Formulation of a Herd Measure for Detecting Monthly Herding Behaviour in an Equity Market

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Abstract

Herding in financial markets refers to a situation whereby a group of investors intentionally adopt the actions of other investors by trading in the same direction over a period of time. In this study we propose a new herd measure for detecting the prevalence of herding of a portfolio of stocks towards the market by exploiting the information contained in the cross-sectional stock price movements. We adopt the same underlying argument as Hwang and Salmon (2001, 2004) - that the changes in the cross-sectional dispersion of the betas reflect investors' sentiments towards the market. The betas are obtained from the multivariate linear regression model where we consider separately both normal and non-normal distributions of the random errors. When the random errors are assumed to be normally distributed, we use the bootstrap method to determine the confidence interval of the herd measure. The modified chi-square method is used instead when non-normal random errors are assumed. We applied the herd measure to a portfolio of stocks in the developing Malaysian market, covering from 1993 to 2004 - a period spanning the market bull-run in the early nineties, the 1998 Asian financial crisis and the subsequent recovery phase. Both methods for obtaining confidence interval of the herd measure yield similar herding results. The patterns of herding found are closely linked to the prevailing market conditions and sentiments.

Keywords: Herd measure, Bootstrap method, Modified chi-square method, Quadratic-normal distribution

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Introduction

Following the widespread financial crises in the last two decades, the issue of herding in equity markets has become a topic of intense interest. It is intuitively recognised that in times of uncertainty and fear, many investors imitate the actions of other investors whom they assume to have more reliable information about the market. Specifically, herding refers to a situation whereby a group of investors intentionally copy the behaviour of other investors by trading in the same direction over a period of time.

Being a non-quantifiable behaviour, herding cannot be measured directly but can only be inferred by studying related measurable parameters. The studies conducted so far can be broadly classified into two categories. The first category focuses directly on the trading actions of the individual investors. Therefore, a study on the herding behaviour would require detailed and explicit information on the trading activities of the investors and the changes in their investment portfolios. Examples of such herd measures are the LSV measure by Lakonishok, Shleifer and Vishny (1992) and the PCM measure by Wermers (1995).

In the second category, the presence of herding behaviour is indicated by the *group effect* of collective buying and selling actions of the investors in an attempt to follow the performance of the market or some factor. This group effect is detected by exploiting the information contained in the cross-sectional stock price movements. Christie and Huang (1995), Chang, Cheng and Khorana (2000) and Hwang and Salmon (2001, 2004) are contributors of such measures.

Previous Studies

This study is motivated by the second category of studies on herding. Thus, we shall briefly review only those studies that are concerned with formulation of herd measures based on similar intuition.

One of the earliest studies that attempt to detect empirically herding behaviour in the financial markets comes from Christie and Huang (1995). They contend that if herding behaviour occurs in an equity market during period of stress or high volatility, the dispersion should increase at a decreasing rate or simply a negative function of price movements in the case of severe herding. The rationale is that if the individuals ignore their beliefs and base their decisions solely on the market consensus during periods of relatively large price movements, the stock returns will not deviate too far from the market return. In short, the dispersion should decrease during periods of extreme price movements when there is herding behaviour. This is, of course, contradictory to the capital asset pricing models which predict that the dispersion should increase with absolute value of the market return. As a measure of dispersion, the cross-sectional standard deviation is used, and it is computed as such:

$$CSSD_t = \sqrt{\frac{\sum_{i=1}^{N}\left(r_{it} - r_{mt}\right)^2}{N-1}},$$

where r_{it} and r_{mt} are, respectively, the observed daily return of stock *i* and the market on day *t* and *N* is the number of stocks in the portfolio.

In this test, market stress is associated with the condition when the market returns lie in the upper and lower 1% or 5% of the market return distribution. In the presence of herding behaviour, the coefficients of β_1 and β_2 in the following regression should be significantly negative:

$$CSSD_t = \alpha + \beta_1 D_t^L + \beta_2 D_t^U + \varepsilon_t$$

where D_t^L is equal to 1 if the market return on day *t* lies in the extreme lower tail of the distribution, and equal to 0, otherwise; and D_t^U is equal to 1 if the market return on day *t* lies in the extreme upper tail of the distribution, and equal to 0, otherwise. These dummy variables are incorporated to capture differences in investor behaviour in extreme up or down against relatively normal markets. If both the coefficients of these dummy variables are significantly positive, then we would empirically conclude that herding behaviour is not detected.

Chang, Cheng and Khorana (2000) modified the Christie and Huang's (1995) approach. In place of *CSSD*, they use the cross-sectional absolute deviation of returns (*CSAD*) as a measure of dispersion. They contend that their model is less stringent though it is premised on a similar intuition. Their alternative empirical model is based on the emphasis that capital asset pricing models predict not only that the dispersions are an increasing function of the market return, it is also linear. Thus, in the presence of herding behaviour the linear and increasing relation between dispersion and market return will no longer be true. Instead, the relation is increasing non-linearly or even decreasing. It is important to note that, just as in Christie and Huang's (1995) approach, the *CSAD* is not a measure of herding. It is the relationship between $CSAD_t$ and r_{mt} that is used to detect herd behaviour.

To accommodate the possibility that the degree of herding may be asymmetric in the up and the down markets, they run two separate regression models as given below and the presence of herding in the up and the down markets is concluded by examining non-linearity in these relationships.

$$CSAD_t^{Up} = \alpha + \gamma_1^{Up} \left| r_{mt}^{Up} \right| + \gamma_2^{Up} \left(r_{mt}^{Up} \right)^2 + \varepsilon_t$$

$$CSSD_t^{Down} = \alpha + \gamma_1^{Down} \left| r_{mt}^{Down} \right| + \gamma_2^{Down} \left(r_{mt}^{Down} \right)^2 + \varepsilon_t$$

where $CSAD_t$ is the average absolute value of the deviation of stock *i* relative to the return of the market portfolio r_{mt} in period *t*. Based on the capital assets pricing models, large swings in price movements should elicit large increase in $CSAD_t$. In other words, there should be a linear relationship between $CSAD_t$ and r_{mt}. If the market participants do follow the collective actions of the market, then we should obtain a non-linear relation between $CSAD_t$ and the average market return. This non-linearity would be captured by a significantly negative γ_2 coefficient. So, in the interpretation of results, if γ_1 is significantly positive while γ_2 is significantly negative, then we conclude that the $CSAD_t$ has not decreased linearly and neither has it increased at a decreasing rate. This would lead to the conclusion that herding behaviour is detected in the model.

Among the latest to contribute to the development of herd measures are Hwang and Salmon (2001, 2004). By examining the cross-sectional variability of the factor sensitivities or betas (obtained by using a linear factor model where r_{mt} and f_{kt} are assumed to be uncorrelated) instead of the returns, they formulated measures to capture *herding towards the market as well as herding towards the fundamental factors*. The basis of their studies is founded on the discoveries from numerous empirical studies which show that the betas are in fact not constant as assumed by the conventional CAPM. They infer that this time-variation in betas actually reflects the changes in investor sentiment. In Hwang and Salmon's (2001) working paper, the herd measure is simply the cross-sectional dispersion of betas and evidence of herding is indicated by a reduction in this quantity. The confidence interval for this herd measure is computed based on their postulation that this herd measure follows an F-distribution.

In Hwang and Salmon (2004), they overcome the necessity to derive a correct distribution for the herd measure by adopting a different approach. They reckon that the action of investors intently following the market performance inadvertently upsets the equilibrium in the risk-return relationship that exist in the conventional Capital Assets Pricing Model (CAPM). The following explains the principle behind their proposed herd measure.

A CAPM in equilibrium is governed by the following relationship:

$$E_t\left(r_{it}\right) = \beta_{imt} E_t\left(r_{mt}\right) \tag{1}$$

where r_{it} and r_{mt} are the stock and market returns at time *t*, respectively, and β_{imt} is the systematic risk measure. The notation $E_t\left(.\right)$ represents the conditional expectation at time *t*. In effect, it means that in order to price a stock we only need β_{imt} if $E_t\left(r_{mt}\right)$ is given. Conventionally, β_{imt} is assumed to be constant over time. However, they pointed out that there are substantial empirical evidences from numerous studies (see, for examples, Ferson and Harvey, 1991, 1993; Ferson and Korajczyk, 1995) which shows that β_{imt} is in fact time-varying, and that this variation in β_{imt} is due to behavioural anomalies like herding and not caused by fundamental changes in β_{imt} or the equilibrium relationship specified above. They argue that when herding occurs, there exists a more pronounced shift of the investors' beliefs in order to follow the market portfolio. This would upset the equilibrium relationship and thus causes β_{imt} and the expected stock return to become biased. So they suggest that Eq. (1) be replaced by

$$\frac{E_t^b\left(r_{it}\right)}{E_t\left(r_{mt}\right)} = \beta_{imt}^b = \beta_{imt} - h_{imt}\left(\beta_{imt} - 1\right) \tag{2}$$

where $E_t^b\left(r_{it}\right)$ is the biased conditional expectation on the returns of stock *i* at time *t*, β_{imt}^b is the biased market beta at time *t*, and h_{mt} (≤ 1) is the latent herding parameter that changes over time and is conditional on market fundamentals. Since they are measuring market-wide herding behaviour, Eq. (2) is assumed to hold true for all the stocks in the market. The cross-sectional mean of β_{imt} is always 1. Thus, the cross-sectional standard deviation of the biased market beta is given by

$$Std_c\left(\beta_{imt}^b\right) = \sqrt{E_c\left[\left(\beta_{imt} - h_{mt}\left(\beta_{imt} - 1\right) - 1\right)^2\right]} = Std_c\left(\beta_{imt}\right)\left[1 - h_{imt}\right]$$

They then model this cross-sectional dispersion of the biased betas in a state space model, and use the technique of Kalman filter to obtain the time-varying herd measure. In this study they found that market-wide herding is independent of market conditions and the stage of development of the market. Their study on the U.S and South Korean markets revealed evidence of herding towards the market under both bullish and bearish market conditions.

Objective of Study

In this study, we propose a new herd measure for detecting prevalence of herding of a portfolio of stocks towards the market. In the formulation of the herd formula, the same underlying argument as Hwang and Salmon (2001, 2004) is adopted, that is, the changes in the cross-sectional dispersion of the betas reflect investors' sentiments towards the market. The herd measure is not meant to measure quantities of herding. It aims to gauge the ***relative degrees*** of herding of a portfolio of stocks towards the market as it is generally believed that herding is ubiquitous; it is present at all time albeit to varying degrees.

We then apply the herd measure to a portfolio of 69 Malaysian stocks to study the profile of monthly herding over the period 1993 – 2004. The multivariate linear model is used in estimating the beta. We consider separately both the assumptions of ***normally*** and ***non-normally distributed random errors***. In the former, the confidence interval of the herd measure is obtained by the ***bootstrap method***; while in the latter, the ***modified chi-square method*** is used instead. The herding results from both methods are then compared. In addition, we test the robustness of the use of the benchmark to conclude whether herding occurs in a particular month by varying the durations of the study period. To validate the plausibility of the herding results, we link the outcomes obtained to the prevailing market conditions and investors' sentiments.

Although in essence the herd measure of our proposed method is similar to that of Hwang and Salmon (2001, 2004), there are several differences. We are investigating the herding behaviour of a ***portfolio of any chosen number of stocks*** towards the ***market***, and not towards the other factors which may also be included in the multivariate linear model for estimation of the beta. In this way, our study differs from that of Hwang and Salmon (2001, 2004) which focuses on the collective ***market-wide*** herding behaviour of ***all*** the stocks in the market as well as herding towards the ***factors***. They use a linear factor model in which they assume that the random variables r_{mt} (market returns) and f_{kt} (returns of factor *k*) are not correlated - an assumption that is necessary in order to include herding towards the other factors in the study.

We outline the formulation of the herd measure and the bootstrap method for finding confidence interval of the herd measure, and then followed by an explanation on the modified chi-square method.

(1) Formulation of the Herd Measure

Since we intend to study the herd behaviour at a monthly frequency, we assume that the time-varying alpha, betas and sigmas are constant within the short period of one month. Therefore in a given month where there are *n* trading days, the multivariate linear model for stock *i* is expressed as follows:

$$r_{it} = \alpha_i + \beta_{im}\, r_{mt} + \sum_{k=1}^{K} \beta_{ik}\, f_{kt} + \varepsilon_{it} \qquad i = 1, 2, \ldots, N \text{ and } t = 1, 2, \ldots, n \tag{3}$$

where r_{it} is the return of stock *i*, α_i is a constant, β_{im} and β_{ik} are the coefficients on the market portfolio return (denoted by r_{mt}) and the *k*th factor (denoted by f_{kt}), respectively. Both r_{mt} and f_{kt} are considered as observable values. Following classical assumptions, the random errors are assumed to be normally distributed, with $E\left(\varepsilon_{it}\right) = 0$, $\operatorname{var}\left(\varepsilon_{it}\right) = \sigma_i^2$, $\operatorname{cov}\left(\varepsilon_{it}, \varepsilon_{jt}\right) = \sigma_{ij}^2$ for $i \neq j$, and $\operatorname{cov}\left(\varepsilon_{it}, \varepsilon_{js}\right) = 0$ for all *i* and *j*, and $t \neq s$. In reality, it is generally found that most financial data follow a fat-tailed and narrow-at-the-waist, unimodal distribution. Hence, we shall also consider the possibility of non-normal random errors.

The cross-sectional expectation (E_c) of all the individual stocks at time *t* constitutes the market portfolio return, that is,

$$E_c\left[r_{it}\right] = \frac{1}{N}\sum_{i=1}^{N} r_{it} = r_{mt}$$

Thus, from Eq. (3), we obtain

$$r_{mt} = E_c\left[\alpha_i\right] + r_{mt} E_c\left[\beta_{im}\right] + \sum_{k=1}^{K} f_{kt} E_c\left[\beta_{ik}\right] + E_c\left[\varepsilon_{it}\right] \qquad t = 1, 2, \ldots, n \tag{4}$$

On taking the ordinary expectation (*E*) on both sides of Eq. (4), we obtain

$$E_c\left[\alpha_i\right] + \left[E_c\left(\beta_{im}\right) - 1\right] E\left[r_{mt}\right] + \sum_{k=1}^{K} E_c\left[\beta_{ik}\right] E\left[f_{kt}\right] = 0 \quad t = 1, 2, \ldots, n \tag{5}$$

The variables in Eq. (5) are $E_c\left[\alpha_i\right]$, $E_c\left(\beta_{im}\right)$ and $E_c\left[\beta_{ik}\right]$. In the case when the number of equations (n) is greater than the number of variables (K + 2), Eq. (5) would imply that

$E_c\left[\alpha_i\right] = 0$, $E_c\left[\beta_{im}\right] = 1$ and $E_c\left[\beta_{ik}\right] = 0$ $\qquad k = 1, 2, 3,..., K$

Essentially, it means that in cross-sectional analysis, the average of the market betas is expected to be equal to 1 while the other coefficients average out to zero.

At any given time t, the stock price movements are supposedly independent of each other and we expect a wide range of β_{im} for the stocks, albeit an average of 1. However, when more investors are imitating the general movement of the market, the range of β_{im} for the stocks is expected to be narrower. In effect, it means that a significant decrease in the cross-sectional variance of the beta would signify an increase in the degree of herding towards the market. Therefore, in a given month, the herding effect is indicated by the deviation of β_{im} from 1 [note that $E_c\left(\beta_{im}\right) = 1$]. This deviation may be positive or negative, depending on the value of β_{im}. Taking h_i as the theoretical but unknown degree of herding towards the market return for stock i, we obtain

$$h_i = \left[\beta_{im} - E_c\left(\beta_{im}\right)\right]^2 = \left(\beta_{im} - 1\right)^2 \tag{6}$$

The estimated herd measure $\left(b_{im} - 1\right)^2$, however, is biased. Therefore, we consider an alternative estimated herd measure of stock i in a given month which is given by

$$\hat{h}_i = \left(b_{im} - 1\right)^2 - S_i^2\psi \tag{7}$$

where $S_i^2\psi$ is the estimated variance of b_{im}.

Hence, the proposed theoretical and the estimated degrees of herding for N stocks are, respectively,

$$H = \frac{1}{N}\sum_{i=1}^{N}\left(\beta_{im} - 1\right)^2 \text{ and} \tag{8}$$

$$\hat{H} = \frac{1}{N}\sum_{i=1}^{N}\left[\left(b_{im} - 1\right)^2 - S_i^2\psi\right]. \tag{9}$$

(2) Bootstrap Method

The distribution of $\hat{H}$ is unknown. But by visual inspection, the distributions of several sets of 100000 values of $\hat{H}$ appear to be unimodal and only slightly skewed. Hence, this suggests the plausibility of using bootstrap procedure to obtain the confidence interval of H.

The unbiased estimate of $\hat{H}$ based on the bootstrap sample is given by

$$\tilde{\hat{H}} = \frac{1}{N}\sum_{i=1}^{N}\left[\left(\tilde{b}_{im} - 1\right)^2 - 2\tilde{S}_i^2\psi\right] \tag{10}$$

where $\tilde{b}_{im}$ and $\tilde{S}_i^2$ represent, respectively, the estimated values of the coefficient and the variance of the random errors based on the bootstrap sample.

Based on the values of a_i, b_{im} and $\hat{\sigma}_i^2$ (the least square estimates of α_i, β_{im}, and the estimate of σ_i^2, respectively), we generate M^* bootstrap samples. The bootstrap confidence interval of H can be determined by the ranking method.

This classical ranking method involves arranging the M^* values of $\tilde{\hat{H}}$ in an ascending order: $\tilde{\hat{H}}^{(1)}, \tilde{\hat{H}}^{(2)}, \ldots, \tilde{\hat{H}}^{\left(M^*\right)}$. The lower and upper boundaries of the $100(1-\alpha)\%$ confidence interval of H are given by

$$L = \tilde{\hat{H}}^{(k)}, \qquad U = \tilde{\hat{H}}^{\left(M^*+1-k\right)} \tag{11}$$

where $k = M^*\left(\alpha/2\right)$ and *k* is an integer.

If *k* is not an integer, we then adopt the convention of Efron and Tibshirani (1993) by setting $k = \left\langle\left(M^*+1\right)\left(\alpha/2\right)\right\rangle$, that is, the largest integer that is less than or equal to $\left(M^*+1\right)\left(\alpha/2\right)$.

(3) Modified Chi-square Method

In this method, we approximate the distribution of $\hat{H}$ by using only the first two moments of $\hat{H}$. The theoretical first and second moments of $\hat{H}$ are given below.

$$E\left(\hat{H}\right) = E\left[\frac{1}{N}\sum_{i=1}^{N}\hat{h}_i\right] = \frac{1}{N}\left\{\sum_{i=1}^{N}\left[E\left(b_{im}^2\right) - 2E\left(b_{im}\right) + 1 - E\left(S_i^2\right)\psi\right]\right\} \tag{12}$$

$$E\left(\hat{H}^2\right) = \frac{1}{N^2}\left\{\sum_{i=1}^{N}E\left(\hat{h}_i^2\right) + 2\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}E\left(\hat{h}_i\hat{h}_j\right)\right\} \tag{13}$$

where

$$\begin{aligned}
E\left(\hat{h}_i^2\right) &= E\left\{\left[\left(b_{im}-1\right)^2 - S_i^2\psi\right]^2\right\} \\
&= E\left[\left(b_{im}-1\right)^4 - 2\left(b_{im}-1\right)^2 S_i^2\psi + S_i^4\psi^2\right] \\
&= E\left(b_{im}^4\right) - 4E\left(b_{im}^3\right) + 6E\left(b_{im}^2\right) - 4E\left(b_{im}\right) + 1 \\
&\quad - 2\left[E\left(b_{im}^2\right) - 2E\left(b_{im}\right) + 1\right]E\left(S_i^2\right)\psi + E\left(S_i^4\right)\psi^2
\end{aligned} \tag{14}$$

$$\begin{aligned}
E\left(\hat{h}_i\hat{h}_j\right) &= E\left\{\left[\left(b_{im}-1\right)^2 - S_i^2\psi\right]\left[\left(b_{jm}-1\right)^2 - S_j^2\psi\right]\right\} \\
&= E\left(b_{im}^2 b_{jm}^2\right) - 2\left[E\left(b_{im}^2 b_{jm}\right) + E\left(b_{im} b_{jm}^2\right)\right] + E\left(b_{im}^2\right) + E\left(b_{jm}^2\right) \\
&\quad + 4E\left(b_{im}b_{jm}\right) - 2\left[E\left(b_{im}\right) + E\left(b_{jm}\right)\right] + 1 \\
&\quad + \left[E\left(b_{im}^2\right) - 2E\left(b_{im}\right) + 1\right]E\left(S_j^2\psi\right) \\
&\quad + \left[E\left(b_{jm}^2\right) - 2E\left(b_{jm}\right) + 1\right]E\left(S_i^2\psi\right) + E\left(S_i^2 S_j^2\right)\psi^2
\end{aligned} \tag{15}$$

The modified chi-square method relies on the use of the quadratic-normal distribution posited by Pooi (2003).

We introduce independent variables $y_1, y_2, ..., y_k$ such that $E\left(y_i^2\right) = 1$ for i = 1, 2,…,k and the random variable y_i follows a quadratic-normal distribution with zero mean and parameters λ_1, λ_2 and λ_3, that is

$$y_i \sim QN\left(0, \lambda_1, \lambda_2, \lambda_3\right).$$

Mathematically, y_i is a non-linear function of a random variable E , as given below:

$$y_i = \begin{cases} \lambda_1 E + \lambda_2\left(E^2 - \dfrac{1+\lambda_3}{2}\right), & E \geq 0 \\ \lambda_1 E + \lambda_2\left(\lambda_3 E^2 - \dfrac{1+\lambda_3}{2}\right), & E < 0 \end{cases} \tag{16}$$

where $E \sim N(0,1)$.

The sum of squares of the y_i is said to have a modified chi-square distribution with *k* degrees of freedom [see Pooi (2005)]. Multiplying this sum of squares of the y_i by a constant c, we get another random variable

$$Y^* = c\left(y_1^2 + y_2^2 + ... + y_k^2\right). \tag{17}$$

We choose the value of *c*, $\lambda_1, \lambda_2, \lambda_3$ and the smallest value of *k* such that

$$E\left(\hat{H}^j\right) = E\left(Y^{*j}\right), \quad j = 1, 2. \tag{18}$$

The relevant procedure is outlined as follows:

We first note that the first and second moments of Y^* are, respectively,

$$E\left(Y^*\right) = ck \tag{19}$$

$$E\left(Y^{*2}\right) = c^2\left\{kE\left(y_1^4\right) + k(k-1)\left[E\left(y_1^2\right)\right]^2\right\}$$

$$= c^2\left\{kE\left(y_1^4\right) + k(k-1)\right\} \tag{20}$$

since $E\left(y_i^2\right) = 1$.

From Eq. (18), Eq. (19) and Eq. (20) we obtain

$$c = \frac{E\left(\hat{H}\right)}{k} \tag{19}$$

$$E\left(y_1^4\right) = \frac{1}{k}\left[\frac{E\left(\hat{H}^2\right)}{c^2} - k(k-1)\right] \tag{20}$$

We next find the smallest value of *k* such that we can determine the values of λ_1, λ_2 and λ_3 which satisfy Eq. (18). Now that the distribution of y_i is known, we can estimate the distribution of Y^* by means of simulation. This distribution of Y^* closely resembles the distribution of $\hat{H}$. The boundaries of the 95% confidence interval are obtained from the percentiles of Y^*.

As emphasised earlier, the formula is not meant to measure quantities of herding; instead it aims to measure the ***relative degrees*** of herding of a portfolio of stocks towards the market. The arithmetic mean of all the monthly values of $\hat{H}$ for the duration of period under study is used as the ***benchmark*** for this purpose. Setting $\alpha = 0.05$, we are 95% confident that the actual unknown value of H lies within L and U. If the ***value of*** U ***is less than or equal to this benchmark***, then we conclude with a 95% level of confidence that ***there is herding***. On the other hand, we cannot make a conclusion of herding at the 95% confidence level for the following two cases: (1) The benchmark is less than U but more than L, and (2) The benchmark is less than or equal to L.

Data

In this study we apply the herd formula to a portfolio of 69 constituent stocks of the Kuala Lumpur Composite Index (KLCI) to study the profile of herding towards the market from January 1993 to December 2004 − a period straddling the market bull-run in the early nineties, the 1998 Asian financial crisis and subsequently the supposedly recovery phase. The criterion for choosing these 69 stocks is based on the fact that these stocks have been continuously listed in the KLCI since 1993. As at December 2005, these 69 stocks constitute about 50% of the total market capitalisation. The KLCI is used as a proxy for the market portfolio. The names of these 69 stocks are listed in Appendix 1. The multivariate linear model is also kept simple by using the basic Market Model where no factors are included (that is, $K = 0$).

The daily stock returns and market returns are computed as follows:

$$r_{it} = \ln\left(\frac{p_{it}}{p_{i,t-1}}\right) \text{ and } r_{mt} = \ln\left(\frac{p_{mt}}{p_{m,t-1}}\right),$$

where p_{it} and p_{mt} represent the daily closing price on day t for stock i and the market, respectively. From the basic Market Model, we estimate the values of a_i, b_{im} and $\hat{\sigma}_i^2$ for each month.

The profile of market volatility is also taken into consideration. The market volatility in a given month is measured by the standard deviation of the daily closing prices of the market, that is,

$$\hat{\sigma}_m = \frac{\sqrt{\sum_{t=1}^{n}\left(r_{mt} - \bar{r}_m\right)^2}}{n-1}$$

where n is the number of trading days in the month and $\bar{r}_m = \frac{1}{n}\sum_{t=1}^{n} r_{mt}$.

Results

The occurrence of herding was analysed in relation to the three periods (given below) as determined by Goh, Wong and Kok (2005).

Pre-crisis period – January 1993 to July 1997

Crisis period – August 1997 to August 1998

Post-crisis period – September 1998 to December 2004

Figure 1 shows the distribution of the 144 monthly values of $\hat{H}$ obtained. The distribution of $\hat{H}$ is not normal; instead it is slightly positively skewed and leptokurtic. The benchmark for the determination of the existence of herding is 0.57109, the arithmetic mean of $\hat{H}$. Herding is said to be present in a given month if the value of U is lower than or equal to this benchmark.

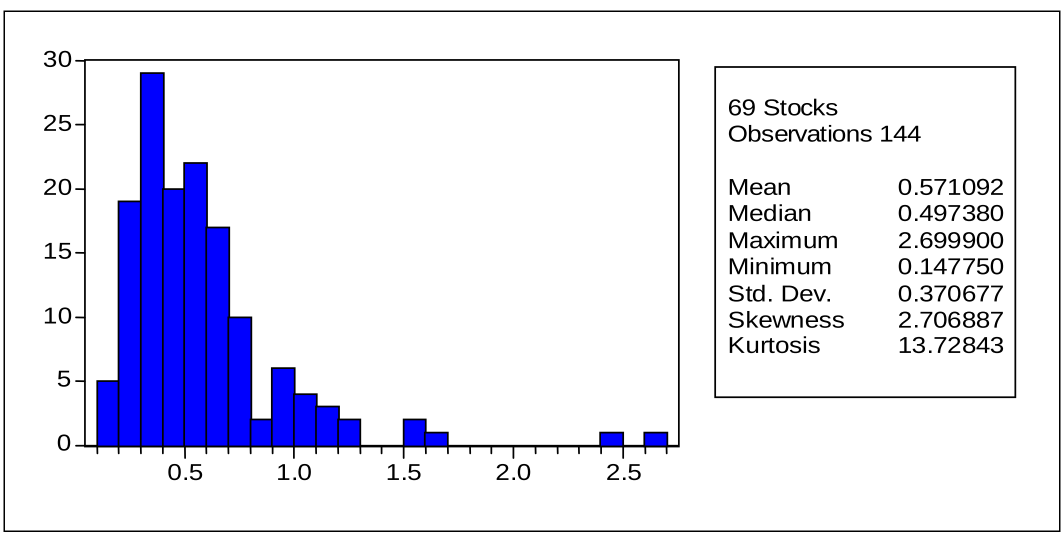

Figure 1 Histogram of $\hat{H}$

The results from the two methods of obtaining confidence interval of H are shown in Table 1. The presence of herding is indicated by the letter h. The numerical values can be provided by the authors upon request. The results reveal that both methods for obtaining confidence interval of H have produced almost identical patterns of herding in the 12-year period. Discrepancies are found only in April 1999, October 1999, September 2001 and January 2002 where herding is detected by the modified chi-square method but not by the bootstrap method. This indicates that the two assumptions on the distribution of the random errors do not make much difference to the herding results.

In order to study herding in relation to the prevailing market trends and market volatility, a graphical approach would be more informative. The values of L, $\hat{H}$ and U for each month are plotted in a vertical line which is named as ***range plot*** of the herd measure. The graphs of range plots are charted chronologically with the graph showing the end-of-the-month closing values of the KLCI and the graph for the monthly estimated market volatilities. The composite graphs are shown in Figure 2. The red horizontal line shown in the graph of range plots is the benchmark line. The red vertical lines that traverse all three graphs in each chart mark the months where discernible occurrence of herding is identified. The four blue vertical lines identify the additional months where herding is detected by the modified chi-square method but not by the bootstrap method. Barring these four months, the patterns of herding obtained through the bootstrap method and the modified chi-square method are almost identical.

In the next section, we shall attempt to explain the pattern of herding behaviour that we obtained by linking it chronologically to the market movements, the prevailing market sentiments and the events that had taken place. In their study on herd behaviour in the financial markets, Bikhchandani and Sharma (2001) have pointedly highlighted that "the investment decisions of early investors are likely to be reflected in the subsequent price of the assets". Without the actions of the investors, obviously there would be no price movements. Therefore, it is certainly justifiable to 'read' the intentions and psychology of the investors from the characteristics derived from studies that use realised data.

Table 1 Herding Results from Bootstrap Method and Modified Chi-square Method

Year	**Month**																							
	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M
Panel A: Pre-crisis Period																								
1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	h	h	-	-
1994	h	h	h	h	-	-	h	h	h	h	-	-	h	h	h	h	-	-	h	h	h	h	h	h
1995	h	h	h	h	h	h	h	h	-	-	h	h	h	h	h	h	h	h	-	-	h	h	h	h
1996	h	h	-	-	h	h	-	-	-	-	-	-	h	h	h	h	-	-	-	-	-	-	h	h
1997	-	-	-	-	-	-	h	h	-	-	-	-	h	h										
Panel B: Crisis Period																								
1997															h	h	h	h	h	h	h	h	h	h
1998	h	h	h	h	-	-	-	-	-	-	h	h	h	h	h	h								
Panel C: Post-crisis Period																								
1998																	h	h	h	h	h	h	-	-
1999	h	h	h	h	-	-	-	**h**	h	h	-	-	-	-	-	-	h	h	-	**h**	-	-	-	-
2000	h	h	-	-	-	-	h	h	h	h	h	h	h	h	h	h	-	-	h	h	h	h	-	-
2001	-	-	-	-	-	-	h	h	-	-	-	-	h	h	-	-	-	**h**	h	h	-	-	-	-
2002	-	**h**	-	-	-	-	-	-	-	-	-	-	h	h	-	-	h	h	-	-	-	-	-	-
2003	-	-	-	-	-	-	h	h	-	-	-	-	-	-	-	-	-	-	-	-	-	-	h	h
2004	-	-	h	h	-	-	h	h	-	-	h	h	-	-	-	-	-	-	-	-	h	h	-	-

Note: The letter B stands for bootstrap method and M for modified chi-square method. The letter h indicates 'Herding occurs'.

Implication of Results from the Behavioural Finance Perspective

Pre-crisis period

During the market rally all through 1993, herding was not detected at all. Instead, it was noted only after the sharp market decline in early 1994.

Possible reasons: Investor success was almost certain regardless of choice of stocks during this period of market bull-run. Fear was minimal and in its place was exuberance and over-confidence. There was no necessity to seek safety in numbers since there was no perceived threat. This is reflected in our study where no herding was found in that period of unrelenting *market rise. In early 1994, the inevitable market correction brought a calamitous downtrend. It was then evident that the investment climate had changed, and in fear and uncertainty, investors looked to one another for direction. Periods of persistent herding appeared all through 1994 and 1995, typically at market peaks and troughs.*

For the remaining months in the pre-crisis period, the market was going through the usual phases of rising and falling prices but generally trending upwards. Herding was still detected, although intermittently.

Crisis Period

The Malaysian market tumbled from a peak of 1200 points to less than half its value by August 1998. Strong evidence of herding was shown in the period from July 1997 to February 1998.
Possible reasons: The patterns of herding in the two-year period of 1997 to 1998 speak volumes of the effect of the 1998 Asian financial crisis. The clearly persistent herding shown from July 1997 to February 1998 corresponded to the time of crisis period when the Malaysian ringgit was floated in reaction to the ensuing pandemonium of currency devaluation that spread rapidly throughout the Southeast Asian region. The high market volatility in this period shows that there were rapid changes in prices.

However, rather unexpectedly, significant herding disappeared altogether in the next three months even though the market was falling steeply.
Possible reasons: In the face of so much uncertainty, the investors were probably adopting a cautious attitude. This postulation is supported by the marked decrease in market volatility during this period.

Persistent herding started to reappear in the few months before the market reached its lowest point (in August 1998) in the entire twelve-year period of our study.

Post-crisis period

Our results show a pattern of persistent herding in the next three months, but this time in an ascending market. This is an interesting observation as it is in contrast to the period of market rally in 1993 where no herding behaviour was picked up by the measure.

Possible reasons: In order to curb the excessive volatility in the foreign exchange rate, on 1 September 1998, the Malaysian government imposed capital controls that pegged the Malaysian ringgit to the US dollar. The market responded immediately and positively. The market was highly volatile in that month as confirmed by the sharp spike shown in the graph of market volatility. This evidence of herding following the imposition of capital controls may well reflect the investors' apprehensive sentiments at that point in time. Such drastic measures adopted by the government were hitherto without precedence and the implementation was fraught with uncertainty and fear. The investors probably believed that the market had hit rock-bottom and they would not want to miss out on the opportunity to reap some profits or to regain their losses. However, under such circumstances, it is not surprising that persistent herding occurred. In contrast, the market sentiments during the continuous rise of 1993 were that of confidence. Perhaps this observation offers circumstantial evidence that herding behaviour is associated with uncertainty and fear.

In 2000, persistent herding occurred again after some unprecedented developments.
Possible reasons: In February 2000, Bank Negara Malaysia enforced the merger of 50 banks into 10 banking groups by year end. This also led to consolidation of the local stock broking industry with mergers and acquisitions among local stock broking companies (source: Securities Commission 2000 Annual Report). In an already declining market, such unusual developments involving financing and transacting of equities were certain to have an unsettling effect on investors and would heighten negative sentiments.

From the year 2001 onwards, the market generally drifted sideways, with no marked price swings. Except for the few sporadic cases, the results do not show much persistent herding behaviour in that period.

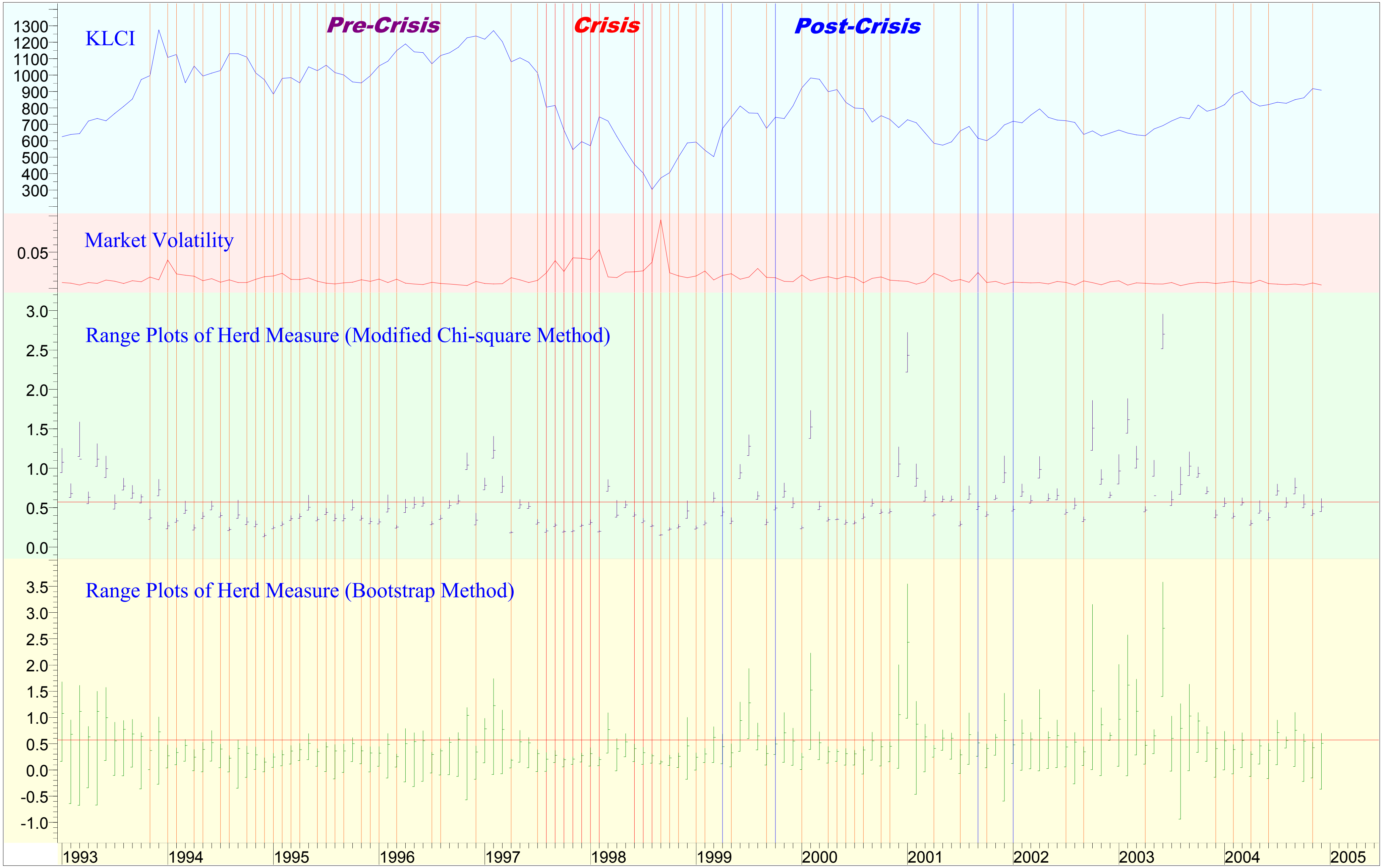

Figure 2 KLCI, Market Volatiity and Range Plots of Herd Measure

Created in MetaStock from Equis International

Varying Periods of Study to Test Robustness of Procedure

The evidence of herding is dependent on the arithmetic mean of $\hat{H}$ or the benchmark for the period under study. We conclude that there is herding in a given month if U is less than or equal to this benchmark. Varying the period of study will certainly change this benchmark.

To verify that this proposed procedure in drawing conclusion on herding outcome is robust, we proceed to vary the periods of study. We differentiate the 12-year study period into three different periods of study – the pre-crisis period, the crisis period and the post-crisis period. When the period of study is stipulated as the 'pre-crisis period', the benchmark is given by the arithmetic mean of $\hat{H}$ for all the months in this period only. Likewise, the benchmarks are calculated for the two other periods of study. To avoid possible confusion, we shall label these periods of study as *D*1, *D*2 and *D*3, and their respective benchmarks are 0.50834, 0.33678 and 0.65658. The herding outcomes through the two methods for the study periods *D*1, *D*2 and *D*3, are compared to the corresponding herding outcomes reported in *Panel A, Panel B* and *Panel C* in Tables 1. The results are shown in Tables 2, 3 and 4.

Table 2: A Comparison of Herding Results for Pre-crisis Period

Year	**Month**																							
	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M
1993D1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	h	h	-	-
1993T1A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	h	h	-	-
1994D1	h	h	h	h	-	-	h	h	-	h	-	-	h	h	h	h	-	-	h	h	h	h	h	h
1994T1A	h	h	h	h	-	-	h	h	h	h	-	-	h	h	h	h	-	-	h	h	h	h	h	h
1995D1	h	h	h	h	h	h	h	h	-	-	h	h	h	h	h	h	h	h	-	-	h	h	h	h
1995T1A	h	h	h	h	h	h	h	h	-	-	h	h	h	h	h	h	h	h	-	-	h	h	h	h
1996D1	h	h	-	-	h	h	-	-	-	-	-	-	h	h	h	h	-	-	-	-	-	-	-	h
1996T1A	h	h	-	-	h	h	-	-	-	-	-	-	h	h	h	h	-	-	-	-	-	-	**h**	h
1997D1	-	-	-	-	-	-	h	h	-	-	-	-	h	h										
1997T1A	-	-	-	-	-	-	h	h	-	-	-	-	h	h										

Note: The letter B stands for bootstrap method and M for modified chi-square method. The letter h indicates 'Herding occurs'. The notation T1A represents the set of herding outcomes from the *Panel A* of Table 1.

Table 3: A Comparison of Herding Results for Crisis Period

Year	Month																							
	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M
1997D2															h	h	-	h	h	h	h	h	h	h
1997T1B															h	h	**h**	h	h	h	h	h	h	h
1998D2	-	-	h	h	-	-	-	-	-	-	-	-	-	-	h	h								
1998T1B	**h**	**h**	h	h	-	-	-	-	-	-	**h**	**h**	**h**	**h**	h	h								

Note: The letter B stands for bootstrap method and M for modified chi-square method. The letter h indicates 'Herding occurs'. The notation T1B represents the set of herding outcomes from the *Panel B* of Table 1.

Table 4: A Comparison of Herding Results for Post-crisis Period

Year	Month																							
	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M	B	M
1998D3																	h	h	h	h	h	h	-	**h**
1998T1C																	h	h	h	h	h	h	-	-
1999D3	h	h	h	h	-	-	-	h	h	h	-	-	-	-	-	-	h	h	**h**	h	-	-	-	**h**
1999T1C	h	h	h	h	-	-	-	h	h	h	-	-	-	-	-	-	h	h	-	h	-	-	-	-
2000D3	h	h	-	-	-	**h**	h	h	h	h	h	h	h	h	h	h	-	**h**	h	h	h	h	-	-
2000T1C	h	h	-	-	-	-	h	h	h	h	h	h	h	h	h	h	-	-	h	h	h	h	-	-
2001D3	-	-	-	-	-	-	h	h	-	**h**	-	**h**	h	h	-	-	-	h	h	h	-	-	-	-
2001T1C	-	-	-	-	-	-	h	h	-	-	-	-	h	h	-	-	-	h	h	h	-	-	-	-
2002D3	-	h	-	-	-	-	-	-	-	-	-	-	h	h	-	**h**	h	h	-	-	-	-	-	-
2002T1C	-	h	-	-	-	-	-	-	-	-	-	-	h	h	-	-	h	h	-	-	-	-	-	-
2003D3	-	-	-	-	-	-	h	h	-	-	-	-	-	-	-	-	-	-	-	-	-	-	h	h
2003T1C	-	-	-	-	-	-	h	h	-	-	-	-	-	-	-	-	-	-	-	-	-	-	h	h
2004D3	-	**h**	h	h	-	**h**	h	h	h	h	h	h	-	-	**h**	**h**	-	-	-	-	h	h	-	**h**
2004T1C	-	-	h	h	-	-	h	h	-	-	h	h	-	-	-	-	-	-	-	-	h	h	-	-

Note: The letter B stands for bootstrap method and M for modified chi-square method. The letter h indicates 'Herding occurs'. The notation T1C represents the set of herding outcomes from the *Panel C* of Table 1.

An analysis of Table 2 to Table 4 reveals that, with the exception of a few months where the occurrences of herding do not coincide, the patterns of persistent herding are generally overlapping. This shows that we can still obtain similar results despite changing the periods of study.

Conclusion

Both methods for obtaining confidence interval of the herd measure yield similar results. This shows that the assumptions on the distribution of the random errors seemingly do not make much difference to the herding outcomes. We found patterns of herding which can be explained by the prevailing market conditions and sentiments. Herding towards the market was found in both rising and falling markets that were preceded by a sharp market reversal. No clear herding was found when the market was confidently bullish in the early nineties. Prolonged market falls – as seen in the financial crisis period and during the times when the market experienced technical corrections after a long period of ascent – practically run in tandem with persistent herding patterns. In period of crisis, herding was expected since in the face of uncertainty and fear, investors would seek safety in numbers. Not surprisingly, the crisis period recorded the highest proportion of herding incidences. Herding was very pronounced during the short market rally that occurred when the market responded immediately to the stringent measures taken by the Malaysian government to arrest further deterioration in the financial system caused by the crisis. However, the resulting market rally was unlike that in the early nineties when the market sentiments were radically different. This evidence of herding at the beginning of the post-crisis period may well reflect the prevailing mood of apprehension in reaction to the measures taken by the government. Overall, our study supports the intuition that herding is related to drastic changes in market conditions, especially so when the atmosphere of uncertainty is prevalent.

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