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Ex-post effects of circuit breakers in crisis and calm markets

Long horizon evidence from wide-band Malaysian price limits

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Abstract

Purpose – Despite regulatory claims of straitening volatility and preventing crashes, evidences on circuit breakers' ability to achieve so are nonconclusive. While previous scholars studies general performances of circuit breakers, the authors examine whether Malaysian price limits aggravate volatility, impede price discovery, and interfere with trading activities in both tranquil and stressful periods.

Design/methodology/approach – The study uses a combination of parametric and nonparametric techniques consistent with Kim and Rhee (1997) to examine the major ex-post hypotheses in circuit breaker research.

Findings – For calm markets, the authors find significant success of upper limits in tempering volatility with low trading interference. Lower limits show mixed results. Conversely, in crisis markets limits fare poorly in nearly all aspects, particularly for lower limits.

Practical implications – Ramifications of the paper's findings are discussed through highlighting the asymmetric nature of price limits' ex-post effects. The paper also contributes to regulatory debate surrounding the quest for an optimal price limit.

Originality/value – The paper is the first of its kind in documenting long-horizon evidence of ex-post effects of a wide-band price limit. Moreover, the paper is unique in its approach in bifurcating circuit breaker performance along the line of market stability periods.

Keywords Circuit breaker, Price limits, Trading halts, Malaysia, Financial crisis

Paper type Research paper

1. Introduction

Circuit breaker is an umbrella term used in finance literature to denote an array of constrictive and/or cessative levers employed by regulators to confine intraday price movements within a preset or discretionary channel. Circuit breakers are broadly of two types: trading halts (suspension of trade) and price limits. This praxis in financial markets has skirted controversy since inception and subsequent adoption since late 1980s. After inchoate postulations of theoretical benefits of such microstructure barriers by the Brady Commission Report (1988) and several academics, concerns about innate conceptual flaws and unintended detriments of the practice surfaced in the wake of budding empirical findings in mid-1990s. Since then, theoretical development in the discipline has stagnated. Instead, academia's focus

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shifted primarily to empirical testing of emergent hypotheses in various geographical regions and sampling periods. The findings, often conflicting or ambiguous, were criticized for design flaws and lack of statistical power. Thus, though the theoretical ennui wasn't reversed by producing an overarching framework of circuit breakers' effects, a quasi-consensus emerged around hypothesized disadvantages of circuit breakers. These include possibilities of circuit breakers encouraging splashing of volatility into future trading days by stifling trade on the trigger day, causing delay in discovery of equilibrium price, interference in traders' strategized trading plans, and inducing an ex-ante gravitational pull toward the trigger. The four hypotheses are now formally known—respectively—as volatility spillover, delayed price discovery, trading interference, and magnet effect. Empirical tests of the ex-post hypotheses trio spur more debate than settle. That prices continue in the same direction as the limit has been documented via positive return autocorrelation in multiple studies done on Seoul, Tokyo, Warsaw, and Istanbul (Bildik and Gulay, 2006; Henke and Voronkova, 2005; Shen and Wang, 1998). Reversals too have been observed in Taiwan, Shanghai, and Shenzhen (Chen *et al.*, 2005; Chou *et al.*, 2006). Volatility spillover has been recorded in Taiwan and Tokyo (Kim and Sweeney, 2002; Wong *et al.*, 2008), while opposite findings were reported in Shanghai and Seoul (Berkman and Lee, 2002; Kim *et al.*, 2013a, b). For futures markets, Chou *et al.* (2005) show that whether price limits are effective depends largely on risk appetite of investors. In Malaysia, price limits have been shown to aggravate order imbalance, worsen information asymmetry, and contribute to delayed arrival of informed traders to the limit order queue (Chan *et al.*, 2005). As for the ex-ante (magnet) effect, the lure of accelerated trading activities near the trigger point beyond a certain threshold has been demonstrated for stocks in Taiwan (Cho *et al.*, 2003), Istanbul (Bildik and Gulay, 2006), China (Wong *et al.*, 2009), and Japan (Nobanee and Al Hajjar, 2017). The opposite is recorded in Taiwan (Huang *et al.*, 2001), Spain (Abad and Pascual, 2007), and China (Kim *et al.*, 2013a, b). As for futures, mostly repellant effect (opposite of magnet effect) has been observed in US Treasury Bond Futures (Arak and Cook, 1997), Nikkei 225 Futures (Martens and Steenbeek, 2001), and Orange Juice Futures on NYBOT (Hall and Kofman, 2001).

A distinguishing feature of ex-post vs ex-ante effect studies is that due to the inherently intraday nature of the magnet effect, end-of-day closing price data sets are ineffective in capturing the existence of a gravitational pull of the trigger point in hastening order flow (Sifat and Mohamad, 2018). Yet, many early researchers, presumably due to dearth of granular data, improvised with daily data sets by using overnight returns or jumps as a predictor of magnet effect the following day. These attempts, though necessary at the time, remain methodologically suboptimal. As for the ex-post hypotheses, daily data sets are adequate and traditionally used to compare volatility, price reversal, and trading activity performances on and after the trigger-hit day. In this approach, the trigger-hit group is pitted against a control group (pseudo-hit or quasi-hit) to determine whether volatility worsens, price discovery is delayed, and traders' activities are hindered (Sifat and Mohamad, 2018).

The locus of current circuit breaker research focuses on amassing empirical evidences for or against circuit breaker efficacy in various markets. Considering the gamut of studies conducted so far, one market stands out as a puzzle in the empiric corpus: Malaysia, a life-long exponent of an unusually wide ±30 percent price limit. The most widely cited major study conducted on price limits in Malaysia focuses on order imbalance, informational arrival, and asymmetry (Chan *et al.*, 2005). While these issues are important to market microstructure literature, the authors—surprisingly—avoided all the major ex-post and ex-ante circuit breaker hypotheses. What's more, the study's sample size consists of two years: 1995–1996, a period when the-then Kuala Lumpur Stock Exchange (KLSE) was a diminutive floor-trade bourse of scant global relevance. Besides, since 1996, the bourse fine-tuned its limit metrics a few times, underwent demutualization, instituted market makers, introduced short selling, and moved to an automated trading platform. Malaysia, too, graduated from "frontier" status and now—apart from being a regional finance hub—commands global attention owing to high capital inflow. Also, since 1996, Malaysia endured two major crises: Asian Financial Crisis (AFC: 1997) and Global Financial Crisis (GFC: 2008). Therefore, aside from the all-purpose questions of Malaysian limits' efficacy, crisis-centered investigation of whether price limits aided in achieving regulatory objectives of curbing volatility, enhancing price discovery, and promoting trading activities makes Bursa Malaysia an exciting laboratory for testing the ex-post hypotheses. To bridge this gap, this paper utilizes a proprietary daily data set from 1994 to 2017 and examines whether the most prominent objections to circuit breakers hold across crisis and calm periods.

The rationale for choosing Malaysia as the venue for this research is manifold. First, Bursa Malaysia uses a very wide band of price limit, set at 30 percent. This is considerably wider than most other venues and therefore more interesting. Besides, a large swathe of empirical testing on price limits' efficacy is conducted on predominantly narrower price limit bands, which some consider overly restrictive. Thus, the question of whether price limits are good or bad can be further narrowed down to whether narrow/wide limits are bad/worse. Lastly, examining a wide band limit contributes to the ongoing debate on the optimum range of a price limit. Though it may be intuitive that wide price limits may be innocuous, prior widening experimentation by Thailand and Korea in the late 1990s yielded ambiguous results (Sifat and Mohamad, 2018). Consequently, understanding the repercussions of a wide band limit remains a significant policy issue and warrants a deeper scrutiny due to its regulatory and policy-related import.

This paper is organized as follows. First, we discuss our data properties and outline subperiod designation. Next, we adumbrate the hypotheses and techniques to test them, followed by presentation of results. Lastly, the findings are recapitulated, and suggestions are advanced for future research in the area.

2. Data and subperiod assignment

Daily data is retrieved from the bourse's proprietary package that includes all opening, close, high, low, volume, shares outstanding, and open interest information for all instruments from 1994. The 23-year sampling period (Jan 1994 to Jan 2017) involved two major crises: AFC and GFC. For precise regime dates, exponentially weighted moving average cross-over technique was employed on daily composite index (FBMKLCI) values to detect change points in 1997–1998 and 2007–2008.

$$EWMA = \sigma^2 = \lambda^2_{t-1} + (1-\lambda)r^2_{t-1,t} \quad (1)$$

λ here is a memory parameter with a value between 0 and 1. A high λ implies longer memory, meaning higher look-back days are needed to incorporate new changes. Experimenting with different λ values, the crisis periods were consolidated as February 24, 1997 to September 1, 1998 and January 11, 2008 to August 16, 2008. The resultant subperiods and sample summary stats are presented in Tables I and II.

3. Methodology

3.1 Hypotheses

We test three ex-post hypotheses identified by Sifat and Mohamad (2018) as the main objections to price limits' efficacy: volatility spillover, price discovery delay, and trading interference (Table III). This paper adopts the methodology pioneered by Kim and Rhee (1997) to test volatility spillover, delayed price discovery, and trading interference. For the first hypothesis, Kim and Rhee (1997) supposed that the volatility of a stock on day t is $V_t = (r_t)^2 \text{ x } 10^3$, where r_t denotes the return on day t. Thus, they select the day when the limit is triggered as day 0 ($t = 0$) and construct an event window 10 days before and after it. This

Start date	End date	Trading days	Subperiod	ΔFBMKLCI	Remarks
1/3/1994	2/21/1997	772	Tranquil period 1	2.037%	±30% price limit in action since Dec 1989
2/24/1997	9/1/1998	377	Asian Financial Crisis	−157.174%	Capital control enacted by Govt., defying IMF bail-out. Short selling banned
9/2/1998	1/10/2008	2,301	Tranquil Period 2	175.296%	Migration to automated trading platform (SCORE) Introduction of market makers and market-wide circuit breaker
1/11/2008	10/29/2008	199	Global Financial Crisis	−59.631%	Relatively insulated from direct effects of global financial exposure. Yet, market lost half its value Bear period not as protracted as global markets
10/30/2008	11/30/2011	762	Tranquil Period 3 (a)	54.502%	Short selling returns, albeit with stringent caveats
12/1/2011	1/31/2017	1,271	Tranquil Period 3 (b)	13.651%	Advent of BTS2 Trading platform With it dynamic "intraday" price limit of ±8% is introduced in addition to prevailing ±30% static limit

Note(s): This table shows the demarcated subperiods examined in this paper, identified through EWMA crossover technique commonly used by technical analysts. Moreover, the number of trading days in each subperiod, performance of the benchmark index in that period, and relevant comments are provided. Total trading days amount to 5,682 days

Table I.
Subperiods under study

Subperiod	S_c	S_c %	S_{pc}	S_{pc} %	S_f	S_f %	S_{pf}	S_{pf} %
1st Tranquil Period	30	2.404	53	2.131	307	7.210	534	7.203
Asian Crisis	37	2.965	55	2.211	712	16.721	1,189	16.037
2nd Tranquil Period	207	16.587	411	16.526	267	6.271	566	7.634
Global Crisis	412	33.013	753	30.277	893	20.972	1,589	21.432
3rd Tranquil Period (Old limit)	802	64.263	1,214	48.814	1,513	35.533	2,602	35.096
3rd Tranquil Period (New limit)	61	4.888	81	3.257	566	13.293	934	12.598
Total	1,549	100%	2,567	100%	4,258	100%	7,414	100%

Note(s): This table shows the number of limit-hit and pseudo-hit days identified according to regimes. The subgroups S_c, S_{pc}, S_f, and S_{pf} refer to *ceiling, pseudo-ceiling, floor, and pseudo-floor* stocks

Table II.
Summary statistics of subsamples

H_{vsh}	Price limits spread volatility over a long period instead of a single day Hence, limits do not reduce volatility
H_{dpd}	Assets hitting upper (lower) limits exhibit positive (negative) overnight returns
H_{tih}	A limit-hit asset exhibits greater trading activity in the day(s) after the limit-hit Other (nonhit) stocks exhibit lower trading activity; i.e. they are more stable

Note(s): This table shows the hypotheses corresponding to issues addressed by this study: volatility spillover, delayed price discovery, and trading interference

Table III.
List of hypotheses

paper deviates slightly from Kim and Rhee's approach by employing nonparametric Mann–Whitney U test to determine if the different subsamples are equally volatile. Moreover, if a particular asset triggers the limit on consecutive days, it is removed from the observation as the latter limit hits constitute as discrete events. The price discovery delay hypothesis is based on multiple return series constructed for all limit-hit securities, which are then used to determine whether prices experience more continuations or reversal on triggered days, as this would be indicative of price limits impeding the process of discovery of fair prices (Miao *et al.*, 2017). Lastly, for the trading interference hypothesis, the theoreticians hold that if circuit breakers indeed suppressed liquidity, trading volume would diminish drastically on the triggered days and increase substantially thereafter (Sifat and Mohamad, 2018). As trading activities wax on the subsequent trading days, rational trading is cut short on the day limit is hit. This phenomenon is traditionally captured via a turnover ratio of trading activity, which measures a proportional change of volume from preceding days (Lu, 2016; Wan *et al.*, 2018)

We use S_c and S_f to denote groups of instruments that hit an upper (ceiling) and lower (floor) limit. Adopting Christie *et al.*'s (2002) approach of a control period of continuous trading for firms with similar net market returns, we use S_{pc} (pseudo-ceiling) and S_{pf} (pseudo-floor) to represent stocks that experience a price change of at least ±25 percent but did not hit the limit. Some studies have used 80 percent and 90 percent of limits as threshold for pseudo-groups (Chang and Hsieh, 2008). However, those markets typically use very tight price bands (5–12.5 percent). Considering Bursa Malaysia's wide magnitude of ±30 percent, we choose to use ±25 percent as control (pseudo) group threshold.

3.2 Volatility spillover

To test spillover, the genus of volatility matters, that is, whether fundamental or transitory. The former occurs due to investors' uncertainty on valuation of the firm, and the latter is caused by uninformed trading. For regulators, curbing transitory volatility is desirable. Traditional approaches in measuring volatility include close-to-close returns (Chen *et al.*, 2005; Fama, 1989), high-to-low returns (Grossman, 1988), and open-high-low-close (OHLC) (Knight and Satchell, 2007). Grossman (1988) points out that close-to-close approach is suitable as a proxy for asset/market direction but not to gauge turbulence. Besides, many have argued that OHLC better captures transitory volatility (Fiess and MacDonald, 2002). Moreover, OHLC approach is eight times more efficient as close-to-close (Bennett and Gil, 2012; Meilijson, 2011). Since we study financial crisis periods with known propensity for overnight jumps, we adopt Yang and Zhang (2000) extension of Garman–Klass model (Eq. (2)), which is argued to perform superior to other approaches due to ability to capture overnight jumps—a pertinent and attractive feature considering universally high jump nature of limit-hit sampling.

$$\sigma_{gkyz} = \sqrt{\frac{F}{n}}\sqrt{\sum_{i=1}^{n}\left(ln\left(\frac{o_i}{c_{i-1}}\right)\right)^2 + \frac{1}{2}\left(ln\left(\frac{h_i}{l_i}\right)\right)^2 - (2\ln(2)-1)\left(ln\left(\frac{c_i}{o_i}\right)\right)^2} \quad (2)$$

Here, N = each period's time interval (set to 1 without loss of generality), F = fraction of closed trading period (between 0 and 1), c_i, h_i, o_i, l_i = closing, high, opening, and lowest price at period i. Next, due to variability of volatility across time, we create a standardized measure to facilitate inter-subperiod comparison. Designating the limit-hit day as day t, we construct a 12-day window and thereupon build a standardized volatility index (SVI) based on $\sigma_{gkyz,t-1}$; that is, volatility on the day before limit was hit (or ±25 percent move for S_{pc} and S_{pf}). Since $\sigma_{gkyz,t-1}$ serves as the baseline for SVI_{t-1}, it is assigned a value of 1.

$$SVI_{t+n} = \text{In}\left(\frac{\sigma_{gkyz,t+n}}{\sigma_{gkyz,t-1}}\right) \quad (3)$$

$SVI_{t+n} > 1$ indicates higher volatility compared to the limit/pseudo-limit day's trade. SVI_t always has a very high value, since the limit/pseudo-limit day is invariably a highly volatile day. $SVI_{t+n} \leq 1$ denotes decrease in volatility. Employing Mann–Whitney *U* test to measure statistical significance and to bypass distribution-specific limitations of parametric tests, SVI_{t+n} values for S_c *and* S_f are compared to S_{pc} and S_{pf} groups for corresponding periods. Higher values would indicate higher volatility in post-hit periods compared to control group and thereby affirm the volatility spillover hypothesis. The converse indicates a desirable effect of price limits.

3.3 Delayed price discovery

To detect price continuation and/or reversal after a hit or pseudo-hit, overnight and intraday returns are calculated.

$$r_{in,t} = \frac{lnc_t}{o_t} \quad (4)$$

$$r_{on,t} = \frac{lno_t}{c_{t-1}} \quad (5)$$

We examine the $r_{in,t}$ and $r_{on,t}$ for two successive days following the hit/pseudo-hit day to establish a continuity/reversal pattern. Designating + for price increase, − for price decrease, and 0 for no change, Tooma (2005) constructs a matrix, whereby continuity of limit/pseudo-limit direction is classifiable as follows (Table IV):

We consider a continuity pattern confirmed when both intraday and overnight classifications agree. Furthermore, to avoid data contamination by breaching maximum price variation rules (George and Hwang, 2004), historical highest and lowest values are discarded. This method of testing price continuation is consistent with delayed informed trading hypothesis of Roll (1989), which suggests price reversal to be consistent with Ma *et al.*'s (1989) overreaction hypothesis. Thus, we can conclude that price limits postpone discovery of equilibrium price when unusually large proportion of price continuity is observed for S_c *and* S_f compared to S_{pc} and S_{pf}. Moreover, we posit that disconfirming continuity alone should not constitute evidence of price limits' efficacy. Consistent with DeBondt and Thaler's (1985) hypothesis that extreme price movements in one direction should be followed by strong reversal, we argue that an effective price limit mechanism

Movement	Returns series	Diagnosis
Upward	[+, +] [0, +]	Continuity
	[+, −] [0, −] [−, +] [−, 0] [−,−]	Reversal
	[+, 0] [0, 0]	Unchanged
Downward	[−,−] [0, −]	Continuity
	[−, +] [0, +] [+,−] [+, 0] [+, +]	Reversal
	[−, 0] [0, 0]	Unchanged

Note(s): This table shows price patterns related to delayed price discovery hypothesis based on direction of the returns series (Tooma, 2005)

Table IV.
Price discovery matrix

should yield price reversal. As such, we introduce and focus on price reversal ratio (PRR) as the primary performance metric (Eq. (5)–(6)). It is the ratio of number of stocks exhibiting reversal patterns within the subgroup (*ceiling, pseudo-ceiling, floor, pseudo-floor*).

$$\mathrm{PRR}_{up} = \frac{\sum S_{[+,-][0,-][-,+][-,0][-,-]}}{\sum S_{(c,pc)}} \tag{6}$$

$$\mathrm{PRR}_{down} = \frac{\sum S_{[-,+][0,+][+,-][+,0][+,+]}}{\sum S_{(f,pf)}} \tag{7}$$

3.4 Trading interference

We examine interference in trading activities following a large price move via two proxies: (1) market-adjusted turnover ratio (MAT) and (2) on-balance volume (OBV). With the limit-hit day being *t,* we compute a logarithmic percentage change in trade activities.

$$\mathrm{MAT}_t = \frac{\text{Value of Stock Traded on day } t}{\text{Market Capitalization on day } t} \tag{8}$$

$$\Delta TA_{MAT} = \ln\left(\frac{MAT_{c,pc,f,pf \to t}}{MAT_{c,pc,f,pf \to t-1}}\right)*100 \tag{9}$$

$$TA_{OBV} = \ln\left(\frac{OBV_{c,pc,f,pf \to t}}{OBV_{c,pc,f,pf \to t-1}}\right)*100 \tag{10}$$

$$OBV_t = OBV_{t-1} + \begin{cases} V_t; if\ c_t > c_{t-1} \\ 0; if\ c_t = c_{t-1} \\ -V_t\ if\ c_t < c_{t-1} \end{cases} \tag{11}$$

Using the day *t-1* as the baseline for OBV, ΔTA_{MAT} and ΔTA_{OBV} are calculated for until five days after the limit (pseudo-limit) was hit. Higher ΔTA_{MAT} and ΔTA_{OBV} values tested to be statistically significant under Mann–Whitney *U* test for S_c *and* S_f compared to S_{pc} and S_{pf} subgroups for corresponding periods would indicate higher trading activities in post-hit periods compared to control group and thereby affirm the volatility spillover hypothesis. The converse indicates a desirable effect of price limits.

4. Empirical findings

4.1 Volatility spillover

For instruments incurring a significant price increase, as Tables IV and V demonstrate, standardized volatility (*SVI*) values gradually retreat to ~1 for S_c and S_{pc} groups from $t+1$ to $t + 10$. Moreover, S_c group outperforms the S_{pc} for most time windows. This suggests regression to normalcy (pre-limit volatility) for upward moving stocks. In other words, long-run transitory volatility is tempered. Also, the phenomenon is most noticeable in the vicinity of day *t*: that is, $t + 1$ to $t + 4$, suggesting an immediate subsidence in volatility. The results hold true across tranquil and turbulent periods, although GFC results are less powerful. On

Table V.
Volatility spillover across tranquil periods

Panel A: Upward movements	Tranquil period 1			Tranquil period 2			Tranquil period 3 (old limit)			Tranquil period 3 (new limit)		
Window	SVI_c		SVI_{pc}	SVI_c		SVI_{pc}	SVI_c		SVI_{pc}	SVI_c		SVI_{pc}
t−*1*	1.000	=	1.000	1.000	=	1.000	1.000	=	1.000	1.000	=	1.000
t	2.381	<<	2.457	1.975	<<<	2.077	3.113	>>>	2.989	1.411	<<	1.783
t+1	1.818	<	2.313	1.715	<<	2.313	2.629	<<	2.681	1.699	<<	2.383
t+2	1.521	<	1.779	1.399	<<	1.832	1.441	<<<	1.594	1.475	<<	1.708
t+3	1.293	<	1.822	1.448	<	1.713	1.607	>>>	1.285	1.318	<	1.895
t+4	1.312	<	1.601	1.312		1.553	1.391	<<	1.444	1.338		1.521
t+5	1.245		2.042	1.295	<<	1.899	1.282	<<	1.633	1.270		2.103
t+6	0.951 *	<	1.645	1.212	>>	1.119	1.057	>>	0.973 **	1.008		1.744
t+7	1.108		1.917	1.053		1.058	1.095	>	0.889 *	1.141		1.859
t+8	0.966 *	<	1.208	0.979 **	>>	0.973 **	1.198	>>	0.904	0.927 *		1.159
t+9	1.181	>	1.143	0.991 *	<	1.280	1.021	<	1.063	1.228	>	1.086
t+10	1.123		1.786	0.957 *	<	1.076	0.890 **	<<	1.002	1.123	<	1.175
Observations	30		53	207		411	802		1,214	61		81
Panel B: Downward movements												
Window	SVI_f		SVI_{pf}	SVI_f		SVI_{pf}	SVI_f		SVI_{pf}	SVI_f		SVI_{pf}
t−1	1.000	=	1.000	1.000	=	1.000	1.000	=	1.000	1.000	=	1.000
t	2.354	>>	2.236	2.401	<<	3.393	2.305	<<<	2.584	1.869	>>	1.688
t+1	1.858	>>	1.691	2.137	<	1.437	1.944	>>>	1.236	1.432	>>	1.310
t+2	1.647	<	1.729	1.614	<<	1.902	1.401	<	1.472	1.481	>	1.363
t+3	1.057	>>	0.835	1.194	<	0.877	1.374	>	0.994 *	1.374	>	0.941 *
t+4	1.221		1.233	1.111	<<	1.418	1.089	<<	1.224	1.226		1.268
t+5	1.186	<	1.257	1.056	<	1.395	1.024		1.201	1.181	<	1.188
t+6	1.083		0.877	1.245	>>	0.815 *	1.032	>>	0.913 **	1.047		0.950
t+7	0.969 *	>	0.843 *	0.959 *	>	0.927 *	0.947 **	>>	0.806 **	1.015		0.863
t+8	0.871 *	<	0.887 *	0.818 *		0.993 *	0.769 *	<	0.884 *	0.946 *	>	0.937 *
t+9	0.986 *	>	0.944 *	0.916 *	<	0.963 *	0.981 *	>	0.933 *	1.020	>	0.859 *
t+1	0.949 *	>	0.891 *	0.873 *	<	0.982 *	0.960 *	>	0.931 *	0.912 *	>	0.828 *
Observations	307		534	267		566	1,513		2,602	566		934

Note(s): This table presents daily volatility neighboring limit-hit and pseudo-limit-hit days; day *t*. The standardized volatility index (*SVI*) refers to the ratio of day's volatility compared to the day before limit or pseudo-limit hit; i.e. day *t*−1. Volatility is computed as per Yang–Zhang extension of Garman–Klass estimator (Eq. (2)). Panels A and B report volatility for up (*S*c = ceiling, S_{pc} = pseudo-ceiling) and down (SVI_f = floor, SVI_{pf} = pseudo-floor) moves, respectively. < and > denote significant less than and greater than relationships between left-hand and right-hand values. * mark is used to *SVI* values significantly lower than 1, implying subsided volatility compared to day *t*−1. * * *, <<< and >>> are significant at 1%; * *, << and >> are significant at 5%; *, <, and > are significant at 10% as per Mann–Whitney *U* test the contrary, downward moving stocks exhibit mixed results, with only one tranquil subperiod registering curtailed volatility. In tranquil markets, SVI_f and SVI_{pf} exhibit across-the-board superior volatility recession with greater statistical significance compared to upward moving stocks—evidenced by many values between 0.818 and 1. Pseudo-hit groups, in general, outperform the hit groups. Additionally, unlike SVI_c and SVI_{pc}, higher proportions of volatility recessions are observable around $t + 7$ to $t + 10$, indicating a deferred volatility reduction. In the crisis market subperiods, limit-hit groups' performance deteriorates, with SVI values exceeding 1 for bulk of the trading days. Overall, upper price limits succeed in restricting volatility in both tranquil and turbulent markets, while lower price limits fare poorly—especially in crisis periods (see Table VI).

4.2 Delayed price discovery

To avoid arbitrary comparison of reversal performance across subgroups and subperiods, we propose the following grading criteria (Table VII) and present our findings (Table VIII).

	Asian financial crisis			Global financial crisis		
Panel A: Upward movements						
Window	SVI_c		SVI_{pc}	SVI_c		SVI_{pc}
$t-1$	1.000	=	1.000	1.000	=	1.000
t	2.774	>>	2.161	2.441	<<<	3.282
$t+1$	2.387	<	2.901	1.829	<<	1.938
$t+2$	1.249	<	1.742	1.700	<<	2.011
$t+3$	1.605	<	1.695	1.596		1.076
$t+4$	1.251		1.805	1.028		1.108
$t+5$	0.992		2.827	1.190	<	1.366
$t+6$	1.267	<	1.690	1.513	<<	1.760
$t+7$	0.999		1.173	0.989		0.923
$t+8$	0.973 *	<	1.266	0.987 *	<	0.105
$t+9$	1.138	<	1.163	1.092	<	1.164
$t+10$	1.240	<	1.344	1.041		1.131
Observations	37		55	412		753
Panel B: Downward movements						
Window	SVI_f		SVI_{pf}	SVI_f		SVI_{pf}
$t-1$	1.000	=	1.000	1.000	=	1.000
t	2.189	>>>	2.014	1.881	>>>	1.557
$t+1$	1.947	>>>	1.857	1.518	<<<	1.238
$t+2$	1.971	>>>	1.837	1.421	>>	1.379
$t+3$	1.259	<	1.757	1.193	<<	1.221
$t+4$	1.104	<	1.146	1.512	>>	1.058
$t+5$	1.245	>>	1.213	1.245	<	1.342
$t+6$	1.116		1.245	0.992	<	1.454
$t+7$	1.108	<	1.317	1.108	<	1.127
$t+8$	1.166	<	1.208	1.066	>>	0.993
$t+9$	1.181	>	1.143	1.081	>	1.015
$t+10$	1.197	>	1.186	1.203	>	1.186
Observations	712		1,189	893		1,589

Note(s): This table presents daily volatility neighboring limit-hit and pseudo-limit-hit days; day t. The standardized volatility index (SVI) refers to the ratio of day's volatility compared to the day before limit or pseudo-limit hit; i.e. day $t-1$. Volatility is computed as per Yang–Zhang extension of Garman–Klass estimator (Eq. (2)). Panels A and B report volatility for up (Sc = ceiling, S_{pc} = pseudo-ceiling) and down (SVI_f = floor, SVI_{pf} = pseudo-floor) moves, respectively. < and > denote significant less than and greater than relationships between left-hand and right-hand values. * mark is used to SVI values significantly lower than 1, implying subsided volatility compared to day $t-1$. * * *, <<< and >>> are significant at 1%; * *, << and >> are significant at 5%; *, <, and > are significant at 10% as per Mann–Whitney U test

Table VI. Volatility spillover across crisis periods

As seen in Table VII, no subgroup for any of the subperiods exhibited sufficient magnitude of price reversal to attain a single ✓. In tranquil times, third subperiods under new and old limit regimes exhibit moderate reversal or outperform the pseudo-group for upward price movement category. On the other hand, first two tranquil subperiods show moderate reversal values.

In crisis market situations, price continuation was substantially high during AFC, while moderate reversal was observed in the GFC (Table IX). The PRR values were noticeably lower compared to price continuation value, with the highest PRR of 0.319 being during second tranquil period. Overall, the results indicate poor performance of price limits in generating price reversals and suggest decidedly strong all-around price continuity.

Table VII.
Delayed price discovery grading scheme

Criterion	$PRR_{c/f} > PRR_{pc/pf}$	Grade	Remarks
PRR ≤ 0.25	Yes	Mixed	Discovery delayed but outperforms control group
PRR ≤ 0.25	No	X	Discovery delayed
0.25 < PRR ≤ 0.50	Yes	✓	Moderate reversal
0.25 < PRR ≤ 0.50	No	Mixed	Moderate reversal but outperformed by control group
0.50 < PRR	Yes	✓✓✓	Superior reversal
0.50 < PRR	No	✓✓	Superior reversal but outperformed by control group

Note(s): This table shows the grading scheme based on price reversal ratio and difference between limit-hit and pseudo-limit groups' metrics to confirm a delay in reaching equilibrium price across tranquil and turbulent markets

Table VIII.
Price discovery metrics in tranquil markets

		Tranquil periods							
		Subperiod 1		Subperiod 2		Subperiod 3(a)		Subperiod 3(b)	
	Pattern	Hit	Pseudo-hit	Hit	Pseudo-hit	Hit	Pseudo-hit	Hit	Pseudo-hit
Limit up	[+, +]	0.587	0.498	0.508	0.390	0.479	0.456	0.413	0.453
	[+, 0]	0.129	0.184	0.161	0.201	0.160	0.129	0.145	0.176
	Continuity	0.716	0.682	0.669	0.591	0.639	0.585	0.558	0.629
	[+, −]	0.051	0.055	0.058	0.065	0.077	0.053	0.069	0.044
	[0, −]	0.045	0.064	0.056	0.063	0.090	0.069	0.054	0.059
	[−, +]	0.020	0.055	0.062	0.044	0.052	0.053	0.082	0.048
	[−, 0]	0.023	0.035	0.031	0.023	0.036	0.029	0.030	0.024
	[−,−]	0.057	0.011	0.000	0.015	0.003	0.061	0.012	0.026
	Reversal	0.195	0.221	0.207	0.211	*0.258*	*0.266*	*0.247*	*0.202*
	[+, 0]	0.076	0.065	0.077	0.125	0.084	0.106	0.166	0.117
	[0, 0]	0.013	0.032	0.047	0.073	0.019	0.043	0.029	0.052
	Unchanged	0.089	0.097	0.124	0.198	0.103	0.149	0.195	0.169
Limit down	[−,−]	0.428	0.410	0.481	0.427	0.444	0.407	0.395	0.405
	[0, −]	0.184	0.144	0.120	0.087	0.164	0.102	0.203	0.108
	Continuity	0.612	0.554	0.601	0.514	0.608	0.509	0.598	0.513
	[−,+]	0.077	0.074	0.077	0.090	0.048	0.094	0.056	0.079
	[0, +]	0.064	0.068	0.073	0.073	0.053	0.077	0.058	0.073
	[+,−]	0.035	0.108	0.096	0.070	0.070	0.070	0.070	0.088
	[+, 0]	0.037	0.043	0.038	0.043	0.035	0.052	0.029	0.046
	[+, +]	0.053	0.015	0.035	0.056	0.013	0.056	0.029	0.018
	Reversal	*0.267*	*0.308*	*0.319*	*0.332*	0.219	0.348	0.243	0.304
	[−, 0]	0.076	0.083	0.052	0.105	0.147	0.120	0.129	0.150
	[0, 0]	0.045	0.055	0.028	0.049	0.026	0.023	0.030	0.033
	Unchanged	0.121	0.138	0.080	0.154	0.173	0.143	0.159	0.183

Note(s): This table presents the price reversal ratios as outlined in Eq. (5)–(6). Following criteria specified in Table VII, PRR ≤ 0.25 and/or inferior performance compared to pseudo-hit groups constitutes inefficacy, leading to a fail (X) grade, while a 0.25 < PRR ≤ 0.50 and/or out-performing pseudo-hit group constitutes a "Mixed" grade. No passing (✓) grade (superior price reversal) was documented
The italicized values indicate significance at 5% or better.

	Pattern	Crisis periods AFC (1997–1998) Hit	Pseudo-hit	GFC (2008) Hit	Pseudo-hit
Limit up	[+, +]	0.680	0.484	0.494	0.384
	[+, 0]	0.139	0.129	0.108	0.142
	Continuity	0.819	0.613	0.602	0.526
	[+, −]	0.026	0.074	0.056	0.095
	[0, −]	0.025	0.068	0.067	0.088
	[−, +]	0.016	0.074	0.064	0.130
	[−, 0]	0.015	0.034	0.042	0.042
	[−,−]	0.032	0.059	0.050	0.027
	Reversal	0.114	0.309	0.279	0.381
	[+, 0]	0.054	0.050	0.087	0.064
	[0, 0]	0.013	0.028	0.032	0.029
	Unchanged	0.067	0.078	0.119	0.093
Limit down	[−,−]	0.661	0.382	0.497	0.411
	[0, −]	0.145	0.172	0.102	0.090
	Continuity	0.806	0.554	0.599	0.501
	[−,+]	0.020	0.062	0.074	0.068
	[0, +]	0.024	0.068	0.061	0.068
	[+,−]	0.012	0.083	0.072	0.092
	[+, 0]	0.013	0.034	0.028	0.049
	[+, +]	0.032	0.062	0.020	0.031
	Reversal	0.102	0.308	0.256	0.308
	[−, 0]	0.061	0.094	0.088	0.122
	[0, 0]	0.031	0.044	0.057	0.069
	Unchanged	0.092	0.138	0.145	0.191

Note(s): This table presents the price reversal ratios as outlined in Eq. (5)–(6). Following criteria specified in Table VII, PRR ≤ 0.25 and/or inferior performance compared to pseudo-hit groups constitutes inefficacy, leading to a fail (*X*) grade, while a 0.25 < PRR ≤ 0.50 and/or out-performing pseudo-hit group constitutes a "Mixed" grade. No passing (✔) grade (superior price reversal) was documented

Table IX. Price discovery metrics in crisis markets

4.3 Trading interference

Using market-adjusted turnover as a proxy for trading activities, as exhibited in Tables X and XI, trading action slows down for both upper and lower limits in tranquil markets, with a minor exception of third subperiod under new limit regime.

For crisis periods, however, the opposite is observed (Tables XII–XIII). Trading activities appear to deteriorate following the limit-hit days; only the lower limit stocks during GFC show mixed results. Most subperiods in both tranquil and turbulent markets show some level of trading deceleration around $t + 2$ and $t + 3$, albeit with mixed statistical significance. The most striking exacerbation of trading activities is observed for the downward price movements during AFC, scoring positive ΔTA_{MAT} values all through $t + 1$ to $t + 5$.

5. Implications

The findings of this study are mixed but marginally favor the regulatory practice of ±30 percent limits in Malaysia. Previous empirical results from Malaysia and other emerging markets broadly indicate deteriorated ex-post market quality. Based on this paper's results alone, a case cannot be made for abandonment of price limits. Instead, fine-tuning the limit mechanism further should be on the cards. The asymmetric nature of ex-post effects of upper and lower limits suggests that asymmetric limits may be used. By far, the limits perform worse in bearish scenarios—a scenario that they are designed to perform well in. Like most emerging markets that are "mostly long" or "long only," Bursa Malaysia regulators are less

Table X. Trading interference in calm market via market-adjusted turnover

Panel A: ΔTA_{MAT} for upward movements

Window	Tranquil period 1			Tranquil period 2			Tranquil period 3 (old limit)			Tranquil period 3 (new limit)		
	S_c		S_{pc}	S_c		S_{pc}	S_c		S_{pc}	S_c		S_{pc}
t	78.45		81.226	81.588	<<	88.115	71.483	>>>	66.373	59.221	<<	60.408
$t+1$	23.441	>>	−11.201	23.441	<	23.675	−27.192	<	23.675	17.335		13.207
$t+2$	−51.069		18.213	−58.729	>	−63.428	−42.015	<	−6.592	−8.874	>	−9.796
$t+3$	−22.106		−19.334	22.991	<	24.83	8.049	<<	26.301	−11.305	>>	−28.606
$t+4$	−18.364	<	−31.218	−20.935		−25.541	−23.238	<<<	9.627	9.117	>	−15.608
$t+5$	−11.539	<	−6.118	−13.154	<<	14.865	−5.654	<<	16.202	14.665	>	−12.103
N	30		53	207		411	802		1,214	61		81

Note(s): Panels A and B above show change in market-adjusted turnover during tranquil markets using *t−1* as a baseline. + and − values represent increase and decrease in trading activities, as calculated by Eq. (8)–(9). Due to the limit (pseudo-limit) day being a very active day, understandably, *t* exhibits very high positive values. Panels A and B report ΔTA_{MAT} for up and down moves, respectively. < and > denote significant less than and greater than relationships between left-hand and right-hand values. <<< and >>> are significant at 1%; << and >> are significant at 5%; <, and > are significant at 10% as per Mann–Whitney *U* test. Subgroups: S_c = ceiling, S_{pc} = pseudo-ceiling, S_f = floor, S_{pf} = pseudo-floor

Table XI. Trading interference in crisis periods via market-adjusted turnover

Panel A: ΔTA_{MAT} for upward movements						
	Asian financial crisis			Global financial crisis		
Window	S_f		S_{pf}	S_f		S_{pf}
t	72.421		56.741	41.643	<<	46.258
t+1	7.821	>>	−12.904	12.799	>>>	−11.627
t+2	−24.109		7.558	−17.001		−18.105
t+3	−4.518	>	−15.906	17.556	>>	5.381
t+4	4.202		19.738	−8.227	>	−11.077
t+5	1.255	>>>	−9.637	−8.331		12.292
N	37		55	412		753

Panel B: ΔTA_{MAT} for downward movements						
	Asian financial crisis			Global financial crisis		
Window	S_f		S_{pf}	S_f		S_{pf}
t	17.512	<<	34.238	45.144	>>	39.501
t+1	31.152		−42.711	−22.77		−16.698
t+2	19.71	>	19.581	34.104	<	38.367
t+3	11.331		−19.327	−21.474		−27.439
t+4	8.832	>>>	−28.65	22.68	>	−15.12
t+5	8.715	>>	5.769	−16.145	>>	−17.431
N	712		1,189	893		11,589

Note(s): This table shows change in market-adjusted turnover during crisis markets using *t−1* as a baseline. + and − values represent increase and decrease in trading activities, as calculated by Eq. (8)–(9). Due to the limit (pseudo-limit) day being a very active day, understandably, *t* exhibits very high positive values. Panels A and B report ΔTA_{MAT} for up and down moves, respectively. < and > denote significant less than and greater than relationships between left-hand and right-hand values. <<< and >>> are significant at 1%; << and >> are significant at 5%; <, and > are significant at 10% as per Mann–Whitney U test. Subgroups: S_c = ceiling, S_{pc} = pseudo-ceiling, S_f = floor, S_{pf} = pseudo-floor

likely to be worried about a miscalibrated price limit for upper limits. Hence, it is suggested that the exchange, leveraging its own access to granular data, investigates the timing of the lower limit hits for a much larger time period, preferably since the early 2000s, when sophisticated trading platform arrived at Malaysia. For fund managers, the asymmetric findings highlight the need for risk minimization strategies and weight assignment techniques during portfolio reshuffling stages—especially if turbulent markets are anticipated. For traders, cues on taking profit or cutting losses can be derived in extraordinary price swing scenarios.

6. Conclusion

Empirical works on price limits' efficacy are no longer scarce. Though we accede that such attempts are merited in normal market situations, limits' potency in achieving the declared regulatory objectives warrants greater scrutiny in stressful times. Puzzlingly, nearly all circuit breaker researchers omitted this crucial angle. To redress this, we test price limits' role in curbing volatility, easing price discovery, and interfering with trading activities in Malaysia in both tranquil and crisis periods since 1994. Our findings suggest a comprehensive performance of limits in tempering volatility in *bullish* markets (crisis or otherwise) but mixed to poor results in *bearish* scenarios. The limits also appear to delay discovery of price equilibrium after large price moves. In terms of interference, the price limits do not appear to inhibit traders' trading activities when prices are moving up in tranquil markets but display mixed results when prices fall. However, they do appear to severely

Table XII. Tests of trading interference hypothesis across tranquil periods via on-balance volume

Panel A: ΔTA_{OBV} for upward movements

Window	Tranquil period 1 S_c		Tranquil period 1 S_{pc}	Tranquil period 2 S_c		Tranquil period 2 S_{pc}	Tranquil period 3 (old limit) S_c		Tranquil period 3 (old limit) S_{pc}	Tranquil period 3 (new limit) S_c		Tranquil period 3 (new limit) S_{pc}
t	45.034		27.261	19.572	<	36.981	48.203	>>>	45.055	37.954	<<	68.809
t+1	33.006	>	−9.508	13.709	<	17.774	−66.539	<<<	33.288	−0.145	<<<	31.480
t+2	−68.466	<<	14.614	14.581		41.045	6.601	<<	12.007	−25.804	>>>	−39.993
t+3	−7.025		−10.885	−12.150	<<	−10.251	−35.416	<<	19.305	26.987	<	45.011
t+4	−22.315	<<	7.637	−37.631	<	−20.914	46.921	>	−18.957	0.425		−20.009
t+5	−15.349		−17.877	3.813		−5.243	−7.173	<<<	47.449	−20.439	>>	−30.125
N	30		53	207		411	802		1,214	61		81

Panel B: ΔTA_{OBV} for downward movements

Window	Tranquil period 1 S_c		Tranquil period 1 S_{pc}	Tranquil period 2 S_c		Tranquil period 2 S_{pc}	Tranquil period 3 (old limit) S_c		Tranquil period 3 (old limit) S_{pc}	Tranquil period 3 (new limit) S_c		Tranquil period 3 (new limit) S_{pc}
t	61.982	>>	40.728	76.146	>>>	37.137	54.086	>	34.644	25.474		70.442
t+1	−30.598	<<<	−28.292	−14.175		15.813	−51.464	<<<	−10.201	−33.134	<	9.794
t+2	−5.840	<<<	29.950	4.363	<<	18.023	−9.201	<	−2.449	−25.528	<<	−9.896
t+3	82.137		−25.666	43.066		26.121	−8.520	>	−40.328	41.172		−5.711
t+4	−45.416	<<	28.968	−43.118	<<	−46.651	31.559	<<	45.155	37.501		−9.962
t+5	−2.578		−1.031	−22.677	<	−17.357	−59.199	<<<	−10.575	−13.194		−22.549
N	307		534	267		566	1,513		2,602	566		934

Note(s): Panels A and B in the Table above show change in on balance during tranquil markets using t−1 as a baseline. + and − values represent increase and decrease in trading activities, as calculated by Eq. (10)–(11). Due to the limit (pseudo-limit) day being a very active day, understandably, t exhibits very high positive values. Panels A and B report ΔTAOBV for up and down moves, respectively. < and > denote significant less than and greater than relationships between left-hand and right-hand values. <<< and >>> are significant at 1%; << and >> are significant at 5%; <, and > are significant at 10% as per Mann–Whitney U test. Subgroups: S_c = ceiling, S_{pc} = pseudo-ceiling, S_f = floor, S_{pf} = pseudo-floor

Panel A: ΔTA_{OBV} for upward movements						
	Asian financial crisis			Global financial crisis		
Window	S_c		S_{pc}	S_c		S_{pc}
t	51.789	>>>	32.713	42.898	>>>	35.132
$t+1$	5.977	>	−10.364	−22.75	<	14.219
$t+2$	−58.881		13.445	18.372	<<	−33.657
$t+3$	−27.095	<<	−11.102	−10.692	>>	−12.506
$t+4$	−18.968		8.095	−12.739	>	−24.051
$t+5$	−18.419	>	−23.249	24.919		5.715
N	37		55	412		753

Panel B: ΔTA_{OBV} for downward movements						
	Asian financial crisis			Global financial crisis		
Window	S_f		S_{pf}	S_f		S_{pf}
t	48.221	<	53.579	80.614		48.466
$t+1$	−36.412	<<	−29.707	−14.317		−28.292
$t+2$	−6.132	>>	−8.153	5.541	<<	24.858
$t+3$	31.85	>	28.746	52.11	>>>	−7.462
$t+4$	−10.875	>	9.837	−19.155	>>>	−29.258
$t+5$	−12.449	>>	−21.309	−22.677		−0.969
N	712		1,189	893		1,589

Note(s): This table shows change in on-balance volume during turbulent markets using $t-1$ as a baseline. + and − values represent increase and decrease in trading activities, as calculated by Eq. (10)–(11). Due to the limit (pseudo-limit) day being a very active day, understandably, t exhibits very high positive values. Panels A and B report ΔTA_{OBV} for up and down moves, respectively. < and > denote significant less than and greater than relationships between left-hand and right-hand values. <<< and >>> are significant at 1%; << and >> are significant at 5%; <, and > are significant at 10% as per Mann–Whitney U test. Subgroups: S_c = ceiling, S_{pc} = pseudo-ceiling, S_f = floor, S_{pf} = pseudo-floor

Table XIII. Tests of trading interference hypothesis across crisis periods via on-balance volume

		Tranquil market			Turbulent market		
Summary of findings		Subperiod 1	Subperiod 2	Subperiod 3(a)	Subperiod 3(b)	Asian (1997–1998)	Global (2008)
Volatility	Limit up	✓	✓	✓	✓	✓	✓
	Limit down	X	✓	Mixed	X	X	Mixed
Price Discovery	Limit up	X	X	Mixed	Mixed	X	Mixed
	Limit down	Mixed	Mixed	X	X	X	Mixed
Trading Interference	Limit up	✓	✓	✓	✓	X	X
	Limit down	✓	✓	✓	X	X	Mixed

Note(s): This table summarizes the findings of the paper vis-à-vis hypotheses tested across Tranquil and Turbulent market conditions for upward and downward moves. ✓ denotes improvement of market quality (i.e. reduced volatility, lessened interference in trading, and faster price discovery), and X the opposite (i.e. exacerbated volatility, greater interference in trading, and delayed price discovery). Mixed grade refers to nonconclusive findings due to conflicting results across subgroups and/or subperiods

Table XIV. Summary of hypotheses testing impede trading activities in crisis periods. Table XIV consolidates the variegated results of all tested hypotheses.

Explaining causality of the surfaced patterns is beyond the scope of this paper. For instance, what role did Prime Minister Mahathir's capital control play in post-1997 panic? Did introduction and thereafter brusque banning of short selling in the 1990s contribute to trend in earlier subperiods? What about reintroduction of short selling in the new millennium and restricting it again later? Moreover, the role of Shariah consonant investment (a subdiscipline of finance/investment rooted in Islamic values—of which Malaysia is a major global exponent) funds and strategies (which heavily favor housing, power, and manufacturing sectors) could provide exciting insights into the matter. We also encourage the cognoscenti to link the findings to fundamental aspects of firms, possible roles of ownership structure, dividend pay-out policy, and—on a broader level—potential roles of regulatory variables such as microstructure control, changes in surveillance/monitoring regimes, and so on.

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