain-bonds-drop.html).

[3] See: Reuters, article by Jan Strupczewski, December 16, 2010, http://www.reuters.com/article/2010/12/16/eu-crisis-barroso-idUSBRU01121920101216).

[4] See: Financial Times article by Neil Hume "Stopping the wolfpack", May 09, 2010 (http://ftalphaville.ft.com/2010/05/09/224426/stopping-the-wolfpack).

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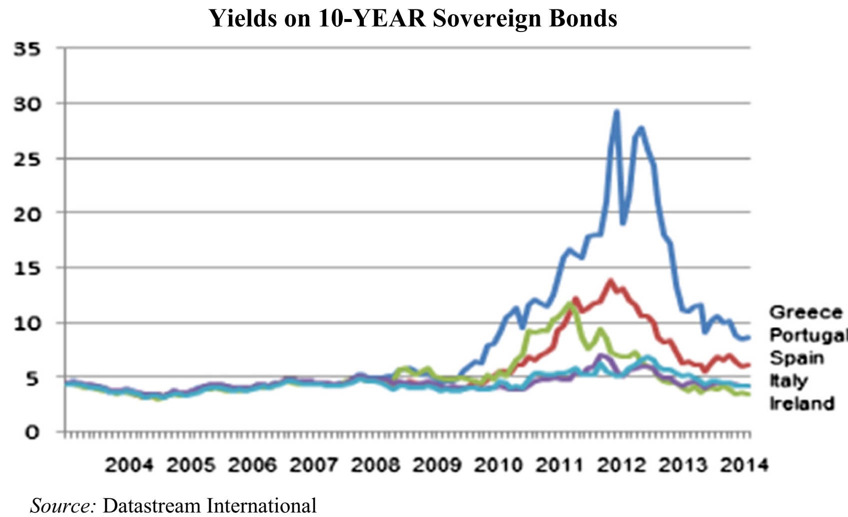

Fig. 1. Yields on 10-year sovereign bonds.
Source: DataStream International.

'intentional' herding where there is an intention by agents to copy each other's actions.

Motivated from the fact that numerous market participants ignored the above types of herding behavior and assumed that the EU financial crisis intensified and bond spreads soared (partly) due to just irrational herd behavior, this paper aims to offer original empirical evidence on whether such behavior, or other, characterized European government bond market prices during the recent European debt crisis. The paper contributes to the relevant literature in a number of ways. *Firstly*, previous studies tend to concentrate on equity markets; as a result, the question of whether bond market investors exhibit herd behavior remains largely unresearched. *Secondly*, we test for herding during the release of important fundamental macroeconomic information, an issue that has not been addressed previously for bond market investors. The only previous study that addresses this issue for equity markets, to the best of our knowledge, reports evidence of herding for US equity investors during days when important US macroeconomic information is released (Galariotis, Rong, & Spyrou, 2015). To this end, we employ days when there are changes in the European Central Bank rate, in the Bank of England base rate, in the US federal funds rate and dates when macroeconomic information is released in the European Union, in order to proxy for days with macroeconomic information releases. Furthermore, since herding may be more probable to be observed during periods of extreme market swings (Christie & Huang, 1995) we split the sample and examine the period before and after the recent EU financial crisis, in order to see whether herd behavior intensifies during the crisis. *Thirdly*, we test for herding spill-over effects between the financially troubled markets and European countries with no financial difficulties, since previous evidence for equity markets suggests that events in one market can help explain herding behavior in other markets (Chiang & Zheng, 2010; Klein, 2013). More specifically we test if events in troubled markets can trigger herding behavior in trouble-free markets or the Euro area market as a whole and respectively if events in trouble-free European markets can have an impact on herding in troubled markets or the whole Euro area market.

To anticipate the results, contrary to popular belief, overall we find limited empirical evidence of herding in European government bond prices, either before or after the EU crisis. Further tests, however, strongly suggest that during the EU crisis period, macroeconomic information announcements, changes in the Bank of England rate, and changes in the US federal funds rate induced bond market investor herding; interestingly we find no herding during ECB rate changes. This finding supports the notion of 'spurious' herding (i.e., herding motivated by changes in fundamentals; proposed by Bikhchandani & Sharma, 2001). It is also consistent with the results of other recent studies. For example, Mobarek, Mollah, and Keasey (2014) study European markets and report insignificant results for their whole sample period; however, they report significant herding behavior during crises and asymmetric market conditions. Beirne and Fratzscher (2013) analyze sovereign risk for 31 advanced and emerging economies and find limited evidence of regional contagion during the financial crisis in Europe, and also that there was an increase in the sensitivity of financial markets to fundamentals during the crisis. Note also that Van Landschoot (2008) finds that euro area yield spreads are strongly affected by the US (instead of the Euro) default-free term structure. Further tests reinforce the finding of fundamental-driven herding and also reveal that during the crisis there were herding spill-over effects running, however, with a direction from European countries with no financial difficulties to the financially troubled European markets. The rest of the paper is organized as follows: Section 2 discusses the previous literature, Section 3 describes the data and the testing methodology, Section 4, presents the results, Section 5 refers to some further tests. Section 6 concludes the paper.

2. A brief review of the literature

The empirical literature on herd behavior can be broadly divided into two main strands: on the one hand, many authors examine institutional investor herding, while on the other hand other authors concentrate on the use of price data and examine herding towards the market average.[5] As regards to the former, in an early study, Lakonishok, Shleifer, and Vishny (1992) examine the behavior of US fund managers, while Grinblatt, Titman, and Wermers (1995) examine, among other issues, the tendency of mutual funds to herd. Both studies find limited evidence in favor of herd behavior. Nofsinger and Sias (1999) report that institutional investor herding affects prices more than individual investor herding, and that institutional investors tend to follow positive feedback strategies more than individuals do. Sias (2004) evaluates the cross-sectional correlation of institutional demand for a security between two successive quarters and finds that the fraction of institutions purchasing over a quarter is positively correlated with the fraction of institutions purchasing over the following quarter. This observation is consistent with both the presence of herding behavior by institutional investors and institutional investors following their own previous-quarter trades. Kim and Nofsinger (2005) find that Japanese institutions engage in

[5] The discussion presented here is not meant to be exhaustive; for a more comprehensive review of the literature see, among others, Spyrou (2013a).

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herding less than US institutions, however, their herding behavior affects prices to a greater extent. Walter and Weber (2006) examine German mutual funds and find evidence of both herding and positive feedback trading.

As regards to the second strand in the literature, Christie and Huang (1995) suggest that herding can be identified by using a measure of cross-sectional dispersion of equity returns; they find that dispersion increases during up markets, relative to down markets. Chang, Cheng, and Khorana (2000) examine both advanced (US, Hong Kong, Japan) and emerging (South Korea and Taiwan) markets; they develop their own measure of herding based on the statistic proposed by Christie and Huang (1995). According to their results herding activity is present in South Korea and Taiwan, almost present in Japan but absent in the US and Hong Kong markets. Bowe and Domuta (2004) examine the Jakarta Stock Exchange and report that foreign investors engage in herding more than local investors. Hwang and Salmon (2004) develop a new herding measure that differentiates from that proposed by Christie and Huang (1995) in that it focuses on the cross-sectional dispersion of betas. They examine the US and South Korean markets and find herding towards the market portfolio, irrespective of the state of the market and macroeconomic fundamentals, and for both up and down markets. Caparrelli, D'Arcangelis, and Cassuto (2004) use similar methodologies to test for herding in the Italian stock market and find evidence of herding during extreme market conditions. Demirer and Kutan (2006) examine herding behavior in Chinese markets and find evidence inconsistent with the presence of herding. Economou, Kostakis, and Philippas (2011) test for herding in Southern European countries and find that herding effects intensified during the crisis period (2007–2008). Chiang and Zheng (2010) examine herding at a global level and test for herding spillover effects; their results indicate the existence of contagion effects between markets during the crisis period. Tan, Chiang, Mason, and Nelling (2008) examine dual-listed Chinese stocks and find evidence of herd behavior by both domestic individual investors and foreign institutional investors.

Brown, Wei, and Wermers (2013) present recent evidence that mutual fund managers "herd" into (out of) stocks with consensus sell-side analyst upgrades (downgrades). They further argue that manager career concern is the main reason for this behavior and that the herding effect is stronger for downgrades since there is higher risk (reputational/litigation risk) in holding a losing asset. This finding is consistent with the recent results of Holmes, Kallinterakis, and Leite Ferreira (2013) who analyze institutional herding behavior under different market conditions in Portugal and find evidence consistent with intentional herding due to reputational reasons. Park and Sabourian (2011) present a standard sequential trading model with noise trading and argue that people herd because their information is dispersed and thus they consider extreme outcomes more likely than moderate ones. They also argue that herding (along with the employment of contrarian strategies) lead to volatile prices and decrease liquidity.

Dasgupta, Prat, and Verardo (2011) present a model on the impact of institutional herding on asset prices and argue that institutional herding negatively predicts long-term returns but positively predicts short-term returns. Tedeschi, Lori, and Gallegati (2012), in an interesting study, show that, since herding usually is profitable, noise traders have an incentive (desire) to imitate (be imitated). Their results also show that intelligent agents cannot enter a noise-trader dominated market with high herding activity. Venezia, Nashikkar, and Shapira (2011) find results consistent with information-based herding behavior among both amateur investors and professional investors; although for the latter the propensity to herd is lower. This behavior is persistent and it is positively correlated with return volatility. By contrast, Hsieh (2013), using high frequency data from Taiwan, examines herding for institutional and individual investors and finds a stronger tendency to herd among institutional investors; they also follow more profitable herding strategies. In addition the results indicate that it is mainly private information that is driving institutional herding while behavior and emotions are more likely to drive individual herding.

In more recent evidence, Philippas, Economou, Babalos, and Kostakis (2013) find evidence consistent with herd behavior in the US REIT market and also find that it is related to deterioration in sentiment and adverse macro-shocks to REIT funding conditions. Bohl, Klein, and Siklos (2014) examine the effect of short-selling restrictions on herding behavior and find that they either do not influence herding or induce adverse herd behavior. Klein (2013) using a Markov switching seemingly unrelated regressions model analyzes the correlation between different markets and finds evidence consistent with herding and intensified herding spillover effects across markets during periods of high volatility. At the same time, recent studies find evidence consistent with an "anti-herding" behavior. For example, Pierdzioch, Rülke, and Stadtmann (2013) analyze metal prices and find forecast heterogeneity that is driven by anti-herding, while Pierdzioch and Rülke (2012) examine S&P 500 forecasts and find an anti-herding behavior that is inversely correlated with forecast accuracy.

Note that herd behavior may be rational, under certain conditions. For instance, a concern for manager/analyst reputation may lead managers and analysts to mimic each other's actions (Scharfstein & Stein, 1990); herd behavior may protect against manager underperformance (Rajan, 2006); herd behavior may be an attempt to copy higher ability and obtain higher compensation (Trueman, 1994). Graham (1999) points out that when analyst private information contrasts with strong public information analysts are more likely to herd; Froot, Scharfstein, and Stein (1992) argue that when investment horizons are short investors may herd on the same information. Bikhchandani, Hirshleifer, and Welch (1992) discuss informational cascades and show that in the case where investors enter the market at a later stage ignoring their private information herding towards the actions of previous investors may be a rational choice, since they may possess important related information.

It becomes apparent from the discussion above that the theoretical and empirical literature on herd behavior has concentrated on equity markets and has neglected fixed income security markets. Furthermore, even though many authors have argued that herd behavior may be driven by rational choices and fundamental information, few studies attempt to examine how and whether specific informational events that release fundamental information induce herding behavior. In addition, recently global bond markets have experienced a period of significant volatility and turmoil, which may reinforce herd behavior. In this paper we attempt to deal with these issues and address this gap in the literature. As discussed in the Introduction, we not only examine bond markets during a period of significant volatility, but also use specific macroeconomic information announcements in order to examine whether investors herd on fundamental information.

3. Data and testing methodology

For the empirical analysis we employ daily clean prices for the 10 year Government Benchmark Bond Indices for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain. For the five counties that acceded between 2007 and 2011 (Cyprus, Estonia, Malta, Slovakia and Slovenia) there are no available data. Luxembourg is also excluded from the present study because of no data availability. The sample period is between January 2000 and January 2013. All data are available from DataStream International.

The sample countries are divided in two sub-sets: the first one consists of the Eurozone countries that run into financial difficulties during the recent crisis (Portugal, Ireland, Greece, Spain) with the addition of Italy (denoted for simplicity as the Southern markets, hereafter), while the second contains the rest of the Eurozone member states (Austria, Belgium, Germany, Finland, France, the Netherlands; denoted for simplicity as the Northern markets, hereafter). As discussed earlier, the sample period is also divided into the pre-crisis period (January 2000 to December 2006) and the "crisis" period (January 2007 to January 2013). Within each sub-period, we further separate the sample to days when the market

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portfolio return is positive ($R_m > 0$) and days when the market portfolio return is negative ($R_m > 0$), in order to examine possible asymmetries.

Christie and Huang (1995) were the first to argue that herding is more likely to appear in periods of market turmoil. During these periods market participants are more likely to conform to the market consensus. Respectively, individual asset returns will tend to cluster around the market return and dispersions will be reduced. On the contrary, rational asset pricing models support that return dispersions will increase because assets differentiate in their sensitivity with respect to the market return movements. Following this line of thinking Chang, Cheng and Khorana (2000, CCK hereafter) propose to use the Cross Sectional Absolute Deviation (CSAD) of returns and the market return as proxies of the unobservable Expected Cross Sectional Absolute Deviation (ECSAD) of returns and the expected market return. They then examine the relationship between CSAD and the market return in order to detect herd behavior. More specifically, the CSAD is estimated as:

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

In Eq. (1), N is the number of assets, $R_{i,t}$ is the return of asset i at time t and $R_{m,t}$ is the cross-sectional average return of N assets at time t. Figs. 2 to 4 present CSAD plots over time for all markets (Fig. 2), the Northern markets (Fig. 3) and the Southern markets (Fig. 4). Note that the behavior of this measure over time is quite different within the sample markets; for instance, while for the Northern markets the measure exhibits variability over time, the Southern market CSAD exhibits significant variability only during the EU financial crisis.

Once the CSAD measure is estimated, a possible way to allow for asymmetries in herding behavior between days with a positive market return and days with a negative market return (up and down markets) is to estimate the following regressions:

$$CSAD_t^{UP} = \beta_0 + \beta_1^{UP}\left|R_{m,t}^{UP}\right| + \beta_2^{UP}\left(R_{m,t}^{UP}\right)^2 + \varepsilon_t, \tag{2}$$

$$CSAD_t^{DOWN} = \beta_0 + \beta_1^{DOWN}\left|R_{m,t}^{DOWN}\right| + \beta_2^{DOWN}\left(R_{m,t}^{DOWN}\right)^2 + \varepsilon_t, \tag{3}$$

In Eqs. (2) and (3), $CSAD_t^{UP}$ ($CSAD_t^{DOWN}$) is the Cross Sectional Absolute Deviation of returns at day t, when the market return is positive (negative), $|R_{m,t}^{UP}|$, ($|R_{m,t}^{DOWN}|$), is the absolute value of the positive (negative) market portfolio return at day t and $(R_{m,t}^{UP})^2$, ($(R_{m,t}^{DOWN})^2$), is the squared positive (negative) market return at day t.

Asset pricing models indicate that the relation between the market portfolio return and asset returns dispersions should be linear and

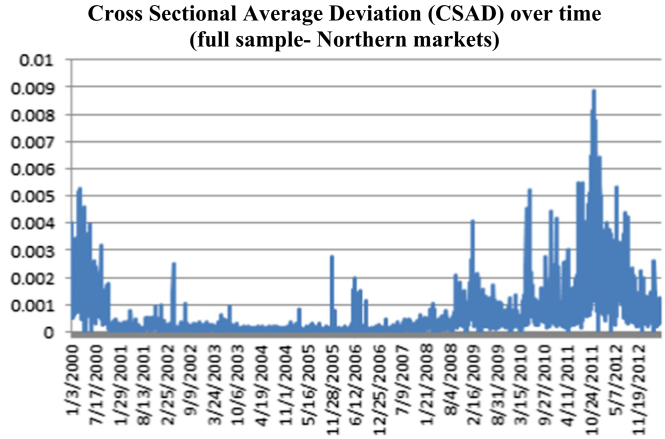

Fig. 3. Cross Sectional Average Deviation (CSAD) over time (full sample — Northern markets).

increasing. However, if there is herding activity during periods of market stress, their relation will be non-linearly increasing or even decreasing (Chang et al., 2000). If herd behavior is detected, the coefficient (β_2) on the nonlinear market return ($R_{m,t}^2$) is expected to be negative and statistically significant. CCK argue that if investors herd around the average consensus there should be a non-linear relation between CSAD and the average market return which will be captured by a negative and statistically significant coefficient on the non-linear term.

Many studies (see for example, Economou et al., 2011) also estimate the following regression to detect herding activity:

$$CSAD_t = \beta_0 + \beta_1\left|R_{m,t}\right| + \beta_2 R_{m,t}^2 + \varepsilon_t. \tag{4}$$

Note that whether one uses the absolute of the market return or not depends on the assumptions one makes about the betas. In this paper we estimate regression (4) both with and without the absolute value on the market return and the results are qualitatively the same; we thus report results based on Eq. (4). As above, if investors herd around the average consensus, this will be captured by a negative and statistically significant coefficient on the non-linear term.

As discussed in the Introduction, a contribution of this paper is that it researches bond market herding activity during days when fundamental macroeconomic information is released. This is done by means of estimating the following regression:

$$CSAD_t = \beta_0 + \beta_1\left|R_{m,t}\right| + \beta_2 R_{m,t}^2 + \beta_3 DUM_t R_{m,t}^2 + \varepsilon_t. \tag{5}$$

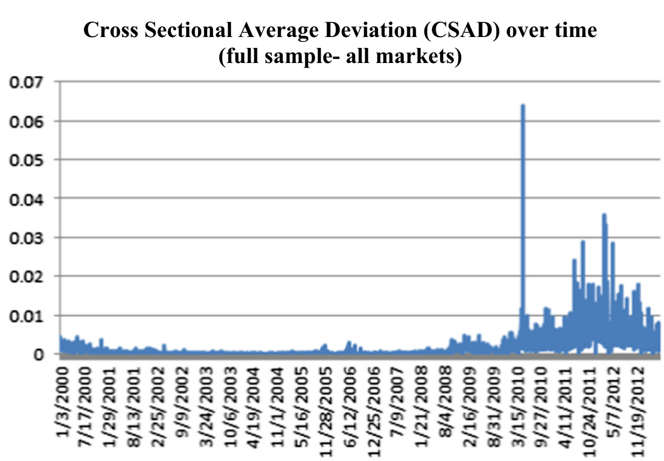

Fig. 2. Cross Sectional Average Deviation (CSAD) over time (full sample — all markets).

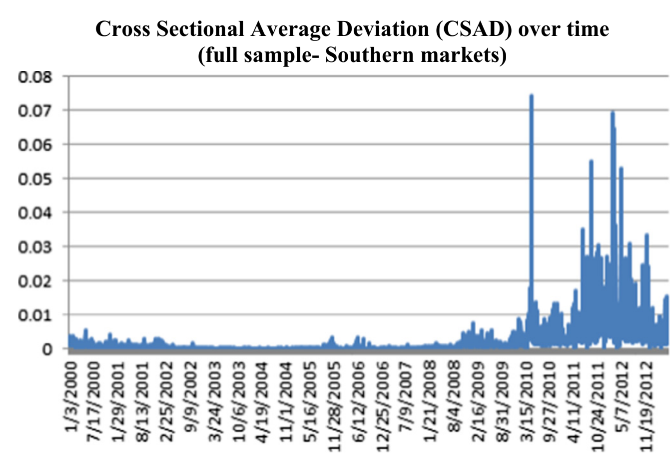

Fig. 4. Cross Sectional Average Deviation (CSAD) over time (full sample Southern markets).

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In Eq. (5), DUM_t is a dummy variable that takes the value of one on a day when important macroeconomic news is released and zero otherwise. If herding activity is detected, the coefficient on the dummy variable (β_3) should be negative and statistically significant. For the dummy variable we employ days when the following informational events take place: rate changes by the European Central Bank, by the Bank of England, by the US Federal Bank, and macroeconomic information release dates such as the days when Eurostat issues the "Data for Short Term Economic Analysis". The latter includes monthly updates of basic macroeconomic indicators such as the Euro area GDP, inflation and unemployment. Note that "Data for Short Term Economic Analysis" refers to the period from July 2004 to January 2013 (sources: European Central Bank, Bank of England, Federal Reserve, and Eurostat). More specifically, the Eurostat issues "Eurostatistics — Data for short term economic analysis", is a monthly review which presents the economic activity evolution in the European Union, euro area and Member states. The analysis is divided into two parts. The first part synoptically presents recent updates of basic macroeconomic indicators and continues with growth forecasts and cyclical indicator analysis. The macroeconomic indicators analyzed are: Euro area GDP, inflation, unemployment, industrial production, interest rates, new orders, retail trade and exchange rates. The second part contains the detailed presentation of the Principal European Economic Indicators (PEEIs) for the European Union, euro area and each country, as well as cross country comparisons.

In order to test for herding spill-over effects we employ a methodology similar to the one proposed by Chiang and Zheng (2010). More specifically, we augment regression (4) by adding the squared return of market *j* at time *t*, as follows:

$$CSAD_{i,t} = \beta_0 + \beta_1 |R_{market\ i,t}| + \beta_2 R^2_{market\ i,t} + \beta_3 R^2_{market\ j,t} + \varepsilon_t. \quad (6)$$

If events in one market induce herding behavior in another market, then the coefficient β_3 should be negative and statistically significant.

4. Results

Table 1 present daily return descriptive statistics for the 10 year Government Benchmark Bond Indices for the sample markets, for the period between 2000 and 2013 (3414 observations for each index). Although the mean daily bond return is similar for all markets a notable exception is Greece: for example the mean daily bond return for Germany is 0.0001 (Greece: −0.0002) with a standard deviation of 0.0035 (Greece: 0.0135), while the skewness and kurtosis coefficients for the German benchmark bond are −0.0552 and 4.7213 respectively (Greek benchmark bond: 1.1561 and 128.3659).

Table 1
Daily 10-year benchmark sovereign bond returns: descriptive statistics.

	Mean	Std. dev.	Skewness	Kurtosis
Austria	0.0001	0.0033	−0.2118	5.3610
Belgium	0.0001	0.0036	−0.1275	7.8943
Finland	0.0001	0.0032	−0.0667	4.4824
France	0.0001	0.0035	−0.0879	5.8491
Germany	0.0001	0.0035	−0.0552	4.7213
Greece	−0.0002	0.0135	1.1561	128.3659
Italy	0.0001	0.0044	1.1354	27.7352
Ireland	0.0000	0.0055	0.5154	33.9750
The Netherlands	0.0001	0.0033	−0.1119	4.3562
Spain	0.0001	0.0044	1.3232	23.4289
Portugal	0.0000	0.0073	−0.4647	62.1761
Observations	3414			

The table presents descriptive statistics for daily log clean price changes for the 10 year Government Benchmark Bond Indices for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain. The sample period is between January 2000 and January 2013. All data are available from DataStream International.

Tables 2 and 3 present the results for regressions (2) and (3), respectively. In Panel A, the first two columns present the results when the CSAD measure is estimated from all sample markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets. The next two columns present the results when the CSAD measure is estimated from the Northern European markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets, while the last two columns present the results when the CSAD measure is estimated from the Southern European markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets. In order to test the sensitivity of results to the choice of the aggregate portfolio, Panel B (Panel C) presents the results when the CSAD measure is estimated from the Northern European markets (Southern European markets) and the aggregate market portfolio is an equally weighted portfolio of the Northern European markets (Southern European markets). We also present results for the whole sample period (2000–2013) and two sub-periods: the before crisis period (2000–2006) and the crisis period (2007–2013). The latter includes both the outbreak of the subprime crisis in the US and the EU financial crisis.

The coefficients presented are those of the linear and nonlinear terms, while the coefficient of interest is β_2. Recall that the coefficient β_2 should be negative and statistically significant if herd behavior towards the average is present. In Table 2 we find limited evidence of herding during days with positive market returns in two cases: for the 2000–2006 period for the Northern markets when the market portfolio is the whole European market ($\beta_2 = -7.9141$, *p*-value: 0.10) and for the 2007–2013 period for the Southern markets when the market portfolio is the Southern markets ($\beta_2 = -1.0282$, *p*-value: 0.03). In Table 3, in no case is this condition met, that is, the coefficient on the non-linear term β_2 is statistically insignificant. Thus, our results reveal no herding activity for days with negative market returns since all the coefficients of interest are positive.

Table 4 presents the results for regression (4). In Panel A, the first two columns present the results when the CSAD measure is estimated from all sample markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets. The next two columns present the results when the CSAD measure is estimated from the Northern European markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets, while the last two columns present the results when the CSAD measure is estimated from the Southern European markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets. In order to test the sensitivity of results to the choice of the aggregate portfolio, Panel B (Panel C) presents the results when the CSAD measure is estimated from the Northern European markets (Southern European markets) and the aggregate market portfolio is an equally weighted portfolio of the Northern European markets (Southern European markets). We also present results for the whole sample period (2000–2013) and two sub-periods: the before crisis period (2000–2006) and the crisis period (2007–2013). The latter includes both the outbreak of the subprime crisis in the US and the EU financial crisis. The coefficients presented are those of the linear and nonlinear terms, while the coefficient of interest is β_2.

Recall that the coefficient β_2 should be negative and statistically significant if herd behavior towards the average is present. In Table 4, in no case is this condition met, that is, overall we find no evidence of herding: note that the β_2 coefficient is statistically insignificant in all cases. For instance, when we test for herding for the Northern European markets and the market portfolio consists of all markets the β_2 coefficient is positive (0.7784) with a *p*-value of 0.11 for the full sample period (2000–2013), negative (−1.9094) but statistically insignificant (*p*-value: 0.44) for the first sub-period (2000–2006), and negative (−0.0188) but statistically insignificant (*p*-value: 0.98) for the second sub-period (2007–2013). The same seems to be the case for all sample specifications and all sub-periods. This implies the absence of herding or adverse herding effects (see Hwang & Salmon, 2004; Klein, 2013).

Table 2
Testing for Herding in Days with a Positive Market Return.

	All markets		Northern European markets		Southern European markets	
	β_1	β_2	β_1	β_2	β_1	β_2
Panel A: market portfolio: all markets						
Full sample	0.2438	26.659	0.0354	6.7270	0.5114	28.045
p-Value	(0.00)	(0.00)	(0.09)	(0.00)	(0.00)	(0.00)
2000–2006	0.0216	−1.1459	0.0672	**−7.9141**	0.0258	−0.2688
p-Value	(0.44)	(0.80)	(0.03)	(**0.10**)	(0.38)	(0.95)
2007–2013	0.3713	22.706	0.0690	3.6325	0.7807	20.480
p-Value	(0.00)	(0.00)	(0.05)	(0.24)	(0.00)	(0.00)

	Panel B: market portfolio: Northern European markets		Panel C: market portfolio: Southern European markets	
Full sample	0.0023	10.639	0.7691	−0.3298
p-Value	(0.93)	(0.00)	(0.00)	(0.31)
2000–2006	0.0504	−4.6177	0.0165	−0.3688
p-Value	(0.10)	(0.32)	(0.64)	(0.94)
2007–2013	0.0183	8.5301	0.8226	**−1.0282**
p-Value	(0.65)	(0.04)	(0.00)	(**0.03**)

The table presents the results for: $CSAD_t^{UP} = \beta_0 + \beta_1^{UP}|R_{m,t}^{UP}| + \beta_2^{UP}(R_{m,t}^{UP})^2 + \varepsilon_t \cdot CSAD_t^{UP}$ is the Cross Sectional Absolute Deviation of returns at day *t*, when the market return is positive. $|R_{m,t}^{UP}|$ is the absolute value of the positive market portfolio return at day *t* and $(R_{m,t}^{UP})^2$ is the squared positive market return at day *t*. In Panel A, the first three columns present the results when the CSAD measure is estimated from all sample markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets. The next two columns present the results when the CSAD measure is estimated from the Northern European markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets, while the last two columns present the results when the CSAD measure is estimated from the Southern European markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets. In order to test the sensitivity of results to the choice of the aggregate portfolio, Panel B (Panel C) presents the results when the CSAD measure is estimated from the Northern European markets (Southern European markets) and the aggregate market portfolio is an equally weighted portfolio of the Northern European markets (Southern European markets). *p*-Values appear in parentheses. Bold cases denote negative and statistically significant herding coefficients at the 5% level.

Table 5 presents the results from estimating Eq. (5), i.e., of testing whether fundamental macroeconomic information announcements induce herding behavior. Panels A to C present results for the case where the dummy variable in Eq. (5) reflects changes in the ECB base rate, the US Federal Funds rate, and the Bank of England rate; respectively. Panel D presents results for the case where the dummy variable takes a value of one during the EU macroeconomic information release days and zero otherwise. We examine the full sample period and the two sub-periods as above. Note that with the exception of the ECB rate changes, in all other cases there is strong evidence of herding induced by fundamental macroeconomic information during the recent EU crisis. For example, as regards the macro announcements (Panel D), the (β_3) coefficient on the dummy variable during the (2007–2013) period is both negative (−35.747) and statistically significant (*p*-value: 0.05), while for the pre-crisis period it is positive (10.480) and statistically significant (*p*-value: 0.04). This finding strongly indicates that, during the EU crisis period, macroeconomic information announcements induced bond market investor herding. The same holds for days when there was a change in the Bank of England rate and the US federal funds rate: during the EU crisis period, bond market investors tend to herd when rate changes are announced. Interestingly, for ECB rate changes there is no statistically significant evidence of investor herding (although the coefficient is negative). This may seem surprising, however, it is consistent with earlier findings that international factors are a major

Table 3
Testing for Herding in Days with a Negative Market Return.

	All markets		Northern European markets		Southern European markets	
	β_1	β_2	β_1	β_2	β_1	β_2
Panel A: market portfolio: all markets						
Full sample	−0.3315	80.112	0.0087	7.4225	−0.7091	148.65
p-Value	(0.00)	(0.00)	(0.65)	(0.00)	(0.00)	(0.00)
2000–2006	0.0087	2.5859	0.0222	−0.2825	0.0259	2.4113
p-Value	(0.72)	(0.38)	(0.40)	(0.93)	(0.30)	(0.41)
2007–2013	−0.2530	78.405	0.0279	6.7765	−0.6733	153.17
p-Value	(0.00)	(0.00)	(0.37)	(0.01)	(0.00)	(0.00)

	Panel B: Market portfolio: Northern European markets		Panel C: Market portfolio: Southern European markets	
Full sample	−0.0051	9.0820	0.3151	23.705
p-Value	(0.84)	(0.00)	(0.00)	(0.00)
2000–2006	0.0200	−0.3264	−0.0125	5.6395
p-Value	(0.45)	(0.91)	(0.64)	(0.08)
2007–2013	−0.0303	15.299	0.3793	20.913
p-Value	(0.46)	(0.00)	(0.00)	(0.00)

The table presents the results for Eq. (3): $CSAD_t^{DOWN} = \beta_0 + \beta_1^{DOWN}|R_{m,t}^{DOWN}| + \beta_2^{DOWN}(R_{m,t}^{DOWN})^2 + \varepsilon_t \cdot CSAD_t^{DOWN}$ is the Cross Sectional Absolute Deviation of returns at day *t*, when the market return is negative. $|R_{m,t}^{DOWN}|$ is the absolute value of the negative market portfolio return at day *t* and $(R_{m,t}^{DOWN})^2$ is the squared negative market return at day *t*. In Panel A, the first three columns present the results when the CSAD measure is estimated from all sample markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets. The next two columns present the results when the CSAD measure is estimated from the Northern European markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets, while the last two columns present the results when the CSAD measure is estimated from the Southern European markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets. In order to test the sensitivity of results to the choice of the aggregate portfolio, Panel B (Panel C) presents the results when the CSAD measure is estimated from the Northern European markets (Southern European markets) and the aggregate market portfolio is an equally weighted portfolio of the Northern European markets (Southern European markets). *p*-Values appear in parentheses.

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Table 4
Testing for Herding: Full Sample.

	All markets		Northern European markets		Southern European markets	
	β_1	β_2	β_1	β_2	β_1	β_2
Panel A: market portfolio: all markets						
Full sample	0.1763	31.352	0.0779	0.7784	0.3324	39.987
p-Value	(0.00)	(0.00)	(0.00)	(0.11)	(0.00)	(0.00)
2000–2006	0.0240	0.4945	0.0310	−1.9094	0.0144	2.6535
p-Value	(0.16)	(0.83)	(0.10)	(0.44)	(0.43)	(0.27)
2007–2013	0.3368	26.235	0.0975	−0.0188	0.6189	31.156
p-Value	(0.00)	(0.00)	(0.00)	(0.98)	(0.00)	(0.00)

	Panel B: Market portfolio: Northern European markets		Panel C: Market portfolio: Southern European markets	
Full sample	0.0190	7.9530	0.7614	0.7502
p-Value	(0.27)	(0.00)	(0.00)	(0.01)
2000–2006	0.0440	−2.8626	0.0113	2.6177
p-Value	(0.01)	(0.22)	(0.54)	(0.29)
2007–2013	0.0231	9.2808	0.8329	−0.3064
p-Value	(0.40)	(0.00)	(0.00)	(0.45)

The table presents the results for Eq. (4): $CSAD_t = \beta_0 + \beta_1|R_{m,t}| + \beta_2 R^2_{m,t} + \varepsilon_t$ · *CSAD* is the Cross Sectional Absolute Deviation of returns at day *t*, R_m is the absolute value of the market portfolio return at day *t* and $R^2{}_{m,t}$ is the squared market return at day *t*. In Panel A, the first three columns present the results when the CSAD measure is estimated from all sample markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets. The next two columns present the results when the CSAD measure is estimated from the Northern European markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets, while the last two columns present the results when the CSAD measure is estimated from the Southern European markets and the aggregate market portfolio is an equally weighted portfolio of all sample markets. In order to test the sensitivity of results to the choice of the aggregate portfolio, Panel B (Panel C) presents the results when the CSAD measure is estimated from the Northern European markets (Southern European markets) and the aggregate market portfolio is an equally weighted portfolio of the Northern European markets (Southern European markets). *p*-Values appear in parentheses.

determinant of intra-euro area government bond spreads (Barrios, Iversen, Lewandowska, & Setzer, 2009), or that euro area yield spreads are strongly affected by the US (instead of the Euro) level and slope of the default-free term structure, implying that US interest rates play a dominant role in the corporate bond markets (Van Landschoot, 2008).

The results for herding spill-over effects (Eq. (6)) are presented in Table 6. Panel A presents results for the case where the CSAD is estimated from all sample markets, the market portfolio is an equally weighted portfolio of all sample markets and the third term (the "spill-over market") is an equally weighted portfolio of the Southern European markets. In other words, a negative and statistically significant coefficient on the third (non-linear) term (β_3) implies spill-over herding effects from the Southern European markets to all sample markets. Panel B presents results for the case where the CSAD is estimated from all sample markets, the market portfolio is an equally weighted portfolio of all sample markets and the third term (the "spill-over market") is an equally weighted portfolio of the Northern European markets. In other words, a negative and statistically significant coefficient on the third non-linear term (β_3) implies spill-over herding effects from the Northern European markets to all sample markets. In Panel C (Panel D) a negative and statistically significant (β_3) coefficient implies spill-over herding effects from the Southern European markets (Northern European markets) to the Northern European markets (Southern European markets). Note that evidence of herding spill-over effects is presented in Panels B and C. More specifically, the β_3 coefficient in Panel B is both negative and statistically significant for the whole sample period ($\beta_3 = -41.870$, *p*-value: 0.00) and the crisis period ($\beta_3 = -39.041$, *p*-value: 0.00). Also, the β_3 coefficient in Panel C is both negative and statistically significant for the whole sample period ($\beta_3 = -51.510$, *p*-value: 0.00) and the crisis period ($\beta_3 = -36.677$, *p*-value: 0.00). That is, during the crisis period there is strong evidence of herding contagion effects from the Northern European markets to all sample markets, and the Southern European markets in particular. Note that the empirical estimations are repeated with other estimation methods (e.g., Two-stage Least Squares, Generalized Method of Moments) and the results are qualitatively the same.

Table 5
Testing for Herding when Macroeconomic Information is Announced.

Period	β_2	*p*-Value	β_3	*p*-Value
Panel A. DUM = ECB rate changes				
2000–2013	31.353	(0.00)	0.5385	(0.98)
2000–2006	0.7220	(0.75)	31.199	(0.00)
2007–2013	26.216	(0.00)	−16.596	(0.66)
Panel B. DUM = US federal rate changes				
2000–2013	31.212	(0.00)	**−55.326**	**(0.00)**
2000–2006	0.5089	(0.82)	−3.6688	(0.60)
2007–2013	26.035	(0.00)	**−78.429**	**(0.01)**
Panel C. DUM = UK rate changes				
2000–2013	31.242	(0.00)	**−55.295**	**(0.01)**
2000–2006	0.4803	(0.83)	−4.2590	(0.70)
2007–2013	26.020	(0.00)	**−83.870**	**(0.01)**
Panel D. DUM = EU macro announcements				
2004–2013	27.637	(0.00)	**−31.219**	**(0.04)**
2004–2006	1.6322	(0.48)	10.480	(0.04)
2007–2013	26.018	(0.00)	**−35.747**	**(0.05)**

The table presents results for Eq. (5): $CSAD_t = \beta_0 + \beta_1|R_{m,t}| + \beta_2 R^2_{m,t} + \beta_3 DUM_t R^2_{m,t} + \varepsilon_t$· *DUM* is a dummy variable that takes the value of one on a day when important macroeconomic news is released and zero otherwise. If herding activity is detected, the coefficient on the dummy variable β_3 should be negative and statistically significant. For the dummy variable we employ days when the following informational events take place: rate changes by the European Central Bank, by the Bank of England, by the US Federal Bank, and macroeconomic information release dates such as the days when Eurostat issues the "Data for Short Term Economic Analysis". See also notes to Table 2. *p*-Values appear in parentheses. Bold cases denote negative and statistically significant herding coefficients at the 5% level.

5. Herding on fundamentals: further tests

Motivated by the important result in the previous section, i.e., that fundamental information induces herding; here we attempt to explore this issue further. More specifically, we decompose the CSAD measure into deviations driven by fundamental factors and deviations driven by non-fundamental factors. To this end, we first estimate the following regression (7):

$$CSAD_t = y_1 + \sum_i^n y_{i,t} X_{i,t} + \varepsilon_{i,t}. \quad (7)$$

In Eq. (7) *X* is a set of variables that proxy for important fundamental factors that determine bond yields.

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Table 6
Herding Spill-Overs.

Period	β_2	*p*-Value	β_3	*p*-Value
Panel A. Herding spillovers from the Southern markets to all				
$CSAD_{ALL,t} = \beta_0 + \beta_1 \lvert R_{m,ALL,t} \rvert + \beta_2 R^2_{m,ALL,t} + \beta_3 R^2_{m,SOUTH,t} + \varepsilon_t$				
2000–2013	−108.73	(0.00)	22.623	(0.00)
2000–2006	−2.0734	(0.70)	2.7014	(0.63)
2007–2013	−117.88	(0.00)	22.978	(0.00)
Panel B. Herding spillovers from the Northern markets to all				
$CSAD_{ALL,t} = \beta_0 + \beta_1 \lvert R_{m,ALL,t} \rvert + \beta_2 R^2_{m,ALL,t} + \beta_3 R^2_{m,NORTH,t} + \varepsilon_t$				
2000–2013	26.912	(0.00)	**−41.870**	**(0.00)**
2000–2006	−60.417	(0.00)	58.157	(0.00)
2007–2013	22.333	(0.00)	**−39.041**	**(0.00)**
Panel C. Herding spillovers from the Northern markets to the Southern markets				
$CSAD_{SOUTH,t} = \beta_0 + \beta_1 \lvert R_{m,SOUTH,t} \rvert + \beta_2 R^2_{m,SOUTH,t} + \beta_3 R^2_{m,NORTH,t} + \varepsilon_t$				
2000–2013	−0.6840	(0.02)	**−51.510**	**(0.00)**
2000–2006	−19.387	(0.00)	22.463	(0.00)
2007–2013	−1.0191	(0.01)	**−36.677**	**(0.00)**
Panel D. Herding spillovers from the Southern markets to the Northern markets				
$CSAD_{NORTH,t} = \beta_0 + \beta_1 \lvert R_{m,NORTH,t} \rvert + \beta_2 R^2_{m,NORTH,t} + \beta_3 R^2_{m,SOUTH,t} + \varepsilon_t$				
2000–2013	7.4648	(0.00)	0.6127	(0.00)
2000–2006	−1.3925	(0.70)	−1.7558	(0.60)
2007–2013	9.0379	(0.00)	0.5149	(0.00)

The table presents results for Eq. (6). Panel A presents results for the case where the CSAD is estimated from all sample markets, the market portfolio is an equally weighted portfolio of all sample markets and the third term (the "spill-over market") is an equally weighted portfolio of the Southern European markets. In other words, a negative and statistically significant coefficient on the third (non-linear) term (β_3) implies spill-over herding effects from the Southern European markets to all sample markets. Panel B presents results for the case where the CSAD is estimated from all sample markets, the market portfolio is an equally weighted portfolio of all sample markets and the third term (the "spill-over market") is an equally weighted portfolio of the Northern European markets. In other words, a negative and statistically significant coefficient on the third non-linear term (β_3) implies spill-over herding effects from the Northern European markets to all markets. *p*-Values appear in parentheses. Bold cases denote negative and statistically significant herding coefficients at the 5% level.

Economic theory does not provide specific guidelines as regards to the variables that determine yield spreads, however, previous studies indicate that bond yields are mainly determined by general market risk, default risk, and liquidity risk (see, among others, Codogno, Favero, Missale, Portes, & Thum, 2003; Haugh, Ollivaud, & Turner, 2009). Default risk reflects the risk that a borrower will not fulfill the obligations for interest payments or capital repayment, while liquidity risk reflects the possibility that bond investors may not be able to sell their holdings without affecting prices in secondary markets. Hund and Lesmond (2008) find that liquidity risk plays an important role in determining bond spreads even after accounting for macroeconomic factors. Other studies report that liquidity is important in explaining spreads along with either default risk (Ferrucci, 2003; Gomez-Puig, 2006; Schwarz, 2009), or, as regards to euro area sovereign spreads, a common factor (Barbosa & Costa, 2010). Spyrou (2013a, 2013b) examines spread determinants for the European markets and captures general market conditions with the Eurozone Consumer Price Index, liquidity as the difference between the European Central Bank (ECB) Reference Rate and the three month Euribor (see also Ebner, 2009), and local default risk with the Debt-to-Reserves ratio (see also Martell, 2008). Spyrou finds that fundamental variables are important for the determination of spreads, along with investor sentiment, especially during the 2007–2011 crisis period. Nayak (2010) examines corporate bond yield spreads and also reports that spreads co-vary with sentiment.

In this paper, in order to proxy for the fundamental type of risks in Eq. (7) we employ the daily log changes in the MSCI global stock market index, the daily log changes in the difference between the yield on BBB rated and AAA rated European Corporate Bonds, and the daily log changes in the 3-month Euribor rate (all data available at DataStream International). The residuals from Eq. (7), denoted as $CSAD_{nonfund}$, can be thought of as the part of *CSAD* that is due to non-fundamental information, since the variables used capture the fundamental component. It follows that the difference between the total *CSAD* and the $CSAD_{nonfund}$ will be the *CSAD* that is due to fundamental information, denote it $CSAD_{fund}$ (see also Galariotis, Rong & Spyrou, 2015). Next, regression (4) is estimated with the decomposed deviations, i.e., the $CSAD_{nonfund}$ and the $CSAD_{fund}$. The results are presented in Table 7. Recall that the coefficient β_2 should be negative and statistically significant if herd behavior towards the average is present. Thus, here we report only this coefficient. Note that the coefficient on the nonlinear term during the second sub-period when the full sample is used is negative (−0.3724) and statistically significant (*p*-value: 0.01); the same holds when we use separately the Northern and the Southern markets (statistically significant values are denoted in bold). This finding reinforces the findings of the previous section and indicates return clustering as a reaction to changes in fundamental factors, during the crisis period.

6. Conclusion

This paper tests and provides original evidence on herd behavior in European government bond prices. We utilize a commonly employed methodology to test for return clustering and, overall, we find no evidence of investor herding either before or after the EU crisis. Further tests indicate that during the EU crisis period macroeconomic information induces bond market investor herding. These findings are in sharp contrast to the popular belief that irrational investor herding intensified the recent EU crisis and was to some extent responsible for the spreads soaring. Our evidence supports the notion of 'spurious' herding (i.e., herding motivated by changes in fundamentals, see Bikhchandani & Sharma, 2001). Further tests reveal that during the recent financial crisis there were indeed herding spill-over effects running, however, with a direction from the European countries with no financial difficulties (Northern European markets) to the financially troubled European markets (Southern European markets).

Table 7
Decomposing deviations.

	All markets		Northern European markets		Southern European markets	
	$CSAD_{nonfund}$ β_2	$CSAD_{fund}$ β_2	$CSAD_{nonfund}$ β_2	$CSAD_{fund}$ β_2	$CSAD_{nonfund}$ β_2	$CSAD_{fund}$ β_2
Panel A: market portfolio: all markets						
Full sample	31.477	−0.1956	0.8783	**−0.1239**	40.139	−0.2255
p-Value	(0.00)	(0.17)	(0.12)	**(0.00)**	(0.00)	(0.29)
2000–2006	1.3885	−0.4838	−1.0827	−0.4063	3.6258	−0.4723
p-Value	(0.56)	(0.67)	(0.54)	(0.15)	(0.30)	(0.79)
2007–2013	26.459	**−0.3724**	0.1200	**−0.1777**	31.4915	**−0.4890**
p-Value	(0.00)	**(0.01)**	(0.77)	**(0.00)**	(0.00)	**(0.03)**

In the table, $CSAD_{nonfund}$ is the part of *CSAD* that is due to non-fundamental information and is obtained as the residuals from Eq. (7). $CSAD_t = y_1 + \sum_i^n y_{i,t} X_{i,t} + \varepsilon_{i,t} \cdot X$ is a set of variables that proxy for important fundamental factors that determine bond yields (daily log changes in the MSCI global stock market index, daily log changes in the difference between the yield on BBB rated and AAA rated European Corporate Bonds, daily log changes in the 3-month Euribor rate). $CSAD_{fund}$ *is* the difference between the total *CSAD* and the $CSAD_{nonfund}$ and it is a proxy for the *CSAD* that is due to fundamental information. *p*-Values appear in parentheses. Bold cases denote negative and statistically significant herding coefficients at the 5% level.

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