Effects of the Short Sale Circuit Breaker on the Stock Market

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Abstract

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We examine the benefits and costs of the short sale circuit breaker (Rule 201) for NYSE and Nasdaq stocks. Not only that the circuit breaker failed to reduce intraday volatility and intraday price decline in the market, evidence suggests that it worsens the event day return and price decline for the most volatile stocks. Market quality in terms of liquidity and fair pricing are unaffected. However, informational efficiency after large price movements is considerably improved by the short sale circuit breaker. Evidence also suggests that triggering the circuit breaker is not a small-cap phenomenon.

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A. Introduction

Short selling has been at the center of debate amongst academics, industry participants, and the media for decades. The core question is the exact role that short selling should play in marketplace. A standard position of academics is that short selling is an essential part of the price discovery process.[1] Many industry observers, including company executives and media commentators, often characterize short selling as a destabilizing factor in the markets that exacerbates market declines during periods of market turmoil. From this perspective, the collapses of Bear Stearns, Lehman Brothers, and Merrill Lynch during the 2008 financial crisis were directly attributable to the actions of shorts sellers.[2]

Regulators have generally taken the position that short selling can promote market efficiency, but requires certain constraints in order to forestall market collapses due to excessive trading by short sellers. In 1938, the United States Securities and Exchanges Commission (SEC) adopted the first short sale regulation, known as the uptick rule, which addresses issues such as failures to deliver and abusive naked short sales. Since then, financial markets have seen a number of regulatory changes that affect short selling.[3] Regulation SHO, which became effective on January 3, 2005 represents a recent overhaul of the rules guiding market participants. In 2007, after conducting a pilot program, the SEC concluded that the uptick rule made no discernible differences in the trading patterns of stocks and repealed the uptick rule (see also Diether, Lee, and Werner, 2009). Rule 204T strengthens close-out requirements by applying Regulation SHO on a broader range of securities and having failures to deliver closed out faster. It was adopted by the SEC as a part of the emergency order in 2008 in the throes of the global financial crisis. During the 2008 financial crisis, the SEC introduced an Emergency Order that banned short

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[1] See, for example, Nilsson (2008) and Boehmer, Jones, and Zhang, (2009).

[2] For example, John Mack, the former Chief Executive Officer of Morgan Stanley, attributed the price decline of Morgan Stanley to short selling, fear, and rumors. (Saporito, B. (2008). Are short sellers to blame for the financial crisis? Time, September, http://www.time.com/time/business/article/0, 8599, 1842499.)Richard Fuld Jr., the former CEO of Lehman Brothers, alleged that naked short selling together with false rumors contributed to the collapse of Bear Stearns and Lehman Brothers. (http://oversight.house.gov/documents/20081006125839.pdf).

[3] See Exchange Act Release No. 55970 (Jun. 28, 2007), 72 FR 36348 (Jul. 3, 2007); Exchange Act Release No. 56212 (Aug. 7, 2007), 72 FR 45544 (Aug. 14, 2007); Exchange Act Release No. 58775 (Oct. 14, 2008), 73 FR 61690 (Oct. 17, 2008); Exchange Act Release No. 60388 (July 27, 2009), 74 FR 38266 (July 31, 2009); Exchange Act Release No. 61595 (Feb. 26, 2010), 75 FR 11232 (Mar. 10, 2010).

selling for a group of financial companies. Boulton and Braga-Alves (2010), Beber and Pagano (2013), Autore, Billingsley, and Kovacs (2011), and Battalio and Schultz (2011) argue that this ban distorts market quality. Christopher Cox, the Chairman of the SEC at the time, also argued that the costs of the short sale ban outweigh the benefits.[4] Regulation SHO reintroduced the price test restriction with Rule 201, also known as the Short Sale Price Test Circuit Breaker/Alternative Uptick Rule or the short sale circuit breaker. Rule 201 tailors the price test restrictions at stocks experienced dramatic downward price pressure and sets a compliance date of November 10, 2010. The short sale circuit breaker activates the price test restriction that proscribes stock short sales when the price of a stock declines more than 10 percent or more in a single day.

We contribute to the debate on short selling by providing new evidence on the effectiveness of this recently introduced Rule 201. Our paper assembles a unique database from various sources that enables us to examine its impact on intraday volatility, market quality, and market efficiency for stocks traded on the NYSE and Nasdaq from 2009 to 2012. We identify targeted stocks by applying Rule 201 on days before its introduction and analyze the changes brought by Rule 201.

We do not find that Rule 201 reduces the intraday volatility or the downward price pressure of stocks. Our decile portfolio test sorted on intraday price declines shows no significant differences. In fact, stocks in nine out of ten decile portfolios decline more in the post-breaker period, on average. But this difference is not significant and reflects the increased volatility of the market overall rather than the effects of Rule 201 per se. To reinforce this result, we construct a 10-percentile portfolio that only includes stocks could have (in the pre-breaker period) or have (in the post-breaker period) triggered the circuit breaker. Surprisingly, our result reports significantly worse price declines when the circuit breaker is effective. However, the 0.9% increase in intraday declines is only significant when the percentile portfolio is value-weighted. Furthermore, the deterioration of returns of affected stocks in the post-breaker period is also found to be statistically significant. We document price reversals following large price declines, which was found to be the evidence that Rule 201 does increase market stability. However, we do not find evidence of overpricing when a stock is affected by Rule 201. We also

[4] Christopher Cox, telephone interview to Reuters, 31 December 2008.

show that the circuit breaker substantially reduces price drifts after large price declines. The circuit breaker facilitates the market's digestion of negative information on the stressed stocks, which is an enhancement of market efficiency.

The remainder of the paper is organized as follows. In the next section, we discuss the background and review the literature. Section C discusses the methodology and hypothesis. The data and sample selection, description, and empirical results are presented in section D. Section E concludes with a summary and implications.

B. Background and Literature Review

1. The Uptick Rule

Despite the nearly 80-year long history of the uptick rule, only a few studies are conducted on its effects. Most the studies find the uptick rule "unfair" to the short sellers and argue that the rule is better released.

Alexander and Peterson (1999) track order execution status on NYSE during May 1996. They find that, because the uptick rule limits the minimum shorting price to be at a level higher than the highest bid price, short orders cannot be executed in more than 89% of the trading time in 1/8-point markets. The proportion of no-short-trade time raises to a more exaggerating figure of 98% in 1/4 -point markets. Although the SEC states "allowing relative short selling in advancing markets" as one of the three goals of the uptick rule[5], Alexander and Peterson find the trading time and order execution rate of short orders to remain very limited in advancing markets.

Macey, Mitchell, and Netter (1988) look at the effect of the uptick rule during the market crash on October 19, 1987 and find it to be exacerbating the decline. They argue that the major side effect of the uptick rule is hampering index arbitrage, which serves the financial market by transferring information between the futures and cash markets. In line with Alexander and Peterson (1999), Macey, Mitchell, and Netter also conclude that the uptick rule hinders the efficiency of price discovery process.

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5 Security Act Release No.16964. July 9, 1980.

In contrast to the few studies on the effects of the uptick rule, several papers address changes associate with its repeal. Alexander and Peterson (2008) find that, after the uptick rule was lifted, the average short orders still trade at a price higher than the bid-ask midpoint. This phenomenon was classified as one of the side effects of the uptick rule in their 1999's paper. Alexander and Peterson also point out the decrease in market liquidity caused by the removal of Rule 10a-1. This finding is corroborated by Blau and Brough (2012), who find that short sellers use more large orders without the uptick rule than with it, possibly due to reduced liquidity.

Boehmer, Jones, and Zhang (2008) study the effect of repealing the uptick rule and argue that the uptick rule has a modest effect on shorting but may benefit the market by increasing liquidity and improving other market quality measures. They do not find evidence supporting the overvaluation effect or the price reversal effect, as implied by short sale constraint theories by Miller (1977) and Harrison and Kreps (1978).

Diether, Lee, and Werner (2009) investigate the changes brought by the "Pilot Program", which was mandated by the SEC to study the necessity of the uptick rule. They find increasing short activity in Pilot stocks but no significant changes in terms of daily return and volatility. Slight increases in spreads and intraday volatility are documented as well. They conclude that the effects of the uptick rule can be largely attributed to order flow distortion created by the rule itself and thus, the uptick rule can be safely removed.

The United States is not the only market with a "tick rule". In 1994, Hong Kong Stock Exchange introduced virtually the same price test for a list of designated securities eligible for short selling. Chang, Chen, and Yu (2007) find the "tick rule" barely hinders short selling activities as stocks added to the short list experience significant return declines. In other words, when stocks are ineligible for short selling, they are overpriced. The overpricing effect is stronger for stocks with a wider dispersion of investor opinions.

2. The 2008 Short Sale Ban

What will happen if we take the regulatory short sale constraint to the extreme? The Emergency Order[6] placed by the SEC during the 2008 financial crisis is by far the most powerful setting

[6] Release NO. 34-58592, 18 September 2008.

available to answer this question. Various studies have been carried out on the impact of the 2008 short sale ban; most of them conclude that the ban severely injured market quality.

Academics have also postulated two deleterious side effect associated with the short sale ban: price inflation and reduced market liquidity. Boulton and Braga-Alves (2010) show that the ban successfully eliminated naked short selling for restricted stocks but led to considerable increases of naked shorts in the closely matched financial firms. In line with Miller's (1977) overvaluation theory, prices of the banned stocks were found to be inflated by 10% (Harris and Namvar, and Phillips, 2013) to 16.5% (Boulton and Braga-Alves, 2010). Beber and Pagano (2013) examine the short sale bans around the world during the crisis period. However, they do not find significant price inflation in other countries due to the bans. After the ban was lifted, the inflated stock prices in the U.S. market reversed (Autore, Billingsley, and Kovacs, 2011).

Liquidity for the banned stocks is significantly reduced not only because short sellers cannot sell short (Woolridge and Dickinson, 1994), but also institutions are less willing to establish long positions that are very difficult to hedge (Autore, Billingsley, and Kovacs, 2011). Spreads for restricted stocks increased dramatically (Boulton and Braga-Alves, 2010; Beber and Pagano, 2013). Grundy, Lim, and Verwijmeren (2012) find more frequent put-call parity violations for the banned stocks and option market makers tended to refrain from writing puts because it is hard to hedge their positions by shorting. Battalio and Schultz (2011) document a sharp increase in option trading costs. The reduction of liquidity is a side effect shared by short sale bans around the world, it is particularly strong for small cap stocks and stocks with no tradable options (Beber and Pagano, 2013).

The overall costs of the 2008 short sale ban on market quality are seen more intuitively in dollar values. In the option market, liquidity costs paid by investors are conservatively estimated to be $505 million (Battalio and Schultz, 2011) whereas in the stock market, the amount of abnormal wealth transferred from buyers to sellers is conservatively estimated to be between $2.3 to $4.9 billion (Harris, Namvar, and Phillips, 2013).[7]

[7] Whether these abnormal transfer actually erode investor confidence is a topic for future research.

3. Rule 201

The paper that is most directly related to our study is Jan, Jain, and McInish (2012). Using daily and intraday short sale data from September 1, 2008 to May 9, 2011, they investigate in the impact of Rule 201 on short seller behavior. Contrary to the SEC's opinion that short sellers would exacerbate market declines, Jan, Jain, and McInish find that short sellers are more active before, instead of after, stocks experience huge price declines. The level of daily short selling activity, measured by the ratio of short selling volume to total trading volume, is lower when stock prices decline dramatically. This is even true before the approval of Rule 201. In addition, their analysis on intraday trading activities also shows no evidence that short sellers manipulate the price downwards for firms affected by Rule 201. Short selling ratios did not increase even during the May 6, 2010 Flash Crash. Jain, Jain, and McInish conclude that Rule 201 seems superfluous.

Halmrast (2015) assembles daily and intraday stock price data on the U.S. market and Canadian market for 2010 and 2012 to study the effect of the short sale circuit breaker. He matches firms that triggered the circuit breaker with firms that do not, based on the stock price, market capitalization, and circuit breaker proximity. By comparing the changes in both groups, he finds that Rule 201 improves liquidity on the ask side but not on the bid side. The circuit breaker does not have significant influences on stock prices or trading volumes. No significant evidence of the circuit breaker supporting the stock prices is found.

While these two papers present empirical evidence for the circuit breaker, their results might be influenced by limitations in the samples as well as in the methodologies, which are addressed in our paper. First, our sample is more comprehensive, covering three years of daily stock returns from 2009 to 2012, with no gaps in the middle. This allows us to contrast the impacts brought by the circuit breaker at finer scales. Jan, Jain, and McInish (2012) only use two months of data after the full compliance date. Their main results are obtained by contrasting differences between their limited full compliance period and the pre-approval period, which leaves a time gap of more than one year in between. Halmrast (2015) also omits data for 2011 and discards four months of data for 2012 because they are deemed to be too volatile. Huge gaps in time are undesirable in difference-in-differences studies as they increase the likelihood that market-wide events to affect target and control group stocks unevenly, distorting the true treatment effect. In

other words, the reliability of the difference-in-differences results is severely impaired. Our study remedies this problem by eliminating gaps in our sample and extending the sample to include two years of daily data in the pre-breaker period and one year in the post-breaker period.

Second, our algorithm for the implementation of Rule 201 is both transparent and more comprehensive. While both Jan, Jain, and McInish (2012) and Halmrast (2015) try to recover short halts that should have taken places in the pre-breaker period, neither of them provide statistics describing the effectiveness and accuracy of their analogous Rule 201 algorithm. We address this issue and present the performance of our analogous algorithm benchmarked against the exchange short halt records.

Third, we account for the effects of huge intraday declines. The nature of the short sale circuit breaker implies that it is a subset of huge price movements. However, neither Jan, Jain, and McInish (2012) nor Halmrast (2015) recognizes that the effects of the circuit breaker are likely mixed with the effects of large price declines. We acknowledge this point and show influences of the circuit breaker with the effects of large price declines removed.

Our paper not only contributes to the literature by proposing a new perspective of examining the effects of Rule 201. Our results suggest that the circuit breaker enhances the efficiency of the markets. As the stocks affected by Rule 201 are posted daily by the exchanges, they are clearly in the spotlight of traders. The enhanced attention drawn to these stocks serves as a catalyst to information collection and analysis for firms likely in distress. This draws the investors' attention to these stocks, boosts the amount of information perceived by investors, and eventually improves market pricing efficiency.

C. Methodology

1. Daily Halts

The daily short sale circuit breaker records from Nasdaq and NYSE are very limited. The Nasdaq and NYSE short sale circuit breaker records date back to February 28, 2011 and March 25, 2015, respectively. While Nasdaq records start exactly from the full compliance date, NYSE records lag years behind. To keep NYSE stocks in the sample, an algorithm that replicates the mechanism of the short sale circuit breaker is implemented to *recover* the short halts data

immediately after the compliance date. More importantly, this algorithm allows us to *back-test* the effectiveness of the circuit breaker even before the announcement date and identify targeted stocks of the circuit breaker.

The mechanism of the circuit breaker is quite straightforward, it rules that stocks decline 10 percent or more from their last closing prices in a single day subject to the alternative uptick rule for the remaining of that day as well as the following trading day. The key is to determine whether a stock declined 10 percent in one day. This can be easily done by looking at tick-by-tick data and examine the price changes in percentage. However, the daily low price records serve us equally well as any stock with a daily low price at least 10 percent less than its last closing price must have triggered the circuit breaker. To see why, assume stock ABC closed at $100 on June 15, 2011, if its daily low price on June 16 is $88, then there was at least one trade made at $88, which is a 12% decline from its last closing price ($100). We can safely conclude that stock ABC has triggered the short sale circuit breaker on June 16, 2011. As stated in Rule 201, the circuit breaker remains effective for the trigger day and the following trading day. In the example, it means the circuit breaker is effective on Friday, June 17, 2011.

Table 1 reports the performance of the analogous method in 2016. Short halt records produced by the analogous method (*CRSP halts*) is compared with actual records from Nasdaq (*Nasdaq halts*) and NYSE (*NYSE halts*). The sample period covers 2016 January 1, 2016 to December 31, 2016. We choose 2016 because the short halts data on NYSE only became available on March 25, 2015, which limits our test period from the front end; the CRSP database is updated annually and only has data until December 31, 2016 at the time of this study, which limits the test period from the back end. In 2016, Nasdaq and NYSE recorded 31,425 short sale halts. We exclude the following records from the sample: 183 records were triggered outside regular trading hours[8], 10 records are duplicated[9], 5,558 records have ticker symbols longer than four letters, and 601 records do not find valid Permno number. The number of total valid exchange records is 25,078. *CRSP halts* cover more than 89.6% (22,481 out of 25,078) of them.

[8] Regular trading hours start from 9:30 and end at16:00, EST. See http://business.nasdaq.com/discover/events/trading-hours.
[9] Duplicated records are short halt records with the same trading symbol on the same day.

Why is a little more than 10 percent exchange short halt records not found in *CRSP halts*? We found that in most cases, the CRSP records show that the intraday declines of the stocks of these non-matched halts were less than 10 percent (in fact, their median decline was 7.7%). In other words, the exchange records indicate that these stock prices declined intraday for at least 10 percent at some point in time but CRSP says they did not. The most likely cause of the small discrepancy lies in the determination of "closing price". Rule 201 states that the percentage decline is computed based on the closing price "as determined by the listing market for the covered security as of the end of regular trading hours on the prior day". However, if there is not a closing price for the security for the prior day, the last traded price, as determined by the listing market, is used. Therefore, there might be differences between the "last closing price" determined by the exchanges and the closing price recorded in CRSP.

[Insert Table 1 here]

2. Hypotheses

From the discussion of the short sale circuit breaker above, the following four hypotheses are proposed.

HYPOTHESIS 1: The short sale circuit breaker reduces large intraday declines but does not affect the intraday volatility.

This hypothesis directly tests the function of the short sale circuit breaker. The circuit breaker becomes effective when the price of a stock drops more than 10 percent in a single day; it prevents short selling at a price lower than the national best bid. If the large price drop is primarily caused by the short sellers, the circuit breaker should be able to slow down or even stop the price from further declining. In fact, with the sell orders restricted, investors on the bid side can restore the price to its equilibrium level. Thus, we expect to see the extent of large intraday declines significantly reduced by the circuit breaker.

However, we do not expect significant changes in terms of intraday volatility because of two reasons. First, due to the extreme trigger condition, only a fraction of the trading stocks will be affected on a day; second, the circuit breaker restricts the price at which short orders can be placed, it does not ban short selling. Furthermore, long selling is not affected. Therefore, we expect the influence of the short-sale circuit breaker on the market as a whole to be limited.

HYPOTHESIS 2: Stocks triggered the circuit breaker become overpriced.

This hypothesis tests for the possible costs to the market quality. It is based on the overvaluation theory introduced by Miller (1977) and optimism models of short sale constraints. Specifically, Miller (1977) suggests that, in the presence of divergent opinion, short sale restraints prevent the market from effectively incorporating negative information and causes stock overvaluation. The short sale circuit breaker imposes the alternative uptick rule that restricts short selling, but its effect only lasts two days. Thus, we expect to see slight overpricing effects while the circuit breaker is active.

HYPOTHESIS 3: The overpricing effect is larger for stocks with wider dispersion in investor opinions.

This hypothesis is an extension of hypothesis 2. It stresses the second condition in Miller's (1997) overvaluation theory, which states that the level of overpricing increases as the investor opinions diverge further. In this paper, this hypothesis indicates that the overvaluation effect of the circuit breaker is positively related to the level of divergence of investor opinions.

HYPOTHESIS 4: The short sale circuit breaker reduces the extent of price reversal and post-shock drift after large price declines.

This hypothesis tests the informational role of the short sale circuit breaker. Stocks exchanges publish lists of short halted stocks every day, which are excellent post boards for bad news. This improves market informational efficiency by bringing negative information to the public and highlighting stocks that might have deteriorated fundamentals. We expect the circuit breaker to reduce the extents of two of the most studied post-shock abnormal price behaviors: price reversal and post-shock drift. The census of literature believes their causes are investor overreaction and underreaction, respectively (Atkins and Dyl, 1990; Larson, Madura, 2003). Overreaction and underreaction are results of inefficient information incorporation. Investors tend to overreact on private information but not on public information (Daniel, Hirshleifer, and Subrahmanyam, 1998; Larson, Madura, 2003). Negative information with public news report is also incorporated into prices faster (Chan, 2003). Price reversal would be also reduced because the circuit breaker restrains short sellers from placing aggressive short orders and helps supporting the stock prices.

This moderates the extent as well as the speed of the price decline, allowing other market participants more time to digest the information and make thoughtful reactions.

D. Data and Empirical Results

1. Data and Sample Description

This paper uses daily security price data from the Center for Research in Security Prices (CRSP), analyst forecasts from I/B/E/S, and short halt records from NYSE and Nasdaq. The sample period ranges from May 10, 2009 to February 10, 2012. Only domestic stocks (share code 10 or 11) are included, financial and utility firms are excluded. Stocks with a ticker longer than 4-letter are excluded. In the selected stock sample, observations with missing closing price, return, or daily low price are deleted. Observations with zero or negative closing prices are also removed from the sample.[10] The final sample includes 3407 stocks from 3385 firms and 1,841,593 stock-day observations. All the sample stocks trade on either Nasdaq or NYSE.

Table 2 reports the summary statistics of the sample. In Panel A, daily short halts summary statistics, we can see that about 167 stocks are affected by the short sale circuit breaker on an average day in the sample period. From the second row, we know about 90 stocks trigger the breaker on an average day, which leaves 77 (=167 - 90) stocks experiencing the lagged short halt effect. It worth noting that among the 90 halted stocks, 13 (14.4%) are retriggering it. That is, while short selling on these stocks are restricted by Rule 201, they still declined 10% or more in one day, hence retriggered the circuit breaker. 14% is not a negligible proportion, we believe that this could be suggesting delayed price discovery process. Scaling these numbers by the average number of trading stocks on each day in the last row, we can easily see that the circuit breaker affects a little more than 3% of stocks on average. To compare, SEC estimated that approximately 4% of stocks in the CRSP universe would have been affected on an average day from April 2001 to September 2009. Thus, the actual number of stocks affected is relatively less than the SEC's estimation.

The worst day in our sample is August 8, 2011, also known as the Black Monday, in which more than 48.8% of the stocks are affected by the short sale circuit breaker. This was a part of the

[10] According to CRSP, a negative closing price indicates that the closing price is not available and the bid/ask average is used whereas a zero closing price means neither closing price nor bid/ask average is available.

story of the S&P's unprecedented downgrading of the United States' credit rating from triple A to "AA+". In fear of another recession, investors decided to sell first and ask questions later. In fact, August 2011 owns five out of top 10 most volatile days.

[Insert Table 2 here]

Panel B shows the summary statistics of stock characteristics. The average daily closing price is around $21. Nearly five percent of the stocks are penny stocks, therefore, we take care of the potential bid-ask bounce problem by excluding stocks traded at a price lower than $10 the day before triggering the circuit breaker. The intraday decline, as reported in the second row, is computed as the difference between daily low price and the previous closing price, scaled by the previous closing price. The average intraday decline is a little more than two percent, while the fifth percentile reaches as deep as 7.2%. A smaller fraction of the observations crossed the 10% circuit breaker line.

In Figure 1, we plot the date and time distribution of the exchange short halts in 2016. As we can see in Panel A, stocks trigger the circuit breaker more frequently in the beginning of the year than near the end of the year. Panel B demonstrates short halts distribution among the trading hours. A considerable proportion of the short halts happen right after market opens. This is expected as investors accumulate information overnight and start adjusting their positions when the market opens. Overall, there is no significant clustering in date or time.

[Insert Figure 1 here]

2. Effects on Intraday Volatility

We first test the effect of the circuit breaker on intraday volatility in general. Since the circuit breaker affects roughly 3% of the stocks, we do not expect significant changes in the intraday volatility. Table 3 reports the empirical results. In Table 3, several intraday volatility measures are used to avoid possible measurement biases. For each volatility measure, the sample stocks are ranked into quintiles based on their time-series average of that volatility measure throughout the sample period. Stocks ranked in the lowest (highest) quintile forms the *low (high)* quintile portfolio. In addition, stocks ranked in the medium, i.e. the second, third, and fourth quintiles, are pooled together to form the *mid* portfolio. For each day, the equally weighted average of the volatility measure for three portfolios are calculated. The *pre (post)* column reports the time-

series average of cross-section average of the variable in the pre-circuit breaker period (May 1, 2009 to February 28, 2011) and post-circuit breaker period (February 28, 2011 to February 28, 2012). The *diff* column reports the coefficient estimate of circuit breaker dummy from a time-series regression of the variable on an intercept (not reported) and the circuit breaker dummy. The *diff-diff* column represents the coefficient estimate of circuit breaker dummy from a time-series regression of the difference of the variable between *high* and *low* portfolio on an intercept (not reported) and the circuit breaker dummy. The circuit breaker dummy equals to one if the date is in the post-circuit breaker period and zero otherwise.

[Insert Table 3 here]

Let us look at the *diff* column of the *low* portfolio first. After the circuit breaker was installed, their Parkinson and semivariance measures show small and non-significant increases. On the other hand, the price range and intraday measures decrease significantly with t-statistics of -17.2 and -16.9, respectively. Thus, the most stable quintile portfolio became even less volatile. Results from the *mid* portfolio are qualitatively the same as the *low* portfolio with somewhat different t-statistics, indicating that market volatility is reduced. The decile portfolio with the highest intraday declines, *high* portfolio, sees no significant changes in any of the measures. More importantly, the *diff-diff* column compares the changes in the *low* and *high* portfolio and finds no significance. This result is consistent with our expectations in hypothesis 1 that the short sale circuit breaker does not influence intraday volatility significantly.

3. Effects on Intraday Price Decline

We now narrow the scope of our test and focus on the intraday price declines. Intraday price decline is an important performance measure for the circuit breaker because it directly determines whether Rule 201 is triggered. If huge intraday price declines are results of downward price manipulation by short sellers, then by applying the alternative uptick rule, the circuit breaker should be able to reduce the extent of declines. Meanwhile, intraday declines of stocks that do not trigger the circuit breaker should not have changed.

In Table 4, stocks are sorted into intraday decline portfolios to identify the difference introduced by the circuit breaker. Since the 10 percent decline requirement is quite high, we sort the stocks into deciles instead of quintiles. In addition, 10, 7.5, and 5 percentile portfolios are constructed to

take closer snapshots of the most volatile parts of the market. The 10-percentile portfolio includes stock that declines intraday by at least 10 percent, the 7.5 and 5 percentile portfolios are constructed in the same fashion. The decile portfolios and the three percentile portfolios are rebalanced daily.

The *pre (post)* column represents the time-series average of the intraday decline of the portfolio in the pre-breaker (post-breaker) period. The *diff* column reports the coefficient estimate of circuit breaker dummy from a time-series regression of the variable on an intercept (not reported) and the circuit breaker dummy. The circuit breaker dummy equals to one if the date is in the post-circuit breaker period and zero otherwise. Value-weighted (VW) and equal-weighted (EW) results are reported to alleviate the potential severe miss-specified model problem for small firms (Fama 1998).

As one can see in Table 4, the EW and VW results are virtually the same.[11] The *diff* column in both Panel A and Panel B reports extended intraday decline in almost every portfolio. However, none of the differences are statistically significant. The exacerbated intraday declines observed for the post circuit breaker period can hardly be attributed to the effects of the short sale circuit breaker per se since this effect is found in every rank of the value-weighted decile portfolios. We believe this is a result of the market-wide intraday volatility shift, as implied in the previous test.

Notice that for the decile that experiences most intraday declines, rank 1, the average intraday decline is merely 0.028%. This is understandable as the sample summary statistics in Table 2 showed us that only a tiny fraction of the sample stocks declines large enough to trigger the breaker. Naturally, we question if the circuit breaker's effect on the highly volatile stocks is "averaged out" by the changes in non-targeted stocks. Thus, three percentile portfolios are implemented to address this concern. Our main interest lies with the 10-percentile portfolio because it includes the same group of stocks as the circuit breaker does. In Panel C, equal-weighted and value-weighted results of 10, 7.5, and 5 percentile portfolios are presented. First, none of the equal-weighted results are significant but all value-weighted results are negatively significant, meaning that they decline more after the short sale circuit breaker was implemented. This does not support the presumption that the circuit breaker would reduce the levels of intraday

[11] Results using data winsorized by 1 percentile and 99 percentiles are qualitatively the same as well.

declines of highly volatile stocks. Since significant results are shown for the value-weighted portfolio, but not for the equal-weighted portfolios, Panel C also suggests that triggering the circuit breaker is not a small-cap phenomenon.

However, an alternative explanation is that intraday volatility of the market increases and the behavior of the sorted portfolios merely reflects the enhanced market volatility. In the next section, we separate the market shift effects from the effects of the short sale circuit breaker by contrasting the changes in the targeted stocks and the non-targeted stocks.

[Insert Table 4 here]

4. Effects on Target Stocks

In this test, a difference-in-differences test is carried out by running pooled regressions of the performance proxies (treated variables) on an intercept, a circuit breaker dummy, a treatment dummy, and the interaction of the circuit breaker dummy and the treatment dummy. Specifically, the model is as follows

$$Perf_{it} = \alpha + \beta_1 Treatment_{it} + \beta_2 SSCB_{it} + \beta_3 SSCB_{it} * Treatment_{it}$$

Where $Perf_{it}$ is the intraday decline, turnover, or raw return of stock i on day t. There are two types of treatments: *Halt* is the dummy that equals to one if the intraday decline of stock i is larger than or equal to 10 percent on day t and zero otherwise; *Effect* is the dummy that equals to one when the circuit breaker is effective for stock i on day t. $SSCB_{it}$ is the circuit breaker dummy that equals to one if the date is in the post-circuit breaker period (February 28, 2011 - February 28, 2012) and zero otherwise. Note that once triggered, the circuit breaker is effective for the remaining of that day and the following business day, so that makes *Effect* cover *Halt* and the day after *Halt*. $SSCB_{it} * Treatment_{it}$ is the interaction term that equals one if both $SSCB_{it}$ and $Treatment_{it}$ are one.

The difference-in-differences model compares the difference between pre- and post-circuit breaker periods in the control group ($\beta_1 = (\alpha + \beta_1) - \alpha$) to the difference in the target group ($\beta_1 + \beta_3 = (\alpha + \beta_1 + \beta_2 + \beta_3) - (\alpha + \beta_2)$). Assuming the common shock(s) influences the control and target group equally, then the interaction term ($\beta_3 = (\beta_1 + \beta_3) - \beta_1$) cancels out the effects of common shocks by subtracting the difference in the control group from that in the

target group. Therefore, β_3 is our main interest and its coefficient estimate represents the effect of the short sale circuit breaker on targeted stocks.

In Table 5, the treatment for model 1, 3, and 5 is the short halt event whereas that for model 2, 4, and 6 is the effect of the circuit breaker. We examine the short halt treatment first. Model 1 tests its influence on the intraday decline. The circuit breaker improved the extent of intraday decline by a non-significant 0.21% (t=0.89). Turnover ratio sees an approximately 0.35% increase, but the change is insignificant (t=1.4). The circuit breaker significantly reduced the return by 0.57%, with a t-statistic of -13.35. When we change the treatment to *effect,* results are qualitatively the same with significances reduced. Thus, the short sale circuit breaker does not significantly reduce the extent of intraday decline of stocks and can potentially worsen the daily returns for affected stocks. The liquidity cost, measured by shares turnover, is not significantly affected by the circuit breaker.

[Insert Table 5 here]

There may be concerns that the highly autocorrelated circuit breaker dummy, which is zero and one for all observations before and after the fully compliance date, respectively, might cause the errors to be autocorrelated. Bertrand, Duflo, and Mullainathan (2004) point out that failure to account for error autocorrelation can result in a high probability of false rejecting the null hypothesis in the difference-in-differences analysis. To access this potential issue, the first, second, and third autocorrelation coefficients are estimated. The coefficients are obtained by simply regressing the residuals on its corresponding lags. The t-statistics for the estimated first, second, and third autocorrelation coefficients are 0.75, -0.95, and 0.33, respectively. The coefficient of determination of the lagged model is 0.00%. Therefore, no significant error autocorrelation is detected and the standard error estimation is robust to autocorrelation. Nonetheless, models are estimated with Newey-West error correction of 5 lags (Newey and West, 1987). The statistics are almost identical to the results reported here.

Questions could also be raised at the difference-in-differences study methodology itself. By the definition of the difference-in-differences study, one implicitly assumes that the other impacts affect the targeted stocks and control stocks equally. There is no guarantee that every market-wide event affect both groups equally, but arguably one could propose the population of effects

of the events would follow a normal distribution and eventually the overall effect of other impacts distribute evenly on target and control stocks.

In response to the first hypothesis, empirical tests find no significant reduction in intraday price declines of the volatile stocks, nor in intraday volatility. The returns after dramatic price declines are worsen. The results reject the first hypothesis and suggest the circuit breaker has no noticeable effect on the stock price.

5. Abnormal Return Measures

Once activated, the short sale circuit breaker imposes the alternative uptick rule, which prevents short selling at a price lower than the national best bid price, on affected stocks. This is a typical type of short sale constraint. Miller (1977) suggests that, in the presence of divergent investor opinions, regulatory short sale constraints can result in overvaluation of stocks. We proceed to test the two parts of Miller's hypothesis. First, we test if the short sale circuit breaker induces overvaluation of stocks; second, we test if wider dispersion in investor opinions can exacerbate the overvaluation.

The expected return is estimated using the Carhart four-factor model (Carhart, 1997), which is an extension of the Fama-French three-factor model (Fama, French, 1993) with an additional momentum factor. The abnormal returns, AR_{it}, and cumulative abnormal returns, CAR_i, are estimated as

$$AR_{it} = (R_{it} - rf_t) - \hat{\alpha}_i - \hat{\beta}_{i1}\, SMB_t - \hat{\beta}_{i2} HML_t - \hat{\beta}_{i3} UMD_t - \hat{\beta}_{i5} MKTRF_t$$

$$CAR_i(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{it}$$

Where R_{it} is stock i's return on day t (the day the stock triggers the breaker is the event day, day 0), rf_t is the risk-free return calculated from the one-month U.S. Treasury bill rate. The coefficients $\hat{\alpha}_i$ and $\hat{\beta}_i$s are estimates of the intercept and risk factor loadings from a time-series regression of stock i's daily return, R_{it}, on the daily risk factors, in an estimation window before the event window. On day t, SMB_t (Small Minus Big) is the average return on the nine small stock portfolios minus the average return on the nine big stock portfolios, HML_t (High Minus Low) is the average return on the two value portfolios minus the average return on the two

growth portfolios, UMD_t (Winners Minus Losers) is the average return on the two high prior return portfolios minus the average return on the two low prior return portfolios. $MKTRF_t$ is the excess return on the market, value-weight return of all CRSP firms incorporated in the US and listed on the NYSE, AMEX, or Nasdaq that have a CRSP share code of 10 or 11 at the beginning of month t.[12] Therefore, AR_{it} is the estimated abnormal return (the difference between the actual return and the expected return based on the asset pricing model) for stock i on day t, and $CAR_i(t_1, t_2)$ is the cumulative abnormal return during event window (t_1, t_2).

Throughout the paper, the length of estimation window is set to 250 days, unless otherwise specified. In addition, for an event to be included in the sample, it must have at least 150 daily return records in its estimation window. Furthermore, stocks must be trading at a price of $10 or higher per share on the day before the event. This requirement is imposed to reduce possible biases due to bid-ask bounce of low-price stocks (Brown, Harlow, Tinic, 1988; Bremer and Sweeney, 1991). The threshold is chosen to be $10 to align our results with those from Park (1995) and Cox, Peterson (1994), who use a $10 criterion to in their studies of large intraday price movements.[13]

6. Abnormal Return Results

In Table 6, the cross-sectional average of ARs surrounding short sale circuit breaker events is reported. For each event, the factor loadings are estimated in a window spanning from 260 days before the event to 31 days before the event.

[Insert Table 6 here]

As per the overvaluation theory, stocks facing short sale constraints might become overpriced. In our case, the days of short sale constraints are the two days that the circuit breaker is active, namely day 0 and day 1. Table 6 documents extreme negative abnormal returns. The mean abnormal return drops to -7.35% and is very significantly different from zero (t=-54.46) on the event day (day 0), which is not a surprise since we are focusing on days with large intraday declines. Apparently, the dramatic declines in stock prices fall out of the scope of the explanation

[12] We are grateful that Kenneth R. French makes these data available on his website.
[13] Tests are repeated with a $5 criterion and the results are qualitatively identical.

power of the four-factor asset pricing model. One drawback of using returns on day 0 as the returns under short sale constraints is that, depending on the exact time of trigger, only a proportion of the trading time is short-constrained. Thus, we also look at day 1, in which the short sale circuit breaker is active throughout the day.

Table 6 shows the average abnormal return on day 1 is negative but is economically (-0.077%) and statistically insignificant (t=-0.9). Neither day 0 nor day 1 reports positive abnormal returns, indicating that short halted stocks do not become overpriced.

Let us look at days in the pre-event and post-event windows. Most of the mean abnormal returns from day -10 to day -1 are negative, but only those of day -2 and -1 are statistically significant. Thus, negative information about the plunged stock may have been leaked. After the short halt (day 2 to day 10), mean abnormal returns show a mixture of significantly positive and negative results. Panel B also confirms this as the mean cumulative abnormal return for the window (1, 5) and (1, 10) are insignificant. This rejects the delayed price discovery hypothesis as subsequent cumulative returns are not significantly negative.

In sum, the short sale circuit breaker does not lead to stock overpricing on average. This result is the opposite of what the overvaluation theory predicts. On the other hand, the mixed results of abnormal returns and cumulative abnormal returns in the post-event period suggest that the price discovery process is not significantly impacted by the circuit breaker.

It worth noting that for cumulative abnormal returns in the post-event window, the negative significance increases as the length of the window extends. Specifically, the cumulative abnormal return from day 1 through day 10 is -0.056% with a t-statistic of -0.32, but the numbers for day 1 through day 30 (-0.336%, t=-1.17) and day 1 through day 60 (-3.87%, t=-9.27) are becoming increasingly significant. The most likely explanation is that the predicting power of the estimated four-factor model decays as time prolongs.

As robustness tests, the event study is also carried out using Fama-French three-factor model and the Fama-French five-factor model. These results are qualitatively the same and corresponding tables are available upon request.

7. Measures of Dispersion of Investor Opinions

In this section, we look at the impact of dispersion in investor opinions on cumulative abnormal returns. This perspective is largely derived from Miller's (1977) conjecture that, in presence of short sale constraints, wider divergence in investor opinion will result in more negative information being removed from the market and hence, increases the extent of overpricing. Many empirical works (see, for example, Boehme, Bartley, and Sorin, 2006) find evidence in favor of this argument.

We use four proxies to capture investor divergent opinion. The first proxy, $SIGMA_{raw}$, is the standard deviation of the daily raw returns measured in the estimation window (i.e. from day -260 to day -11). Our second proxy for divergent opinions is $SIGMA_{ab}$, the standard deviation of the daily abnormal returns based on the Carhart four-factor model, estimated in the same window. $TURNOVER$, another widely agreed-upon opinion divergence measure, is used as our third divergent opinion proxy.[14] It represents the daily trading volume scaled by the total number of shares outstanding, averaged over the same estimation window. Our fourth proxy is analyst forecast, $ANALYST$, is another frequently used divergent opinion proxy[15]. It is the standard deviation of analyst forecasts on company earnings scaled by the mean forecast. Table 7 reports the summary statistics of these proxies.

[Insert Table 7 here]

8. Cross-Sectional Regression of Abnormal Returns over Dispersion Measures

Hypothesis 4 is tested by estimating several versions of cross-sectional regression in which the dependent variables are the post-event period cumulative abnormal returns, and the dispersion of opinion proxy variables discussed above as predictors. Table 8 provides the results.

Model 1 to 3 uses the cumulative abnormal return on day 0 as the dependent variable. All divergent opinion measures are significantly negative, meaning that more disagreement among investor opinions lead to lower returns when stocks become short halted. Model 4 to 6 look at effects on the day 1 abnormal return. On the opposite of results from model 1 to 3, the

[14] See, for example, Chang, Cheng, and Yu (2007), and Shalen (1993).
[15] See, for example, Goetzmann, Massa (2005), Diether, Malloy, and Scherbina (2002), and Snehal (2011).

divergence measures become positively significant. Thus, higher divergence level results in higher return on the day after short halt trigger. This result supports Miller's (1977) conjecture that wider divergence in investor opinions leads to higher overpricing effect for stocks under short constraints.

Model 7 to 9 gives results on the post-event return. The standard deviation of raw return and abnormal return do not have significant influence with t-statistics of 0.03 and 0.03, respectively. Turnover ratio continues to show significant predictive power over post-event return, with a t-statistic of -5.3. These results indicate that after the short sale circuit breaker expired, there is little to none relation between the divergence of investor opinion and subsequent returns.

These results support hypotheses 4, that wider divergence of investors' opinions exacerbates the potential overvaluation effect of the short sale circuit breaker.

[Insert Table 8 here]

9. Price Reversal

Stocks trigger the short sale circuit breaker usually experience substantial price declines. Strictly speaking, a stock that declines 10% or more in one day could recover its losses before the market closes. However, most of the halted stocks in the sample do not fully recover their losses, as the mean abnormal return on day 0 is a significant -7.3% in Table 6. Consequently, short halts are usually accompanied by large price declines. These declines are likely due to deteriorated firm fundamentals. Because if they are manipulated, we should see price bouncing back up on day 0 and 1, which we do not.

This raises questions about possible price reversal effects. Many scholars have documented reversals following large changes in price. Bremer and Sweeney (1991) study subsequent returns of stocks that decline more than 10% and find significant raises in return in the following two days. Their result is robust to different sub-periods and threshold values. Atkins and Dyl (1990) also found evidence in return reversals after price plunges (-10.2%). In addition, they documented downward adjustments after large price increases (+14.31%). Although the reversals are statistically significant, Atkins and Dyl pointed out that traders' ability to profit from it are largely removed by transactions costs.

To formally test it, the post-event cumulative abnormal returns of different periods are regressed cross-sectionally on the event period cumulative abnormal return from day 0 to day 1. In Table 9, model 1 and 2 report the regression results of the post-event cumulative abnormal return from day 2 to day 5 on an intercept and the event CAR. Evidence suggests that event CAR is not significantly related to post-event cumulative abnormal return (t=-0.26); however, it is slightly more significant when controlling for firm capitalizations (t=0.77). The post-event cumulative abnormal return period extends to an 11-day period in model 3 and 4. In model 3, the coefficient estimate of event CAR is significantly negative (t=-2.18). This result indicates that lower event cumulative returns lead to higher post-event cumulative returns. The negative relation is more pronounced when firm capitalization joins the regression. Note that the estimated intercepts for four models are negative. This implies that for price reversal to occur (return>0), the event CAR must be substantially negative. This translates to event CAR thresholds of -34% and -27.1% (=-0.01084/ 0.0399) in model 3 and 4, respectively. The clear majority of short halted stocks would not satisfy this requirement as the event CAR has a mean of 7% and a standard deviation of 7.2% (see Table 6). Therefore, we conclude that there are no significant price reversal effects after the short sale circuit breaker. This confirms our hypothesis 4 that price reversal effect is reduced.

[Insert Table 9 here]

10. Post-shock Drift

Large price declines are often followed by poor performance. We compare long-term abnormal returns between pre-breaker and post-breaker periods. The abnormal return results for the post-breaker period (February 28, 2011 to February 28, 2012) has been discussed above. Because our short sale circuit breaker algorithm is not restricted by time, we take this advantage and determine stocks that should have triggered the circuit breaker in the per-breaker period (May 1, 2009 to February 28, 2011). An event study is conducted in the same fashion on the pre-breaker period. To save space, only details for day -10 to day 10 are printed in Table 10. Results for extended period of time are shown in Figure 2. In Table 10, mean abnormal returns from the pre-breaker period are subtracted from that of the post-breaker period to derive the mean difference abnormal returns, as presented in the *Mean Diff* column. *T value* reports statistics from two-sample t-tests. The two-sample t-test is suitable because the samples are independently drew from pre-breaker and post-breaker periods and the large size of the samples (average $N > 3000$)

satisfies the normality requirement. Most of the event day samples passed the Welch's unequal variances t-test, indicating that the homogeneous assumption holds. Results from the two-sample t-test assuming equal variances (formula not presented) are nearly identical.

[Insert Table 10 here]

In Table 10, the mean difference between the pre-breaker and post-breaker abnormal returns on the event day is slightly over 0.1% with a t-statistic of 0.47. In other words, the changes brought by the short-sale circuit breaker on the event day is economically and statistically insignificant. This agrees with our previous finding that the circuit breaker is unable to affect the stock return process or restrain the intraday price decline. Most of the differences are not significant until day 2. The circuit breaker substantially increased the abnormal returns from day 2 to day 7. The effect is more pronounced in the long-term, as the cumulative difference increases to as much as 2.5% in Figure 2. The direct result of enhanced post-shock returns is the reduced post-shock drift effect.

[Insert Figure 2 here]

Figure 2 plots the cumulative abnormal returns in pre- and post-breaker periods together, with the solid (dotted) line representing post-breaker CAR (pre-breaker CAR). We can see both subsamples do not experience significant abnormal returns before triggering the breaker. However, as noted above, there seems to be some information leakage in the post-breaker period as the cumulative abnormal return starts showing signs of plunging since day -3. The extent of decline is almost identical in both subsamples. The most interesting part is the subsequent returns. For the pre-breaker period, an apparent downward trend extends to at least two months after the large decline. This is typical post-shock drift. After the circuit breaker was implemented, the cumulative abnormal return remains stable for over 30 days. The difference reaches a substantial 2.5% on day 30. This implies that the circuit breaker significantly reduced the post-shock drift effect. The gap gradually closes afterwards. Currently, we do not have a formal conjecture on the causes. It may simply be due to the asset-pricing model losing its predictive power in the prolonged future. Together with results in the price reversal section, our evidence supports hypothesis 4 and confirms the informational value of the short sale circuit breaker.

E. Conclusion

Our paper examines the effects of Rule 201, also known as the short sale circuit breaker, on the US stock market. Using a comprehensive sample of stocks from NYSE and Nasdaq, we test the hypothesis that the circuit breaker has no major impact on market intraday volatility. Our difference-in-differences test involves several intraday volatility measures and none of them show significant changes. To have a closer look at the effects of the circuit breaker on highly volatile stocks, we study stock portfolios sorted on intraday price declines. Neither sorted portfolio nor multiple regression reports significant improvements in intraday price declines. We also show that Rule 201 does not impact liquidity. But returns of the targeted stocks on the event day are somewhat worsened by the circuit breaker.

Next, we measure potential detrimental effects of the short sale circuit breaker in terms of creating stock overvaluation. We identify short halt events by applying Rule 201 on the sample stocks, then use Carhart four-factor asset pricing model to derive the risk-adjusted returns. The results show no sign of overpricing on the day after the event day. Our results are robust to differences in asset pricing model. Furthermore, we find that dispersion in investor opinions has a strong negative relationship with the event day return but a significant positive relationship with the post-event day return; this implies that the large price decline on the event day might be an exaggerated outcry of negative opinions.

Another important effect of Rule 201 that has not been studied before is its informational role. The lists of short halted stocks published by the exchanges serve as a billboard of highly risky stocks. This public information facilitates the informational efficiency of the market and reduces price reversal and post-shock drift effects. Evidence suggests that the short sale circuit breaker substantially reduced price reversal effect during the event period and post-shock drift effect for over 30 days.

This paper contributes to the literature by addressing several concerns raised since the introduction of the short sale circuit breaker. Specifically, we document that the breaker does not reduce intraday volatility or liquidity. Our findings are consistent with Jain, Jain, and McInish (2012), who document no clear benefits of the circuit breaker in ensuring fair valuations, promoting liquidity, or preventing a sudden flash. However, we document for the first time that Rule 201 improves price stability in the post-shock periods.

It worth noting that although the circuit breaker does not impact market quality, the compliance costs of market participants are estimated to be $2 billion in the first year and $1 billion per year thereafter (Johnson, 2010).[16] Whether its informational value justifies its costs is a question for further investigations. Future works with comprehensive intraday data could also look at how the short sale circuit breaker affects intraday price dynamic, especially around the -10% intraday price decline threshold.

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Table 1 Summary statistics of the analogous Rule 201 implementation in 2016.

Exchange records consist of short sale circuit breaker records obtained from Nasdaq and NYSE websites. *CRSP records* are produced analogously by implementing the Rule 201 on prices drew from CRSP. *Regular trading hour* is from 09:30 to 16:00. *Duplicates* are short sale circuit breaker records with the same trading symbol on the same day. The sample period is January 1, 2016, to December 31, 2016.

Item	**NOBS**
Exchange records	31425
Less records outside regular trading hour	183
Less duplicates	10
Less ticker longer than 4-letter	5558
Less cannot find permno	601
Total	25078
Found in CRSP records	22481

Table 2 Summary statistics

This table reports the summary statistics of the pooled stock-day observations. *Affected* is the number of stocks affected by the short sale circuit breaker on a day. *Halted* is the number of circuit breaker triggers. *Refreshed* is the number of stocks that trigger the circuit breaker while under its effect. *Stock* is the total number of trading stocks on that day in the sample. The sample period is from May 1, 2009 to February 28, 2012

Panel A. Summary statistics on daily short halts.

Variable	Mean	Median	Std Dev	5th Pct	95th Pct
affected	167.4128	126	206.1317	78	299
halted	90.40933	65	141.6838	38	167
retrigger	13.13299	9	22.0452	3	28
stock	5434.4	5435	62.87744	5335	5534

Panel B. Summary statistics on stock characteristics.

Variable	Unit	Mean	Median	5th Pct	95th Pct
Market Capital	Million dollars	3735.27524	473.4691	21.57783	13910.41
Volume	Thousand shares	1369.11529	245.15	4.729	5675.7
Closing Price	Dollar	21.7496475	13.75	1.27	64.76
Intraday Decline	Percentage	-2.07992	-1.53689	-7.20721	0.87336

Table 3 Difference-in-difference test on intraday volatility before and after the extended compliance date.

For each volatility measure, the sample stocks are ranked into quintiles based on their time-series average of that volatility measure throughout the sample period. *Low (high)* portfolio consists of stocks in the lowest (highest) quintile. *Mid* portfolio includes stocks in the second, third, and fourth quintiles. For each day, the equally weighted average of the volatility measure for three portfolios are calculated. The *pre (post)* column reports the time-series average of cross-section average of the variable in the pre-circuit breaker period (May 1, 2009 to February 28, 2011) and post-circuit breaker period (February 28, 2011 to February 28, 2012). The *diff* column reports the coefficient estimate of circuit breaker dummy from a time-series regression of the variable on an intercept (not reported) and the circuit breaker dummy. The *diff-diff* column represents the coefficient estimate of circuit breaker dummy from a time-series regression of the difference of the variable between *high* and *low* portfolio on an intercept (not reported) and the circuit breaker dummy. The circuit breaker dummy equals to one if the date is in the post-circuit breaker period and zero otherwise. *P_var* is Parkinson volatility calculated as $(\ln(High) - \ln(Low))^2 / (4 \ln 2)$ (Parkinson, 1980). *Close-close (close-open)* volatility is calculated as the square of daily returns based on closing prices (opening to previous day closing price). *Intraday (price range)* is the difference between daily high and low prices standardized by closing price (high price). Positive semivariance is calculated as $\max[0, \log(x_t/x_{t-1})]^2$and negative semivariance is calculated as $\min[0, \log(x_t/x_{t-1})]^2$ (Markowitz 1959). T-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Low			**Mid**			**High**			**High-Low**
	Pre	Post	Diff	Pre	Post	Diff	Pre	Post	Diff	Diff-Diff
P_var	0.00027	0.00028	0.00001	0.00096	0.00093	-0.00004	0.00486	0.00321	-0.00166	-0.00167
t-stat			(0.76058)			(-0.76577)			(-1.207)	(-1.22837)
close_close	0.00035	0.00044	0.00009***	0.00116	0.00128	0.00012	0.0424	1.7811	1.7387	1.73861
t-stat			(2.93382)			(1.82118)			(1.3469)	(1.34683)
close_open	0.00009	0.00013	0.00004***	0.00033	0.00039	0.00006***	0.04147	0.96521	0.92374	0.92369
t-stat			(4.16605)			(3.06806)			(1.33902)	(1.33896)
Intraday	0.02453	0.02057	-0.00396***	0.12197	0.11173	-0.01024***	1.03173	0.80891	-0.22281	-0.21885
t-stat			(-16.9052)			(-6.59262)			(-1.13263)	(-1.11261)
Price range	0.0242	0.0203	-0.0039***	0.1191	0.10904	-0.01006***	0.97783	0.7695	-0.20833	-0.20444
t-stat			(-17.2133)			(-6.87724)			(-1.13297)	(-1.11189)
semidown	0.00015	0.0002	0.00005**	0.00051	0.00062	0.00011*	0.00202	0.00215	0.00013	0.00008
t-stat			(2.12667)			(1.88372)			(0.86702)	(0.5637)
semiup	0.00018	0.00021	0.00003	0.00062	0.00062	0.00001	0.0044	0.00366	-0.00074	-0.00077
t-stat			(1.45129)			(0.15127)			(-1.52127)	(-1.58697)

Table 4 The impact of Rule 201 on intraday decline

Sample stocks are sorted into decile portfolios on percentage of intraday decline, which is calculated as $decline_t = (low_t - close_{t-1})/close_{t-1}$, where low is the daily low price, and $close$ is the closing price. The *pre (post)* column represents the time-series average of intraday decline of the portfolio. The *diff* column reports the coefficient estimate of circuit breaker dummy from a time-series regression of the variable on an intercept (not reported) and the circuit breaker dummy. The circuit breaker dummy equals to one if the day is in the post-circuit breaker period (February 28, 2011 – February 28, 2012) and zero otherwise. The portfolios are rebalanced daily. Value-weighted (Equal-weighted) results are reported in Panel A (Panel B). Percentile portfolios only consist of stocks with intraday decline larger than or equal to 10%, 7.5%, or 5% are built in the same fashion and are presented in Panel C. The sample period is from May 1, 2009 to February 28, 2012. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Value-Weighted Decile Intraday Decline Portfolio.

	Pre	**Post**	**Diff**	**T-stat**
1	-0.00028	-0.00029	-1.00386E-05	-1.38151
2	-0.00015	-0.00015	-1.8192E-06	-0.37859
3	-0.00011	-0.00011	-0.000003005	-0.68644
4	-8.6E-05	-9E-05	-3.5385E-06	-0.87263
5	-6.9E-05	-7.2E-05	-0.000003894	-1.03551
6	-5.4E-05	-5.8E-05	-3.9072E-06	-1.12177
7	-4E-05	-4.4E-05	-3.7781E-06	-1.17446
8	-2.7E-05	-3.1E-05	-3.4665E-06	-1.18051
9	-1.2E-05	-1.5E-05	-3.1041E-06	-1.1724
10	2.46E-05	1.91E-05	-5.4765E-06	-1.76741*

Panel B. Equal-Weighted Decile Intraday Decline Portfolio.

	Pre	**Post**	**Diff**	**T-stat**
1	-0.000303973	-0.00030405	-0.000000077	-0.012245697
2	-0.000153192	-0.000154902	-1.7099E-06	-0.356163492
3	-0.000111904	-0.000114858	-2.9533E-06	-0.673709561
4	-8.70865E-05	-9.06253E-05	-3.5388E-06	-0.872278755
5	-6.89251E-05	-7.27843E-05	-3.8592E-06	-1.022672201
6	-5.39681E-05	-5.78723E-05	-3.9042E-06	-1.117593841
7	-4.05477E-05	-4.43362E-05	-3.7885E-06	-1.173645094
8	-0.000027209	-3.07349E-05	-3.5258E-06	-1.19228637
9	-1.10427E-05	-0.000014586	-3.5433E-06	-1.332367427
10	6.83362E-05	6.85709E-05	2.347E-07	0.016475512

Table 4 Cont'd The impact of Rule 201 on intraday decline

Panel C. Equal-Weighted and Value-Weighted Intraday Decline Percentile Portfolios.

	Intercept	**Diff**
10 pct EW	-0.14889	-0.00021
t-stat	-239.99	-0.2
10 pct VW	-0.15148	-0.00861**
t-stat	-60.54	-2.05
7.5 pct EW	-0.11481	0.000198
t-stat	-275.16	0.28
7.5 pct VW	-0.11282	-0.00709**
t-stat	-67.74	-2.53
5 pct EW	-0.08186	0.000339
t-stat	-258.27	0.64
5 pct VW	-0.07538	-0.00346**
t-stat	-83.74	-2.29

Table 5 Difference-in-difference regression on intraday volatility, liquidity, and returns.

Intraday decline, *Turnover*, and *Return* are regressed on the *Halt (Effect)* dummy and its interaction with the *SSCB* dummy, *SSCB*Halt (SSCB*Effect)*. *Trigger* equals to one if the stock triggers the short sale circuit breaker on that day and zero otherwise. *Effect* dummy equals to one if the stock is under the circuit breaker's effect and zero otherwise. *SSCB* is a dummy indicating whether the date is after the full compliance date, it equals to one in the post-breaker period (February 28, 2011 to February 28, 2012) and zero otherwise. All regressions include firm-fixed effect and intercepts are dropped to avoid perfect collinearity. T-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Model					
	1	2	3	4	5	6
	Intraday Decline		Turnover		Return	
Intercept	N/A	N/A	N/A	N/A	N/A	N/A
SSCB	0.000149	0.000158	0.0863**	0.082104**	-0.00137***	-0.00149***
	(0.43)	(0.45)	(2.37)	(2.23)	(-21.82)	(-22.85)
Halt	-0.12703***		18.87807***		-0.09241***	
	(-89.92)		(127.74)		(-364.04)	
SSCB*Halt	0.002128		0.349262		-0.00571***	
	(0.89)		(1.4)		(-13.35)	
Effect		-0.06752***		13.89128***		-0.04365***
		(-63.31)		(124.66)		(-220.52)
SSCB*Effect		-0.0002		0.207852		-0.00086***
		(-0.11)		(1.12)		(-2.59)
Firm FE	YES	YES	YES	YES	YES	YES
R-square	0.009	0.006	0.158	0.158	0.104	0.041
F-stat	5.49	3.56	110.34	109.83	68.27	25.17

Table 6 Abnormal returns and cumulative abnormal returns around short halts

This table reports abnormal returns and cumulative abnormal returns based on the Carhart four-factor model around short halts. A short halt event is defined as one in which the price of an individual stock dropped at least 10 percent from its last closing price and therefore is subjected to the alternative uptick rule. The event day is denoted as day 0. The estimation window is (-280,-31) with a minimum length of 150 days. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Daily abnormal returns (%) around short halts

Day	Mean	Median	N Obs.	T Value	Std. Dev.
-10	-0.0006	-0.00021	2078	-0.92	0.029405
-9	-0.0004	-0.00163	1750	-0.5	0.033488
-8	-0.00017	-0.00105	2166	-0.24	0.031427
-7	0.000757	0.00025	2977	1.31	0.031613
-6	-0.00046	-0.00192	2585	-0.71	0.033241
-5	0.001521	-0.00032	1702	1.6	0.039169
-4	-0.00096	-0.00138	1630	-0.97	0.039631
-3	-0.00053	-0.0018	2076	-0.64	0.037782
-2	-0.0026***	-0.00369	1753	-2.96	0.036749
-1	-0.0034***	-0.00252	2189	-3.78	0.042104
0	-0.07355***	-0.06233	3061	-56.71	0.071761
1	-0.00077	-0.00194	2601	-0.9	0.043712
2	-0.00015	-0.0006	1728	-0.15	0.042011
3	0.002219**	0.001044	1643	2.28	0.039438
4	-0.00195**	-0.00301	2082	-2.38	0.037435
5	0.003049***	0.000524	1753	2.65	0.048174
6	2.93E-05	-0.00103	2178	0.04	0.033912
7	0.002129***	0.000531	2999	3.24	0.035997
8	-0.0018***	-0.00218	2578	-2.91	0.031405
9	-0.00119	-0.00143	1713	-1.59	0.03099
10	-0.00254***	-0.0034	1631	-3.14	0.032662

Panel B. Cumulative daily abnormal returns (%) around short halts

CAR Window	Mean	Median	t Value
(-10,-1)	-0.00435***	-0.00714	-2.42
(-1,1)	-0.07664***	-0.06778	-48.57
(1,5)	0.00087	-0.00063	0.64
(1,10)	-0.00056	-0.00221	-0.32
(1,30)	-0.00336	-0.00766	-1.17
(1,60)	-0.03875***	-0.02218	-9.27

Table 7 Descriptive Statistics of measures of dispersion of investor opinions

The table reports the description statistics of variables that proxy for the dispersion of investor opinions around short halts. A short halt event is defined as one in which the price of an individual stock dropped at least 10 percent from its last closing price and therefore is subjected to the alternative uptick rule. $SIGMA_{raw}$ is the standard deviation of the daily raw returns in the estimation window of (-280, -31), with a minimum length of 150 days. $SIGMA_{abret}$ is the standard deviation of daily abnormal returns in the same estimation window based on the Carhart four-factor model. $TURNOVER$ is the average daily trading volume in the same estimation window, scaled by outstanding shares. *ANALYST* is the standard deviation of the analyst forecasted values of earnings-per-share, scaled by the absolute value of average forecasts.

Variable	N	Mean	Median	Std Dev	Minimum	Maximum
$SIGMA_{raw}$	8296	0.038171	0.034383	0.0218306	0.002999	0.467521
$SIGMA_{abret}$	8296	0.032926	0.028303	0.0218486	0.004744	0.465446
$TURNOVER$	8296	0.019692	0.01217	0.0396833	7.59E-05	1.043121
$ANALYST$	6260	0.551004	0.142959	1.5298791	0.015347	11.15346

Table 8 Cross-sectional Regression of Cumulative Abnormal Returns around Short Halts over Dispersion of Opinions

This table reports the cross-sectional regression results of CARs with different windows around short halts over proxy variables for dispersion of investor opinions. A short halt event is defined as one in which the price of an individual stock dropped at least 10 percent from its last closing price and therefore is subjected to the alternative uptick rule. $CAR(0,0)$, $CAR(1,1)$, and $CAR(2,5)$, are the cumulative abnormal returns on the event day, the day after the event day, and in the 4-day window (2,5) around the short halt event, respectively. The abnormal returns are based on the Carhart four-factor model with an estimation window of (-280, -31) and a minimum length of 150 days. $SIGMA_{raw}$ is the standard deviation of the daily raw. $SIGMA_{abret}$ is the standard deviation of daily abnormal returns in the same estimation window. $TURNOVER$ is the average daily trading volume in the same estimation window, scaled by outstanding shares. *ANALYST* is the standard deviation of the analyst forecasted values of earnings-per-share, scaled by the absolute value of average forecasts. T-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	MODEL											
	CAR(0,0)				CAR(1,1)				CAR(2,5)			
	1	2	3	4	5	6	7	8	9	10	11	12
INTERCEPT	-0.06724***	-0.0607***	-0.08649***	-0.08897***	-0.00498***	-0.00448***	-0.00298***	-0.00149**	-0.00194	-0.00116	-0.00086	-0.00235***
	(-36.12)	(-36.85)	(-83.13)	(-94.55)	(-3.83)	(-3.87)	(-4.23)	(-2.02)	(-1.46)	(-0.97)	(-1.17)	(-3.34)
$SIGMA_{raw}$	-0.59679***				0.09829***				-0.01703			
	(-14.09)				(3.32)				(0.0302)			
$SIGMA_{abret}$		-0.89075***				0.0995***				-0.04357		
		(-21.37)				(3.36)				(0.03017)		
TURNOVER			-0.17929***				0.0898***				-0.08785***	
			(-7.63)				(5.6)				(-5.3)	
ANALYST				-0.00246***				0.00051				-0.00022
				(-4.00)				(1.08)				(-0.49)
Adj. R-square	0.0233	0.0521	0.0069	0.0024	0.0015	0.0016	0.0046	0.000	-0.0001	0.0001	0.0033	-0.0001

Table 9 Cross-sectional Regression of post-event cumulative abnormal returns during 3-day and 10-day Windows around short halts

This table reports the cross-sectional regression results of the post-event CARs around short halts over the $Event\ CAR$ and the size-control variable CAP. A short halt event is defined as one in which the price of an individual stock dropped at least 10 percent from its last closing price and therefore is subjected to the alternative uptick rule. Post-event $CARs$ are the cumulative returns in 4-day window (2,5) and 11-day window (2,12) around the short halt event date. $Event\ CAR$ is the cumulative abnormal return in the 2-day window (0,1) around the event date. The abnormal returns are based on the Carhart four-factor model with an estimation window of (-280, -31) and a minimum length of 150 days.CAP is the logarithm of market capital six days before the short halt event. T-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	MODEL			
	CAR(2,5)		CAR(2,12)	
	1	2	3	4
INTERCEPT	-0.00277***	-0.02463**	-0.00912***	-0.01084
	(-2.89)	(-2.13)	(-5.98)	(-0.58)
Event CAR	-0.00201	-0.0065	-0.0268**	-0.0399***
	(-0.26)	(-0.77)	(-2.18)	(-2.95)
LG(CAP)		0.00107*		6.84E-05
		(1.92)		(0.08)
Adj. R-sq.	-0.0001	0.0003	0.0005	0.001

Table 10 Difference in the event returns between the pre-breaker and post-breaker periods

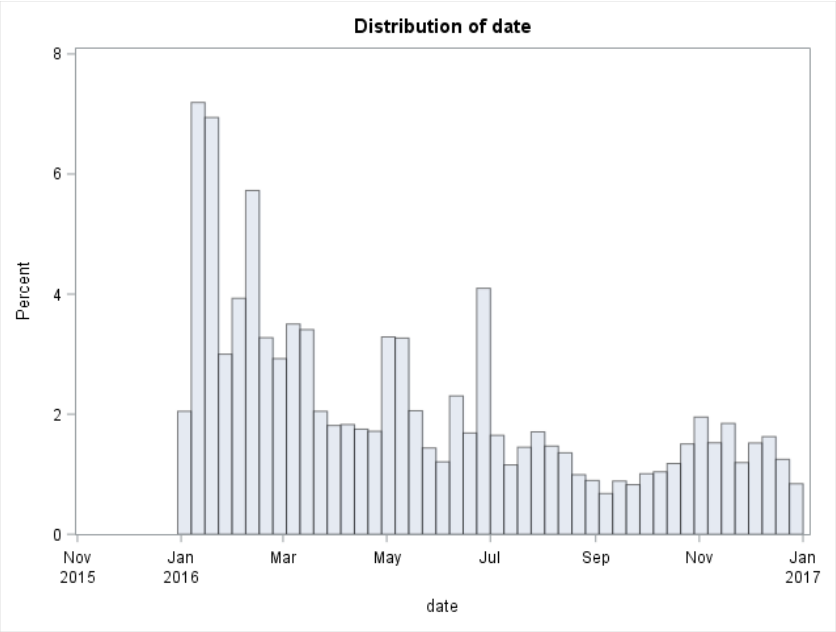
This table reports the abnormal returns based on the Carhart four-factor model around short halts in both pre-breaker (May 1, 2009 to February 28, 2011) and post-breaker (February 28, 2011 to February 28, 2012) subsamples. A short halt event is defined as one in which the price of an individual stock dropped at least 10 percent from its last closing price and therefore is subjected to the alternative uptick rule. The event day is denoted as day 0. The estimation window is (-280,-31) with a minimum length of 150 days. *Pre-breaker mean (Post-breaker mean)* column is the mean abnormal return in the pre-breaker (post-breaker) subsample. *Mean Diff* is the mean difference calculated by subtracting the pre-breaker mean from the post-breaker mean. The *t-value* is the t-statistic from a two-sample test for equal means. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Day	pre-breaker mean	post-breaker mean	Mean Diff	T value
-10	0.000308	-0.0006	-0.0009	-1.0
-9	-0.00038	-0.0004	-1.4E-05	0.0
-8	0.000493	-0.00017	-0.00066	-0.7
-7	0.000416	0.000757	0.000341	0.4
-6	0.000784	-0.00046	-0.00125	-1.3
-5	0.000722	0.001521	0.0008	0.5
-4	-0.00011	-0.00096	-0.00085	-0.5
-3	2.13E-06	-0.00053	-0.00053	-0.5
-2	0.00088***	-0.0026	-0.00348	-3.0
-1	-0.00026***	-0.0034	-0.00315	-2.6
0	-0.07463	-0.07355	0.001083	0.6
1	-0.00049	-0.00077	-0.00028	-0.2
2	-0.00345**	-0.00015	0.003296	2.2
3	-0.00472***	0.002219	0.006942	4.5
4	-0.00277	-0.00195	0.000816	0.7
5	-0.00144***	0.003049	0.004485	3.4
6	-0.00109	2.93E-05	0.001121	1.2
7	-0.00034***	0.002129	0.002469	2.8
8	-0.00142	-0.0018	-0.00038	-0.4
9	-0.00152	-0.00119	0.000326	0.3
10	-0.00073	-0.00254	-0.00181	-1.5

Figure 1 Distribution of short sale circuit breaker events

The following figures show the date and time distribution of short sale circuit breaker triggers in 2016. A short sale circuit breaker event is defined as a stock triggers the circuit breaker. Events include records from NYSE and Nasdaq during the regular trading hours from 9:30 to 16:00.

Panel A. Distribution of date



Panel B. Distribution of time

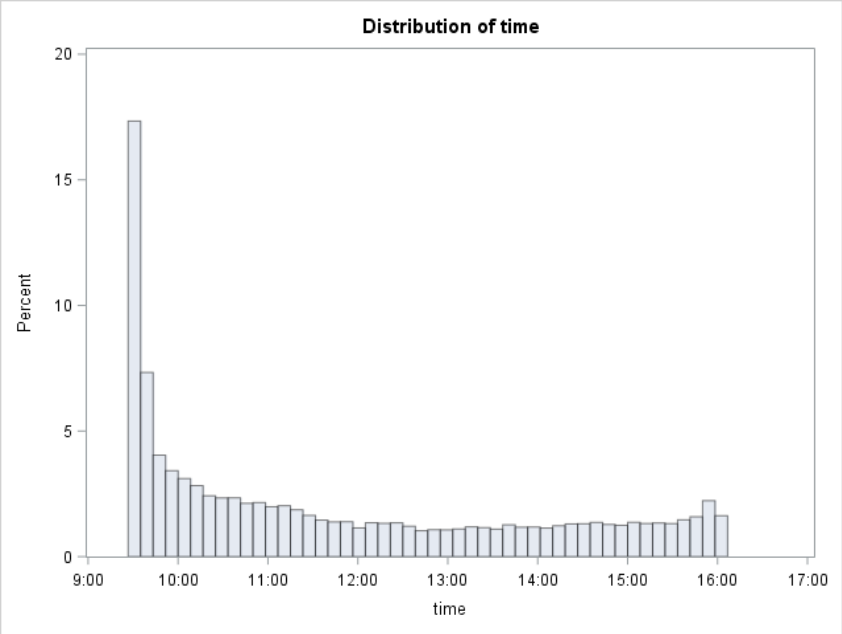


Figure 2 Daily cumulative abnormal returns around short halts

This figure reports cumulative abnormal returns around short halts in pre- (May 1, 2009 to February 28, 2011) and post-breaker (February 28, 2011 to February 28, 2012) subsamples calculated based on the Carhart four-factor model. A short halt event is defined as one in which the price of an individual stock dropped at least 10 percent from its last closing price and therefore is subjected to the alternative uptick rule. The event day is denoted as day 0. The estimation window is (-280, -31), with a minimum length of 150 days.