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ORIGINAL RESEARCH

The price impact of foreign institutional herding on large-size stocks in the Taiwan stock market

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Abstract This study constructs a panel threshold regression model to explore the price impact of foreign institutional herding of firms listed in the Taiwan Stock Exchange during January 2000 to June 2008. Our panel threshold model is constructed to explore the price impact of foreign institutional investors' herding in the Taiwan stock market after controlling the firm size. By examining the presence of threshold effect, this study analyzes whether firm size would obviously and asymmetrically affect the explanation for the effect of changes in foreign investors' share ownership on abnormal returns. The empirical results of this study find the significant evidence of threshold effect which divides the stocks into large-size and small-size firms. It is found that foreign institutional investors in the Taiwan stock market tend to hold large-size stocks listed in the Taiwan Stock Exchange. There is an apparent increase in the subsequent abnormal returns on large-size stocks bought in bulk by foreign investors. The signals of changes in share ownership initiated by foreign institutional investors would reveal further information for improving the performance of asset reallocation decisions in Taiwan. The panel threshold model constructed in this paper well describes the price impact of institutional herding yet eschews the possibly subjective data snooping issue resulting from the two-pass sorting method as proposed by previous related researches.

Keywords Institutional herding · The price-impact of herding · Firm size · Panel threshold · Taiwan stock market

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1 Introduction

Although foreign institutional investors hold just 20% of total equity and their trading accounts for only 8% of total turnover in the Taiwan stock market, their share ownership and trading amount are greater than those of local institutional investors, inferring possible greater market influence. Besides, foreign institutional investors are in general equipped with exceptional know-how in investment, and they are relatively more rational than other investors. In addition, foreign institutional investors tend to focus more on long-term investment performance than local institutional investors since 1998. As the government gradually loosens the restrictions on share ownership by foreign investors, Taiwan stock market would become more attractive.

Chen et al. (2007) demonstrate that MSCI Taiwan Index (MSCI-TWI) and the net foreign investment dollar have a positive contemporaneous correlation. Li and Yung (2004) find a significant positive relation between changes in institutional ownership and ADR returns over the same period, and the positive relation persists after they control for the momentum effect in the US stock markets. Chakravarty (2001), Dennis and Weston (2000), and Sias et al. (2002) conclude that the relation between changes in institutional ownership and returns measured over the same period results primarily from price effects associated with institutional trading. Empirical results of Nofsinger and Sias (1999) and Wermers (1999) found that stocks institutional investors buy do outperform those they sell. Their results further demonstrate that the subsequent performance of small-size stocks with large herding by institutional investors is stronger. Sias (2004) documents that institutional herding is weakly positively correlated with future returns. Sias also finds institutional cascades are more likely to occur in small-capitalization securities. Similar work proposed by Chen et al. (2005) demonstrate that abnormal returns driven by buy herding of mutual funds are larger than those driven by sell herding in the Taiwan stock market. The price impact of institutional herding of firm size may obviously be differenced in an emerging equity market like Taiwan's because foreign institutional investors prefer to hold large-size stocks in emerging markets. Therefore, the post-herding prices of these stocks on their large herding are easily pushed up (such as shown in Lin and Swanson 2003).[1] This phenomenon may result from the lower market value in market structure of plain-plate type than that in the developed markets. In that case, abnormal returns of large-size stocks come up with the herding of foreign investors. In comparison with the general sorting procedure, adopted by prior studies to further analyze the price-impact of institutional herding by firm size in the Taiwan stock market, it is beneficial to adopt a more objective research method for exploring this issue in Taiwan.

It is also found from previous literatures that firm size is one of the major determinants for institutional investors' decision on their shareholdings.[2] Hessel and Norman (1992), Falkenstein (1996), Lin and Swanson (2003) and Chiao and Lin (2004) propose that

[1] Hoitash and Krishnan (2008) deemed that specific measure of speculative intensity (SPEC) based on autocorrelation in daily trading volume by market participants has a significant positive impact on returns.

[2] The series studies of Fama and French (1992, 1993, 1995, 1996) clearly pointed out that the three factors model of market, size and book-to-market ratio can catch the main variation of the cross-sectional expected returns of stocks. Daniel and Titman (1997) demonstrated that firm size and book-to-market ratio are correlated with the mean returns of assets, and the reason is not that they are the substitute of risk but that characteristics can determine the mean stock returns.

institutional investors tend to hold the large-size stocks with high growth, high visibility and good performance. Chen et al. (2009) find that company size is among the predominant factors in which foreign institutional investors take into account when making decisions in each industry in the Taiwanese stock market. In addition, Lin and Swanson (2003) find that, after controlling for firm size, foreigner' short-term performance for large-size stocks is better than performance for small-size stocks since the proportion of positive net share purchases difference for large-size stocks is larger than the proportion for small-size stocks on the Taiwan stock exchange (TSE).[3] However, several representative literatures on herding demonstrate that the subsequent abnormal returns of small-size stocks with large increase in shareholding by institutional investors are larger than those of large-size stocks. Wermers (1999) uses a two-pass sorting procedure to analyze the correlations between institutional herding, firm size and post-herding returns. He finds that subsequent abnormal returns on overbought portfolio are obviously larger than those of oversold portfolio, and the impact of herding on abnormal returns for small-size stocks is larger than that for large-size stocks. The results of Nofsinger and Sias (1999) find that, no matter adopting one-way or two-pass sorting method, the subsequent performance of small-size stocks with large increase in share ownership by institutional investors is stronger. In other words, they support the price impact of institutional herding of small-size stocks in the US stock market.

The two-pass sorting procedure of Nofsinger and Sias (1999) and Wermers (1999) is a sequential sorting method which can result in a problem of subjective determining for threshold. Such a research design would give rise to estimation bias resulting from the interactions between institutional investors' herding and the block variable of firm size. Therefore, we apply the panel threshold model proposed by Hansen (1999) to use observations of threshold variables to estimate the adaptive threshold in a panel data set, which might eschew the possible data snooping problem of the $N \times N$ classification as employed in the two-pass sorting method of Nofsinger and Sias (1999) and Wermers (1999). We employ firm size as threshold variable to explore the impact of foreign institutional herding on stocks' abnormal returns while controlling variation caused by the market value. It is examined that the relationship of changes in foreign institutional investors' share ownership and firm size in the same interval with post-herding abnormal returns by adopting panel threshold method. Through this procedure, we can evaluate whether abnormal returns driven by changes in foreign institutional investors' share ownership are markedly differentiated by firm size and analyze the information contents embedded therein.

The empirical results of this study find that there is one threshold which separates the firms based on market capitalization. Large-size firms in the TSE-listed stocks are significantly affected by the price impact of foreign institutional investors' herding. If other investors follow foreign institutional investors to purchase the stocks of large-size firms, especially in Electronics and Plastics sectors, the average abnormal return would be better if those stocks are held for 1 month or so. The major contribution of this study lies in the design of a panel threshold model to objectively quantify the extent of firm size rather than assuming in advance the degree of such constraints. Adopting this method could improve the problem caused by subjective threshold determining and the interaction between the two variables as seen in the two-pass sorting method of Nofsinger and Sias (1999) and Wermers (1999). The explanation capability of foreign institutional herding on stocks' abnormal returns in Taiwan is significantly increased by our econometric method.

[3] Lin and Swanson (2003) used firm size as control variable to explore subsequent performance of the winners and losers held by foreign investors while using proportion of positive net share purchases as dependent variable.

Remainder of this paper is organized as follows: Sect. 2 describes the research design and methodology, including variable measurement, sample type and the establishment of panel threshold model. The empirical results are discussed in Sect. 3, including data, basic statistics and estimating results. The conclusions are summarized in Sect. 4.

2 Research design and methodology

2.1 The trading of foreign investors reflects information signals

Previous studies (such as Nofsinger and Sias 1999; Wermers 1999; Lin and Swanson 2003) find that firm size is one of the information signals for the performance of institutional trading. Nofsinger and Sias (1999) propose that the subsequent performance of small-size stocks with a large increase in share ownership by institutional investors is stronger. Wermers (1999) demonstrate that the impact of herding on abnormal returns for small-size stocks is larger than that for large-size stocks. However, the results of Lin and Swanson (2003) show that the foreign investors' short-term performance of large-size stocks is better than the performance of small-size stocks after controlling for the firm size in Taiwan. Therefore, it is worth our clarifying whether the subsequent performance of foreign institutional herding on the large-size stocks is larger than that on the small-size stocks in an emerging market like Taiwan since foreign institutional investors prefer to trade in the stocks of large firms in the Taiwan stock market with the market structure of the plain-plate type. In other words, we focus on the point of view that the trading of foreign investors reflects information signals rather than trading based on information asymmetry. The more complete integration of the price effects of the herding by foreign institutional investors and firm size in Taiwan might well improve analyses of the performance in terms of herding by institutional investors in the emerging market.

2.2 Types of sampling

To fulfill the requirement of duration of panel threshold model, this study uses the monthly shareholding ratio of foreign institutional investors over the period from January 2000 to June 2008. Based on well liquidity and general industrial property, we select the listed companies who all traded over the period of 2000–2008 excluding preferred stocks, warrants and full-cash delivery stocks in the Taiwan stock market. The majority of foreign institutional investors prefer to trade the listed stocks as a way to closely and effectively follow Taiwan's stock index. Therefore, this study explores the monthly returns on individual TSE-listed stocks all traded over the above mentioned period and the returns on Taiwan weighted stock index (TAIEX) during the same period.

2.3 Variable measures

2.3.1 Measure of changes in institutional ownerships

Foreign institutional investors that are referred to in this study are qualified foreign institutional investors (QFIIs) and general foreign institutional investors (GFIIs). Share ownership of foreign investors is defined as their shareholdings divided by the number of shares outstanding. Thus, an increase (decrease) in the fraction of shares held by foreign investors represents a decrease (increase) in the percentage held by other investors.

2.3.2 Abnormal returns

The abnormal return on individual stock i for a given month is initially calculated based on a capital asset pricing model:[4]

$$R_i^a = \left(r_{i,t1} - r_{f,t1}\right) - \beta_i\left(r_{m,t1} - r_{f,t1}\right), \quad t1 = -11, \ldots, 0 \tag{1}$$

2.3.3 Firm size

Firm size is measured by the market value of common shares, i.e., the unadjusted closing price of stock i in the tth month times the number of shares outstanding.

$$ME_{i,t} = Q_{i,t} \times P_{i,t} \tag{2}$$

$Q_{i,\,t}$ ($P_{i,t}$) is the number of shares outstanding (the unadjusted closing price) of stock i in the tth month, and $ME_{i,t}$ is monthly market value (defined as firm size) of stock i in the tth month.

2.4 The price-impact of institutional herding of firm size

Nofsinger and Sias (1999) employ one-way sorting procedure to explore the impact of changes in share ownership of institutional investors on stock returns. Further, Nofsinger and Sias (1999) and Wermers (1999) adopt a two-pass sorting procedure to clarify whether subsequent performance of stocks that institutional investors herd towards, or away from, evidently differs by firm size in last year or last quarter. But in emerging markets with high turnover, like Taiwan, changes in share ownership of institutional investors should be measured in more frequent interval such like 1 month. Thus, this study uses the essence of two-pass sorting of Nofsinger and Sias (1999) and Wermers (1999) to define control variable as firm size in last month. The relation of these variables can be summarized as the following regression:

$$R_{i,t}^a = u_i + \alpha_1 \Delta IN_{i,t-1} + \alpha_2 s_{i,t-1}, \qquad i = 1, 2, \ldots, N, \quad t = 1, 2, \ldots, T. \tag{3}$$

where $R_{i,t}^a$ indicates abnormal returns of stock i in the tth month, $\Delta IN_{i,t-1}$ indicates changes in share ownership of stock i held by foreign institutional investors in last month, and $s_{i,t-1}$ indicates firm size of stock i in last month. T is the number of experiencing month, and N is the number of the TSE-listed stocks selected in this study.

The coefficient α_1 of $\Delta IN_{i,t-1}$ represents the predictability of changes in share ownership of foreign institutional investors in last month on abnormal returns in this month. To eschew the possibly subjective division and the resulting data snooping issue adopted by the two-pass sorting procedure of Nofsinger and Sias (1999) and Wermers (1999) and the possible estimation bias resulting from the interactions between changes in institutional investors' share ownership and firm size, this study adopts the panel threshold method of Hansen (1999) and uses the following threshold model to take firm size into account.[5]

[4] $r_{i,t1}$ is the monthly return for individual stock i in this month and past 11 months; $r_{f,t1}$ is the risk-free rate in this month and past 11 months, which is the interest rate for a 1-month term deposit offered by Taiwan First Bank; $r_{m,t1}$ is the change ratio of net value of TAIEX in this month and past 11 months.

[5] We mainly explore whether there is a difference between the post-herding premium of foreign institutional investors' trading on the large-size stocks and the post-herding premium of their trading on the small-size stocks.

$$R^a_{i,t} = u_i + \theta s_{i,t-1} + \beta^{(1)}\Delta IN_{i,t-1} I(s_{i,t-1} > \gamma) + \beta^{(2)}\Delta IN_{i,t-1} I(s_{i,t-1} \leq \gamma) + e_{i,t} \quad (4)$$

$I(.)$ is the indicator function, which is equal to 1 when $s_{i,t-1} > \gamma$, and 0 otherwise. γ is the value of threshold, which is unknown but can be estimated. The coefficient $\beta^{(1)}$ denotes the parameter vector in higher regime of firm size, and $\beta^{(2)}$ denotes the parameter vector in lower regime.

The meaning of Eq. (4) is accounted for as follows. Our sample is divided into two regimes depending on whether the threshold variable of $s_{i,t-1}$ is smaller or larger than the threshold valueγ. Thus, when $s_{i,t-1} > \gamma$, firms are in a high regime of threshold variable; otherwise, firms are in a low regime. Moreover, when foreign institutional investors increase their share ownership in firms of smaller size, abnormal returns of smaller-size firms are significantly positive, suggesting a positive $\beta^{(2)}$. Alternatively, when foreign institutional investors decrease their share ownership in firms of larger size, those of larger-size firms are still positive, suggesting an insignificant $\beta^{(1)}$. According to the results of Nofsinger and Sias (1999) and Wermers (1999), we create the following null hypothesis to explore whether there is an opposite result in the emerging stock market like Taiwan. The null hypothesis constrained by the above statement is to test $H_0 : \beta^{(2)} > 0, \beta^{(1)} \leq 0$.

The estimation and testing procedures in the panel threshold model used by this study are based on Hansen's (1999) suggestions. First, we rewrite Eq. (4) into an Eq. (5).

$$R^a_{i,t} = u_i + \theta s_{i,t-1} + \beta \Delta IN_{i,t-1}(\gamma) + e_{i,t} \quad (5)$$

where $\beta \Delta IN_{i,t-1}(\gamma) = \begin{cases} \beta^{(1)}\Delta IN_{i,t-1}, & \text{if} \quad s_{i,t-1} > \gamma; \\ \beta^{(2)}\Delta IN_{i,t-1}, & \text{if} \quad s_{i,t-1} > \gamma. \end{cases}$

To delete individual-specific means, the regressing model of de-mean in this study is as follows:

$$R^{a*}_{u} = \beta \Delta IN^*_u(\gamma) + e^*_u \quad (6)$$

where * denotes variables deviated from the group mean; that is, $R^{a,*}_{i,t} = R^a_{i,t} - \overline{R^a_i}$, $\Delta IN^*_{i,t-1} = \Delta IN_{i,t-1}(\gamma) - \overline{\Delta IN_i}(\gamma)$, $e^*_{i,t} = e_{i,t} - \overline{e_i}$, and $\overline{R^a_i}$, $\overline{\Delta IN_i}$ and $\overline{e_i}$ are the means of R^a, ΔIN and e of firm i. Subsequently, we stack the time series data for an individual, with one time period deleted, and let

$$R^{a*}_i = \begin{bmatrix} R^{a*}_{i2} \\ \vdots \\ R^{a*}_{iT} \end{bmatrix}, \Delta IN^*_i(\gamma) = \begin{bmatrix} \Delta IN^*_{i2}(\gamma) \\ \vdots \\ \Delta IN^*_{iT}(\gamma) \end{bmatrix}, e^*_i = \begin{bmatrix} e^*_{i2} \\ \vdots \\ e^*_{iT} \end{bmatrix}.$$

Then, let $r^{a*}, \Delta IN^*(\gamma)$and e^*denote the data stacked over all individuals, for example:

$$\Delta IN^*(\gamma) = \begin{bmatrix} \Delta IN^*_1(\gamma) \\ \vdots \\ \Delta IN^*_i(\gamma) \\ \vdots \\ \Delta IN^*_n(\gamma) \end{bmatrix}.$$

From the above definition, we can further rewrite Equation (6) as Equation (7):

$$R^{a*} = \Delta IN^{*}(\gamma)\beta + e^{*} \quad (7)$$

For any given γ, the slope coefficient β can be estimated by ordinary least squares (OLS). That is,

$$\widehat{\beta}(\gamma) = \left(\Delta IN^{*}(\gamma)^{'}\Delta IN^{*}(\gamma)\right)^{-1}\Delta IN^{*}(\gamma)^{'}R^{a*} \quad (8)$$

The sum of squared errors is the following Eq. 6

$$S_1(\gamma) = \widehat{e}^{*}(\gamma)^{'}\widehat{e}^{*}(\gamma) = R^{a*^{'}}\left(I - \Delta IN^{*}(\gamma)^{'}\left(\Delta IN^{*}(\gamma)^{'}\Delta IN^{*}(\gamma)\right)^{-1}\Delta IN^{*}(\gamma)^{'})R^{a}\right)^{*} \quad (9)$$

Hansen (1999) recommended estimation of γ by lease squares. This is most easily achieved by minimizing the concentrated sum of squared errors in Eq. 10. Hence, the least squares estimator of γ is

$$\overset{\wedge}{\gamma} = \arg\min_{R^{a}} S_1(\gamma) \quad (10)$$

Once $\hat{\gamma}$ is obtained, the slope coefficient estimate is $\widehat{\beta} = \widehat{\beta}(\gamma)$.

It is important to determine whether the threshold effect is statistically significant. This can be examined by testing whether coefficients in two regimes are the same. The null hypothesis of no threshold effect is as follows:

$$H_0 : \beta^{(1)} = \beta^{(2)} \quad (11)$$

In other words, the coefficients $\beta^{(1)}$ and $\beta^{(2)}$ in two regimes have different explanations, implying that there is an asymmetric threshold effect at least on the value of threshold variable $s_{i,t-1}$ for changes in share ownership by foreign institutional investors explaining abnormal returns. The likelihood ratio ofH_0suggested by Hansen (1999) is based on the following test statistics:[6]

$$F_1 = S_0 - S_1(\hat{\gamma})/\hat{\sigma}^2 \quad (12)$$

Hansen (1996) suggests a bootstrap to simulate the asymptotic distribution of the likelihood ratio test, and he proposed that a bootstrap procedure attains the first-order asymptotic distribution.

However, it is possible that the specification contains more than one threshold. Examination of whether the system has more than one threshold can be preceded as follows. First, we employ F_1 test to assess the null hypothesis of no threshold. If this null hypothesis is rejected, at least one threshold is ensured. Then, we proceed to test the null of one threshold against the two thresholds. The notation F_2 is used to denote this test.[7]

$$F_2 = S_1(\hat{\gamma}_1) - S_2^{\tau}\left(\hat{\gamma}_2^{\tau}\right)/\hat{\sigma}^2 \quad (13)$$

The significant F_2 implies the rejection of the null of one threshold and two thresholds are expected. We repeat this procedure to test the null hypothesis of two and more

[6] Where S_0 and S_1 are the residual sum of squares under the null and alternative of (12) respectively, and $\hat{\sigma}^2 = \hat{e}^{*^{'}}\hat{e}^{*}/n(T-1)$ is residual variance under H_1, where the residual vector is $\hat{e}^{*} = \hat{e}^{*}(\hat{\gamma})$. Under the null hypothesis the threshold is not identified, the classical tests have non-standard distributions, which is called the 'Davies' Problem proposed by Davies (1977).

[7] Where $\hat{\sigma}^2 = S_2^{\tau}\left(\hat{\gamma}_2^{\tau}\right)/n(T-1)$ and γ_2 is the second threshold.

thresholds and denote them as F_2, F_3,… etc. The critical values are also based on bootstrapping method.

Once the existence of the threshold effect is determined, the next question is whether the threshold value, γ, can be known. When there is a threshold effect ($\beta^{(1)} \neq \beta^{(2)}$), Chan (1993) and Hansen (1999) show that $\hat{\gamma}$ is consistent for γ_0 (the true value of γ). They also show that the asymptotic distribution is highly non-standard. Hansen (1999) argues that the best way to form confidence intervals for γ is to form the no-rejection region $C(\alpha)$, where $C(\alpha) = -2\log\left(1 - \sqrt{1-\alpha}\right)$.[8] To test the hypothesis $H_0 : \gamma = \gamma_0$, the no-rejection region of confidence level $(1-\alpha)$ is the set of values of γ such that $LR_1(\gamma) \leq C(\alpha)$, where[9]

$$LR_1(\gamma) = S_1(\gamma_0) - S_1(\hat{\gamma})/\hat{\sigma}^2 \tag{14}$$

If two thresholds cannot be rejected, the confidence intervals for two threshold parameters (γ_1, γ_2) can be constructed in the following statement.[10]

$$LR_2^{\tau}(\gamma) = S_2^{\tau}(\gamma_0) - S_2^{\tau}\left(\hat{\gamma}_2^{\tau}\right)/\hat{\sigma}^2 \tag{15}$$

3 Empirical results

3.1 The basic statistics of data and the use of panel unit root

In this study we use an unbalanced panel of TSE-listed stocks, and our methods are designed for balanced panels. We take a subset of 247 firms observed during 2000.01–2008.06. Table 1 reports the descriptive statistics of the four main variables. The means of $R^a_{i,t}$, $\Delta IN_{i,t-1}$, and $ME_{i,t-1}$ are 0.767, 0.052, and 27,902.520, respectively.[11] The standard deviations, maximum, minimum values of these variables are also reported. Firm size has the largest standard deviation of 106,605, and is in sharp contrast to 4.038 and 1.355 for the remaining two variables, respectively. In addition, the nontrivial standard deviation of abnormal returns results from huge variation of abnormal returns across firms. Finally, the skewness far from 0 and kurtosis far from 3 show the non-normal distributions for these variables.

Hansen's (1999) panel threshold regression is an extension of the traditional least squared estimation method, and the variables in the model must be stationary to avoid spurious regression. Since the data are all panel in our investigation, the well known LLC (Levin et al. 2002), IPS (Im et al. 1997) and Hadri (2000) techniques are employed to proceed the panel unit root test.[12] The results of the stationary test for each panel ($\Delta IN_{i,t-1}$, $\ln ME_{i,t-1}$, and $R^a_{i,t}$) show that regardless of the method used, all the variables are most

[8] He uses the likelihood ratio statistic for tests on γ.

[9] $S_1(\gamma_0)$ and $S_1(\hat{\gamma})$ are the residual sum of squares from Eq. 10 given the true threshold γ_0 and estimated $\hat{\gamma}$, respectively.

[10] $S_2^{\tau}\left(\hat{\gamma}_2^{\tau}\right)$ is defined in (14). The asymptotic $(1-\alpha)\%$ confidence intervals for γ_2 and γ_1 are the set of values of γ, such that $LR_2^{\tau}(\gamma) \leq C(\alpha)$ and $LR_1(\gamma) \leq C(\alpha)$ respectively.

[11] The means of one-month abnormal returns $R^a_{i,t}$ from 2000.01 to 2005.12, 2006.12, 2007.12 and 2008.06 are 0.630, 0.600, 0.728 and 0.767, respectively. That is, the 1-month abnormal returns present the stable increase in price.

[12] The LLC (2001) and IPS (1997) techniques assumed that the null hypothesis are set as unit root, and the Hadri (2001) assumed that the null hypothesis is set as stationary.

Table 1 Summary statistics of variables

Variables	Mean	Std dev.	Max	Min	Skew.	Kurt.
$R^a_{i,t}$	0.766879	4.038008	33.22512	−15.197	1.22901	4.29466
$\Delta IN_{i,t-1}$	0.051868	1.355089	30.44	−42.61	−4.05897	181.149
$ME_{i,t-1}$ (NT$ million)	27902.52	106605	1873427	213	10.4993	132.520
$TO_{i,t-1}$	16.80002	21.63623	264.4124	0.001	2.94523	12.2762

likely to carry stationary characteristics. The stationary natures of those variables make estimations of the panel threshold regression move forward.

3.2 Results of test and estimation

This study adopts statistics F to examine the equality of coefficients in two regimes of firm size. That is, to examine the presence of threshold effect. In addition, we adopt LR test to examine the potential threshold value. Table 2 presents that statistics F_2 and F_3 are smaller than the critical values at the 10% significance level, while F_1 exceeds the critical value at the same significance level. Thus, the null hypothesis of no threshold is clearly rejected and one threshold is suggested. Table 1 depicts that the standard deviation of firm size is nearly 106,605, and the maximum and minimum values are nearly 1,873,427 and 213. Therefore, using at least one threshold may avoid neglecting the dispersed firm sizes.

The bottom of Table 2 reports the estimated one threshold, which is $e^{8.0226}$ (amounting to the market value of 3,049.0947 NT$ million) and attain statistically significant level. In other words, the influence of changes in foreign investors' share ownership on abnormal returns may be further divided into two regimes by using firm size as threshold variables. The two regimes are referred to as small size and large size if their market value falls in-between 0 and 3,049.0947 (NT$ million) and exceed 3,049.0947 (NT$ million), respectively. Subsequently, we can estimate the corresponding confidence intervals by computing the LR test. Figure 1 shows that the 95% confidence intervals are from 531.1260 to 4,783.8460 (NT$ million) for the significant threshold, which the likelihood ratio lies beneath the dotted line. Table 3 reports the number of firms in each category and in each year.[13] Figure 2 reveals that on average, roughly 71–72 firms fall in the small-size regime each month, while approximately 175–176 firms fall in the large-size regime in each month. The use of two regimes could take the heteroskedasticity due to firm size into account.

Other than the conventional OLS standard errors, this study also uses the White-corrected standard errors in favor of heteroskedasticity which violates one of the assumptions of our asymptotic analysis.[14] The regression slope estimates, OLS and White-corrected standard errors are displayed in Table 4. We find that $\ln ME_{i,t-1}$ and its powers are statistically significant, indicating an obviously positive relationship between firm size

[13] First, we find the number of firms in each regime by each month. Then, we take an average on the number of firms in a specific regime for each month by each year.

[14] Based on the theory of Hansen (1999) for least squares threshold regression, we would expect the threshold estimates to be consistent and the distribution theory of Theorem 1 to be correct up to a scale effect.

Table 2 Tests for threshold effects and threshold estimates of firm size

Null hypothesis	Statistic F	Bootstrap p value
H_0: no threshold	$F_1 = 15.381$**	0.040
H_1: single threshold		
(Critical values of 10, 5, 1%)		(12.367, 14.633, 20.672)
H_0: single threshold	$F_2 = 7.835$	0.380
H_1: double threshold		
(Critical values of 10, 5, 1%)		(13.146, 15.967, 33.493)
H_0: double threshold	$F_3 = 7.094$	0.180
H_1: triple threshold		
(Critical values of 10, 5, 1%)		(7.915, 9.958, 10.931)
Estimate		**95% Confidence interval**
Threshold estimates		
$\hat{\gamma}_1^{\tau} = e^{8.0226} = 3049.0947$ (NT\$million)		$[e^{6.275}, e^{8.473}]$

The numbers in () indicate the p values of bootstrap, and the numbers in [] indicate the confidence interval of threshold estimates in 95% significant level

** denotes significance at the 5% level

and abnormal returns. The coefficients of changes in foreign institutional investors' share ownership of primary interest suggest that the firms with the large size unexpectedly have the larger and significantly positive coefficient of 0.138, and the firms with the small size have the smaller and insignificantly negative coefficient of −0.024. The signs of the two coefficients reject the price impact of institutional herding of small-size stocks, and oppositely suggesting that abnormal returns of large-size firms obviously increase when foreign investors increase their share ownership in them (market value larger than 3049.0947 NT$ million). In addition, the coefficient in the large-size regime attains 1% significant level. Unexpectedly, when foreign investors increase their share ownership in small-size firms, abnormal returns of those firms decrease insignificantly. On the one hand, as Hessel and Norman (1992), Falkenstein (1996) and Lin and Swanson (2003) demonstrate that institutional investors prefer to hold the large-size stocks with good performance. Therefore, large herding of foreign investors on large-size stocks pushes the prices of these stocks up. This means that there is greater influence on the price movements of large-size stocks, which is consistent with the result of Lin and Swanson (2003). On the other hand, market values of most TSE-listed firms in Taiwan are obviously lower than those of firms in the developed countries. Thus, the large-size stocks with good performance in the TSE-listed firms are much favored by foreign institutional investors. Subsequent abnormal returns of these large stocks tend to increase significantly.

It is notable that the 247 balanced panels in the TSE-listed stocks can be divided into fifteen sectors based on the industry category of TSEC.[15] The result of Table 5 presents that the average size of Electronics sector is larger, but its standard deviation is the largest among all sectors. Further, we find that firms in the large-size regime are apparently concentrated in five sectors, with the highest number of observations in Electronics sector, followed in sequence by Plastics, Others, Chemistry and Textiles sectors. Such results imply that among the TSE-listed firms that foreign investors prefer to hold, subsequent

[15] TSEC is the Taiwan Stock Exchange Corporation.

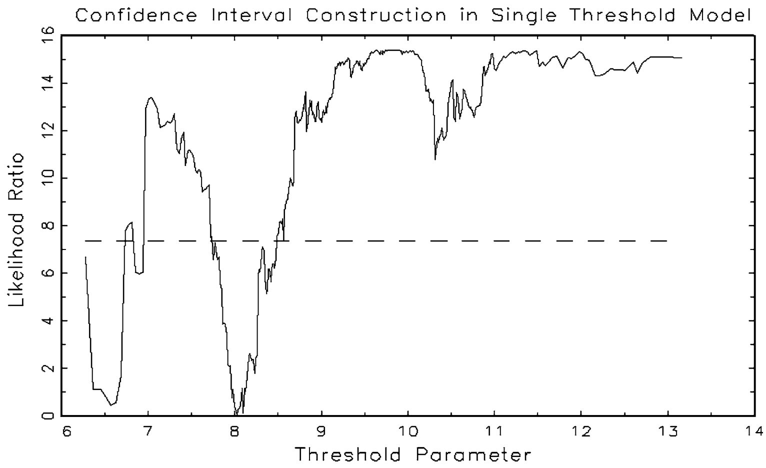

Fig. 1 Confidence interval of ln (market value) construction in single threshold model

Table 3 Number of firms in each regime by year

Number of firm class	Year								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
$\Delta IN_{i,t-1}(ME_{i,t-1} \leq 3049.09)$	173	137	157	165	183	177	180	206	205
$\Delta IN_{i,t-1}(ME_{i,t-1} > 3049.09)$	74	110	90	82	64	70	67	41	42
Total number	247	247	247	247	247	247	247	247	247

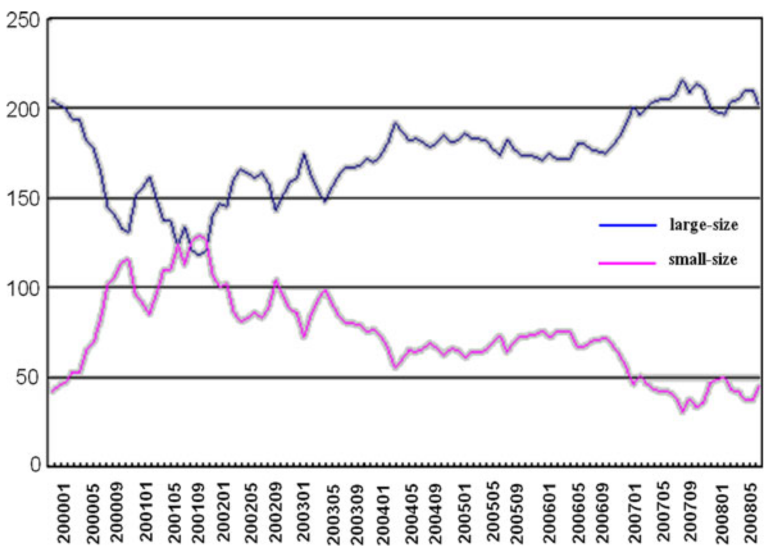

Fig. 2 Number of firms in small-size and large-size regimes each month

Table 4 Regression estimates: single threshold model of firm size

Regressor	Coefficient estimate	OLS SE	White SE
$\ln ME_{i,t-1}$	1.84203***	0.05244	0.05684
$\Delta IN_{i,t-1}(ME_{i,t-1} \leq 3049.0947)$	−0.02432	0.03566	0.04485
$\Delta IN_{i,t-1}(ME_{i,t-1} > 3049.0947)$	0.13791***	0.02140	0.02421

*** denotes significance at the 1% level

abnormal returns on large-size firms, especially those in the Electronics and Plastics sectors are stronger. In other words, if other investors follow foreign investors to purchase the stocks of large-size firms in TAIEX belonging to those two sectors and hold them for 1 month, the performance persistence of subsequent abnormal returns is significantly better.

3.3 Robustness tests

To explore whether the time period affects the conclusion regarding the effect of size, the paper further resupplies a sub-sample analysis from January 2000 to December 2005, December 2006, December 2007 and June 2008, respectively, so as to add valuable insights into the stability of the price-impact of institutional herding on firm size in an emerging market like that of Taiwan. Tables 6, 7, 8 and 9 in appendix report the tests for the threshold effects and threshold estimates of firm size. The results consistently find the presence of one threshold based on the test of the threshold effect regardless of changes in the data periods from 2000.01 to 2005.12, 2006.12, 2007.12 or 2008.06. Then, Tables 10, 11, 12 and 13 in appendix report the regression estimates of the single threshold of firm size. The estimated results of the threshold regression consistently demonstrate that the large firms have larger and significantly positive coefficients, and the small firms have smaller and negative coefficients. The signs of the two-regime coefficients suggest that the abnormal returns of large firms obviously increase when foreign investors increase their share ownership in them. In addition, the coefficient in the large-size regime consistently attains a 1% significance level. Conversely, the abnormal returns of those firms decrease when foreign investors increase their share ownership in small-size firms.

Moreover, to explore whether post-herding abnormal returns are due to a permanent or simply transitory price appreciation, this paper regards turnover and the book-to-market ratio as control variables, respectively, when analyzing the price-impact of institutional herding on firm size. The added threshold models are illustrated as follows:

$$R^a_{i,t} = u_i + \theta_1 q^1_{i,t-1} + \beta^{(1)} \Delta IN_{i,t-1} I(s_{i,t-1} > \gamma) + \beta^{(2)} \Delta IN_{i,t-1} I(s_{i,t-1} \leq \gamma) + e_{i,t} \tag{16}$$

where $q^1_{i,t-1}$ is turnover$_{i,t-1}$.

$$R^a_{i,t} = u_i + \theta_2 q^2_{i,t-1} + \beta^{(1)} \Delta IN_{i,t-1} I(s_{i,t-1} > \gamma) + \beta^{(2)} \Delta IN_{i,t-1} I(s_{i,t-1} \leq \gamma) + e_{i,t} \tag{17}$$

where $q^2_{i,t-1}$ is book/market$_{i,t-1}$.

Tables 14 and 15 in appendix report the regression estimates of the single threshold of firm size including the control variables of turnover and the book-to-market ratio, respectively. The results find the consistent one-month abnormal returns of the large firm effect regardless of turnover, the book-to-market ratio or firm size as a control variable.

Table 5 The basic statistics of market values in small-and large-sized regimes of different industries

SIC	Industry	Regime	Obs	$ME_{i,\ t-1}$ (unit: NT$ million)			
				Mean	SD	Max	Min
11	Cement	Large-sized regime	619	191344	3070	22921.08	32924.91
		Small-sized regime	95	3043	979	2313.64	538.12
12	Food	Large-sized regime	594	182746	3051	16839.59	28506.22
		Small-sized regime	834	3048	296	1626.59	725.77
13	Plastics	Large-sized regime	1262	737201	3059	72118.59	127016.00
		Small-sized regime	268	3046	968	2183.44	507.57
14	Textiles	Large-sized regime	1066	232081	3054	17865.52	30689.01
		Small-sized regime	1892	3042	334	1450.66	659.47
15	Electric & Machinery	Large-sized regime	657	71765	3051	10658.45	9347.00
		Small-sized regime	771	3041	225	1772.86	690.92
16	Electric appliance and Cable	Large-sized regime	606	92682	3051	12051.90	15742.94
		Small-sized regime	210	3046	770	2165.90	572.89
17	Chemistry	Large-sized regime	1086	144550	3055	12046.80	13614.56
		Small-sized regime	750	3048	213	1826.88	754.90
18	Glass	Large-sized regime	104	79806	3132	37306.45	12462.95
		Small-sized regime	100	2836	885	1544.89	528.30
19	Papermaking	Large-sized regime	476	25403	3171	10382.59	5146.27
		Small-sized regime	34	3018	1555	2497.26	415.13
20	Steel & Iron	Large-sized regime	985	597817	3060	37856.19	92213.95
		Small-sized regime	545	3037	396	1942.30	722.99
21	Rubber	Large-sized regime	611	96423	3057	12779.90	13575.08
		Small-sized regime	103	3047	1199	2444.64	411.36
22	Automobile	Large-sized regime	408	90219	3744	33662.93	21106.16
		Small-sized regime	319	3046	876	2118.59	568.21

Table 5 continued

SIC	Industry	Regime	Obs	$ME_{i,\ t-1}$ (unit: NT$ million)			
				Mean	SD	Max	Min
23	Electronics	Large-sized regime	4373	1873427	3057	86135.74	228784.54
		Small-sized regime	212	3047	505	1888.38	676.56
24	Electronic component	Large-sized regime	102	26221	8499	16005.63	3667.99
		Small-sized regime	Non	Non	Non	Non	Non
25	Construction	Large-sized regime	808	44725	3058	10806.05	7224.87
		Small-sized regime	426	3031	314	1416.69	668.04
26	Transportation	Large-sized regime	900	95719	3055	28491.74	22010.98
		Small-sized regime	239	3032	379	1968.42	863.78
27	Tourism	Large-sized regime	271	20746	3063	6958.82	3664.89
		Small-sized regime	30	3032	2252	2820.37	182.31
28	Finance	Large-sized regime	888	118794	3063	20112.11	23208.78
		Small-sized regime	197	3049	640	1530.48	587.22
29	Department stores	Large-sized regime	721	105243	3076	16110.71	19075.18
		Small-sized regime	102	2849	489	1392.57	539.00
99	Others	Large-sized regime	1218	93161	3068	13658.88	14812.92
		Small-sized regime	312	3048	1144	2188.77	524.18
	Total	Large-sized regime	17755	246003.65	3374.70	24738.48	36239.76
		Small-sized regime	7439	2869.30	720.95	1854.67	556.84

Non represents no firm is ascribed in this regime as panel threshold is used

The results of these robustness tests show that the one-month abnormal returns of herding by foreign institutional investors on large firms in an emerging market like Taiwan are not affected by the different periods of data expansion or the different control variables. Thus, these one-month abnormal returns are a permanent rather than a simply transitory price appreciation.

4 Conclusion

This study constructs a panel threshold regression model to explore the price impact of foreign institutional herding of firms listed in the Taiwan Stock Exchange during January 2000 to June 2008. By examining the presence of threshold effect, this study analyzes whether firm size would obviously and asymmetrically affect the explanation for the effect of changes in foreign investors' share ownership on abnormal returns. We find the significant evidence of one threshold which separates the firms based on firm size in Taiwan.

The panel threshold model proposed by this paper could objectively quantify the extent of firm size rather than assuming the degree of such constraints in advance. It could avoid the data snooping issue inherent in the two-pass sorting method (Nofsinger and Sias 1999; Wermers 1999), and strengthen the reliability of explanation of abnormal returns by institutional herding.

The empirical results of this study find that, among firms in large-size regime, the price impact of changes in share ownership of foreign investors is positively significant. Empirical results also find that foreign investors tend to hold the large-size firms in TSE. Therefore, the subsequent prices of these stocks on their large herding would be pushed up. While foreign investors increase their share ownership in firms with the market equity larger than the estimated threshold, abnormal returns on those stocks obviously increase. The result is opposite to the price impact of institutional herding of small-size stocks as proposed in prior empirical studies like Nofsinger and Sias (1999) and Wermers (1999) which states that subsequent performance of small-size stocks largely held by institutional investors is stronger. However, the phenomenon agrees with the fact that the subsequent performance of large-size stocks is bought in bulk by institutional investors as counters of index manipulation in market structure of plain-plate type, like Taiwan, which is consistent with the argument of Lin and Swanson (2003).

This study further finds that, among the TSE-listed firms that are held by foreign investors, the price impact of institutional herding of large-size firms, especially in Electronics and Plastics sectors, are particularly stronger. The signals of changes in share ownership initiated by foreign investors would reveal further information for improving the performance of asset reallocation decisions in Taiwan. Results of this study contribute to studies on price effects of institutional herding such as Sias et al. (2002), and will be integrated with a series of studies on herding by controlling the effect caused by firm characteristics. The panel threshold model constructed in this paper well describes the price impact of institutional herding yet eschews the possibly subjective data snooping issue resulting from the two-pass sorting method as proposed by previous related research.

Appendix

See Tables 6, 7, 8, 9, 10, 11, 12, 13, 14, 15.

Table 6 Appendix from 2000.01 to 2005.12: tests for threshold effects and threshold estimates of firm size

Null hypothesis	Statistic F	Bootstrap p value
H_0: no threshold	$F_1 = 6.5579$*	0.090
H_1: single threshold		
(Critical values of 10, 5, 1%)		(11.895, 15.888, 17.886)
H_0: single threshold	$F_2 = 8.1011$	0.710
H_1: double threshold		
(Critical values of 10, 5, 1%)		(12.322, 16.396, 26.658)
H_0: double threshold	$F_3 = 8.3204$	0.820
H_1: triple threshold		
(Critical values of 10, 5, 1%)		(13.582, 17.665, 28.852)
Estimate		95% Confidence interval
Threshold estimates		
$\hat{\gamma}_1^{\tau} = e^{6.5579} = 704.7901$ (NT$million)		$[e^{6.1883}, e^{12.7229}]$

The numbers in () indicate the p values of bootstrap, and the numbers in [] indicate the confidence interval of threshold estimates in 95% significant level

* denotes significance at the 10% level

Table 7 Appendix from 2000.01 to 2006.12: tests for threshold effects and threshold estimates of firm size

Null hypothesis	Statistic F	Bootstrap p value
H_0: no threshold	$F_1 = 6.5439$*	0.060
H_1: single threshold		
(Critical values of 10, 5, 1%)		(10.572, 13.631, 32.997)
H_0: single threshold	$F_2 = 8.1080$	0.460
H_1: double threshold		
(Critical values of 10, 5, 1%)		(11.237, 14.315, 21.698)
H_0: double threshold	$F_3 = 8.3217$	0.280
H_1: triple threshold		
(Critical values of 10, 5, 1%)		(7.501, 10.887, 19.940)
Estimate		95% Confidence interval
Threshold estimates		
$\hat{\gamma}_1^{\tau} = e^{6.5439} = 694.9918$ (NT$million)		$[e^{6.2166}, e^{8.5753}]$

The numbers in () indicate the p values of bootstrap, and the numbers in [] indicate the confidence interval of threshold estimates in 95% significant level

* denotes significance at the 10% level

Table 8 Appendix from 2000.01 to 2007.12: tests for threshold effects and threshold estimates of firm size

Null hypothesis	Statistic F	Bootstrap p value
H_0: no threshold	$F_1 = 6.5425$**	0.030
H_1: single threshold		
(Critical values of 10, 5, 1%)		(11.173, 12.608, 15.352)
H_0: single threshold	$F_2 = 8.0196$	0.360
H_1: double threshold		
(Critical values of 10, 5, 1%)		(12.132, 13.869, 22.675)
H_0: double threshold	$F_3 = 8.7142$	0.150
H_1: triple threshold		
(Critical values of 10, 5, 1%)		7.866, 10.044, 11.856)
Estimate		95% Confidence interval
Threshold estimates		
$\hat{\gamma}_1^{\tau} = e^{6.5425} = 694.0195$ (NT$million)		$[e^{6.2538}, e^{8.4865}]$

The numbers in () indicate the p values of bootstrap, and the numbers in [] indicate the confidence interval of threshold estimates in 95% significant level

** denotes significance at the 5% level

Table 9 Original from 2000.01 to 2008.06: tests for threshold effects and threshold estimates of firm size

Null hypothesis	Statistic F	Bootstrap p value
H_0: no threshold	$F_1 = 15.381$**	0.040
H_1: single threshold		
(Critical values of 10, 5, 1%)		(12.367, 14.633, 20.672)
H_0: single threshold	$F_2 = 7.835$	0.380
H_1: double threshold		
(Critical values of 10, 5, 1%)		(13.146, 15.967, 33.493)
H_0: double threshold	$F_3 = 7.094$	0.180
H_1: triple threshold		
(Critical values of 10, 5, 1%)		(7.915, 9.958, 10.931)
Estimate		95% Confidence interval
Threshold estimates		
$\hat{\gamma}_1^{\tau} = e^{8.0226} = 3049.0947$ (NT$million)		$[e^{6.275}, e^{8.473}]$

The numbers in () indicate the p values of bootstrap, and the numbers in [] indicate the confidence interval of threshold estimates in 95% significant level

** denotes significance at the 5% level

Table 10 Appendix from 2000.01 to 2005.12: regression estimates of single threshold of firm size

Regressor	Coefficient estimate	OLS SE	White SE
$\ln ME_{i,t-1}$	1.23795***	0.07038	0.09054
$\Delta IN_{i,t-1}(ME_{i,t-1} \leq 704.7901)$	−0.28690**	0.14243	0.059278168
$\Delta IN_{i,t-1}(ME_{i,t-1} > 704.7901)$	0.08205***	0.02344	0.025773603

***, ** denote significance at the 1 and 5% level, respectively

Table 11 Appendix from 2000.01 to 2006.12: regression estimates of single threshold of firm size

Regressor	Coefficient estimate	OLS SE	White SE
$\ln ME_{i,t-1}$	1.23342***	0.06264	0.08174
$\Delta IN_{i,t-1}(ME_{i,t-1} \leq 694.9918)$	−0.30749***	0.10739	0.03782
$\Delta IN_{i,t-1}(ME_{i,t-1} > 694.9918)$	0.08695***	0.02137	0.02363

*** denotes significance at the 1% level

Table 12 Appendix from 2000.01 to 2007.12: regression estimates of single threshold of firm size

Regressor	Coefficient estimate	OLS SE	White SE
$\ln ME_{i,t-1}$	1.44533***	0.05309	0.07186
$\Delta IN_{i,t-1}(ME_{i,t-1} \leq 694.0195)$	−0.29298***	0.10415	0.03830
$\Delta IN_{i,t-1}(ME_{i,t-1} > 694.0195)$	0.09891***	0.01958	0.02158

*** denotes significance at the 1% level

Table 13 Appendix from 2000.01 to 2008.06: regression estimates of single threshold of firm size

Regressor	Coefficient estimate	OLS SE	White SE
$\ln ME_{i,t-1}$	1.84203***	0.05244	0.05684
$\Delta IN_{i,t-1}(ME_{i,t-1} \leq 3049.0947)$	−0.02432	0.03566	0.04485
$\Delta IN_{i,t-1}(ME_{i,t-1} > 3049.0947)$	0.13791***	0.02140	0.02421

*** denotes significance at the 1% level

Table 14 Appendix for control variable of TO: regression estimates of single threshold of firm size including the control variable of turnover

Regressor	Coefficient estimate	OLS SE	White SE
$TO_{i,t-1}$	0.07366***	0.00126	0.00195
$\Delta IN_{i,t-1}(ME_{i,t-1} \leq 3049.0947)$	−0.02915	0.03436	0.04442
$\Delta IN_{i,t-1}(ME_{i,t-1} > 3049.0947)$	0.13354***	0.02057	0.02351

*** denotes significance at the 1% level

Table 15 Appendix for control variable of BM: regression estimates of single threshold of firm size including the control variable of book-to-market ratio

Regressor	Coefficient estimate	OLS SE	White SE
$BM_{i,t-1}$	−0.00139***	0.00043	0.00076
$\Delta IN_{i,t-1}(ME_{i,t-1} \leq 3049.0947)$	0.00461	0.03665	0.04358
$\Delta IN_{i,t-1}(ME_{i,t-1} > 3049.0947)$	0.17360***	0.02194	0.02560

*** denotes significance at the 1% level

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