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THE MAGNET EFFECT UNDER RELAXED DAILY PRICE LIMITS: EVIDENCE FROM TAIWAN

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ABSTRACT

This study investigates the magnet effect after relaxing the daily price limits in the Taiwan Stock Exchange by using a logit model, as proposed by Hsieh, Kim, and Yang (2009). Our empirical results indicate that the magnet effect disappears after the relaxed daily price limits, especially in the down market. That is, the relaxation of the daily price limits lowers market volatility and thus facilitate market stability. Our empirical findings have important policy implications for regulators who are especially concerned about financial market stability and capital market development due to the price limit changes.

JEL: G14, G15, G18

KEYWORDS: Price Limits, Magnet Effect, Logit Model

INTRODUCTION

The famous event in financial history called "Black Monday" occurred on October 19, 1987. In the United States, the Dow Jones Industrial Average fell 508 points and the global stock market also crashed abnormally; the impact of the Lehman Brothers incident in September 2008 caused many global stock markets to fall sharply; on May 6, 2010, the Dow Jones Industrial Index fell 600 points. All of these events caused heavy losses to investors due to rapid falls in stock prices over a short time period. These events also led to the development of circuit breakers. One of the circuit breaker mechanism is the price limits, which stipulate that the daily stock price can only fluctuate within a range and have been adopted by many countries such as Taiwan, South Korea, Malaysia, Thailand, and Japan to stabilize stock prices. Although daily price limits have been adopted by many exchanges across the world for the last few years, there has been no consistent conclusion in academia about its impact on market quality.

Previous studies believe that limiting the fluctuations can reduce overreactions in the market, effectively reduce the volatility of stock prices, temporarily cool investors, and provide sufficient time to reevaluate trading strategies and avoid certain irrational trading behaviors to achieve a cooling-off effect (see Greenwald and Stein, 1991; Lee and Kim, 1995). Opponents argue that limiting fluctuations fails to reduce the market's volatility, affects the quality of the market, and produces other problems such as the magnet effect. Fama (1989) once proposed that the daily price limits would result in a magnet effect. He believed that investors may be more active in trading when a stock price is close to its up (down) limit, out of concern that individual stocks cannot be bought (sold), thus increasing irrational investment behavior. If such a phenomenon exists substantially in the market, they will cause the stock price to accelerate toward the up (down) limit and then reach the up (down) limit in a phenomenon called the magnet effect. Subrahmanyam (1994) was the first to use the theoretical model to verify whether the magnet effect exists when the stock market establishes a limit for fluctuations; their results support the existence of a magnet effect in the market.

From the opposing scholars' arguments, we found that establishing a daily price limits both negatively impacts the market's efficiency, volatility, and liquidity and encourages investors to perform irrational trading behaviors. In recent years, market participants have become more mature. To create a more efficient securities market and integrate this with the international market to enhance competitiveness, Taiwan officially relaxed the daily price limits from 7% to 10% on June 1, 2015. The Taiwan's equity market is dominated by retail investors who are easily affected by emotions. Past literature indicate that the magnet effect exists in the Taiwan's stock market (see Hsieh, Kim, and Yang, 2009; Wang, Hsiao, and Lin, 2012). Based on the above reasoning, this study intends to use the listed stocks in the Taiwan securities market as a sample and explore whether the magnet effect will be delayed when price limits are relaxed by using the logit model proposed by Hsieh, Kim, and Yang (2009).

Most past research in this area has focused on testing whether there is a magnet effect in the stock market or when it happens. However, relatively few studies have focused on the changes in the magnet effect that result from changes in price limits. Therefore, this article hopes to study through changes in Taiwan's regulation to explore whether the magnet effect in the market will change when the market's fluctuations are adjusted. Our empirical results indicate that in the up model, the magnet effect starts when the share price is four tick sizes away from the up limit both before and after the restructuring. The magnet effect did not happen either earlier or later due to the relaxation of the price limits to 10%. Moreover, we could observe that in the down model, the magnet effect started when the price was three tick sizes away from the down limit prior to restructuring. However, the magnet effect became insignificant after restructuring, whether the distance to the down limit was 2–6 tick sizes away. The empirical results support our research hypothesis, indicating that after the price limit is relaxed from 7% to 10%, the magnet effect disappears in the down market. Overall, our empirical findings indicate that the relaxation of price limits would reduce the magnet effect and lower the short-run market volatility, thereby promoting sustainable development in capital markets. Our analysis and results have important policy implications for policy makers in terms of reforming the regulation of financial markets. We first briefly review prior literature and proposes the hypotheses. Then, we introduce the background of Taiwan Stock Exchange. We also describe the data and methodology. Finally, we present the empirical results and conclude in the final section.

LITERATURE REVIEW

Price Limits

There are two schools of thought in academia regarding the effectiveness of price limits. Supporters believe that price limits can effectively reduce stock price volatility. For example, Greenwald and Stein (1991) believed that price limits can calm investors, allowing them space to rethink and collect new information and thus reduce stock price volatility. Lee and Kim (1995) tested whether price limits could effectively reduce stock price volatility. This study examined the South Korean stock market in 1980–1989 and summarized that price limits can indeed reduce volatility. In addition, Kim, Liu, and Yang (2013) studied the Chinese stock market to compare before and after the establishment of daily price limits. The research discovered that the limits of price fluctuations could reinforce the discovery of equilibrium prices, moderately suspend volatility, and alleviate abnormal trading activities. The research also pointed out that price restrictions could help a collapsed market recover. Opponents believe that price limits negatively impact the market's quality. Kim and Rhee (1997), and Bildik and Gulay (2006), studied the Tokyo Stock Exchange for 1989–1992 and the Istanbul Stock Exchange for January 5, 1998–December 9, 2002. By testing delayed price discovery, volatility spillover, and trading interference through analyzing stock prices, they wanted to analyze whether daily price limits benefited the market; they concluded that price limits do not benefit the stock market. Chang and Ma (2012) also selected the Taiwan's stock market as their research target to analyze the frequency with which individual stock prices reached their price limits by observing jumps in stock prices for 1996–2005. Then, they simulated different ranges of daily price limits relaxations (10%, 12%, and 15%) to record the frequency with which stock prices reached their price limits. The simulation results indicated that when restrictions on fluctuations are relaxed, the frequency of stock price jumps greater than the fluctuations is approximately half of the original frequency. The study also discovered that the Taiwan's stock market has delayed price discovery. Relaxing daily price limits can increase market efficiency. Kim and Limpaphayom (2000) did not discuss the effectiveness of price limits but explored the characteristics of stocks that may be more susceptible to price limits. They selected Taiwan's and Thailand's Stock Exchanges as research samples and found that stocks with high volatility, small market capitalization, and frequent trading were more likely to reach their daily limit.

Magnet Effect

In addition to the negative impact on the market, the price limits also affect investors' trading behaviors and cause the magnet effect. The term "magnet effect" was first introduced by Fama (1989); he believed that price limits alter investors' trading strategies in that when stock prices move closer to the limit up or limit down price, investors become more active in submitting orders out of fear of a potential trading halt. When such phenomena exist abundantly in the market, stock prices would move closer to the limit up or limit down price, forcing certain stocks to reach the daily price limits that would not have happened otherwise. Subrahmanyan (1994) was the first to discuss the limit of price fluctuations in a theoretical model. The research found that when the market introduced a circuit-breaking mechanism, stock prices tended to fluctuate more, the probability of a stock price reaching its limit increased substantially, and the magnet effect exists. After that, many studies started discussing whether stock markets in different countries have similar magnet effects and many articles found that this phenomenon exists. In Chen (1997), the trading volume may increase significantly when a stock price approaches its price limit. The reason for this is that investors execute their orders early in fear of a trading halt.

The study analyzed 390 public shares in the Taiwan's stock market in 1994 and the empirical results showed that as the share price approached its price limit, the trading volume increased significantly, indicating that the magnet effect exists in the Taiwan stock market. Additionally, Du, Liu, and Rhee (2006) took the Korean stock market as the research object, selecting individual stocks that reached their daily price limits in September 1998–March 1999. The study pointed out that there is a magnet effect in the Korean stock market. In addition, it found that the narrower the range of price limits, the stronger the magnet effect. Hsieh, Kim, and Yang (2009) used a Logit model to analyze changes in stock prices and selected 439 stocks listed on the Taiwan's stock market in 2000 as their research target. Their results showed that as the stock price got closer to the price limit, the probability of the stock price reaching its price limit would also increase significantly. The research proves that the magnet effect exists for both the up and down limits in the Taiwan's stock market. Moreover, the study also pointed out that the magnet effect of ascending and descending stock prices does not exist in the same positions. The magnetic effect occurs nine tick sizes away from the up limit but only four tick sizes away from the down limit. Wang, Hsiao, and Lin (2012) also analyzed the Taiwan's stock market using the sample period of January 2007–June 2008. Their research results also supported the cause of the magnet effect from daily price limits. The research discovered that price limits impacted market makers' order strategies.

The magnet effect can also occur asymmetrically, that is, only while the share price either ascends or descends. Cho, Russell, Tiao, and Tsay (2003) used the GARCH model and GMM to detect whether the magnet effect exists in the Taiwan's stock market. The study collected the stock market rate of return every five minutes on the Taiwan's stock market for March 1, 1998–March 20, 1999. The empirical results found that the magnet effect exists when the prices approached their up limits, but the effect was not significant when prices approached their down limits. Nath (2003) examined the Indian stock market for March 1993–April 2000 with the hypothesis that as share prices approached their daily price limits, investors would submit orders more actively, thus shortening the time between each order. The study found that as share prices approached their down limits, the average time between orders decreased, signaling the magnet effect. However, this effect was not significant when share prices approached their up limits. Chan, Kim, and Rhee (2005) based their study on the Malaysian stock market for 1995–1996 and inspected whether the magnet effect exists in relatively loose daily price limits. Their results showed that the magnet effect exists in the Malaysian stock market when the stock price was closer to its up limit. In addition, some literature discussed whether the magnet effects would be different for different types of investors. Wong, Chang, and Tu (2009) selected the stocks of 711 listed companies in the Taiwan's stock market for January 1, 2004–December 31, 2004 as the research object and divided the investors into institutional investors and retail investors. Compared to institutional investors, the magnet effect was stronger for retail investors. They believe that the magnet effect in the Taiwan's stock market was caused by individual investors given that individual investors have less information and trade more actively, thus accelerating the pace at which stock prices approach their price limits.

HYPOTHESIS DEVELOPMENT

Previous research mentioned that the magnet effect exists in the Taiwan's stock market; for example, Chen (1997), Cho, Russell, Tiao, and Tsay (2003), Wong, Chang, and Tu (2009), Hsieh, Kim, and Yang (2009), Wang, Hsiao, and Lin (2012). This study believes that due to the relaxation of daily price limits, reaching price limits is more difficult. Thus, investors would alleviate worries about trading halts as a result of rapidly approaching price limits, thereby reducing irrational trading behavior and delaying the magnet effect or even making the magnet effect disappear. In other words, for the delayed magnet effect, when daily price limits are relaxed to 10%, the position at which the magnet effect occurs, measured as the number of ticks would be less than before restructuring. These predictions lead to the following hypothesis:

Hypothesis: *After the price limit is relaxed from 7% to 10%, the magnet effect will be delayed or disappear.*

The Introduction of Taiwan Stock Exchange

The Taiwan Stock Exchange centralized trading market is one of the most active markets in the Asia-Pacific region. According to the Taiwan Securities Exchange Annual Report on Securities Statistics, at the end of 2015, there were 874 listed companies in total with a combined market value of approximately $24.503 trillion NTD, a total annual transaction value of approximately $20.191 trillion NTD in 511,248,018 transactions. The annual turnover rate was 74.45%. The Taiwan Stock Exchange was established on February 9, 1962. Since Taiwan's stock market is dominated by retail investors, the government initially set a limit of 5% to avoid significant losses for investors due to drastic changes in stock prices, thus stabilizing stock prices and protecting investors. To comply with investors' and public opinions' requests, the range of fluctuations was relaxed to 7% on October 11, 1989. As market participants have gradually matured in recent years, to create a more efficient securities market, for integration with the international market, and to enhance competitiveness, the government relaxed the daily stock price fluctuation limits from 7% to 10% on June 1, 2015. In addition, the government had flexibly adjusted the limits of fluctuations in response to major political and economic events at home and abroad to prevent the stock market from being affected and causing serious fluctuations. Table 1 provides further details.

Table 1: Overview of Historical Changes in Fluctuation Limits

Time	Fluctuation Limit	Note
February 09, 1962	-5%~+5%	First implementation of fluctuation limit
April 09, 1973	-3%~+3%	Only applicable to second board (TIGER Board) stocks
August 08, 1973	-5%~+5%	
February 19, 1974	-1%–+5%	Oil Crisis
March 19, 1974	-5%~+5%	
April 15, 1974	-1%~+1%	
May 21, 1974	-3%~+3%	
June 17, 1974	-5%~+5%	
December 19, 1978	-2.5%~+2.5%	The second Oil Crisis
January 05, 1979	-5%~+5%	
October 27, 1987	-3%~+3%	Global stock market crashes
November 14, 1988	-5%~+5%	
October 11, 1989–September 26, 1999	-7%~+7%	The first relaxation to 7%
September 27–October 08, 1999	-3.5%~+7%	The 921 Jiji Earthquake
March 20–March 24, 2000	-3.5%~+7%	Presidential Election, the first party alteration
October 04–October 11, 2000	-3.5%~+7%	The resignation of Tang Fei, the Premier of the Republic of China
October 20–November 07, 2000	-3.5%~+7%	Persistent languish in the stock market
November 21–end of year, 2000	-3.5%~+7%	US Dot Com Bubble Crash
September 19–September 21, 2001	-3.5%~+7%	US September 11 attacks
October 13–December 31, 2008	-3.5%~+7%	Global financial crisis
June 01, 2015–Present	-10%~+10%	First relaxation to 10%

Source: Taiwan Stock Exchange and this study

DATA AND METHODOLOGY

Sample Selection and Variable Definition

The Taiwan Mid-Cap 100 Index is an index that consists of 100 mid-cap stocks. Its constituent stocks include major industries such as electronics, finance, and traditional industries. The index sorted listed stocks based on market capitalization, free float, and liquidity and then selected the 51^{st}–150^{th} company stocks, totaling 100 companies. The index has a certain degree of correlation with the overall stock market in Taiwan, so this study uses the constituent stocks of the Taiwan Mid-Cap 100 Index in 2015 as a research sample. The relevant data sources were taken from the Taiwan Stock Exchange and Taiwan Economic Journal. We obtained the daily closing prices of individual stocks and a list of the constituent stocks of the mid-cap 100 index from the Taiwan Stock Exchange. The Taiwan Economic Journal provides trading information for individual stocks such as stock codes, daily stock prices, transaction volumes, transaction prices, and matching times. To test whether the magnet effect is delayed after changing the daily price limits, the sample period of the study was selected as three months before and after the system change, from March 1, 2015–August 31, 2015, totaling 127 trading days. The final sample includes 12,700 firm-year observations. To verify the hypothesis of this study, we follow the method of Hsieh, Kim, and Yang (2009) to detect the magnet effect by using the logit regression model to estimate the probabilities and examine the relationship between the distance from price limits and the probability of the price rising (falling). The logit model is specified as follow:

$$\ln\left(\frac{P(Y_k = 1|X_k)}{1-P(Y_k = 1|X_k)}\right) = X_k' A \quad (1)$$

The up (down) model can help us detect the magnet effect when stock prices are rising (falling). For the up (down) model, when the price of the k^{th} period is more (less) than the price of the $(k-1)^{th}$ period, $Y_k = 1$. If the magnet effect exists, the probability of the price rising (falling) would increase greatly when the stock price approaches the upper (lower) price limit. We follow previous studies to incorporate the time duration of trades, the trading volume, the distance to price limits, the position of the magnet effect, the stock index returns, the bid-ask spread, and the buyer/supplier-initiated transaction as our independent variables (X) to capture the features of the trading prices changes. According to Easley and O'Hara (1992), the longer the time duration of trades, the lower their impact on the transaction prices. To capture the effect of time duration of trades, we thus consider the variable ΔTD_k as one of our independent variable. Karpoff (1987) studied the relationship between stock price changes and trading volume and pointed out that there is a positive relationship between the two. Therefore, we add lag three periods of trading volume (Vol_{k-p}) $(p = 1,2,3)$ to capture the trading volume impact on prices. In addition, as pointed out by Hsieh, Kim, and Yang (2009) in support of the magnet effect, as share prices approach the price limits, the probability of the magnet effect occurring increases. We use the variable DT_{k-1} to represent the distance between share prices and price limits, defined as the distance between the share price and price limits in the $(k-1)^{th}$ period. Assuming that the magnet effect exists, the closer the stock price is to the price limits, the higher the probability that it reaches the price limits, indicating a negative correlation between the two. We also use the variable DT_{k-1}^{m} indicates whether the $(k-1)^{th}$ period trading price falls in the range of m tick sizes from the price limits, which is used to capture the position whether the magnet effect occurs. Then, to capture the market's effect on price changes, we follow Hsieh, Kim, and Yang (2009) to control the market-wide effects on price movements by including the Mkt_{k-p} variable, defined as the return of the Taiwan Capitalization Weighted Stock Index in the $(k-p)^{th}$ period, where $p = 1,2,3$. Referencing Brockman and Chung (1999), this study also include the $Spread_{k-1}$ variable to capture the bid–ask bounce effect and the liquidity effect. Finally, to identify whether a transaction was initiated by the buyer or the seller, the study refers to Hsieh, Kim, and Yang (2009)'s model and adds the BSI_{k-p} variable in our model. Also, the $Vol_{k-p} \times BSI_{k-p}$ $(p = 1,2,3)$ variable was added to measure the impact of a unit of trading volume when the transaction was either buyer- or supplier-initiated.

Empirical Models

This study deployed the Logit model, which is a non-linear regression model developed by Berkson in 1944. The dependent variables are usually binary (e.g. yes/no, success/failure) and represented by 0 and 1, which is applicable for binary classification problems. In the up (down) models in this study, 1 is assigned to the states where the stock price is higher (lower) than the previous period, and 0 otherwise. With the abovementioned variable definition and description, we represent $X_k'A$ using the following regression equation:

$$X_k'A = a_0 + a_1\Delta TD_k + a_2Vol_{k-1} + a_3Vol_{k-2} + a_4Vol_{k-3} + a_5DT_{k-1} + a_6DT_{k-1}^{m} \times DT_{k-1} + a_7Spread_{k-1} + a_8BSI_{k-1} + a_9BSI_{k-2} + a_{10}BSI_{k-3} + a_{11}Vol_{k-1} \times BSI_{k-1} + a_{12}Vol_{k-2} \times aSI_{k-2} + a_{13}V_{olk-3} \times BSI_{k-3} + a_{14}Mkt_{k-1} + a_{15}Mkt_{k-2} + a_{16}Mkt_{k-3} \quad (2)$$

ΔTD_k represents the time from the $(k-1)^{th}$ period to the k^{th} period in minutes; Vol_{k-p} represents the trading volume in the $(k-p)^{th}$ period; DT_{k-1} represents the distance between the share price and price limits in the $(k-1)^{th}$ period; DT_{k-1}^{m} is a dummy variable with 1 when the trading price in the $(k-1)^{th}$ period falls between m tick sizes from price limits, 0 otherwise; $Spread_{k-1}$ is the bid–ask spread in the $(k-1)^{th}$ period, 0 if bid or ask prices did not exist in the trading period; BSI_{k-p} is a dummy variable with 1 if the trading price in the $(k-p)^{th}$ period is greater than the average of the bid and ask prices, -1 if the trading price is less than the average of the bid and ask and 0 otherwise; Mkt_{k-p} represents the return on the Taiwan Capitalization Weighted Stock Index in the $(k-p)^{th}$ period. Since the existing literature does not clearly indicate where the magnet effect starts, past studies have usually chosen an arbitrary location. We added dummy variables to capture all possibilities for forming a threshold price (see Kim and Yang, 2004), observing where the magnet effect starts through dummy variables. To achieve the research objective, we will aggregate the coefficients a_5 and a_6 and convert it to the probability of continuing to move toward the price limits. Then, we calculated the mean and median of these probabilities to find where the magnet effect starts.

EMPIRICAL RESULTS

Estimation of the Logit Regression Model

To complete the hypothesis of this study, we separated the data period into pre-restructuring and post-restructuring and referred to the model in Hsieh, Kim, and Yang (2009)'s research to include the companies of Taiwan's Mid-Cap 100 index stocks in the up model and the down model to compare the difference between the magnet effect before and after the restructuring. Table 2 presents the regression results when the stock price is 2–6 tick sizes away from the daily price limit in the up model before and after restructuring at a 5% confidence level. The study counts the signs of the coefficients for each variable and uses the majority sign to represent the most possible sign for that coefficient. The coefficient is represented by 0 if not significant. From Table 2 we can observe that in the up model, the coefficient changes are not much different before and after the restructuring. Table 2 shows that the signs of coefficient a_2 of Vol_{k-1} are positive, indicating that if the trading volume increases significantly in the current period, share prices will more likely rise in the next period. Additionally, the coefficient of DT_{k-1}, a_5 is negative, signaling that as a share price approaches its up limit, it becomes more likely that the share price will increase, a negative correlation between the distance from the limit and the probability of price increases. We also discovered that the coefficient of Mkt_{k-1}, a_{14} is positive both before and after restructuring, meaning that as the market trends upward, the more likely the share prices will increase, signaling that share price increases correlate positively with market trends.

Table 2: Estimations Results of Logit Regression Model in the Up Model

Pre-restructuring																	
	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}
2	-	0	+	0	0	-	0	+	-	+	+	+	+	0	+	0	0
3	-	0	+	0	0	-	0	+	-	+	+	+	+	0	+	0	0
4	-	0	+	0	0	-	0	+	-	+	+	+	+	0	+	0	0
5	-	0	+	0	0	-	0	+	-	+	+	+	+	0	+	0	0
6	-	0	+	0	0	-	0	+	-	+	+	+	+	0	+	0	0
Post-restructuring																	
	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}
2	-	0	+	0	0	-	0	+	-	+	+	+	0	0	+	0	+
3	-	0	+	0	0	-	0	+	-	+	+	+	0	0	+	0	+
4	-	0	+	0	0	-	0	+	-	+	+	+	0	0	+	0	0
5	-	0	+	0	0	-	0	+	-	+	+	+	0	0	+	0	+
6	-	0	+	0	0	-	0	+	-	+	+	+	0	0	+	0	+

Note 1. $X_k'A = a_0 + a_1 \Delta TD_k + a_2 Vol_{k-1} + a_3 Vol_{k-2} + a_4 Vol_{k-3} + a_5 DT_{k-1} + a_6 DT_{k-1}^m \times DT_{k-1} + a_7 Spread_{k-1} + a_8 BSI_{k-1} + a_9 BSI_{k-2} + a_{10} BSI_{k-3} + a_{11} Vol_{k-1} \times BSI_{k-1} + a_{12} Vol_{k-2} \times BSI_{k-2} + a_{13} Vol_{k-3} \times BSI_{k-3} + a_{14} kt + a_{15} Mkt_{k-2} + a_{16} Mkt_{k-3}$。 *2. At the 5% confidence level, when the distance of the stock price from the up limit is 2–6 tick sizes, these are the possible signs of each coefficient. If the p-value > 0.05, it is represented by 0.*

Table 3 shows the possible signs of the coefficients for each variable when the stock price is 2–6 tick sizes from the down limit under the 5% confidence level before and after restructuring. Insignificant coefficients are indicated by 0. Table 3 shows that the signs of coefficients changed insignificantly before and after the restructuring. Next, we find that the coefficients of Vol_{k-1}, a_2 are positive, meaning that if the trading volume in the previous period increases significantly, the stock price for this period will fall more easily. In addition, although a_5—the coefficient of DT_{k-1}—is less significant than in the up model, they are mostly negative, indicating that that the closer the stock price is to the down limit, the more likely the stock price will fall. The coefficients of Mkt_{k-1}, a_{14} are both negative before and after the restructuring. When the market trend decreases, the stock price will more likely fall, which indicates that the stock price decline is negatively correlated with the market trend.

Table 3: Estimations Results of Logit Regression Model in the Down Model

Pre-restructuring																	
	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}
2	-	+	+	0	0	-	0	+	+	-	-	-	-	0	-	0	0
3	-	+	+	0	0	-	0	+	+	-	-	-	-	0	-	0	0
4	-	+	+	0	0	-	0	+	+	-	-	-	-	0	-	0	0
5	-	+	+	0	0	0	0	+	+	-	-	-	-	0	-	0	0
6	-	+	+	0	0	0	0	+	+	-	-	-	-	0	-	0	0
Post-restructuring																	
	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}
2	-	+	+	0	0	-	0	+	+	-	-	-	0	0	-	0	-
3	-	+	+	0	0	0	0	+	+	-	-	-	0	0	-	0	-
4	-	+	+	0	0	-	0	+	+	-	-	-	0	0	-	0	-
5	-	+	+	0	0	0	0	+	+	-	-	-	0	0	-	0	-
6	-	+	+	0	0	-	0	+	+	-	-	-	0	0	-	0	-

Note ： 1. $X_k'A = a_0 + a_1\Delta TD_k + a_2Vol_{k-1} + a_3Vol_{k-2} + a_4Vol_{k-3} + a_5DT_{k-1} + a_6DT^m_{k-1} \times DT_{k-1} + a_7Spread_{k-1} + a_8BSI_{k-1} + a_9BSI_{k-2} + a_{10}BSI_{k-3} + a_{11}Vol_{k-1} \times BSI_{k-1} + a_{12}Vol_{k-2} \times BSI_{k-2} + a_{13}Vol_{k-3} \times BSI_{k-3} + a_{14}kt + a_{15}Mkt_{k-2} + a_{16}Mkt_{k-3}$。 *2. At the 5% confidence level, when the distance of the stock price from the up limit is 2–6 tick sizes, these are the possible signs of each coefficient. If the p-value > 0.05, it is represented by 0.*

Analysis of the Magnet Effect

To examine the location of the magnet effect, we first estimated the coefficients of DT_{k-1} and $DT^m_{k-1} \times DT_{k-1}$—$a_5$ and a_6—for the constituent companies in the Taiwan Mid-Cap 100 Index and then found the average and median from these estimates. We then aggregated the a_5 and a_6 of these 100 companies, converted them into the probability of the continuing rise/fall movement, and calculated the average and median from these probability values. The formula with which to calculate probabilities was $e^{-(a_5+a_6)} - 1$. According to Hsieh, Kim, and Yang (2009), when the conditional probability of the average was <2%, it can be regarded as the location where the magnet effect starts to occur. Table 4 shows the average and median values of a_5, a_6, and $a_5 + a_6$ in the up model when the stock price is 2–6 tick sizes away from the up limit before and after the restructuring. The table also shows the probability of the stock price continuing to ascend to the up limit given the distance to the up limit in tick size. From Table 4, we can see that before the restructuring, when the stock price is four tick sizes away from the up limit, the probability that the stock price will continue to move toward the up limit is 1.31%, i.e. <2%.

This indicates that the magnet effect starts when the distance is four tick sizes away. Next, we observe that after the restructuring, when the stock price is four tick sizes away from the up limit, the probability that the stock price will continue to move to the up limit is 0.65%, which is <2%, indicating that the magnet effect starts when the distance is four tick sizes away.

From the above table, no matter before or after the restructuring, the location of the magnet effect is four tick sizes away from the up limit with no advance or delay. Similar to Table 4, Table 5 shows the average and median values of a_5, a_6, and $a_5 + a_6$ in the down model when the stock price is 2–6 tick sizes away from the down limit before and after the restructuring. In addition, the table shows the probability of the stock price continuing to descend to the down limit given the distance to the down limit in tick size. From Table 5, we can see that before the restructuring, when the stock price was three tick sizes away from the down limit, the probability that the stock price would continue to move toward the down limit is 0.72%, which is <2%; this indicates that the magnet effect starts when the distance is three tick sizes away. Additionally, we can observe that after restructuring, the probabilities that the stock price will continue to descend toward the down limit are >2% when the share price is 2–6 tick sizes away from the down limit. As a result, where the magnet effect starts to occur is inconclusive after restructuring and the magnet effect is less significant. Overall, our empirical results for the down model confirm our hypothesis.

Table 4: Conditional Probability of the Regression Results in the UP Model

Pre-restructuring								
m	a_5		a_6		$a_5 + a_6$		**Average probability of** $a_5 + a_6$ **(%)**	**Median probability of** $a_5 + a_6$ **(%)**
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**		
2	-0.0036	-0.0023	0.0609	0.0000	0.0574	-0.0023	7.07	0.60
3	-0.0032	0.0000	0.1322	0.0000	0.1290	0.0000	3.43	0.67
4	-0.0032	0.0000	0.0960	0.0000	0.0928	0.0000	1.31	0.64
5	-0.0032	0.0000	0.0497	0.0000	0.0465	0.0000	0.78	0.61
6	-0.0028	0.0000	0.0175	0.0000	0.0148	0.0000	5.47	0.74
Post-restructuring								
m	a_5		a_6		a_5		**Average probability of** $a_5 + a_6$ **(%)**	**Median probability of** $a_5 + a_6$ **(%)**
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Mean**		
2	-0.0017	0.0000	0.0893	0.0000	0.0876	0.0000	6.40	0.57
3	-0.0017	0.0000	0.1026	0.0000	0.1009	0.0000	2.82	0.57
4	-0.0017	0.0000	0.0949	0.0000	0.0932	0.0012	0.65	0.56
5	-0.0017	0.0000	0.0730	0.0000	0.0713	0.0013	0.66	0.59
6	-0.0020	0.0000	0.0299	0.0000	0.0279	0.0000	0.65	0.60

Note:1. Results from the logit model estimation. a_5 *and* a_6 *are the coefficients of* DT_{k-1} *and* $DT^m_{k-1} \times DT_{k-1}$*, respectively. 2. The probabilities of share prices continuing to move toward price limits are calculated with* $e^{-(a_5+a_6)} - 1$*. 3. m represents the distance from the price limits in tick sizes.*

Table 5: Conditional Probability of the Regression Results in the Down Model

Pre-restructuring								
m	**a_5**		**a_6**		**a_5+a_6**		**Average probability of a_5+a_6 (%)**	**Median probability of a_5+a_6 (%)**
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**		
2	-0.0035	-0.0025	0.0084	0.0000	0.0049	-0.0025	4.99	0.60
3	-0.0030	0.0000	0.0331	0.0000	0.0301	0.0000	0.72	0.55
4	-0.0030	0.0000	0.0174	0.0000	0.0144	0.0000	4.40	0.75
5	-0.0030	0.0000	0.0116	0.0000	0.0087	0.0000	4.39	0.80
6	-0.0041	0.0000	-0.0047	0.0000	-0.0088	-0.0038	3.52	0.81
Post-restructuring								
m	**a_5**		**a_6**		**a_5**		**Average probability of a_5+a_6 (%)**	**Median probability of a_5+a_6 (%)**
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Mean**		
2	-0.0019	0.0000	-0.0715	0.0000	-0.0734	0.0000	27.40	0.61
3	-0.0018	0.0000	0.0054	0.0000	0.0037	0.0000	11.19	0.51
4	-0.0017	0.0000	0.0182	0.0000	0.0165	0.0000	9.66	0.60
5	-0.0017	0.0000	0.0129	0.0000	0.0112	0.0000	4.60	0.49
6	-0.0016	0.0000	0.0163	0.0000	0.0146	0.0000	5.01	0.52

Note:1. Results from the logit model estimation. a_5 and a_6 are the coefficients of DT_{k-1} and $DT_{k-1}^{m} \times DT_{k-1}$, respectively. 2. The probabilities of share prices continuing to move toward price limits are calculated with $e^{-(a_5+a_6)}-1$. 3. m represents the distance from the price limits in tick sizes.

CONCLUSIONS

The magnet effect was first proposed by Fama (1989); Subrahmanyam (1994) was the first to verify this phenomenon with a theoretical model, discovering that the magnet effect occurs when markets establish price limits. Subsequent research focused on whether the magnet effect exists in each country's stock market and many studies have found such phenomena. Whether the magnet effect exists in the Taiwan's stock market has also been repeatedly discussed and proved (Chen, 1997; Cho, Russell, Tiao, and Tsay, 2003; Wong, Chang and Tu, 2009; Hsieh, Kim, and Yang, 2009; Wang, Hsiao, and Lin, 2012). In addition, as market participants gradually mature and to create a more efficient securities market, Taiwan officially relaxed its daily price limits from 7% to 10% fluctuations on June 1, 2015. In this study, to analyze whether the magnet effect would be delayed after restructuring, we refer to the approach of Hsieh, Kim, and Yang (2009) and detect the difference between the magnetic effects before and after the restructuring with the data of the Taiwan Mid-Cap 100 Index component stocks for March 1–August 31, 2015. We found that for the up model whether before or after the restructuring, the magnet effect began to occur when it was four tick sizes away from the daily limit. The magnet effect did not delay or occur early because of the relaxation to 10%. On the other hand, for the down model, we found that before the restructuring, the magnetic effect began to occur when the price was three tick sizes away from the down limit, but the magnet effect was less obvious after the restructuring, whether it was 2–6 tick sizes. The empirical results of the down model confirm the research hypothesis.

Overall, our empirical results provide substantial evidence of an insignificant magnet effect after the relaxed daily price limits, especially in the down market. To the extent that the magnet effect disappears, the relaxation of price limits may reduce the short-run market volatility. The policy implication of our empirical findings for policy makers is that the relation of price limits could help reduce the impact of magnet effect and thus lower the market volatility, leading to a more stable capital market. The paper has a limitation in the sample selection. This study selected the constituent stocks of the Taiwan Mid-Cap

100 Index. As a result, the sample size in this study is relatively small, which may impact the empirical results. Future research can expand the research sample to the entire stock market. Another interesting extension of this paper would be a more detailed examination of the impact of trading activity by trader types on the changes in the magnet effect. The magnet effects may differ between different types of investors when institutional investors have more information and are more rational than individual investors.

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