Intraday Rallies and Crashes: Spillovers of Trading Halts

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Abstract

This paper analyses a set of intraday rally and crash events at the firm level during the single stock circuit breaker (SSCB) program, and documents the cross-sectional spillover effects of such events on non-halted stocks. We test whether such major price jumps, and subsequent trading halts, affect related stocks through the destabilizing arbitrage channel. We find that extreme price movements that trigger the circuit breakers at the firm level are accompanied by a massive surge in volume, spread and short-term volatility, which gradually revert back to normal. Speculative strategies of arbitrageurs such as momentum and pairs trading cause cross-sectional spillovers in volume and volatility during the trading halt.

(J.E.L Classification: G12, G14, G18, G28)

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1 Introduction

Modern trading environment which largely benefits from the advances in technology is also more exposed to technical problems associated with automated trading. At the same time, security prices react much faster to news thanks to the speed technology. Hence it is not uncommon to see market disruptions by extreme intraday price movements. On 8 July 2015, NYSE stopped trading due to an internal technical issue, similar to the Nasdaq halt in 2013.[1] Both U.S. equity (2010) and treasury markets (2014) have experienced flash crashes, that is, abrupt intraday price movements with a fast recovery. Such intraday events raise concerns about the correct policy response to avoid potentially adverse effects of intraday trading turmoil on market stability.

As one of the policy measures to prevent market disruptions, market-wide circuit breakers have been in place since the October 1987 crash (Goldstein and Kavajecz, 2004; Goldstein, 2015). Circuit breakers aim at temporarily suspending trading under extreme market conditions to prevent excessive intraday price fluctuations. On the unusual turbulent day, the Flash Crash, 6 May 2010, the existing market-wide circuit breaker failed to stop sharp price downturn of individual stocks. Following the Flash Crash, the U.S. Securities and Exchange Commission (SEC) launched a new single stock circuit breaker rule (SSCB, hereafter). The rule stipulates that stocks whose price moves 10 percent or more in a five-minute window should be halted for a five-minute period.[2] The trading suspension can be triggered either be a large discrete price jump or a cumulative price change over the five-minute window.

Our first contribution is a detailed analysis of such intraday events at the firm level. We look into 54 SSCB events that involve only S&P 500 or Russell 1000 firms, and take place during the period between June 2010 and April 2013. Unlike the earlier studies that focus

[1]There are other examples from the international markets. For instance, trading on the Mumbai stock exchange, BSE, stopped several hours on 3 July 2014. Similarly, trading on the Phillippine Stock Exchange (PSE) halted on several days in August 2015. On 7 January 2016, Chinese stock market halted in the opening minutes due to an automatic circuit breaker.

[2]The circuit breakers are implemented during the continuous trading hours from 9.45am until 3.35pm.

on the Flash Crash (e.g., Easley et al., 2011; Kirilenko et al., 2014; Madhavan, 2012), we filter out a set of intraday rallies and crashes at the firm level that trigger the SSCB. These events are not caused by market-wide volatility or material news, that is, news released by the firm that affects the fundamental value, e.g., stock splits or earning announcements. However, there may be firm-specific non-material news circulating in the financial media, e.g., merger/buyout talks or rumors regarding a restructuring, that trigger the SSCB. We first document the trading activity around SSCB events to understand how the trading halts affect different measures of market quality such as volume, spread and volatility.

Our primary objective is to understand the implication of such intraday extreme price movements and subsequent trading halts on market stability. Our strategy is to test the cross-sectional spillover effects of trading halts on other stocks, that is, any effect on the trading activity of related non-halted stocks.[3] In particular, we investigate the speculative activity of arbitrageurs, as one of the channels for such cross-sectional spillover effects. De Long et al. (1990) show that in a market with feedback traders, rational speculation may be destabilizing. In light of the De Long et al. (1990) model, the paper by Lou and Polk (2013) propose a comomentum measure, that is, an abnormal return correlation among stocks controlling for Fama-French risk factors, which reflects the speculative activity of arbitrageurs (Moskowitz et al., 2012). Using their measure, we first identify the set of candidate stocks that are part of a momentum strategy. Given the lack of a fundamental anchor (Stein, 2009), such feedback trading is more likely to have a destabilizing effect, that is, moving prices away from the fundamental value. We question whether such arbitrage activity has destabilizing effect on market quality beyond price efficiency. We also consider an anchored arbitrage strategy, namely, pairs trading that exploits the price discrepancy between historically similar stocks (Gatev et al., 2006; Do and Faff, 2010), as a potential channel for spillover effects.[4] Thus we test how the results on the spillover effects depend on

[3]Our focus on cross-sectional spillover effects (Brugler and Linton, 2016) is different from the earlier literature on volatility spillover, that is, the effect of circuit breakers on volatility in subsequent periods (see, e.g., Abad and Pascual, 2013) .

[4]We implement two versions of pairs trading: with and without an industry match between the stocks in

the existence of a price anchor.

Our first observation is that extreme intraday price jumps are temporary, and revert back quickly in the case of intraday crashes. Earlier studies on the Flash Crash event (e.g., Easley et al., 2011; Kirilenko et al., 2014; Madhavan, 2012) document a similar temporary price effect. However, intraday rallies exhibit persistent price effects if there are firm-specific news on the day of the SSCB. This result is consistent with the prediction of De Long et al. (1990) that asset prices overreact to news due to both positive feedback traders and anticipatory trades of rational speculators.[5] We also observe that circuit breakers are triggered by abnormal trading activity, that is, activity compared to a 30-day benchmark, in particular high trading volume and volatility along with increased spread just before the trading halt. If there is news associated with the firm on the SSCB day, the abnormal trading activity already starts five minutes before the trading halt. After trading resumes, the abnormal trading activity reverts back to its normal level in about 20 minutes only if there are no news. The changes persist beyond half an hour in the case of firm-specific news. The difference-in-differences (diff-in-diff) analysis shows that the abnormal trading activity on the SSCB day is not driven by a common shock to firms with similar characteristics, such as price, market capitalization or index membership.

Our main contribution is to identify the channel through which the abnormal trading activity is transmitted to related non-halted stocks during the trading halt. We show that mainly the firms which are part of a risky arbitrage activity that involve SSCB stocks are affected by the trading halts. In particular, speculative portfolio strategies such momentum trading or pairs trading cause trading externalities during extreme market conditions. The former strategy bets on the price trend of a group of stocks, that is, winner stocks with a better past return performance, while the latter places speculative bets on the price convergence between stocks with similar past price paths. The diff-in-diff analysis reveals that

the pair. The former strategy is restricted to stocks within the same industry.

[5] In a recent paper, Fishe et al. (2015) show the existence of anticipatory traders in the market who detect the local price trends before the other traders.

the SSCB trading halts cause abnormal volume and short-term volatility spillovers for these non-halted stocks in the arbitrage portfolio. To the best of our knowledge, none of the earlier papers investigate the implication of such arbitrage strategies on liquidity and volatility transmission across stocks.

There is some theoretical literature that analyzes the role of circuit breakers on market quality. According to the models, circuit breakers may serve as safeguards by providing a cooling-off period that allows extra time to reassess trading decisions (Ma et al., 1989), reduce transactional risk (Greenwald and Stein, 1991), and lower information asymmetry in the presence of information frictions (Spiegel and Subrahmanyam, 2000). If traders incur adverse selection costs, then introducing circuit breakers might be beneficial for market participants by reducing volatility while increasing trading volume. However, circuit breakers might also have an adverse effect on volatility. According to the Subrahmanyam (1994)'s model, large liquidity traders might anticipate trading halts, and rush to trade to satisfy their trading needs, and hence cause the so-called magnet effect.

Earlier empirical studies show that rule-based trading halts, such as the SSCBs introduced by the SEC, affect market activity, and result in high trading volume without reducing volatility (Abad and Pascual, 2010; Ferris et al., 1992; Martens and Steenbeek, 2001). However, consistent with the Subrahmanyam (1994)'s model, Lee et al. (1994) find that both volume and volatility significantly increase in a matched sample analysis around discretionary suspensions.[6] On the other hand, Lehmann (1989) and Goldstein and Kavajecz (2004) show evidence in favor of the magnet effect. In our SSCB setting, where the trading halts are not triggered by material information released by the firm, information asymmetry is unlikely to play a major role, instead the speculative activity of arbitrageurs would generate higher volume and an adverse effect on volatility on SSCB days.

There is less theoretical guidance on the spillover effects of circuit breakers on other related stocks. Spiegel and Subrahmanyam (2000) propose a model in the context of in-

[6] Subrahmanyam (1995) compares discretionary vs. rule-based (automatic) trading suspensions.

formation disclosure, and conjecture spillover effects on firms in the same industry. The model developed by Cespa and Foucault (2014) propose that (il)liquidity can be contagious across assets through a multiplier mechanism: the price of one security is a noisy signal for traders in other securities, so if a price shock to one security changes the view or risk appetite of traders on other securities, this information learning process will yield a similar return pattern. However, neither of the models are directly applicable to the SSCBs.

Jiang et al. (2009) find that trading halts cause a liquidity impact on informationally related stocks, which are identified as the stocks in the same four-digit SIC industry. We deviate from the earlier literature which focuses on the information channel for the spillover effects. In light of the De Long et al. (1990) and Stein (2009) models, we use the identification strategy suggested by Lou and Polk (2013) and Gatev et al. (2006) to collect a set of stocks that are part of an unanchored and anchored arbitrage strategy, respectively. In the absence of asymmetric information, we would expect increased volume and volatility of non-halted stocks through the speculative activity of arbitrageurs, without a significant change in spreads. Thus, we test whether there are liquidity and volatility spillovers across securities through the risky arbitrage channel during the trading halts triggered by intraday rallies and crashes. The recent finding by Goldstein (2015), that NYSE's Rule 80A is effective in reducing volatility spillover to the cash market from the futures market, hints at the importance of the arbitrage channel in the context of circuit breakers.[7]

In a concurrent working paper, Brogaard and Roshak (2015) test the ex-ante effects of price limits during the same SSCB period, and find evidence on less aggressive trading of informed market participants supporting the holding back hypothesis proposed by Subrahmanyam (1997). Our focus is different, since we study the intraday events caused by non-material information where informed trading is less likely to be the primary channel. In another recent working paper, Brugler and Linton (2016) study the cross-sectional spillover

[7]Rule 80A, a market-wide circuit breaker involving trades of S&P 500 constituents, limits index arbitrage traders' ability to post directional orders following large price changes in the market index to avoid destabilizing effects across markets.

effects of circuit breakers implemented on the London Stock Exchange (LSE). However, they mainly focus on the hedging motive proxied by market-wide shocks as the main channel for the spillover effect, while market-wide information plays no role in our setting.

The remainder of the paper is organized as follows: In Section II, we describe the data and explain our identification strategy. In Section III, we provide empirical results on abnormal trading activity of SSCB stocks. We show evidence on non-halted stocks in Section IV. In Section V, we conclude.

2 Data

In this section we first explain the details of our data collection to construct the set of SSCB events. Next, we discuss the identification of related non-halted stocks for each SSCB event.

2.1 SSCB Events

We obtain data from various data sources: intraday trades and quotes data are from the daily TAQ dataset via WRDS. We also collect company information from the CRSP daily stock files. After the Flash Crash on 6 May 2010, the SEC introduced the single stock circuit breaker (SSCB) program in three phases: Phase I (11 Jun 2010 - 13 Sept 2010) which applies only to S&P 500 stocks, Phase II (14 Sept 2010 - 7 Aug 2011) which also includes Russell 1000 firms, and Phase III (8 Aug 2011 - 8 April2013) until the start of the Limit up limit down (LULD) regulation.[8] The last phase included all NMS stocks (see Figure 1). In our main analysis we focus only on the most liquid S&P 500 and Russell 1000 firms.[9] To identify SSCB stocks, we use an algorithm that checks both the trade resumption condition,

[8]Under the LULD mechanism, individual stocks are halted only if a trade occurs outside the price band which is set dynamically. Under the new regulation, the number of halts is reduced substantially, except the day, 24 Aug 2015, when there were 1,278 trading halts for 471 different ETFs and stocks (CNBC, 2015, http://www.cnbc.com/2015/09/25/what-happened-during-the-aug-24-flash-crash.html).

[9]For the less liquid NMS stocks traded above (below) $1, the halt was triggered after a 30 (50) percent price jump.

the duration of the halt, and the size of the price jump preceding the halt. We filter out quotes with special conditions, that is, quote mode different than 11. We cross-validate each SSCB event collecting firm-specific news from the Factiva database. We limit our sample to common stocks (share code 10 and 11) with only a single halt in a day, and trading at a price higher than $1 on the SSCB day.

We apply several filters to make sure that the trading is not halted via another type of circuit breaker, for example, circuit breaker triggered by order imbalance (mode code=7) or pending news (mode code=11). We excluded all the events with a scheduled company announcement, SEC filings, initial public offerings, stock splits or reverse splits. We create a dummy variable to control for the *non-material* news on the day of the SSCB, that is, any unexpected news or rumor that might trigger the trading halt. Our final SSCB sample consists of 54 trading halts on NYSE and Nasdaq exchanges during the period between 16 June 2010 and 27 March 2013.[10] As Appendix Table A.1 shows, the sample includes several well-known companies such Washington Post, Citigroup, Adobe, Apple, Dell, Visa, Mastercard and others. In Appendix Table A.2, which describes SSCB event details, we report the ratio of the VIX index on the day of the SSCB relative to the average index level in the SSCB month. On average, this ratio is not statistically different from one, suggesting that SSCB events are ideosyncratic events, and not triggered by market-wide shocks.[11]

2.2 Identification

In this section we explain our identification strategy to construct a set of candidate stocks which are related to the SSCB stocks through the arbitrage channel. In particular, we consider two types of arbitrage strategies: i) *momentum* (feedback) trading initiated by rational speculators, an unanchored strategy (De Long et al., 1990; Stein, 2009)[12], and ii)

[10] See Appendix Table A.1 and Table A.2 for SSCB stock and event details.

[11] There is only one case with two correlated SSCBs: both Visa and Mastercard experience the trading halt on the same day. Our Factiva news search shows that the SSCBs are related to the Fed's proposal of debit card fee raise.

[12] According to Nanex research available at http://www.nanex.net/aqck/2950.html, momentum ignition events triggered by predatory high frequency traders are ubiquitous in the recent period.

pairs trading which is based on exploiting the deviations from the relative-value arbitrage rule, an anchored strategy (Gatev et al., 2006; Do and Faff, 2010).

2.2.1 Momentum stocks

This section describes how we define *momentum* stocks for each SSCB stock that was halted during the SEC pilot period. Our aim is to measure the effect of firm level intra-day rally and crash events on other stocks that are related to halted stocks through the destabilizing arbitrage activity. First, we focus on a portfolio strategy which relies on past performance of stocks: stocks are sorted based on their past returns over a formation period, then past winners are bought and past losers are shorted (Jegadeesh and Titman, 1993). This strategy involves risks since the investor places a bet on the continuation of a price trend.

We identify momentum stocks based on the degree of abnormal return correlation with SSCB stocks (Lou and Polk, 2013). This methodology allows us to capture the connection between the SSCB stocks and other related stocks which arbitrageurs are likely to consider as part of a momentum trading strategy in the absence of a fundamental anchor, that is, a clear valuation benchmark. Following Lou and Polk (2013) we find canditate momentum stocks that have abnormal return correlation with the SSCB stocks after controlling for the three Fama-French risk factors:

$$partialCorr(ret_i, ret_{-i}|mkt, smb, hml) \tag{1}$$

where ret_i is the daily return of stock i in our 54 SSCB sample, ret_{-i} is the daily return of any S&P500 or Russell 1000 common stock (with a price greater than \$1) except for stock i, mkt is the market factor, that is, the excess return on the broad market index, smb is the size factor, that is, the return on the small market cap minus the large market cap stocks, and hml is the value factor, that is, the return on the stocks with high book-to-market ratio

minus the return on the stocks with low book-to-market ratio. We obtain residuals of the previous six-month daily return after controlling for the three Fama-French risk factors, and then calculate the pairwise partial correlations between the residuals of the halted SSCB stock and other eligible stocks. The stocks with a significant partial return correlation (at the 1% level) with a halted SSCB stock are identified as momentum stocks. We select the five strongest candidates with the highest (absolute) partial correlation, for each SSCB stock, to create a balanced panel of 270 momentum stocks. We report the results of the balanced panel in the main analysis to compare different arbitrage strategies.

2.2.2 Pairs trading stocks

Pairs trading is a simple statistical arbitrage strategy that involves identifying stocks with similar price paths and a bet on the convergence of the prices whenever they drift apart. The price of the other stock in the pair provides a tangible price anchor. Such an anchored strategy based on relative pricing may improve price efficiency due to law of one price, assuming that both stocks in the pair are close substitutes. Yet, this strategy clearly involves risks as well since pairs are identified based on the historical data and on the implicit assumption that the relative price relation will hold in the future.

Using data over forthy years, Gatev et al. (2006) document that pairs trading strategy is highly profitable, even after taking into account transaction costs, bid-ask bounds and short-selling costs. Do and Faff (2010) confirm their evidence using a more recent sample involving the crisis period. Engelberg et al. (2009), on the other hand, show that pairs trading profitability depends on both ideosyncratic news and liquidity shocks to the stocks in the pair that trigger the divergence in prices.

We follow Gatev et al. (2006) to find the candidate stocks of a pairs trading strategy for each SSCB stock. Using a one-year data before each SSCB event, we consider only those stocks from the CRSP daily files, which have at least one trade each day during the formation period. Then we compute a cumulative total returns index for each SSCB stock

over the formation period. We select candidate stocks for each SSCB stock by minimizing a distance measure between the price paths based on the sum of squared deviations. To form a balance panel as we did above for the momentum strategy, we choose the top five strongest candidates with the minimum distance measure relative to each SSCB stock.[13] In addition to the unrestricted search, we also conduct a second search to find potential candidates for the pairs trading, but this time, considering the 2-digit SIC industry code. This tighter match, which also captures the *industry* channel, may potentially yield a stronger transmission mechanism. However, this industry link is distinct from the information channel considered in earlier studies (e.g., Spiegel and Subrahmanyam, 2000; Jiang et al., 2009).

2.3 Descriptive Statistics

Table 1 shows the summary statistics for SSCB and other related non-halted stocks. In the table, we report information regarding the non-halted stocks identified via momentum trading, pairs trading and pairs trading within the same industry. The last column reports the pooled results across different arbitrage strategies. The number of circuit breakers in our sample varies across years with a maximum of 26 in 2011. Correspondingly, for each arbitrage strategy the number of related non-halted stocks changes each year. We categorize the SSCBs by the direction of the price jump, that is, *rally* versus *crash*, and we also report whether the price jump is discrete or cumulative in the five-minute period before the trading halt. The majority of the jumps are intraday rallies. Over two third of the SSCB events are cumulative jumps suggesting that some of these events might be related to intraday momentum strategies, in particular positive feedback trading, rather than an abrupt expreme price movement.

[Table 1 about here.]

Based on the Factiva search, we identify 34 SSCB events associated with firm-specific non-material news. In the last column of Appendix Table A.2, we provide the details of news

[13] For two SSCB stocks, we cannot find a sufficiently large set of pairs trading stocks.

information we collected from Factiva. For example, while the news about a merger talk with Microsoft might have triggred Adobe intraday rally, the news about the failed labor agreement could be the cause of the AMR Corporation intraday crash, which is the parent company of American Airlines.[14] The remaining 20 SSCB halts are triggered by either a fat finger trade[15], technical problems, e.g., the BATS platform technical issue in the case of Apple intraday crash, or other unidentified reasons.

There is some dispersion in our sample in terms of price and market capitalization of SSCB stocks. The average price of the SSCB stocks is $52.90 with an average market capitalization of $37 billion. Apple stock has the highest share price in our sample, followed by Washington Post. The top three largest companies are Apple, ExxonMobil and Cisco systems. The median price of non-halted stocks ($24.98) is similar to the median price of SSCB stocks ($26.86), while the market capitalization of non-halted stocks is smaller compared to SSCB stocks.[16]

3 SSCB stocks

In this section, we explore how the trigger of the circuit breaker at the firm-level affects the price dynamics, and different aspects of market quality such as volume, liquidity and volatility of halted securities on the day of the SSCBs.

3.1 Price dynamics

Single stock circuit breakers temporarily suspend trading under extreme price movements. Our first task is to understand how the prices evolve around intraday rallies and crashes at the firm level. We first look at the speed of adjustment of prices to the pre-halt

[14] Since we do not know the exact timing of the news release, we cannot make a causal claim.

[15] For example, in the case of Anadarko petroleum which was trading at $38.64 per share prior to the SSCB, an erroneous trade at $99,999.09 triggered the halt according to Wall Street Journal.

[16] The main reason for this difference is that, following Gatev et al. (2006) we consider all liquid CRSP stocks for the pairs trading strategy regardless of the index membership.

level 20 minutes around the SSCB events. In Figure 2, we plot the average price of each SSCB stock normalized at the price that prevailed 20 minutes before the trading halt.[17]

[Figure 2 about here.]

Panel A of Figure 2 shows the price paths of intraday rallies for both news and no news cases. Our first observation is that, regardless of the related news, prices remain flat with no significant change until five minutes before the circuit breaker is triggered. Prices build up relatively slowly few minutes before the halt, in the events with news, resembling feedback trading activity, while there is an abrupt price jump just before the SSCB trigger in the case of no news. We note a larger price jump (with a wide confidence interval) if there is no news, presumably due to fat finger trades or other technical problems. Interestingly, after trading resumes, prices revert back to normal levels relatively fast, within five minutes, in the events with no news. However, when there is firm-specific news circulating in the financial media, prices remain abnormally high in the post-event window. This finding is in line with the overreaction of prices to news as predicted by the De Long et al. (1990) model.

The picture is different for intraday crashes. The intraday crashes are more similar to the Flash Crash event studied in other papers (Easley et al., 2011; Kirilenko et al., 2014; Madhavan, 2012). The prices are not significantly different from the benchmark price 40 minutes around the halt, with a large sudden downward spike right before the halt, particularly in the case of no news. In the SSCB events with news, prices gradually drop before the halt and revert back to normal after the halt.[18]

3.2 Market quality

A policy relevant question is whether the implementation of the single stock circuit breakers was effective in improving market quality. However, we do not observe the counterfactual,

[17] We exclude one outlier related to a fat finger trade (Anadarko petroleum) from this part of the analysis.

[18] We have only six (nine) crash observations with news (no news) associated with the event. Hence, the confidence bands around the average prices, computed using non-parametric rank test, are relatively wider.

that is, what would have happened if the trading halt had not been in place. Nevertheless, it is informative to see how the trading halt affects the course of trading on a SSCB day compared to other days. We focus on different dimensions of market quality measures such as trading activity (number of trades, number of quotes, share volume of trades, dollar volume of trades), liquidity (quoted, relative and effective spread), short-term volatility measured by (high-low)/high midquotes, and order-to-trade ratio (OTR), a proxy for algorithmic trading (AT) (Skjeltorp et al., 2013)[19], 40 minutes around the SSCB events.[20] The quoted spread is the time-weighted difference between ask and bid prices. Relative spread is the time-weighted average of the ratio of quoted spread over the prevailing midquote. Finally, effective spread is a time-weighted average of the ratio of two times the absolute value of the difference between transaction price and the prevailing midquote over the midquote.

In order to control for intraday effects and firm characteristics, we compute abnormal market quality measures by taking into account a 30-day average calculated from the same intraday period 30 days around the SSCB event, excluding the SSCB day. We follow Lee et al. (1994), Corwin and Lipson (2000) and Christie et al. (2002), and compute the percentage change of market quality measures relative to the benchmark period as follows:

$$\frac{mq^{SSCB\ days} - mq^{benchmark}}{mq^{benchmark}} \tag{2}$$

In Panel A of Table 2, we test whether market quality measures are significantly different than the 30-day benchmarks. We note that indeed all the measures are significantly higher than the normal levels, both in a short five-minute window, and a larger 20-minute window. One exception is the OTR measure which is significantly lower both before and after the trading halt (approx. by 32% just before the halt, and by %60 in the five minutes after the

[19] Skjeltorp et al. (2013) argue that this proxy is highly correlated with HFT activity, identified in studies with higher quality data using cancellations or HFT flags (e.g., Hendershott et al., 2011; Hasbrouck and Saar, 2013; Brogaard et al., 2014). Hagströmer and Norden (2013) also show that market making HFTs have higher OTR compared to other types of HFTs.

[20] We extended the window up to one hour. The results are very similar, but we lose some observations, in particular those events which take place early or late in the day.

halt).[21] This preliminary evidence hints at the extraordinary trading conditions on the day of the SSCB event.

[Table 2 about here.]

Next, we investigate in detail the evolution of three main dimensions of market quality. Figure 3 illustrates the abnormal (share) volume, relative spread, and volatility for SSCB stocks. In each panel, we show news and no news cases separately. The total 40-minute observation window is divided into one-minute increments. For each one-minute interval, we calculate the abnormal market quality measures, and then take the average across all SSCB stocks. The vertical lines indicate the 95% confidence bands.

[Figure 3 about here.]

3.2.1 Volume

Panel A of Figure 3 shows that the trading volume is not abnormally high until five minutes before the trading halt. Volume gradually increases in the last few minutes before circuit breaker is triggered. In the last minute before the halt, in the SSCB events with news (no news) trading volume jumps to a 50 (35) times higher level than the 30-day benchmark. We already notice the difference between news and no news cases when the volume builds up before the halt, but the differences become especially pronounced once trading resumes. In the no news cases, volume quickly reverts back to normal levels right after two minutes after the halt. However, in the news case, the share volume remains at high levels in the first few minutes after the resumption of trading, and decays gradually afterwards. It stays at significantly higher levels (compared to no news case) even after 20 minutes of trading. The causal link between news and trading volume has been long established (e.g., Karpoff, 1986; Hong and Stein, 2007). Disagreement about the news (Hong and Stein, 2007), differences

[21] This reduction in OTR could be driven by reduced AT activity due to uncertainty. However, since we do not have a better proxy for AT or market making HFT activity, we do not explore this further.

in prior expectations (Karpoff, 1986) or speculative trading due to overreaction to news (De Long et al., 1990) may explain the elevated trading volume.

3.2.2 Liquidity

Panel B of Figure 3 shows that the relative spread is not abnormally high until the last two minutes before the trading halt. In fact, it does not change significantly before the halt in the SSCB events with no news, while it increases almost 75% in the last minute of trading before halt when there is news. While trading volume either stays at the same level or reduces after the resumption of the trade, we observe a significant increase in transaction costs right after the halt, and more pronounced for the SSCB events with news. The trading remains shallow in the next five minutes with a significant increase in illiquidity. Afterwards, relative spreads revert back to the normal level in the SSCB events with no news, but spreads stay at significantly higher levels even 20 minutes after the halt when there is news. Higher trading volume coupled with increased transactions costs suggest aggressive trading using market orders to bet on the news. This conjecture is in line with the prediction of the (De Long et al., 1990) model where feedback traders post market orders based on past price changes.

3.2.3 Volatility

Panel C of Figure 3 shows that the pattern of short-term volatility is similar to the one of relative spread before the SSCB trigger: sudden increase in volatility in the last minute of trading before the halt (though with a much larger magnitude, 20 times the normal level in the case of news) which remains high after trading resumes. Differently though, volatility stays at significantly high levels beyond five minutes, both in news and no news cases, reflecting the uncertainty following the trading halts. This latter finding is in contrast with the evidence shown Christie et al. (2002) who document reduced post-halt uncertainty due to information transmission during the halt.

3.2.4 Matched Sample

In order to see whether the abnormal trading activity on the SSCB day is also documented in other stocks with similar firm characteristics, we conduct a difference-in-differences (diff-in-diff) test using a matched sample of stocks that are not subject to the trading halts due to a SSCB trigger. In particular, following Davies and Kim (2009), we match each SSCB stock one-to-one to a control stock within the same index, that is, S&P 500 or Russell 1000, based on the share price and market capitalization.[22] The results reported in Panel B of Table 2 are very similar to the results shown in Panel A which are also confirmed by the graphical evidence provided in Appendix Figure A.1. This suggests that firm characteristics alone, including the index membership, cannot explain the abnormal activity on SSCB days.[23]

Overall, the pattern of intraday volume, spread and volatility are broadly consistent with the abnormal activity reported in some of the earlier studies on circuit breakers (e.g., Lee et al., 1994; Corwin and Lipson, 2000). However, the mechanism behind is different: SSCBs are not triggered by material news releases or order imbalances as it was the case in those studies. Thus, we conjecture that even in the absence of the information channel, the activity of a certain type of market participants, namely arbitrageurs in the market, affects the trading dynamics of other stocks through their speculative strategies, in particular during market disruptions. In the next section, we explore different types of (risky) arbitrage strategies, and test whether the speculative activity of the arbitrageurs causes cross-sectional liquidity and volatility spillover during the trading halts.

4 Non-halted stocks

An important, yet less studied, aspect of circuit breakers is the implication of such a trading friction on overall market stability. In this section, we explore the repercussions

[22] The matching is conducted based on the average closing price and market capitalization one month before the SSCB event.

[23] In Appendix Table A.3, we also show the diff-in-diff results at the event level.

of circuit breakers on other related stocks that continue trading during the SSCB trading halt. Specifically, we test whether price dynamics, liquidity and volatility measures of related non-halted stocks are affected via risky arbitrage activity by the SSCB triggers, and subsequent trading halts. The related non-halted stocks are identified via two types of arbitrage strategies explained in Section 2.2: momentum stocks (unanchored) and pairs trading stocks (anchored) with and without industry matching. We use the above mentioned abnormal market quality measures relative to the 30-day benchmark around the SSCB day.

In order to examine the dynamic response of non-halted stocks to SSCB events, we provide graphical evidence on the price dynamics (Figure 4), and on different dimensions of market quality, that is, share volume (Figure 5), relative spread (Figure 6) and short-term volatility (Figure 7), over a 40-minute observation window around the SSCB event. The total 40-minute observation window is divided into one-minute increments. For each one-minute interval, we calculate the abnormal measure for each stock, and then compute the average across all non-halted stocks within the same arbitrage category.

4.1 Price dynamics

In Figure 4, we plot the average price of each non-halted stock normalized at the price that prevailed 20 minutes before the trading halt. The left (right) column shows the rallies (crashes). Each row corresponds to a set of non-halted stocks identified with a different arbitrage strategy. The gray shaded area in the figures indicate the five-minute trading halt. First of all, regardless of the arbitrage strategy, we note that the price of the non-halted stocks react to the triggered of the SSCB. In the first row, we see that the price of momentum stocks significantly increase during the trading halt, though the magnitude of the price change is substantially lower compared to SSCB stocks. In the case of intraday rallies, the prices stay at slightly higher levels even after the trading halt, similar to the observation we made for SSCB stocks. On the contrary, in the case of intraday crashes, prices immediately revert back to the pre-halt levels. For pairs trading stocks, the figures

are very similar to the ones of the momentum stocks during intraday crashes, regardless of the industry matching. However, we note that intraday rallies do not cause significant price changes (wide confidence bands) for non-halted pairs trading stocks without industry matching. On the other hand, the price jump is significant for the pairs trading stocks in the same industry, hinting at the importance of destabilizing effect of arbitrage activity via industry channel, even for anchored strategies.

[Figure 4 about here.]

4.2 Market quality

We next look at how share volume, relative spread and volatility of non-halted stocks are evolve around the SSCBs. If the destabilizing trading activity of the arbitrageurs cause spillover effects, as we conjecture, then we should observe abnormal trading activity on SSCB days around the trading halts (the gray shaded in the figures below).

4.2.1 Volume

Figure 5 shows the abnormal share volume of the non-halted stocks identified through different arbitrage strategies. Regardless of the type of arbitrage strategy, we note that share volume significantly jumps (above 50%) just before the trading halt, and gradually decreases during the halt with another significant jump when trading resumes after the halt. Compared to anchored pairs trading strategies, the decline in trading volume is more gradual in the case of momentum stocks with abnormally high volume even several minutes after the halt which eventually reverts back to the normal level.

[Figure 5 about here.]

4.2.2 Liquidity

Figure 6 which shows the abnormal relative spread of the non-halted stocks draws a different picture. In none of the panels, the illiquidity is abnormally high before the halt,

ruling out any market-wide liquidity shock as the trigger of the trading halts. The liquidity of momentum stocks is unaffected both during and after the halt. However, we do see a significant increase in relative spreads of pairs trading stocks (both with and without industry matching). There is only a temporary jump in illiquidity after trading resumes, which reverts back to the normal level two minutes after the halt.

[Figure 6 about here.]

4.2.3 Volatility

Figure 7 reveals that the short-term volatility of the momentum stocks starts increasing gradually in the last five minutes before the halt with a significant jump (around 40%) in the last minute, and it remains at high levels during the halt with some decline towards the end of suspension. The volatility jumps again once trading resumes and declines only gradually to normal levels. In the case of anchored strategies, we do not observe a clear pattern in volatility before the halt, but the volatility remains at high levels during the halt, with a significant jump (more than 50%) right after the SSCB trigger in the case of pairs trading with industry matching. While trading resumes at high levels of volatility, it reverts back to normal relatively fast.

[Figure 7 about here.]

4.3 Difference-in-differences

The graphical evidence in the previous section shows that the market quality measures are abnormally high during the SSCB trading halt for the non-halted stocks identified through different arbitrage strategies. The results reported in Panel A of Table 3 confirm this evidence for a larger set of market quality measures. We note that regardless of the arbitrage strategy used to identify the non-halted stocks, trading activity, volume and volatility significantly increase for non-halted stocks. We also observe an increase in illiquidity of non-halted

(around 5% overall) during the halt, however the change is not significant for momentum stocks. We also do not observe any significant change in the OTR measure of non-halted stocks, a proxy for AT, once we focus on strong candidates for arbitrage activity.

[Table 3 about here.]

In order to pin down the channel for the cross-sectional spillover effects during the SSCB halts, we conduct a difference-in-differences (diff-in-diff) test using a matched sample of stocks that are not candidates of any arbitrage strategy we consider in relation to the SSCB stocks. In particular, following Davies and Kim (2009), we match each non-halted stock one-to-one to a control stock based on share price and market capitalization. For example, in the case of momentum stocks, we choose control stocks among the S&P500 and Russell 1000 index firms which have no significant partial correlation (after controlling for three FF risk factors) both with the SSCB and momentum stock, and are matched to each momentum stock one-to-one based on price and market capitalization. For the control group of pairs trading stocks, we sort candidate stocks based on the distance of price paths, and consider the bottom 500 stocks with the maximum distance to the SSCB stocks, that is, the least likely candidates for pairs trading. Using the same two characteristics, price and market capitalization, we match each pairs trading stock one-to-one to a control stock. We follow the same strategy for pairs trading stocks within the same industry, imposing the constraint that the control stock belong to the same 2-digit SIC code of the SSCB stock.[24]

We report the results of the diff-in-diff tests in Panel B of Table 3 for each arbitrage strategy. The last column also shows the pooled results. The evidence clearly shows that the speculative activity of the arbitrageurs in the market is an important channel in transmitting volume and volatility increases to other non-halted stocks. Incidentally both increase around 14% above the 30-day benchmark during the halt compared to the control sample. However,

[24]Imposing the industry constraint on the control group reduces substantially the number of potential matches as a control. Therefore, some stocks in the control group still can be weak candidates for pairs trading.

there is no significant change in illiquidity of non-halted stocks, except for pairs trading stocks, once the control sample is taken into account.[25]

In Table 4 we show the diff-in-diff results for different categories of SSCB events. In Panel A, we compare intraday rallies with crashes, and events with non-material news versus events with no news. We note that trading activity and volatility of non-halted stocks significantly increase both for intraday rallies and crashes, with no significant change in spread measures. On the other hand, we observe that the spillover in trading volume and volatility is particularly strong when there is news on SSCB days. Interestingly, the only case with significant increase in spreads is when there is no news associated with SSCB events, e.g., fat finger trades or other technical problems. Next, we sort the non-halted stock based on two firm characteristics, share price and market capitalization, and report the results for top and bottom quintiles. We note that volume and volatility spillover effects do not primarily come from extreme price quintiles, yet the liquidity of lower price stocks are significantly affected by SSCB trading halts. However, volatility spillovers mainly concentrate around larger stocks.

[Table 4 about here.]

Next, we run a panel regression to see how firm and event characteristics affect the diff-in-diff results shown in previous tables. The dependent variables are share volume, relative spread and short-term volatility. As control variables we include share price, market capitalization, primary exchange of both SSCB and non-halted stocks, *momentum*, a dummy variable indicating whether the non-halted stock is part of momentum strategy, *pairs trading*, a dummy variable indicating whether the non-halted stock is part of pairs trading strategy, and *industry*, a dummy variable equal to one if both SSCB and correlated stocks are in the same 4-digit SIC industry. We also control for the following characteristics of the SSCB events: *rally* a dummy variable equal to one if it is an intraday rally, *news*, dummy variable equal to one if there is non-material news found on Factiva on the SSCB day, *disc*, a dummy

[25] Graphical evidence provided in Appendix Figure A.2 confirm these findings.

variable equal to one if the circuit breaker is triggered by a discrete jump, *weekday*, week day of the SSCB event, *time*, time (in seconds) of the SSCB trigger relative to 9.45am, the level of the VIX index on the SSCB day, and the abnormal VIX measured as the VIX level on the SSCB day relative to the average VIX level in the SSCB month.

[Table 5 about here.]

Table 5 shows that most of the firm and event characteristics due not explain the differences between the abnormal trading activity of non-halted stocks relative the matched control sample during the trading halt. In line with the evidence in Panel B of Table 3, the volume effect is particularly strong for the momentum stocks, that is, those stocks which are part of an unanchored risky arbitrage strategy (Stein, 2009). The absence of any news on the SSCB implies a higher abnormal spread for non-halted stocks during halt. This result, also confirmed in Panel A of Table 3, suggests the lack of any firm-specific news on the day of the SSCB creates uncertainty, and hence causes illiquidity for other non-halted stocks in the arbitrage portfolio. None of the controls considered in the table explain the volatility spillover to non-halted stocks. Most importantly, neither the VIX level nor the abnormal measure of VIX, is significant in the regression. This result lends strong support for the idiosyncratic nature of the SSCB events. Overall, the table confirms our initial conjecture that the arbitrage channel is the major driving force behind the cross-sectional spillovers to non-halted stocks.

5 Conclusion

This is one of the first studies that analyses a set of intraday rally and crash events at the firm level during the SEC initiated single stock circuit breaker (SSCB) program. These intraday events that are unrelated to material news release by the firm or other market-wide information shocks, provide an ideal setting to analyze the effects of circuit breakers to other non-halted stocks beyond the information channel. Our identification of related non-halted

stocks through the arbitrage channel differentiates our study from other papers, and helps us test the effects of such trading interventions on other related stocks in the context of market quality beyond price efficiency.

Our results show that the circuit breakers not only interrupt the trading activity of halted stocks but also affect the volume and volatility of other related non-halted stocks through the speculative trading strategies of arbitrageurs. Our evidence on the role of arbitrageurs for cross-sectional spillovers during market disruptions is highly relevant for the revived discussion on the introduction of transaction (Tobin) tax in the securities markets to limit speculation. Yet, our analysis solely focuses on the behavior of a subset of market participants in a stylized setting, namely arbitrageurs who take risk following speculative trading strategies such as momentum or pairs trading. It would be interesting to look at the interaction of different type of market participants, say, arbitrageurs versus (high frequency) liquidity suppliers identified using direct measures such as HFT flags, to have a complete picture on cross-sectional spillovers.

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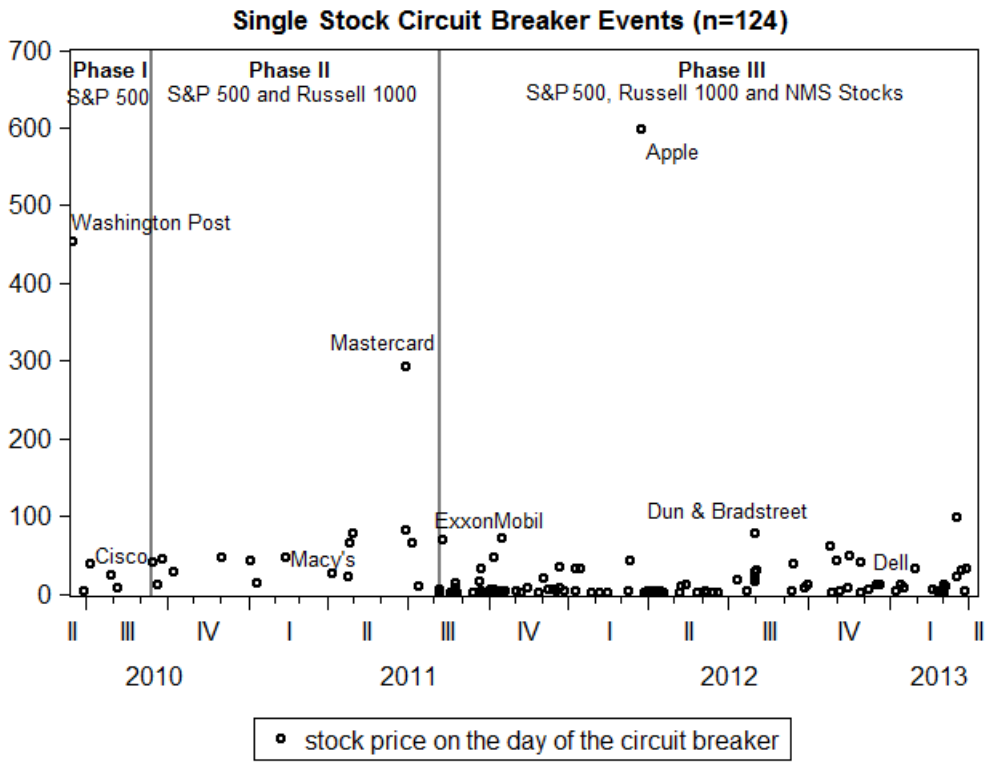
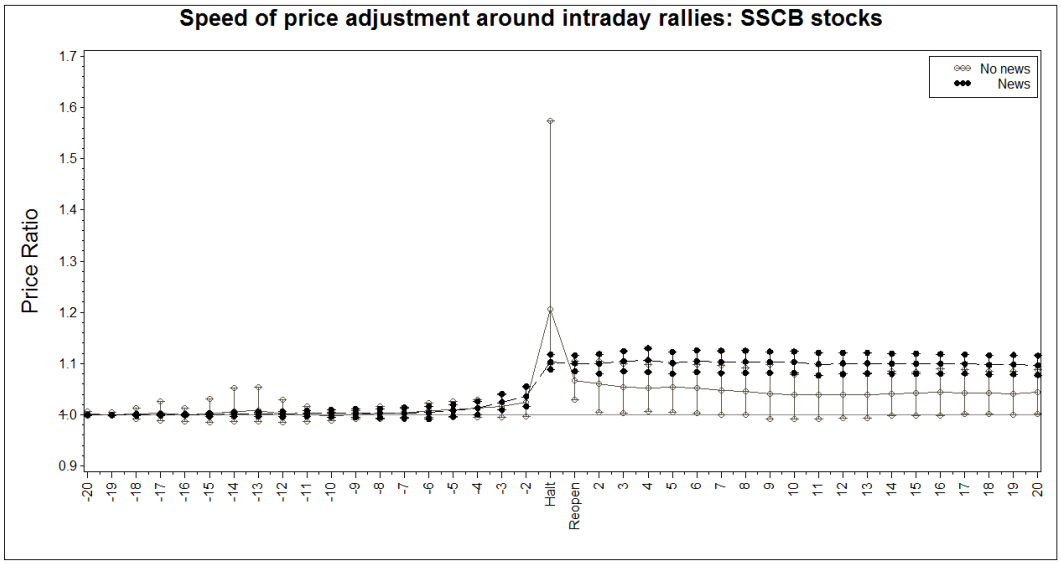
Figure 1: SSCB events



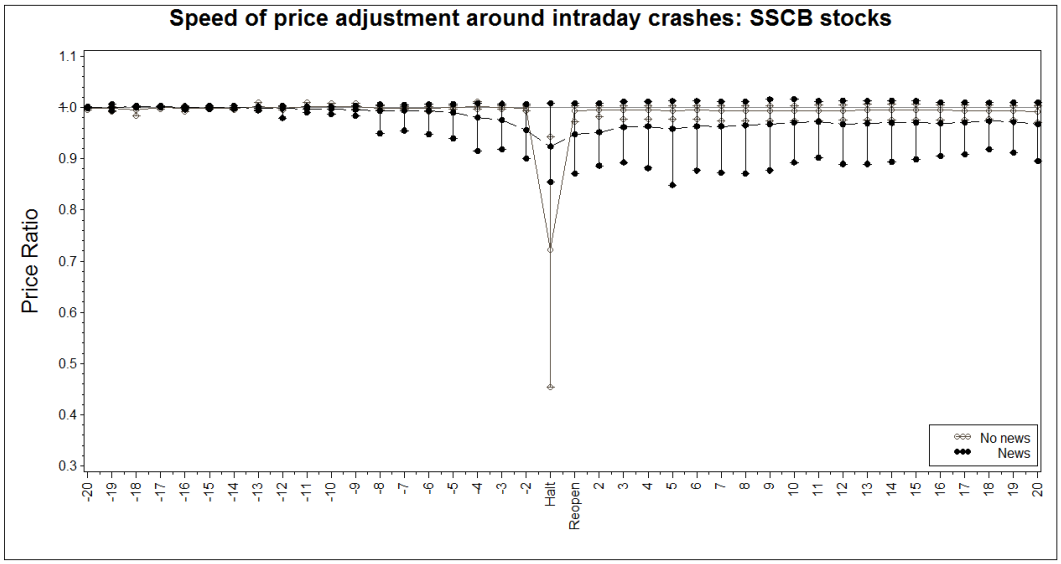
The figure shows the SSCB events over the SEC pilot period between June 2010 and April 2013. The x-axis is the time of the SSCB event. The y-axis shows the price of individual SSCB stocks. The vertical lines shows the three phases of the pilot program: Phase I from 11 June 2010 until 13 September 2010 which includes only S&P 500 stocks, Phase II: from 14 September 2010 until 7 August 2011 which also includes Russell 1000 firms, and Phase III from 8 August 2011 until the start of the Limit up limit down regulation on 8 April 2013. The last phase includes all NMS stocks.

Figure 2: Speed of price adjustment on SSCB days: SSCB stocks

(a)



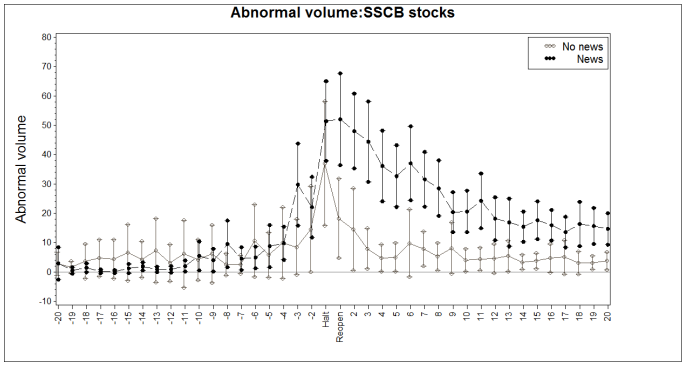
(b)



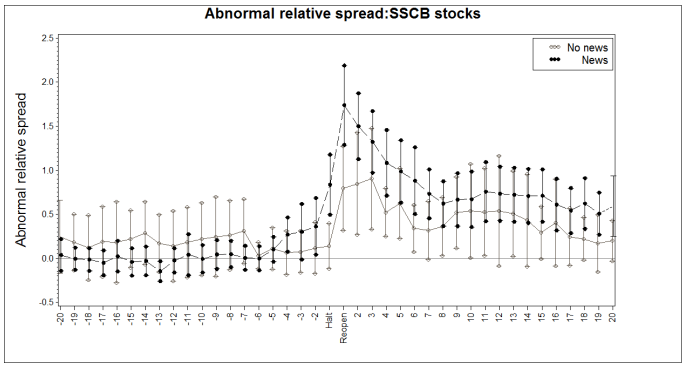
The figures show how the price of SSCB stocks evolves 40 minutes around the trading halt. The x-axis represents the time (in minutes) relative to the SSCB event. The y-axis shows the price ratio, that is the stock price in each minute relative to the price 20 minutes before the start of the trading halt. Panel A (Panel B) shows the average price of intraday rallies (crashes). The solid line with asterisks (95% confidence interval) exhibits the events with no news on the SSCB day while the dashed line with filled circles (95% confidence interval) represent the events with related news found in Factiva on the SSCB day. The halt label in the x-axis refers to the last one-minute interval before the circuit breaker. The reopen is defined as the first one-minute interval after the restart of trading.

Figure 3: Market quality on SSCB days: SSCB stocks

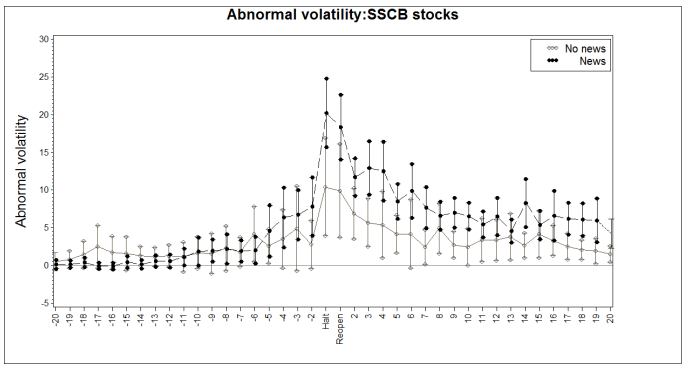
(a)



(b)



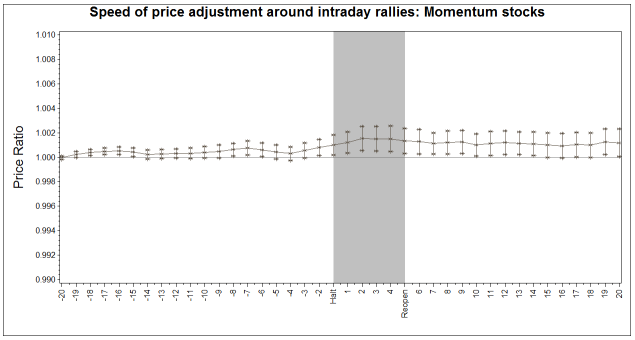
(c)



These figures show the abnormal market quality measures of SSCB stocks, that is, volume (Panel A), relative spread (Panel B) and volatility (Panel C) measured on SSCB days relative to the 30-day average around the SSCB day (excluding the SSCB day), 40 minutes around the trading halt. The x-axis represents the time (in minutes) relative to the SSCB event. Volume is calculated as the total trading volume in shares. Volatility is defined as the highest midquote in a one-minute interval minus the lowest midquote in the same interval, divided by the highest midquote. Relative spread is the time-weighted average of the ask price minus bid price over the midquote in a one-minute interval. The solid line with asterisks (95% confidence interval) exhibits the events with no news (N=20) on the SSCB day while the dashed line with filled circles (95% confidence interval) represent the events with related news (N=34) found in Factiva on the SSCB day.

Figure 4: Speed of price adjustment around SSCB: Non-halted stocks

(a)



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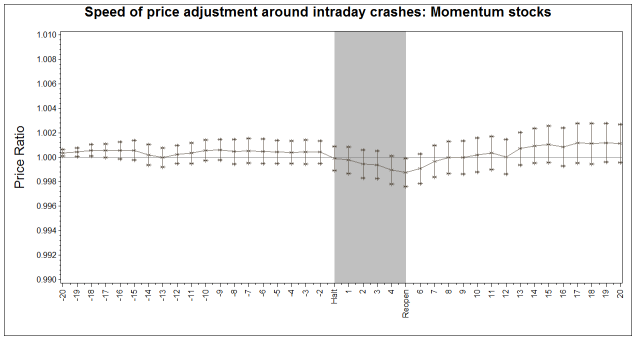

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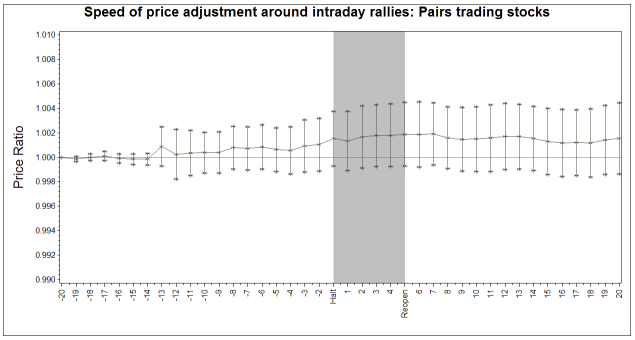

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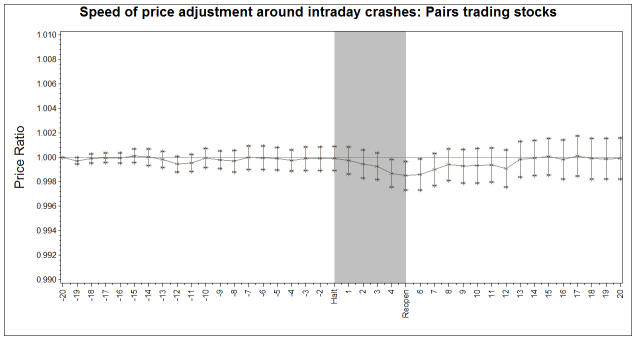

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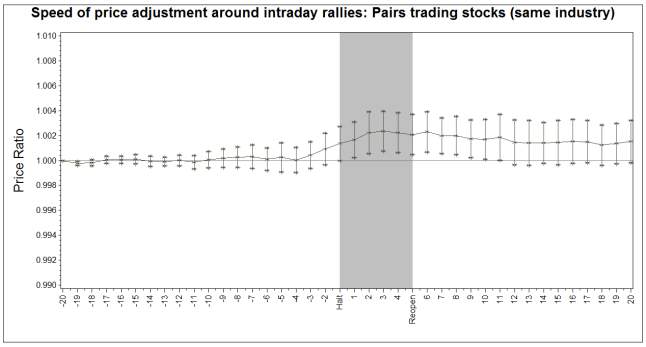
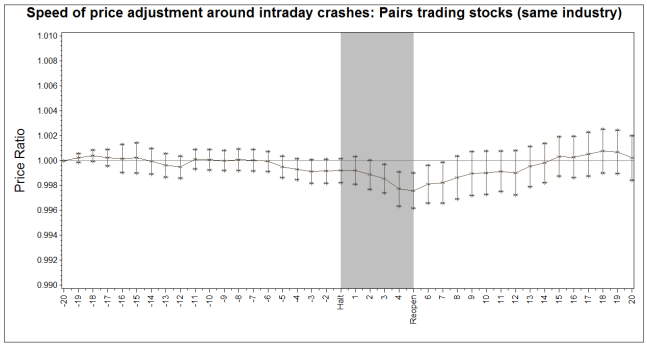


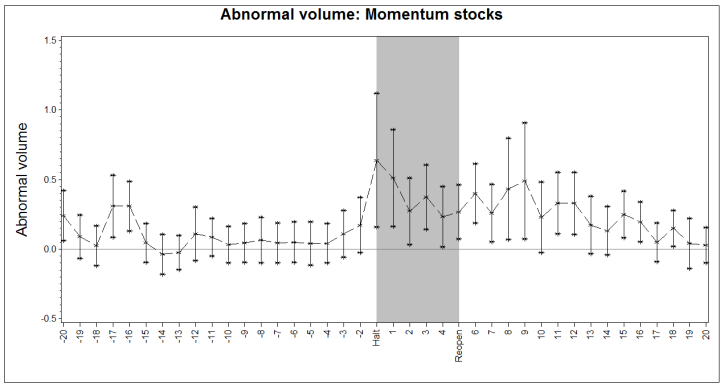
(f)



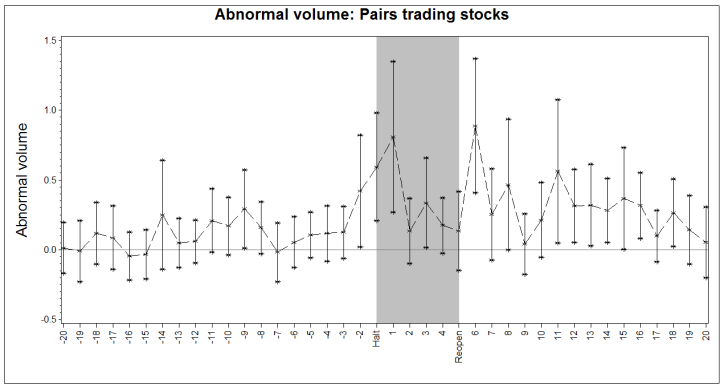
These figures show how the price of related non-halted stocks evolves 40 minutes around the trading halt. The x-axis represents the time (in minutes) relative to the SSCB event. The y-axis shows the price ratio, that is the stock price in each minute relative to the price 20 minutes before the start of the trading halt. The first (second) column shows the average price of intraday rallies, N=195 (crashes, N=75). Panel A and B show the speed of price adjustment for the candidate stocks of a momentum strategy. Panel C and D show the speed of price adjustment for the candidate stocks of a pairs trading strategy. Panel E and F show the speed of price adjustment for the candidate stocks (within the same broad industry category with the SSCB stocks) of a pairs trading strategy. The asterisks indicate 95% confidence interval. The gray shaded area indicates the trading halt.

Figure 5: Share volume on SSCB days: Non-halted stocks

(a)



(b)



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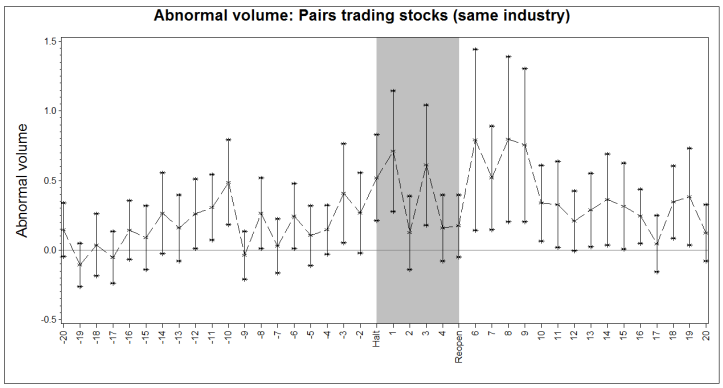
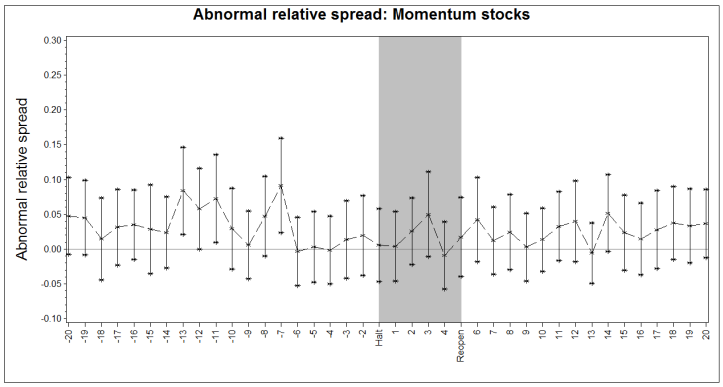


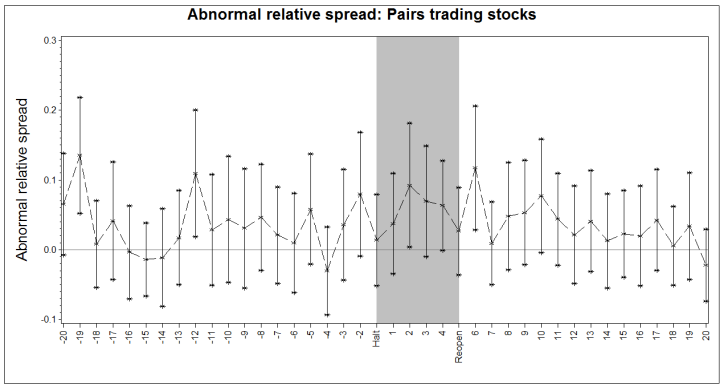
These figures show the abnormal share volume of related non-halted stocks, that is, momentum stocks (Panel A), pairs trading stocks (Panel B) and pairs trading (industry) stocks (Panel C). Share volume is measured on SSCB days relative to the 30-day average around the SSCB day (excluding the SSCB day), 40 minutes around the trading halt. The x-axis represents the time (in minutes) relative to the SSCB event. Volume is calculated as the total trading volume in shares in a one-minute interval. The asterisks indicate 95% confidence interval. The gray shaded area indicates the trading halt.

Figure 6: Relative spread on SSCB days: Non-halted stocks

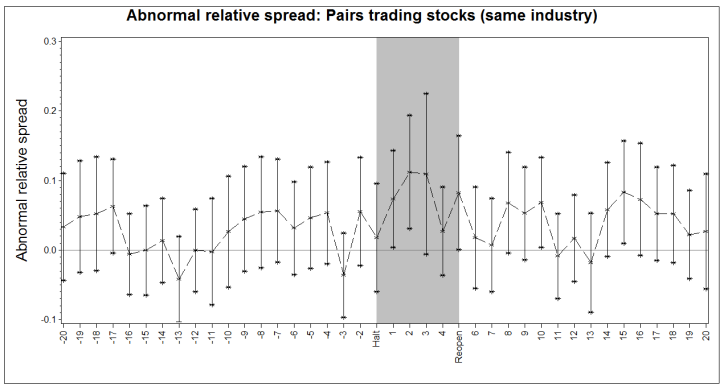
(a)



(b)



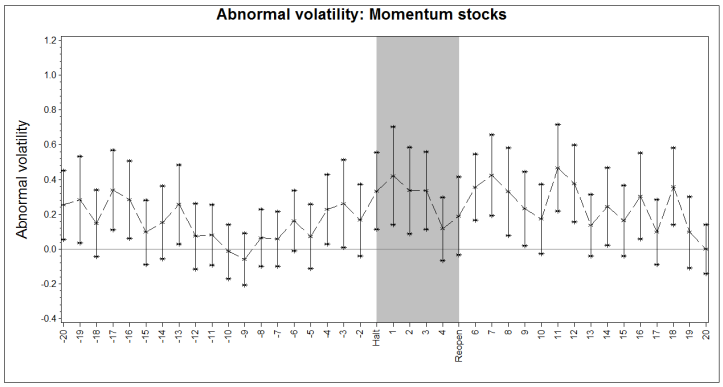
(c)



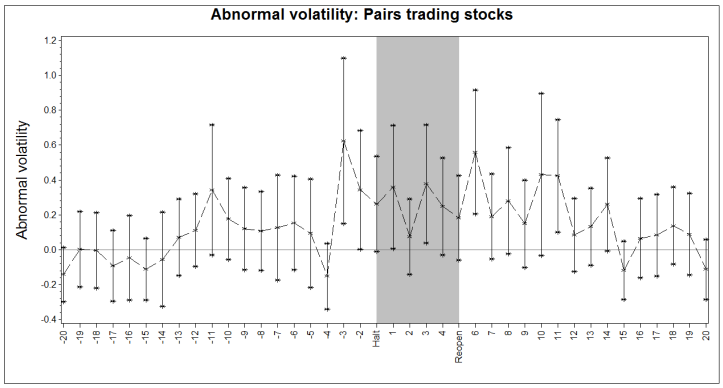
These figures show the abnormal relative spread of related non-halted stocks, that is, momentum stocks (Panel A), pairs trading stocks (Panel B) and pairs trading (industry) stocks (Panel C). Share volume is measured on SSCB days relative to the 30-day average around the SSCB day (excluding the SSCB day), 40 minutes around the trading halt. The x-axis represents the time (in minutes) relative to the SSCB event. Relative spread is the time-weighted average of the ask price minus bid price over the midquote in a one-minute interval. The asterisks indicate 95% confidence interval. The gray shaded area indicates the trading halt.

Figure 7: Volatility on SSCB days: Non-halted stocks

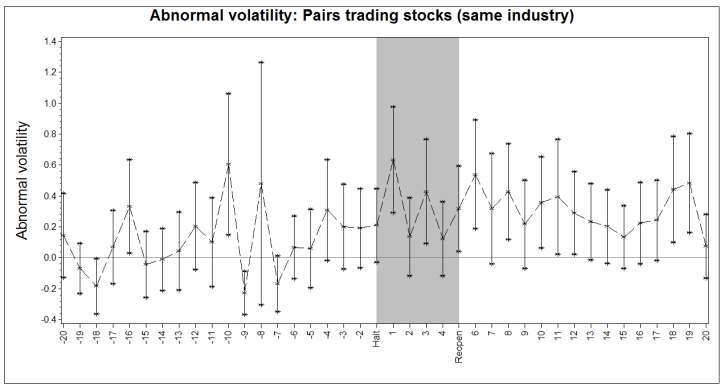
(a)



(b)



(c)



These figures show the abnormal share volume of related non-halted stocks, that is, momentum stocks (Panel A), pairs trading stocks (Panel B) and pairs trading (industry) stocks (Panel C). Volatility is measured on SSCB days relative to the 30-day average around the SSCB day (excluding the SSCB day), 40 minutes around the trading halt. The x-axis represents the time (in minutes) relative to the SSCB event. Volatility is defined as the highest midquote in a one-minute interval minus the lowest midquote in the same interval, divided by the highest midquote. The asterisks indicate 95% confidence interval. The gray shaded area indicates the trading halt.

Table 1: Summary statistics for SSCB and non-halted stocks

This table provides the summary statistics for 54 SSCB stocks and 740 related non-halted stocks. Non-halted stocks are identified as candidate stocks that are part of an arbitrage strategy which involves SSCB stocks. We consider momentum trading, pairs trading and pairs trading within the same industry sector. The last column reports the pooled results (with non-overlapping observations) across different arbitrage strategies.

	SSCB stocks	Momentum stocks	Pairs trading stocks	Pairs trading stocks (same industry)	All non-halted stocks
Number of observations					
Jun 2010 - Dec 2010	9	45	45	45	119
Jan 2011 - Dec 2011	26	130	125	125	359
Jan 2012 - Dec 2012	14	70	65	65	193
Jan 2013 - Mar 2013	5	25	25	25	69
Jump direction					
Rally	35	175	165	165	544
Crash	19	95	95	95	196
News					
Non-material news	34	170	160	160	457
No news	20	100	100	100	283
Jump type					
Discrete jump	17	85	85	85	233
Cumulative jump	37	185	175	175	507
Price ($)					
Mean	52.00	47.12	29.21	26.62	33.87
Median	26.86	37.20	18.60	19.59	24.98
Max	596.05	528.94	457.01	309.70	528.94
Min	1.54	1.70	0.15	0.23	0.15
Market cap ($billion)					
Mean	39.36	12.99	8.08	8.99	9.96
Median	4.06	6.35	1.32	1.25	2.59
Max	555.74	201.09	268.59	238.08	268.59
Min	0.40	0.79	0.005	0.005	0.005

Table 2: Trading activity on SSCB days: SSCB stocks

The table presents the average abnormal market quality measures for SSCB stocks (N=54). In Panel A, for each SSCB stock, we compute the percentage change of each measure relative to the 30-day benchmark in a 5-minute and a 20-minute (excluding the 5-minute around the halt) window around the halt. Quoted, effective and relative spreads are time weighted averages, while the number of trades, the number of quotes, share and dollar volume are aggregated over the observation window. We calculate the benchmark measures of the same intraday period for 30 days around the SSCB day, excluding the day of SSCB. Panel B shows the results of a diff-in-diff analysis using a control group matched based on price and market capitalization within the same index, that is, S&P or Russell 1000. We conduct a two-sided t-test to evaluate the significance of the difference between SSCB day and the benchmark period. The symbols ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively.

Panel A. Abnormal market quality measures

Variables	[-5 min, Halt]	[Reopen, 5 min]	[-20 min, -6 min]	[6 min, 20 min]
Number of trades	21.628***	25.669***	2.921***	10.862***
Number of quotes	8.548***	8.198***	1.461***	5.187***
Share volume	29.567***	38.795***	3.387***	15.137***
Dollar volume	30.268***	40.384***	3.536***	15.957***
Quoted spread	0.395***	1.524***	0.062***	0.704***
Relative spread	1.265***	2.556***	0.416**	1.235***
Effective spread	0.394***	1.416***	0.054**	0.634***
Volatility	10.017***	12.670***	1.250***	5.789***
OTR	-0.323***	-0.601***	-0.110***	-0.478***

Panel B. Market quality measures (diff-in-diff)

Variables	[-5 min, Halt]	[Reopen, 5 min]	[-20 min, -6 min]	[6 min, 20 min]
Number of trades	21.402***	25.283***	2.883***	10.815***
Number of quotes	8.486***	8.127***	1.490***	5.202***
Share volume	29.308***	38.306***	3.226***	14.973***
Dollar volume	30.060***	39.954***	3.435***	15.841***
Quoted spread	0.419***	1.489***	0.068**	0.706***
Relative spread	1.319***	2.143***	0.203	0.600***
Effective spread	0.379***	1.343***	0.018	0.805***
Volatility	9.976***	12.264***	1.065***	5.464***
OTR	-0.394***	-0.594***	-0.171**	-0.376***

Table 3: Trading activity on SSCB days: Non-halted stocks

The table presents the average of abnormal measures during the trading halt for non-halted stocks related to 54 SSCB stocks. In Panel A, for each non-halted stock identified through three different arbitrage strategies, we present the percentage change for each measure for the halt period of the circuit breaker relative to 30-day the benchmark around the SSCB day. The last column shows the results aggregated over all arbitrage strategies (non-overlapping observations). Quoted, effective and relative spreads are time weighted averages, while the number of trades, the number of quotes, share and dollar volume are aggregated over the observation window. Panel B shows the results of a diff-in-diff analysis using a control group matched based on price and market capitalization. We conduct a two-sided t-test to evaluate the significance. The symbols ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively.

Panel A. Abnormal market quality measures

Variables	Momentum stocks (N=270)	Pairs trading stocks (N=260)	Pairs trading stocks (same industry) (N=260)	All non-halted stocks (N=740)
Number of trades	0.241***	0.161***	0.247***	0.175***
Number of quotes	0.220***	0.109***	0.193***	0.156***
Share volume	0.331***	0.314***	0.356***	0.275***
Dollar volume	0.325***	0.311***	0.365***	0.272***
Quoted Spread	0.010	0.055***	0.082***	0.044***
Relative spread	0.018	0.058***	0.081***	0.048***
Effective spread	0.022	0.103*	0.135**	0.080**
Volatility	0.280***	0.246***	0.328***	0.248***
OTR	-0.023	-0.007	-0.039	-0.018

Panel B. Market quality measures (diff-in-diff)

Variables	Momentum stocks (N=270)	Pairs trading stocks (N=260)	Pairs trading stocks (same industry) (N=250)	All non-halted stocks (N=730)
Number of trades	0.246***	0.112***	0.017	0.128***
Number of quotes	0.166***	0.134***	0.020	0.103***
Share volume	0.303***	0.172*	-0.047	0.141***
Dollar volume	0.306***	0.171*	-0.046	0.142***
Quoted Spread	-0.022	0.059***	0.073	0.018
Relative spread	-0.019	0.056**	0.070**	0.018
Effective spread	-0.130	0.212**	-0.012**	-0.023
Volatility	0.170**	0.161*	0.186*	0.140***
OTR	-0.032	0.017	-0.026	-0.012

Table 4: Trading activity on SSCB days: Non-halted stocks (categories)

The table presents the results of a diff-in-diff analysis using a control group matched based on price and market capitalization for different event categories. In Panel A we split the pooled sample of non-halted stocks by event type, namely, intraday rallies versus crashes, and SSCB event with non-material news on Factiva versus SSCB events with no news. In Panel B, we split the pooled sample of non-halted stocks based on two characteristics, price and market capitalization. We report the results for the top and bottom quintiles. We conduct a two-sided t-test to evaluate the significance. The symbols ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively.

Panel A. Market quality measures: type of event (diff-in-diff)

Variables	Rally (N=544)	Crash (N=196)	News (N=457)	No news (N=283)
Number of trades	0.098**	0.196**	0.144***	0.105
Number of quotes	0.072**	0.179***	0.120***	0.078*
Share volume	0.119**	0.191*	0.171***	0.097
Dollar volume	0.115**	0.204**	0.177***	0.089
Quoted spread	0.018	0.019	-0.012	0.066***
Relative spread	0.019	0.016	-0.014	0.067***
Effective spread	-0.045	0.027	-0.043	0.007
Volatility	0.124**	0.178*	0.158***	0.115
OTR	0.001	-0.043	-0.002	-0.025

Panel B. Market quality measures: price and market cap quintiles (diff-in-diff)

Variables	Bottom quintile price (N=158)	Top quintile price (N=158)	Bottom quintile mkt cap (N=158)	Top quintile mkt cap (N=158)
Number of trades	0.110	0.086*	0.207	0.153***
Number of quotes	0.143**	0.057*	0.166*	0.130***
Share volume	0.087	0.070	0.145	0.118*
Dollar volume	0.082	0.091	0.138	0.130*
Quoted spread	0.043*	0.023	0.032	0.019
Relative spread	0.045**	0.017	0.035	0.017
Effective spread	0.024	0.023	-0.287	0.016
Volatility	-0.008	0.139*	-0.166	0.215***
OTR	-0.027	-0.003	-0.014	-0.007

Table 5: Trading activity during the halt (diff-in-diff): Controls

The table shows the diff-in-diff results of the trading activity during the trading halt controlling for stock and SSCB event characteristics. The dependent variables are the share volume, relative spread and volatility. As controls we include share price, market capitalization, primary exchange of both SSCB and non halted stocks, *industry*, a dummy variable equal to one if both SSCB and non-halted stocks are in the same 4-digit SIC industry category, *momentum*, a dummy variable indicating whether the non-halted stock is part of momentum strategy and *pairs trading*, a dummy variable indicating whether the non-halted stock is part of pairs trading strategy. We also control for the following characteristics of the SSCB events: *rally* a dummy equal to 1 if it is an intraday rally, *news*, dummy variable equal to one if there is non-material news found on Factiva on SSCB day, *disc*, a dummy variable equal to one if the circuit breaker is triggered by a discrete jump, *weekday*, week day of the SSCB event, *time*, time (in seconds) of the SSCB trigger relative to 9.45am, and the level of the VIX index on the SSCB day and the abnormal VIX measured as the VIX level on the SSCB day relative to the average VIX level in the SSCB month. We report p-values in parentheses. Errors are clustered at the SSCB event level.

Variables	(1) $Volume_{nh}^{halt}$	(2) $Relative\ spread_{nh}^{halt}$	(3) $Volatility_{nh}^{halt}$
$Price_{nh}$	0.059	0.002	0.033
	(0.689)	(0.950)	(0.712)
$Mktcap_{nh}$	-0.091	0.024	-0.035
	(0.120)	(0.175)	(0.580)
$Exch_{nh}$	0.129	-0.075*	0.194
	(0.423)	(0.083)	(0.223)
$Price_{sscb}$	0.001	0.009	-0.028
	(0.994)	(0.730)	(0.784)
$Mktcap_{sscb}$	0.033	-0.003	0.058
	(0.688)	(0.850)	(0.446)
$Exch_{sscb}$	0.198	-0.002	-0.251
	(0.185)	(0.973)	(0.212)
Momentum	0.570**	-0.077	0.010
	(0.012)	(0.226)	(0.957)
Pairs trading	0.271	0.054	-0.101
	(0.227)	(0.390)	(0.648)
Industry	0.628*	0.026	0.202
	(0.089)	(0.736)	(0.469)
Rally	0.076	0.074	-0.092
	(0.756)	(0.329)	(0.697)
News	0.215	-0.119**	0.187
	(0.314)	(0.041)	(0.460)
Disc	-0.018	-0.041	0.090
	(0.938)	(0.594)	(0.760)
Weekday	-0.059	0.005	-0.079
	(0.506)	(0.751)	(0.299)
Time	-0.000	-0.000	-0.000
	(0.913)	(0.689)	(0.775)
VIX	-0.007	0.002	-0.008
	(0.642)	(0.595)	(0.634)
Abnormal VIX	1.123	-0.261	0.689
	(0.383)	(0.595)	(0.634)
Intercept	-1.180	0.139	0.436
	(0.548)	(0.778)	(0.783)
Observations	740	740	740
Adj. R^2	0.016	-0.014	0.006
Cluster error	yes	yes	yes

6 Appendix

Table A.1: SSCB stocks

This table lists the company ticker, name, the industry sector (according to the 2-digit SIC code), the index, S&P 500 versus Russell 1000, the primary exchange, NYSE versus Nasdaq, the share price and market capitalization on the SSCB day for a sample of 54 SSCB events at the firm level during the period between June 2010 and April 2013.

Ticker	Name	Industry	Index	Exchange	Price	Mktcap($million)
WPO	Washington Post	Printing & Publishing	S&P 500	NYSE	458.19	3,623.37
C	Citigroup	Depository Institutions	S&P 500	NYSE	3.73	108,094.95
APC	Anadarko Petroleum	Oil & Gas Extraction	S&P 500	NYSE	38.64	19,116.91
CSCO	Cisco Systems	Electronic & Other Electric Equipment	S&P 500	Nasdaq	23.21	132,555.81
MU	Micron Technology	Electronic & Other Electric Equipment	S&P 500	Nasdaq	7.70	7,655.12
NUE	Nucor Corporation	Primary Metal Industries	Russell 1000	NYSE	39.41	12,436.26
PGN	Progress Energy	Electric, Gas, & Sanitary Services	Russell 1000	NYSE	44.43	12,999.37
ADBE	Adobe Systems	Business Services	S&P 500	Nasdaq	28.69	14,595.09
GAS	Nicor Gas	Electric, Gas, & Sanitary Services	Russell 1000	NYSE	46.63	2,123.25
ATHR	Atheros Communication	Electronic & Other Electric Equipment	Russell 1000	Nasdaq	44.00	3,247.86
MBI	MBIA	Insurance Carriers	Russell 1000	NYSE	13.53	2,704.08
GMCR	Green Mountain	Food & Kindred Products	Russell 1000	Nasdaq	46.35	6,563.21
M	Macy's	General Merchandise Stores	S&P 500	NYSE	25.40	10,815.47
REGN	Regeneron Pharmaceuticals	Chemical & Allied Products	Russell 1000	Nasdaq	67.05	5,949.95
RAH	Ralcorp Holdings	Printing & Publishing	Russell 1000	NYSE	77.80	4,227.37
MA	Mastercard	Business Services	S&P 500	NYSE	309.70	37,369.95
V	Visa	Business Services	S&P 500	NYSE	86.50	45,296.80
KCI	Kinetic Concepts	Instruments & Related Products	Russell 1000	NYSE	66.20	4,811.55
MBI	MBIA	Insurance Carriers	Russell 1000	NYSE	10.02	2,001.79
XOM	ExxonMobil	Petroleum & Coal Products	S&P 500	NYSE	71.58	348,021.97
MBI	MBIA	Insurance Carriers	Russell 1000	NYSE	6.90	1,378.48
LINTA	Liberty Media	Printing & Publishing	Russell 1000	Nasdaq	16.77	9,603.88
CLWR	Clearwire	Communications	Russell 1000	Nasdaq	2.50	621.26
CLWR	Clearwire	Communications	Russell 1000	Nasdaq	2.41	598.89
BPOP	Popular	Electronic Other Electric Equipment	Russell 1000	Nasdaq	1.54	1,577.17
CLWR	Clearwire	Communications	Russell 1000	Nasdaq	2.15	536.87
CSE	Capitalsource	Nondepository Institutions	Russell 1000	NYSE	6.23	2,011.02
S	Sprint Nextel	Communications	Russell 1000	NYSE	2.41	7,209.99
CLWR	Clearwire	Communications	Russell 1000	Nasdaq	1.59	397.03
AMR	AMR Corporation	Transportation by Air	Russell 1000	NYSE	2.76	925.17
WLT	Walter Energy	Coal Mining	Russell 1000	NYSE	71.98	4,492.92
DNDN	Dendreon Corporation	Chemical & Allied Products	Russell 1000	Nasdaq	7.51	1,118.67
WFR	MEMC Electronic	Electronic & Other Electric Equipment	Russell 1000	NYSE	4.20	967.96
CEG	Constellation Energy	Electric, Gas, & Sanitary Services	Russell 1000	NYSE	39.60	7,981.93
SD	Sandridge Energy	Oil & Gas Extraction	Russell 1000	NYSE	8.21	3,383.34
BKU	Bankunited	Depository Institutions	Russell 1000	NYSE	24.48	2,381.51
AAPL	Apple	Industrial Machinery & Equipment	S&P 500	Nasdaq	596.04	555,739.13
DAL	Delta Air Lines	Transportation by Air	Russell 1000	NYSE	11.43	9,711.37
BAH	Booz Allen	Engineering & Management Services	Russell 1000	NYSE	16.76	2,153.58
DNB	Dun & Bradstreet	Business Services	S&P 500	NYSE	80.19	3838.21
KRO	Kronos Worldwide	Chemical & Allied Products	Russell 1000	NYSE	18.00	2,086.124
TRN	Trinity Indutries	Transportation Equipment	Russell 1000	NYSE	28.32	2,237.34
ANF	Abercrombie & Fitch	Apparel & Accessory Stores	Russell 1000	NYSE	37.92	3130.94
MDRX	Allscripts Healthcare Solutions	Business Services	Russell 1000	Nasdaq	12.42	2,129.56
GDI	Gardner Denver	Industrial Machinery & Equipment	Russell 1000	NYSE	66.00	3,232.22
VRSN	Verisign	Business Services	S&P 500	Nasdaq	41.15	6,389.17
BMRN	Biomarin Pharmaceuticals	Chemical & Allied Products	Russell 1000	Nasdaq	47.60	5,894.33
WLL	Whiting Petroleum	Oil & Gas Extraction	Russell 1000	NYSE	40.94	4,815.81
CPWR	Compuware corporation	Business Services	Russell 1000	Nasdaq	10.76	2,294.52
DELL	Dell	Industrial Machinery & Equipment	S&P 500	Nasdaq	12.29	21,351.07
ENDP	Endo Pharmaceuticals	Chemical & Allied Products	Russell 1000	Nasdaq	31.66	3,507.74
MBI	MBIA	Insurance Carriers	Russell 1000	NYSE	12.78	2,463.38
CHTR	Charter Communications	Communications	Russell 1000	Nasdaq	98.04	9,919.59
MXIM	Maxim Integrated Products	Electronic & Other Electric Equipment	Russell 1000	Nasdaq	32.15	9,403.17

Table A.2: SSCB events

This table reports detailed information on the 54 SSCB events during the period between June 2010 and April 2013. The *date*, *time* and *day* show the SSCB date, start of the trading halt, and the weekday when the SSCB is triggered. The table also presents the following characteristics of the SSCB events: *disc*, a dummy variable equal to one if the circuit breaker is triggered by a discrete jump, *rallies*, indicating the sign of the jump, *news*, a dummy variable equal to one if the circuit breaker is associated with firm-specific non-material news, zero otherwise, and *details of Factiva search* lists the corresponding detailed news information found in Factiva on the event day. The abnormal VIX is the ratio of the VIX index on the day of the SSCB relative to the average index level in the SSCB event month.

Ticker	Date	Time	Day	Discrete	Rally	Abnormal VIX	News	Details of Factiva Search
WPO	16 Jun 2010	15:07:30	Wed	1	1	0.909	0	Erroneous trade (Reuters)
C	29 Jun 2010	13:03:51	Tue	1	0	1.095	0	Erroneous report (Bloomberg)
APC	06 Jul 2010	10:56:26	Wed	1	1	1.103	0	Erroneous trade at $99,999.09 (WSJ)
CSCO	29 Jul 2010	10:41:33	Thu	1	1	0.890	0	Erroneous trade (Reuters)
MU	05 Aug 2010	10:14:30	Thu	1	0	0.962	0	No specific news
NUE	14 Sep 2010	11:52:21	Tue	1	0	0.983	0	Liquidity related, penny trades at $0.01
PGN	27 Sep 2010	12:57:42	Mon	1	0	0.932	0	Typo in sell order
ADBE	07 Oct 2010	15:08:03	Thu	1	1	1.113	1	Microsoft merger talk
GAS	02 Dec 2010	14:34:09	Thu	0	1	1.113	1	Firm hired JPMorgan to seek a buyer (Bloomberg)
ATHR	04 Jan 2011	15:00:56	Tue	0	1	1.101	1	Qualcomm is near a deal talk to buy the company
MBI	11 Jan 2011	11:48:22	Tue	0	1	1.054	1	The company won an important ruling
GMCR	14 Feb 2011	15:16:23	Mon	0	1	0.932	1	Partnership talk with Starbucks
M	07 Apr 2011	11:31:54	Thu	1	0	1.063	0	Nine canceled trades
REGN	27 Apr 2011	13:16:50	Wed	0	1	0.888	1	Reports published with positive results on cancer drug
RAH	29 Apr 2011	12:36:26	Fri	0	1	0.873	1	Rumors of an unsolicited bid
MA	29 Jun 2011	15:13:05	Wed	0	1	0.931	1	Fed debit card fee raise proposal
V	29 Jun 2011	15:12:53	Wed	0	1	0.931	1	Fed debit card fee raise proposal
KCI	06 Jul 2011	10:09:13	Wed	0	1	0.944	1	Rumors about talk with private equity firms
MBI	14 Jul 2011	15:20:01	Thu	0	1	1.062	1	BAC preliminary offer to settle lawsuits (Bloomberg)
XOM	11 Aug 2011	10:33:59	Thu	1	0	0.941	0	Bad trade (CNBC)
MBI	25 Aug 2011	15:11:53	Thu	0	1	1.183	1	5-year Credit Default Swap tightened 47.55 basis points
LINTA	21 Sep 2011	14:47:26	Wed	0	1	1.024	1	Delaware Supreme Court has affirmed a ruling
CLWR	22 Sep 2011	13:05:46	Thu	0	1	1.104	1	Cnet reports talks with AT&T about 4G LTE network
CLWR	23 Sep 2011	14:45:09	Fri	0	1	1.120	1	Firm eyes Verizon in network capacity talks (Reuters)
BPOP	27 Sep 2011	12:04:32	Tue	0	1	1.052	0	No specific news
CLWR	04 Oct 2011	10:18:01	Tue	0	1	1.169	0	No specific news
CSE	04 Oct 2011	12:12:28	Tue	1	1	1.169	0	No specific news
S	07 Oct 2011	11:52:56	Fri	0	0	1.103	1	Firm considers public markets to raise capital
CLWR	14 Oct 2011	15:15:13	Fri	0	1	0.900	1	Moody's downgrade
AMR	17 Oct 2011	10:54:11	Mon	0	0	1.011	1	American Airlines fails to reach labor agreement
WLT	17 Oct 2011	15:31:30	Mon	1	0	1.011	1	BHP Billiton takeover rumors
DNDN	16 Nov 2011	13:08:31	Wed	0	1	1.037	1	Goldman Sachs conference call with urology experts
WFR	08 Dec 2011	09:47:57	Thu	1	1	1.138	1	Announcement of a series of actions for restructuring
CEG	21 Dec 2011	12:03:05	Wed	0	0	0.869	1	Bloomberg headline of block of acquisition
SD	22 Dec 2011	15:03:28	Thu	0	1	0.890	0	No specific news
BKU	13 Jan 2012	13:48:46	Fri	0	1	1.044	1	Media reports that the company is considering a sale
AAPL	23 Mar 2012	10:57:36	Fri	1	0	0.829	0	BATS technical problem
DAL	14 May 2012	10:39:25	Mon	1	0	0.987	0	Fat finger trade, seeking alpha website
BAH	11 Jul 2012	12:17:22	Wed	0	1	1.024	1	Firm is considering $1 bln special dividend
DNB	31 Jul 2012	14:49:02	Tue	0	1	0.996	1	News on working with banks to explore sale
KRO	01 Aug 2012	09:56:20	Wed	0	1	1.119	0	Knight capital technical glitch (Forbes)
TRN	01 Aug 2012	09:59:45	Wed	0	0	1.119	0	Knight capital technical glitch, (Forbes)
ANF	12 Sep 2012	13:58:38	Wed	0	1	1.008	1	Firm retains Goldman Sachs
MDRX	28 Sep 2012	12:43:52	Fri	0	1	0.939	1	Firm talks with private equity firms
GDI	25 Oct 2012	15:11:26	Thu	0	1	1.027	1	Firm asks Goldman Sachs to explore sale (Reuters)
VRSN	01 Nov 2012	14:03:02	Thu	0	1	1.023	1	Market talk about registry renewal agreement
BMRN	15 Nov 2012	09:50:45	Thu	1	1	1.080	0	No specific news
WLL	29 Nov 2012	14:38:30	Thu	0	0	0.872	1	Firm explored selling itself (WSJ Blog)
CPWR	17 Dec 2012	10:11:39	Mon	0	1	0.925	1	Cash buyout offer from Elliott Management
DELL	14 Jan 2013	14:04:13	Mon	0	1	1.030	1	Buyout talks private-equity firms (WSJ blog)
ENDP	30 Jan 2013	14:29:31	Wed	0	1	0.978	0	No specific news
MBI	04 Mar 2013	12:59:11	Mon	0	1	1.060	1	U.S. court dismisses bank lawsuit (Reuters)
CHTR	18 Mar 2013	12:42:13	Mon	0	1	1.030	0	No specific news
MXIM	27 Mar 2013	10:33:58	Wed	1	0	0.963	1	Researchers submit a patent application (Verticalnews)

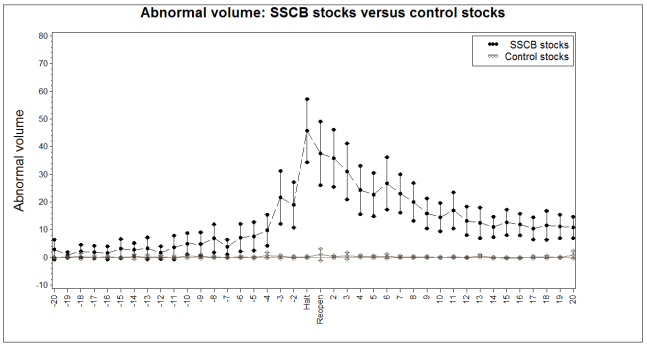
Table A.3: Market quality measures (diff-in-diff): event level

The table shows the results of a diff-in-diff analysis of the average abnormal market quality measures for each SSCB event (N=54) using a control group matched based on price and market capitalization within the same index, that is, S&P or Russell 1000. We compute the percentage change of each measure relative to the 30-day benchmark in a 5-minute and a 20-minute (excluding the 5-minute around the halt) window around the halt. Quoted, effective and relative spreads are time weighted averages, while the number of trades, the number of quotes, share and dollar volume are aggregated over the observation window. We calculate the benchmark measures of the same intraday period for 30 days around the SSCB day, excluding the day of SSCB. We conduct a two-sided t-test to evaluate the significance of the difference between SSCB day and the benchmark period. The symbols ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively.

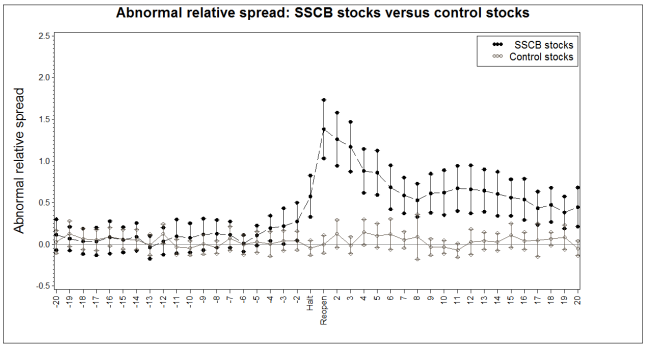
	[-20 min, -6 min]			[-5 min, Halt]			[Reopen, 5 min]			[6 min, 20 min]		
Event	volume	spread	volatility	volume	spread	volatility	volume	spread	volatility	volume	spread	volatility
WPO	0.477	0.197**	-0.778***	9.428	-1.121	4.318	3.001	-0.067	3.317	1.179*	-0.017	0.574
C	0.384	0.004	1.051	1.136	0.027***	0.564	1.535*	0.025***	0.58	1.885	0.015	0.935
APC	-0.137	-0.026	-0.534	-0.113	0.4	-1.392**	-0.236	0.491**	-2.2	-0.044	-0.001	-2.465*
CSCO	-0.816**	0.062***	0.56	-0.743	0.053	9.756	-0.061	0.177	0.267	-0.026	0.036	-0.174
MU	-0.308	0.015	-0.368	-0.781	-0.164	0.24	1.122*	0.731***	4.449*	0.036	0.270***	0.37
NUE	1.159	-0.367	0.88	1.222	-1.071**	-0.819	9.564	-0.452	7.134	0.433	0.08	-0.179
PGN	0.998**	-0.580***	0.233	22.396	-1.559***	9.525	15.359	1.506	8.603**	3.029**	1.774***	5.338***
ADBE	14.464**	0.126	5.937***	33.841***	0.141	13.369***	47.965***	0.354**	19.813***	21.841***	0.136*	11.080***
GAS	0.99	0.413	0.397	51.583	0.672	11.615	119.733	1.563***	13.641***	23.719***	0.348	5.768***
ATHR	-0.452**	-0.411**	-1.139	17.579	0.279	13.859***	76.601***	-0.143	18.558**	39.312***	-0.378*	14.426***
MBI	7.298***	0.294***	2.857**	55.256***	0.421***	8.616	43.678**	0.590*	4.749**	14.983***	0.085**	3.703***
GMCR	0.289	-0.06	1.838***	8.562	1.559*	7.756**	38.537***	0.687*	11.515***	10.020***	0.763***	5.572***
M	0.65	0.057	1.169	2.979**	-0.142*	-0.498	1.723*	0.379*	4.432***	1.096***	0.739**	2.478***
REGN	9.823	0.411**	-0.263	60.767**	0.361**	6.996*	81.020***	0.099	4.184	44.065***	-0.181	3.467***
RAH	-1.643	-0.077	0.062	6.958	0.97	4.922*	98.703***	2.150***	9.879**	37.600***	1.553***	4.464***
MA	0.535**	0.112	0.886***	34.752**	0.992**	7.874	37.806***	1.332***	5.504***	18.790***	0.629***	2.397***
V	1.248***	-0.14	3.281	48.862**	3.143*	20.320***	42.727***	2.170***	15.778***	27.501***	1.784***	11.226***
KCI	-1.986**	0.382***	-1.137	3.665	0.913***	4.613	35.280***	0.781**	5.047**	7.577***	0.118	6.489***
MBI	0.126	-0.013	0.118	64.791***	0.996***	30.720**	60.600***	3.699***	22.985**	11.695***	2.505***	14.122***
XOM	0.383	-0.417***	-0.362*	-0.589	-0.289***	0.446	-0.201	0.157	-0.568**	-0.467*	-0.232***	-0.345
MBI	0.127	-0.129**	0.607	18.092***	0.775*	8.629	9.649***	1.831***	8.664***	3.868***	0.961***	8.262**
LINTA	-0.547**	0.237**	-1.673***	20.855**	0.127	10.81	31.326*	3.307***	29.924**	5.025***	1.732***	4.553***
CLWR	-0.093	0.337***	-0.165	1.263	0.128**	7.549	20.274*	0.782**	41.212**	0.128	0.854***	4.344***
CLWR	-0.095	0.056	-0.309*	1.995	-0.002	5.622	3.301	2.425***	19.283***	-0.221	0.685***	5.526***
BPOP	3.525	-0.007***	1.585	2.31	0.015	6.722	-6.22	-0.381	15.484**	5.325**	-0.319***	1.373
CLWR	-2.130**	-1.175***	-2.179***	0.049	-0.842***	4.338	0.018	0.696*	8.728***	-1.637***	-0.214	-1.156
CSE	-1.235*	0.253***	1.181***	16.221	0.029	18.846	10.078**	3.180***	13.438*	5.118***	0.185**	2.852***
S	3.406	-0.051	2.591**	17.037***	0.118**	13.139***	20.491***	0.127	27.120***	9.760***	0.154***	5.390***
CLWR	6.140***	0.051	3.654***	8.021***	0.158***	8.763***	2.480***	1.897***	6.308***	0.852**	0.479***	5.045***
AMR	-1.006*	-0.237***	-0.455	11.113*	-0.084	10.382	3.556**	0.026	6.628**	1.270*	-0.155**	0.802*
WLT	0.06	-0.013	-0.168	0.429	0.260*	0.308	1.885*	0.095	0.412	0.692***	0.200***	0.205
DNDN	7.350***	0.053	1.745***	20.207***	0.2	8.174	15.211***	2.363**	18.327***	3.364***	1.141***	6.869***
WFR	9.244	0.354	2.862***	13.724***	0.306***	5.616***	5.849***	0.527***	7.210***	6.035***	0.154***	3.696***
CEG	-0.636**	-0.108	0.108	137.072***	5.955**	48.407*	156.302**	5.375***	55.802**	43.341***	2.487***	33.197***
SD	5.125	0.220***	5.360**	27.955***	0.404***	19.612***	18.109**	0.684***	18.450**	10.091***	0.307***	8.676***
BKU	0.126	-0.385***	0.153	0.78	-0.059	-0.418	27.5	0.4	4.362	39.632***	0.662**	10.755***
AAPL	-0.755***	0.236**	-1.487*	-0.737***	0.104	-0.022	0.287	0.531***	-0.606	-0.322**	0.233***	-1.435
DAL	0.858***	-0.033	0.015	0.792	-0.063	0.256	2.402	0.013	-0.212	1.786	-0.045	1.037
BAH	-0.174	-0.193	-0.24	101.564	0.894**	15.737*	47.369**	2.010***	13.854***	58.386***	0.599**	8.823***
DNB	-0.999***	-0.189*	-0.900***	57.282	-0.345	11.696	99.693***	1.440**	17.472***	34.867***	0.479***	3.021**
KRO	21.363***	2.619***	8.359***	59.890***	0.987***	8.034***	13.929***	0.807*	6.759**	8.911***	0.098	5.257***
TRN	49.212***	1.394***	10.652***	92.074***	-0.072	13.602***	7.645***	0.363	2.77	4.765***	-0.704*	1.818*
ANF	0.406	-0.091	0.119	153.664**	1.118***	21.056***	111.028***	1.698***	18.513***	36.785***	0.922***	6.819***
MDRX	0.698	-0.128	-0.656**	24.054	-0.257	10.656	69.350***	3.866***	16.352***	38.816***	2.094***	12.528***
GDI	1.883	-0.062	0.072	32.289	-0.005	9.102	143.366**	0.850***	6.723**	31.792***	0.339***	5.171***
VRSN	7.515*	-0.480***	2.51	50.364**	0.1	10.531***	71.517***	2.540***	15.953***	21.739***	0.903***	5.624***
BMRN	-1.285	-0.154*	-0.073	7.925	-0.541***	3.64	2.031**	1.438**	2.552	0.371	-0.021	1.688***
WLL	0.315*	-0.697***	-0.156	58.627	0.409	23.833	51.707**	0.939	14.101***	9.599***	0.658**	7.108***
CPWR	-0.960***	-0.078	-0.360**	26.657	-0.307***	3.852	74.573***	1.201***	9.541	42.450***	-0.012	1.630***
DELL	0.166	0.015	0.107	5.676	0.21	12.881	35.335**	0.898***	29.480***	19.646***	0.305***	16.890***
ENDP	-0.096	-0.207	-0.778*	14.036	0.192	19.177	121.574***	7.492***	30.651**	37.190***	3.073***	12.515***
MBI	13.441**	0.393***	5.762***	62.937**	1.284***	19.650***	77.953***	2.524***	14.106**	46.840***	1.423***	8.813***
CHTR	8.878	-0.384	-0.053	82.608**	1.092***	10.655***	61.838**	0.206	8.518**	18.682***	1.023***	5.695***
MXIM	3.144*	0.395***	0.608*	1.348	0.356	2.564	1.15	2.379***	2.685**	2.829*	1.612***	0.936**

Figure A.1: Market quality on SSCB days: SSCB versus control stocks

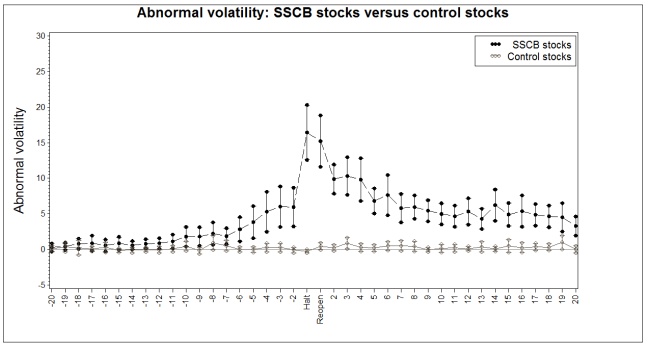
(a)



(b)



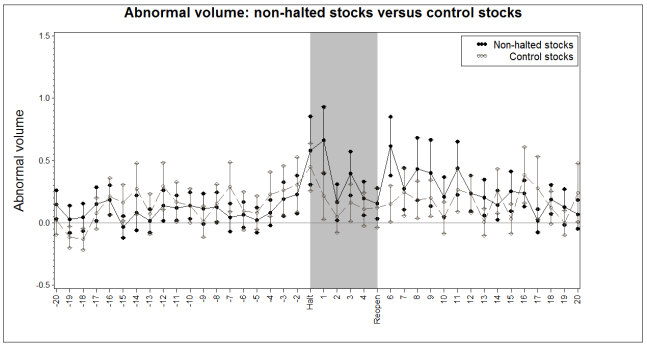
(c)



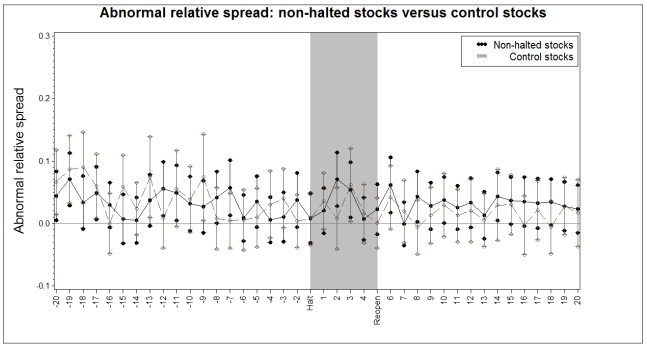
These figures compare the abnormal market quality measures of SSCB stocks and control stocks, that is, share volume (Panel A), relative spread (Panel B) and volatility (Panel C) measured on SSCB days relative to the 30-day average around the SSCB day (excluding the SSCB day), 40 minutes around the trading halt. Control stocks are within same index, and matched based on share price and market capitalization. The x-axis represents the time (in minutes) relative to the SSCB event. Volume is calculated as the total trading volume in shares. Volatility is defined as the highest midquote in a one-minute interval minus the lowest midquote in the same interval, divided by the highest midquote. Relative spread is the time-weighted average of the ask price minus bid price over the midquote in a one-minute interval. The black dashed line with filled circles (95% confidence interval) exhibits the SSCB stocks while the gray solid line with circles (95% confidence interval) represent the control stocks.

Figure A.2: Market quality on SSCB days: Non-halted versus control stocks

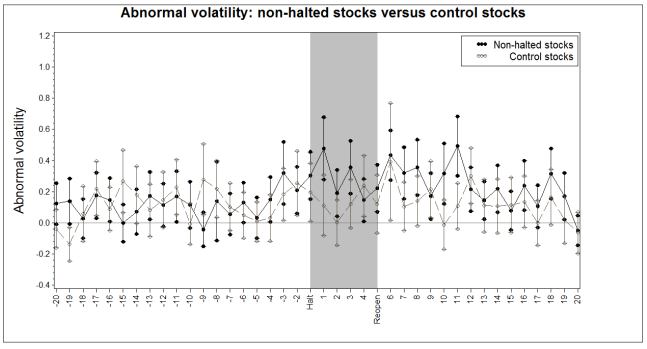
(a)



(b)



(c)



These figures compare the abnormal market quality measures of all non-halted stocks and control stocks, that is, share volume (Panel A), relative spread (Panel B) and volatility (Panel C) measured on SSCB days relative to the 30-day average around the SSCB day (excluding the SSCB day), 40 minutes around the trading halt. Control stocks are matched based on share price and market capitalization. The x-axis represents the time (in minutes) relative to the SSCB event. Volume is calculated as the total trading volume in shares. Volatility is defined as the highest midquote in a one-minute interval minus the lowest midquote in the same interval, divided by the highest midquote. Relative spread is the time-weighted average of the ask price minus bid price over the midquote in a one-minute interval. The black dashed line with filled circles (95% confidence interval) exhibits all non-halted stocks while the gray solid line with circles (95% confidence interval) represent the control stocks.