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An empirical analysis of herd behavior in South Korea stock market

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Abstract

In this paper, the presence of herd behaviors among market participants in South Korea stock market in the period 1999-2018 is examined. The approach of Christie and Huang (1995) and Chang, Cheng, and Khorana (2000) is applied to detect market-wide herd behaviors. The empirical result using the cross-sectional absolute deviation (CSAD) suggests that the evidence of herding is captured only during the down-markets. However, the empirical result on a yearly basis suggests existing herd behavior during the up- and down-markets. This supports Chiang and Zheng (2010) in that herding is still found regardless of market development.

1. Introduction

Traditional economists have long assumed that every individual makes rational decisions based on their best analysis using all available information. As everyone has different amount of and different quality of information and capacity to utilize the information, each decision for each investor should be considered to be different. However, in the real stock market, investors and managers are often willing to suppress their own beliefs and just conform with the aggregate market behaviors. Such tendency to mimic others is called a 'herd behavior' and this is considered to distort market efficiency.

There are substantial empirical studies of herd behavior and various measurement methodologies have been suggested in empirical studies. For example, Lakonishock et al. (1992) used an LSV model, Grinblatt et al. (1995) used a Portfolio Change Measure (PCM), Christie and Huang (1995) used a Cross-Sectional Standard Deviation (CSSD), and Chang et al. (2000) used a Cross-Sectional Absolute Deviation (CSAD). Herding is examined on the entire equity market for the country level (Chiang and Zheng (2010); Wang (2008)), but also examined by sector- or firm-level (Demirer et al. (2010); Demirer and Kutan (2006); Choi and Sias (2009); Gebka and Wohar (2013)). Moreover, herding towards the US market for non-US markets is also studied in Chiang and Zheng (2010). Motivated by these empirical studies, I examine the presence of herd behavior in the entire Korean stock markets along the lines of Christie and Huang (1995) and Chang et al. (2000).

Christie and Huang (1995) examined the presence of herd behavior on the part of investors in the US equity market utilizing the cross-sectional standard deviation of returns (CSSD) as a measure of the average proximity of individual asset returns to the average market return. They compared the predictions of herd behavior and those of rational asset pricing models about equity dispersions during the periods of market stress. They found no evidence of herding behavior and indicated that herding is not an important determinant of equity returns during periods of market stress.

Chang et al. (2000) used the cross-sectional absolute deviation (CSAD) instead of the CSSD to investigate the herd behavior of investors within different international markets. They divided five countries into two groups: the advanced markets (the US, Hong Kong, and Japan) and the emerging economies (South Korea, Taiwan). No evidence of herding was found for the advanced markets, but the evidence was pronounced for the emerging markets.

South Korea, which is the subject of my study, has made a significant improvement in socio-economically development and indeed, it has been reclassified as a developed market in some indexes while it remains as an emerging market in some indexes. For example, Financial Times Stock Exchange (FTSE) Russell and Standard & Poor's (S&P) classified South Korea as developed while the Morgan Stanley Capital International Emerging Market Index (MSCI Index) classified South Korea as emerging. Therefore, considering the finding that the advanced markets have no evidence of herd behavior, it would be predicted that South Korea has no evidence of herding, or if it has, the evidence would be much less than the previous study.

Therefore, a research question can rise – Is there evidence of herding formation for the equity markets in South Korea in the period 1999-2018, when South Korea has developed economically and after Chang et al.'s study (2000)? Additionally, the second research question is dealt with – Does herding appearance in South Korea have a trend over time? This paper basically follows Chang et al. (2000) but extends the analysis to the period from 1999 to 2018. In this paper, analysis based on the dummy variables regressions suggested by Christie and

Huang (1995) finds that equity return dispersions in South Korea increase during periods of large price movements in the aggregate market index. This is in line with the rational asset pricing models, implying no herding during extreme price movements. However, using the CSAD measure suggested by Chang et al. (2000), the equity return dispersions show non-linear relationship with the aggregate market return during down-markets, which can be evidence of herding formation. However, examining non-linearity for the sub-samples of each year, the herd behavior is observed in most of the years both in up- and down-markets.

There has been a variety of previous studies on South Korean stock market. Chang et al. (2000) found the significant evidence of herding in South Korean stock markets for the period 1978-1995 where they attributed the herding to the incomplete information disclosure in the emerging markets. Consistently, Chiang and Zheng (2010) found evidence of herding in South Korea for the period 1989-2009 and confirmed that the US return dispersions have a dominant influence on Korean markets. Laih & Liau (2013) examined the herd behavior during the subprime mortgage crisis, and they found the evidence of herding in South Korea when markets are rising. Also, Hwang, Kim, and Shin (2016) analyzed herding behaviors in Korean stock markets using Christie and Huang (1995) and Chang et al. (2000) methodology and found strong evidence of herding only when market is in stress. They found asymmetric features of herding between bull and bear market states : adverse herding is found during bull states, whereas both core stocks and peripheral stocks exhibit herding during bear states.

The remainder of this paper is structured as follows. Section 2 describes the methodological details and data. In Section 3 the empirical results are provided, and Section 4 closes the paper with concluding remarks and further research discussion.

2. Methodology and data description

2.1. Methodology

In my study, two methods using cross-sectional data on stock returns are used to detect herding behavior. The first method is proposed by Christie and Huang (1995) (henceforth referred as CH), using cross-sectional standard deviation of returns (CSSD) as a measure of equity return dispersion to capture herd behavior on the part of investors during periods of market stress. The CSSD measure is defined as

$$CSSD_t = \sqrt{\frac{\sum_{i=1}^{N}\left(R_{i,t}-R_{m,t}\right)^2}{N-1}}, \tag{1}$$

where $R_{i,t}$ is the observed return on firm *i* at time *t* and $R_{m,t}$ is the cross-sectional average of the *N* returns in the aggregate market portfolio at time t. As $CSSD_t$ shows the degree to which equity returns tend to rise and fall in accord with the market portfolio return, CH predicted $CSSD_t$ to be low when there is herd behavior. That is because investors suppress their own beliefs and make decisions based on the collective actions of the market instead. Based on the rational asset pricing model, however, equity dispersions are predicted to increase with the absolute value of market return because of different sensitivity of each asset to the market return. Therefore, herd behavior and rational asset pricing models offer conflicting predictions for equity dispersions. (Christie and Huang, 1995)

This methodology suggests that the presence of herd behavior is most likely to occur during periods of unusual market movements. Thus, CH isolated the level of dispersion in the extreme tails of the distribution of market returns and tested whether it differs significantly from the average levels. They performed the following linear regression model:

$$CSSD_t = \alpha + \beta^L D_t^L + \beta^U D_t^U + \varepsilon_t, \tag{2}$$

$D_t^L = 1$, if the market return on day t lies in the extreme *lower* tail of the distribution; and equal to zero otherwise, and

$D_t^U = 1$, if the market return on day t lies in the extreme *upper* tail of the distribution; and equal to zero otherwise.

The α constant stands for the average level of equity return dispersion (CSSD) of the sample by excluding the periods of extreme market stress covered by the two dummy variables. The statistically significant and negative β^L and β^U coefficients indicate evidence of herd behavior while rational asset pricing models predict statistically significant and positive β^L and β^U coefficients. Extreme market stress is defined using one or five percent of the observations in the upper and lower tail of the market return distribution. Chang, Cheng, and Khorana (2000) (henceforth referred as CCK) performed this dummy regression model using another measure of equity dispersions instead of $CSSD_t$: the cross-sectional absolute deviation of returns ($CSAD_t$). In my paper, the dummy variable regression models suggested by CH are performed using both $CSSD_t$ and $CSAD_t$ as a dependent variable.

Furthermore, CCK demonstrate the rational asset pricing models predict that the equity dispersions are not only an *increasing* function of the market return but also a *linear* relation with market return (Chang et al., 2000). To be more specific, the relation between CSAD and the market return is illustrated using the conditional version of the Black (1972) CAPM:

$$E_t(R_i) = \gamma_0 + \beta_i E_t(R_m - \gamma_0), \tag{3}$$

where γ_0 is the return on the zero-beta portfolio. $CSAD_t$ is defined as the average AVD_t (Absolute Value of the Deviation) of each stock relative to the return of the equally weighted market portfolio, where AVD_t is expressed as follows:

$$AVD_{i,t} = |\beta_i - \beta_m| E_t(R_m - \gamma_0), \tag{4}$$

where β_i is the time-invariant systematic risk measure of the security, $i = 1, \ldots, N$ and $t = 1, \ldots, T$, and β_m be the systematic risk of an equally-weighted market portfolio. Then, the expected cross-sectional absolute deviation of stock returns (ECSAD) in period t is defined as follows:

$$ECSAD_t = \frac{1}{N}\sum_{i=1}^{N} AVD_{i,t} = \frac{1}{N}\sum_{i=1}^{N}|\beta_i - \beta_m| E_t(R_m - \gamma_0). \tag{5}$$

Then, the first and second derivatives show the positive and linear relation between equity return dispersion and the expected market returns as follows:

$$\frac{\partial ECSAD_t}{\partial E_t(R_m)} = \frac{1}{N}\sum_{i=1}^{N}|\beta_i - \beta_m| > 0 \tag{6}$$

$$\frac{\partial^2 ECSAD_t}{\partial E_t(R_m)^2} = 0 \tag{7}$$

Note that observing $ECSAD_t$ and $E_t(R_{m,t})$ is impossible using ex post data, the conditional version of the CAPM is only used to illustrate the increasing and linear relation between $ECSAD_t$ and $E_t(R_{m,t})$. Instead, the $CSAD_t$ and $R_{m,t}$ are introduced to proxy for the unobservable $ECSAD_t$ and $E_t(R_{m,t})$. Then, the $CSAD_t$ measure is defined as:

$$CSAD_t = \frac{1}{N}\sum_{i=1}^{N}\left|R_{i,t} - R_{m,t}\right|. \tag{8}$$

The relationship between $CSAD_t$ and $R_{m,t}$ is used to detect herd behavior while the $CSAD_t$ is not used as a measure itself.

Furthermore, CCK examined the asymmetric degree of herding in the up-versus the down-market performing two following empirical specification:

$$CSAD_t^{UP} = \alpha + \gamma_1^{UP}\left|R_{m,t}^{UP}\right| + \gamma_2^{UP}\left(R_{m,t}^{UP}\right)^2 + \varepsilon_t, \tag{9}$$

$$CSAD_t^{DOWN} = \alpha + \gamma_1^{DOWN}\left|R_{m,t}^{DOWN}\right| + \gamma_2^{DOWN}\left(R_{m,t}^{DOWN}\right)^2 + \varepsilon_t, \tag{10}$$

where $CSAD_t$ is the average AVD_t (Absolute Value of the Deviation) of each stock relative to the return of the equally weighted market portfolio, $R_{m,t}$ in period t, and $\left|R_{m,t}^{UP}\right|(\left|R_{m,t}^{DOWN}\right|)$ is the absolute value of an equally-weighted realized return of all available securities on day *t* when the market is up (down) (Chang et al., 2000). All variables are computed on a daily basis and the absolute values are included for convenience when comparing the coefficients of the linear term. CCK indicate that with market participants' herd behaviors during periods of relatively large price swings, a non-linear relation between $CSAD_t$ and the average market return would be observed. Therefore, a negative and statistically significant γ_2 coefficient could be evidence of herd behavior.

I will use the CH methodology and the CCK methodology, but there is possibility that the results from each methodology may conflict regarding the presence of herd behavior since the evidence of herd behavior required for by the CH approach is a much greater magnitude of non-linearity than that by the CCK approach.

2.2. Data

The data set used in this study contains daily stock returns for the entire population of firms in South Korea over the 4 January 1999 – 28 December 2018 period. They are obtained from Compustat via Wharton Research Data Services (WRDS). For the accurate analysis, I only use stocks which are South Korea Won (KRW) denominated and traded in South Korea, and stocks whose prices are available with a price code status (PRCSTD) is 10 (prices as reported). Moreover, in the case of company which has more than one stock issues, I choose only one issue which has the longest history and the largest number of shares outstanding if it has more than one issues with the same length of history. This is to avoid any problem from some stocks with multiple issues be given a greater weighting.

The daily stock returns were calculated by multiplying the current day adjusted close price ($PRCCD_t/AJEXDI_t$) by the current daily total return factor ($TRFD_t$) and dividing the result by the product of the adjusted close price ($PRCCD_{t-1}/AJEXDI_{t-1}$) multiplied by the total return factor ($TRFD_{t-1}$) from the prior day:

$$R_t = ((PRCCD_t/AJEXDI_t)^* \, TRFD_t)/\,((PRCCD_{t-1}/AJEXDI_{t-1})^* \, TRFD_{t-1}).$$

The daily closing stock price in local currency (won) (PRCCD), daily adjustment factor (AJEXDI), and daily total return (TRFD) were obtained from the Compustat Global Security Daily.

3. Empirical result

3.1. Descriptive statistics

For now, I report univariate statistics for daily mean returns and the return dispersions for South Korea (Table 1). The analysis is based on a sample period over 20 years (January 1999 – December 2018). The average daily return is 0.55% with standard deviation of 1.50%, showing higher magnitude of volatility than CCK's result (January 1978 – December 1995). According to the maximum and minimum value of the daily mean return, South Korea experienced the largest price decline of 12.86% over the 1999-2018 period occurred on the day after September 11 attack in 2001. The largest price rise was 11.01% occurred on the day when the

Table 1 . Summary statistics of returns (R_t) and cross-sectional absolute deviations ($CSAD_t$) for South Korea

Variables	Sample Period (number of observations)	Mean(%) (Date)	S.D.(%)	Maximum (%) (Date)	Minimum(%) (Date)	Serial correlation at lag					
						1	2	3	5	20	DF-test
R_t	04/01/1999-28/12/2018 (4939)	0.5507	1.4954	11.0076 (30/10/2008)	-12.8567 (12/09/2001)	0.15	0.05	0.05	-0.06	0.02	-60.71**
$CSSD_t$		3.6837	0.9037	19.9409 (21/11/2017)	2.0396 (17/09/2013)	0.74	0.70	0.68	0.65	0.54	-27.01**
$CSAD_t$		2.4044	0.6897	6.8021 (04/01/2000)	1.2829 (17/09/2013)	0.88	0.85	0.81	0.77	0.64	-17.65**

This table reports the mean, standard deviation, and the maximum and minimum values of returns (R_t) and the cross-sectional absolute deviation of returns ($CSAD_t$) which are all calculated on a daily basis over the sample period for South Korea. Also, the serial correlation of R_t and $CSAD_t$ is reported for lags 1, 2, 3, 5, and 20 along with test-statistics of the Dickey-Fuller test.

*** The coefficient is significant at the 1% level*

first currency swap contract between the United States and South Korea was signed, 30 October 2008.

I also report univariate statistics on the CSSD and CSAD measure. Compared to the average cross-sectional standard deviation for South Korea over 1978-1995 period shown by CCK's study (1.5949%), the average CSAD for South Korea over 1999-2018 period has grown up to 2.40%. According to the definition CCK gave to CSAD, the level of CSAD increases when individual returns begin to deviate from the market return and CCK provided evidence that developed markets such as U.S. and Hong Kong have larger mean values of return dispersions than emerging markets. Therefore, increased CSAD value of South Korea is consistent with my expectation in introduction that stocks over 1999-2018 period show less herding as a group than those over 1978-1995 period.

The first order autocorrelation of CSAD is 0.88, and the CSAD series seems to be highly autocorrelated. Thus, the approach suggested by Newey and West (1987) is used to adjust all standard errors of the estimated regression coefficients in all subsequent tests for heteroskedasticity and autocorrelation. Moreover, the 1% significant test-statistics of the unit root test (Dickey-Fuller tests) show that the daily average returns and the CSAD series are exhibiting stationarity.

3.2. Examining herding behavior under market stress

Table 2. Regression results of the daily equity dispersions during periods with extreme price movements

Variables	1% Criterion			5% Criterion		
	α	β^L	β^U	α	β^L	β^U
$\boldsymbol{CSSD_t}$	3.6463	1.8290	1.8991	3.5611	1.2961	1.1590
	(293.89)**	(13.41)**	(13.49)**	(297.74)**	(21.13)**	(15.83)**
$\boldsymbol{CSAD_t}$	2.3660	1.8545	1.9744	2.2843	1.2522	1.1519
	(260.85)**	(18.30)**	(14.86)**	(275.37)**	(25.31)**	(19.73)**

This table reports the estimated coefficients of the following regression models: $CSSD_t = \alpha + \beta^L D_t^L + \beta^U D_t^U + \varepsilon_t$ and $CSAD_t = \alpha + \beta^L D_t^L + \beta^U D_t^U + \varepsilon_t$, where $D_t^L(D_t^U)$ equals 1 if the market return on day t lies in the extreme lower (upper) tail of the return distribution, otherwise $D_t^L(D_t^U)$ equals 0. The extreme tail of the return distribution is defined with two criteria : the 1% and 5%, which represent the percentage of observations in the upper or lower tail of the market return distribution. Heteroskedasticity consistent t-statistics are reported below the estimated coefficients in parentheses.

** The coefficient is significant at the 5% level*
*** The coefficient is significant at the 1% level*

Christie and Huang (1995) predicted that market participants are more likely to suppress their own beliefs and mimic other investors' behavior during the extreme market stress. Thus, they expected to observe herd behaviors as decreased equity dispersions during the extreme market stress compared to the usual market. In Section 3.1., the univariate statistics show the increased value of the equity dispersions in general, but the dispersions under market stress might show different picture. Hence, my first investigation of the presence of herd behavior in the equity market of South Korea is employing dummy variable regression tests that are proposed by Christie and Huang (1995). I use the CSAD as a measure of equity dispersion as well as the CSSD, which is the modification by Chang et al. (2000). Table 2 provides the regression estimates for the regressions:

$$CSSD_t = \alpha + \beta^L D_t^L + \beta^U D_t^U + \varepsilon_t \quad (2)$$

$$CSAD_t = \alpha + \beta^L D_t^L + \beta^U D_t^U + \varepsilon_t \quad (11)$$

for South Korea. Equations use two sets of dummy variables to identify days with extreme up or down price movement versus relatively normal markets. Following the methodology in CH and CCK, extreme price movements are defined if the market return on day t lies in the extreme lower or upper tail of the distribution which is specified based on the 1% and 5% criterion. The coefficients on the dummy variables indicates the differences between the

CSSDs (or CSADs) under extreme market movements and those under the usual movements and this may clarify the presence of herd behavior under the market stress. CH suggest individuals are most likely to suppress their belief in favor of the market consensus during periods of extreme market movements (Christie and Huang, 1995). Thus, negative and statistically significant β^L and β^U coefficients would signify herd behavior. In table 2, I report the regression estimates along with heteroscedasticity consistent *t*-statistics. Considering the significant variation in dispersions and strong correlation, all estimations are done using the Newey-West heteroskedasticity and autocorrelation consistent standard errors.

In CCK's study, the developed countries (the US and Japan) have the positive and statistically significant β^L and β^U coefficients across three criterion (1%, 2%, and 5%) and they noted that these findings show that equity return dispersions tend to increase rather than decrease under extreme price movements (Chang et al., 2000). As the definition of herding by CH requires a decrease in dispersion levels under extreme price movements, this indicates no herding in the developed countries. In my study, based on table 2, both estimated of the β^L and β^U coefficients for South Korea are positive and statistically significant, no matter which variable is used as an equity dispersion and which percentage criterion is used. These findings are a bit different with CCK, who found the positive and statistically significant β^U in all three models (1%, 2%, and 5% criteria), but found the positive and statistically significant β^L in only 5% criterion model for South Korea. They found the negative and insignificant β^L in 1% criterion, and the positive and insignificant β^L in 2% criterion. In conclusion, the result for South Korea over the 1999-2018 period becomes more consistent with that for the developed markets indicating no herding behavior under market stress.

In the next section, I examine relationship between the equity return dispersion and the average market return using the approach developed by CCK.

3.3. Examining the non-linearity in the CSAD-market return relationship

The dummy regression is based on the assumption that the rational asset pricing models predict the positive relationship between the equity return dispersion and the average market return. However, Chang et al. (2000) discussed a different view that the rational asset pricing models predict the linearly increasing relationship between the equity return dispersion and the average market return. Thus, CCK examined the relation between the level of equity return dispersions (from here, I only use the cross-sectional absolute deviation of returns, i.e., CSAD) and the market return by non-linear regression specifications. In this section, especially the non-linear relationship between the CSAD and the market return is investigated as an evidence of herding in South Korea.

Regression estimates of the regressions specified in Equation (9) and (10) are provided in table 3. Equation (9) is specified for the subsample of up-markets (Model A) and equation (10) is for the subsample of down-markets (Model B. Also, the null hypotheses that $\gamma_1^{UP} = \gamma_1^{DOWN}$ and $\gamma_2^{UP} = \gamma_2^{DOWN}$ are tested and those results are reported with F_1 and F_2 statistics, respectively.

Table 3. Regression results of the daily cross-sectional absolute deviation on the absolute and squared term of the market return – separated into Up- and Down-markets

Country (Sample period)	**Model A**				**Model B**				**Test statistics**	
	α	γ_1^{UP}	γ_2^{UP}	Adjusted R^2	α	γ_1^{DOWN}	γ_2^{DOWN}	Adjusted R^2	F_1	F_2
South Korea (05/01/1999-28/12/2018)	1.9447 (93.83)**	0.4721 (13.01)**	-0.0104 (-1.20)	0.3510	2.0334 (94.99)**	0.4753 (15.27)**	-0.0235 (-4.16)**	0.4178	0.00	1.59

This table reports the estimated parameters of the following regression models:

Model A: $CSAD_t^{UP} = \alpha + \gamma_1^{UP}|R_{m,t}^{UP}| + \gamma_2^{UP}(R_{m,t}^{UP})^2 + \varepsilon_t$

Model B: $CSAD_t^{DOWN} = \alpha + \gamma_1^{DOWN}|R_{m,t}^{DOWN}| + \gamma_2^{DOWN}(R_{m,t}^{DOWN})^2 + \varepsilon_t$

where $CSAD_t^{UP}(CSAD_t^{DOWN})$ *is the absolute value of cross-sectional average of the returns in the aggregate market portfolio on day t when the market is up [down],* $|R_{m,t}^{UP}|$ $[|R_{m,t}^{UP}|]$ *is the absolute term of the equally-weighted return of all available stocks on day t when the market is up [down], and* $(R_{m,t}^{UP})^2$ $[(R_{m,t}^{DOWN})^2]$ *is the squared term of the equally-weighted return. Along with the estimated coefficients, the heteroscedasticity consistent t-statistics are reported in parentheses. The* F_1 *and* F_2 *statistics test the null hypotheses that* $\gamma_1^{UP} = \gamma_1^{DOWN}$ *and* $\gamma_2^{UP} = \gamma_2^{DOWN}$*, respectively.*

** The coefficient is significant at the 5% level*
*** The coefficient is significant at the 1% level*

CCK expected that with herding behavior, the equity return dispersions will decrease or increase at a decreasing rate with an increase in the market return (Chang et al., 2000). Therefore, they noted that the statistically significant and negative coefficient of γ_2 can capture the non-linearity. In their research, they found a significant non-linear relation between equity return dispersions and market price movement for both the up- and down-markets in South Korea. In other words, they found the evidence of herding behavior in South Korea over the period of 1978-1995.

My finding is consistent with CCK only for the down-markets. For the up-markets, the γ_2^{UP} estimate is negative but statistically insignificant – consistent with the rational capital asset pricing model. In other words, the rational capital asset pricing model predicts the $CSAD_t$ increases linearly with the average market return generally, and the insignificant coefficient estimate supports this linearity. This evidence is consistent with the result of statistically significant and positive β^L and β^U coefficients from the dummy variables regression in Section 3.2. However, the γ_2^{DOWN} estimate is contrary with the prediction of the rational capital asset pricing model with the statistically significant and negative value. This estimate provides evidence of non-linear relation between equity return dispersions and the mean market realized return of the day. That is, the $CSAD_t$ increases at a decreasing rate as the average market return increases in absolute terms., being grounds for herding during down-markets.

This result for down-markets from non-linearity regression model conflicts with that from dummy variable regression suggested by CH. That is because CH approach requires a far greater magnitude of non-linearity for the relationship between the return dispersions and the aggregate market return for evidence of herding (Chang et al., 2000). Following the illustration of CCK, a quadratic equation between $CSAD_t$ and $R_{m,t}$ for all negative $R_{m,t}$ values in general market (not specified into up- or down-markets) is shown as follows:

$$CSAD_t = \alpha - \gamma_1 R_{m,t} + \gamma_2 R_{m,t}^2, \tag{12}$$

where the negative γ_2 estimate means herd behaviors. If considering $\gamma_1 = 0.4753$ from result of Model B and using a 5% average market return to define market stress, the estimated value of the γ_2 parameter needs to be -4.753 or smaller in order the β^U parameter to be negative. Hence, as the approval standard required as evidence of herding of CH approach is stricter than that of CCK, only the result from the non-linearity regression shows herding evidence in South Korea.

Moreover, as CCK note, the negative coefficient indicates that $CSAD_t$ declines as $|R_{m,t}|$ go beyond a certain threshold. To elaborate in detail, when coefficients in the equation specified in Eq.(10) are substituted with the estimated coefficients of Model B (γ_1=0.4753 and γ_2=-0.0235), the substituted quadratic equation shows that $CSAD_t$ has its maximum value at the point where $|R_{m,t}|$=10.11% (the quadratic relation suggests that $CSAD_t$ maximizes when $|R^*_{m,t}| = -(\frac{\gamma_1}{2\gamma_2})$). This indicates that $CSAD_t$ tends to become smaller when the absolute value of market return surpasses this threshold level during down-markets period. In other words, individual investors are shown to behave based on the aggregate market consensus rather than their own decisions during the periods of extremely bad market movements. These findings are consistent with the prediction about herd behavior by CH.

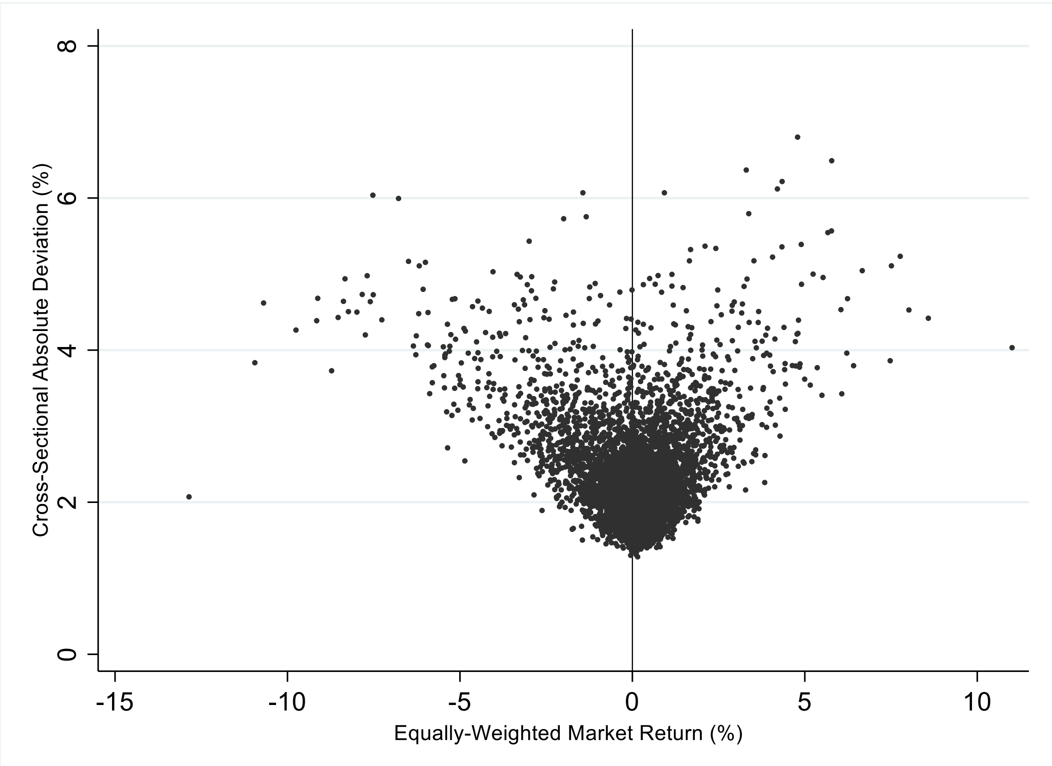

Figure 1. Plot indicating relationship between the daily cross-sectional absolute deviation ($CSAD_t$) and the corresponding equally-weighted market return ($R_{m,t}$) for South Korea (January 1999-December 2018)

In Figure 1, the relationship between the CSAD and the market return is plotted for the purpose of the more elaborate illustration. The plot indicates that the relation in the up-market and that in the down-market are dissimilar. Let us consider the right-hand side area where the equally-weighted market returns are all positive. By substituting the regression estimates in Table 3, the equation (9) can be shown as follows:

$$CSAD_t = 1.9986 + 0.4721\, R^{UP}_{m.t} - 0.0041\left(R^{UP}_{m,t}\right)^2 + \varepsilon_t.$$

(13.01)** (-1.20)

The positive and statistically significant linear coefficient and the insignificantly negative coefficient of squared term is implying the linear relationship between the CSAD and the equally-weighted market return. This is verified in the Figure 1 which shows linear relationship on the right-hand side. This result is consistent with the conclusion using the dummy variables that there is no evidence of herding behavior.

However, focusing the left-hand side area where all realized average daily returns were negative (DOWN in the equation), the plot shows the relationship between the CSAD and the equally-weighted market return far from linear. Also, the slopes in the up market looks slightly steeper than those in the down market. This is consistent with the visualization by CCK. The coefficients and the corresponding t-statistics area:

$$CSAD_t = 2.0334 + 0.4753\, R^{UP}_{m,t} - 0.0235\left(R^{UP}_{m.t}\right)^2 + \varepsilon_t.$$

(15.27)** (-4.16)**

The estimated γ_2 parameter is negative and statistically significant, which is suggested as an evidence of herd behavior. This implies that the presence of herding is asymmetric in the up- versus the down-market and the herding is shown only in the down market.

3.4. Examining herding behavior trend in South Korea for 20 years

South Korea has developed dramatically, and its development naturally has been existed for my sample period of 1999-2018. Its market has been changing for that period, and the market participants also have changed over time. Therefore, the same approach of examining non-linearity between the equity return dispersions and the average market return is conducted, but with new variables focusing the relationship for each year.

To investigate whether the relationship between $CSAD_t$ and the aggregate market return differs over the sub-sample period, the dummy variables indicating each year are used. The non-linear relation is my principal interest to capture herd behavior, so the interaction term of squared market return and the year-indicating dummy variables are included in the equations (9) and (10). To avoid collinearity, the interaction term with the year 1999 dummy

Table 4. Regression results of the daily cross-sectional absolute deviation on the linear and squared term of the market portfolio return with interaction terms: Up and Down markets

	Model A	**Model B**
α	1.9411	2.0303
	(107.17)**	(105.19)**
γ_1	0.6219	0.5280
	(18.87)**	(19.14)**
γ_2	-0.0091	-0.0125
	(-0.99)	(-1.69)
γ_3	-0.0107	-0.0064
	(-1.10)	(-0.82)
γ_4	-0.0321	-0.0239
	(-3.54)**	(-3.63)**
γ_5	-0.0689	-0.0296
	(-5.51)**	(-4.83)**
γ_6	-0.0758	-0.0418
	(-5.29)**	(-4.22)**
γ_7	-0.1098	-0.0179
	(-6.36)**	(-2.58)**
γ_8	-0.0656	-0.0254
	(-3.74)**	(-2.72)**
γ_9	-0.1486	-0.0204
	(-6.51)**	(-2.55)*
γ_{10}	-0.0517	-0.0211
	(-4.92)**	(-3.25)**
γ_{11}	-0.0257	-0.0118
	(-3.04)**	(-1.93)
γ_{12}	-0.0311	-0.0134
	(-2.38)*	(-1.36)
γ_{13}	-0.2351	-0.0620
	(-6.56)**	(-3.05)**
γ_{14}	-0.0990	-0.0279
	(-4.76)**	(-3.29)**
γ_{15}	-0.2913	-0.0825
	(-8.24)**	(-6.45)**
γ_{16}	-0.3379	-0.1080
	(-3.18)**	(-2.14)*
γ_{17}	-0.9558	-0.2176
	(-7.89)**	(-2.68)**
γ_{18}	-0.1739	-0.0627
	(-7.89)**	(-3.23)**
γ_{19}	-0.2828	-0.0887
	(-3.47)**	(-7.09)**
γ_{20}	-0.7876	-0.3567
	(-4.34)**	(-5.21)**
γ_{21}	-0.1911	-0.0621
	(-3.69)**	(-2.75)**
Adjusted R^2	0.4633	0.4734

This table reports the estimated coefficients of the following regression models:

Model A: $CSAD_t^{UP} = \alpha + \gamma_1^{UP}\left|R_{m,t}^{UP}\right| + \gamma_2^{UP}\left(R_{m,t}^{UP}\right)^2 + \sum_{i=3}^{21}\gamma_i^{UP}\left(R_{m,t}^{UP}\right)^2 * year\_(i+1997) + \varepsilon_t$

Model B: $CSAD_t^{DOWN} = \alpha + \gamma_1^{DOWN}\left|R_{m,t}^{DOWN}\right| + \gamma_2^{DOWN}\left(R_{m,t}^{DOWN}\right)^2 + \sum_{i=3}^{21}\gamma_i^{DOWN}\left(R_{m,t}^{DOWN}\right)^2 * year\_(i+1997) + \varepsilon_t$

where $CSAD_t^{UP}$ $(CSAD_t^{DOWN})$ *is the absolute value of cross-sectional average of the returns in the aggregate market portfolio on day t when the market is up [down],* $\left|R_{m,t}^{UP}\right|$ $\left[\left|R_{m,t}^{UP}\right|\right]$ *is the absolute term of the equally-weighted return of all available stocks on day t when the market is up [down], and* $\left(R_{m,t}^{UP}\right)^2$ $\left[\left(R_{m,t}^{DOWN}\right)^2\right]$ *is the squared term of the equally-weighted return. Interaction terms are used to capture an impact of year on the relationship between* $CSAD_t$ *and* $\left(R_{m,t}^{UP}\right)^2$ $\left[\left(R_{m,t}^{DOWN}\right)^2\right]$ *where year_i (i=1999,2000,,,2018) is the dummy variable indicating each year.* $\left(R_{m,t}^{UP}\right)^2 * year\_1999$ $\left[\left(R_{m,t}^{DOWN}\right)^2 * year\_1999\right]$ *is excluded from the equation because of collinearity. Along with the estimated coefficients, the heteroscedasticity consistent t-statistics are reported in parentheses.*

** The coefficient is significant at the 5% level*

*** The coefficient is significant at the 1% level* variable is excluded and considered as a reference group. Table 4 provides the regression results with the interaction variables.

For up-markets, the statistically insignificant γ_2 estimate indicates no herd evidence in 1999. However, except for the γ_3 estimate, all the coefficients of the interaction variables are negative and statistically significant. This shows that the negative and non-linear relationships between $CSAD_t$ and the aggregate market return are observed every year, 1999 and 2000 excluded. In Section 3.3., the herd behavior is not found in up-markets for the full sample period 1999-2018, but when inspecting herding for each year, the herding formation keeps existing except for the first two years. The results are same for down-markets. The non-linear relations as an evidence of herding are found for every year except 1999, 2000, 2008, and 2009. Contrary to my expectation, the herding behavior is prevalent in South Korea stock market regardless of its development. This result is in line with the conclusion of Chiang and Zheng (2010) that there is no correlation between the presence of herding and the advancement of stock markets.

3.5. Examining scarcity of information as a factor of herding

Table 5. Market model adjusted R^2

	Market model adjusted $\mathbf{R^2}$		
	Mean	Minimum	Maximum
Full sample	0.1159	0.0422	0.2388
Up market	0.0410	0.0097	0.1225
Down market	0.0885	0.0267	0.2019

This table reports the mean, minimum, and maximum adjusted R^2 value of the market model regressions based on the observations with all available stocks in South Korea. The underlying market benchmark in the market model regressions is represented with the equally-weighted market return. The results are reported separately for the full sample, up-market, and the down-market.

In this sector, I address the question – "Does systematic risk play a greater role than unsystematic risk in market of South Korea where the evidence of herding behavior is detected?" (Chang et al., 2000) The table 5 provides the R^2 values for the market model regressions which are regressing the individual stocks' daily return on the equally-weighted return. The average R^2 value is 11.6% for the full sample, which is lower than the value of 1978-1995 by CCK, 23.2%. Lower value of R^2 means that systematic risk plays a relatively less important role than before, and the same results are observed for the sub-sample of both up- and down-markets. CCK notes that the rapid and accurate firm-specific information is scarce in developing markets, and this makes investors focus on macroeconomic information. (Chang et al., 2000) The lower R^2 value thus implies that the information scarcity as a factor of herding is no longer true of South Korea. That is, herd behavior is not from the scarcity of useful firm-specific information.

4. Conclusion

In this paper, I use the cross-sectional standard deviation (CSSD) and the cross-sectional absolute deviation (CSAD) to examine herd behavior towards market index in South Korea.

The results of the empirical analysis are as follows. First, the analysis of dummy variables regression shows that no evidence of herding behavior is found during the period of extreme market movements, both extremely up and down market. Second, the result of the non-linearity regression shows that the relationship between the equity return dispersions and average market index is non-linear in the down-market. This indicates that herd behavior is likely to exist when the market index is negative, consistently illustrated in the plot of the relation between CSAD and the market return as well. This result is consistent with previous studies which found herding behavior only in bear markets. Third, by conducting the non-linearity regression with interaction variables, it turns out herding has never disappeared in South Korea despite its significant advancement in many ways. Lastly, according to the comparison of R_2 values from the market model regressions, the relative scarcity of rapid and accurate firm-specific information is no longer a main contributor to herd formation contrasted with Chang et al. (2000).

In this paper, I examined herding behavior with a market-wide evidence. This approach is easy to measure and to be understood intuitively, but it is hard to figure out which factors have influence on the presence of herding. Therefore, the further study can be extended into the industry-specific evidence or size-varying evidence. Also, I benchmarked Chang et al. (2000) which observed the significant herding behaviors only in the emerging markets. However, Chiang and Zheng (2010) conducted empirical test using the CSSD and CSAD measure and found that there was evidence of herding in all countries' markets except for the US and Latin American markets. In other words, they found that there is no correlation between the presence of herd behavior and the advancement of stock markets. Their finding is consistent with my finding by conducting regression with interaction variables. Thus, the further research can investigate various countries and clarify the relationship between herding formation and the stock market's level of development . Finally, my results by different methodologies are conflicting each other. Hence, if further research can establish the most suitable methodology to detect herding, it can draw more reliable conclusion.

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