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Characteristics of stocks that frequently hit price limits: Empirical evidence from Taiwan and Thailand☆

Kenneth A. Kim[a,*], Piman Limpaphayom[b]

[a]*School of Business Administration, University of Wisconsin-Milwaukee, P.O. Box 742, Milwaukee, WI 53201, USA*

[b]*Faculty of Business, Asian University of Science and Technology, 89 Highway 331, Chonburi 20260, Thailand*

Abstract

Daily price limits in the securities markets may affect certain securities more often than other securities. To examine this issue empirically, we examine two stock markets that impose daily price limits (Taiwan Stock Exchange and the Stock Exchange of Thailand). Overall, we find that volatile stocks, actively traded stocks, and small market capitalization stocks hit price limits more often than other stocks. Our findings, therefore, provide new considerations into the current discussions surrounding price limit mechanisms, an important topic in which very little is known.

JEL classification: G10; G14

Keywords: Price limits; Taiwan; Thailand

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* Corresponding author. Tel: + 1-414-229-6530; fax: + 1-414-229-6957.

E-mail address: kkim@uwm.edu (K.A. Kim).

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Price limits are artificial boundaries established by market regulators to confine daily movements of security prices. Price limits are currently used in the U.S. futures market and in many stock exchanges around the world including: Austria, Belgium, France, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, Spain, Switzerland, Taiwan, and Thailand (Roll, 1989). Therefore, a considerable portion of the world's capital markets is affected by price limit mechanisms. Surprisingly, despite their significant presence, very little is known regarding price limit effects. Perhaps the main reason for this lack of knowledge is that there are very few price limit studies. As pointed out by Kuhn et al. (1991) and Harris (1998), reasonable sample sizes using U.S. data are difficult to obtain. Thus, France et al. (1994) state that there are many unanswered questions regarding price limit mechanisms, and Harris (1998) states that this ignorance is unfortunate because we need to make informed decisions as to how our markets should be protected. In this paper, we attempt to shed some much-need light on price limit effects by empirically investigating stock markets where price limits are systematically imposed and regularly used: the Taiwan Stock Exchange (TSE) and the Stock Exchange of Thailand (SET).

In addition to the difficulties of obtaining a reasonable sample size, perhaps another important reason why price limit studies are scarce is that there is no perfect way to measure their consequences (Harris, 1998). That is, we cannot observe what would have happened in the absence of price limits. Therefore, most studies have used an event-study type methodology where they examine stock price behavior (such as volatility and trading volume) before and after a price-limit-hit (e.g., Chen, 1998; Ma et al., 1989a, b; Kim and Rhee, 1997).[1] These before-and-after studies, while potentially insightful, are subject to problems of interpretation because stock price behavior, such as volatility, is well known to be serially dependent (Chen, 1998; France et al., 1994; Lehmann, 1989; Miller, 1989). Furthermore, there are problems related to sample selection bias because stocks that hit limits on consecutive days are usually excluded from the final samples (Lehmann, 1989; Miller, 1989; Kim and Rhee, 1997).

In our study, we take a completely different approach to identifying price limit effects. Our research attempts to identify the characteristics of stocks that frequently hit price-limits. Overall, we find that stocks that frequently hit price limits typically have the following characteristics: they are volatile, as measured by beta and residual risk, they are actively traded, and they have small market capitalizations. These observations are rather revealing in and of themselves, but they can also be considered complementary to recent research that finds price-*continuations* after securities hit their price limit (e.g., Chen, 1998; Kim and Rhee, 1997). Price-continuations subsequent to limit-hits suggest that price limits are merely restricting fair or rational price movements. Our own findings can be

[1] See Harris (1998) and Kim and Rhee (1997) for an overview of the price limit literature. These papers also summarize the surrounding issues and the current debates.

interpreted in the same way to the extent that these characteristics are related to fundamental values. This study represents the first attempt to identify characteristics of stocks that frequently hit daily price limits and, as such, it can shed new light on the issues surrounding price limit mechanisms.

The rest of our paper is organized along the following lines. The next section describes the institutional characteristics of both the Taiwan Stock Exchange (TSE) and Stock Exchange of Thailand (SET). Section 2 discusses our data and empirical approach. Section 3 provides descriptive statistics and the empirical results. Section 4 offers concluding remarks.

1. Institutional background of the TSE and SET

1.1. Taiwan Stock Exchange

At the end of 1993, there were 305 stocks listed on the Taiwan Stock Exchange (TSE) with a total market capitalization of NT\$$5.23 \times 10^{12}$ (US\$1 = NT\$26.40 on December 31, 1993). Trading on the TSE begins at 9:00 a.m. and ends at 12:00 noon, Monday through Friday. On Saturday, trading takes place from 9:00 a.m. to 11:00 a.m. Orders can be submitted one half-hour prior to the market opening. The opening price is the one that maximizes trading volume. The TSE is completely order-driven with no market makers or specialists. At the beginning of our sample period, all trades were carried out by the TSE computer-assisted trading system (CATS), which was modeled after the Toronto and Tokyo trading systems. Furthermore, after the morning call market determined the opening price, trading took place under a continuous auction market. At the end of the trading day, however, a call market determined closing prices. On August 2, 1993, the TSE went to a fully automated securities trading system (FAST), where trading now takes place under a call market method at 60–90 second intervals throughout the entire day. For stocks listed on the TSE, tick sizes vary with market prices.[2] The TSE sets its daily price limit for each stock at 7%, both upward and downward, based on the previous day's closing price of each stock (TSE Fact Book, 1996). During the trading day,

[2] TSE tick sizes are determined as follows:

Price (P)	Tick size
$P <$ NT\$5	NT\$0.01
NT\$5 $\leqslant P <$ NT\$15	NT\$0.05
NT\$15 $\leqslant P <$ NT\$50	NT\$0.10
NT\$50 $\leqslant P <$ NT\$150	NT\$0.50
NT\$150 $\leqslant P <$ NT\$1,000	NT\$1.00
NT\$1000 $\leqslant P$	NT\$5.00

stocks that hit their price limit are still allowed to trade as long as the transaction price is within the limits. Thus, it is important to note that TSE price limits are boundaries, not trading-halt triggers.

1.2. Stock Exchange of Thailand

At the end of 1993, there were 347 stocks listed on the Stock Exchange of Thailand (SET) with a total market capitalization of 3.40×10^{12} baht (US\$1 = 25.48baht on December 31, 1993). It should be noted that SET trading hours varied during our sample period. At the beginning of our sample period, trading occurred from 9:00 a.m. to 12:00 noon. On July 2, 1992, the SET expanded trading to four hours that composed of two trading sessions: a morning session between 10:00 a.m. to 12:30 p.m. and an afternoon session between 2:30 p.m. and 4:00 p.m. As in the case of the TSE, orders are accumulated prior to the market open and the opening price is the one that maximizes trading volume. On April 1991, the SET went to a fully computerized trading system and an automated matching process (developed by the Midwest Stock Exchange) to replace the old floor trading system. As in the case of the TSE once again, the SET is also completely order-driven and does not employ market makers or specialists. However, the SET is similar to the NYSE in that a call market determines opening prices and trading continues under a continuous auction market until the end of the session. The tick sizes of stocks listed on the SET vary with stock prices.[3] The daily price limit is set at 10% of the preceding day's closing price for each stock (SET Fact Book, 1996). As in the case of the TSE again, SET price limits are boundaries, not trading-halt triggers.

2. Data and empirical approach

2.1. Data

Daily and monthly stock price and return data are retrieved from the PACAP Databases provided by the Sandra Ann Morsilli Pacific-Basin Capital Markets

[3] SET tick sizes are determined as follows:

Price (P)	Tick size
$P < 10$ Baht	0.10 Baht
10 Baht $\leqslant P < 50$ Baht	0.25 Baht
50 Baht $\leqslant P < 100$ Baht	0.50 Baht
100 Baht $\leqslant P < 200$ Baht	1.00 Baht
200 Baht $\leqslant P < 600$ Baht	2.00 Baht
600 Baht $\leqslant P < 1000$ Baht	4.00 Baht
1000 Baht $\leqslant P$	6.00 Baht

(PACAP) Research Center at the University of Rhode Island. In the PACAP database, daily opening, closing, high, and low stock prices are available for both Taiwan and Thailand. We further adjust our price data to reflect capital distributions, which include stock splits, reduction of capital, rights offerings, and stock dividends. For our study, we use the four-year period from 1990 to 1993.

2.2. Empirical approach

For both stock exchanges, we first identify all occurrences when price limits are hit. Because daily high, low, and closing prices are available in the PACAP database, and because the TSE and the SET both set price limits based on each stock's closing price from the previous trading day, it is feasible to identify occurrences when price limits are hit.[4] Summary statistics are presented in Table 1a and b for Taiwan and Thailand, respectively.

Table 1a and b provide the number of times that price-limit-hits occur. The observations are sorted by year, by month, by the day of the week, and by industry. For the calendar statistics, the first column indicates the total number of limit-hits, the second column shows the number of times upper price limits (ceiling) are hit, and the third column shows the number of times that lower price limits (floor) are hit. We also examine the monthly and daily distributions on a yearly basis but we do not report the results due to the lack of discernible patterns in the distributions. For the industry statistics, the first column shows the number of firms in each industry, and the second and third columns indicate the average number of times that upper and lower price limits are hit, respectively. We report industry statistics in this fashion because the different number of firms in each industry leads to ambiguous summary statistics.[5]

It should be noted that the number of price-limit-hits has declined drastically on both the Taiwan Stock Exchange and the Stock Exchange of Thailand. However, we consider 1990–1991 to be somewhat of an unusual period due to the crash of the Japanese market and the Gulf War. There also seem to be some monthly patterns in both markets. However, we find that the patterns change from year to year in both markets so we conclude that there is limited evidence of a calendar effect. With regard to a day-of-the-week effect, we find that the distributions of price limit hits in both markets are quite uniform. Finally, we

[4] Any time an observed high or low price matches the high and low price that is allowed under price limits (7% and 10% for Taiwan and Thailand, respectively), it is classified as a limit-hit. Therefore, this includes occurrences where the high or low price is less than a full tick size away from hitting the daily price limit. TSE and SET price limits are mechanically imposed such that prices cannot exceed the price limit even by a fraction of a tick size.

[5] The industry classifications that we use are categories that have been established by each of the respective stock exchanges (TSE and SET Industry Classifications).

Table 1
(a) Summary statistics: Taiwan Stock Exchange

This table reports the frequency distributions of price limit hits for stocks listed on the Taiwan Stock Exchange (TSE) during 1990–1993. We report the number of price limit hits by year, by month and by day-of-the-week. For the frequency distribution by industry, we report the number of companies in each industry and the average number of times each stock in the industry hits price limits. Upper and Lower indicate the two subsamples of upper limit-hits and lower limit-hits.

Year	All	Upper	Lower
1990	20,100	8624	11,476
1991	7145	3575	3570
1992	2404	1119	1285
1993	2864	2007	857
Month	**All**	**Upper**	**Lower**
January	3417	1861	1556
February	2268	1530	738
March	1678	1007	671
April	1784	893	891
May	3054	908	2146
June	2816	813	2003
July	2571	1443	1128
August	4181	1467	2714
September	2521	779	1742
October	2747	1353	1394
November	2999	1899	1100
December	2477	1372	1105
Day-of-the-week	**All**	**Upper**	**Lower**
Monday	5870	2747	3123
Tuesday	5691	2589	3102
Wednesday	5114	1965	3149
Thursday	5693	2555	3138
Friday	5473	2942	2531
Saturday	4672	2527	2145
Industry	**No. of companies**	**Upper**	**Lower**
Cement	9	47.3	60.8
Foods	23	56.6	65.8
Plastics	17	52.2	52.9
Textiles	46	72.2	78.3
Electric Machinery & Machinery	10	56.5	58.5
Electric Products & Wires	12	67.8	80.5
Chemicals	16	74.0	85.6
Glass Products	6	55.8	68.8
Pulp and Paper	8	69.5	77.9
Iron and Steel	20	50.9	60.8

Table 1 (*continued*)

Industry	No. of companies	Upper	Lower
Rubber Products	8	67.5	76.8
Motor	4	57.3	61.3
Electronic	28	52.4	55.4
Construction	19	41.6	44.0
Transportation	10	51.6	49.4
Tourism	6	94.5	105.2
Banking and Insurance	18	68.7	57.7
Groceries	8	61.3	65.6
Others	17	39.4	35.0

(b) Summary Statistics: Stock Exchange of Thailand

This table reports the frequency distributions of price limit hits for stocks listed on the Stock Exchange of Thailand (SET) during 1990–1993. We report the number of price limit hits by year, by month and by day-of-the-week. For the frequency distribution by industry, we report the number of companies in each industry and the average number of times each stock in the industry hits price limits. Upper and Lower indicate the two subsamples of upper limit-hits and lower limit-hits.

Year	All	Upper	Lower
1990	4568	2327	2241
1991	2539	1872	667
1992	2105	1399	706
1993	1276	954	322
Month	**All**	**Upper**	**Lower**
January	755	615	140
February	990	666	324
March	421	354	67
April	310	235	75
May	877	499	378
June	727	561	166
July	734	564	170
August	1881	778	1103
September	803	384	419
October	945	723	222
November	1172	475	697
December	873	698	175
Day-of-the-week	**All**	**Upper**	**Lower**
Monday	2393	1477	916
Tuesday	2066	1193	873
Wednesday	1941	1158	783
Thursday	2343	1492	851
Friday	1745	1232	513

Table 1 (*continued*)

Industry	No. of companies	Upper	Lower
Agribusiness	39	30.6	18.4
Banking	16	33.5	18.3
Building & Furnishing Materials	26	22.0	13.9
Chemicals and Plastics	9	29.8	19.3
Commerce	12	27.9	13.8
Communication	6	18.0	10.0
Electrical Products & Computer	10	32.5	16.4
Electronic Components	5	33.2	19.4
Energy	5	24.4	15.0
Entertainment & Recreation	2	22.5	8.5
Finance & Securities	38	38.7	21.6
Foods & Beverages	11	29.3	12.9
Health Care Services	9	18.4	10.2
Hotels & Travel Services	13	31.5	19.8
Household Goods	8	13.9	9.4
Insurance	21	19.7	10.4
Jewelry & Ornaments	5	23.8	13.0
Machinery & Equipment	2	11.5	6.5
Mining	3	58.3	36.0
Packaging	15	30.7	17.9
Pharmaceuticals & Cosmetics	2	38.0	18.0
Printing & Publishing	9	25.6	13.8
Professional Services	2	21.0	14.5
Property Development	27	21.7	13.9
Pulp & Paper	3	21.3	10.0
Textiles, Clothing & Footwear	33	24.0	13.1
Transportation	4	24.0	12.5
Vehicles & Parts	6	23.3	11.8
Warehouse & Silo	4	33.5	19.0
Others	3	15.0	7.3

find some evidence of an industry effect. In Taiwan, stocks of companies in textiles, chemicals and tourism industries hit limits more often than stocks in other industries such as construction. In Thailand, finance and mining stocks hit price limits most frequently while household goods and machinery stocks rarely hit price limits. Nevertheless, we fail to find any statistically significant difference among industries in both stock markets. Therefore, we conclude that calendar and industry effects are not present in our data. This conclusion also implies that a clustering effect should not plague our statistical analysis.

The purpose of our study is to see if certain attributes characterize those stocks that inherently reach their price limits more often than others. Because this area of research is somewhat underdeveloped, we rely on related research to identify potential factors and propose five such variables: beta, residual risk,

trading volume, firm size, and the book-to-market value of equity. Risky stocks exhibit more price volatility and thus are more likely to experience price-limit-hits. We separate risk into systematic and unsystematic components to see if they have a differential impact on the likelihood of hitting price limits. Firm size and book-to-market value of equity have both been shown to explain cross-sectional variation in stock returns (see, for example, Chan et al., 1991; Daniel and Titman, 1997; Fama and French, 1992). Fama and French (1992) and Chan and Chen (1991) argue that small firms and high book-to-market firms are viewed by the market as inherently riskier and have correspondingly higher expected returns. Price limits might be expected to affect such stocks when they experience large ex post returns.

Trading volume merits special comment. In principle, it reveals, in part, the flow of new information (Bamber, 1986; Karpoff, 1986; Verrecchia, 1981) into the market. As such, a stock that frequently experiences high trading volume will typically experience frequent price changes and elevated volatility, holding constant price volatility per transaction. Furthermore, a large literature argues that trading volume is positively related to the magnitude of price changes (see Karpoff (1987) for an overview of this literature). The impact that news has on trading volume depends on the significance and quality of the news, which, in turn, increases the magnitude of price changes. Hence, price limits should be hit more often by stocks with frequent flows of significant information. Accordingly, we hypothesize that frequently traded stocks are more likely to hit price limits.

We employ the following model to measure the effect of each variable:

$$\log[\%\mathrm{Hit}_j]/\{1-\log[\%\mathrm{Hit}_j]\} = \psi + \theta_1\ \mathrm{Beta}_j + \theta_2\ \mathrm{RR}_j + \theta_3\ \mathrm{TV}_j + \theta_4\ \mathrm{Size}_j + \theta_5\ \mathrm{BM}_j + \varepsilon_j, \quad (1)$$

where, $\%\mathrm{Hit}_j$ denotes the frequency with which each stock j hits a price limit (calculated as the number of days a limit-hit occurs divided by the total number of trading days), ψ is the intercept, Beta_j is the usual market beta, RR_j is residual risk, TV_j denotes trading volume (calculated as daily trading volume divided by the total shares outstanding), Size_j is the log of market capitalization which represents our proxy for firm size, and BM_j denotes the book-to-market value of equity. We estimated beta from the standard market model using monthly stock and equally-weighted market returns, both without dividends re-invested, over the four-year sample period (1990–1993). We use the market model residual standard deviation as a measure of residual risk. Finally, the θ's are the corresponding regression coefficients and ε_j represents the error term.

Both heteroskedasticity and autocorrelation have been found to be problematic in price limit studies (Kodres, 1993; Shen and Wang, 1998). Accordingly, we follow Shen and Wang (1998) and estimate the model using the generalized method of moments (GMM), which is asymptotically more efficient than ordinary least squares estimates in these circumstances (Hansen, 1982). We follow

the procedures suggested by Gallant (1987) and Ogaki (1993) and use the Parzen kernel estimator to specify the appropriate weighting matrix (W). We calculate the usual χ^2 goodness-of-fit statistic to see if the model is well-specified, which has $r - p$ degrees of freedom where r is the number orthogonality conditions in the model and p is the number of parameters (Hansen, 1982).

We need sufficient data to estimate the price-limit-hit frequencies as well as the betas and residual standard deviations with sufficient precision. Accordingly, we require stocks to have at least 500 daily observations during our four-year sample period. The resulting sample contains 223 Taiwan stocks and 228 Thai stocks.

3. Empirical results

Because we find results from Taiwan and Thailand to be similar, we only discuss Taiwan results, except where they differ substantially. Table 2a and b present summary statistics for Taiwan and Thailand, respectively. In these tables, we categorize stocks into quintiles (Q) based on the frequency with which they hit price limits during the four-year sample period. Q1 contains stocks that hit limits most frequently and Q5 contains those that hit them least often. For each quintile, we report the average frequency (in %) with which the stocks hit a price limit (% Hit) along with the average beta, residual risk, trading volume, market capitalization, and number of stocks in each quintile (N). Panel A reports results for the entire limit-hit sample. Because events that cause upper and lower limit hits may be quite different, Panel B reports the corresponding results only for upper-limit-hits (ceiling) while Panel C reports those for lower-limit-hits (floor).

Several important insights emerge from the Taiwan summary statistics. First, we find that some stocks hit their price limits very often. For example, Q1 stocks hit price limits over 20% of the time (for Thailand, it's over 11% of the time). Second, we observe that as the frequency of hitting the price limit decreases (going from Q1 to Q5), the stocks' beta and residual risk decreases monotonically. From results in Panels B and C, we also observe that a similar pattern exists for both subsamples of upper and lower limit-hits. Third, we find that, in general, frequently traded stocks hit price limits more often. Fourth, it appears that small market capitalization stocks experience price-limit-hits more often than larger market capitalization stocks. Finally, we cannot detect a pattern with the book-to-market results. Overall, from the summary statistics, we have noted some interesting observations. In general, it seems that volatile stocks, actively traded stocks, and small stocks frequently hit daily price limits.

We report the GMM results in Table 3a and b for Taiwan and Thailand, respectively. The instrumental variables in the models include a constant, the

Table 2
(a) Quintile analysis: Taiwan Stock Exchange

In this table, stocks are categorized into five groups (Q) based on the frequency of price limit hits. Q1 contains stocks that hit price limits most frequently and Q5 contains stocks that hit price limits least frequently. The table reports the average percent frequency in which price limits are hit (%Hit), the average beta, the average residual risk (RR), the average trading activity (daily trading volume divided by total shares outstanding) (TV (%)), the average market capitalization in millions of Taiwan dollars (Size), and the average book-to-market value of equity (BM). N denotes the number of stocks in each quintile. F-Statistics are obtained from the one-way ANOVA testing for mean differences among quintiles. Panel A reports the full sample results and Panels B and C differentiates between the samples of upper and lower price-limit-hits, respectively.

Quintile	%Hit	Beta	RR	TV (%)	Size	BM	N
Panel A: Full sample							
Q1	22.74	1.234	0.144	25.50	6875	0.309	44
Q2	16.93	1.100	0.116	16.25	10867	0.410	46
Q3	13.58	0.941	0.104	12.76	11,725	0.449	44
Q4	10.46	0.850	0.098	10.16	32,877	0.465	45
Q5	5.91	0.769	0.083	16.01	16,382	0.386	44
F-stat.	525.81	38.24	7.70	10.84	13.08	5.67	
Panel B: Upper limit-hit sample							
Q1	10.97	1.227	0.158	25.98	7369	0.317	44
Q2	7.96	1.091	0.106	16.70	11,196	0.393	45
Q3	6.63	0.989	0.102	11.81	22,250	0.430	44
Q4	5.18	0.865	0.103	14.80	19,728	0.472	46
Q5	3.16	0.726	0.074	11.32	18,273	0.403	44
F-stat.	440.39	42.16	15.74	11.36	6.39	5.25	
Panel C: Lower limit-hit sample							
Q1	12.38	1.230	0.145	24.62	6806	0.306	45
Q2	9.21	1.097	0.103	16.46	6570	0.438	44
Q3	7.19	0.946	0.108	13.18	15,507	0.429	44
Q4	5.41	0.824	0.094	8.29	30,844	0.481	45
Q5	2.55	0.830	0.095	17.97	18,953	0.369	45
F-stat.	475.54	34.65	6.12	12.13	18.67	7.10	

(b) Quintile Analysis: Stock Exchange of Thailand

In this table, stocks are categorized into five groups (Q) based on the frequency of price limit hits. Q1 contains stocks that hit price limits most frequently and Q5 contains stocks that hit price limits least frequently. The table reports the average percent frequency in which price limits are hit (%Hit), average beta, the average residual risk (RR), the average trading activity (daily trading volume divided by total shares outstanding) (TV (%)), the average market capitalization in millions of baht (Size), and the average book-to-market value of equity (BM). N denotes the number of stocks in each quintile. F-Statistics are obtained from the one-way ANOVA testing for mean differences among quintiles. Panel A reports the full sample results and Panels B and C differentiates between the samples of upper and lower price-limit-hits, respectively.

Table 2 (*continued*)

Quintile	%Hit	Beta	RR	TV (%)	Size	BM	*N*
Panel A: Full sample							
Q1	11.01	1.303	0.186	18.23	2021	0.434	45
Q2	8.35	1.248	0.137	14.94	3399	0.411	46
Q3	6.64	1.049	0.132	9.20	3855	0.424	46
Q4	5.29	0.816	0.119	8.42	4223	0.410	46
Q5	3.60	0.699	0.097	4.50	9289	0.474	45
F-stat.	317.37	25.13	29.01	15.45	7.40	0.47	
Panel B: Upper limit-hit sample							
Q1	7.04	1.298	0.187	17.88	1665	0.456	45
Q2	5.29	1.267	0.143	13.81	3577	0.386	46
Q3	4.28	1.076	0.124	10.94	3944	0.422	46
Q4	3.43	0.796	0.120	8.49	4712	0.418	46
Q5	2.22	0.691	0.096	4.16	8874	0.480	45
F-stat.	390.27	28.68	31.96	13.56	8.65	0.91	
Panel C: Lower limit-hit sample							
Q1	4.41	1.339	0.175	20.71	2717	0.431	45
Q2	3.10	1.189	0.138	11.97	3264	0.386	46
Q3	2.36	0.924	0.128	8.77	4103	0.456	46
Q4	1.86	0.889	0.120	8.64	3007	0.389	46
Q5	1.17	0.784	0.107	5.27	9722	0.491	45
F-stat.	271.35	17.62	15.28	18.59	6.04	1.44	

five explanatory variables, and the squares of the explanatory variables.[6] The first column of results reports parameter estimates for the full sample, and the second and third columns of results report upper and lower price-limit-hit samples, respectively.

For Taiwan, from Table 3a, we are able to confirm the positive relation between beta and the frequency of limit-hits, and between residual risk and the frequency of limit-hits (albeit, the relation is not statistically significant for the

[6] In choosing our instruments, we employ a common procedure that uses the explanatory variables to identify the model, and their squares (of which they are uncorrelated with the error term) to test for remaining misspecifications. This overidentification allows us to test to see if the model restrictions are well specified (indicated by a χ^2 that is not statistically significant). Overall, our results are robust to the choice of instrumental variables.

lower limit-hit sample).[7] These observations imply that riskier stocks are more inclined to hit price limits.[8] Next, we see that the positive relation between trading volume and the frequency of limit-hits is also confirmed, but we note that the relation is not statistically significant for the lower limit-hit sample. In fact, from the summary statistics in Table 2a, we see that stocks that hit lower price limits least often (Q5 stocks) have relatively high trading volume (see Table 2a, Panel C). For Taiwan, we may be observing some sort of liquidity effect where the depth of the market allows for less erratic price movements, and thus a lower frequency with which dramatic price decreases occur. The negative relation between firm size and the frequency of limit-hits is also statistically confirmed. Finally, a book-to-market effect does not seem to be a major factor in explaining the frequency of limit-hits. This observation may not be surprising in light of recent research on these two markets. Chui and Wei (1998) find that a book-to-market effect does not exist in either Taiwan or Thailand. Our findings, therefore, can be viewed as providing consistent evidence with Chui and Wei (1998). The Thailand results are similar to the Taiwan results, with one noteworthy difference: while the relationship between trading volume and the frequency of limits-hits is positive, it is only statistically significant for the lower-hit sample. Finally, we test the null hypothesis that parameter coefficients between the upper- and lower-limit-hit samples are equal. Here, a Wald statistic is 19.26 and 64.25 for Taiwan and Thailand, respectively, which rejects the hypothesis at the one percent level, which, in turn, justifies differentiating limit-hit events between upper- and lower-limit-hits.

Overall, the impressions from the summary statistics are confirmed in the regression analysis. Volatility, trading activity, and size are significant factors that affect a stock's propensity to hit price limits. However, the two main advantages to estimating a regression is that (1) we can measure the marginal effects of different variables on the propensity to hit price limits and (2) we can estimate the impacts of these variables jointly rather than in isolation, i.e., the effect of each variable can be evaluated while holding constant the other

[7] We also considered models that included a total risk measure as an explanatory variable (calculated as the variance of close-to-close daily returns) to ensure the robustness of our risk results, but these results are qualitatively similar to the reported results that reveals that volatile stocks are more inclined to hit price limits.

[8] We acknowledge that beta is measured with sampling error (e.g., see Lehmann (1990) for a discussion of this issue, especially with regard to its affect on standard errors). To see if this measurement error induces significant biases in the context of our other explanatory variables, we executed various permutations of our models, which sometimes included or excluded beta, to identify sign changes and we also conducted variance–inflation-factor tests. Overall, our beta measure does not appear to be problematic in that it does not induce significant biases. We also test our model using ordinary-least-squares and the results are qualitatively similar to the reported results (i.e., the signs on all variable coefficients remain in the same direction), so we do not report them.

Table 3
(a) GMM results: Taiwan Stock Exchange

This table presents the generalized method of moments (GMM) estimates for the following model:

$$\log[\%\mathrm{Hit}_j]/\{1-\log[\%\mathrm{Hit}_j]\} = \psi + \theta_1\ \mathrm{Beta}_j + \theta_2\ \mathrm{RR}_j + \theta_3\ \mathrm{TV}_j + \theta_4\ \mathrm{Size}_j + \theta_5\ \mathrm{BM}_j + \varepsilon_j,$$

where, $\%\mathrm{Hit}_j$ denotes the frequency for which each stock j hits price limits, ψ represents the intercept term, Beta_j represents a measure of stock volatility which is associated with market movements (calculated from the standard market model using monthly stock returns without dividends re-invested and the equally-weighted market returns without dividends re-invested), RR_j denotes residual risk (residual standard deviation of the market model from which beta is calculated), TV_j denotes trading volume (daily trading volume divided by total shares outstanding), Size_j denotes market capitalization (in millions of Taiwan dollars), and BM_j denotes book-to-market value of equity. All variables are estimated from the four-year sample period, 1990–1993. Log transformations are applied to the Size measure. θ_I are the estimated coefficients. ε_j represents the error term. θ_I estimates are multiplied by 100. Standard errors are reported in parentheses. χ^2 (d.f. = 5) is calculated by multiplying the number of observations with the minimized value of the GMM criterion function. The p-values of the χ^2 statistics are reported in brackets. R^2 denotes the adjusted r^2. We report full sample results, and the results of the samples differentiated by upper-limit-hits and lower-limit-hit results, respectively.

	Full sample	Upper limit-hit sample	Lower limit-hit sample
ψ_j (Intercept)	−0.700[a]	−0.773[a]	−0.733[a]
	(0.027)	(0.017)	(0.024)
θ_1 (Beta)	10.315[a]	6.163[a]	8.233[a]
	(1.204)	(0.731)	(1.071)
θ_2 (RR)	6.389	7.275[a]	1.202
	(4.014)	(2.624)	(2.793)
θ_3 (TV)	5.453[b]	4.089[a]	1.907
	(2.410)	(1.234)	(2.341)
θ_4 (Size)	−0.808[a]	−0.296[b]	−0.818[a]
	(0.205)	(0.131)	(0.178)
θ_5 (BM)	−1.303	−1.115	−0.311
	(1.261)	(0.794)	(1.093)
χ^2	4.139	10.167	2.331
	(0.531)	(0.075)	(0.798)
R^2	0.547	0.573	0.481

Table 3 (*continued*)
(b) GMM results: Stock Exchange of Thailand

This table presents the generalized method of moments (GMM) estimates for the following model:

$$\log[\%\mathrm{Hit}_j]/1 - \log[\%\mathrm{Hit}_j] = \psi + \theta_1\ \mathrm{Beta}_j + \theta_2\ \mathrm{RR}_j + \theta_3\ \mathrm{TV}_j + \theta_4\ \mathrm{Size}_j + \theta_5\ \mathrm{BM}_j + \varepsilon_j,$$

where $\%\mathrm{Hit}_j$ denotes the frequency for which each stock j hits price limits, ψ_j represents the intercept term, Beta_j represents a measure of stock volatility which is associated with market movements (calculated from the standard market model using monthly stock returns without dividends re-invested and the equally-weighted market returns without dividends re-invested), RR_j denotes residual risk (residual standard deviation of the market model from which beta is calculated), TV_j denotes trading volume (daily trading volume divided by total shares outstanding), Size_j denotes market capitalization (in millions of baht), and BM_j denotes book-to-market value of equity. All variables are estimated from the four-year sample period, 1990–1993. Log transformations are applied to the Size measure. θ_I are the estimated coefficients. ε_j represents the error term. θ_I estimates are multiplied by 100. Standard errors are reported in parentheses. χ^2 (d.f. = 5) is calculated by multiplying the number of observations with the minimized value of the GMM criterion function. The p-values of the χ^2 statistics are reported in brackets. R^2 denotes the adjusted r^2. We report full sample results, and the results of the samples differentiated by upper-limit-hits and lower-limit-hit results, respectively.

	Full sample	Upper limit-hit sample	Lower limit-hit sample
ψ_j (Intercept)	−0.729[a]	−0.755[a]	−0.789[a]
	(0.009)	(0.008)	(0.009)
θ_1 (Beta)	3.137[a]	2.304[a]	2.024[a]
	(0.453)	(0.351)	(0.410)
θ_2 (RR)	25.372[a]	20.533[a]	12.392[a]
	(4.310)	(2.829)	(3.765)
θ_3 (TV)	1.735	0.429	2.830[c]
	(1.768)	(1.276)	(1.559)
θ_4 (Size)	−0.915[a]	−0.746[a]	−0.500[a]
	(0.104)	(0.073)	(0.098)
θ_5 (BM)	0.462	0.502	−0.140
	(0.554)	(0.474)	(0.423)
χ^2	7.648	8.980	6.834
	(0.191)	(0.115)	(0.238)
R^2	0.613	0.651	0.446

[a]Statistically significant at 0.01 level.
[b]Statistically significant at 0.05 level.
[c]Statistically significant at 0.10 level.

variables. For the Taiwan sample, our regression results suggest that the "average" stock will hit price limits 13.66% of the time.[9] However, if beta, residual risk, and trading activity are each only 10% larger than average, and if firm size is 10% smaller than average, then a stock with this particular profile may be expected to hit price limits 15.22% of the time (or, to put it another way, a stock with this profile will hit a price limit 11–12% more often than the "average" stock). When we examine the effect of each explanatory variable one at a time, holding constant the other variables, we find that beta accounts for 80% of this increase.

For Thailand, the regression results suggest that the "average" stock will hit price limits 6.16% of the time.[10] When beta, residual risk, and trading activity are each 10% larger than average, and when firm size is 10% smaller than average, then a stock with this particular profile will hit a price limit 11–12% more often than the "average" stock, just as we found for Taiwan. However, for Thailand, we find that both beta and residual risk, individually, account for about 40% of this change.

Overall, our regression results suggest that stock risk, as measured by beta (and residual risk for Thailand) plays a major role in explaining the propensity to hit price limits. While the regression results indicate that firm size and trading activity also explains the propensity to hit price limits, as revealed by statistical significance, we find that it is only at large differences in size and trading volume where their effect is economically significant.

4. Conclusion

In this paper, we identify stocks that hit their price limits frequently to see if certain types of stocks are more inclined to hit their price limits than other types of stocks. We know of no other research that attempts to do this. In addition, another attractive feature of our price limit study is that we do not rely on an event-study style methodology as has been done in prior research. To conduct our investigation, we use data of stocks listed on the Taiwan Stock Exchange and the Stock Exchange of Thailand because price limits are a regular part of their stock trading mechanisms.

[9] Here, we are simply taking the average beta of our Taiwan sample, 0.998, the average residual standard deviation, 0.109, the average trading activity, 0.152, the average firm size (market capitalization), 16,750 million, and the average book-to-market ratio of equity, 0.409, and we use our regression's parameter estimates to obtain a fitted dependent value, $\hat{Y}$, which is then used to obtain a percent (%Hit) by calculating e^x, where $x = [1/(\hat{Y}^{-1} + 1)]$.

[10] For Thailand, the average value for beta, residual risk, trading activity, firm size, and book-to-market value of equity is 1.032, 0.134, 0.108, $4637 million, and 0.439, respectively.

Our empirical investigation reveals that higher volatility stocks hit price limits more frequently than lower volatility stocks. While this finding may be viewed as un-surprising, we feel that it should *not* be viewed as harmless. Stock volatility is a fundamental risk in which stock prices are determined in an efficient market. Second, we find that smaller market capitalization stocks hit price limits more frequently than larger stocks. Recent research has confirmed that size is one of the most important factors in valuing securities (Fama and French, 1992). Chan and Chen (1991) also contend that while the additional risk factor inherent in small stocks is not captured by beta, it is still priced. Third, we find that high trading volume stocks hit price limits more frequently than lower trading volume stocks. This finding may also be viewed as un-surprising because we would expect that stocks with frequent, and more significant, information flows would experience frequent, and more significant, price changes. However, and similar to our prior contention, we do not think this finding is harmless. In our opinion, price limits should not restrict rational price movements associated with 'real' information flows, otherwise, observed prices may not always indicate 'true' prices.

Overall, we feel that price limits are imposing constraints such that it interferes with security valuation. Prior research has shown that price continuations occur after limits are hit. Thus, the earlier research suggests that price limits do not mitigate transitory volatility as intended, but only serves to delay *rational* price movements. Our study can be viewed as providing complementary evidence. By documenting some regularities with which price-limit-hit events occur, we offer new considerations to the current debates and discussions surrounding price limit mechanisms.

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