# Better Ways to Test for Herding.

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**Abstract**

In this paper we outline problems with the standard test for herding developed by Chang, Cheng and Kohrana (2000), subsequently called the CCK test, which is based on the proposition that the cross-sectional absolute deviation of stock returns (CSAD) should be linearly related to overall market returns. We show that the test is highly biased against finding herding. The bias arises because the test assumes that, in the absence of herding, stock prices follow the CAPM but does not account for the implications of the CAPM not being a perfect asset pricing model. We suggest several simple alternative tests for herding. Finally, we show that the new tests give radically different results to the CCK test finding herding in many of the world's major financial markets when the CCK test rejects herding.

**Keywords:** Herding; CCK test; CSAD; CAPM; Stock Markets

**JEL classification**: G10; G15; G40

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# Better Ways to Test for Herding

## 1. Introduction

The concept of herding is the idea that investors suppress their own beliefs and instead are guided by the collective behaviour of other market participants. A number of theoretical papers propose strong rationales for herding. Sharfstein and Stein (1990) cover compensation based rational herding which is motivated by the professional considerations of market participants. Graham (1999) and Trueman (1994) discuss how people may imitate others in order to preserve their reputation. Zhou and Lai (2009) confirm the existence of informational cascades related to imperfect information. Park and Sabourian (2009) discuss the conditions necessary for the presence of rational informational herding in financial markets. The empirical evidence, however, supporting herding is rather more modest. A substantial number of studies have investigated herding in many world markets with mixed results with herding not appearing to be a significant issue in most major stock markets except in particular circumstances. Christie and Huang (1995) failed to capture evidence of herding in the US market. Philippas, Economou, Babalos and Kostakis (2013); Litimi, BenSaïda and Bouraoui (2016); Bekiros, et al., (2017); Clements, Hurn and Shi (2017) also examine the existence of herding behaviour in the US market and most of these studies only find evidence of herding behaviour during periods of market turbulence. Economou, Kostakis and Philippas (2011); Mobarek, Mollah and Keasey (2014); Economou, Gavriilidis, Goyal and Kallinterakis (2015); Galariotis, Krokida and Spyrou (2016) focus on European financial markets and find that herding behaviour is more likely to occur during the global and Eurozone financial crisis periods. In the Asian markets, Demirer and Kutan (2006); Lao and Singh (2011); Bhaduri and Mahapatra (2013); Arjoon, Bhatnagar and Ramlakhan (2020) have found that herding behaviour is more likely during periods of large market price movements. In summary, the literature has generally shown that herding is mainly present only when there are large overall market movements. Most of this work uses a standard 'workhorse' test developed by Chang, Cheng and Kohrana (2000) based on the proposition that the cross-sectional absolute deviation of stock returns (CSAD) should be linearly related to overall market returns (for convenience we subsequently refer to this as the CCK test)[1]. This test appears very plausible and has the major advantage of being very easy to use.

[1] The Chang, Cheng and Kohrana paper has been and still is being very extensively used as can be seen by the fact that as at 3 June 2022 it has been cited 1464 times and 292 times since the start of 2019 according to Google Scholar.

The CCK test is based on the expected properties of the CSAD. We have:

$$CSAD_t = \frac{1}{N}\sum_{i=1}^{N}|R_{it} - R_{mt}| \qquad \text{(Equation 1)}$$

Chang et. al. (2000) argues that given rational asset pricing, as represented by the CAPM, the CSAD dispersion measure should increase linearly in line with the market return if there is no herding or anti-herding (stocks being less likely to move together as market returns increase). Given this, a standard approach for testing for herding is to examine a regression model of the following form:

$$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2|R_{m,t}| + \gamma_3 {R_{m,t}}^2 + \varepsilon_t \qquad \text{(Equation 2)}$$

The sign and significance of $\gamma_3$ is used to determine the presence of herding. If $\gamma_3$ is not significant that is taken as evidence of no herding, if $\gamma_3$ is negative and significant that is evidence of herding and if $\gamma_3$ is positive and significant that is evidence of anti-herding.

In this paper we initially outline problems with the CCK test for herding and show that the CCK test is highly biased against finding herding. The bias arises because the CCK test assumes that, in the absence of herding, stock prices follow the CAPM but does not account for the implications of the CAPM not being a perfect asset pricing model. There are inevitably differences between the stock price movements predicted by the CAPM and the observed stock price movements. These differences are manifested in the error term in the CAPM model. The CCK test is implicitly based on the false assumption that the error terms are unimportant and can be ignored. Given this problem the CCK test is a very flawed test of herding. Our criticism of the CCK test broadly confirms the problems identified by Bohl et. al (2017) although our investigation does take a rather different approach.

Given the evident problems of the CCK approach to testing for herding, we suggest several very simple but robust alternative approaches to test for herding that avoid the bias in the normal method. Our proposed approaches are as simple to apply as the CCK test and so can be easily taken up by researchers which is important given the extensive use of the CCK test. In contrast, the approach suggested by Bohl et al. (2017) is quite difficult to implement and seems not to be having a rapid take-up by researchers[2]. Our suggested approaches are also relatively free of underlying distributional assumptions and thus are more robust than the approach proposed in the paper of Bohl et. al. (2017) although that approach is certainly more appropriate that the CCK test.

Empirically, we show that our new tests give radically different results to the standard CCK method finding herding in many of the world's major financial markets even though the CCK method rejects herding on exactly the same data.

Although our paper focuses on issues with the CCK method, which is the most extensively used in the literature, for completeness we acknowledge that there have been subsequent papers addressing the issue of empirical testing for herding in other ways. It is appropriate to briefly assess the attributes of the approaches recommended. Hwang and Salmon (2004 and 2009) use an approach based on the cross-sectional dispersion of the factor sensitivity of assets within a given market. This approach allows the use of asset pricing models with a number of factors and also allows explicitly for the time-varying nature of market volatility. The use of multiple factors to price assets, is in line with the recent asset pricing literature where a number of multi-factor models, for example, the Fama French 3 factor and the more recent Fama French 5 factor model, have been shown to outperform the CAPM (Fama, E. F. and French, K. R., 1993; 2015). There are certainly some advantages to this approach. Herding can be assessed in a more nuanced way, such as, whether it is towards particular factors, sectors or styles in the market. Herding towards the market itself is a particular case of this so the more commonly used definition of herding can still be examined in this framework. Despite the evident advantages of the Hwang and Salmon approach it does retain some features which we find problematic in the CCK test. Inevitably no asset pricing model will be a perfect fit to the data so the implications of the resulting error term for tests of herding need to be carefully considered as we do for the CCK test[3]. In the present paper our focus is very much on issues with the CCK test and we do not consider the Hwang and Salmon approach in detail. However, in our conclusions we do advocate that future work should consider the relevance of our findings for this and similar multifactor approaches.

[2] The Bohl et al. Paper has only been cited 28 times on Google Scholar as at 3 June 2022 since its publication in 2017.

[3] In Hwang and Salmon (2004) this issue is briefly discussed but the authors make various assumptions such that the problem is theoretically minimised although its true empirical magnitude is unclear.

In the remainder of this paper we initially show some drawbacks in the CCK method because of the way it interacts with the CAPM. We then introduce and justify some methods to deal with these drawbacks. The first method is to suppress the constant term in the regression used in the CCK method. The second method is a new test approach based on the expected symmetry in returns which we call symmetrical cross-sectional absolute deviation (SCSAD). The third method involves investing only returns associated with larger market movements which can be selected in various ways.

## 2. Drawbacks with the CCK method

The intuition behind our discussion of the drawbacks in the CCK method is that the expected properties of the CSAD jointly depend both on the degree of herding and on how well the CAPM models the returns of stocks in the market. If the CAPM is not a perfect model (that is if it contains an idiosyncratic error term), even if there is no herding, the graph of CSAD against $|R_{mt}|$ will not be a straight line but will be convex. Having said this as $|R_{mt}|$ increases, CSAD will tend towards a straight line if there is no herding present and this enables valid tests of herding to be constructed.

We show that the standard method of testing for herding is biased against finding herding as it assumes that in the case of no herding there will be a linear relationship between CSAD and $|R_{mt}|$ when the true relationship is convex.
We have:

$$CSAD = \frac{1}{N}\sum_{i=1}^{N}|R_{it} - R_{mt}|$$

Where $R_{it}$ follows the CAPM:

$$R_{it} = R_f + \beta_i(R_{mt} - R_f) + \mu_{it}$$

Assume $E\ [\mu_{it}] = 0$
And $\mu_{it}$ is independent of $(R_{mt} - R_f)$ and hence of $R_{mt}$.

Then:

$$CSAD = \frac{1}{N}\sum_{i=1}^{N}\left|R_f + \beta_i\left(R_{mt} - R_f\right) + \mu_{it} - R_{mt}\right|$$

For convenience, we can assume that $R_f$ is sufficiently small compared to the $\mu_{it}$ and $R_{mt}$ terms to be neglected which is reasonable for daily data[4]. We then have:

$$CSAD = \frac{1}{N}\sum_{i=1}^{N}|\beta_i.(R_{mt}) + \mu_{it} - R_{mt}|$$

$$= \tfrac{1}{N}\textstyle\sum_{i=1}^{N}|(\beta_i - 1)(R_{mt}) + \mu_{it}|.$$

Now if $\mu_{it}$ is disregarded CSAD is directly proportional to $|R_{mt}|$ . In the literature a regression testing for the implied linear relationship between CSAD and $|R_{mt}|$ is the standard test for herding. However, is it not generally valid to disregard $\mu_{it}$.

If $\mu_{it}$ is less than or equal to $-(\beta_i - 1)(R_{mt})$ then

$$|(\beta_i - 1)(R_{mt}) + \mu_{it}| = (\beta_i - 1)(R_{mt}) + \mu_{it}$$

Recall $E\ [\mu_{it}] = 0$
And $\mu_{it}$ is independent of $R_{mt}$

Thus if $\mu_{it}$ is always less than $-(\beta_i - 1)(R_{mt})$ then

$$E[|(\beta_i - 1)(R_{mt}) + \mu_{it}|] = (\beta_i - 1)(R_{mt})$$

Thus, CSAD is expected to be proportional to $|R_{mt}|$.

Now if $\mu_{it}$ is greater than $-(\beta_i - 1)(R_{mt})$ then

$$|(\beta_i - 1)(R_{mt}) + \mu_{it}| > (\beta_i - 1)(R_{mt}) + \mu_{it}$$

Thus if $\mu_{it}$ is sometimes greater than $-(\beta_i - 1)(R_{mt})$ then

$$E[|(\beta_i - 1)(R_{mt}) + \mu_{it}|] > (\beta_i - 1)(R_{mt})$$

Thus, CSAD is not always proportional to $|R_{mt}|$. The more frequently $\mu_{it}$ is greater than $-(\beta_i - 1)(R_{mt})$ then the higher CSAD will be relative to what it would be in a proportional relationship with $|R_{mt}|$. Given $\mu_{it}$ is independent of $R_{mt}$ the excess values of $\mu_{it}$ happen most often when $|R_{mt}|$ is small and least often when $|R_{mt}|$ is large.

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[4] We confirm the validity of this assumption in Appendix 1.

In the limits as $|R_{mt}|$ tends to 0.

$$CSAD \approx \frac{1}{N}\sum_{i=1}^{N}|\mu_{it}| > 0$$

So

$$E[CSAD] \approx \; E\,|\mu_{it}| > 0$$

And

$$\frac{\partial E[CSAD]}{\partial |R_{mt}|} = 0$$

Which means that if $R_{mt}$ is small, E[CSAD] will always be positive and its size will depend on $\mu_{it}$ which is a random variable which is determined by how well the CAPM fits the data rather than by any attribute related to herding

In the limit as $|R_{mt}|$ tends to ∞.

$$CSAD = \frac{1}{N}\sum_{i=1}^{N}|\beta_i.(R_{mt}) - R_{mt}|$$

$$= \tfrac{1}{N}\textstyle\sum_{i=1}^{N}|(\beta_i - 1)(R_{mt})|.$$

$$= |R_{mt}|\frac{1}{N}\sum_{i=1}^{N}|(\beta_i - 1)|$$

$$E[CSAD] = |R_{mt}|\frac{1}{N}\sum_{i=1}^{N}|(\beta_i - 1)|$$

And

$$\frac{\partial E[CSAD]}{\partial |R_{mt}|} = \frac{1}{N}\sum_{i=1}^{N}|(\beta_i - 1)|$$

So, given the above, even if there is exactly 0 herding plotting CSAD against $|R_{mt}|$ will have a graph of the form shown in Figure 1. That is, it will have a positive value and a gradient of 0 at $|R_{mt}| = 0$ and will tend to a value of $|R_{mt}|\frac{1}{N}\sum_{i=1}^{N}|(\beta_i - 1)|$ with a gradient of $\frac{1}{N}\sum_{i=1}^{N}|(\beta_i - 1)|$ as $|R_{mt}|$ increases.

Clearly, the graph in Figure 1 shows this is a convex relationship and will be associated with a positive coefficient of a quadratic curve fitted to it. So, the standard test for herding will be highly biased against finding herding.

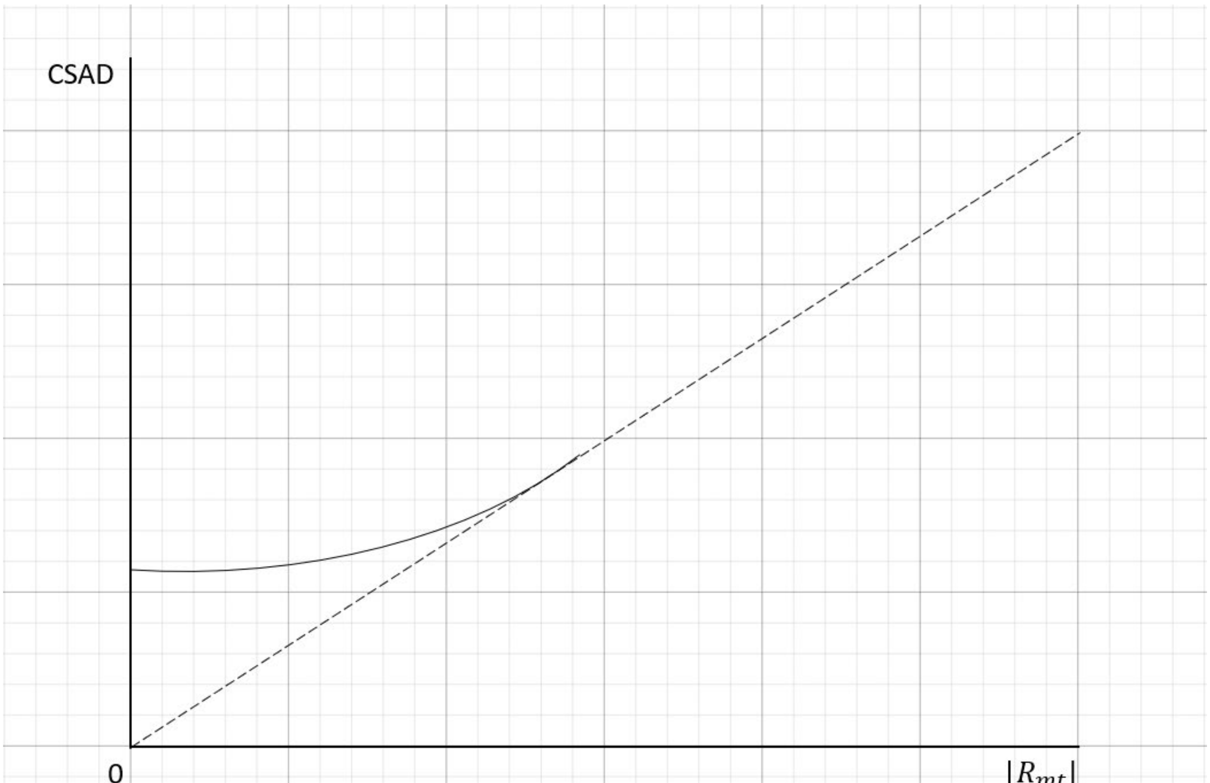


Figure 1

*Horizontal axes are the absolute value of the average market return.*
*Vertical axes are the cross-sectional absolute deviation (CSAD).*

In Figure 1, the dotted line shows the hypothetical relationship between the CSAD and the absolute value of market return if the CAPM model is a perfect fit with no idiosyncratic error term. And the curved line is what will be observed if there is no herding and there is a realistic model of the CAPM with a random, non-zero, error term.

In summary, if regressions of CSAD on $|R_{mt}|$ are used to test for herding there will be issues as the test will not be solely of herding but of how well the CAPM fits the data. The standard approach in the literature assumes that if there is no herding or anti-herding (we term this zero herding), there will be a straight-line relationship between CSAD and $|R_{mt}|$ and it is not an issue if there is a significant constant term

It is fairly easy to see the rationale for the standard approach. If there is herding one can modify the CAPM as follows:

$$R_{it} = R_f + \beta(R_{mt})_i(R_{mt} - R_f) + \mu_{it}$$

The term corresponding to $\beta_i$ in the normal CAPM is now a function of $R_{mt}$

Now in the case of herding one would see that as $R_{mt}$ increases stocks would act more and more similarly to one another so the $\beta(R_{mt})_i$ terms will tend to 1. That is stocks will tend to move more in line with the market as $R_{mt}$ increases. Thus, CSAD will not increase linearly in proportion to $R_{mt}$. The literature assumes this can be simply captured by a negative coefficient of $R_{m,t}^2$ in the standard regressions. The problem with this rationale is that it is only necessarily true if there is no idiosyncratic error term in the modified CAPM. As we have seen, if there is an idiosyncratic error term, there will be a tendency to see a positive coefficient of $R_{m,t}^2$ independently of whether there is any herding or not. If the modified CAPM is an appropriate model and there is no idiosyncratic error term, and we neglect $R_f$ due to its relatively small size, the regression of CSAD on $|R_{mt}|$ will still go through the origin.

In summary, to test for herding one conventionally checks whether there is a concave relationship between CSAD and $|R_{mt}|$. However, we have shown that if there is exactly zero herding there will be a convex relationship between CSAD and $|R_{mt}|$ so even if a degree of herding exists, the standard test is likely to show no evidence of herding. We consider various solutions to this problem in section 3

## 3. Solutions to the problems with CSAD

### 3.1 Solution 1 – Supressing the constant term in the regression test

Herding is expected to be most acute when there are large overall market movements. As shown above in Figure 1, if there is zero herding and market movements are large, we can expect the gradient of the curve between CSAD and $|R_{mt}|$ to be a straight line. For large $|R_{mt}|$, CSAD will have a value of $|R_{mt}|\frac{1}{N}\sum_{i=1}^{N}|(\beta_i - 1)|$ with a gradient of $\frac{1}{N}\sum_{i=1}^{N}|(\beta_i - 1)|$ if a straight line with that gradient is fitted though that point, it will go through the origin of the graph. Also, as shown above, even if there is zero herding the effect of the idiosyncratic error term in the CAPM will cause the any line fitted to the data to be convex and to have a positive constant coefficient. Thus, a reasonable way to test for herding is to adopt the standard approach in the literature but constrain the constant in the regression to be zero so that the fitted line goes through the origin of the graph. This means that less emphasis will be given to the effect of the idiosyncratic CAPM error term for small values of $|R_{mt}|$ and the shape of the fitted line will be a better test of whether herding exists. This method has the advantages of both being extremely simple and not requiring any assumptions about the distributional properties of the idiosyncratic CAPM error terms other than those in the basic assumptions underlying the CAPM. This contrasts with the approach of Bohl et al (2017) which requires a set of distributional assumptions about the error terms in order to bootstrap a test statistic for the coefficient of $R_{m,t}^2$

### 3.2 Solution 2 – Create a New Variable SCSAD

We can set up a variable SCSAD as below:

$$\text{SCSAD} = \text{CSAD if } R_{mt} > 0$$

$$\text{SCSAD} = -\ \text{CSAD if } R_{mt} < 0$$

Now we can plot and regress SCSAD against $R_{mt}$ (not $|R_{mt}|$ ).

The purpose of creating SCSAD is that when $R_{mt}$ is close to 0, in 50% of cases SCSAD will be greater than 0 and in 50% of cases it will be less than 0, so there will not be any systematic random bias related to small values of $R_{mt}$, and fitted lines will go through the origin. This means any fitted lines will be related to herding, not to the attributes of how well the CAPM fits.

To test for herding the curve of SCSAD should be convex if $R_{mt}$ is positive and concave if $R_{mt}$ is negative, as shown in Figure 2. The appropriate regression model for the SCSAD is:

$$SCSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 R_{m,t}^2 + \gamma_3 R_{m,t}^3 + \mu_t \qquad \text{(Equation 3)}$$

A negative coefficient on the cubic term will indicate herding.

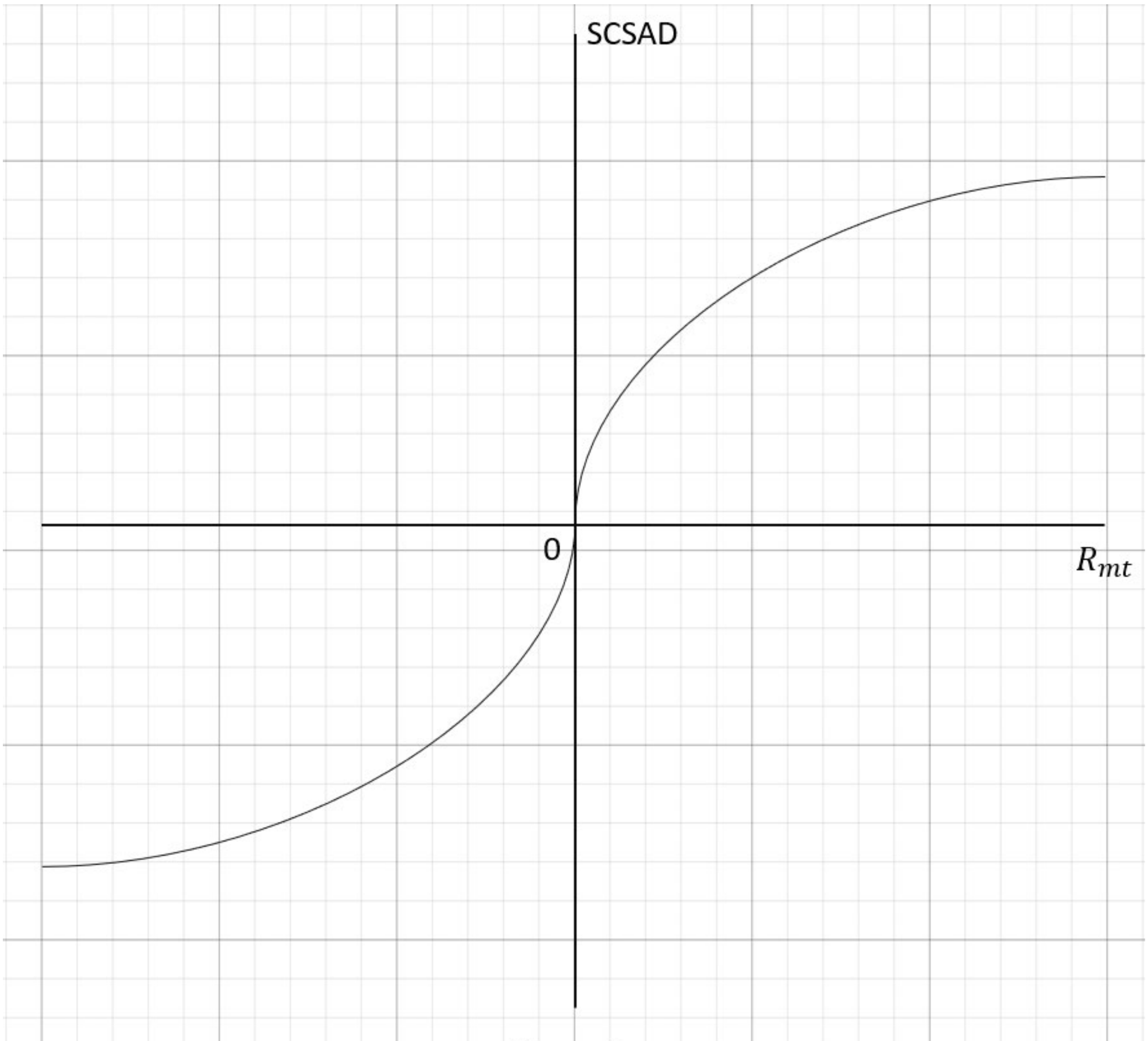


Figure 2

*The horizontal axis is the value of the average market return.*
*The vertical axis is the symmetrical cross-sectional absolute deviation (SCSAD).*

### 3.3 Solution 3 – Investigating the situation given large market movements

As herding is expected to be most acute when there are large overall market movements, and the results of the tests for herding are distorted by the values of CSAD associated with small values of $|R_{mt}|$ another viable approach is to use the normal test for herding but disregard data associated with small values of $|R_{mt}|$. This, however, gives rise to the issue of which values of $|R_{mt}|$ should appropriately be disregarded. This can potentially be done in two ways either by examining values of $|R_{mt}|$ over a certain magnitude or alternatively examining a certain proportion of the set of the market returns which are the largest in absolute magnitude.

## 4. Market Simulations

In this section we examine markets, with and without herding, using analytical approaches and simulations, to examine the effectiveness of the CCK method and our proposed alternative tests for herding. If we run tests for herding on actual market data, it is difficult to know the extent to which the results are influenced by herding effects or by the less than perfect fit of the CAPM. We can overcome these problems by running tests on simulated data with known properties.

To detect whether the market has herding behaviour, we need to simultaneously examine the whole market return and that of each stock in the market. We use analytical approaches or simulations, as appropriate, to create sets of returns with the properties we desire.

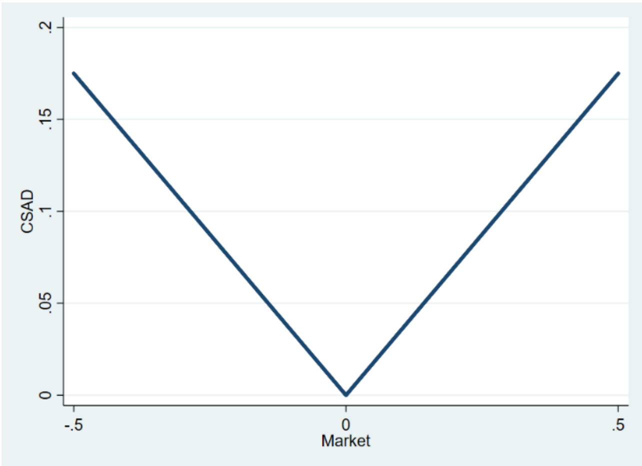
### 4.1 Simulation with zero herding in the market

In order to create a market where there is no herding (or anti-herding) behaviour, we initially assume the CAPM is a perfect model for returns, that is, the error term in the CAPM equation is 0. Given this assumption, we have a deterministic relationship so it is not necessary to conduct stochastic simulations to determine the relationship between CSAD and $|R_{mt}|$.
. For our particular exercise, without loss of generality, we further assume that there are four different types of stock in the market, and the corresponding stock betas are 0.5; 0.8; 1.2 and 1.5. Then we assume we have five stocks with each level of beta, so given the four different stock betas, we have a total of 20 stocks in the market. We consider overall market returns ranging from -0.5 to 0.5, in increments of 0.001, and thus we have a total of 1001 market observations. In this experiment we are simply aiming to observe the shape of the relationship between CSAD and $|R_{mt}|$ so it is not necessary for market returns of different sizes to occur with the same relative frequency as they would in an actual market situation.

#### 4.1.1 Standard CCK Approach

After we calculate the CSAD results, we can fit the regression of CSAD on $|R_{mt}|$ applying equation 2, the standard CCK test for herding. We have a small and insignificant coefficient for the squared market return. Thus, the standard regression used to test for herding correctly confirms that the market does not have herding behaviour. In addition, we have got an intercept value equal to zero, so the fitted curve is a straight line which goes through the origin. The graph is shown in Figure 3:

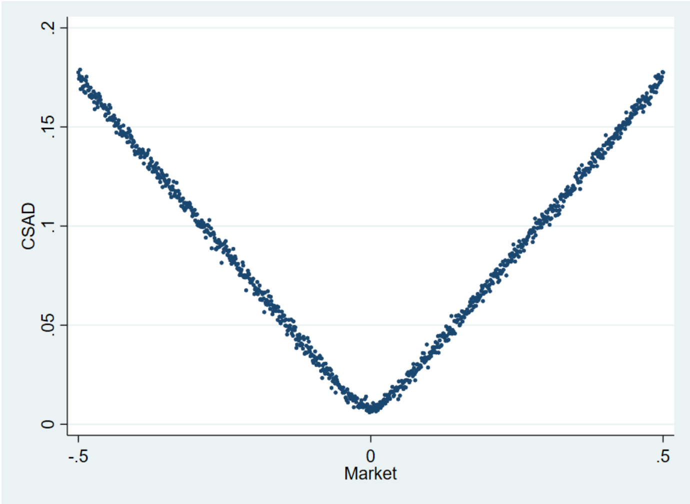
**Figure 3: Zero herding without the influence of the random error term in the CAPM equation:**




The above graph shows the regression results without the influence of the random variable in the CAPM

After this, we consider the effect of the CAPM not being a perfect model by adding a random error variable into each stock return CAPM calculation, the random error variable is generated to follow the standard normal distribution. We run 500 simulations of the returns of all the stocks in the market for each overall market return. For each simulation we calculate the CSAD and then the regression of CSAD on $|R_{mt}|$ applying equation 2, the standard CCK test for herding. The results show a significantly positive coefficient of squared market return for every regression with extremely high adjusted R squares. Thus, the standard CCK approach indicates that the market does not have herding behaviour but, in fact, has anti-herding behaviour. This contradicts the fact that we have set up the simulations so that there is no herding or anti-herding behaviour. The fitted line is shown in Figure 4:

**Figure 4: Zero herding influenced by the random variable:**




Compared with the graph of the results without the random error variable in the CAPM formula, we find that with the market movement, the graph slope continuously changes, so the fitted line is no longer straight. In addition, the fitted line has a larger intercept above the origin. This confirms our theoretical predictions. In conclusion, 100% of the regressions incorrectly indicate anti-herding in the market and this result is entirely due to the error term in the CAPM. Below we investigate whether our suggested solutions can produce more appropriate results

**4.1.2 Solution 1: Standard regression without constant value**

The mathematical meaning of a constant term is the value of the interpreted variable when the value of all explanatory variables is zero. In our case, the theoretical considerations discussed above indicate that, if the CAPM is an appropriate model for individual share returns without an error term, the graph of CSAD against $|R_{mt}|$ should be a straight line through the origin. From the results of the regressions without a constant value, unlike the regression with a constant value, the large majority (73.8%) of the regression results show an insignificant coefficient of the squared market return. This indicates that the regression correctly indicates no herding and no anti-herding. Around 26.2% of the coefficient values of the squared market return are significantly negative, this indicates that the market has herding behaviour which is an incorrect finding.

**4.1.2 Solution 2: Regression with SCSAD model**

The regression model for the SCSAD is:

$$SCSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 R_{m,t}^2 + \gamma_3 R_{m,t}^3 + \mu_t$$

By using the new regression model, we need to have a significantly negative coefficient of the cubic market return to confirm herding behaviour. For the graph of the SCSAD method, if the fitted line is straight then there is no herding behaviour. In the results, most of the cubic market coefficients are insignificant correctly indicating there is no herding in the market. Around 14.4% of the cubic market coefficients are significantly negative, which indicates herding behaviour in the market, whereas a positive coefficient would indicate herding. The fitted scatter graph is shown in Figure 5:

**Figure 5: Zero herding under SCSAD regression:**

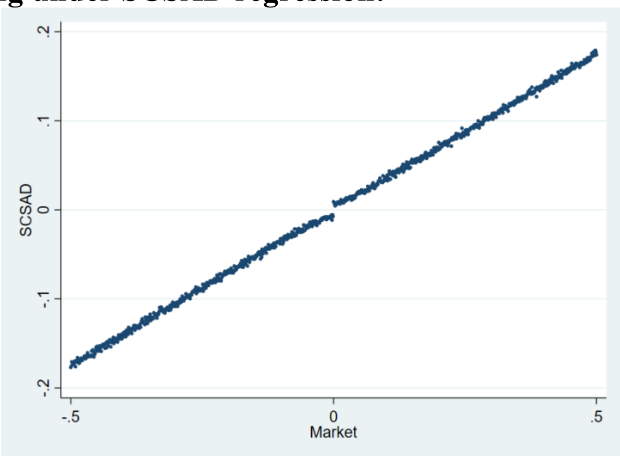



Table 1: Results for the simulation with neither herding nor anti-herding

| Full Range Market Return | Anti-Herding | Nothing | Herding |
|---|---|---|---|
| Standard Regression | 100% | 0 | 0 |
| Regression without constant | 0 | 73.80% | 26.20% |
| Cubic Regression (SCSAD) | 0 | 85.60% | 14.40% |

Table 1 summarises the results for the simulation where there is no herding or anti-herding. The standard regression model shows 100% anti-herding as in every regression the coefficient of squared market return is significantly positive. Thus, the conclusions drawn from the standard approach are 100% incorrect. For solution 1, where the regression model does not have a constant value, 73.8% of the regressions lead to the correct conclusion that there is no herding. For solution 2, using the SCSAD regression model, 85.6% of the regressions lead to the correct conclusion. The two solutions are clearly considerably more accurate than the standard approach although they perhaps have a slight bias towards finding herding when it does not exist.

### 4.1.3 Solution 3 Investigating the situation given large market movements using the Standard CSAD regression

Solution 3 states that herding behaviour is more likely happen under larger market movement, we will check the herding behaviour under three market movement condition with absolute market returns larger than 0.5%, 5% and 10%. The market returns we investigate are necessarily somewhat arbitrary which is a drawback of this approach. Market returns larger than 5% and 10% do not happen very often in the real market but are more common in our simulations.

The results are shown in Table 2. When absolute returns of less than 0.5% are removed 100% of the squared market returns have a significantly positive coefficient, which implies an anti-herding effect. Thus, the conclusions are almost entirely incorrect, given there is no herding or anti-herding, so removing absolute returns of this magnitude 0.5% has not been sufficient to correct the biases in the underlying method. The results are much more encouraging when there are larger thresholds for removing returns. When absolute returns of less than 5% are removed, 84.4% of the regressions correctly identify that there is neither anti-herding nor herding in the data. Similarly, when absolute returns of less than 10% are removed, we see a further modest improvement with 92.4% of the regressions correctly identifying that there is neither anti-herding nor herding.

Table 2: Results for the simulation with neither herding nor anti-herding for the standard herding test using large market returns determined by absolute market size

| | Anti-Herding | Nothing | Herding |
|---|---|---|---|
| Market Return >= \|0.5%\| | 100% | 0 | 0 |
| Market Return >= \|5%\| | 15.4% | 84.4% | 0.20% |
| Market Return >= \|10%\| | 3.8% | 92.4% | 3.8% |

### 4.1.4 Larger market movements based on a proportion of the data

In this section we detect herding under situations where we use proportions of the observations based on absolute return size. We investigate the largest 50% of returns by their absolute size, the largest 10% of returns by absolute size and the largest 5% of returns by absolute size, again these figures are necessarily somewhat arbitrary.

Table 3: Results for the simulation with neither herding nor anti-herding for the standard herding test excluding large market returns determined by proportion of observations

| | Anti-Herding | Nothing | Herding |
|---|---|---|---|
| Largest 50% of observations | 2% | 94.8% | 3.2% |
| Largest 10% of observations | 3% | 95.4% | 1.6% |
| Largest 5% of observations | 3.4% | 94.2% | 2.4% |

With the largest 50% of observations, we examined 94.8% of the squared market returns have an insignificant coefficient. Thus, the conclusions are mostly correct, given there is no herding or anti-herding. The results are slightly better when observations are selected based on larger absolute returns. When the largest 10% of observations are examined, 95.4% of the regressions correctly identify that there is neither anti-herding nor herding in the data. Similarly, when the largest 5% of observations are examined, 94.2% of the regressions correctly identify that there is neither anti-herding nor herding in the data.

In conclusion from the simulation with no herding we can see that the performance of the standard regression using all the market data is extremely poor with both the regression without a constant (solution 1) and the cubic regression (solution 2) performing much more accurately. When the effect of examining market returns in excess of a particular size is considered the accuracy of the approaches is quite dependent on the return threshold. If we consider the standard regression the accuracy of the results improves as the threshold increases. The results are still very poor with a threshold of 0.5% but quite good with a threshold of 5% and even better with a threshold of 10%. Similarly, in table 3 when a subset of returns is selected based on their absolute size the results are quite good in all cases where over 50% of absolute returns are selected.

**4.2 Simulation with herding in the market**

In order to find out the effectiveness of our tests in the market, we set up a market simulation where there is definitely herding. As previously with have five different stock types with particular patterns of beta. In our simulation market returns still increase from -0.5 to 0.5 as in the previous simulation. When the market return is 0 the betas of the stock groups range from 0.95 to 1.05 (0.95, 0.975, 1.025 and 1.05). The betas then progress linearly with market size until the betas of the different groups are all 1 when returns are -0.5 and 0.5, that is, there is perfect herding under extreme market conditions. Table 4 below shows how the betas vary. For example, in the second and third columns for stocks with a beta of 0.95 when market returns are 0, as the market return increases from -0.5 to 0.5, the stock beta starts from 1 when the market return is -0.5 and decreases to 0.95 when the market return is 0 and then increases back to 1 when the market return reaches 0.5. Also, by using the market return times the stock beta and then adding a random variable which follows the normal distribution, we obtain the results shown in the third column which shows the average return of a single security in the group 1 to 5. Applying this calculation method, we can obtain the returns for each of the 20 securities.

Table 4: Herding simulation sample:

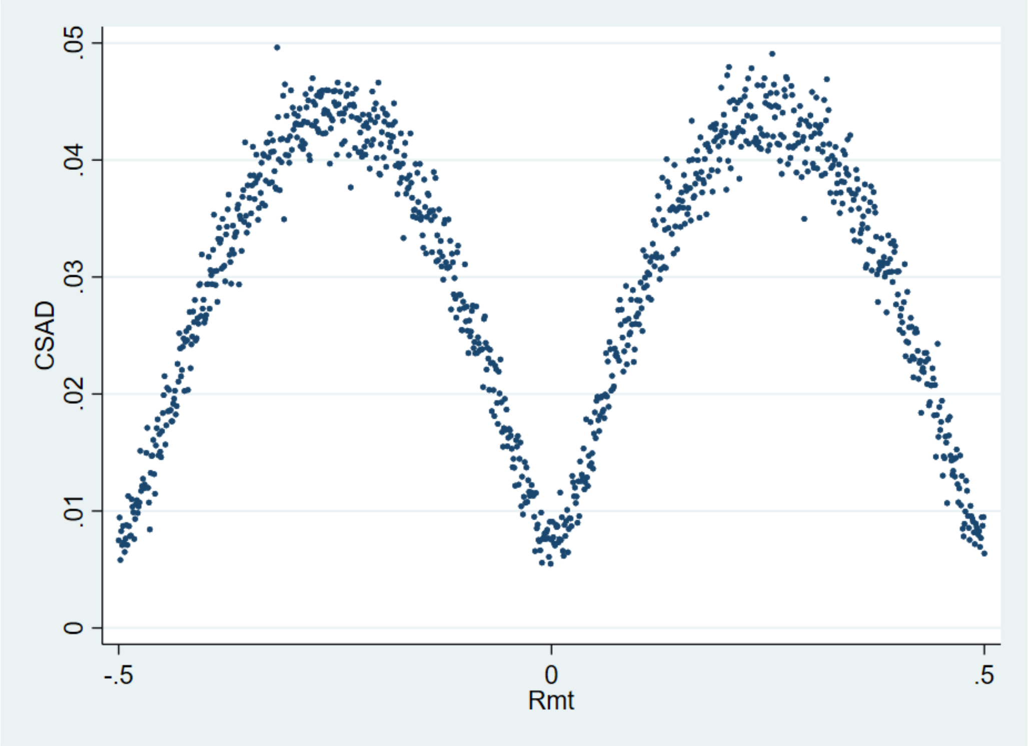
| Market Return | Stocks 1-5 With Beta of 0.95 when Market Return is 0 | | Stocks 6-10 With Beta of 0.975 when Market Return is 0 | | Stocks 11-15 With Beta of 1.025 when Market Return is 0 | | Stocks 16-20 With Beta of 1.05 when Market Return is 0 | |
|---|---|---|---|---|---|---|---|---|
| | Beta[1] | Return[2] | Beta[1] | Return[2] | Beta[1] | Return[2] | Beta[1] | Return[2] |
| -0.5 | 1 | -0.49727 | 1 | -0.50526 | 1 | -0.49417 | 1 | -0.50341 |
| 0 | 0.95 | 0.00503 | 0.975 | 0.00098 | 1.025 | 0.00432 | 1.05 | 0.00188 |
| 0.5 | 1 | 0.49754 | 1 | 0.50063 | 1 | 0.49917 | 1 | 0.49794 |

[1]Beta for the five stock portfolios associated with that Market Return.

[2]Average return for the five stock portfolios associated with that Market Return.

When we plot CSAD against market return, the scatter graph is shown in Figure 6.

**Figure 6: Herding Simulation:**




The graph shows that extreme herding behaviour exists in the market as was designed into the simulation.

**4.2.1 Standard Regression Approach**

In this simulation the standard CCK test has poor ability to detect herding behaviour, the results show that only 60% of the coefficients of the squared market return are significantly negative which indicates herding behaviour in the market. This means that 40% of the simulations incorrectly indicate no herding.

**4.2.2 Solution 1: Standard regression without constant value**

When we take out the constant value in the regression model, the results meet the expectation of our solution 1. The coefficients of the squared market return become 100% significantly negative, correctly showing that the market has herding behaviour.

**4.2.3 Solution 2: Regression with SCSAD model**

When using the SCSAD regression method, we find that the coefficient of the cubic market return is 100% significantly negative, which correctly indicates the market has herding behaviour.

Table 5: Results for the simulation with herding from the standard regression and solutions 1 and 2

| Full Range Market Return | Anti-Herding | Nothing | Herding |
|---|---|---|---|
| Standard Regression | 0 | 40% | 60% |
| Regression without constant | 0 | 0 | 100% |
| Cubic Regression | 0 | 0 | 100% |

From table 5 above, under the simulation where herding behaviour exists, the standard regression incorrectly fails to detect herding in 40% of cases, whereas solution 1 without a constant value and solution 2 the SCSAD cubic regression successfully detect the herding behaviour in the market in 100% of the cases.

### 4.2.4 Solution 3: Investigating the situation given large market movements using the Standard CCK approach

In the regressions, the coefficient of the absolute market return was omitted because of collinearity. The results relating to excluding different levels of absolute market returns are shown in Table 6. For market returns >= |0.5%| 70% of the regressions correctly detect herding. As the level at which returns are excluded increases the results become less accurate with 56% of regressions correctly detecting herding when market returns >= |5.0%| and 26% when market returns >=|10.0%|. As the market movement in the simulation is from -50% to 50%, which is rather extreme compared to what is normally observed in real markets it is debatable whether the levels at which market data is excluded are necessarily appropriate for real market situations.

Table 6: Results for the simulation with herding for the standard herding test excluding large market returns determined by absolute market size

| | Anti-Herding | Nothing | Herding |
|---|---|---|---|
| Market Return >= \|0.5%\| | 0 | 30% | 70% |
| Market Return >= \|5.0%\| | 0 | 44% | 56% |
| Market Return >=\|10.0%\| | 0 | 74% | 26% |

### 4.2.5 Larger market movements based on a proportion of the data

In this section we detect herding under situations where we use proportions of the observations based on absolute return size. We investigate the largest 50% of returns by their absolute size, the largest 10% of returns by absolute size and the largest 5% of returns by absolute size. Our results are shown in Table 7.

When the largest 50% of observations examined none of the squared market returns in the regressions have a significantly negative coefficient, which implies there is no indication of the existence of herding. According to the results based on the largest 10% and 5% proportions of the observations based on absolute return size, 4% of the regressions detect herding behaviour in the top 10% observations, and only 2% of the regressions detect herding behaviour in the top 5% observations.

Table 7: Results for the simulation with herding for the standard herding test excluding large market returns determined by proportion of observations

| | Anti-Herding | Nothing | Herding |
|---|---|---|---|
| Largest 50% of observations | 4% | 96% | 0 |
| Largest 10% of observations | 4% | 92% | 4% |
| Largest 5% of observations | 2% | 96% | 2% |

To summarise the results of Section 4, the market simulations with zero anti-herding and herding in the market show the differing accuracy of the prevalent herding detection approaches and our three different solutions. When the market has no herding behaviour, the standard regression results are likely to incorrectly show anti-herding exists in the market. Our first two proposed solutions correctly identify that there is neither herding nor anti-herding in the market. In respect of our third solution, when the market returns larger than 0.5%, 5% and 10% in absolute terms are considered, the standard regression produces reasonably accurate results which show that no herding exists in the market, when large market returns determined by proportion of observations are considered the results are again quite accurate.

Under the simulation which ensures that herding behaviour exists in the market, the standard regression results are quite poor with 40% of our regressions incorrectly concluding that there is no herding whereas our first two proposed solutions show a high degree of accuracy. In respect of our third solution, when the market returns larger than 0.5% and 5%, and 10% in absolute terms are considered, the results are rather mixed with standard regression results showing varying levels of evidence of herding behaviour but under the condition where the largest 50%, 10% and 5% of observations are selected based on the absolute market returns, the tests do not detect herding behaviour effectively. The varying results regarding the third solution indicate that the effectiveness of this solution are quite dependent on the parameters determining how the data to be used is selected.

## 5.0 Worldwide Herding Results

In this section we present the results of herding tests for a number of major world markets based on the traditional CCK test and compare them the new approaches we have suggested. Logarithmic returns and robust regression methods are used throughout.

The data set is constructed from the most of the companies in the leading indices of Denmark (OMXC-20), Finland (HEX-25), US Dow Jones Composite, Germany (DAX-30), France (CAC-40), Greece (ATHEX), Italy (FTSE-MIB), Norway (OBX), Portugal (PSI-20), Spain (IBEX-35), Sweden (OMXS-30), Hong Kong Heng SENG as well as the UK market (FTSE-100). The data sample period is collected from Bloomberg over the period from 02/Jan/2002 to 31/May/2018. The time period covers the global financial crisis and the Eurozone crisis. The time period for the global financial crisis is identified as being from Aug/2007 to Dec/2009 and the Eurozone crisis from May/2010 to Feb/2012. Total observation in our data sample for each country is around 4150[5].

Table 8 reports the descriptive statistics for the equally weighted average market return and the CCK measurements for each of the total thirteen different countries. We have only considered the stock of active companies. The statistics shown in table 8 show that the mean returns of $R_{m,t}$ in all the countries other than Greece are positive during this time period. The standard deviation of $R_{m,t}$ varies between countries and is particularly high in Norway, Greece and Sweden. The minimum and maximum returns are substantial in all of the markets reflecting the times of financial turbulence in the sample period. Regarding the CASD results model, we find that the mean value of the CSAD results of 1.50196 in Norway and of 1.805907 in Greece are much higher than the other countries in our sample. Similarly, Norway has the highest standard deviation of CSAD, and Denmark and Greece have a high standard deviation of CSAD compared to the other countries where the value tends to be around 0.5. According to Chiang and Zheng (2010), within markets with similar conditions such as in the European market, countries which have a higher standard deviation of returns may have abnormal cross-sectional variations in CSAD due to irregular fluctuations in the stock market and the statistics tend to bear this out.

[5] Data sharing not applicable – no new data generated. Data is from standard financial databases.

Table 8: Descriptive data

| | variable | mean | p50 | sd | variance | skewness | kurtosis | min | max | N |
|---|---|---|---|---|---|---|---|---|---|---|
| Denmark | $R_{m,t}$ | .044824 | .079958 | 1.21182 | 1.46851 | -.467417 | 8.55016 | -10.5563 | 7.99761 | 4105 |
| | CSAD | 1.2098 | 1.07417 | .615005 | .378231 | 3.24419 | 35.3323 | .261331 | 12.504 | 4105 |
| US | $R_{m,t}$ | .030009 | .038953 | 1.20649 | 1.45563 | .14144 | 9.13323 | -8.06138 | 9.54237 | 4132 |
| | CSAD | .908568 | .79745 | .425425 | .180987 | 2.52794 | 13.4162 | .239378 | 4.90784 | 4132 |
| Finland | $R_{m,t}$ | .029096 | .050983 | 1.45997 | 2.13152 | -.07426 | 6.78326 | -8.92102 | 8.93025 | 4124 |
| | CSAD | 1.16771 | 1.04695 | .535559 | .286823 | 1.83597 | 8.65557 | .297071 | 5.02699 | 4124 |
| France | $R_{m,t}$ | .020807 | .047334 | 1.45872 | 2.12787 | -.084209 | 7.24377 | -9.31602 | 8.91817 | 4202 |
| | CSAD | 1.0055 | .887954 | .466806 | .217907 | 2.00715 | 8.57732 | .30269 | 3.90096 | 4202 |
| Germany | $R_{m,t}$ | .022635 | .064752 | 1.41664 | 2.00688 | -.145255 | 7.73682 | -9.02234 | 11.1545 | 4171 |
| | CSAD | 1.03381 | .89293 | .52707 | .277803 | 2.33098 | 11.1605 | .252214 | 5.52583 | 4171 |
| Greece | $R_{m,t}$ | -.01962 | .073511 | 1.66795 | 2.78204 | -.402569 | 8.74461 | -15.9129 | 12.6811 | 4063 |
| | CSAD | 1.82591 | 1.65927 | .733065 | .537384 | 2.57838 | 17.2899 | .547966 | 10.5073 | 4063 |
| HK | $R_{m,t}$ | .041765 | .075253 | 1.40087 | 1.96245 | -.112577 | 8.26348 | -12.413 | 11.4602 | 4050 |
| | CSAD | 1.15378 | 1.04552 | .491691 | .241761 | 2.22905 | 12.3862 | .31458 | 5.98583 | 4050 |
| Italy | $R_{m,t}$ | .004424 | .0734 | 1.41339 | 1.99768 | -.260081 | 6.32218 | -8.56588 | 9.27357 | 4168 |
| | CSAD | 1.10248 | .972056 | .536711 | .288059 | 3.63257 | 36.4007 | .26375 | 9.58212 | 4168 |
| Norway | $R_{m,t}$ | .026429 | .101438 | 1.83862 | 3.38053 | -.325514 | 6.70776 | -12.3905 | 10.4173 | 4120 |
| | CSAD | 1.50196 | 1.24975 | .939018 | .881754 | 2.47601 | 12.9371 | .241345 | 10.65 | 4120 |
| Portugal | $R_{m,t}$ | .007854 | .057838 | 1.1991 | 1.43784 | -.357844 | 6.78024 | -7.98493 | 8.74228 | 4194 |
| | CSAD | 1.16989 | 1.05155 | .573614 | .329033 | 1.63503 | 7.98275 | .218911 | 5.92302 | 4194 |
| Spain | $R_{m,t}$ | .017445 | .071006 | 1.31686 | 1.73412 | -.177199 | 7.03014 | -8.06577 | 9.71678 | 4174 |
| | CSAD | .977813 | .872125 | .468243 | .219251 | 2.41187 | 16.7452 | .244522 | 7.24106 | 4174 |
| Sweden | $R_{m,t}$ | .030535 | .069444 | 1.61524 | 2.60901 | .035124 | 8.47388 | -9.30306 | 13.0496 | 4123 |
| | CSAD | 1.01083 | .870042 | .507458 | .257513 | 2.32108 | 13.8771 | .28091 | 7.36813 | 4123 |
| UK | $R_{m,t}$ | .020814 | .072211 | 1.18132 | 1.39552 | -.367365 | 9.56934 | -9.38468 | 7.88027 | 4131 |
| | CSAD | 1.09882 | .949193 | .532577 | .283638 | 3.15562 | 19.1501 | .370236 | 7.37284 | 4131 |

### 5.1 Full range of data

In this sub-section we fit the regressions needed to apply the CCK to the full set of data with no returns excluded. The results are shown in the following Tables.

#### 5.1.1 Standard regression

Table 9: Full range of data robust regression using equation 2, Robust Regression

$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R_{m,t}^2 + \varepsilon_t$ (equation 2)

| | (1) Denmark | (2) US | (3) Finland | (4) France | (5) Germany | (6) Greece |
|---|---|---|---|---|---|---|
| $R_{m,t}$ | -0.00255 | -0.00850 | 0.0122 | 0.0118 | 0.00789 | 0.00791 |
| $(\gamma_1)$ | (-0.21) | (-1.19) | (1.76)* | (2.09)** | (1.01) | (0.97) |
| $\lvert R_{m,t}\rvert$ | 0.201 | 0.214 | 0.169 | 0.167 | 0.188 | 0.317 |
| $(\gamma_2)$ | (3.24)*** | (9.14)*** | (7.71)*** | (9.95)*** | (6.16)*** | (19.59)*** |
| $R_{m,t}^2$ | 0.0328 | 0.0116 | 0.0111 | 0.0179 | 0.0204 | 0.0160 |
| $(\gamma_3)$ | (1.62) | (1.76)* | (2.00)** | (4.74)*** | (2.60)*** | (5.35)*** |
| _cons | 0.987 | 0.710 | 0.968 | 0.795 | 0.804 | 1.406 |
| | (35.87)*** | (59.32)*** | (68.79)*** | (73.61)*** | (48.95)*** | (102.62)*** |
| *N* | 4105 | 4132 | 4124 | 4202 | 4171 | 4063 |
| adj. $R^2$ | 0.224 | 0.281 | 0.175 | 0.310 | 0.291 | 0.427 |

*t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9 (continued)

| | (7) Hong Kong | (8) Italy | (9) Norway | (10) Portugal | (11) Spain | (12) Sweden | (13) UK |
|---|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0246 | 0.00883 | 0.00669 | 0.0298 | 0.0127 | 0.00702 | 0.00344 |
| $(\gamma_1)$ | (3.33)*** | (1.05) | (0.62) | (3.80)*** | (1.79)* | (1.10) | (0.37) |
| $\lvert R_{m,t}\rvert$ | 0.229 | 0.179 | 0.321 | 0.310 | 0.178 | 0.175 | 0.263 |
| $(\gamma_2)$ | (9.07)*** | (6.65)*** | (11.09)*** | (15.57)*** | (11.52)*** | (8.06)*** | (9.30)*** |
| $R_{m,t}^2$ | 0.0101 | 0.0223 | 0.00122 | 0.00684 | 0.0175 | 0.00721 | 0.0270 |
| $(\gamma_3)$ | (1.49) | (2.89)*** | (0.23) | (1.47) | (4.22)*** | (1.59) | (3.26)*** |
| _cons | 0.902 | 0.878 | 1.074 | 0.894 | 0.780 | 0.795 | 0.850 |
| | (63.73)*** | (60.43)*** | (47.53)*** | (70.38)*** | (77.05)*** | (55.37)*** | (66.04)*** |
| *N* | 4050 | 4168 | 4120 | 4194 | 4174 | 4123 | 4131 |
| adj. $R^2$ | 0.304 | 0.257 | 0.197 | 0.234 | 0.246 | 0.239 | 0.377 |

*t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Based on the results under the standard approach. We find that Finland, France, Germany, Greece, Italy, Spain and UK have a significantly positive coefficient of squared market return with the US also having a positive coefficient which is significant at the 10% level. Under the

CCK method this indicates that anti-herding exists in these markets. The rest of the countries in our data sample have an insignificantly positive coefficient of squared market return, which shows that neither herding nor anti-herding behaviour is indicated in these markets.

### 5.1.2 Solution 1 Regression results without constant

Table 10: Full range of data Regression results without constant, Robust Regression

$CSAD_t = \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R_{m,t}^2 + \varepsilon_t$

| | (1)<br>Denmark | (2)<br>US | (3)<br>Finland | (4)<br>France | (5)<br>Germany | (6)<br>Greece |
|---|---|---|---|---|---|---|
| $R_{m,t}$ | -0.000468 | 0.00934 | 0.0255 | 0.0234 | 0.0219 | 0.0128 |
| $(\gamma_1)$ | (-0.03) | (1.00) | (2.40)$^{**}$ | (2.87)$^{***}$ | (2.14)$^{**}$ | (0.94) |
| $\|R_{m,t}\|$ | 1.216 | 0.953 | 1.086 | 0.914 | 0.930 | 1.322 |
| $(\gamma_2)$ | (25.56)$^{***}$ | (41.04)$^{***}$ | (42.91)$^{***}$ | (50.30)$^{***}$ | (39.05)$^{***}$ | (18.49)$^{***}$ |
| $R_{m,t}^2$ | -0.119 | -0.0988 | -0.126 | -0.0912 | -0.0836 | -0.0875 |
| $(\gamma_3)$ | (-5.47)$^{***}$ | (-10.02)$^{***}$ | (-12.95)$^{***}$ | (-13.71)$^{***}$ | (-9.38)$^{***}$ | (-3.90)$^{***}$ |
| $N$ | 4105 | 4132 | 4124 | 4202 | 4171 | 4063 |
| adj. $R^2$ | 0.664 | 0.699 | 0.679 | 0.711 | 0.694 | 0.738 |

*t* statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

Table 10 (continued)

| | (7)<br>Hong Kong | (8)<br>Italy | (9)<br>Norway | (10)<br>Portugal | (11)<br>Spain | (12)<br>Sweden | (13)<br>UK |
|---|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0312 | 0.0170 | 0.00755 | 0.0409 | 0.0297 | 0.0265 | 0.00521 |
| $(\gamma_1)$ | (2.60)$^{***}$ | (1.44) | (0.61) | (2.44)$^{**}$ | (2.55)$^{**}$ | (3.20)$^{***}$ | (0.40) |
| $\|R_{m,t}\|$ | 1.007 | 1.059 | 1.127 | 1.293 | 0.980 | 0.815 | 1.175 |
| $(\gamma_2)$ | (27.69)$^{***}$ | (31.07)$^{***}$ | (43.76)$^{***}$ | (26.52)$^{***}$ | (28.38)$^{***}$ | (36.94)$^{***}$ | (40.01)$^{***}$ |
| $R_{m,t}^2$ | -0.0882 | -0.121 | -0.0949 | -0.165 | -0.112 | -0.0693 | -0.114 |
| $(\gamma_3)$ | (-6.26)$^{***}$ | (-8.82)$^{***}$ | (-12.69)$^{***}$ | (-7.19)$^{***}$ | (-7.79)$^{***}$ | (-10.11)$^{***}$ | (-9.24)$^{***}$ |
| $N$ | 4050 | 4168 | 4120 | 4194 | 4174 | 4123 | 4131 |
| adj. $R^2$ | 0.714 | 0.695 | 0.661 | 0.696 | 0.692 | 0.677 | 0.703 |

*t* statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

As mentioned above, one of the solutions to detect herding behaviour more accurately is to remove the constant in the regression in order to ensure that the fitted line goes through the origin, which reduces the impact of the idiosyncratic error term in the CAPM when $|R_{m,t}|$ is small. Our results are shown in Table 10. All the countries have a highly significantly negative coefficient of squared market return, giving strong evidence that there is herding behaviour in these markets. These results are in marked contrast to those from the standard CCK method.

### 5.1.3 Solution 2 Regression results in SCSAD

Table 11: Full range of data robust regression using SCSAD (equation 3), Robust Regression

$SCSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 R_{m,t}^2 + \gamma_3 R_{m,t}^3 + \mu_t$ (equation 3)

| | (1) Denmark | (2) US | (3) Finland | (4) France | (5) Germany | (6) Greece |
|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.985 | 0.775 | 0.837 | 0.728 | 0.754 | 1.071 |
| ($\gamma_1$) | (53.50)*** | (69.81)*** | (56.70)*** | (65.04)*** | (64.43)*** | (47.41)*** |
| $R_{m,t}^2$ | -0.00815 | 0.0106 | 0.00956 | 0.00656 | 0.00880 | -0.00736 |
| ($\gamma_2$) | (-1.07) | (2.63)*** | (1.87)* | (1.89)* | (2.32)** | (-1.35) |
| $R_{m,t}^3$ | -0.00900 | -0.00865 | -0.0110 | -0.00758 | -0.00620 | -0.00402 |
| ($\gamma_3$) | (-4.68)*** | (-9.30)*** | (-8.79)*** | (-9.30)*** | (-7.64)*** | (-3.35)*** |
| _cons | 0.0255 | -0.0152 | 0.000307 | 0.00998 | 0.00845 | 0.0997 |
| | (1.58) | (-1.50) | (0.02) | (0.86) | (0.70) | (4.66)*** |
| $N$ | 4105 | 4132 | 4124 | 4202 | 4171 | 4063 |
| adj. $R^2$ | 0.637 | 0.672 | 0.642 | 0.683 | 0.670 | 0.709 |

*t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11 (continued)

| | (7) Hong Kong | (8) Italy | (9) Norway | (10) Portugal | (11) Spain | (12) Sweden | (13) UK |
|---|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.806 | 0.819 | 0.893 | 1.003 | 0.769 | 0.650 | 0.953 |
| ($\gamma_1$) | (61.55)*** | (45.23)*** | (51.77)*** | (48.16)*** | (42.39)*** | (56.07)*** | (63.92)*** |
| $R_{m,t}^2$ | 0.00144 | 0.00772 | -0.00126 | 0.0154 | 0.0114 | 0.00977 | -0.00475 |
| ($\gamma_2$) | (0.27) | (1.25) | (-0.32) | (1.59) | (1.94)* | (4.02)*** | (-0.95) |
| $R_{m,t}^3$ | -0.00515 | -0.0101 | -0.00656 | -0.0141 | -0.00954 | -0.00478 | -0.00917 |
| ($\gamma_3$) | (-5.26)*** | (-5.57)*** | (-8.37)*** | (-5.01)*** | (-4.91)*** | (-8.05)*** | (-7.84)*** |
| _cons | 0.0522 | 0.0108 | 0.0425 | 0.0350 | 0.0243 | 0.00793 | 0.0383 |
| | (3.56)*** | (0.72) | (2.23)** | (2.11)** | (1.93)* | (0.68) | (3.17)*** |
| $N$ | 4050 | 4168 | 4120 | 4194 | 4174 | 4123 | 4131 |
| adj. $R^2$ | 0.682 | 0.663 | 0.635 | 0.661 | 0.660 | 0.648 | 0.676 |

*t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11 shows the results for our second solution 2 - the new SCSAD method. The results show that all the countries have highly significantly negative coefficients of $R_{m,t}^3$, which means we can confirm that these countries have herding behaviour in their stock market. Also, the adjusted $R^2$ is much higher than in the traditional method.

### 5.1.3 Solution 3 Regression considering large market returns

In this sub-section we present results related to our third solution which is to only consider large market returns selected by various criteria.

#### 5.1.3.1 Market return larger than |0.5%|

Table 12 panel A: Robust Regression with market return larger than |0.5%|

$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R_{m,t}^2 + \varepsilon_t$ (equation 2)

| | (1) Denmark | (2) US | (3) Finland | (4) France | (5) Germany | (6) Greece |
|---|---|---|---|---|---|---|
| $R_{m,t}$ | -0.00245 | -0.00547 | 0.0138 | 0.0127 | 0.00914 | 0.00766 |
| $(\gamma_1)$ | (-0.20) | (-0.78) | (1.98)** | (2.26)** | (1.20) | (0.95) |
| $\|R_{m,t}\|$ | 0.275 | 0.320 | 0.203 | 0.225 | 0.231 | 0.388 |
| $(\gamma_2)$ | (2.72)*** | (9.01)*** | (5.99)*** | (9.04)*** | (4.97)*** | (15.83)*** |
| $R_{m,t}^2$ | 0.0223 | -0.00311 | 0.00629 | 0.00993 | 0.0147 | 0.00922 |
| $(\gamma_3)$ | (0.89) | (-0.43) | (0.91) | (2.26)** | (1.57) | (2.51)** |
| _cons | 0.906 | 0.592 | 0.927 | 0.725 | 0.749 | 1.294 |
| | (12.01)*** | (20.18)*** | (30.22)*** | (31.02)*** | (18.99)*** | (47.44)*** |
| $N$ | 2457 | 2396 | 2668 | 2696 | 2636 | 2762 |
| adj. $R^2$ | 0.245 | 0.316 | 0.183 | 0.331 | 0.301 | 0.444 |

*t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12 panel A (continued)

| | (7) Hong Kong | (8) Italy | (9) Norway | (10) Portugal | (11) Spain | (12) Sweden | (13) UK |
|---|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0258 | 0.0105 | 0.00736 | 0.0309 | 0.0140 | 0.00927 | 0.00501 |
| $(\gamma_1)$ | (3.63)*** | (1.24) | (0.68) | (3.84)*** | (1.94)* | (1.48) | (0.53) |
| $\|R_{m,t}\|$ | 0.301 | 0.242 | 0.404 | 0.342 | 0.222 | 0.235 | 0.341 |
| $(\gamma_2)$ | (9.92)*** | (5.69)*** | (10.19)*** | (10.01)*** | (9.06)*** | (8.43)*** | (7.87)*** |
| $R_{m,t}^2$ | 0.00161 | 0.0126 | -0.00820 | 0.00146 | 0.0111 | 0.000359 | 0.0158 |
| $(\gamma_3)$ | (0.26) | (1.32) | (-1.39) | (0.22) | (2.28)** | (0.08) | (1.68)* |
| _cons | 0.806 | 0.807 | 0.950 | 0.863 | 0.729 | 0.710 | 0.764 |
| | (29.91)*** | (23.05)*** | (22.27)*** | (28.29)*** | (31.57)*** | (26.07)*** | (22.22)*** |
| $N$ | 2584 | 2602 | 2968 | 2420 | 2524 | 2757 | 2211 |
| adj. $R^2$ | 0.323 | 0.267 | 0.193 | 0.223 | 0.259 | 0.263 | 0.386 |

*t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

#### 5.1.3.2 Market return larger than |1%|

Table 12 panel B: Robust Regression with market return larger than |1%|

$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R_{m,t}^2 + \varepsilon_t$ (equation 2)

| | (1) Denmark | (2) US | (3) Finland | (4) France | (5) Germany | (6) Greece |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.00239 | -0.00304 | 0.0162 | 0.0147 | 0.0132 | 0.00783 |
| $(\gamma_1)$ | (0.17) | (-0.40) | (2.22)** | (2.49)** | (1.70)* | (0.94) |
| $\lvert R_{m,t}\rvert$ | 0.364 | 0.446 | 0.237 | 0.271 | 0.330 | 0.423 |
| $(\gamma_2)$ | (2.38)** | (8.33)*** | (4.45)*** | (7.13)*** | (5.02)*** | (11.18)*** |
| $R^2_{m,t}$ | 0.0117 | -0.0183 | 0.00211 | 0.00433 | 0.00344 | 0.00621 |
| $(\gamma_3)$ | (0.38) | (-2.14)** | (0.24) | (0.79) | (0.32) | (1.31) |
| _cons | 0.778 | 0.407 | 0.873 | 0.656 | 0.592 | 1.225 |
| | (4.95)*** | (6.66)*** | (13.52)*** | (13.65)*** | (7.71)*** | (22.45)*** |
| $N$ | 1319 | 1267 | 1606 | 1578 | 1570 | 1775 |
| adj. $R^2$ | 0.266 | 0.342 | 0.191 | 0.339 | 0.321 | 0.435 |

$t$ statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12 panel B (continued)

| | (7)<br>Hong Kong | (8)<br>Italy | (9)<br>Norway | (10)<br>Portugal | (11)<br>Spain | (12)<br>Sweden | (13)<br>UK |
|---|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0257 | 0.0139 | 0.00847 | 0.0327 | 0.0157 | 0.0122 | 0.00736 |
| $(\gamma_1)$ | (3.49)*** | (1.51) | (0.75) | (3.78)*** | (2.01)** | (1.88)* | (0.72) |
| $\lvert R_{m,t}\rvert$ | 0.366 | 0.238 | 0.461 | 0.305 | 0.254 | 0.323 | 0.413 |
| $(\gamma_2)$ | (9.58)*** | (3.31)*** | (8.20)*** | (5.56)*** | (6.21)*** | (9.26)*** | (6.14)*** |
| $R^2_{m,t}$ | -0.00498 | 0.0133 | -0.0139 | 0.00700 | 0.00687 | -0.00854 | 0.00711 |
| $(\gamma_3)$ | (-0.83) | (1.03) | (-2.00)** | (0.85) | (1.13) | (-1.94)* | (0.63) |
| _cons | 0.699 | 0.815 | 0.848 | 0.907 | 0.684 | 0.557 | 0.657 |
| | (14.57)*** | (9.77)*** | (10.83)*** | (13.53)*** | (13.05)*** | (11.79)*** | (8.41)*** |
| $N$ | 1544 | 1535 | 2011 | 1326 | 1437 | 1673 | 1105 |
| adj. $R^2$ | 0.321 | 0.234 | 0.173 | 0.197 | 0.252 | 0.283 | 0.388 |

$t$ statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

### 5.1.3.3 market return larger than |2%|

Table 12 panel C: Robust Regression with market return larger than |2%|
$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R^2_{m,t} + \varepsilon_t$ (equation 2)

| | (1)<br>Denmark | (2)<br>US | (3)<br>Finland | (4)<br>France | (5)<br>Germany | (6)<br>Greece |
|---|---|---|---|---|---|---|
| $R_{m,t}$ | -0.00128 | 0.00307 | 0.0185 | 0.0172 | 0.0202 | 0.00393 |
| $(\gamma_1)$ | (-0.06) | (0.29) | (2.00)** | (2.37)** | (2.05)** | (0.38) |
| $\lvert R_{m,t}\rvert$ | 0.493 | 0.538 | 0.198 | 0.418 | 0.470 | 0.420 |
| $(\gamma_2)$ | (1.59) | (4.34)*** | (1.61) | (5.07)*** | (3.33)*** | (5.50)*** |
| $R^2_{m,t}$ | -0.000173 | -0.0279 | 0.00541 | -0.0111 | -0.01000 | 0.00610 |
| $(\gamma_3)$ | (0.00) | (-1.91)* | (0.35) | (-1.24) | (-0.60) | (0.92) |
| _cons | 0.488 | 0.228 | 0.975 | 0.369 | 0.299 | 1.246 |
| | (0.98) | (1.02) | (4.38)*** | (2.35)** | (1.16) | (7.43)*** |
| $N$ | 341 | 318 | 528 | 544 | 506 | 716 |
| adj. $R^2$ | 0.274 | 0.283 | 0.173 | 0.336 | 0.324 | 0.388 |

$t$ statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12 panel C (continued)

| | (7) Hong Kong | (8) Italy | (9) Norway | (10) Portugal | (11) Spain | (12) Sweden | (13) UK |
|---|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0285 | 0.0221 | 0.00712 | 0.0280 | 0.0206 | 0.0212 | 0.0103 |
| $(\gamma_1)$ | (3.10)*** | (1.79)* | (0.53) | (2.33)** | (1.97)** | (2.74)*** | (0.75) |
| $\|R_{m,t}\|$ | 0.494 | 0.322 | 0.444 | -0.0817 | 0.273 | 0.465 | 0.747 |
| $(\gamma_2)$ | (7.23)*** | (1.76)* | (3.63)*** | (-0.55) | (2.38)** | (7.32)*** | (4.94)*** |
| $R^2_{m,t}$ | -0.0158 | 0.00430 | -0.0127 | 0.0497 | 0.00440 | -0.0205 | -0.0259 |
| $(\gamma_3)$ | (-2.39)** | (0.18) | (-1.10) | (3.11)*** | (0.38) | (-3.59)*** | (-1.57) |
| _cons | 0.414 | 0.647 | 0.899 | 1.639 | 0.661 | 0.222 | -0.0366 |
| | (2.93)*** | (2.04)** | (3.55)*** | (5.75)*** | (2.98)*** | (1.68)* | (-0.13) |
| $N$ | 513 | 534 | 837 | 364 | 434 | 623 | 330 |
| adj. $R^2$ | 0.327 | 0.226 | 0.111 | 0.170 | 0.230 | 0.269 | 0.377 |

$t$ statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

### 5.1.3.4 market return larger than |3%|

Table 12 panel D: Robust Regression with market return larger than |3%|
$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R^2_{m,t} + \varepsilon_t$ (equation 2)

| | (1) Denmark | (2) US | (3) Finland | (4) France | (5) Germany | (6) Greece |
|---|---|---|---|---|---|---|
| $R_{m,t}$ | -0.00820 | 0.00958 | 0.0222 | 0.0181 | 0.0263 | 0.00674 |
| $(\gamma_1)$ | (-0.26) | (0.69) | (1.85)* | (2.01)** | (1.93)* | (0.49) |
| $\|R_{m,t}\|$ | 0.886 | 0.770 | 0.386 | 0.632 | 0.740 | 0.373 |
| $(\gamma_2)$ | (2.02)** | (2.98)*** | (1.33) | (3.57)*** | (2.76)*** | (2.53)** |
| $R^2_{m,t}$ | -0.0337 | -0.0481 | -0.0106 | -0.0295 | -0.0327 | 0.00884 |
| $(\gamma_3)$ | (-0.68) | (-1.99)** | (-0.37) | (-1.85)* | (-1.34) | (0.88) |
| _cons | -0.510 | -0.354 | 0.468 | -0.191 | -0.389 | 1.409 |
| | (-0.52) | (-0.55) | (0.67) | (-0.44) | (-0.57) | (3.31)*** |
| $N$ | 112 | 113 | 204 | 222 | 174 | 278 |
| adj. $R^2$ | 0.236 | 0.188 | 0.202 | 0.330 | 0.288 | 0.397 |

$t$ statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12 panel D (continued)

| | (7) Hong Kong | (8) Italy | (9) Norway | (10) Portugal | (11) Spain | (12) Sweden | (13) UK |
|---|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0258 | 0.0276 | 0.0111 | 0.0168 | 0.0251 | 0.0233 | 0.00415 |
| $(\gamma_1)$ | (2.02)** | (1.46) | (0.67) | (1.08) | (1.68)* | (2.34)** | (0.22) |
| $\|R_{m,t}\|$ | 0.779 | 0.457 | 0.651 | 0.140 | 0.545 | 0.516 | 1.124 |
| $(\gamma_2)$ | (5.30)*** | (1.21) | (2.97)*** | (0.45) | (1.83)* | (4.94)*** | (3.08)*** |
| $R^2_{m,t}$ | -0.0355 | -0.00670 | -0.0282 | 0.0306 | -0.0190 | -0.0244 | -0.0596 |
| $(\gamma_3)$ | (-3.54)*** | (-0.17) | (-1.64) | (1.11) | (-0.70) | (-3.11)*** | (-1.89)* |
| _cons | -0.425 | 0.272 | 0.299 | 1.035 | -0.0607 | 0.0801 | -0.955 |
| | (-1.01) | (0.32) | (0.51) | (1.30) | (-0.08) | (0.28) | (-1.03) |
| $N$ | 164 | 197 | 356 | 110 | 150 | 260 | 129 |
| adj. $R^2$ | 0.380 | 0.172 | 0.093 | 0.313 | 0.215 | 0.195 | 0.308 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

As we mentioned above, according to the existing literature, herding is expected to be most acute when there are large overall market movements. We have also proposed that the effects of a less than perfect fit of the CAPM model will distort the standard CCK for herding in favor of finding anti-herding and this effect is primarily associated with periods of relatively low absolute market returns. Thus, we expect concentrating on larger market returns to show more evidence of herding. In this section, we have tested for herding behaviour with market returns larger than |0.5%|, |1%|, |2%| and |3%| using the standard regression model. The results shown in the various panels in Table 12 are strongly supportive of our expectations. As we progress from panel A to panel D the number of countries with significantly negative coefficients of squared market returns, which is indicative of herding, progressively increases from 0 in panel A to 5 in panel D. Furthermore, if just the signs of the coefficients are considered, only 2 are negative in panel A whereas 11 are negative in panel D. There is a corresponding pattern for positive coefficients of squared market returns. If we consider the number of significant positive coefficients which are associated with anti-herding these reduce from 4 in panel A to 0 in panel D. If we further consider the normal CCK test on all the data shown in Table 9 all the coefficients are positive, 8 of them at a significant level.

### 5.1.4 Larger market movements based on a proportion of the data condition

#### 5.1.4.1 Largest 50% of returns (50% of absolute value (above 25% and 25% below 0))

**Regression results by using the CCK regression method**

Table 13 panel A Robust Regression largest 50% of returns by absolute value
$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R^2_{m,t} + \varepsilon_t$ (equation 2)

| | (1) Denmark | (2) US | (3) Finland | (4) France | (5) Germany | (6) Greece |
|---|---|---|---|---|---|---|
| $R_{m,t}$ | -0.00286 | -0.00604 | 0.0142 | 0.0136 | 0.00834 | 0.00774 |
| $(\gamma_1)$ | (-0.23) | (-0.85) | (2.00)$^{**}$ | (2.38)$^{**}$ | (1.08) | (0.94) |
| $\|R_{m,t}\|$ | 0.294 | 0.345 | 0.193 | 0.246 | 0.258 | 0.401 |
| $(\gamma_2)$ | (2.59)$^{***}$ | (8.71)$^{***}$ | (4.45)$^{***}$ | (8.18)$^{***}$ | (4.58)$^{***}$ | (12.31)$^{***}$ |
| $R^2_{m,t}$ | 0.0199 | -0.00625 | 0.00745 | 0.00727 | 0.0116 | 0.00806 |
| $(\gamma_3)$ | (0.75) | (-0.83) | (0.93) | (1.51) | (1.13) | (1.91)$^{*}$ |
| _cons | 0.881 | 0.558 | 0.942 | 0.694 | 0.710 | 1.272 |
| | (9.46)$^{***}$ | (15.46)$^{***}$ | (20.24)$^{***}$ | (21.27)$^{***}$ | (12.59)$^{***}$ | (28.78)$^{***}$ |
| $N$ | 2052 | 2066 | 2062 | 2102 | 2086 | 2032 |
| adj. $R^2$ | 0.252 | 0.319 | 0.176 | 0.340 | 0.300 | 0.431 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

Table 13 panel A (continued)

| | (7) Hong Kong | (8) Italy | (9) Norway | (10) Portugal | (11) Spain | (12) Sweden | (13) UK |
|---|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0253 | 0.0121 | 0.00862 | 0.0323 | 0.0137 | 0.0103 | 0.00450 |
| $(\gamma_1)$ | $(3.54)^{***}$ | (1.39) | (0.77) | $(3.99)^{***}$ | $(1.86)^{*}$ | (1.64) | (0.48) |
| $\lvert R_{m,t}\rvert$ | 0.332 | 0.251 | 0.454 | 0.316 | 0.226 | 0.293 | 0.346 |
| $(\gamma_2)$ | $(9.86)^{***}$ | $(4.82)^{***}$ | $(8.32)^{***}$ | $(8.52)^{***}$ | $(7.88)^{***}$ | $(9.45)^{***}$ | $(7.71)^{***}$ |
| $R_{m,t}^2$ | -0.00166 | 0.0114 | -0.0133 | 0.00522 | 0.0104 | -0.00551 | 0.0151 |
| $(\gamma_3)$ | (-0.27) | (1.07) | $(-1.94)^{*}$ | (0.79) | $(2.03)^{**}$ | (-1.28) | (1.58) |
| _cons | 0.757 | 0.795 | 0.862 | 0.895 | 0.723 | 0.613 | 0.757 |
| | $(21.35)^{***}$ | $(15.90)^{***}$ | $(11.54)^{***}$ | $(24.85)^{***}$ | $(23.86)^{***}$ | $(16.62)^{***}$ | $(20.48)^{***}$ |
| $N$ | 2026 | 2083 | 2060 | 2098 | 2088 | 2062 | 2066 |
| adj. $R^2$ | 0.327 | 0.257 | 0.175 | 0.213 | 0.256 | 0.284 | 0.389 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

From the results shown in table 13 panel A, which is based on the largest 50% of returns in absolute terms, we find little evidence herding or anti-herding behaviour. Norway has a negative coefficient of squared market return which is only significant at the 10% level giving an indication of herding. Spain has a positive coefficient which is significant at the 5% level giving an indication of anti-herding.

### 5.1.4.2 Largest 10% of returns (10% of absolute value (above 5% and 5% below 0))

**Regression results using the CCK regression method**

Table 13 panel B, Robust Regression largest 10% of returns by absolute value
$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 \lvert R_{m,t}\rvert + \gamma_3 R_{m,t}^2 + \varepsilon_t$ (equation 2)

| | (1) Denmark | (2) US | (3) Finland | (4) France | (5) Germany | (6) Greece |
|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.00469 | 0.00486 | 0.0189 | 0.0177 | 0.0209 | 0.00414 |
| $(\gamma_1)$ | (0.24) | (0.50) | $(1.90)^{*}$ | $(2.26)^{**}$ | $(2.01)^{**}$ | (0.35) |
| $\lvert R_{m,t}\rvert$ | 0.404 | 0.506 | 0.133 | 0.492 | 0.532 | 0.434 |
| $(\gamma_2)$ | (1.38) | $(4.65)^{***}$ | (0.85) | $(4.85)^{***}$ | $(3.45)^{***}$ | $(3.90)^{***}$ |
| $R_{m,t}^2$ | 0.00816 | -0.0252 | 0.0116 | -0.0179 | -0.0154 | 0.00525 |
| $(\gamma_3)$ | (0.19) | $(-1.88)^{*}$ | (0.64) | $(-1.74)^{*}$ | (-0.89) | (0.62) |
| _cons | 0.688 | 0.305 | 1.123 | 0.195 | 0.149 | 1.201 |
| | (1.53) | $(1.65)^{*}$ | $(3.62)^{***}$ | (0.92) | (0.50) | $(4.24)^{***}$ |
| $N$ | 410 | 414 | 412 | 420 | 418 | 406 |
| adj. $R^2$ | 0.265 | 0.277 | 0.158 | 0.329 | 0.331 | 0.420 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

Table 13 panel B (continued)

| | (7) Hong Kong | (8) Italy | (9) Norway | (10) Portugal | (11) Spain | (12) Sweden | (13) UK |
|---|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0291 | 0.0251 | 0.00978 | 0.0276 | 0.0193 | 0.0242 | 0.0135 |
| $(\gamma_1)$ | (2.93)*** | (1.76)* | (0.62) | (2.37)** | (1.82)* | (2.77)*** | (1.06) |
| $\lvert R_{m,t}\rvert$ | 0.457 | 0.370 | 0.628 | 0.105 | 0.278 | 0.495 | 0.640 |
| $(\gamma_2)$ | (5.53)*** | (1.61) | (3.13)*** | (0.85) | (2.40)** | (5.90)*** | (5.24)*** |
| $R^2_{m,t}$ | -0.0130 | -0.000246 | -0.0267 | 0.0305 | 0.00384 | -0.0229 | -0.0156 |
| $(\gamma_3)$ | (-1.72)* | (-0.01) | (-1.65)* | (2.24)** | (0.32) | (-3.33)*** | (-1.07) |
| _cons | 0.511 | 0.538 | 0.372 | 1.248 | 0.651 | 0.144 | 0.199 |
| | (2.78)*** | (1.25) | (0.72) | (5.46)*** | (2.90)*** | (0.71) | (0.93) |
| $N$ | 406 | 416 | 412 | 420 | 418 | 412 | 414 |
| adj. $R^2$ | 0.302 | 0.221 | 0.099 | 0.185 | 0.226 | 0.228 | 0.389 |

*t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13 panel B shows the results associated with the largest 10% of observations in absolute terms. We capture some evidence of herding behaviour in a number of the markets. Sweden has a highly significantly negative coefficient of squared market return, and US, France, Hong Kong and Norway have negative coefficients which are significant at 10% level. There is little evidence of anti-herding with just Portugal having a significantly positive coefficient of squared market returns.

**5.1.4.3 Largest 5% of returns (5% of absolute value (above 2.5% and 2.5% below 0))**

**Regression results using the CCK regression method**

Table 13 panel C, Robust Regression largest 5% of returns by absolute value
$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 \lvert R_{m,t}\rvert + \gamma_3 R^2_{m,t} + \varepsilon_t$ (equation 2)

| | (1) Denmark | (2) US | (3) Finland | (4) France | (5) Germany | (6) Greece |
|---|---|---|---|---|---|---|
| $R_{m,t}$ | -0.00189 | 0.0153 | 0.0243 | 0.0206 | 0.0233 | 0.00344 |
| $(\gamma_1)$ | (-0.08) | (1.31) | (2.06)** | (2.24)** | (1.77)* | (0.23) |
| $\lvert R_{m,t}\rvert$ | 0.713 | 0.727 | 0.476 | 0.631 | 0.862 | 0.325 |
| $(\gamma_2)$ | (1.92)* | (4.51)*** | (1.75)* | (3.33)*** | (4.08)*** | (1.90)* |
| $R^2_{m,t}$ | -0.0189 | -0.0452 | -0.0183 | -0.0294 | -0.0417 | 0.0114 |
| $(\gamma_3)$ | (-0.39) | (-2.62)*** | (-0.69) | (-1.74)* | (-2.12)** | (1.04) |
| _cons | -0.0676 | -0.226 | 0.226 | -0.190 | -0.759 | 1.592 |
| | (-0.10) | (-0.67) | (0.35) | (-0.40) | (-1.49) | (3.02)*** |
| $N$ | 206 | 208 | 206 | 210 | 208 | 204 |
| adj. $R^2$ | 0.295 | 0.277 | 0.216 | 0.321 | 0.345 | 0.396 |

*t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13 panel C (continued)

| | (7) Hong Kong | (8) Italy | (9) Norway | (10) Portugal | (11) Spain | (12) Sweden | (13) UK |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0309 | 0.0281 | 0.00263 | 0.0339 | 0.0236 | 0.0301 | 0.0116 |
| $(\gamma_1)$ | (2.65)*** | (1.43) | (0.13) | (2.53)** | (1.78)* | (2.80)*** | (0.75) |
| $\lvert R_{m,t}\rvert$ | 0.715 | 0.157 | 0.611 | 0.00393 | 0.342 | 0.651 | 0.964 |
| $(\gamma_2)$ | (5.92)*** | (0.39) | (1.70)* | (0.02) | (1.65) | (5.69)*** | (4.34)*** |
| $R^2_{m,t}$ | -0.0312 | 0.0186 | -0.0257 | 0.0419 | -0.00158 | -0.0336 | -0.0454 |
| $(\gamma_3)$ | (-3.62)*** | (0.44) | (-1.01) | (2.12)** | (-0.08) | (-4.18)*** | (-2.15)** |
| _cons | -0.230 | 1.092 | 0.426 | 1.434 | 0.479 | -0.366 | -0.554 |
| | (-0.70) | (1.22) | (0.37) | (3.41)*** | (1.02) | (-1.06) | (-1.11) |
| *N* | 202 | 208 | 206 | 210 | 208 | 206 | 206 |
| adj. $R^2$ | 0.380 | 0.138 | 0.048 | 0.238 | 0.212 | 0.212 | 0.355 |

*t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13 panel C shows the results associated with the largest 5% of observations in absolute terms. The results indicate that US, Germany, Hong Kong, Sweden and UK, have herding behaviour as shown by significantly negative coefficients on the squared market return variable. Only Portugal shows any indication of anti-herding behaviour as shown by the significantly positive coefficient of the squared market return.

Overall, the results shown in the various panels in Table 13 are strongly supportive of our expectations that larger market returns will be associated with greater herding.

**5.2 Fitted lines for regression results**

**5.2.1 Fitted lines for CSAD based on Log returns for the full range of data.**

The plots in Figure 7 give a clear visual illustration of our findings. They show the fitted lines for the standard herding CCK test based on regressing CSAD on $R_{mt}$. The fitted lines almost all curve in a convex way which corresponds to a positive coefficient on the $R^2_{m,t}$ term. As discussed above, one would expect this even if there is no herding.

The scatter shows the distribution of the CSAD figures and the fitted line shows the fitted value based on regression results using equation 2. According to the regression results shown in Table 9, no significant herding behaviour is indicated in the selected country in the sample period, and from these figures, we see that the fitted regression line is upwards curved in most cases although some are close to a straight line such as Norway and Portugal, which also indicates there is no herding behaviour in those markets.

**Figure 7 Plots of CSAD against $R_{mt}$ for the Countries under investigation using the CCK approach**

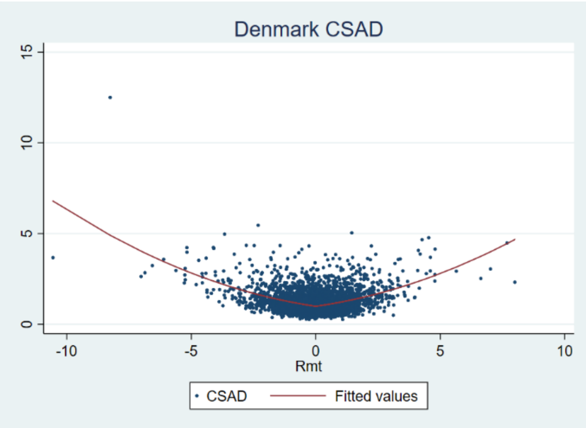



Figure7.1

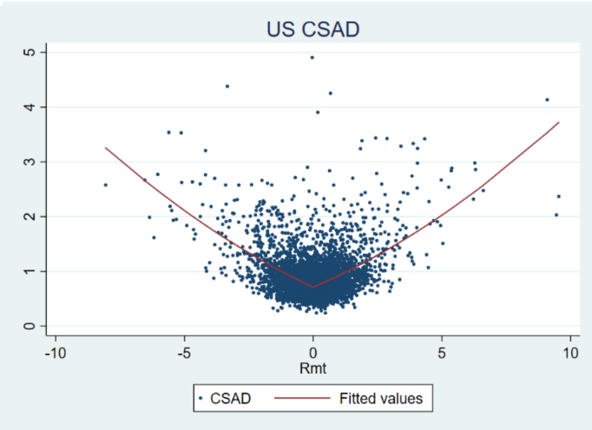



Figure 7.2

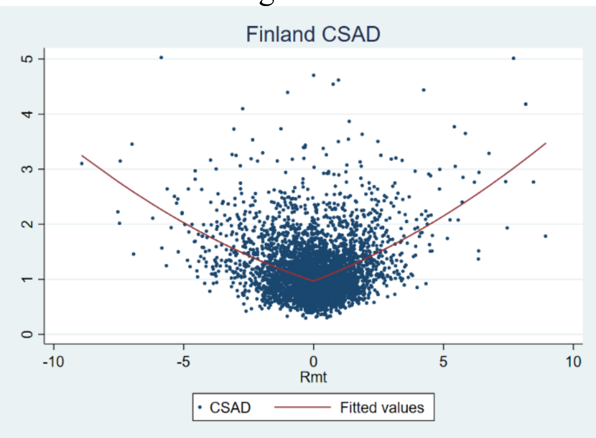



Figure 7.3

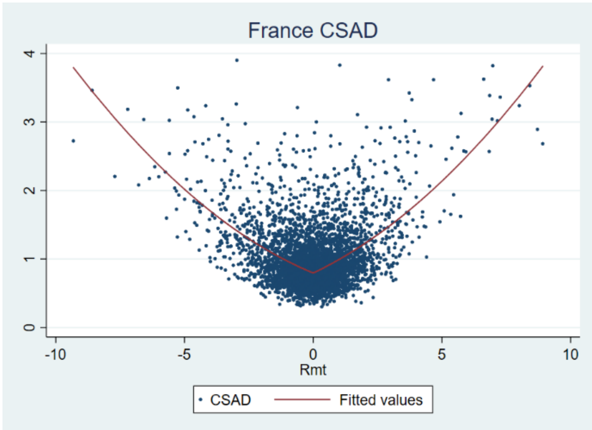



Figure 7.4

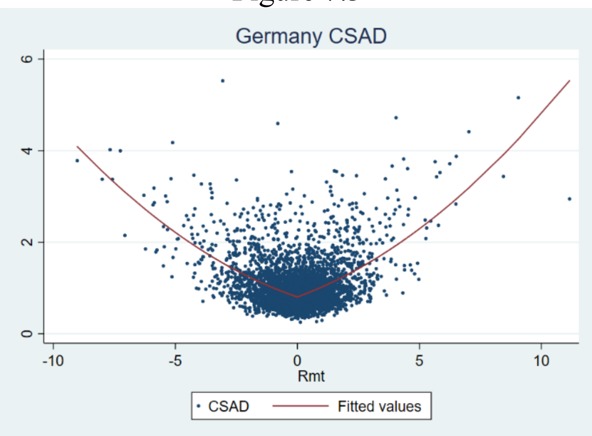



Figure 7.5

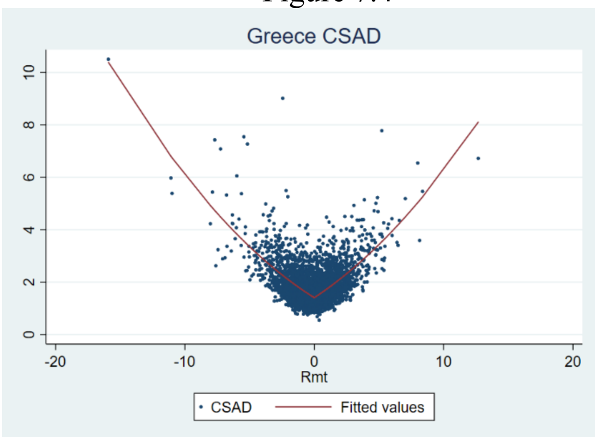



Figure 7.6

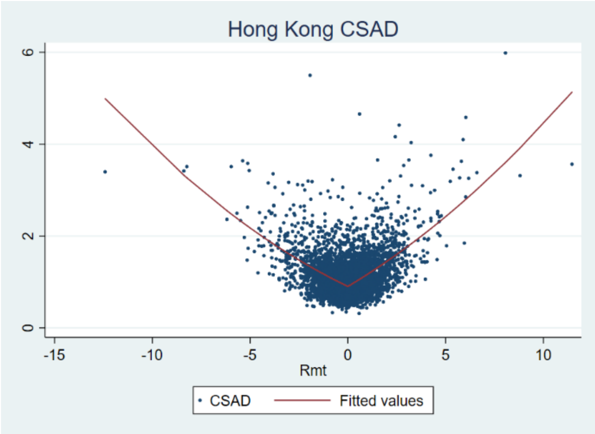



Figure 7.7

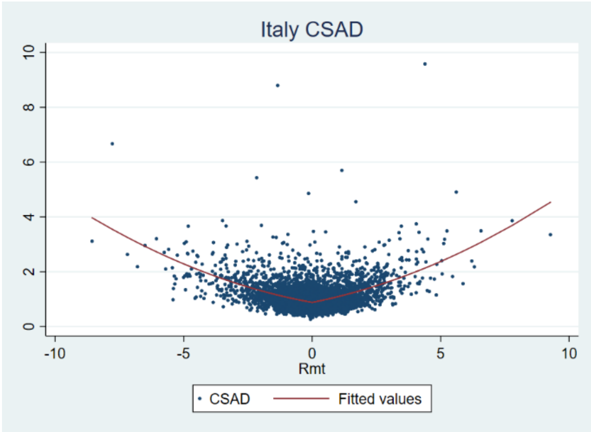



Figure 7.8

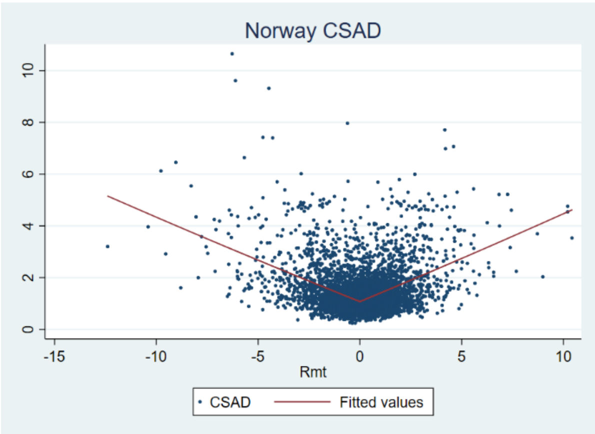



Figure 7.9

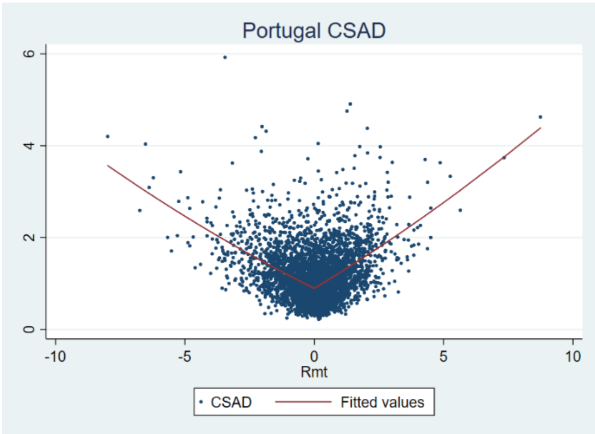



Figure 7.10

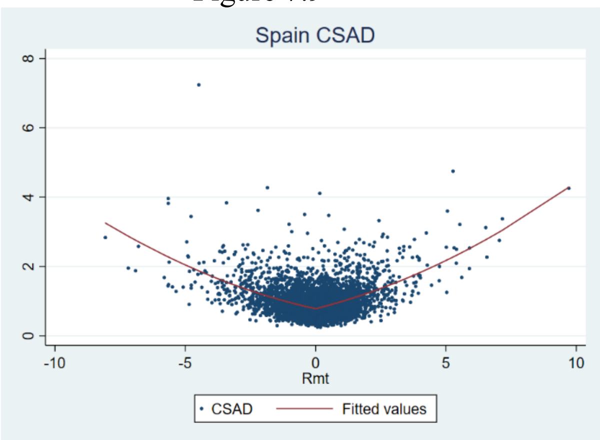



Figure 7.11

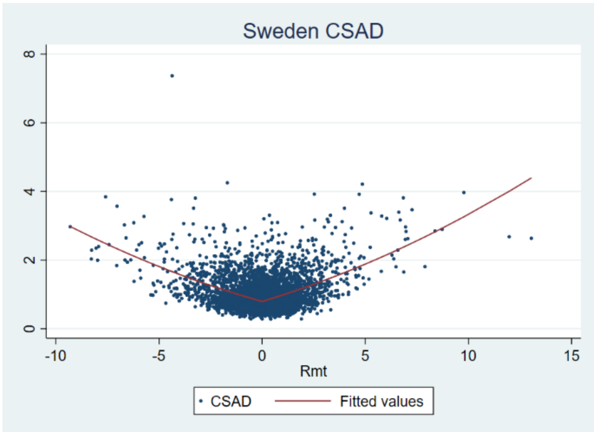



Figure 7.12

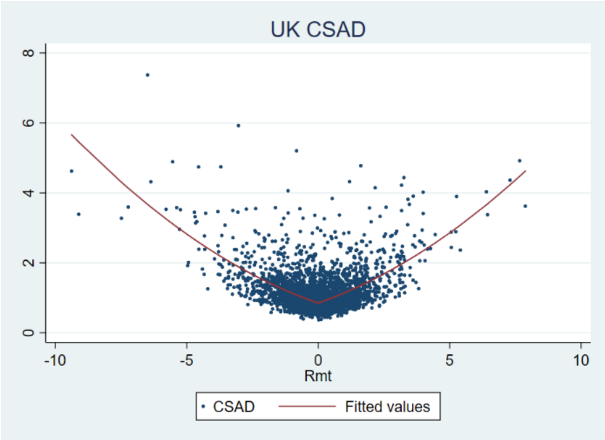



Figure 7.13

### 5.2.2 Solution 1: Fitted line for CSAD without constant.

By using the solution 1 regression without constant value where the results are shown in Table 10, all countries have a significantly negative coefficient of squared market return which indicates the existence of herding behaviour in their stock market. Also, from these figures, we can see that the regression line is curved downwards, this indicates the presence of herding behaviour in the stock market.

**Figure 8 Plots of CSAD against $R_{mt}$ without constant term for the Countries under investigation**

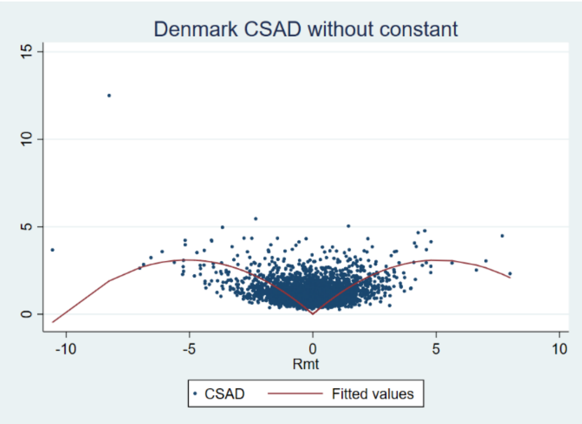



Figure 8.1

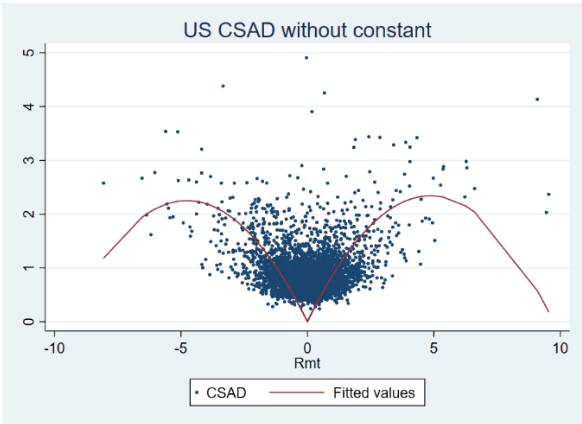



Figure 8.2

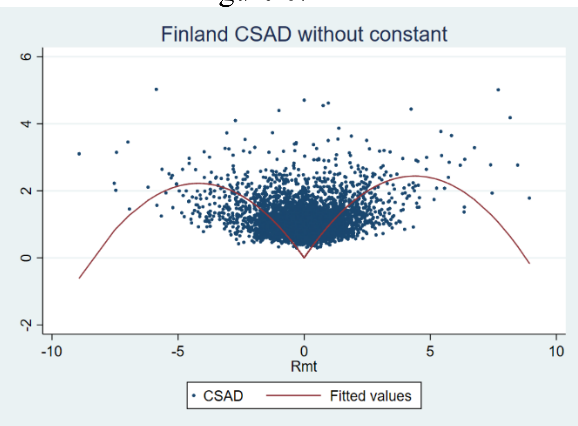



Figure 8.3

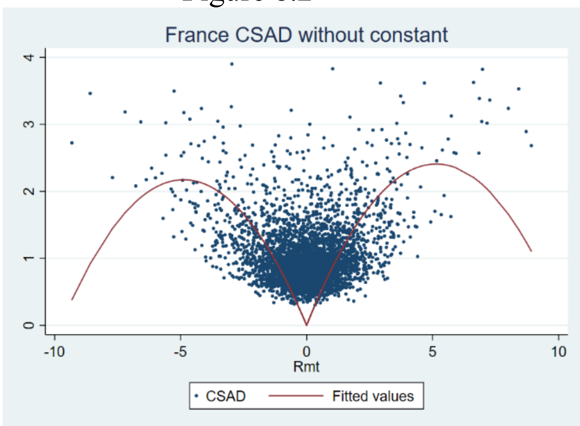



Figure 8.4

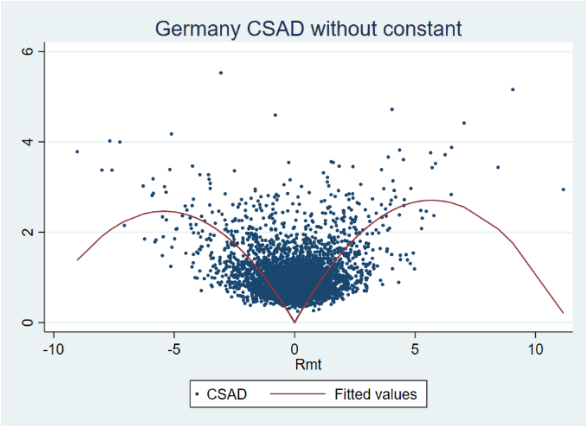



Figure 8.5

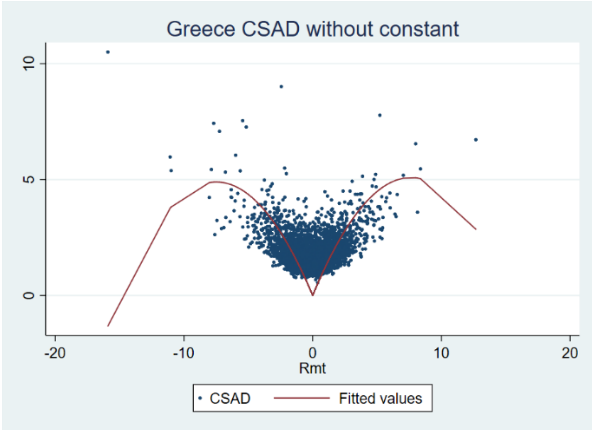



Figure 8.6

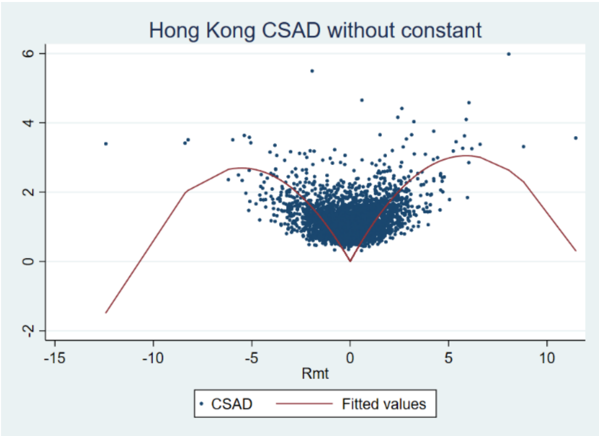



Figure 8.7

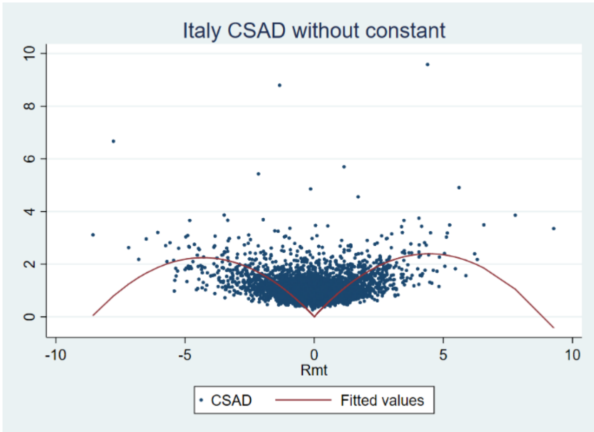



Figure 8.8

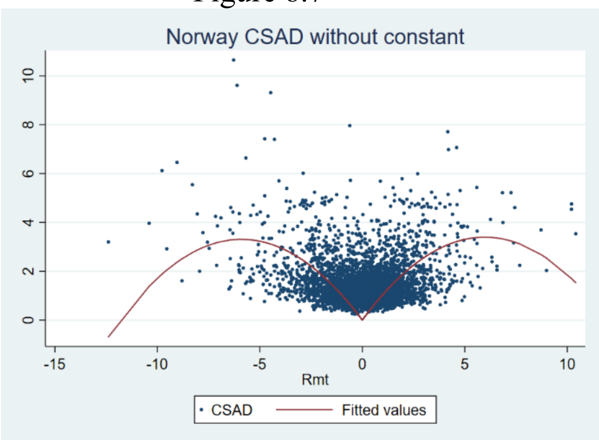



Figure 8.9

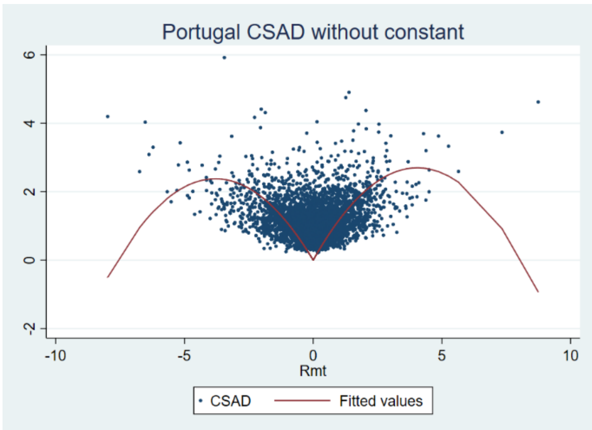



Figure 8.10

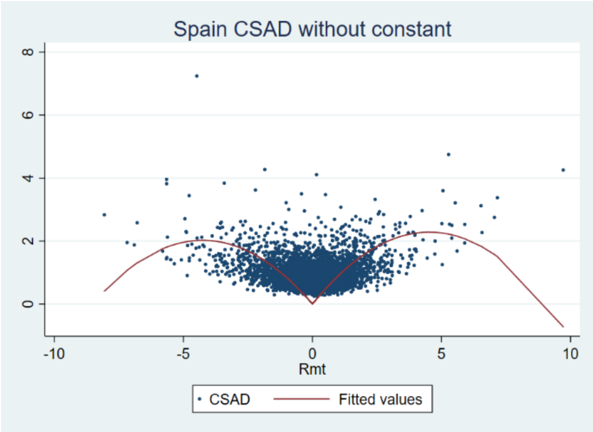


Figure 8.11

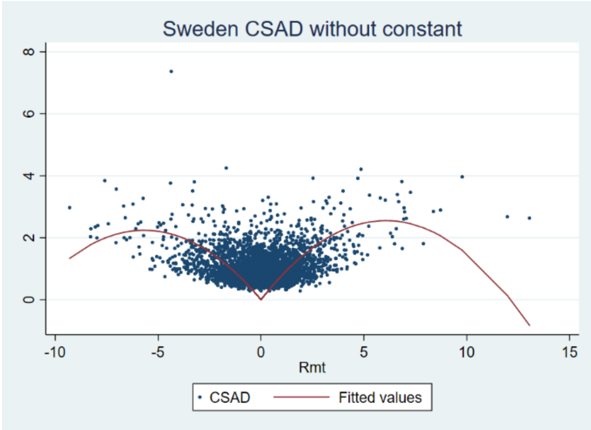


Figure 8.12

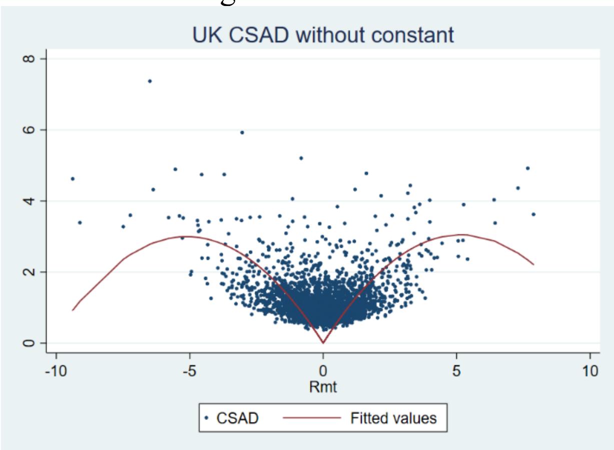


Figure 8.13

### 5.2.3 Fitted line for SCSAD based on Log returns for the full range of data.

When we apply our new method, the solution 2 SCSAD regression model, to detect the presence of herding behaviour in the stock market, as the results shown in Table in 11, we have captured significant evidence of herding behaviour. The following figures show the regression line curved as expected indicating that herding behaviour exists in the stock markets of the selected countries in our data sample.

Figure 9 Plots of SCSAD against $R_{mt}$ for the Countries under investigation

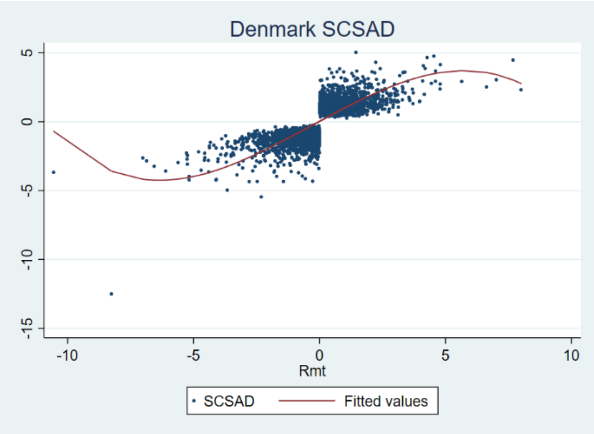



Figure 9.1

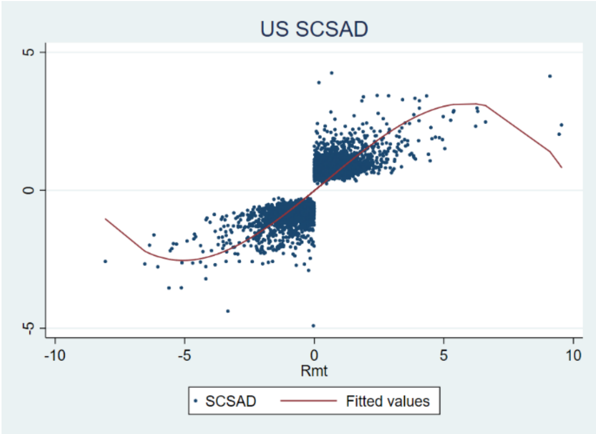



Figure 9.2

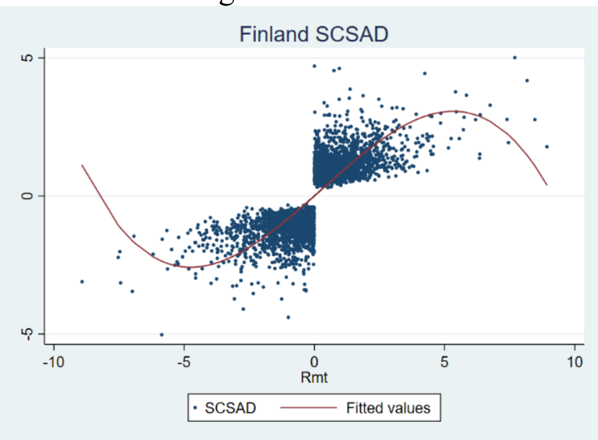



Figure 9.3

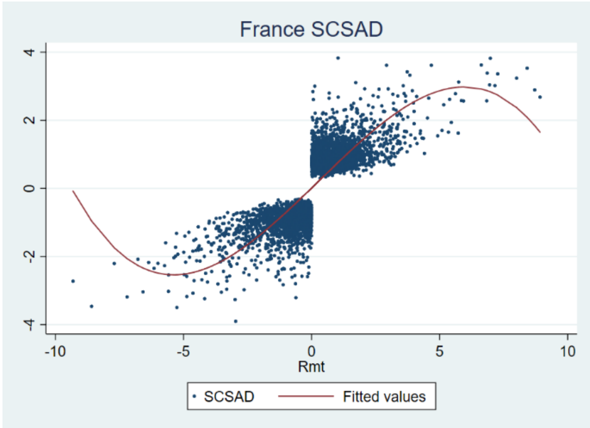



Figure 9.4

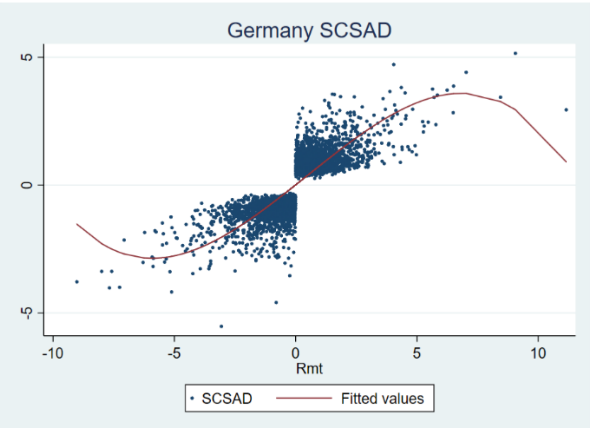



Figure 9.5

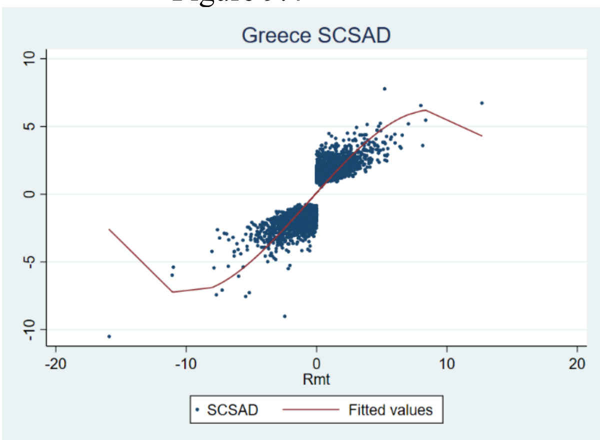



Figure 9.6

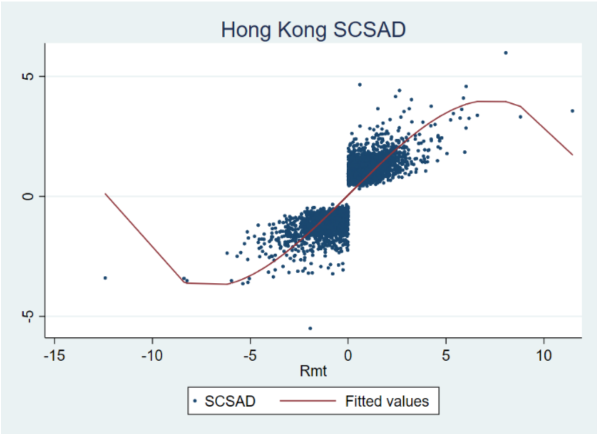



Figure 9.7

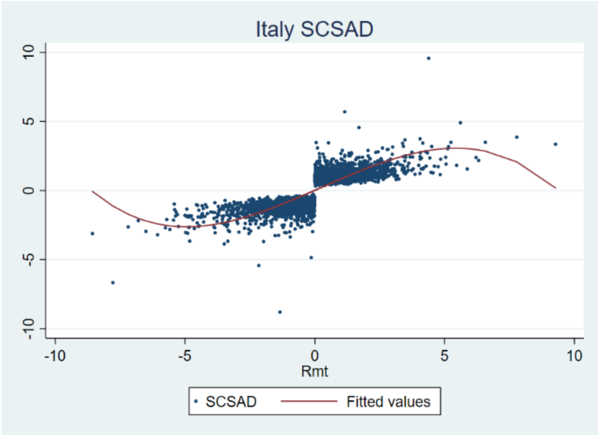



Figure 9.8

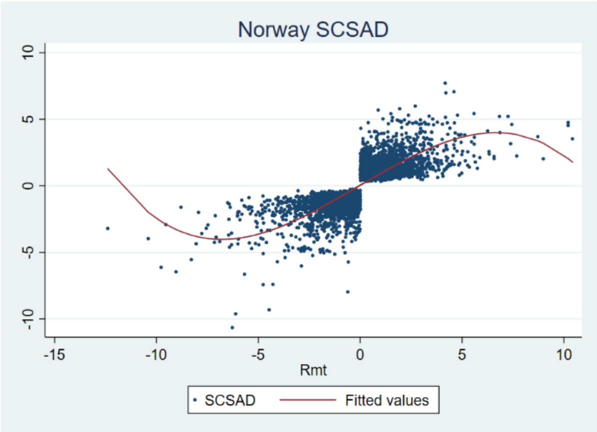



Figure 9.9

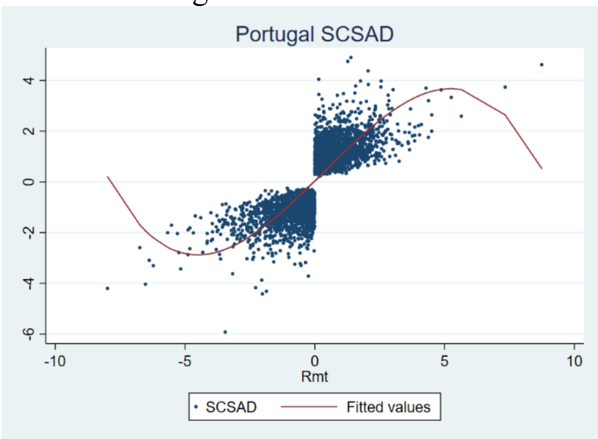



Figure 9.10

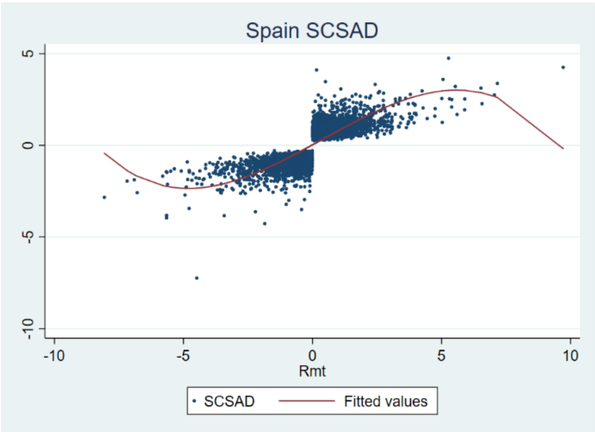



Figure 9.11

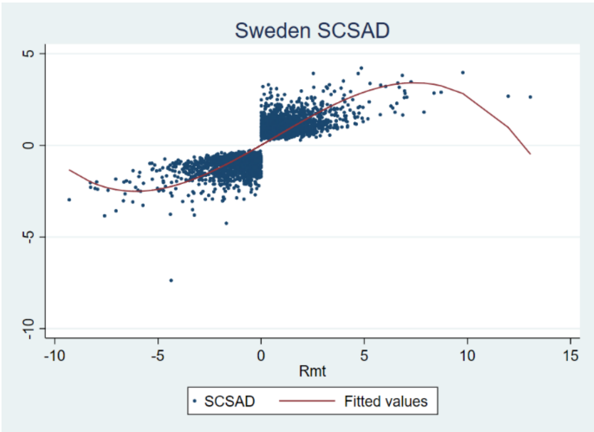



Figure 9.12

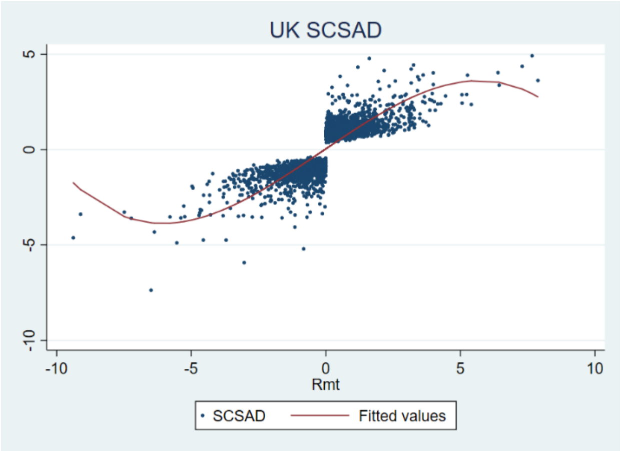


Figure 9.13

**6.0 Conclusions**

Initially, our work shows that the standard CCK test is highly biased against finding herding. The method has the disadvantage that it is heavily influenced by the error term in the CAPM model when the average market return $R_{m,t}$ is small. Theoretical and empirical analysis shows that this problem causes the CCK approach to lose its effectiveness. We introduce several alternative methods to detect herding and provide theoretical and simulation evidence to support their superiority over the CCK approach. The methods we propose have been designed to be very easy to apply so they can be taken up by the finance research community without difficulty

We then apply the CCK method and our new approaches to a number of major world stock markets. The CCK generally provides little support for herding, which is broadly in line with the existing literature, whereas our proposed new approaches indicate a high level of herding in many of the markets.

Our work indicates the need to revise many of the previous findings in the herding area. As an example, Appendix 2 shows how the conclusions in a well-known paper in the literature can be completely changed by applying our methods.

Our work focuses on revising the CCK method which is very commonly used in the literature to test for herding, but other methods are also used and an interesting avenue for future research would be to assess the effectiveness of these methods particularly those using multifactor asset pricing models in the light of our approach in this paper. Although multifactor models should fit the data better than the single factor CAPM model It is not clear to what extent using multifactor models will eliminate the problems caused by asset pricing models not being a perfect fit to the data.

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## Appendix 1 – Confirmation that our results are robust to neglecting the risk free interest rate.

We assumed that we can neglect the risk free rate of interest when we derived our solutions 1 and 2. We can demonstrate that even in periods of high interest rates $R_f$ can be reasonably neglected. The CSAD calculation is primarily driven by the absolute size of daily market returns $R_{mt}$. The magnitude of these are usually much larger than the daily risk free rate even in periods of high interest rates, Say interest rates were 10% p.a. so, assuming 260 trading days in a year, the daily rate would 10%/260 = 0.0385%. Now assuming the market has an annual standard deviation of returns of 20%, the daily sd of $R_{mt}$ would be of the order of $20\%/260^{0.5}$ = 1.24% which is approximately 30 times the daily risk free rate. Some simple calculations can show the implications of the relative magnitudes of these figures. Say we have a market of 20 stocks, 10 of which have a beta of 1.2 and 10 of which have a beta of 0.8. Furthermore, let us assume the risk free rate is 10% p.a., and an annual standard deviation of stock market returns of 20% p.a.. Now if stock returns are normally distributed, the median absolute daily market return would be about 0.83%. If the daily market return was 0.83% the corresponding CSAD would be 0.1585% now if, say, the daily market return was 1.83% the corresponding CSAD would be 0.3585% a factor of 2.261 greater. If we repeat the calculations with a risk-free rate of 0% the increase in CSAD would be from 0.1662% to 0.3662% a factor of 2.203 greater so even a very considerable change in the risk free rate has little effect on the relationship between CSAD and market returns. In these calculations we can neglect $\mu_{it}$ as it is independent of $(R_{mt} - R_f)$ and hence of $R_{mt}$ and $R_f$ and so on average including it would not alter the fact that the relationship between CSAD and market returns is little affected by the risk free rate.

As well as mathematical demonstrations like the one above, we can also empirically confirm the validity of this assumption that the risk free rate can be neglected by including the daily change of LIBOR as an explanatory variable in the solution 1 and 2 regression models to determine whether our solutions are robust to changes in interest rates. The results are shown in Appendix 1 Table 1 and Appendix 1 Table 2. In Appendix 1 Table 1 we can see that the coefficients of the squared market returns, which we use to determine the presence of herding, are very similar to those in Table 10 which is the corresponding Table without the interest rate variable. Similarly, in Appendix 1 Table 2 we can see that the coefficients of the cubed market returns, which we use to determine the presence of herding, are very similar to those in Table 11 which is the corresponding Table without the interest rate variable. Hence, we can see that our results are very robust to changes in interest rates.

Appendix 1 Table 1: Solution 1 with LIBOR as an extra explanatory variable
Full range of data Regression results without constant, Robust Regression
$CSAD_t = \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R^2_{m,t} + \gamma_4 \text{LIBOR} + \varepsilon_t$

| | (1) Denmark | (2) US | (3) Finland | (4) France | (5) Germany | (6) Greece |
|---|---|---|---|---|---|---|
| $R_{m,t}$ | -0.00188 | 0.0104 | 0.0254 | 0.0239 | 0.0202 | 0.0116 |
| $(\gamma_1)$ | (-0.14) | (1.11) | (2.40)$^{**}$ | (2.95)$^{***}$ | (1.95)$^{*}$ | (0.85) |
| $\|R_{m,t}\|$ | 1.215 | 0.951 | 1.083 | 0.914 | 0.931 | 1.320 |
| $(\gamma_2)$ | (25.32)$^{***}$ | (40.79)$^{***}$ | (42.80)$^{***}$ | (51.83)$^{***}$ | (37.70)$^{***}$ | (18.47)$^{***}$ |
| $R^2_{m,t}$ | -0.120 | -0.1000 | -0.126 | -0.0926 | -0.0857 | -0.0873 |
| $(\gamma_3)$ | (-5.43)$^{***}$ | (-10.03)$^{***}$ | (-12.95)$^{***}$ | (-14.36)$^{***}$ | (-9.21)$^{***}$ | (-3.90)$^{***}$ |
| LIBOR | -0.0720 | -0.0710 | -0.0619 | -0.0663 | -0.0957 | -0.0688 |
| $(\gamma_4)$ | (-4.18)$^{***}$ | (-5.59)$^{***}$ | (-3.99)$^{***}$ | (-3.25)$^{***}$ | (-6.04)$^{***}$ | (-3.68)$^{***}$ |
| $N$ | 4105 | 4132 | 4124 | 4202 | 4171 | 4063 |
| adj. $R^2$ | 0.665 | 0.702 | 0.680 | 0.713 | 0.698 | 0.738 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

| | (7) Hong Kong | (8) Italy | (9) Norway | (10) Portugal | (11) Spain | (12) Sweden | (13) UK |
|---|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0310 | 0.0184 | 0.00800 | 0.0424 | 0.0301 | 0.0269 | -0.00190 |
| $(\gamma_1)$ | (2.59)$^{***}$ | (1.55) | (0.64) | (2.53)$^{**}$ | (2.58)$^{**}$ | (3.24)$^{***}$ | (-0.15) |
| $\|R_{m,t}\|$ | 1.004 | 1.055 | 1.128 | 1.292 | 0.977 | 0.814 | 1.178 |
| $(\gamma_2)$ | (27.61)$^{***}$ | (31.01)$^{***}$ | (43.55)$^{***}$ | (26.42)$^{***}$ | (28.01)$^{***}$ | (36.75)$^{***}$ | (37.98)$^{***}$ |
| $R^2_{m,t}$ | -0.0880 | -0.121 | -0.0961 | -0.165 | -0.112 | -0.0697 | -0.119 |
| $(\gamma_3)$ | (-6.24)$^{***}$ | (-8.79)$^{***}$ | (-12.70)$^{***}$ | (-7.18)$^{***}$ | (-7.71)$^{***}$ | (-10.10)$^{***}$ | (-8.94)$^{***}$ |
| LIBOR | -0.0331 | -0.0719 | -0.0762 | -0.0434 | -0.0692 | -0.0455 | -0.128 |
| $(\gamma_4)$ | (-1.93)$^{*}$ | (-3.04)$^{***}$ | (-2.98)$^{***}$ | (-3.17)$^{***}$ | (-4.38)$^{***}$ | (-3.60)$^{***}$ | (-6.08)$^{***}$ |
| $N$ | 4050 | 4168 | 4120 | 4194 | 4174 | 4123 | 4131 |
| adj. $R^2$ | 0.714 | 0.697 | 0.662 | 0.697 | 0.694 | 0.678 | 0.709 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

Appendix 1 Table 2: Solution 2 with LIBOR as an extra explanatory variable
Full range of data Regression results, Robust Regression
$SCSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 R^2_{m,t} + \gamma_3 R^3_{m,t} + \gamma_4 \text{LIBOR} + \mu_t$

| | (1) Denmark | (2) US | (3) Finland | (4) France | (5) Germany | (6) Greece |
|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.985 | 0.775 | 0.837 | 0.728 | 0.754 | 1.071 |
| $(\gamma_1)$ | (53.46)$^{***}$ | (69.80)$^{***}$ | (56.69)$^{***}$ | (65.77)$^{***}$ | (64.38)$^{***}$ | (47.31)$^{***}$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| $R^2_{m,t}$ | -0.00802 | 0.0107 | 0.00958 | 0.00668 | 0.00876 | -0.00736 |
| $(\gamma_2)$ | (-1.04) | (2.62)*** | (1.87)* | (1.96)* | (2.28)** | (-1.35) |
| $R^3_{m,t}$ | -0.00899 | -0.00865 | -0.0110 | -0.00759 | -0.00619 | -0.00402 |
| $(\gamma_3)$ | (-4.68)*** | (-9.30)*** | (-8.79)*** | (-9.46)*** | (-7.64)*** | (-3.35)*** |
| LIBOR | 0.00727 | 0.00301 | 0.00221 | 0.00612 | -0.00172 | -0.0143 |
| $(\gamma_4)$ | (0.44) | (0.19) | (0.13) | (0.42) | (-0.12) | (-0.69) |
| _cons | 0.0256 | -0.0152 | 0.000370 | 0.00995 | 0.00846 | 0.0990 |
| | (1.59) | (-1.50) | (0.02) | (0.85) | (0.70) | (4.64)*** |
| *N* | 4105 | 4132 | 4124 | 4202 | 4171 | 4063 |
| adj. $R^2$ | 0.637 | 0.672 | 0.642 | 0.683 | 0.670 | 0.709 |

*t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

| | (7) Hong Kong | (8) Italy | (9) Norway | (10) Portugal | (11) Spain | (12) Sweden | (13) UK |
|---|---|---|---|---|---|---|---|
| $R_{m,t}$ | 0.806 | 0.819 | 0.893 | 1.004 | 0.769 | 0.650 | 0.953 |
| $(\gamma_1)$ | (61.45)*** | (45.29)*** | (51.44)*** | (48.27)*** | (42.25)*** | (56.03)*** | (63.83)*** |
| $R^2_{m,t}$ | 0.00151 | 0.00786 | -0.000924 | 0.0152 | 0.0112 | 0.00985 | -0.00532 |
| $(\gamma_2)$ | (0.28) | (1.27) | (-0.23) | (1.57) | (1.88)* | (4.01)*** | (-1.04) |
| $R^3_{m,t}$ | -0.00514 | -0.0101 | -0.00659 | -0.0141 | -0.00953 | -0.00479 | -0.00925 |
| $(\gamma_3)$ | (-5.24)*** | (-5.57)*** | (-8.29)*** | (-5.02)*** | (-4.89)*** | (-8.04)*** | (-7.81)*** |
| LIBOR | 0.0197 | 0.0165 | 0.0249 | -0.00998 | -0.0125 | 0.00606 | -0.0175 |
| $(\gamma_4)$ | (1.06) | (1.08) | (1.14) | (-0.70) | (-0.73) | (0.36) | (-0.74) |
| _cons | 0.0530 | 0.0112 | 0.0425 | 0.0349 | 0.0242 | 0.00800 | 0.0382 |
| | (3.63)*** | (0.75) | (2.22)** | (2.11)** | (1.92)* | (0.69) | (3.17)*** |
| *N* | 4050 | 4168 | 4120 | 4194 | 4174 | 4123 | 4131 |
| adj. $R^2$ | 0.682 | 0.663 | 0.635 | 0.661 | 0.660 | 0.648 | 0.676 |

*t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

## Appendix 2 Robustness Tests to compare our results to existing results in the literature.

It is appropriate to compare the results from our suggested approaches with existing results in the literature to see if we do, in fact, observe substantially different results.

We have considered the European data in Mobarek et al. (2014) as this paper covers a substantial number of markets which we also cover in our main analysis. We use daily data is from 02/Jan/2002 to 16/Feb/2012 which is substantially the same period as in Mobarek et al. (2014). The results from applying the CCK to ten European countries are shown in Appendix Table 1 and these can be compared to those in the paper by Mobarek et al. (2014) which are in their table 2 under Model 2. The precise numerical regression estimates are not exactly the same as those in Mobarek et al. (2014) which is to be expected as the time period and the companies covered are not identical. However, regarding the presence of herding, the qualitative conclusions are the same. At the conventional 5% significance level there is no herding found in either our results or those of Mobarek et al. (2014).

We use our suggested solutions to detect herding behaviour on the same data set. Using our solution 1 to detect herding behaviour which is to fit the CCK regression model without a constant value we capture clear evidence of herding behaviour in all the countries in our data sample, shown by highly significant negative coefficients of squared market return. Solution 2 using SCSAD model also captures clear evidence of herding behaviour in all the markets. Using solution 3 which considers large price movement in the market, with different definitions of large being used in the different panels, we can see that herding is detected in various countries for all the definitions. Our results are summarised in Appendix 2 Table 1 with the detailed results for each country for each model being set out in Appendix 2 Tables 2 to 5. Overall, it is clear that our solutions, especially Solutions 1 and 2, provide very different results to Mobarek et al. (2014) and we would expect that this would be generally true for other papers in the literature.

Appendix 2 Table 1 Summary: Number of countries with evidence of herding which is significant at the 5% level

| Method Used to Detect Herding | No. of Countries with herding |
|---|---|
| Mobarek et al. (2014) standard CCK method (their Table 2 Model 2) | 0 |
| Standard CCK method (Appendix 2 Table 2) | 0 |
| Solution 1 (Appendix 2 Table 3) | 10 |
| Solution 2 (Appendix 2 Table 4) | 10 |
| Solution 3 (Appendix 2 Table 5 Panel A Market return larger than \|0.5%\|) | 1 |
| Solution 3 (Appendix 2 Table 5 Panel B Market return larger than \|1%\|) | 2 |
| Solution 3 (Appendix 2 Table 5 Panel C Market return larger than \|2%\|) | 1 |
| Solution 3 (Appendix 2 Table 5 Panel D Market return larger than \|3%\|) | 1 |
| Solution 3 (Appendix 2 Table 5 Panel E Largest 50% of returns) | 1 |
| Solution 3 (Appendix 2 Table 5 Panel F Largest 10% of returns) | 2 |
| Solution 3 (Appendix 2 Table 5 Panel F Largest 5% of returns) | 1 |

Appendix 2 Table 2: CCK Model 02 Jan 2002 to 16 Feb 2012

$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R_{m,t}^2 + \varepsilon_t$ (equation 2)

| | (1) Denmark | (2) Finland | (3) France | (4) Germany | (5) Greece |
|---|---|---|---|---|---|
| $R_{m,t}$ | -0.00131 | 0.0144 | 0.0166 | 0.0118 | 0.0212 |
| $(\gamma_1)$ | (-0.09) | (1.71)* | (2.53)** | (1.30) | (3.12)*** |
| $\lvert R_{m,t}\rvert$ | 0.252 | 0.182 | 0.206 | 0.249 | 0.246 |
| $(\gamma_2)$ | (3.58)*** | (6.88)*** | (10.43)*** | (7.47)*** | (16.88)*** |
| $R_{m,t}^2$ | 0.0230 | 0.00713 | 0.0112 | 0.0108 | 0.0140 |
| $(\gamma_3)$ | (1.09) | (1.18) | (2.88)*** | (1.41) | (5.65)*** |
| _cons | 1.066 | 1.053 | 0.842 | 0.860 | 1.327 |
| | (31.80)*** | (56.80)*** | (57.09)*** | (42.34)*** | (101.88)*** |
| *N* | 2541 | 2548 | 2597 | 2582 | 2529 |
| adj. $R^2$ | 0.254 | 0.187 | 0.335 | 0.324 | 0.411 |

*t* statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

| | (6) Italy | (7) Norway | (8) Portugal | (9) Spain | (10) Sweden |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0150 | 0.00394 | 0.0397 | 0.0169 | 0.00677 |
| $(\gamma_1)$ | (1.82)* | (0.30) | (4.21)*** | (2.06)** | (0.93) |
| $\lvert R_{m,t}\rvert$ | 0.248 | 0.364 | 0.319 | 0.220 | 0.185 |
| $(\gamma_2)$ | (11.91)*** | (10.34)*** | (14.36)*** | (11.25)*** | (7.75)*** |
| $R_{m,t}^2$ | 0.00775 | -0.00658 | 0.00593 | 0.00852 | 0.00418 |
| $(\gamma_3)$ | (1.70)* | (-1.19) | (1.40) | (1.99)** | (0.96) |
| _cons | 0.818 | 1.247 | 0.817 | 0.768 | 0.900 |
| | (60.62)*** | (40.33)*** | (58.38)*** | (56.95)*** | (49.36)*** |
| *N* | 2576 | 2548 | 2589 | 2569 | 2548 |
| adj. $R^2$ | 0.300 | 0.191 | 0.284 | 0.256 | 0.247 |

*t* statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix 2 Table 3: Solution 1; 02 Jan 2002 to 16 Feb 2012

$CSAD_t = \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R_{m,t}^2 + \varepsilon_t$

| | (1) Denmark | (2) Finland | (3) France | (4) Germany | (5) Greece |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.00290 | 0.0345 | 0.0294 | 0.0277 | 0.0531 |
| $(\gamma_1)$ | (0.17) | (2.74)*** | (3.22)*** | (2.33)** | (2.40)** |
| $\lvert R_{m,t}\rvert$ | 1.276 | 1.122 | 0.940 | 0.988 | 1.311 |
| $(\gamma_2)$ | (23.21)*** | (39.77)*** | (47.79)*** | (36.97)*** | (18.15)*** |
| $R_{m,t}^2$ | -0.122 | -0.126 | -0.0900 | -0.0871 | -0.115 |
| $(\gamma_3)$ | (-5.40)*** | (-12.99)*** | (-14.33)*** | (-9.84)*** | (-4.49)*** |
| *N* | 2541 | 2548 | 2597 | 2582 | 2529 |
| adj. $R^2$ | 0.675 | 0.688 | 0.727 | 0.715 | 0.744 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

| | (6) Italy | (7) Norway | (8) Portugal | (9) Spain | (10) Sweden |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0331 | 0.00806 | 0.0746 | 0.0375 | 0.0288 |
| $(\gamma_1)$ | $(2.29)^{**}$ | (0.53) | $(3.55)^{***}$ | $(2.58)^{***}$ | $(3.09)^{***}$ |
| $\lvert R_{m,t}\rvert$ | 1.070 | 1.233 | 1.211 | 0.978 | 0.845 |
| $(\gamma_2)$ | $(27.14)^{***}$ | $(38.59)^{***}$ | $(22.06)^{***}$ | $(24.82)^{***}$ | $(33.33)^{***}$ |
| $R_{m,t}^2$ | -0.121 | -0.104 | -0.135 | -0.106 | -0.0706 |
| $(\gamma_3)$ | $(-7.96)^{***}$ | $(-12.70)^{***}$ | $(-5.41)^{***}$ | $(-6.89)^{***}$ | $(-10.06)^{***}$ |
| $N$ | 2576 | 2548 | 2589 | 2569 | 2548 |
| adj. $R^2$ | 0.711 | 0.672 | 0.696 | 0.693 | 0.691 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

Appendix 2 Table 4: Solution 2; 02 Jan 2002 to 16 Feb 2012

$SCSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 R_{m,t}^2 + \gamma_3 R_{m,t}^3 + \mu_t$

| | (1) Denmark | (2) Finland | (3) France | (4) Germany | (5) Greece |
|---|---|---|---|---|---|
| $R_{m,t}$ | 1.020 | 0.858 | 0.747 | 0.795 | 1.026 |
| $(\gamma_1)$ | (44.39)*** | (48.01)*** | (56.41)*** | (55.03)*** | (45.55)*** |
| $R_{m,t}^2$ | -0.00761 | 0.00869 | 0.00699 | 0.0101 | 0.0123 |
| $(\gamma_2)$ | (-0.94) | (1.65)* | (2.03)** | (2.54)** | (1.35) |
| $R_{m,t}^3$ | -0.00920 | -0.0109 | -0.00750 | -0.00657 | -0.00648 |
| $(\gamma_3)$ | (-4.73)*** | (-8.82)*** | (-9.54)*** | (-8.03)*** | (-3.88)*** |
| _cons | 0.0274 | 0.0198 | 0.0171 | 0.00591 | 0.0665 |
| | (1.27) | (0.98) | (1.09) | (0.36) | (2.45)** |
| *N* | 2541 | 2548 | 2597 | 2582 | 2529 |
| adj. $R^2$ | 0.646 | 0.649 | 0.699 | 0.689 | 0.706 |

*t* statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

| | (6) Italy | (7) Norway | (8) Portugal | (9) Spain | (10) Sweden |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.827 | 0.960 | 0.970 | 0.769 | 0.664 |
| $(\gamma_1)$ | (40.19)*** | (42.78)*** | (45.21)*** | (39.40)*** | (47.21)*** |
| $R_{m,t}^2$ | 0.0128 | -0.00174 | 0.0275 | 0.0136 | 0.00907 |
| $(\gamma_2)$ | (1.94)* | (-0.40) | (2.93)*** | (2.22)** | (3.69)*** |
| $R_{m,t}^3$ | -0.0102 | -0.00715 | -0.0115 | -0.00885 | -0.00479 |
| $(\gamma_3)$ | (-5.54)*** | (-8.38)*** | (-5.18)*** | (-4.99)*** | (-7.90)*** |
| _cons | 0.0201 | 0.0623 | 0.0373 | 0.0300 | 0.0131 |
| | (1.17) | (2.26)** | (2.19)** | (1.92)* | (0.80) |
| *N* | 2576 | 2548 | 2589 | 2569 | 2548 |
| adj. $R^2$ | 0.676 | 0.644 | 0.662 | 0.660 | 0.659 |

*t* statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix 2 Table 5: Solution 3; 02 Jan 2002 to 16 Feb 2012

Panel A Market return larger than |0.5%|

$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R_{m,t}^2 + \varepsilon_t$

| | (1) Denmark | (2) Finland | (3) France | (4) Germany | (5) Greece |
|---|---|---|---|---|---|
| $R_{m,t}$ | -0.00139 | 0.0166 | 0.0173 | 0.0139 | 0.0229 |
| $(\gamma_1)$ | (-0.09) | (1.97)** | (2.65)*** | (1.58) | (3.36)*** |
| $\lvert R_{m,t} \rvert$ | 0.329 | 0.224 | 0.263 | 0.309 | 0.303 |
| $(\gamma_2)$ | (2.97)*** | (5.71)*** | (9.15)*** | (6.45)*** | (15.10)*** |
| $R_{m,t}^2$ | 0.0127 | 0.00139 | 0.00378 | 0.00344 | 0.00757 |
| $(\gamma_3)$ | (0.49) | (0.19) | (0.82) | (0.39) | (2.88)*** |
| _cons | 0.976 | 1.001 | 0.769 | 0.778 | 1.248 |
| | (11.33)*** | (26.49)*** | (26.01)*** | (17.77)*** | (52.35)*** |

| | | | | | |
|---|---|---|---|---|---|
| $N$ | 1548 | 1689 | 1739 | 1691 | 1706 |
| adj. $R^2$ | 0.272 | 0.195 | 0.351 | 0.333 | 0.430 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

| | (6) Italy | (7) Norway | (8) Portugal | (9) Spain | (10) Sweden |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0168 | 0.00475 | 0.0413 | 0.0179 | 0.00920 |
| $(\gamma_1)$ | (2.01)$^{**}$ | (0.36) | (4.17)$^{***}$ | (2.13)$^{**}$ | (1.28) |
| $\lvert R_{m,t}\rvert$ | 0.320 | 0.446 | 0.354 | 0.257 | 0.245 |
| $(\gamma_2)$ | (10.61)$^{***}$ | (9.28)$^{***}$ | (9.33)$^{***}$ | (8.09)$^{***}$ | (8.22)$^{***}$ |
| $R_{m,t}^2$ | -0.00290 | -0.0153 | 0.000611 | 0.00346 | -0.00236 |
| $(\gamma_3)$ | (-0.58) | (-2.44)$^{**}$ | (0.10) | (0.62) | (-0.54) |
| _cons | 0.736 | 1.118 | 0.784 | 0.724 | 0.807 |
| | (25.29)$^{***}$ | (19.92)$^{***}$ | (23.22)$^{***}$ | (23.73)$^{***}$ | (25.20)$^{***}$ |
| $N$ | 1546 | 1899 | 1399 | 1536 | 1792 |
| adj. $R^2$ | 0.309 | 0.182 | 0.289 | 0.263 | 0.269 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

Panel B Market return larger than |1%|

$$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R_{m,t}^2 + \varepsilon_t$$

| | (1) Denmark | (2) Finland | (3) France | (4) Germany | (5) Greece |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.00253 | 0.0182 | 0.0199 | 0.0181 | 0.0226 |
| $(\gamma_1)$ | (0.15) | (2.07)$^{**}$ | (2.94)$^{***}$ | (2.00)$^{**}$ | (3.16)$^{***}$ |
| $\lvert R_{m,t}\rvert$ | 0.376 | 0.245 | 0.297 | 0.390 | 0.332 |
| $(\gamma_2)$ | (2.27)$^{**}$ | (4.03)$^{***}$ | (6.84)$^{***}$ | (5.80)$^{***}$ | (10.89)$^{***}$ |
| $R_{m,t}^2$ | 0.00718 | -0.00100 | -0.000256 | -0.00541 | 0.00454 |
| $(\gamma_3)$ | (0.23) | (-0.10) | (-0.04) | (-0.53) | (1.32) |
| _cons | 0.911 | 0.965 | 0.717 | 0.644 | 1.198 |
| | (5.17)$^{***}$ | (12.47)$^{***}$ | (12.25)$^{***}$ | (7.74)$^{***}$ | (25.84)$^{***}$ |
| $N$ | 864 | 1047 | 1070 | 1045 | 1059 |
| adj. $R^2$ | 0.273 | 0.195 | 0.352 | 0.340 | 0.434 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

| | (6) Italy | (7) Norway | (8) Portugal | (9) Spain | (10) Sweden |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0210 | 0.00654 | 0.0408 | 0.0181 | 0.0117 |
| $(\gamma_1)$ | (2.35)$^{**}$ | (0.48) | (3.68)$^{***}$ | (2.00)$^{**}$ | (1.58) |
| $\lvert R_{m,t}\rvert$ | 0.322 | 0.488 | 0.278 | 0.226 | 0.320 |
| $(\gamma_2)$ | (6.54)$^{***}$ | (7.28)$^{***}$ | (4.47)$^{***}$ | (4.45)$^{***}$ | (8.35)$^{***}$ |
| $R_{m,t}^2$ | -0.00316 | -0.0194 | 0.0102 | 0.00717 | -0.00963 |
| $(\gamma_3)$ | (-0.48) | (-2.56)$^{**}$ | (1.29) | (1.02) | (-2.17)$^{**}$ |
| _cons | 0.737 | 1.038 | 0.890 | 0.773 | 0.671 |
| | (11.00)$^{***}$ | (10.48)$^{***}$ | (11.19)$^{***}$ | (11.36)$^{***}$ | (12.05)$^{***}$ |
| $N$ | 853 | 1337 | 701 | 867 | 1152 |

| | | | | | |
|---|---|---|---|---|---|
| adj. $R^2$ | 0.272 | 0.157 | 0.257 | 0.236 | 0.275 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

Panel C Market return larger than |2%|

$$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R_{m,t}^2 + \varepsilon_t$$

| | (1) Denmark | (2) Finland | (3) France | (4) Germany | (5) Greece |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.00338 | 0.0219 | 0.0236 | 0.0240 | 0.0204 |
| $(\gamma_1)$ | (0.15) | (2.08)$^{**}$ | (2.99)$^{***}$ | (2.22)$^{**}$ | (2.32)$^{**}$ |
| $\|R_{m,t}\|$ | 0.401 | 0.208 | 0.446 | 0.451 | 0.338 |
| $(\gamma_2)$ | (1.24) | (1.56) | (4.99)$^{***}$ | (2.99)$^{***}$ | (4.91)$^{***}$ |
| $R_{m,t}^2$ | 0.00605 | 0.00244 | -0.0153 | -0.0107 | 0.00397 |
| $(\gamma_3)$ | (0.13) | (0.15) | (-1.61) | (-0.62) | (0.69) |
| _cons | 0.818 | 1.053 | 0.408 | 0.497 | 1.189 |
| | (1.55) | (4.25)$^{***}$ | (2.35)$^{**}$ | (1.75)$^{*}$ | (7.74)$^{***}$ |
| $N$ | 268 | 399 | 416 | 382 | 400 |
| adj. $R^2$ | 0.249 | 0.170 | 0.354 | 0.314 | 0.422 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

| | (6) Italy | (7) Norway | (8) Portugal | (9) Spain | (10) Sweden |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0321 | 0.00757 | 0.0417 | 0.0248 | 0.0196 |
| $(\gamma_1)$ | (2.91)$^{***}$ | (0.49) | (2.72)$^{***}$ | (2.16)$^{**}$ | (2.34)$^{**}$ |
| $\|R_{m,t}\|$ | 0.405 | 0.432 | 0.0415 | 0.137 | 0.437 |
| $(\gamma_2)$ | (3.68)$^{***}$ | (3.14)$^{***}$ | (0.28) | (1.19) | (6.49)$^{***}$ |
| $R_{m,t}^2$ | -0.0121 | -0.0149 | 0.0338 | 0.0157 | -0.0193 |
| $(\gamma_3)$ | (-1.08) | (-1.19) | (2.25)$^{**}$ | (1.42) | (-3.26)$^{***}$ |
| _cons | 0.580 | 1.184 | 1.375 | 0.972 | 0.381 |
| | (2.64)$^{***}$ | (4.03)$^{***}$ | (4.69)$^{***}$ | (4.16)$^{***}$ | (2.65)$^{***}$ |
| $N$ | 299 | 610 | 204 | 282 | 501 |
| adj. $R^2$ | 0.254 | 0.091 | 0.266 | 0.237 | 0.252 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

Panel D Market return larger than |3%|

$$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R_{m,t}^2 + \varepsilon_t$$

| | (1) Denmark | (2) Finland | (3) France | (4) Germany | (5) Greece |
|---|---|---|---|---|---|
| $R_{m,t}$ | -0.00352 | 0.0243 | 0.0225 | 0.0278 | 0.0220 |
| $(\gamma_1)$ | (-0.11) | (1.85)$^{*}$ | (2.39)$^{**}$ | (1.96)$^{*}$ | (1.92)$^{*}$ |
| $\|R_{m,t}\|$ | 0.879 | 0.374 | 0.639 | 0.682 | 0.334 |
| $(\gamma_2)$ | (2.04)$^{**}$ | (1.21) | (3.52)$^{***}$ | (2.44)$^{**}$ | (2.59)$^{**}$ |
| $R_{m,t}^2$ | -0.0335 | -0.0111 | -0.0319 | -0.0302 | 0.00407 |

| | | | | | |
|---|---|---|---|---|---|
| ($\gamma_3$) | (-0.69) | (-0.37) | (-1.96)$^{*}$ | (-1.21) | (0.46) |
| _cons | -0.447 | 0.581 | -0.0897 | -0.0908 | 1.208 |
| | (-0.46) | (0.78) | (-0.20) | (-0.13) | (3.30)$^{***}$ |
| $N$ | 104 | 175 | 186 | 153 | 147 |
| adj. $R^2$ | 0.227 | 0.195 | 0.323 | 0.268 | 0.460 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

| | (6)<br>Italy | (7)<br>Norway | (8)<br>Portugal | (9)<br>Spain | (10)<br>Sweden |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0324 | 0.00818 | 0.0350 | 0.0334 | 0.0199 |
| ($\gamma_1$) | (2.27)$^{**}$ | (0.45) | (1.85)$^{*}$ | (2.21)$^{**}$ | (1.92)$^{*}$ |
| $\lvert R_{m,t}\rvert$ | 0.455 | 0.578 | 0.0480 | 0.328 | 0.528 |
| ($\gamma_2$) | (1.88)$^{*}$ | (2.42)$^{**}$ | (0.16) | (1.15) | (5.12)$^{***}$ |
| $R^2_{m,t}$ | -0.0145 | -0.0256 | 0.0353 | -0.000347 | -0.0259 |
| ($\gamma_3$) | (-0.70) | (-1.39) | (1.44) | (-0.01) | (-3.43)$^{***}$ |
| _cons | 0.378 | 0.750 | 1.276 | 0.457 | 0.115 |
| | (0.61) | (1.15) | (1.61) | (0.64) | (0.40) |
| $N$ | 124 | 286 | 64 | 106 | 231 |
| adj. $R^2$ | 0.230 | 0.067 | 0.462 | 0.314 | 0.190 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

Panel E Largest 50% of returns (50% of absolute value (above 25% and 25% below 0))
$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R^2_{m,t} + \varepsilon_t$

| | (1)<br>Denmark | (2)<br>Finland | (3)<br>France | (4)<br>Germany | (5)<br>Greece |
|---|---|---|---|---|---|
| $R_{m,t}$ | -0.000728 | 0.0164 | 0.0193 | 0.0146 | 0.0223 |
| ($\gamma_1$) | (-0.05) | (1.91)$^{*}$ | (2.92)$^{***}$ | (1.64) | (3.17)$^{***}$ |
| $\lvert R_{m,t}\rvert$ | 0.360 | 0.224 | 0.292 | 0.339 | 0.329 |
| ($\gamma_2$) | (2.88)$^{***}$ | (4.37)$^{***}$ | (7.99)$^{***}$ | (5.68)$^{***}$ | (12.37)$^{***}$ |
| $R^2_{m,t}$ | 0.00897 | 0.00141 | 0.000383 | 0.0000121 | 0.00484 |
| ($\gamma_3$) | (0.33) | (0.16) | (0.07) | (0.00) | (1.51) |
| _cons | 0.932 | 1.000 | 0.725 | 0.730 | 1.204 |
| | (8.63)$^{***}$ | (16.93)$^{***}$ | (16.34)$^{***}$ | (11.00)$^{***}$ | (32.48)$^{***}$ |
| $N$ | 1270 | 1274 | 1298 | 1292 | 1264 |
| adj. $R^2$ | 0.283 | 0.189 | 0.359 | 0.326 | 0.433 |

$t$ statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

| | (6)<br>Italy | (7)<br>Norway | (8)<br>Portugal | (9)<br>Spain | (10)<br>Sweden |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0183 | 0.00592 | 0.0426 | 0.0175 | 0.0102 |
| ($\gamma_1$) | (2.16)$^{**}$ | (0.43) | (4.32)$^{***}$ | (2.06)$^{**}$ | (1.40) |
| $\lvert R_{m,t}\rvert$ | 0.330 | 0.489 | 0.328 | 0.247 | 0.304 |
| ($\gamma_2$) | (9.63)$^{***}$ | (7.00)$^{***}$ | (8.51)$^{***}$ | (6.86)$^{***}$ | (8.53)$^{***}$ |
| $R^2_{m,t}$ | -0.00428 | -0.0195 | 0.00398 | 0.00473 | -0.00806 |

| | | | | | |
|---|---|---|---|---|---|
| ($\gamma_3$) | (-0.80) | (-2.51)** | (0.66) | (0.80) | (-1.85)* |
| _cons | 0.723 | 1.035 | 0.818 | 0.738 | 0.702 |
| | (19.52)*** | (9.77)*** | (22.56)*** | (19.15)*** | (14.51)*** |
| $N$ | 1288 | 1274 | 1294 | 1284 | 1274 |
| adj. $R^2$ | 0.302 | 0.154 | 0.279 | 0.255 | 0.279 |

$t$ statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Panel F Largest 10% (10% of absolute value (above 5% and 5% below 0))
$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R_{m,t}^2 + \varepsilon_t$

| | (1) Denmark | (2) Finland | (3) France | (4) Germany | (5) Greece |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.00264 | 0.0194 | 0.0257 | 0.0255 | 0.0193 |
| ($\gamma_1$) | (0.11) | (1.62) | (2.92)*** | (2.12)** | (1.97)** |
| $\|R_{m,t}\|$ | 0.305 | 0.118 | 0.575 | 0.605 | 0.316 |
| ($\gamma_2$) | (0.88) | (0.57) | (4.09)*** | (3.34)*** | (3.54)*** |
| $R_{m,t}^2$ | 0.0143 | 0.0109 | -0.0268 | -0.0237 | 0.00542 |
| ($\gamma_3$) | (0.30) | (0.49) | (-2.00)** | (-1.27) | (0.80) |
| _cons | 1.049 | 1.267 | 0.0918 | 0.102 | 1.258 |
| | (1.79)* | (2.81)*** | (0.28) | (0.26) | (5.67)*** |
| $N$ | 254 | 254 | 260 | 258 | 252 |
| adj. $R^2$ | 0.228 | 0.145 | 0.325 | 0.323 | 0.437 |

$t$ statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

| | (6) Italy | (7) Norway | (8) Portugal | (9) Spain | (10) Sweden |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0326 | 0.00584 | 0.0463 | 0.0263 | 0.0203 |
| ($\gamma_1$) | (2.75)*** | (0.31) | (3.14)*** | (2.21)** | (2.00)** |
| $\|R_{m,t}\|$ | 0.388 | 0.528 | 0.215 | 0.141 | 0.526 |
| ($\gamma_2$) | (2.93)*** | (2.00)** | (1.71)* | (1.15) | (5.40)*** |
| $R_{m,t}^2$ | -0.0103 | -0.0222 | 0.0170 | 0.0154 | -0.0258 |
| ($\gamma_3$) | (-0.79) | (-1.12) | (1.28) | (1.31) | (-3.54)*** |
| _cons | 0.616 | 0.914 | 1.007 | 0.962 | 0.126 |
| | (2.22)** | (1.22) | (4.40)*** | (3.79)*** | (0.47) |
| $N$ | 258 | 254 | 258 | 256 | 254 |
| adj. $R^2$ | 0.228 | 0.053 | 0.269 | 0.246 | 0.200 |

$t$ statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Panel G Largest 5% (5% of absolute value (above 2.5% and 2.5% below 0))
$CSAD_t = \alpha + \gamma_1 R_{m,t} + \gamma_2 |R_{m,t}| + \gamma_3 R_{m,t}^2 + \varepsilon_t$

| | (1) Denmark | (2) Finland | (3) France | (4) Germany | (5) Greece |
|---|---|---|---|---|---|
| $R_{m,t}$ | -0.00198 | 0.0291 | 0.0313 | 0.0289 | 0.0179 |
| ($\gamma_1$) | (-0.07) | (2.07)** | (3.12)*** | (2.00)** | (1.54) |

| | | | | | |
|---|---|---|---|---|---|
| $\lvert R_{m,t}\rvert$ | 0.813 | 0.772 | 0.724 | 0.708 | 0.278 |
| $(\gamma_2)$ | (1.94)$^{*}$ | (1.94)$^{*}$ | (3.18)$^{***}$ | (2.50)$^{**}$ | (2.05)$^{**}$ |
| $R_{m,t}^2$ | -0.0282 | -0.0438 | -0.0386 | -0.0324 | 0.00769 |
| $(\gamma_3)$ | (-0.56) | (-1.21) | (-1.96)$^{*}$ | (-1.29) | (0.83) |
| _cons | -0.265 | -0.548 | -0.349 | -0.156 | 1.392 |
| | (-0.31) | (-0.53) | (-0.57) | (-0.21) | (3.54)$^{***}$ |
| $N$ | 128 | 128 | 130 | 130 | 126 |
| adj. $R^2$ | 0.268 | 0.227 | 0.328 | 0.272 | 0.443 |

*t* statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

| | (6) Italy | (7) Norway | (8) Portugal | (9) Spain | (10) Sweden |
|---|---|---|---|---|---|
| $R_{m,t}$ | 0.0325 | -0.00488 | 0.0469 | 0.0343 | 0.0200 |
| $(\gamma_1)$ | (2.24)$^{**}$ | (-0.22) | (2.89)$^{***}$ | (2.32)$^{**}$ | (1.53) |
| $\lvert R_{m,t}\rvert$ | 0.125 | 0.163 | -0.0930 | 0.288 | 0.557 |
| $(\gamma_2)$ | (0.52) | (0.28) | (-0.47) | (1.19) | (3.23)$^{***}$ |
| $R_{m,t}^2$ | 0.0121 | 0.000392 | 0.0459 | 0.00298 | -0.0281 |
| $(\gamma_3)$ | (0.56) | (0.01) | (2.35)$^{**}$ | (0.14) | (-2.57)$^{**}$ |
| _cons | 1.316 | 2.260 | 1.691 | 0.563 | 0.0440 |
| | (2.18)$^{**}$ | (1.14) | (4.02)$^{***}$ | (0.96) | (0.07) |
| $N$ | 128 | 128 | 130 | 128 | 128 |
| adj. $R^2$ | 0.151 | 0.002 | 0.326 | 0.301 | 0.111 |

*t* statistics in parentheses
$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$