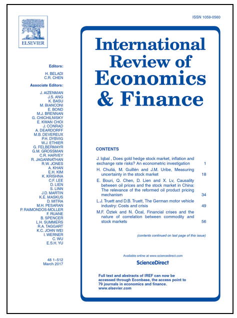

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A Survey on the Magnet Effect of Circuit Breakers in Financial Markets

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Keywords: Circuit Breakers; Financial Markets; Price Limits; Trading Halts; Volatility Spillover

JEL Codes: D47, D53, G15, G18.

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A Survey on the Magnet Effect of Circuit Breakers in Financial Markets

Abstract

Proponents of circuit breakers justify the practice citing its utility in placating stressed markets, persuading agents to reflect on available information, and to trade rationally. Opponents counter by calling it an infringement on *laissez-faire* price discovery process citing the lack of conclusive evidence of their effectiveness in market crises. After nearly three decades of theoretical and empirical scrutiny, this discord persists. Most of the empirical focus in this domain revolves around *ex-post* performance of circuit breakers in cooling off the market, interference in trading, volatility splattering, and delayed assimilation of information. A less explored hypothesis is a potential for traders to hasten trading plans fearing illiquidity or trading blockade. Thus, the existence of the circuit breaker alone can induce its tripping. Known formally as the magnet effect, this hypothesis remains less explored due–*inter alia*–to paucity of data and methodological limitations. Greater availability of high-frequency datasets in recent times, however, has spurred a growth in empirical works focusing purely on the *magnet effect* hypothesis. As this nascent sub-discipline in market microstructure grows, this paper undertakes one of the first formal surveys looking to consolidate theoretical and empirical works on *magnet effect.* Moreover, we discuss methodological challenges and analytic limitations which strain the credibility of academic research findings in this domain; particularly among regulators.

Keywords: Circuit Breakers; Financial Markets; Price Limits; Trading Halts; Volatility Spillover

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A Survey on the Magnet Effect of Circuit Breakers in Financial Markets

1. Introduction

Circuit breaker, in financial market parlance, is an umbrella term used to refer to a regulatory mechanism that partially or wholly impedes, interrupts, or suspends trading of a financial security (or the entire market) should price or volatility levels reach pre-defined key levels. This control mechanism gained notoriety following the *Black Monday* crash of October 1987 and has since then been a staple tool of exchanges and regulators to avert panic during large sell-offs. Though studied extensively over the past few decades, interest in circuit breakers is undergoing a resurgence, spurred, *inter alia*, by the flash crash of May 2010 in US markets, repeated flash crashes in Cryptocurrency exchanges in 2017, the Brexit referendum, and large intraday plunges of the DJIA in February 2018. Regulators' purported *raison d'etre* for it is to inhibit investor overreaction, enforce control at microstructure level, prevent crashes, and to smoothen volatility. These barriers are generally of two kinds: trading halts (suspensions) and price limits. Halts entail a temporary suspension of the trading session; a time-out. They can be market-wide or asset specific and can be triggered based on preset parameters or at the discretion of regulator(s). Limits, on the other hand, operate by pre-specifying a tolerable channel of volatility around a reference value that is based on previous session's settling price. While traditionally limits were set on a daily basis, it is increasingly common now for exchanges to enforce intraday limits. The magnitude and category of price limits exhibit considerable global variation. Nevertheless, regulators in emerging markets appear keener to enforce limits, motivated ostensibly by stymying large fluctuations stemming from noise trades or trades by a large pool of inexperienced (uninformed) investors. In fact, except for rare cases (e.g., Australian Stock Exchange), it is hard to find any exchange in developed economies without an active circuit breaker practice.

The practice of circuit breakers has long been a subject of interest to market agents and researchers. Although the regulators and exchanges have viewed favorably this practice, academics' position on its utility has been mixed. Much of the latter's interest manifests itself in debates over efficiency of the practice and whether the intended regulatory objectives are achieved. Consequently, the role of circuit breakers in curbing volatility, suppression and migration of liquidity, spillover and contagion of volatility, etc. have received considerable attention. The results are largely mixed but can be argued to be slightly tilted against the regulatory practice. As such, skepticism regarding circuit breakers' usefulness persists. It is worth noting that all the possible effects of circuit breakers stated above are *ex-post* in nature. That is to say that the researchers' primary focus has been on scrutiny of the aftermath of a trade constraint. These effects aside, some scholars point out that circuit breakers may prompt an *ex-ante* gravitational effect without requiring market agents to forego trading discretion. The argument is that the existence of circuit breaker itself can incentivize market agents to rush their trading decisions when price nears the constraint threshold, which catalyzes achievement of the threshold. This possibility is known as the magnet effect. This hypothesis states that circuit breakers—by the very existence—attract trading activities toward themselves, usually after a certain threshold has been crossed. Thus, if a magnet effect exists, the circuit breaker in play would be directly contributing to the same problem it is designed to forestall. Whether this effect exists in practice has been the subject of considerable conjecture and debate. Following a largely theoretical series of propositions and models in the early 1990s, empirical works post-2000s exhibit inconsistent and mixed results. The lack of generalizability of these results is further compounded by the variation in results due to heterogenous exchange-specific rules and the nature of intervention; i.e. whether it is a trading halt or a price limit or other combinations. Moreover, the majority of scholarly works till date had to focus on individual stocks or futures since market-wide circuit breaker triggers are extremely rare. As such, even if circuit breakers carry a built-in design flaw in the form of magnet effect, substantiating it has proven difficult. Notable among these challenges is access to–and identification of–data representative of investors' trading sentiment near the barrier threshold. This makes the popularly used daily time-series datasets unsuitable for identifying magnet effect. Nonetheless, a sizeable number of earlier studies employed daily data near the beginning of theoretical development of magnet effect literature. This problem has waned in recent years as high-frequency data has become more accessible. Furthermore, insights from behavioral finance are beginning to be incorporated into market microstructure literature, of which magnet effect hypothesis is a beneficiary. Consequently, within the broader debate over circuit breakers' efficacy, the magnet effect hypothesis is starting to receive more attention than before, leading to a growing number of papers examining the possibility of a magnetic pull by circuit breakers. As the theory and empirics on the concept approaches maturity, we observe that till date (as of 2019) no formal survey has been attempted on the magnet effect alone. This motivates us to undertake a critical review of the magnet effect studies to distill some key takeaways from the current state of knowledge.

Our survey contributes to finance literature in three ways. First, given the maturity of research on magnet effect hypothesis in market microstructure, this paper presents the first (to the authors' best knowledge) formal review of the ex-ante magnet phenomenon. This is in contrast to most prior surveys on circuit breakers (Harris, 1997; Kim & Yang, 2004; Abad & Pascual, 2013) where discussion on the magnet effect featured in a modest scope and was somewhat subsumed under broader circuit breaker efficiency discourse. Secondly, the proliferation of recent empirical works has generated an impressive body of findings since last major reviews. This paper updates the literature and consolidates the research streams thematically. Lastly, after a relative stagnation of theoretical development in the topic for nearly two decades, recently some breakthroughs in modeling and approaches have been observed (e.g., Chen et al., 2018; Lera et al., 2019). This paper surveys the new approaches critically and recommends avenues for advancing the discourse further.

2. Circuit Breaker Praxis

In a frictionless financial market, trading collars would be unnecessary. However, in reality, most exchanges prefer having at disposal a lever to protect the market agents from excessive volatility—or at least project the appearance of attempting to protect investor interests in this way. Thus, the common *raison d'etre* trumpeted by exchanges and regulators is to facilitate a window of re-assessment. Its purport is to help traders calm down and reflect on news and fundamentals of underlying assets when the security trading gets too volatile. Following introduction in post-Black-Monday (1987) climate which saw world markets crashing, it is easy to see why regulators found the option palatable to regulate sharp declines or rises of asset or index prices within a day. The same allure holds today. This regulatory preference is clearly manifested in the near ubiquity of the practice on a global scale. There are considerable variations, however, regarding what type of circuit breakers are employed. Some markets enforce both market-wide and single-stock circuit breakers, whereas others use just one. Another form of trading barrier is gaining popularity in recent years, especially in Europe, known as Volatility Interruption.[1] Markets without any limiting mechanisms exist also but are increasingly rare. Figure 1 below provides a classification of different kinds of circuit breakers. Following that, Table 1 presents a short overview of the current circuit breaker regimes in important global exchanges as of 2019.

<Insert Figure 1 Here>

<Insert Table 1 Here>

3. Justifications for Circuit Breakers

Pricing efficiency lies at the heart of financial market integrity. Not only do prices channel savings mobilization and resource allocation, they also determine worth and signal liquidity demand or supply. Therefore, malfunctioning price signals from a market suggest that demand and supply are no longer supreme determinants and/or arbitrage opportunities exist. Consequently, regulatory intervention to iron out such kinks, in theory, appears condign. Moreover, historical contextualization of circuit breakers' earliest adoptions (late 1980s) helps rationalize the regulatory need for drastic intervention considering "Black Swan" emergencies. Although the intent behind this regulatory practice is noble, whether it truly delivers the desired benefits is worthy of a closer look, especially in light of academic and public skepticism.

Originally, support for the circuit breaker mechanism came from the report by the Brady Commission in 1988 following orders by President Reagan's administration to prevent abnormal crashes in the markets. The practice gained support from Ma, Rao, and Sears (1989), who advanced the "cool off" hypothesis, which states circuit breakers have the potential to stabilize prices by suppressing large swings caused by speculation or panic, which, in turn, could discourage manipulation. Others also noted that since traders are at liberty to alter or withdraw their limit orders during trade interruptions, it could help informed traders devise better risk management plans without incurring losses. These could, in aggregate, ameliorate liquidity and participation in times of market duress, and aid convergence on equilibrium price once trade resumes (Copeland & Galai, 1983). Furthermore, Greenwald and Stein (1988) argue that price

[1] Volatility Interruption refers to a practice where continuous trading is interrupted if the next potential execution of a market/limit order falls outside the pre-set range around a reference price. In case of such a triggering order, some exchanges partially execute the order before halting trade, while others outright reject the order. The rising popularity of the volatility interruption scheme can be partly attributed to the proliferation of high frequency and program-based trading around the world, which brings along with it a heightened risk of sudden liquidity evaporation. This fear, along with the structural flexibility of the mechanism, MiFID implementation in Europe, and failure (and immediate abandonment) of market-wide trading halt in China in 2016 are among the reasons driving exchanges to adopt volatility interruption as a preferred mechanism. In fact, the recently adopted Limit-up Limit-down (LULD) scheme in the US can be argued to be a variant of volatility interruption given that it relies on a recursive window enforcement of a ±5%/10% channel around the prior five minutes' trades.

discovery could quicken, and information asymmetry improve as circuit breakers can better educate the market at times of broken information transmission (through quotes).

From a design perspective, regulators understand that circuit breakers can be used as a make-shift brake against fast or abrupt price changes. The opponents, however, point out that fast-changing price dynamics is not necessarily undesirable, especially if it arises because of newly available sensitive information. In such a case, a trading barrier would only delay the realization of market consensus. Besides, when price formation is disturbed, investors are unable to form price expectations. Though, if a mechanism were to be developed that is capable of blocking panic-induced trades from noise traders, the effects of non-fundamental volatility could be diminished. Also, order imbalance originating from frequent noise trades can be interrupted since a trade barrier eliminates the traders' opportunity to execute orders in an order book of sub-optimal depth. At this stage, market makers would be incentivized to capitalize on the liquidity shortage (Kodres & O'Brien, 1994). In these situations, some have shown that if prices fluctuate excessively as a result of noise trades, informed traders recoil from the order book because of heightened uncertainty surrounding the rate at which their orders will be executed (Greenwald & Stein, 1991). Consequently, their transaction risk falls. On the flip side, informed traders may feel disincentivized to monitor the price dynamics if they are aware that they will be notified in the event of a trade barrier. This could lead to degradation of market liquidity in between trading halts; reinforcing the noise-induced volatility (Fong, 1996). Additionally, in countries where more than one stock exchange exists, a trigger in one venue can affect other(s). This problem has now expanded beyond geographical boundaries as cross-border market integrations are becoming more common; especially in Europe. This has led to some calling for synchronizing the regulatory actions between exchanges to forestall toxic order flow migration and to preserve liquidity (Chen et al, 2018).

In addition to the criticisms outlined above, proliferation of high frequency trading, algorithmic trading, and recurrences of flash crashes re-ignite the question of whether a regulatory mechanism devised for a market ecosystem of 30 years ago is still useful today. As important as the discussion of circuit breakers' relevance in the modern market is, it is not the primary focus of this paper. Rather, in this section we have attempted to present a brief snapshot of the major pros and cons of the practice to allow the reader contextualize the upcoming discussion on magnet effect in the domain of market microstructure scholarship. In the next few pages, we discuss the theoretical and empirical works surrounding the magnet effect.

4. Theoretical Works on Magnet Effect

Up until Brennan (1986) proposed using limits as a roundabout substitute for futures market margins to minimize investor default risk, hardly any theoretical discussion existed regarding what is known as circuit breaker in the modern day. Among the earliest theorists of the potential for a magnet effect was Miller (1989), who conjectured that trade barriers can induce a flurry of fear-fueled trades in the direction of the barrier if the agents suspect they cannot close an open position. Later, Greenwald and Stein (1991) argued by formulating two theoretical models that sacrificing the timeliness benefit of continuous trading at the expense of efficiency has some merit if the source of disturbance to the market (or order book) is large volume shocks. In such a situation, they add, circuit breakers can help future orders rely on a more relevant (larger) information set. Moreover, traders are participation-averse when uncertainty amplifies concerning the fair value of an asset. Greenwald and Stein also assigned random and exogenous values to value-minded market players who are forced to adjust their trading plans due to noise and volume shocks arising from uninformed traders' orders. Moreover, the authors hint at an extra layer of transaction risk incurred by informed agents arising from the cost associated with uncertainty revolving around the number of active participants closely watching the market in stressful periods. Thus, usually, the informed traders retire from the order book if they perceive quick price movements to be caused by uninformed trades. We note, however, that although this model accounts for the value-seeking agents, it neglects the distinction between the early and late responders. Nevertheless, the model's contribution has been significant in shaping the future theoretical works. Case in point, Kodres and O'Brien (1994) design a Pareto-Optimal model of risk sharing via diminishing unanticipated volatility dynamics. The model predicts that circuit breakers can help market makers and liquidity providers save in transaction expenses who can otherwise not afford to continually monitor the market activities. On a related note, Gerety and Mulherin (1992) highlight the tradeoff of calming volatility at the expense of illiquidity and aggravated credit problems in the event of a margin call. Additionally, the authors deduce from their results that forcing some investors into continued ownership when they would rather transfer the risk to those more willing is detrimental to market efficiency. They further extend this argument, buttressed by McMillan's (1990) gravitational effect model, that barriers to trade could make investors skittish once a threshold percentage of the permissible fluctuation band is achieved—leading to negative welfare. Meanwhile, arguing from a pricing efficiency standpoint, Chowdhury and Nanda (1998) advance a model that postulates circuit breakers can aid in eliminating potentially inefficient prices. Moreover, the authors predict that price limits coupled with elastic margin requirements can significantly stabilize a troubled market.

Among the few theoretical works in early the new millennium, Chou, Lin, and Yu (2003) develop a model which demonstrates the utility of circuit breakers in countering default risk and margin requirements. Though the features of this model are different from Brennan's, its conclusions are identical. Another model by Westerhoff (2003) predicts that trading barriers have the capacity for maximizing social welfare by smoothening volatility.

The earliest theoretical works, as discussed above, focus on circuit breakers operational in continuous (simple) trading platforms. A notable exception is Madhavan's (1992) work, who recommends switching to a call auction in a harried market. Moreover, Madhavan argues that continuous markets may be sub-optimal when information asymmetry is high; hence, enforcing a halt can exacerbate the initial problem. Besides, resumption of continuous trade with re-established information flow may prove difficult. Instead, periodic trading systems can be more useful in addressing the information asymmetry problem. Thus, Madhavan's suggestion is to switch to a stop-gap call auction to avoid market failure. In fact, he argues a batch market will outperform a trading halt since a discrete trading system can remain alive in the event of dealers' refusal to act as market makers and thus providing information signals facilitating resumption of normal trades. Additionally, the model proposes tethering the trigger stochastically to recent volume and spreads. It should lead to a bid-spread greater than a preset critical level and thus outperform the conventional trading halts since large price changes can occur because of change in underlying fundamentals.[2]

[2] The Chicago Mercantile Exchange's Dynamic Circuit Breaker practice today is similar to what Madhavan had envisioned.

Another stream of theoretical works focus on trading strategies of informed traders and liquidity providers. Pioneering among them was Subrahmanyam (1994), who proposed a model suggesting the possibility of a magnet effect, first hinted at by Lehmann (1989). In Subrahmanyam's model, rule-based halts give incentive to noise (uninformed) actors to hurry their trades in a concerted way, which precipitates a higher ex-ante volatility as the price accelerates to trigger proximity. The phenomenon can intensify if liquidity is particularly depressed in near-trigger ticks. A year later, Subrahmanyam (1995) expounds on his original argument and predicts that discretion based halts should function better than rule-based halts in escalating the magnet effect. In a later paper, Subrahmanyam (1997) shows that when investors believe a trigger-hit to be imminent, informed and liquid traders can temporarily withdraw their order book presence to avert a trigger hit. As this leads to liquidity depression, the model suggests introducing randomness at the regulator's discretion so as to not allow informed traders the opportunity to strategically retire from the order book. Subrahmanyam's series of explanations of the magnet effect provides the baseline for much of the empirical works attempted post-1997.

Though not a formal examination of the magnet effect, Slezak's (1994) multi-period model of market closures strengthened the case for it through demonstration of risk redistribution across time and different market players in the presence of a trade closures. Most importantly, the model showed that informed participants' risk rose at a higher pace, motivating them to engage in trades that would insure them against the possibility of being locked out of a position. That fear functions as an extra source of risk, requiring further insurance trades. Slezak's report is quite striking considering he clearly distinguishes between the risk distribution effects of market closures in a pre- and post-basis. Meanwhile, in an experimental exercise using simulations, Ackert et al.'s (2001) model reports that in the face of impending circuit breaker trigger, traders hasten their orders; a finding that indirectly supports the magnet effect.

After a relative theoretical lull of nearly 15 years, two important works in recent times have re-ignited the circuit breaker debate: the first by suggesting designing a barrier based on variables other than observed price (Chen et al., 2018), and the other by quantifying the effect of circuit breakers by performing counterfactual analysis tied to fundamental values (Lera et al., 2019). Firstly, Chen et al. construct a dynamic model to examine the effects of market-wide circuit breakers on trading and price dynamics. Their model shows that the benefits of lower price-dividend ratio and shrinkage of daily fluctuation limit leads to higher conditional and realized volatility. Additionally, the model's predictions suggest that market-wide circuit breakers elevate the likelihood of a stock triggering the circuit breaker once a certain threshold is breached; i.e., the magnet effect. Such an effect is stronger when the source of the shock is fundamental in nature, or if it stems from market agents' cognitive biases.

In an important recent breakthrough within circuit breaker literature, Lera et al. (2019) propose a General Circuit Breaker Equation (GCBE), which postulates a counterfactual fundamental value (*f*) that would prevail if the circuit breaker had not existed.

$$s_t = f_t + p_{hit}\gamma(f_t - \underline{s}) + p_{hit}\gamma\mu(E[t_s - t] + \Delta t_h \qquad \text{Eq. (1)}$$

The authors posit the underlying dynamic of this (log(*f*)) fundamental value is underpinned by a stochastic process with a continuous random walk, negative drift, and constant volatility. Thereafter, the authors disaggregate the effect of the circuit breaker by imposing a trading barrier effect on the fundamental value via decomposing the difference between price formation (*s*) and fundamental value (*f*). Their numerical analysis finds that volatility waxes as price approaches the limit, consistent with many prior empirical works. The authors also demonstrate the utility of the GCBE by modeling the behavior of Shanghai CSI-300 index, Bitcoin futures, and S&P500 Index against it. The GCBE framework also confirmed the magnet effect for all realistic combinations of different parameters.

5. Empirical Findings on Magnet Effect

The earliest investigators of magnet effect observed that during an abnormally optimistic or pessimistic price juncture in futures markets, traders relentlessly trade at prices near the trigger points, helping push the price to the limit. The flurry of trading activity and its direction near the price limit has since then been attributed to: (a) investor apprehension toward illiquidity (in case of markets where limits trigger suspension) and (b) fear of missing out on a trend. Following further development of the theory and crystallization of the magnet effect framework according to the discussions of Madhavan and Subrahmanyam, empirical results of studies after 1997 indicate mixed results regarding existence and strength of such an effect. In particular, a distinct divide is observed between futures and equity markets, whereby evidence is weaker for the former. The opposite is largely true for equities. In the following subsections, the empirical works are systematically reviewed based on their findings for or against the magnet effect, followed by a discussion on the prevalent methodological and data-based approaches.

5.1 Studies Confirming the Magnet Effect

The number of studies finding magnet effect in the stock markets is comparatively higher than those that do not. The most highly examined stock markets are China (Wong et al., 2009; Xu et al., 2014; Wu et al., 2016; Wang et al., 2016) and Taiwan (Cho et al., 2003; Hsieh et al., 2007, 2009). Among the developed markets, Goldstein and Kavajecz (2004) reported on the existence of magnet effect based on event-study approach on New York Stock Exchange stocks. A recent investigation of the NASDAQ by Hautsch and Horvath (2019) provides support for the phenomena observed by Goldstein and Kavajecz. Meanwhile, Brugler and Linton's (2014) results for London Stock Exchange, too, are suggestive of a magnet effect corresponding to intraday auctions (AESP) triggered by order movements. Interestingly, a large portion of magnet effect studies hail from Asian exchanges, where price limits are significantly more popular than elsewhere in the world. Among these studies, Du et al. (2009) report that magnet effect exists for stocks based on two-year KRX intraday data. For Turkey, all paper investigating the phenomenon report affirmative results, whether using end of day (Bildik & Gulay, 2006; Danisoglu & Guner, 2016), or intraday (Aktas, 2016), data. Similar confirmations are reported for stocks in Malaysia and Egypt (Chan et al., 2005; Sifat & Mohamad, 2018; Tooma, 2011; Omar, 2012). In contrast to the abundant positive evidence in stocks, only a handful of studies find magnet effect in futures. Key among them is Levy et al.'s (2013) work on Pork Bellies and Oats futures in the US based on a 41-year dataset. More recently, Syed and Auret (2018) show the same for Maize futures in South Africa.

5.2 Studies Failing to Confirm the Magnet Effect

Though smaller in number compared to the affirmative findings, several studies fail to find magnet effect in stock markets. Prominent among them are: Huang et al. (2001) for Taiwan, Abad and Pascual (2007) for Spain, Kim et al. (2013), Hao (2016), and Wan et al. (2015) for China, Dabbou (2013) for Tunisia, and Clapham (2018) for Germany. Aside from Hao's work which deals with market-wide circuit breaker, the remaining papers mentioned above deal with individual stocks. Meanwhile, for futures, evidence against the magnet effect is more commonplace (Arak & Cook, 1997; Berkman & Steenbeek, 1998; Hall & Kofman, 2001).

It is important to note that while the papers mentioned above–for both stocks and futures–do not find evidence for magnet effect, the findings do not necessarily imply a retarding effect of the circuit breaker; i.e., the barrier repels trades away from realization of the trigger. Such a phenomenon, which can be a vindication of the regulatory practice, has been documented by Arak and Cook (1997), who call it the repellant effect. The authors employ two models to study US treasury bond futures in the mornings after a substantial overnight price change and disaggregate the circuit breakers' effects from that of price-sensitive news and observe that an overnight price reversal ensues. This reversal shows sensitivity to how close the prices are to the trigger point and exhibits a mild repellant effect, in opposition to the hypothesized magnet effect. The repellant effect was also found later by Hall and Kofman (2001) in five agricultural futures contracts in Chicago Board of Trade. It should be pointed out, however, empirical findings from futures markets are not generalizable for equities, since derivatives are known to have close substitute contracts. Nevertheless, the repellant effect, in a moderate form, has been reported for Shanghai Stocks by Wan et al. (2018) and for Malaysian equities by Sifat et al. (2019b).

5.3 Methodologies

Among all the studies surveyed for the purpose of this paper, event study methodology appears to be overwhelmingly the most popular technique, which is often paired with parametric and nonparametric tests of changes or comparisons between means and variances of pre-event and post-event groups. This approach has been applied to both daily and intraday datasets (Chan et al., 2005; Kim et al., 2013). The next most commonly used technique is a binary classification approach via logistic regression, whereby the dependent variable is assigned a 0 or 1 value based on whether the corresponding event triggered the circuit breaker threshold or not. This approach was pioneered by Hsieh et al. (2007, 2009) and later followed by Tooma (2011), Levy et al. (2013), and Wan et al. (2018). Meanwhile, two other important papers–by Cho et al. (2003) and Abad and Pascual (2007)–adopted drastically different approaches by relying on autoregressive modeling and seemingly unrelated regression modeling respectively. Interestingly, the quadratic modeling approach of earlier studies (Berkman & Steenbeek, 1998; Du et al., 2007) was not adopted by subsequent researchers at all. Some authors, however, have tried to innovate by using uncommon techniques to capture the magnet effect. For example, Xu et al. (2014) look at the power law dynamics of cumulative abnormal returns in the post-event hit window to infer the strength and existence of magnet effect. Bruglet and Linton (2014) augment the classical Cho et al. (2003) by using an asymmetric flavor of GARCH, augmented with Variance Ratio testing. Sifat and Mohamad (2018) use an NARDL on order aggression and observed price dynamics to infer whether gravitational pull exists. Danisoglu and Guner (2016) use a propensity score matching approach for Turkey.

5.4 Extrapolating Magnet Effect from Data

Given the abstract nature of magnet effect, detection of such phenomenon has to be extrapolated in several ways. First off, intensification of order submission (sell orders in a bearish scenario and vice versa) as the trigger threshold approaches is a tell-tale indication of *magnet effect*. Alternatively, cancellation of limit sale orders, which are to be replaced with market sell-orders can be construed as signaling magnet effect. This can happen independently of or in conjunction with the first scenario. Moreover, limit order liquidity providers (both on buy or sell side) could cancel or reposition their trading strategies, fearing a market-wide trade interruption. In this regard, Goldstein and Kavajecz (2004) utilized a combination of the above approaches in investigating the market-wide trading halt in US markets when DJIA marked a substantial decline, falling just 6 points short of the trigger point of 7366. The authors find, consistent with the hypothesized scenarios above, a larger concentration of significant cancellation of buy-side limit orders in the 9 minutes prior to approaching the trigger threshold. While these scenarios appear reasonable for trading halt scenarios, they are transferable for price limits and volatility interruptions as well.

5.5 Recent Innovations

In contrast to the classical approaches outlined above, Brogaard and Roshak (2016) study the largest 2000 US stocks' extreme price paths using a difference-in-difference approach. The authors construct a price path before and after introduction of the trading barrier in 2010. Their results from a control group of stocks which was not constrained by limits suggests results consistent with Holding Back Hypothesis; i.e., traders with good information shy away from trading in price ranges in the vicinity of the trade barrier to avoid tripping it. Their finding constitutes indirect evidence against magnet effect as per Subrahmanyam's (1997) prediction. Also, more recently, Wang et al. (2019) have studied the effects of market-wide circuit breakers in achieving a cooling off effect both at a macro and micro level in China using order book data. The authors use a Lasso-based Instrumental Variable model to capture the effects of microstructure and policy-level regressors and report that circuit breakers fail to cool off the sell pressure, brake the fall of price, curb volatility or improve order imbalance. Worse yet, the circuit breakers appear to induce magnet effect at individual stock levels by worsening order imbalance and trade sizes.

5.6 Summary of the Survey of Empirical Findings

<Insert Table 2 Here>

In spite of the apparent dominance of findings confirming the magnet effect, it's fair to surmise that academic consensus is far from conclusive. This dissensus can be imputed to several factors. First, derivatives markets' findings aren't laterally transferable to equities due to structural differences. Second, most of earlier studies relied on EOD (end-of-day) data to investigate magnet effect instead of limit order book of trade transactions data. Though availability of tick-dataset in recent years has partially offset this limitation, the unavailability dilemma persists for a variety of factors: technical constraints, regulatory recalcitrance, costly nature of data, etc. Moreover, up until very recently, most of the studies neglected incorporating market microstructure indicators such as turnover, volume, quote spreads, order types, order flow, etc. What's more, methodology-wise, bulk of the empirical works heavily depend on price-return series to gauge magnet effect. This strategy remains highly influential due to patronage of two seminal works: Cho, Russell, Tiao, and Tsay (2003) and Hsieh, Kim, and Yang (2009) even though the latter's binary outcome regression is a considerable improvement and relevant in identifying a threshold point for magnet effect. Lastly, the lack of a counterfactual event plagues methodological designs of most studies. In this regard, Lera et al.'s (2019) GCBE framework can be put to greater use to fit the circuit breaker behavior of stocks or futures to see if the model generates more insights compared to common approaches. Also encouraging is Brogaard and Roshak's (2016) price-path approach, which appears to be a promising way to deal with the counterfactual conundrum.

6. Empirical Challenges

6.1 Counterfactual Dilemma

The problem of designing counterfactual scenarios manifests itself in the failure to disentangle the factors explaining why some assets trigger the circuit breaker and others do not, and also what could have happened had the trade barrier not been in place. Existing approaches at bypassing this problem relied mainly on using control periods via constructing a sample of pseudo-events which exhibit threshold-like behavior. One problem of this approach is that pseudo-events are more prone to uncertainty instead of a control sample in an experimental study. Moreover, this could partially explain why studies using pseudo-events typically exhibit low statistical power in their results. While designing experimental studies to circumvent this issue may seem appealing, that too comes at a cost. Experimental designs within market microstructure realm often run the risk of oversimplifying the underlying dynamics of market forces due to being grounded to a priori theoretical assumptions. Moreover, distinguishing between the behavior of an informed and an amateur investor is not an easy task. Nevertheless, experimental studies remain the most promising alternative to the prevailing approaches in better answering whether magnet effect truly exists.

6.2 Volatility

Revisiting the premise that circuit breakers are employed to curtail unwanted volatility, it is necessary to distinguish between types of volatility. Thus, discriminating between fundamental and transitory volatility is important (Krause & Tse, 2013). This aspect remains surprisingly ignored in existing empirical works. An exception is the work by Du et al. (2007) who made an effort to differentiate *magnet effect* from intraday momentum effect. Regulators too are guilty of demonizing volatility as an absolute undesirable. We argue that straitening fundamental volatility equates promoting pricing inefficiency. So long as price volatility springs from a rational decision trigger by market actors, it shapes the market's perception of the altered fundamental value of the asset. Hence, high volatility is not necessarily an evil that must be shunned. Though we agree with previous researchers–in principle–that transitory volatility should be treated as undesirable, it is important to trace its sources. Most market microstructure experts impute transitory volatility to friction in financial markets and the trading processes, such as illiquidity (or fear of it, in case of trading halts), order imbalances, speculation (which too has its own theory of healthy and unhealthy classification), manipulation, boom-and-bust cycles, overreactions and underreactions, herding, regulatory constraints, etc. In this regard, the topic of information related changes of price versus friction induced changes of price and their joint impact on circuit breaker remains largely unaddressed. Furthermore, given the increasing availability of granular and order flow data, and in presence of high-frequency trading, addressing the behavioral/rational triggers causing price changes near the threshold is grossly underexplored.

6.3 Futures-specific Issues

From a futures market perspective, Margulis (1990) points out that market agents, who in usual conditions act as liquidity providers, are compelled to withdraw from the market if futures prices draw near the trigger point. Thus, market makers, intraday traders, and short-term speculators may be spurned by the prospect of holding an overnight risky position and could be forced to alter their trading strategy. To illustrate further, let us suppose a futures market has fallen drastically. Arbitrageurs in this circumstance would be bearish (short) on stocks and bullish (long) on futures. Under normal circumstances, liquidity providers, given the spot rate of the underlying asset/index, buy from the public at a price of P_0 while anticipating that if the market moves against them, the position can be closed by selling the futures down a few ticks; say $P_0 - T_{1/2/3/4/5}$. Hence, when operating in our hypothetical sharp fall market, the liquidity provider cannot buy from the public at a few ticks above the limit price, because in case the market moves south, the ability to sell—and thus closing the position—may be jeopardized for an indefinite period. As a result, they would require greater premium to compensate for inventory risk. Therefore, the logical choice would be to bid at a price much lower than P_0, which, incidentally, is a price further closer to the lower limit. The same holds true for agents would are usually ready to buy at a price a few ticks higher—$P_0 + T_{1/2/3/4/5}$. Hence, around ticks in the vicinity of the lower price limit, bid quotes recoil closer to the limit. Due to the lucrative nature of bid premium around the lower limit (owing to wide spreads), market makers would be happy selling to the public (lift-ask: trading at ask) while buying (hit-bid: trading at bid) from the public and thus earning a good spread premium. Therefore, the more competitive a market is, both bid and ask quotes would be skewed towards the lower limit. Similarly, in highly bullish scenarios, quotes would be skewed closer to the upper limit due to similar magnetic effect.

6.4 VPIN related issues

In addition to classical market safeguards like circuit breakers, an alternative mechanism called Volume Synchronized Probability of Informed Trading (VPIN) has emerged as a candidate for smoothening volatility in markets. This mechanism relies on quantifying information asymmetry in the market. Some argue that VPIN can have inadvertent consequences and as such could reinforce the magnet effect on top of aggravating the documented ex-post effects. For example, assuming a market operates according to Subrahmanyam’s (1994) model, when VPIN value approaches a limit, it implies a trading constraint is imminent. As a result, market agents are incentivized to shift trading strategies away from a previously desired one, potentially leading to order imbalance in the market. This can, in turn, compound the magnet effect. Furthermore, similar to Slezak’s (1994) market closure model, VPIN can induce liquidity providers’ premature retirement from the order book, leading to a rise in the spread of smaller orders. Accordingly, short term volatility is likely to worsen. These issues are, thus far, evaluated mostly on theoretical terms using artificial market models. Whether VPIN would induce or supplement magnet effect is a matter worthy of incorporation into the ongoing VPIN literature.

7. The Way Forward

In light of the drawbacks of the existing research as outlined above, we argue that solutions have to be found to address two key methodological constraints: (a) counterfactual dilemma, and (b) dissection of volatility into desirable and undesirable. On practicality front, most studies have been unable to satisfy the selection filters for direct comparison of different types of price limits (and/or trading halts) within the same market. Coursey and Dyl (1990) dabbled into experimental market tests to see how the market would function with and without trading curbs (both price limits and trading halts). Such efforts have been rarely attempted since then. More empirical tests along this line are needed to allow optimal decision making by both regulators and market operators. In addition to augmenting the existing trend of natural experiments (e.g., market regulatory changes, event-studies of price limit hits and trading halts), novel empirical approaches are needed to produce fresh insights about the role of circuit breakers in inducing the magnet effect. Also, barring a few minor exceptions, the focus of most papers is invariably on market microstructure variables. The linkage to fundamental economic and accounting variables are less noticeable.

In addition to our prescriptive remarks above, we note that vast majority of the studies are focused on different aspects of efficiency or justification of circuit breakers. Less explored is whether circuit breakers can act as an alternative deterrent to market manipulation. Although no such formal acknowledgement exists from the regulators or exchanges, it is nonetheless somewhat of a received wisdom in the financial industry (Sifat and Mohamad, 2019a). Kim and Park (2010) deal with this issue by advancing a model that shows the tradeoff of price signaling efficiency prompted by circuit breakers versus discouraging price manipulation. Their model predicts that in the presence of high fear over market manipulations, exchanges are likeliest to employ circuit breakers. Additionally, they analyze 43 markets' efficiency performances against individual country's corruption and law enforcement variables. The latter function is a proxy for market manipulation. The authors conclude that their model indicates exchanges with countries with high corruption levels and lax law enforcements exhibit the highest propensity to enact circuit breakers. We find this conclusion interesting, given that previously McDonald and Michayluk (2003) hinted that circuit breakers themselves can be wielded as a tool for manipulation, based on close examination of suspicious activities near the threshold point in French market. This issue of circuit breakers as an antidote to—versus a tool of—manipulation is surprisingly under-explored. Meanwhile, though focusing not quite on suspicious trading activities, a relevant new explanation for the existence of the magnet effect has been tested by Chen et al. (2019), who ascribe the journey of the price towards the limit to deliberate effort by large investors. The authors dissect transaction level data according to investor groups and report that price limits induce a pattern of pushing the price near to upper limit by large investors who then go on to sell the stock the following day. We find this approach of bifurcating the order flow along institutional and retail lines to be promising which merits more empirical testing; even better if the studies can be designed to test behavioral biases underpinning trading preferences of different classes of investors.

Another interesting new remark concerning the ex-ante gravitational effects of price limits has been provided in a recent unpublished work by Chong and Kwok (2019). In the process of quantifying the interference effect of price limits on trading activities, the authors conjecture that the effect is higher for upper limit hits compared to lower limit hits because of a ban on short selling, coupled with the possibility of a magnet effect due to inexperienced traders' irrational optimism in buying securities even at the upper limit but reluctance to sell at the lower limit due to a hope that the Chinese government would intervene and inject liquidity in the system to push prices higher. This conjecture lays the groundwork for an interesting avenue of research where the interaction between an ex-ante and ex-post hypothesis (trading interference vs. magnet effect) can be studied at greater depth. In this regard, a noteworthy approach is observed in the study by Jian et al. (2018), who dissemble magnet effect hypothesis into three parts: trend, volatility, and extreme market risk. They investigate the same using high-frequency data for Chinese index futures and find evidence mostly supportive of a cooling effect, with an exception found in futures' proclivity for a negative jump when CSI-300 index nears the market-wide circuit breaker threshold. In addition to these novelties, we note that a unique study quantizes the market quality spillover effect of halted stocks to non-halted stocks during the single-stock circuit breaker program by the SEC in the US (Cui & Gozloklu, 2016). The authors report that circuit breakers interfere not merely with the activities of the halted stocks but also those not halted via the arbitrage and speculative channels. Along this line, the authors propose that the idea of Tobin Tax (transaction tax) be revived for speculative activities.

In recent times, the proliferation of high-speed algorithmic trading provides another fertile ground for empirical research into *magnet effect*. This phenomenon was obviously absent when circuit breakers were conceptualized. More specifically with respect to magnet effect, we note that bulk of the developed market literature surveyed in this paper deal with empirical testing on data or periods without the presence of high frequency or algorithmic trading. Also, earlier works with end of day data had no way of accounting for the presence and effect of high-frequency traders. Although intraday data appears to feature more prominently in recent years, most of them are aggregations of insufficiently granular seconds or minutes returns and thus do not fully capture dynamics of the magnet effect at the agents' decision-making level. As a result, understanding of high-frequency traders' contribution to or deterring of magnet effect is significantly under-developed. We note some important contributions in this topic which are likely to pave the way for future research on magnet effect and perhaps broader circuit breaker and market efficiency debate. Firstly, Easley et al. (2014) introduce the idea of volume synchronized probability of informed trading (VPIN) to measure short-term toxicity-induced volatility and suggest it as an early warning system for regulators before triggering trading halts or other actions to prevent crashes. VPIN is controversial, however, due to possibilities of false positives, limited preventive capacity, difficulty in calculation in fragmented or single trading platforms (Chakrabarty, Pascual, & Shkilko, 2015), statistical integrity (O'Hara, 2015), and unfavorable findings from various empirical studies (Cheung, Chou, & Lei, 2015; Pöppe, Moos, & Schiereck, 2016). In a similar vein, Bethel et al. (2011) suggest a yellow-light signal approach in real time to allow regulators to decelerate the trading pace rather than suspend trading.

Radical suggestions like Volume-Synchronized Probability of Informed Trading (VPIN: a proxy to measure information asymmetry) can have inadvertent consequences as well. It is entirely possible that—like circuit breakers—VPIN may reinforce the magnet effect on top of deteriorating volatility and worsening liquidity. For instance, in a Subrahmanyam-esque market, VPIN approaching a limit means an impending halt. Thus, some market actors trade prematurely (i.e., in advance of what an optimal trading strategy entails), which intensifies order imbalance and—ipso facto—pushes VPIN towards the limit. Additionally, liquid investors may recoil from trading activities since the ex-ante impact of limits/halts amplify the spread of small orders, further aggravating short term volatility. Unfortunately, these issues are, thus far, only evaluated on theoretical terms of by experimental markets.

8. Conclusion

Ever since the financial crisis spurred by subprime mortgage debacle, and especially in wake of emerging market crises in 2015 onward, many regulatory bodies on stock markets have implemented circuit breakers to thwart irrational mania of investors by facilitating a forced cool-off period. The purported rationale is that a calmer market carries less risk and thereby attracts more participants by elevating resource re-allocation function of markets. However, these circuit breakers constrict intraday movements by forcing a move within a bounded interval bracket. Typically, these limits are decided on by governing agencies such as securities and exchanges commissions by preset volatility percentages against previous trading day's close price. A survey of prevalent circuit breakers around the world shows that usually the upper and lower limits of circuit breakers are often symmetric, although recently various exchanges have imposed market-wide circuit breakers for bearish scenarios only. The uncertainties baked in with extreme volatilities of stock markets worldwide led to widespread concern for stability from experts. A common understanding is that intraday swings of prices that are not connected to fundamental aspects of an economic entity hinder the market's capacity to allocate economic resources effectively. Furthermore, the recent controversies regarding flash clashes and high-frequency trading's role in worsening volatilities of prices in the markets also contribute to the ongoing debate on how to curb the irrational price swings. While it is true that automated trades minimize trade costs and transaction fees, the lack of human discretion in its trades poses considerable challenges for regulators intent on preserving the market health. In this regard, circuit breakers pose an attractive choice to interrupt undesirable trading patterns. Despite such prospects of utility, due to a mixture of unflattering theoretical and empirical performances, efficacy of circuit breakers remains hotly contested. More specifically regarding magnet effect, though nearly all theoretical and most of empirical works support the hypothesis, suggesting that a flaw exists at the design level, the general trend among regulators and exchanges is to embrace them. In fact, barring emergency discretionary trade suspensions, we found no incidence of an exchange consciously deserting an existing circuit breaker regime (with the minor exception of the Chinese abandonment in 2016). Juxtaposing the magnet effect studies upon its sister hypotheses related to circuit breakers (volatility spillover, trading interference, price discovery delay), the regulatory disregard for this subset of market microstructure research has been somewhat puzzling. However, upon deeper inspection of methodological constraints and design challenges of such studies, the regulatory incredulity appears more of sympathy. In this paper, we consolidate the theoretical and empirical literature pertaining to magnet effect hypothesis and highlight the drawbacks of such studies which needs to be redressed in academia before regulators begin to take its findings more seriously.

Having surveyed nearly a hundred studies relevant to the magnet effect, we are encouraged by several innovative suggestions that have emerged in recent times. These include multi-tiered circuit breakers, coordinated cross-market circuit breakers, hybrid volatility interruptions, VPINs, etc. Also, on the theoretical front, it appears that acknowledgement of the circuit breakers' potential to induce the magnet effect is driving researchers to pay greater attention to the design of circuit breakers. These efforts underline significant progress after nearly two decades of incremental fine-tuning of the mechanism by most exchanges. However, these innovative practices are taking place only in a few highly developed and liquid markets. We anticipate another 5-10 years before the innovations are more widely implemented globally. The emerging market exchanges stand to suffer the most in this regard, which already grapple with a combination of ineffective regulation, weaker governance, higher market manipulation, and lax enforcement. Nevertheless, the encouraging new changes in the realm of circuit breaker practice are sure to motivate a sprawling body of new literature testing its efficiency. We hope that our suggestions of extending the scope of research in this domain are heeded by researchers so that we have a well-rounded answer to not merely whether circuit breakers are a good idea but also their ties to other fundamentals connected to economics and accounting.

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Table 1: Circuit Breaker Practices Around the World.

	Panel A: Australasia						
No	**Exchange**	**Symbol**	**City**	**Country**	**Static Limit**	**Dynamic Limit**	**Remarks**
1	Shanghai Stock Exchange	SSE	Shanghai	China	±10%		A-Shares; different limits for special treatment stocks
2	Hong Kong Stock Exchange	HKEX	Hong Kong	Hong Kong	±10%		Volatility Control Mechanism suspends trading for 5 minutes if limit is exceeded.
3	Tokyo Stock Exchange	TSE	Tokyo	Japan	±¥30-¥7000000		Absolute Yen values depending on price day's closing price or special quote
4	Korea Exchange	KRX	Busan	Korea	±15% (Equities) 10%-20%-30% (SSF)		
5	Taiwan Stock Exch	TSE	Taipei	Taiwan	±10%		No limit for newly listed stocks. Non-convertible bonds are subject to ±5% limit.
6	Indonesia Stock Exchange	IDX	Jakarta	Indonesia	±10%		
7	Bursa Malaysia	MYX	Kuala Lumpur	Malaysia	±30%	±8%	FBMKLCI is subject to 1 hour of trading halt if down by 10%. 20% fall thereafter is a day-long halt.
8	Malaysia Derivatives Exchange	BMDB	Kuala Lumpur	Malaysia	±10%		Not applicable to spot month trades of futures.
9	Philippine Stock Exch	PSE	Manila	Philippines	50% up, 40% down	20%, 15%, 10%	10% drop in benchmark index triggers a 15-minute market-wide halt.
10	Singapore Stock Exchange	SGX	Singapore	Singapore		±10%	5-minute cooling period. SGX is, as of 2019, mulling ±30% and ±10% collars for pre-opening and mid-day/closing auctions.
11	Stock Exchange of Thailand	SET	Bangkok	Thailand	±30%	±1 price spread	±60% fluctuation is tolerated for foreign stocks
12	National Stock Exchange of India	NSE	Mumbai	India	±10% ±15% ±20%	None	Different tiers apply to different times of the day, leading to halts of 15, 45 or 105 minutes. In case of subsequent trigger, daylong trading may be suspended.
							±20% limits apply to debentures and preference shares.
13	Pakistan Stock Exchange	PSX	Karachi	Pakistan	±5%, 7.5%, 10%	None	
14	Tadawul	TADAWUL	Riyadh	Saudi Arabia	±10%	None	
15	Borsa Istanbul	ISE	Istanbul	Turkey	±10%	None	15-minute suspension
16	NASDAQ Dubai		Dubai	UAE	±10%		
17	Australian Securities Exchange	ASX	Sydney	Australia	None	None	Provisions for halt on discretionary basis or at the request of a company or anticipating announcement.
18	New Zealand Stock Exchange	NZSX	Wellington	New Zealand	Varying	Varying	Ranges from 10% to 85% for minimum offer prices based on references prices. For bid prices, the band is substantially wider; ranging from 125% to 1000%.

	Panel B: Africa						
No	Exchange	Symbol	City	Country	Static Limit	Dynamic Limit	Remarks
1	Algiers Stock Exch	SGBV	Algiers	Algeria	None	None	
2	Bourse Regionale des Valeurs Mobilieres	BVRM	Abidjan	Cote D'Ivoire	±15%		Overnight
3	The Egyptian Stock Exch	EGX	Cairo	Egypt	±10%	±5%	30-minute suspension for dynamic limit triggers
4	Ghana Stock Exch	GSE	Accra	Ghana	±7.5%		
5	Nairobi Securities Exch	NSE	Nairobi	Kenya	±10%		Overnight
6	Malawi Stock Exch	MSE	Blantyre	Malawi	None	None	
7	Stock Exch of Mauritius	SEM	Port Louis	Mauritius	None	None	
8	Casablanca Stock Exch	Casa SE	Casablanca	Morocco	None	None	
9	Bolsa de Valores de Mozambique	BVM	Maputo	Mozambique	±15%	None	
10	Nigerian Stock Exch	NSE	Lagos	Nigeria	±10%		Compounded
11	Johannesburg Stock Exchange	JSE	Johannesburg	South Africa	None	None	

	Panel C: Europe						
No.	Exchange	Symbol	City	Country	Static Limit	Dynamic Limit	Remarks
1	Wiener Börse	XWBO	Vienna	Austria	2%-4%	None	Exchange discretion
2	Euronext Paris	XPAR	Paris	France	±10%	±2%	4-minute suspension
3	Deutsche Börse Group	XETRA	Frankfurt	Germany	±5%	Conditional	Depends on volatility
4	Athens Stock Exch	XATH	Athens	Greece	±10%-20%	None	15-minute break.
							10% for FTSE/ASE20
5	Irish Stock Exch	XDUB	Dublin	Ireland	None	None	Depends on volatility
6	Borsa Italiana	XMIL	Milan	Italy	±10%	None	Based on opening price
7	Euronext Amsterdam	XAMS	Amsterdam	Netherlands	±10%	±2%	Based on overnight price change
8	Oslo Stock Exchange	XOSL	Oslo	Norway	None	None	Exchange discretion
9	Moscow Exchange	MISX	Moscow	Russia	±30%-40%	None	Doesn't apply to negotiated trades

10	Stockholm Stock Exchange	XSTO	Stockholm	Sweden	None	None	
11	SIX Swiss Exchange	XSWX	Zürich	Switzerland	None	±1.5%	5-minute interruption
12	London Stock Exchange	XLON	London	UK	Yes	±5%	5-minute interruption

Panel D: North America

No.	Exchange	Symbol	City	Country	Static Limit	Dynamic Limit	Remarks
1	Toronto Stock Exchange	TSX	Toronto	Canada	±10%	None	5-minute cooling period
2	NASDAQ	NASDAQ	New York	USA	7%, 13%, 20%	None	Market-wide
3	New York Stock Exchange (1)	NYSE	New York	USA	7%, 13%, 20%	None	Rule 7.12-E: part of cross-market trading halt scheme that can be activated in 3 levels. This pilot project has been proposed to be extended as of 3rd quarter of 2019.
3	New York Stock Exchange (2)	NYSE	New York	USA		±5%; ±10%	LULD: Limit-up Limit-down scheme is a trading curb that imposes a two-tiered limit based on Tier 1 and Tier 2 classification and nominal value of the stocks. For stocks valued over $3, 5% and 10% are imposed for Tiers 1 and 2 during market hours. For stocks valued between $0.75 and $3, a uniform limit of 20% applies. The above limits do not apply during market open or close.
3	New York Stock Exchange (3)	NYSE	New York	USA	10%, 20%, 30%		Rule 80B: three levels of market wide circuit breaker are activated based on a 10%, 20% or 30% drop in the Dow Jones Industrial Average.
4	Chicago Mercantile Exchange	CME	Chicago	USA		DCB Variant	Dynamic Circuit Breaker (DCB) references the prior day's settlement price during market opening to set upper/lower limits through a rolling lookback window. Triggering the circuit breaker reinstates the order book to pre-open market state for 2 minutes.

Note: This table chronicles the various circuit breakers employed by stock exchanges around the world. The information is procured from a variety of sources including public domain information, website disclosures, day trading of the world guidebooks, consultancy firm reports, etc.

Table 2: Survey of empirical works on magnet effect

No.	Study	Year	Subject of Study	Data Used	Period Covered	Magnet Effect?	Methodology
1	Arak & Cook	1997	USA: Treasury Bond Futures	Intraday	1980-1987	No	Two multiple linear models
2	Berkman & Steenbeek	1998	Japan: Nikkei 225 Futures	Intraday	1992	No	Quadratic model
3	Huang et al.	2001	Taiwan: Stocks	End of Day	1990-1996	No	Event study
4	Hall & Kofman	2001	USA: Frozen Concentrated Orange Juice Futures (FCOJ) on NYBOT	End of Day	1988	No	GARCH (1,1)
5	Cho et al.	2003	Taiwan: Stocks	Intraday	1998-199	Yes	AR (3) GARCH (2,2)
6	Goldstein & Kavajecz	2004	USA: NYSE Market	Intraday	1997	Yes	Event study
7	Chan et al.	2005	Malaysia: Kuala Lumpur Stock Exchange Stocks	Intraday	1995-1996	Yes	Event study
8	Du et al.	2006	Korea: Stocks	Intraday	1998-1999	Yes	Time-distanced quadratic modeling
9	Bildik & Gulay	2006	Turkey: Borsa Istanbul Stocks	End of Day	1998-2002	Yes	Kim & Rhee (1997)
10	Abad & Pascual	2007	Spain: Spanish Stock Exchange Stocks	Intraday	2001-2006	No	Seemingly Unrelated Regression (via FGLS)
11	Hsieh et al.	2007	Taiwan: Stocks	Intraday	2002	Yes	Logistic regression
12	Wong et al.	2009	China: Shanghai Stocks	Intraday	2002	Yes	Monte Carlo simulation; AR (3) GARCH (2,2)
13	Hsieh et al.	2009	Taiwan: Stocks	Intraday	2000	Yes	Logistic regression
14	Tooma	2011	Egypt: 4 Stocks from Egyptian Stock Exchange	End of Day	1997-2002	Yes	Logistic regression
15	Omar	2012	Egypt: Stocks	End of Day	1999-2009	Yes	Event study
16	Levy et al.	2013	USA: Pork Bellies and Oats Futures	End of Day	1970-2010	Yes	Logistic regression
17	Kim et al.	2013	China: Stocks	End of Day	1997-2000	No	Event study
18	Dabbou	2013	Tunisia: Stocks	End of Day	2007	No	ARIMA
19	Xu et al.	2014	China: Shanghai	Intraday		Yes	Power law dynamics of cumulative abnormal returns
20	Brugler & Linton	2014	UK: FTSE-100 Stocks	Intraday	2011	Yes	MA (1) EGARCH; Variance Ratio
21	Wan et al.	2015	China: Stocks	Intraday	2000-2012	No	Comparison of probability density functions
22	Wu et al.	2017	China: Shanghai and Shenzen Stocks	Intraday	2000-2011	Yes	Multiple linear regression
23	Wong et al.	2020	China: Shanghai and Shenzen Index and Stocks	Intraday	2016	Yes	AR (3) GARCH (2,2)
24	Lu	2016	China	End of Day	1997-2012	No	Event study
25	Hao	2016	China: Market-wide	Intraday	2016	No	Difference-in-Difference AR (3) GARCH (1,1)
26	Danisoglu & Guner	2016	Turkey: Borsa Istanbul Stocks	End of Day	1995-2013	Yes	Propensity score matching
27	Aktas	2016	Turkey: BIST-30 Stocks	Intraday	2008	Yes	Event study
28	Sifat & Mohamad	2018	Malaysia: Stocks	Intraday	2015-2017	Yes	Non-linear Autoregressive Distributed Lags
29	Wan et al.	2018	China: Stocks	Intraday	2000-2011	No	Logistic regression
30	Syed & Auret	2018	South Africa: Commodities	End of Day	2010-2017	Yes	Mean comparison
31	Clapham	2018	Xetra and BME: Stocks	Intraday	2011-2015	No	Seemingly Unrelated Regression (via FGLS)
32	Sifat et al.	2019	Malaysia: Stocks	End of Day	1994-2017	Yes	Event study; Mann-Whitney U Test

33	Hautsch & Horvath	2019	NASDAQ: Stocks	Intraday	2010-2014	Yes	Paired t-test; Wilcoxon-Cox Ranked Sum Test

Note: This table chronicles the empirical works surrounding magnet effect of stocks and/or futures up until 2019.

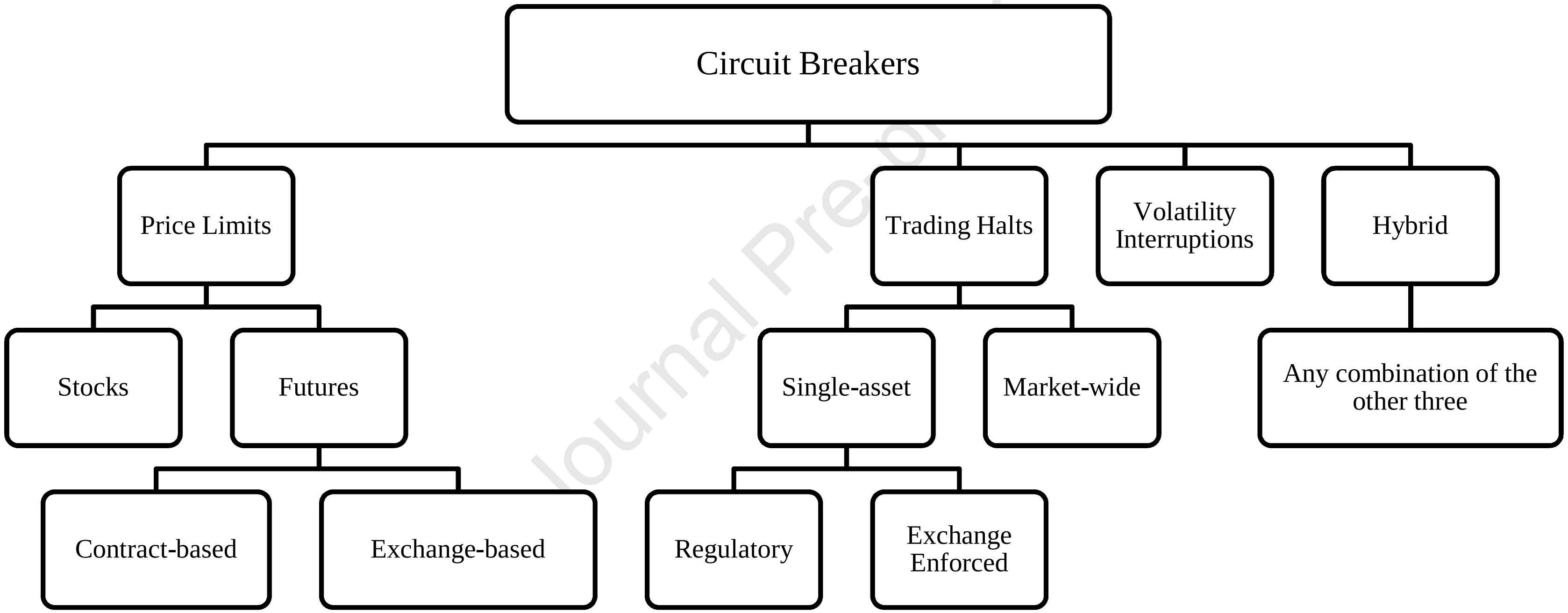

Figure 1: Circuit Breaker Classification

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