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# Harmonized circuit breakers

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# Contents

- 1. Objective ..... 3
- 2. Background..... 3
- 3. Risk assessment ..... 5
- 4. Options ..... 7
- 5. Costs, risks, and benefits..... 8
- 6. The future ..... 9
- 7. Summary ..... 10
- References ..... 12

# Harmonized circuit breakers

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## 1. Objective

Circuit breakers have come into sharp focus as a regulatory tool since the Flash Crash of 2010, which resulted from a single large order which seemed to momentarily have panicked the market. A 10% decline and almost full recovery in an hour is clearly not healthy for financial markets and regulators alike. Many legitimately executed orders were cancelled the next day, taking investors by surprise and such cancellations would not happen in a regime with a circuit breaker in place. Note that episodes like the Flash Crash cannot be ruled out in increasingly high-frequency trading environments where human errors in submitting as well as interpreting new orders have become more likely.

More generally, extreme order imbalances during rapid market movements might create large price pressures and cause investor panic. Circuit breakers that allow a cool-down period and a batching of trades can mitigate this problem. The balance of the evidence thus suggests a cautious case for breakers, namely, to counteract extreme order imbalances, and overly disruptive and possibly erroneous trades.

## 2. Background

We review the literature on circuit breakers and examine whether they may be helpful in protecting the capital and confidence of investors, in the era of increased order fragmentation and increased automated trading. We start with examining the literature on circuit breakers and then move on to discussing automated trading with a focus on the Flash Crash of 2010.

Circuit breakers are usually triggered when prices cross certain pre-established boundaries and cause markets to halt trading for a pre-determined period of time. Such halts allow a cessation of trades before a significant trade imbalance or an important news announcement. Price limits on derivatives markets disallow trade at prices outside of established boundaries, though trade within those boundaries may continue to take place. While price limits date back several decades, circuit breakers are a comparatively new phenomenon.

Circuit breakers came into prominent focus after the market crash on October 19, 1987, when the US market dropped by more than 20%, and again during the Flash Crash of 2010 (discussed later). The general notion is that rapidly falling prices may exacerbate panic amongst investors and cause limit orders to become unfairly stale, and prices may depart from fundamental values owing to panic-driven selling. Circuit breakers that allow a cool-down period and a batching of trades can mitigate this problem. Another reason for breakers is that extreme order imbalances during rapid market movements might result in prices that are clearly at odds with fundamentals. Letting orders accumulate and then batching them may lead to better quality execution prices and thus lower volatility. Finally, circuit breakers may preclude trade at prices that occur in response to automated execution of erroneous order (e.g., those typed in with an extra and erroneous “zero” at the end).

Currently, the NYSE circuit breaker levels are as follows. Circuit-breaker levels are set every quarter as Level 1 (10%), Level 2 (20%), and Level 3 (30%) where the percentages are relative to the closing values of Dow Jones Industrial Average (DJIA) in the last month of the previous quarter. The halt for a 10% decline in DJIA is one hour if it occurs before 2 p.m., for 30 minutes

between 2 and 2:30, but no halts after 2:30. The halt for a 20% decline is two hours if before 1 p.m., and one hour between 1 p.m. and 2 p.m., and market closure for the rest of the day after 2 p.m. If the market declines by 30%, trading does not occur for the remainder of the day. Circuit breakers are also in effect on the London Stock Exchange (the bounds in this case are more complicated, see <http://www.londonstockexchange.com/about-the-exchange/regulatory/lsegresponsetoes-maconsultationonsystemsandcontrols.pdf>).

We will now review the theory and evidence on the efficacy and impact of circuit breakers. Importantly, circuit breakers may affect prices even if they are not triggered. But, since they are triggered so rarely (NYSE market-wide circuit breakers have been triggered only once, in 1997), at the present moment, it is challenging to ascertain their costs or benefits with any degree of reliability. Any discussion of potential benefits has to be based on logic, rather than evidence.

We first review theoretical arguments on breakers. Greenwald and Stein (1991) and Kodres and O'Brien (1994) argue that when noise traders continuously move prices away from fundamentals, more sophisticated traders refrain from trading because prices are noisy. Circuit breakers allow the batching of orders and improving liquidity. A breaker may also decrease volatility because it allows for more time for traders to react. Thus, in sharply falling markets traders may receive margin calls. Without a halt traders may be caught by surprise and may not be able to satisfy their margin calls. This, in turn, may cause brokers to suspect an impending default and sell securities to raise cash. Such orders may lead to further selling which may exacerbate the price decline. A halt that collects and matches orders after trading resumes may allow for more time for margin calls to be fulfilled. This may allow for restored confidence reduced order imbalances, thereby improving liquidity.

In terms of costs, a circuit breaker may affect decisions of investors prior to the triggering of the breaker. Subrahmanyam (1994) demonstrates the "magnet effect." Thus, as the price nears the limit, investors anxious about being denied the opportunity to trade will advance their trades in time, thus increasing trading-generated price volatility. Subrahmanyam (1997) argues that informed agents also might be concerned that their large trades might trigger the breaker. In this case, they would simply reduce their order sizes which would increase the bid-ask spread for small orders. This might end up harming retail investors, who typically submit smaller orders than large institutions.

In terms of empirical evidence, Goldstein and Kavajecz (2004) consider an episode on October 27, 1997, when circuit breakers were triggered. They find that circuit breakers cause a reduction in liquidity on the day following the circuit breaker, because limit order traders do not wish to resubmit previous days' expired orders. This causes a lack of depth in the limit order book. This evidence does not support the notion that circuit breakers calm down markets and increase market liquidity. Likely this happens because market participants are still recovering on the next day from a complete inability to trade, which is a psychologically significant event.

Since circuit breakers are rarely triggered, experimental studies are one way to investigate likely impacts of these impediments to trade. Ackert, Church, and Jayaraman (2001a) conduct such an experiment to focus on the effects of NYSE-type market-wide breakers. They find that circuit breakers cause agents to speed up their trading activity as the price approaches a trigger, supporting a magnet effect. It also is likely that an impending circuit breaker in one market might cause volume to migrate away to another market, an issue that has not yet been tested in an experimental setting. More studies are needed on the magnet effect as well as the

effect of breakers on satellite markets. Following their previous study, Ackert, Church, and Jayaraman (2001b) examine circuit breakers when agents are uncertain about the presence of private information. They find that circuit breakers perform no useful function in experimental asset markets. During a temporary halt, the price moves away from fundamental value in periods without private information (which it should not in a rational market), possibly because agents may be more likely to mistakenly infer that others possess private information. Temporary halt provides traders time for focusing on irrelevant information, as opposed to promoting rational thought.

Kuhn, Kuserk, and Locke (1991) consider cash and futures markets on October 13, 1989, when circuit breakers were triggered. They are not able to find evidence that circuit breakers reduced volatility in either market on the day after the triggering of the breaker. Lauterbach and Ben-Zion (1993) consider order flow data from the Tel-Aviv Exchange during the crash of 1987, when the exchange imposed a closure due to extreme order imbalance. They find that the closure smoothes price fluctuations around the crash but has no long-run impact on the price drop. The evidence supports the notion that long-run price behavior would be unaltered with or without the presence of the breaker.

Santoni and Liu (2003) perform a rare study to directly determine how coordinated circuit breakers adopted by the NYSE, CME, and other derivatives exchanges affect day-to-day volatility. They test for changes in volatility following the adoption of circuit breakers using an autoregressive conditional heteroskedasticity (ARCH) model. Using data from the inception of the breakers after the October 1987 crash to 1991, they find that breakers have had no significant effects on volatility. Kim and Rhee (1997) find that price limits on the Tokyo Stock Exchange result in increased volatility during the days after limit hits, suggesting that price limits may be harmful.

Gerety and Mulherin (1992) investigate how the daily opening and closing of financial markets affects trading volume. They find that closing volume is related to expected price moves overnight and opening volume is positively related to overnight volatility. This indicates that circuit breakers may block the investors' desire to shed risk to others. The difference between a regular and a circuit breaker closure makes it difficult to generalize this finding. Thus, a circuit breaker closure is associated with large market movements and high volatility (when agents would probably be wary of trading even if the market is open), but a regular closing is not.

Importantly, all volatility itself is not harmful to financial markets; instead it is non-informational volatility that is the issue. But, the bulk of the literature has not found solid evidence that circuit breakers reduce or increase any sort of volatility. Thus, it is not possible to state with certainty whether breakers hurt or harm financial markets in general, because they are rarely triggered.

### **3. Risk assessment**

The "flash crash" and concerns about automated trading renewed interest in circuit breakers. In the modern era, large institutional orders are often programmed to execute algorithmically and automatically across markets as well as across time. Algorithms are also used to seek out misaligned prices across multiple markets. Such algorithmic trading is thought to account for 70% of US equity volume (Zhang, 2010 and [en.wikipedia.org/wiki/Algorithmic\\_trading](http://en.wikipedia.org/wiki/Algorithmic_trading)).

Algorithms may improve liquidity if they act as de facto market makers. On the other hand if they create extra imbalance (e.g., by place large orders to exploit pricing discrepancies), they can hurt liquidity. Therefore, whether algorithmic trading is beneficial remains an empirical issue. Hendershott, Jones, and Menkveld (2011) show that when algorithmic activity increases, liquidity increases as well. In recent years (after 2003), the positive impact of algorithmic trading proxies on liquidity has increased. There is other evidence that in the algorithmic trading regime with much higher levels of volume, market quality has actually increased. For example, Chordia, Roll, and Subrahmanyam (2011) show that intraday volatility has declined on the NYSE during recent years. It is also shown using an analysis of hourly to daily variance ratios that prices are closer to the efficient market benchmark of a random walk in recent years.

Dramatic improvements in technology have allowed computer algorithms to speedily discern (possibly short-lived) profit opportunities over units of time as small as microseconds and determine optimal order submission strategies. Such very short-term algorithmic trading is often termed “high frequency trading” (HFT). HFT programs often monitor prices and liquidity across different markets and choose order submission strategies to efficiently execute orders at the lowest cost. A second impetus for this study is the fact that HFT strategies are agnostic to a stock’s price level and have no intrinsic interest in the fate of companies, leaving little room for a firm’s fundamentals to play a direct role in its trading strategies.

The evidence on the impact of HFT on financial markets is mixed, though most studies show HFT is beneficial. Thus, in analyzing the behavior of one high-frequency trading firm, Menkveld (2010) argues that HFT trades are mostly passive, in that their price quotes are “hit upon” by the market 80% of the time, suggesting that HFT traders act as de facto market makers. In this sense they provide liquidity to the market. Hendershott and Riordian (2011) argue that HFT traders trade to remove transitory pricing errors, i.e., price changes that reverse after a short period of time.

Brogaard (2010) finds that HFT not only trade to remove pricing errors, but also add to the “price discovery” process, i.e., their trades incorporate permanent information into stock prices. However, Zhang (2010) finds that a measure of HFT (inferred from changes in institutional holdings) is associated with price overreaction to fundamental news, and also is associated with slightly higher volatility. Biais, Foucault, and Moinas (2010) argue that faster computerized trading exposes human traders to “adverse selection.” Specifically, since computers can react faster to news, they can submit or cancel orders faster than investors, leaving humans exposed to adverse price moves. Chaboud, Chiquoine, Hjalmarsson, and Vega (2009) find that algorithmic trades in general are more cross-correlated than human trades, suggesting that algorithmic trading may contribute to market instability.

High frequency trading has order cancellation rates in the region of 90% and Madhavan (2012) argues that these strategies are not well understood. For example, some high-frequency traders allegedly use quote stuffing, characterized by unexpected increases in quote frequency without any significant information releases. The idea is to spam an exchange with a lot of quotes in a short span of time creating a false illusion that there is interest in a stock when there is none, and canceling such quotes later. An arbitrage opportunity is created if exchanges become overwhelmed with such orders and lag other exchanges, and traders are tricked into submitting orders on the belief that is indeed an interest in a stock. Egginton, Van Ness, and Van Ness (2011) indirectly investigate this practice by looking at periods of high quote volume, and conclude that stocks become more illiquid and volatile during such periods. Hasbrouck and Saar (2010) examine low-latency strategies, i.e, those strategies that trade in units of

milliseconds. They explore submitted, executed, and cancelled orders likely part of an HFT program. They argue that low latency HFT activity improves market quality measures such as liquidity and volatility.

Overall, some studies find that algorithmic trading is harmful to markets and many find that it is beneficial. It is therefore difficult to conclude one way or the other whether HFT trading should be regulated or controlled from a policy perspective, via circuit breakers or via some other method.

On May 6, 2010, U.S. stock markets and associated derivatives lost more than 5 percent, and recovered most of it in less than an hour. This “Flash Crash” was a momentous event in the stock market (like the October 1987 crash) that attracted the interest of many policymakers and regulators. A survey conducted by iShares/Blackrock

([http://www.cftc.gov/About/CFTCCcommittees/CFTC.../cftcsecac\\_archardstudy.pdf](http://www.cftc.gov/About/CFTCCcommittees/CFTC.../cftcsecac_archardstudy.pdf)) found that 46% of investors believed that HFT was the biggest cause of the Flash Crash. Kirilenko et al. (2010) find, however, that HFT trader inventories remained rather small throughout the Flash Crash, suggesting that HFT traders did not cause the crash. Specifically, the Flash Crash was triggered by a 75,000 contract sell program, and net holdings of the HFTs were so modest that HFTs could not have caused volatility on the day of the flash crash. Madhavan (2012) finds that strong evidence that securities that experienced greater prior fragmentation of orders across multiple exchanges were disproportionately affected on May 6, 2010. He suggests that when markets are fragmented, prices are more sensitive to liquidity shocks because fragmentation leads to each venue’s limit order book being thinner than in a consolidated market setting.

The Flash Crash affected many investors, primarily because exchanges cancelled trades at prices below 60% of the 2:40 pm ET price, but many investors whose execution prices did not meet the 60% threshold lost considerable wealth. In addition, the cancellations themselves caused an erosion of investor confidence. The risk is that without circuit breakers, investors will continue to lose confidence if rogue algorithms cause events similar to the Flash Crash.

## 4. Options

The options available to regulators are to impose price-triggered circuit breakers, triggered upon point movements in one market, percentage movements in one market, point movements in multiple markets, and percentage movements in multiple markets.

Alternatives to such halts are of course to do nothing, or to impose “sidecars”, where market orders are batched over short intervals and then matched against limit order books, and moving from a continuous auction to batching orders during extreme market moves, which would potentially slow trading down and calm markets. The latter options do not cause all cessation of trade and price discovery, but may still not resolve the problem of extreme order imbalances due to panic-driven selling by retail investors in response to rogue algorithms. As pointed out earlier, the breaker would be designed to reduce panic during times of extreme market declines triggered possibly by anomalous algorithms.

## 5. Costs, risks, and benefits

In general, markets become fragile when significant imbalances arise because of very large anomalous orders. Such orders may be larger than what market makers are willing to hold, and this may cause a crash because no-one may be willing to take the other side without a significant price drop. As markets become more institutionalized and automated, regulation may be required. Thus, since the flash crash, there have been moves to regulate high-frequency trading. Indeed, there has been some talk about having algorithms vetted by regulators (<http://www.ft.com/cms/s/0/28130ab2-650c-11e0-9369-00144feab49a.html>). However, such efforts may be misplaced because, as we have seen, the evidence is not conclusive on whether HFT helps or hurts markets.

The flash crash has also resulted in the imposition of stock-specific circuit breakers. For example, under recent rules, trading in the larger stocks would pause for a five-minute period in the event that the stock experiences a 10 percent change in price over the preceding five minutes. The trigger is larger for small caps not in the Russell 2000: it is 30% for stocks with a previous-day closing price of \$1 or more, and 50% for penny stocks. The avowed objective again is to promote market confidence by allowing market participants time to assimilate information and mobilize liquidity during periods of sharp and potentially destabilizing price swings. The NYSE also has introduced liquidity replenishment points (LRP) that preclude automatic execution beyond a lower trigger, typically 2 to 4% price movements. It is too early to tell whether these impediments have hurt or helped the US stock markets.

As pointed out in the previous section, the main drawback of circuit breakers are possible “magnet effects” and the inability of investors to realize their trading needs in a timely manner (after the breaker has been triggered). An ancillary drawback is that with the breaker in place there is no liquidity at all. Also, with a breaker in place investors may become complacent and stop monitoring their systems. It is, however, hard to believe that these costs of circuit breakers are material when a completely unexpected algorithm moves markets by a large amount like in the Flash Crash. Such an algorithm is unlikely to cause a magnet effect precisely because it is unpredictable (recall magnet effects are caused when investors accelerate their trading in response to an *anticipated* triggering of the breaker). In addition, the consideration during the Flash Crash was a temporary and unexpected slide in the market at prices completely at odds with fundamental values and in this situation the objective is to prevent trade at these prices not facilitate trades.

Further, as we already have observed, during the Flash Crash prices fell so quickly that exchange officials had to cancel already-executed orders. This type of phenomenon seriously threatens investor confidence. One does not, as an investor, expect that an already executed order will be nullified the next day. A circuit breaker has the distinct advantage of preventing such order cancellations because when the market is closed due to the breaker being triggered, no order can execute.

Finally, when prices fall, Avery and Zemsky (1998) argue that traders may condition their trades only on past sell orders and sell even if their own information tells them to buy. This may exacerbate a market crash. By interrupting a sequence of sell orders, a circuit breaker can also prevent this phenomenon. While the same argument would also apply to buy orders, policy-makers are much more concerned about falling markets as traders derive more disutility from a

loss of wealth than utility from a gain in wealth of the same magnitude (Kahneman and Tversky, 1979).

Given the experience with the crash there is a compelling and important case to be made for circuit breakers that would act as a calming influence on the market and build investor confidence. This point is also made by Kirilenko, Samadi, Kyle, and Tuzun (2011) who argue that “appropriate safeguards must be implemented to keep pace with trading practices enabled by advances in technology.” There are, however, a few issues to be resolved before circuit breakers are imposed to prevent Flash Crashes and similar episodes of extreme order imbalances.

First, with deeply fragmented markets and inter-related assets, it is a challenge to make circuit breakers in the modern era successful. For example, if a breaker is triggered in a primary exchange, the volume is sure to migrate off-exchange, specifically, in the case of institutional volume, to a dark pool where institutions can directly cross orders. Indeed, dark pools are increasing in popularity and one was recently introduced in Switzerland (<http://www.marketwatch.com/story/swiss-exchange-launches-dark-pool-venture-2011-07-08>). Zhu (2012) indicates that dark pools handled about 12% of total order flow in the US during 2011. Patterson (2010) states that in December 2010, the NYSE handled only 37% of the total equity volume. In Europe Chi-X, NYSE Euronext, and other exchanges all attract a considerable fraction of volume. Specifically, the primary regulated exchanges handle only about 60% of volume for the Stoxx Europe 600 index (Fioravanti and Gentile, 2011).

Because of fragmentation it is imperative that breakers be coordinated. If not, a disruptive algorithm will simply search for execution at avenues other than the closed exchange, moving disruption elsewhere. Indeed, one issue the Flash Crash raised was precisely that of coordinating circuit breakers. In the flash crash, the derivatives exchange (CME) hit circuit breakers but NYSE did not. This meant that CME derivatives halted trading, but cash products at NYSE did not. This paradoxically led to situations where equity orders were executed and got cancelled whereas derivatives hedges did execute when markets opened after the breaker. Thus investors lost money on the hedges (Madhavan 2012). Had the breakers been applied to both exchanges, this phenomenon would not have taken place. Overall, the preceding arguments strongly indicate that closures should be coordinated across markets to preclude the possibility of disruptive trading automatically moving to other markets.

The final issue has to do with trigger points. Investors obviously would prefer to have a continuous market to realize their trading needs. Thus the triggers for circuit breakers should be set wide enough to not interfere with the trading process. A price triggered breaker should be used only during periods of extreme market stress due to extreme order imbalances. Also, different markets have different index levels and different degrees of volatility. A price trigger therefore, should be based on percentage, rather than point moves to allow for comparable triggers across markets. While the breaker, once applied, should be coordinated, if different markets have extremely varying levels of volatility, the trigger may also be based on volatility levels on each individual market.

## 6. The future

Since circuit breakers are designed to apply to financial markets, before reviewing the future of circuit breakers, it is worth reviewing what roles financial markets serve in society. First, prices

in financial markets serve as (imperfect) signals about the health of companies and the overall economy. A rising price/market index signals a healthy stock/economy and vice versa. Second, financial markets serve as arenas where people can choose an appropriate risk appetite. If they want to take on more risk in the expectation of a higher return, they would use stocks as an appropriate investment vehicle. Circuit breakers impede these roles by interrupting the continuous availability of market prices and by precluding investment trades. Because they are an imposition on the financial system, they should be used with caution.

Algorithmic trading is often viewed as a threat to the stability of financial markets. The evidence on this issue is mixed. Many studies find that automated algorithmic trading has improved pricing efficiency and liquidity but at least one study finds that it has increased volatility. The evidence does not provide a strong case for circuit breakers. There also is a concern that algorithms can be designed to counteract circuit breakers. For example, orders can be split up to ensure that price changes occur slowly and breaker bounds are not tripped.

The problem is compounded by the fact that little evidence in the literature that these benefits of breakers actually transpire. Specifically, for example, there is no evidence that breakers reduce volatility after trade recommences, and no evidence that they reduce panic-driven selling. In fact, there is some evidence in an experimental setting that breakers encourage magnet effects, wherein subjects advance their trading before the breaker bounds are crossed. Further, the situations that any proposed breakers might be designed to address (like the Flash Crash) are episodic in nature.

Overall, the above observations suggest that the future of circuit breakers should take into account the fact that they are impediments to trade. While markets with circuit breakers in place like the NYSE have flourished, so there is no significant cost based on the US experience, there is always the future danger that the breaker, if it is triggered too frequently, could cause institutions to lose confidence in financial markets. It is therefore necessary that the harmonized breaker be designed to be triggered only in extreme cases where prices clearly depart from fundamentals by a wide margin (such as in the case of the Flash Crash).

## 7. Summary

Circuit breakers may help combat extremely disruptive trades such as the single large order which caused a 10% decline and almost full recovery in an hour. Such declines and corrections lead to reduced investor confidence, which is compounded by the possibility that without the breaker, with extremely disruptive algorithms, orders executed at prices far from fundamentals may need to be cancelled (as in the Flash Crash), further eroding investor confidence. In general, any event that causes extreme order imbalances can lead to panic in stock markets, and circuit breakers may have a calming influence.

What type of breakers are the best way to go about the design? First, the trigger bounds should be wide enough and the duration short enough (e.g., an hour) that the normal functioning of financial markets is not impeded. Second, given that disruptive trades can hit any stock, they should be implemented at the level of the individual stock. Third, to reduce disruption when reopening, the breakers should batch accumulated market orders at the reopen. Fourth, given the considerable levels of fragmentation in financial markets, one should use coordinated halts that are triggered using percentage movements on more than one exchange. This is imperative also because of algorithmic trades that involves “sweep orders”

which scan all exchanges for the best available execution price. The preclusion of trade in one market could automatically allow search in substitute markets. An erroneous order could then have a disruptive effect in those markets which eventually would spill over to the primary market (possibly causing a longer closure). Thus, coordinated halts would preclude halts being triggered on an anomalous trade on a single exchange, and also prevent preclude traders from migrating other exchanges and disrupting trade at alternative venues. Finally, different markets use different point systems to compute indices. Triggers should be based on percentage, rather than point moves to ensure consistency.

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