Do Traders Use Options Markets to Bypass Regulatory Short Sale Restrictions? Evidence from the Short Sale Circuit Breaker Rule 201 ☆

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Abstract

This paper provides new evidence on the effects of the short selling circuit breaker on firms with traded options. Over the full compliance period for SEC Rule 201, stocks with traded options react more negatively on short sale restriction trigger days relative to their counterparts without traded options. We show that the short sale circuit breakers increase put and call options spreads as well as put-call parity violations around the trigger days. Accounting for endogeneity, we show that the increase in spreads only partially deters traders from using the options markets, which remain active throughout, to bypass short sale restrictions.

JEL Codes: G01, G12, G14, G18

Keywords: short selling circuit breaker; options trading; trading costs

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1. Introduction

SEC Rule 201, which prohibits short sales on a stock when its price drops more than 10 percent in a single day on the stock market has been the subject of considerable debate in recent years. The presumption for regulators is that the circuit breakers should help restore investor confidence by immunizing the stocks that suffer declines caused by dedicated short sellers who would otherwise destabilize the markets. However, traders can circumvent regulations on short sales using the derivatives markets, as noted by Grundy, Lim, and Verwijmeren (2012). It is straightforward to show that a dedicated short seller could mimic the returns with a synthetic short sale position by simultaneously buying a put option and writing a call option on the same stock.[1]

Should direct short sale restrictions be coupled with regulation of derivatives markets to limit synthetic short sales? This argument of course requires that trading of options occurs in liquid markets with low transactions costs, and that options prices are unaffected by short selling restrictions. If option market liquidity and transactions costs are adversely affected by short selling restrictions, the ability of pessimistic investors to undermine market stability through derivatives trades might be limited or offset. Indeed, Grundy et al (2012) suggest that the high spreads for financial stocks that were subject to the September 2008 short sale ban provided an effective restriction on options trading, which would block this "bypass channel[2]." The purpose of this study

[1] Figlewski and Webb (1993) introduce a market completeness argument, to show how options enhance efficiency under short selling restrictions. Danielsen and Sorescu (2001) and Blau and Wade (2011) document how options trading circumvents short selling restrictions. Johnson and So (2012) argue that short selling constraints would encourage pessimistic investors to go to the options market.

[2] These results are consistent with Cho and Engle (1999) that the options spreads are affected by stock liquidity, as well as Boehmer, Jones, and Zhang (2009) and Beber and Pagano (2013) who document an increase in stock illiquidity for those affected by the 2008 Short Sale Ban.

is to provide new evidence whether the short sale restrictions under SEC Rule 201 are vulnerable to offset by options traders. Indeed, while we observe an increase in bid-ask spreads for affected options on short sale restricted days, unlike Grundy et al (2012), the increase only *partially deters* traders from using the options markets to bypass the short sale rule. Our analysis begins by examining the relationship between options trading as such and stock returns around circuit breaker days. In fact, we show in this paper that during the full compliance period for SEC Rule 201, stocks with traded options react more negatively on short sale restriction trigger days compared to their counterparts without traded options. Stocks with traded options also experience slower recovery after the restrictions are in place. We also conduct event studies that compare stocks with and without options during the compliance period vs. stocks in a control period, in which short selling is unencumbered by regulatory restrictions. The differential performance of these stocks vs. the sample of full compliance stocks can be viewed as a measure that isolates the incremental effects of short selling restrictions per se. We note that in fact during the control period without short sale restrictions, stocks with options actually outperform stocks without options during periods of market turmoil. We demonstrate that put-call parity violations increase significantly on the event day. However, bypassing short sales restrictions using synthetic short positions during Regulation 201 trigger events is still shown to be tractable since: a) the synthetic short price remains quite close to the actual stock price; and b) the options market remains active for the affected stocks.

The remainder of the paper is organized as follows. In the next section, we provide some background to the analyses and introduce our hypotheses. Section 3 provides a description of the data and methodology. Section 4 provides the empirical results for the event studies. Section 5

analyzes the impact of the short sale circuit breaker on option spreads and option trading volume. In section 6, we look at violations of put-call parity, and the tractability of synthetic short positions during Regulation 201 events as well as other periods of heightened market volatility. The paper concludes with a summary in section 7.

2. Background and Hypotheses

Regulators have historically viewed short-selling as a means to improve price discovery and market efficiency. However, they have also been wary of the potential of short sellers to destabilize markets when prices fall. As a consequence, short sales have been generally permitted, subject to certain constraints. In 1938, the United States Securities and Exchanges Commission (SEC) enacted the first short sale regulation, known as the Uptick Rule, permitting short sales only when on an uptick. Regulators have also tried to address issues such as failures to deliver on covered positions and abusive naked short sales.[3] Over the past twenty-five years, the regulatory environment has been in somewhat of a flux. A major overhaul of the rules was embodied in Regulation SHO, which became effective on January 3, 2005, and temporarily suspended the uptick rule for a subset of "pilot" securities. At the end of the pilot program in 2007, after concluding that the Uptick Rule made no discernible differences in the trading patterns of stocks, the SEC repealed the Uptick Rule.[4] Rule 204T strengthens close-out requirements by applying Regulation SHO on a broader range of securities and requiring faster close-out of failures to deliver. It was adopted by the SEC as a part of the 2008 Emergency Order that banned short-selling

[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).

[4] See also Diether, Lee, and Werner (2009).

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, Chairman of the SEC at that time argued that the costs of the short sale ban outweigh the benefits.[5] Subsequently, regulation SHO was amended to include a 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. The compliance date for stocks under Rule 201 is February 28, 2011. Rule 201 activates the price test restriction that proscribes stock short sales when the price of a stock declines by more than 10 percent in a single day.

Most of the papers to date look at the behavior of stock prices around alternative short sale regulatory constraints, such as during the uptick rule, and the 2008 short selling ban. Only a few published studies look at the impact of Rule 201. Jain, Jain, and McInish (2012) conclude that it is ineffective in preventing short sellers during periods of crisis. Switzer and Yue (2019) show that the circuit breaker fails to reduce intraday volatility and intraday price declines, especially for the most volatile stocks in the market. Market quality measures based on liquidity and pricing efficiency are largely unaffected. Only a few papers examine the impact of short-sale restrictions on the derivatives markets. These studies focus on the 2008 short sale ban.

The conclusions of the extant literature are mixed. Danielsen and Sorescu (2001) and Blau and Wade (2011) suggest that option trading activities reduce the effect of short sale constraints. Caciki, Goswami,and Tan (2010) and Hayunga, Lung, and Nishikaw (2011) show that options spreads increase for stocks affected by the short sale ban. Battalio and Schultz (2011) document a sharp increase in options trading costs (bid-ask spreads) during the short sale ban. Grundy, Lim,

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

and Verwijmeren (2012) document a significant increase in bid-ask spreads, a decrease in options trading volumes and more frequent put-call parity violations for banned stocks. This result is not surprising, since options market makers are deterred from writing puts when they are unable to hedge their positions by shorting. In a more recent paper, Hu (2018) shows that the negative options listing effect may be caused by informed traders circumventing short sale constraints – i.e. stocks have a greater chance of experiencing selling pressure after option listing.

To date, we are unaware of any study that has looked at the impact of the short sale circuit breaker Rule 201 on options. This study will help fill this gap. Based on the aforementioned discussions on short sale restrictions, we introduce our first hypothesis:

HYPOTHESIS 1: Stocks with traded options experience more negative abnormal returns than their counterparts without traded options when short sale circuit breaker rule is triggered.

This hypothesis tests the efficacy of options for informed traders to circumvent short sale restrictions. To the extent that options holders have covered positions, they are more likely to sell the underlying shares in response to bad news when the full impact of the decline can be offset by the gains in their options positions. Shareholders may be less prone to selling when they must absorb the full brunt of the expected losses. In addition, pessimistic investors that are unable to take short positions can buy puts or build synthetic short positions by buying puts and writing calls (Figlewski and Webb (1993)), adding to the downward pressure on stocks affected by the short sale circuit breaker rule.

Rule 201's objective on inception was to reduce market stress during periods of falling prices. Rule 201 does not directly apply to options markets. However, when the short selling circuit breaker is triggered, the increased illiquidity in the stock market could adversely affect liquidity in

the option market (see Cho and Engle (1999)). This in turn will lead to an increase in option spreads for stocks that trigger the circuit breaker rule. This motivates our second hypothesis:

HYPOTHESIS 2: The short sale circuit breaker should lead to higher option spreads for affected stocks

If active market participants rely on the options market as a means to bypass the short sale ban, we expect an increase in both call and put trading activities (call and put volumes in our case) for stocks affected by the ban and on the event day when the ban is triggered in particular. However, the ability of equity option investors to successfully work around the short sale ban is largely dependent on the costs of doing so, as reflected in spreads. If spreads increase sufficiently, option traders may be deterred from acting on their predilections. Grundy et al. (2012) argue that during the 2008 short sale ban, the increase in options spreads served as a strong deterrent to options trading. This finding can explain the drastic decline in options trading volume that was observed. In line with this reasoning, we formulate our third and last hypothesis:

HYPOTHESIS 3: The inducement to trade in options to create synthetic short positions will be enhanced during periods of large market declines (circuit breaker events). The effects might be tempered to the extent that circuit breakers give rise to higher trading costs (higher spreads).

3. Data and Methodology

3.1 Daily Halt Identification

We use the official Nasdaq short sale circuit breaker records to obtain the Nasdaq sample halts for the analyses, as they are available since the Full Compliance date of Rule 201 for the study. The NYSE records are less complete, beginning only on March 25, 2015. To complete the gaps for the NYSE sample, we adopt an algorithm that replicates the mechanism of the short sale circuit

breaker: stocks are subject to Rule 201 if they decline in the day by 10 percent or more from their last closing prices. In this case, they are subject to Rule 201 for the remainder of that day and the following trading day. A stock with a daily lowest price at least 10 percent less than its last closing price by definition is thus identified as a subject to the short sale prohibition under Rule 201.

To determine whether a stock declines 10 percent in one day, one can use tick-by-tick data and examining the price changes across the trading day. However, the daily lowest price records from the Center for Research in Security Prices (CRSP) database can provide the same information. Any stock whose daily lowest price is at least 10 percent less than its last closing price will trigger the circuit breaker. To illustrate let us assume stock ABC closes at $100 on June 14, 2011. If its daily lowest price on June 15 is $85, then there was at least one trade made at $85, which is a 15% decline from its last closing price ($100). We can thus conclude that stock ABC has triggered the short sale circuit breaker on June 15, 2011. As stated by Rule 201, the circuit breaker remains effective for the trigger day and the following trading day. In the example above, the circuit breaker is effective on June 16, 2011.

To validate the approach, we compare short halt records generated by our approach to the actual records from Nasdaq and NYSE over the period January 1, 2016, to December 31, 2016. The year 2016 is chosen, since short halts data on the NYSE only became available on March 25, 2015, which limits our test period from the front end. In the year 2016, the Nasdaq and NYSE report 31,425 short sale halts. We exclude the following observations from the sample: 183 events that are triggered outside regular trading hours,[6] 10 duplicated records,[7] 5,558 records that have ticker

[6] Regular trading hours start from 9:30 and end at16:00, EST. See http://business.nasdaq.com/discover/events/trading-hours.

[7] Duplicated records are short halt records with the same trading symbol on the same day.

symbols longer than four letters, and 601 records that do not provide valid firm identifiers in the CRSP database.. The number of total valid exchange records is 25,078. *Our analogous method* performs quite well, and captures about 90% of the exchange record halts (22,481 out of 25,078).[8]

3.2 Sample Construction

The short sale circuit breaker sample in our study spans from 28Feb2011 to 10Dec2016. This represents a period in which the Circuit Breaker Rule 201 mandated Full Compliance for firms listed on the markets. The stocks analyzed cover those companies that were subject to short sale restrictions due to Rule 201. We also conduct the analyses over a control period, over which short selling is unencumbered by regulatory restrictions. The control sample spans from 10Oct2008, which is the day after the short sell ban that was imposed in response to the financial crisis, to 2Aug2009, which is the day prior to the pre-approval period for the circuit breaker rule. This sample is limited to stocks that encounter a daily drop in price greater than 10% that would have triggered a circuit breaker if this performance is to happen when Rule 201 was effective and in full compliance. These "quasi-halted" companies are used as benchmarks to isolate the actual impact of the circuit breakers.

This paper uses daily security price data from the CRSP, and short halt records from NYSE and Nasdaq. For the event study analyses for the market responses to short selling circuit breaker halts, across the various portfolios of option bearing vs non option bearing stocks we estimate expected

[8] The most likely cause of the discrepancy between exchange records and CRSP records 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 no 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 in the "last closing price" determined by the exchanges and the closing price recorded in CRSP.

returns using the Carhart four-factor model (Carhart (1997)). The abnormal returns AR_{it}, and cumulative abnormal returns CAR_i, are estimated as:

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

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

Where R_{it} is stock i's return on day t (the day the stock triggers the breaker is event day 0), and r_f is the risk-free return represented by 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 Fama-French risk factors in the estimation window.[9] SMB_t (Small Minus Big) is the average return on the three small stock portfolios minus the average return on the three large stock portfolios on day t; 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-weighted 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.

The length of the 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 for at least $5 per share to be included in our sample. This requirement is imposed in order to reduce possible microstructure bias due to the bid-ask

[9] These factors are obtained from the website of Professor Kenneth R. French.

bounce of low-priced stocks (Grundy et al. (2012), Brown, Harlow, Tinic (1988), Bremer and Sweeney (1991) and Ball, Kothari, and Shanken (1995)).

3.3 Measuring Options Spreads and Trading Activity

To conduct the analyses of option spreads and trading activity, we obtain end of day prices, open interest, traded volumes as well as implied volatility for all options of every halted and "quasi-halted" stock[10] in our sample from OptionMetrics. We gather options data for 30 days around the CB halt day.

For the option spread analyses, we use the Grundy et al (2012) relative spread measure, which they refer to as the Spread Relative to Optionality (SRO):

$$SRO = \frac{Best\ offer - Best\ bid}{(Best\ offer + Best\ bid)/2 \ - \max[Intrinsic\ Value, PV(forward)]} \times 100$$

Where

$$Intrinsic\ Value\ = \begin{cases} \max[0, S-K]\ \ for\ calls \\ \max[0, K-S]\ \ for\ puts \end{cases}$$

$$PV(forward) = \begin{cases} S - PV(div) - K^{-rt}\ for\ calls \\ K^{-rt} - \ S + \ PV(div)\ for\ puts \end{cases}$$

The present value of dividend is estimated by summing up all the discounted dividends whose payment ex-dates fall within the options maturities. We obtain the dividend file from CRSP. We use the Zero file from OptionMetrics as a proxy for the continuously compounded discount rate.

For the option volume analyses, we also rely on the option volume per stock (OVS hereafter) definition of Grundy et al (2012). OVS on a particular day is equal to the sum of all options volume

[10] A quasi-halted stock is one that would have been halted in accordance with the price limits set by Rule 201.

on the stock for the corresponding day, considering these options share the same characteristics (being calls or puts in our case). Stock Daily Volume is the daily trading volume of the stock (in millions of shares) obtained from CRSP database.

3.4 Estimated Models

To capture the effects of the short selling circuit breakers on the option spread, we modify the Grundy et al (2012) analysis to incorporate the specific circuit breaker event days, and size effects (market capitalization). The latter is included to account for Beber and Pagano's (2013) finding that short sale bans are particularly detrimental for liquidity, for stocks with small capitalization. More specifically, we perform the following regressions:

$$SRO = \alpha + \beta_1 D \times Moneyness + \beta_2 [D \times Moneyness]^2 + \beta_3 (1 - D) \times Moneyness + \beta_4 [(1 - D) \times Moneyness]^2 + \beta_5 (time\ to\ maturity)^{-1} + \beta_6 VIX + \beta_7 Market\ Cap + \sum_{-5}^{+5} \gamma_i D_i + e$$

D_i: is a dummy variable that takes a value of 1 for a circuit breaker trigger day and zero otherwise, i is the event day and the days around the event day and e is a random error term. D is a dummy variable equal to one if ln(S/K) is greater than one and zero otherwise. (Time to Maturity)$^{-1}$ is the inverse of the option time to option maturity, in days. The terms including D allow us to control for the nonlinear effect of moneyness and the effects of in- and out-of-the money options.[11] For every option in our sample, we obtain the corresponding daily ATM implied volatility by interpolating between the nearest ATM implied volatilities surrounding the options maturity. ATM implied volatilities are obtained from the volatility surface file in OptionMetrics. VIX is the daily

[11] See Grundy et al. (2012).

closing value of the CBOE volatility index. Market Cap is equal to the firm's daily stock price multiplied by the number of shares outstanding. The above equation is estimated for every option on every halted stock in our model in a sample that includes the halt day as well 30 days around the halt day.

To measure the impact of the short selling circuit breakers on the option trading volume (OVS), we similarly modify the Grundy et al (2012) analysis to incorporate the specific circuit breaker event days, and size effects (market capitalization). More specifically, we perform the following regressions:

$$OVS = \alpha + \beta_1 \, Stock \, Volume + \beta_2 Stock \, Returns + \beta_3 \, VIX + \beta_4 \, Market \, Cap + \sum_{-5}^{+5} \gamma_i D_i + e$$

3.5 Data Span and Applied Filters

Our sample for the full compliance of Rule 201 which, as mentioned above spans the period from 28Feb2011 to 10Dec2016 consists of 2,062 firms with options, (31,956 halt-firm observations), and 2,062 firms without options, (44,493 observations). The control period covers 10OCT2008 to 2AUG2009. The control period sample consists of 5,851 (55,172 halt-firm observations). This sample consists of 2,837 firms with options (22,585 halt-firm observations), and 3,171 firms without options (32,587 halt-firm observations).

When applying our options related tests, we impose the following filters, following Grundy et al. (2012). More specifically, the criteria for options' deletion are:

- For call options, the bid price is less than the strike price minus the stock closing ask price;
- For put options, the bid price is less than the stock closing ask price minus the strike price;

- The closing offer price is less than the closing bid price;
- The time to expiration is less than 30 days;
- The time to expiration is more than one year;
- Open interest is zero;
- The spread is more than 50% of the excess of the midpoint over and above the maximum of the intrinsic value and PV(forward). This implies that the maximum value of the SRO measures included in our sample is 50;
- The option's price is less than the maximum of the intrinsic value and the PV(forward);
- When option's spread is equal to zero;
- When the best bid is equal to zero;
- When the best offer is equal to zero.

4. Estimation Results

Our analysis begins by examining the relationship between options trading as such and stock returns.

4.1 Abnormal Return Estimates for Stocks with Options vs. Stocks without Options

4.1.1 Abnormal Returns Surrounding Short Sale Circuit Breaker events during the Full compliance period of Rule 201

Table 1 shows the cross-sectional average of abnormal returns, and cumulative abnormal returns surrounding short sale circuit breaker events during the full compliance period for Rule 201 from 28Feb2011 to the end of our sample period, 10Dec2016. The abnormal returns are estimated using

the 4 factor Carhart Model. Panel A shows the results for the stocks that have traded options. Panel B comprises stocks that have no traded options, while Panel C looks at the differences in abnormal returns between the two groups. While circuit breaker events are negative for all firms, as shown in Panel C, the results are more negative for the stocks with traded options. The t value for the event day period is 7.23. Furthermore, the recovery process is worse for firms with traded options, based on the post event windows. The t value of the differential return over the (1, 60) post event window is 10.83.

[Please insert Table 1 about here]

4.1.2 Differential Performance of Stocks with and Without Options during the control period: without short sale constraints.

Another way of looking at the impact of short sale restrictions is to look at stocks with and without options during a control period, when short sale restrictions are not present. Our comparison or control sample consists of the period in which short selling is unencumbered by regulatory restrictions: from 10Oct2008, which is the day after the short sell ban that was imposed in response to the financial crisis, to 2Aug2009, which is the day prior to the pre-approval period for the circuit breaker rule. In this sample, we consider stocks that undergo a daily drop in stock price that is greater than 10%. The results are shown in Table 2 below.

[Please insert Table 2 about here]

Panel A (B) shows the returns for the stocks with (without) options, and Panel C shows the

differential abnormal returns. Focusing on the event day differential returns, we note that in the control period which is free of short sale restrictions, stocks with options actually perform significantly better than their counterparts that do not have options (t value of 65.74). In sum, these results are consistent with Hypothesis 1: The short sale circuit breaker has a more negative effect on stocks with traded options vs. their counterparts without traded options.

5. Effects on Options Spreads and Options Trading Activity

To further explore the effects of the circuit breaker on options markets, we look at the behavior of option trading volume, and option spreads, following the approach of Grundy et al (2012) who focus on the Short Sale Ban of 2008 on financial stocks in the US.

Table 3 provides some summary statistics of the trading volume, spreads and underlying stock returns and volumes for stocks in the sample; Panel A comprises firms that trigger the short selling circuit breakers in the compliance period. Corresponding statistics for the control sample, consisting of stocks experiencing 10% intraday falls in the period free of short sale constraints, are shown in Panel B.

[Please insert Table 3 about here]

We find that stocks with short sales halts (affected by Rule 201) exhibit higher option spreads (both call and put SROs) than stocks in the control sample. The evolution of spreads around trigger days is depicted in Figures 1 and 2 for firms experiencing circuit breaker days in the compliance period as well as the control sample where short selling is unconstrained.

[Please insert Figures 1 and 2 about here]

Note that both call and put option spreads experience a clear jump around trigger days for firms subject to Rule 201. In sharp contrast, the option spreads show no particular spike on trigger-like days in the control sample. The higher options spreads shown for the short sale circuit breaker firms seem to reflect higher illiquidity of the stocks and options, consistent with Cho and Engle (1999), Boehmer, Jones, and Zhang (2013) and Beber and Pagano (2013).

In Table 4 we report the OLS regression results for the put and call option spread (SRO) determinants during the short-sale circuit breaker compliance period (columns 1 and 2) vs. the control sample period (columns 3 and 4). We note that after controlling for option moneyness and maturity, as well as general market volatility (VIX), both call and put option spreads increase significantly on circuit breaker days. This is not the case for firms experiencing "trigger level" returns in the control sample, where short selling is unconstrained. On the whole, our results support Hypothesis 2: Options spreads increase for stocks affected by the short sale circuit breaker.

The evolution of call and put volumes around Rule 201 trigger days is depicted in Figure 3, which includes firms experiencing circuit breaker days in the Rule 201 compliance period. For comparative purposes, we also show the behavior of stock volume and the (scaled) ratio of options volume to stock volume. Put and call options trading volumes increase around Rule 201 trigger days in tandem with increased stock trading. In essence, in the period surrounding short sale halts the trading of options relative to stocks is essentially trendless.

[Please insert Figure 3 about here]

In Figure 4 we show the analogous trading evolution for periods in which firms experience "trigger level" returns in the control sample, where short selling is unconstrained.

[Please insert Figure 4 about here]

In contrast to Figure 3, we note that the volume of put options trading as well as the ratio of put options trading to stock trading increase around the 10% negative return/trigger like days of the control sample. In other words, when short selling is unconstrained, trading in put options rises significantly.

In Table 5 we report OLS regression results for the put and call options trading volume determinants during the short-sale circuit breaker compliance period (columns 1 and 2) vs. the control sample period (columns 3 and 4). The results show that the effect of short sale circuit breakers on put options trading is positive, but not significant, and is significantly negative for call options, after accounting for underlying stock returns, stock trading volume, market volatility, and company size (market capitalization). However these tests do not take into account the endogeneity between trading volumes and spreads for options (George and Longstaff (1993) and Grundy et al (2012)). To this end, in Tables 6 and 7, we report the 2SLS estimates using the fitted values for Option Volume as an instrumental variable in the SRO equation (Table 6) and the fitted SRO as an instrumental variable in the Option volume equation (Table 7). These tables document a significantly negative relationship between options volumes and option spreads. The conclusions of the OLS analyses are reinforced for the spread analysis: on circuit breaker days, we find a significant increase in spreads. Furthermore, this increase persists for up to 4 trading days after the

initial circuit breaker event for put options and 5 trading days for call options. This result is not observed for the pseudo-events in the control sample period. Accounting for changes in spreads in the stock trading volume analysis, we also find an increase in option trading volume on circuit breaker event days. The increased trading volume is more pronounced for put options than call options. However, in contrast with the OLS results, we note that both put and call option volumes also increase significantly around circuit breaker days. In sum, accounting for endogeneity between trading costs (spreads) and trading volume, our results support Hypothesis 3: During periods of large market declines (circuit breaker events) there is significant increase in option trading. Such trading, we conjecture, reflects new synthetic short positions that are created as a mean to bypass regulatory restrictions. The increase in spreads is not sufficiently high to deter option traders, however.

6. Short Selling Circuit Breakers, Violations of Put-Call Parity and Synthetic Short Positions

In this section, we examine the effect of the short selling circuit breaker on violations of American put-call parity. The approach extends Grundy et al (2012) to incorporate potential size effects as well as the discrete event dates relevant to our study. To this end, we estimate the following probit model:

$$Violation = \alpha + \beta_1 Stock\ Volume + \beta_2 Stock\ Returns + \beta_3 VIX + \beta_4 Market\ Cap + \sum_{-5}^{+5} \gamma_i D_i + e$$

Stock volume and Stock Returns are the daily stock volume and return for the companies, respectively. VIX is the closing value of the CBOE volatility index. Market Cap is equal to stock price multiplied by the number of shares outstanding on the corresponding day. The put-call parity

related dependent variables take a value of 1 if the put-call parity relationship is violated: P + S > C + K + PV(div). Following Grundy et al. (2012), the violations are measured from two perspectives: a) Potential decoupling and b) violation arbitrage. The Potential decoupling variable is constructed using closing daily midpoint prices for stocks and options respectively; the violation arbitrage measure is constructed using closing ask prices for call options and closing bid prices for both put options and share prices,

Table 8 shows the descriptive statistics for our put-call parity sub-samples: the full compliance period and the control period. It is evident that there are more put-call parity violations during the circuit breaker full compliance period than the control period. These results are shown for both the potential decoupling and violation arbitrage measures. We also observe higher option prices for the full compliance period relative to the control periods. In contrast, higher option volumes and open interest are observed for the control period sample. These findings are shown for both call and put options.

[Please insert Table 8 about here]

Table 9 shows that the likelihood of observing a violation in put-call parity is positively associated with both stock trading volume and stock returns; violations are negatively associated with company size (market capitalization) and the aggregate market uncertainty proxy (VIX). Potential decoupling put-call parity violations increase significantly on the event day. This result is observed for both full compliance sample and the control sample; the effect is stronger for the full compliance sample relative to the control sample.

[Please insert Table 9 about here]

On the other hand, we observe no significant increase in the likelihood of put-call parity violation when the violation arbitrage measure is used as proxy for put-call parity violations. The latter results could be explained by high transactions costs (reflected in higher spreads) that would be incurred by passive traders submitting market orders (buying at ask prices and selling at bid prices) while conducting the arbitrage; for market makers who or for traders who conduct the arbitrage within the spread, significant profits from arbitrage are more likely, as shown in the analyses when we use the mid-prices. Our results support the hypothesis that during days of large drops in stock price, put-call parity violations are more likely to be observed. This phenomenon is more pronounced for stocks in the short sale circuit breaker full compliance period than for the control period.

In a related vein, a direct results of put-call parity violations would be a deviation of the price of synthetic stock price from the traded stock price. Since short selling circuit breaker rule is intended to reduce the downward pressure on stocks though limiting the opportunistic short sales, we expect investors with option expertise to replace actual short sales with synthetic shorts using option markets. As a consequence, we foresee a jump in the price of synthetic short relative to actual stock prices on the circuit breaker trigger day.

Figure 5 shows the sample average of the ratio of the synthetic short price to the stock price for the affected stocks around the halt days. The Synthetic short position is created by being long put option and short call option using the following formula:

$$Synthetic\ Short = Put - Call - K - PV(div)$$

K is the strike price and PV(div) is the present value of all dividends that fall within the options' maturities. Closing daily call and put mid-prices are used to construct synthetic shorts presented in Figure 5. The synthetic short to stock ratio is obtained by dividing the synthetic short price by the stock end of day mid-price.

[Please insert Figure 5 about here]

Figure 5 shows a slight increase in the synthetic short to stock price ratio on the event day for both the full compliance sample and the control sample. This suggests that the ability of option traders to mimic short positions is not undermined by the circuit breaker rule or by high volatility for the comparable stocks in the control sample. However, since the ratios are higher in the control sample than their counterparts in the circuit breaker sample, as shown in Panel A of Table 10, synthetic shorting provides greater proceeds when actual shorting is not constrained.

[Please insert Table 10 about here]

Figure 6 and Panel B of Table 10 provide qualitatively similar inferences, when we create synthetic short positions using daily put best offer, call best bid and stock bid prices.

[Please insert Figure 6 about here]

7. Conclusion

This paper provides new evidence on the effects of the short-sale circuit breaker on firms with options and on the US options markets in general. We demonstrate that over the full compliance

period for SEC Rule 201, stocks with traded options reacted more negatively on short sale restriction trigger days relative to their counterparts without traded options. Stocks with traded options also experience a slower recovery process after the restrictions are in place. We also conduct event studies that compare stocks with and without options during the compliance period vs. stocks in a control period, where short selling is unencumbered by regulatory restrictions. In the control period without short sale restrictions, stocks with options outperform stocks without options during periods of market turmoil. These results suggest that options positions may increase market stress when short selling restrictions are in force.

Our analyses show that short sale circuit breaker is associated with increased option spreads. As such, option market liquidity and transactions costs are adversely affected by short selling restrictions. Hence, the ability of pessimistic investors to undermine market stability through derivatives trades may be partially offset. When we account for endogeneity between option trading volume and option spreads. we still find a significant increase in (potentially) destabilizing put and call options trading around the short sale halts days, as traders create synthetic short-sale positions to bypass Rule 201.

We also find that potential decoupling put-call parity violations increase significantly on the short sale circuit trigger days for companies in the sample. This result is tempered for traders who submit market orders to establish their positions, and are exposed to higher transactions costs as reflected in the spreads they incur. Finally, while synthetic shorting provides greater proceeds when actual shorting is not constrained, mimicking short sales positions during Rule 201 events using synthetics remains tractable.

References:

Autore, Don M., Billingsley, Randall S., and Kovacs, Tunde,.2011 . "The 2008 short sale ban, Liquidity, dispersion of opinion, and the cross-section of returns of US financial stocks." *Journal of Banking & Finance* 35, 2252-2266.

Battalio, R., and Schultz, P., 2011. Regulatory uncertainty and market liquidity: the 2008 short sale ban's impact on equity option markets. *Journal of Finance* 66, 2013–2053.

Beber, Alessandro, and Pagano, Marco. 2013. Short-selling bans around the world: Evidence from the 2007–09 crisis, *Journal of Finance* 68, 343–381.

Blau, B. M. and Wade, C. (2013) Comparing the information in short sales and put options, *Review of Quantitative Finance and Accounting* 41, 567–583.

Boehmer, E., Jones, C. M., and Zhang, X. 2008. Which shorts are informed? *Journal of Finance, 63*, 491–527.

Boehmer, E., Jones, C. M., and Zhang, X. 2013. Shackling the Shortsellers? *Review of Financial Studies* 26, 1363-1400.

Boulton, Thomas J., and Braga-Alves, Marcus V. 2010. The skinny on the 2008 naked short-sale restrictions. *Journal of Financial Markets* 13, 397-421.

Bremer, Marc, and Sweeney, Richard J. 1991. The reversal of large stock-price decreases." *Journal of Finance* 46, 747-754.

Brown, Keith C., Harlow, W.V., and Tinic, Seha M. 1988 Risk aversion, uncertain information, and market efficiency. *Journal of Financial Economics* 22, 355-385.

Carhart, Mark M. 1997. On persistence in mutual fund performance. *Journal of Finance* 52, 57-82.

Cakici, N., Goswami, G., and Tan, C. 2010. Equity Options During the Shorting Ban of 2008, SSRN https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1618873

Cho, Young-Hye, and Engle, Robert. 1999, Modeling the impacts of market activity on bid-ask spreads in the option market, NBER Working paper No. W7331.

Danielsen, B.R., Sorescu, S.M., 2001. Why do option introductions depress stock prices? An empirical study of diminishing short-sale constraints. *Journal of Financial and Quantitative Analysis* 36, 451–484.

Diether, Karl B., Kuan-Hui Lee, and Werner, Ingrid M. 2009. It's SHO Time! Short-Sale Price Tests and Market Quality. *Journal of Finance* 64, 37-73.

Figlewski, S., and Webb, G., 1993. Options, short sales, and market completeness. *Journal of Finance* 48, 761–777.

George, T.J., and Longstaff, F.S. 1993. Bid-ask spreads and trading activity in the S&P 100 Index options market. *Journal of Financial and Quantitative* Analysis 28, 381-397.

Grundy, Bruce D., Lim, Bryan, and PVerwijmeren, Patrick. 2012, Do option markets undo restrictions on short sales? Evidence from the 2008 short-sale ban, *Journal of Financial Economics* 106, 331–348.

Hayunga, Darren, Peter Lung, Peter, and Nishikawa, Takeshi. 2010, Option markets in the presence of divergence of opinions and a short-sale ban, Working paper, University of Texas at Arlington.

Jain, Chinmay, Jain, Pankaj, and McInish, Thomas M. 2012. Short-selling, the impact of SEC rule 201 of 2010. *Financial Review* 47, 37-64.

Johnson, Travis L., and So, Eric C. 2012, The option to stock volume ratio and future returns, *Journal of Financial Economics* 106, 262–286.

Switzer, Lorne N. and Heng Yue 2019.Effects of the Short Sale Circuit Breaker on the Stock Market," *Journal of International Financial Management and Accounting* 30, 250–274.

Figure 1.
This figure shows Call and Put Average Spreads (SRO) around the short sale halt day. The Sample consists of stocks that triggered a Circuit Breaker and it spans from Feb 28, 2011 till Dec 10, 2016.

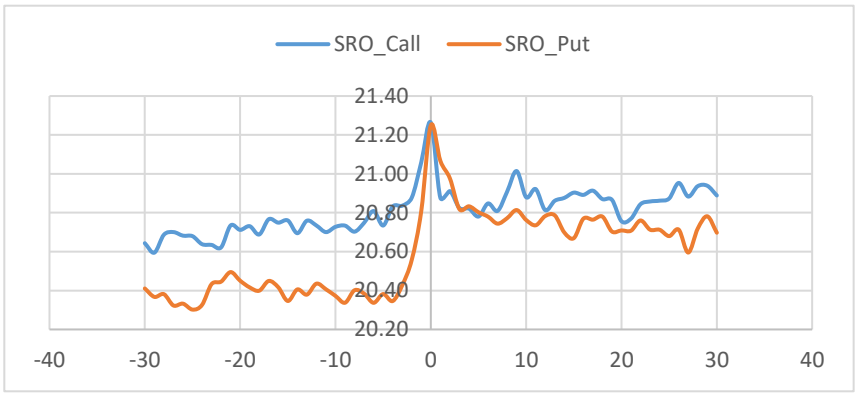


Figure 2.
This figure shows Call and Put Average Spreads (SRO) around the hypothetical halt day for the Control Sample. The Sample spans from Oct 10, 2008 till Aug 2, 2009. Firm in this sample are identified as having more than 10% intraday drop in stock price. A behavior that would have triggered a short sale restriction if the Rule 201 was effective and in full compliance.

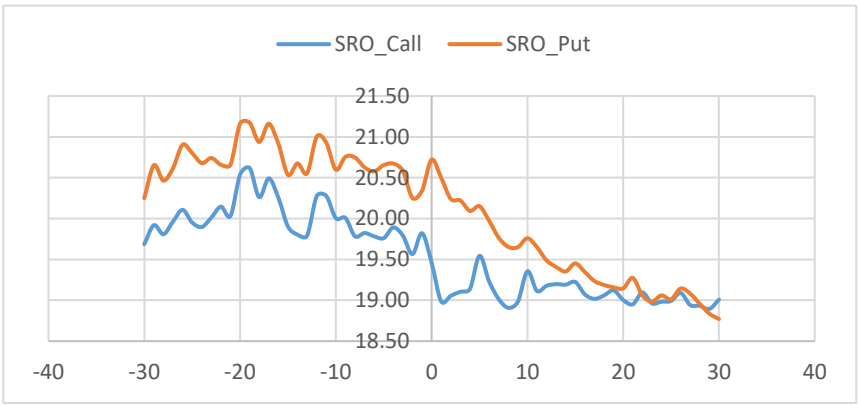
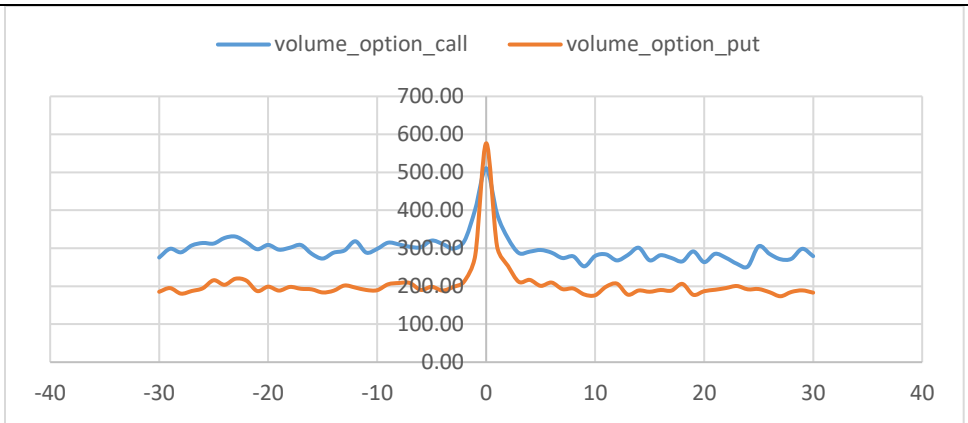
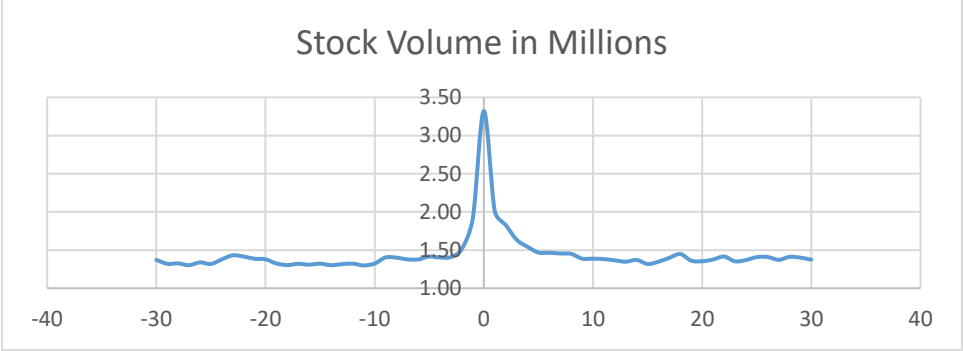


Figure 3.
The figure shows Average Call and Put Option Volumes around the halt day. Panel A depicts the Options volumes whereas Panel B depicts the Average Stock volumes in millions. Daily option volumes (OVS) are obtained by adding all the options volume that share the same characteristic (calls or puts) for a particular day. Panel C presents the Average Relative Volumes that is identified as the option volume (OVS) divided by the stock daily volume. The sample consists of stocks that triggered a Circuit Breaker and it spans from Feb 28, 2011 till Dec 10, 2016.

Panel A



Panel B



Panel C

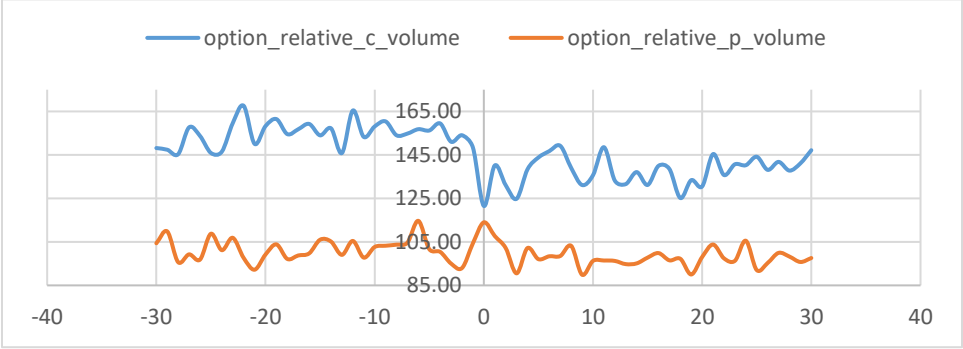
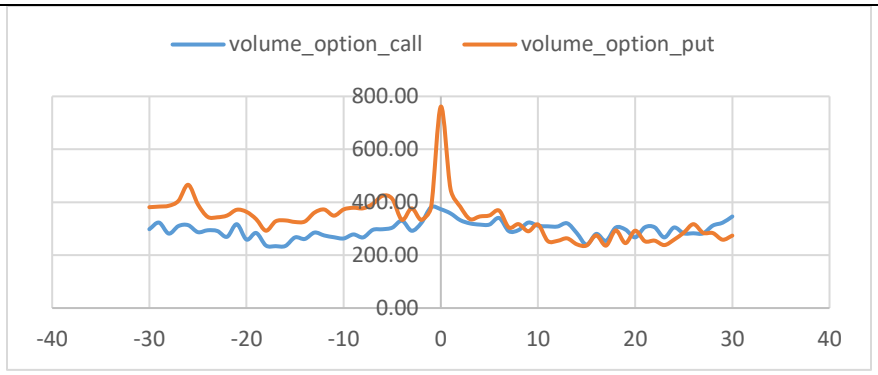
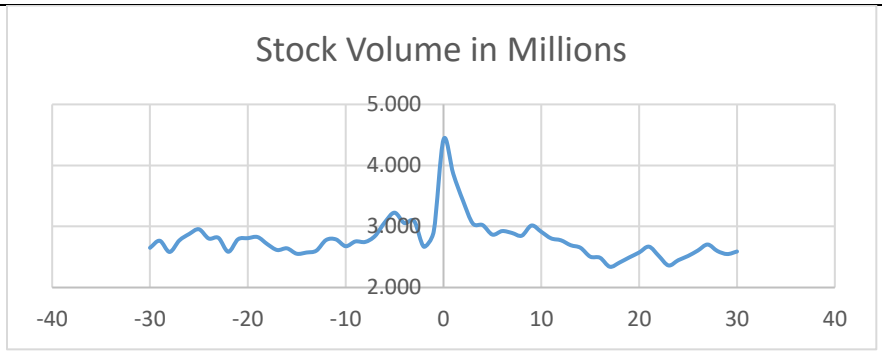


Figure 4.
The figure shows Average Call and Put Option Volumes around the hypothetical halt day for the Control Sample. Panel A depicts the Options volumes whereas Panel B depicts the Average Stock volumes in millions. Daily option volumes (OVS) are obtained by adding all the options volume that share the same characteristic (calls or puts) for a particular day. Panel C presents the Average Relative Volumes that is identified as the option volume (OVS) divided by the stock daily volume. The Sample spans from Oct 10, 2008 till Aug 2, 2009. Firm in this sample are identified as having more than 10% intraday drop in stock price. A behavior that would have triggered a short sale restriction if the Rule 201 was effective and in full compliance.

Panel A



Panel B



Panel C

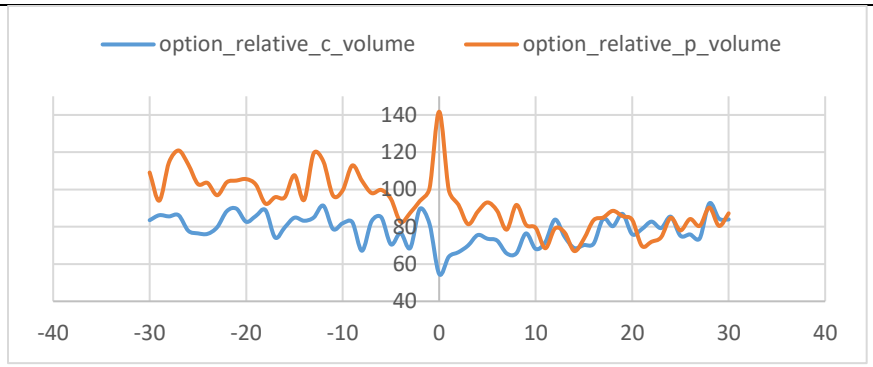
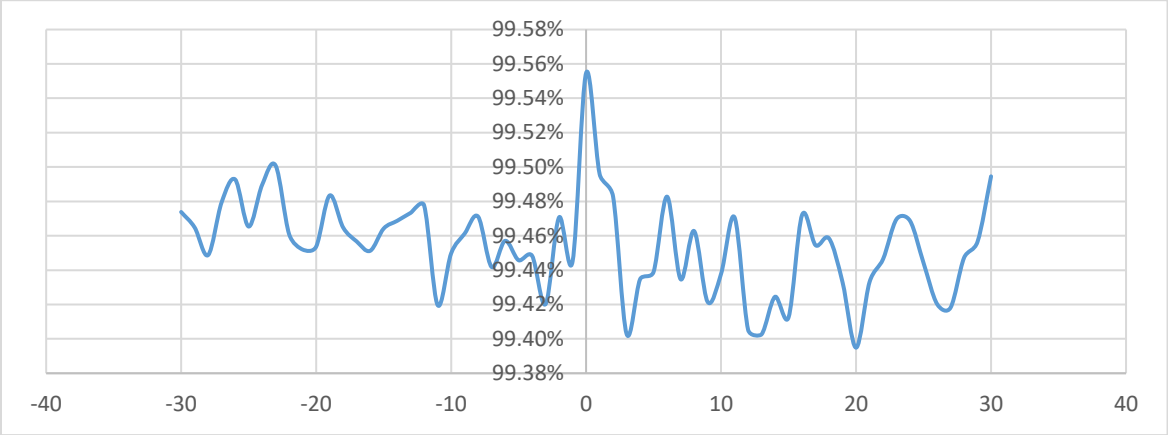


Figure 5: Synthetic Short to Stock Ratio

The figure shows the sample average of the ratio of the synthetic short price to the stock price for the affected stocks around the halt day. The circuit breaker Rule 201 data spans from 28th of February 2011 which is the day in which the circuity breaker rule became in full compliance till the 10th of December 2016. The control sample data spans from the 10th of October 2008 that is one day after the short sale ban till the 2nd of August 2009 that is one day before the circuit breaker pre-approval period. Synthetic short is created by being long put option, short call option using the following formula: synthetic short = put – call - K – PV(div). K is the strike price and PV(div) is the present value of all dividend falling within the options maturities. Closing daily call and put mid-prices are used to construct to synthetic short. The synthetic short to stock ratio is obtained by dividing the synthetic short by the stock end of day mid-price

Panel A: Circuit Breaker Rule 201 is in Full Compliance (from 28feb2011 to 10dec2016)



Panel B: Control Sample – Rule 201 not Applicable (from 9oct2008 to 2aug2009)

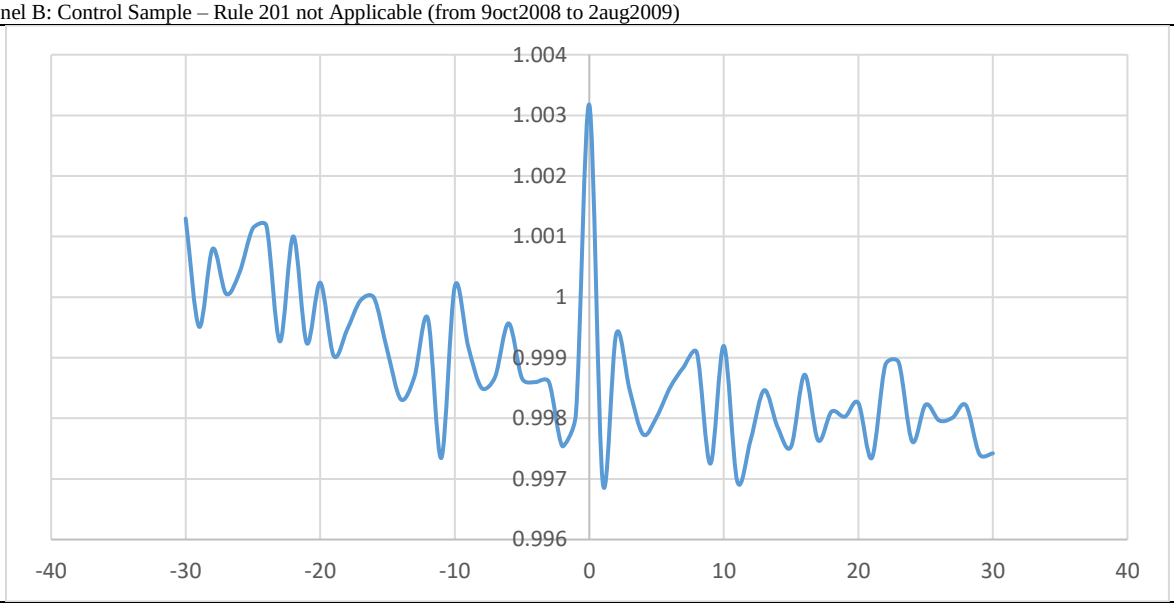
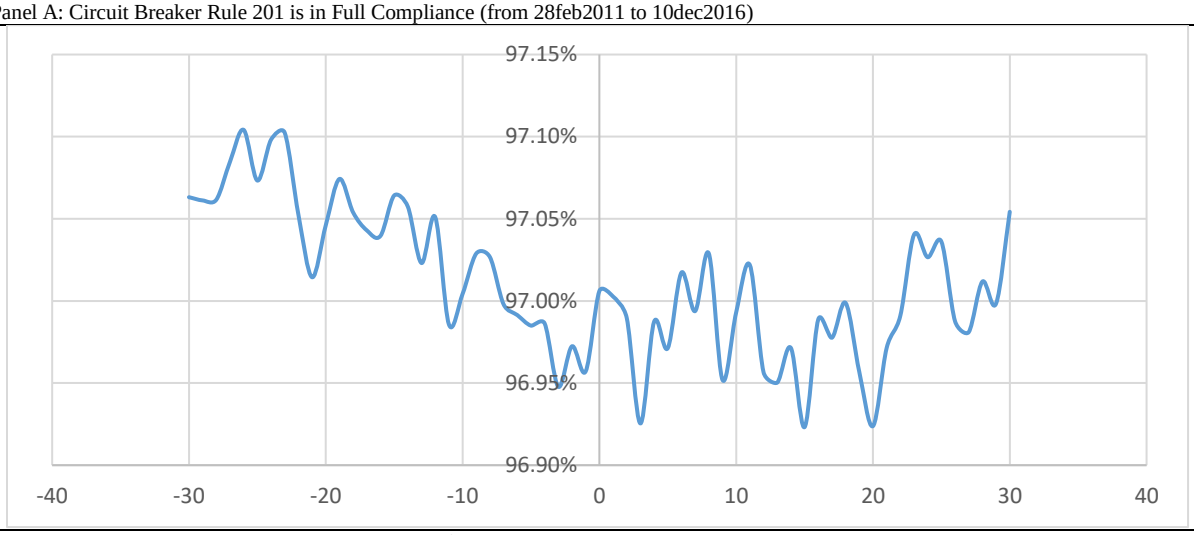


Figure 6: Synthetic Short to Stock Price – Based on Best Bid and Best Offer

The figure shows the ratio of synthetic short prices to stock prices around the halt day. The circuit breaker Rule 201 data spans from 28th of February 2011 which is the day in which the circuity breaker rule became in full compliance till the 10th of December 2016. The control sample data spans from the 10th of October 2008 that is one day after the short sale ban till the 2nd of August 2009 that is one day before the circuit breaker pre-approval period. Synthetic short is created by being long put option, short call option using the following formula: synthetic short = put – call - K – PV(div). K is the strike price and PV(div) is the present value of all dividend falling within the options maturities. Daily Put Best Offer, Call Best Bid are used. The synthetic short to stock ratio is obtained by dividing the synthetic short by the stock best bid.

Panel A: Circuit Breaker Rule 201 is in Full Compliance (from 28feb2011 to 10dec2016)



Panel B: Control Sample – Rule 201 not Applicable (from 9oct2008 to 2aug2009)

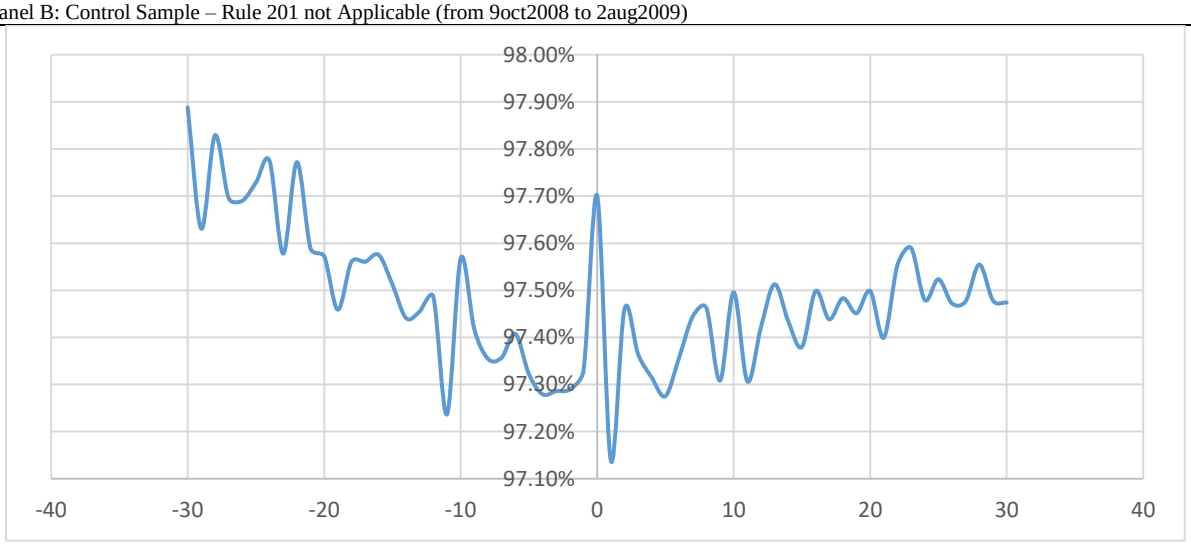


Table 1

Abnormal returns and cumulative abnormal returns for the Rule 201 Full Compliance Sample Period.

The table reports the average Abnormal returns and the average cumulative abnormal returns around the short sale restriction day. The sample consists of stocks that triggered a Circuit Breaker and it spans from Feb 28, 2011 till Dec 10, 2016. We estimate the abnormal returns using the Carhart four-factor model (Carhart '1997'). *, **, *** represents significance at 10%, 5%, and 1% respectively.

Panel A: Stocks with traded Options

Daily abnormal returns

Days	NOBS	Mean	Median	T-Value	SD
-10	30,598	-1.30E-04	-1.74E-03	-0.38	0.060
-9	30,597	5.38E-04	-1.69E-03	1.45	0.065
-8	30,597	-1.50E-04	-1.85E-03	-0.4	0.063
-7	30,598	9.44E-04**	-1.83E-03	2.47	0.067
-6	30,597	-1.20E-04	-1.88E-03	-0.34	0.062
-5	30,597	3.09E-04	-1.55E-03	0.82	0.066
-4	30,596	6.51E-04	-1.71E-03	1.55	0.073
-3	30,598	8.73E-04**	-2.08E-03	2.11	0.073
-2	30,596	1.36E-03***	-2.68E-03	2.8	0.085
-1	30,590	3.45E-03***	-2.25E-03	6.53	0.092
0	30,599	-5.06E-02***	-3.92E-02	-101.36	0.087
1	30,595	2.57E-04	-1.35E-03	0.59	0.077
2	30,566	-4.10E-04	-3.12E-03	-0.95	0.075
3	30,537	1.85E-03***	-1.43E-03	4.2	0.077
4	30,513	9.21E-04**	-1.82E-03	2.25	0.071
5	30,483	9.32E-04**	-1.80E-03	2.26	0.072
6	30,456	8.86E-04**	-2.00E-03	2.11	0.073
7	30,428	1.47E-03***	-1.53E-03	3.56	0.072
8	30,412	-6.20E-04*	-2.30E-03	-1.76	0.062
9	30,392	8.46E-04**	-1.41E-03	2.06	0.072
10	30,375	6.36E-04	-1.84E-03	1.61	0.069

Cumulative daily abnormal returns

CAR Window	Mean	T-value	Median
(-10, -1)	7.73E-03***	5.92	-6.41E-03
(-1, 1)	-4.69E-02***	-57.64	-3.61E-02
(1, 5)	3.54E-03***	3.9	-2.87E-03
(1, 10)	6.74E-03***	5.51	-3.53E-03
(1, 30)	9.00E-03***	4.58	-5.35E-03
(1, 60)	1.17E-02	4.24	-8.43E-03

Table 1.

Abnormal returns and cumulative abnormal returns for the Rule 201 Full Compliance Sample Period.

The table reports the average Abnormal returns and the average cumulative abnormal returns around the short sale restriction day. The sample consists of stocks that triggered a Circuit Breaker and it spans from Feb 28, 2011 till Dec 10, 2016. We estimate the abnormal returns using the Carhart four-factor model (Carhart '1997'). *, **, *** represents significance at 10%, 5%, and 1% respectively.

Panel B: Stocks with no traded options.

Daily abnormal returns

Days	NOBS	Mean	Median	T-Value	SD
-10	38,425	8.34E-04*	-2.82E-03	1.9	8.59E-02
-9	38,426	9.13E-04**	-2.95E-03	2.08	8.61E-02
-8	38,424	1.64E-03**	-2.57E-03	3.41	9.43E-02
-7	38,421	3.08E-03***	-2.23E-03	5.81	1.04E-01
-6	38,424	2.36E-03***	-2.23E-03	4.8	9.62E-02
-5	38,427	2.72E-03***	-2.66E-03	5.4	9.86E-02
-4	38,428	4.18E-03***	-2.00E-03	7.83	1.05E-01
-3	38,428	4.12E-03***	-2.40E-03	7.22	1.12E-01
-2	38,432	7.34E-03***	-2.18E-03	12.09	1.19E-01
-1	38,437	1.03E-02***	-2.37E-03	15.38	1.31E-01
0	38,446	-4.57E-02***	-4.08E-02	-97.82	9.15E-02
1	38,441	3.26E-03***	-1.89E-03	6.55	9.76E-02
2	38,383	1.06E-03**	-3.21E-03	2.23	9.30E-02
3	38,320	2.47E-03***	-2.61E-03	4.87	9.93E-02
4	38,265	9.34E-04**	-2.99E-03	2	9.16E-02
5	38,209	1.24E-03**	-2.74E-03	2.54	9.54E-02
6	38,173	7.94E-04*	-3.27E-03	1.82	8.55E-02
7	38,121	1.44E-03***	-2.92E-03	3.18	8.87E-02
8	38,083	6.77E-04	-2.76E-03	1.57	8.44E-02
9	38,040	1.06E-03**	-2.58E-03	2.41	8.56E-02
10	38,004	6.46E-04	-3.22E-03	1.42	8.89E-02

Cumulative daily abnormal returns

CAR Window	Mean	T-value	Median
(-10, -1)	3.74E-02***	23.02	-1.91E-03
(-1, 1)	-3.21E-02***	-36.76	-3.17E-02
(1, 5)	8.94E-03***	8.74	-4.26E-03
(1, 10)	1.35E-02***	9.99	-4.72E-03
(1, 30)	3.17E-02***	14.11	-1.94E-03
(1, 60)	5.85E-02***	18.43	3.93E-03

Table 1.

Difference in the AR and CAR for the for the Rule 201 Full Compliance Sample Period. This table reports Difference in the AR and CAR for stocks affected by short sale constraints: stocks with traded options versus stock with no traded options. The sample consists of stocks that triggered a Circuit Breaker and it spans from Feb 28, 2011 till Dec 10, 2016. We estimate the abnormal returns using the Carhart four-factor model (Carhart '1997'). *, **, *** represents significance at 10%, 5%, and 1% respectively.

Panel C: Stocks with options vs. stocks with no options.

Daily abnormal returns

Days	No Options mean	With Options mean	Mean Diff	T-Value
-10	8.34E-04	-1.30E-04	9.65E-04*	1.67
-9	9.13E-04	5.38E-04	3.75E-04	0.63
-8	1.64E-03	-1.50E-04	1.79E-03***	2.84
-7	3.08E-03	9.44E-04	2.13E-03***	3.12
-6	2.36E-03	-1.20E-04	2.48E-03***	3.9
-5	2.72E-03	3.09E-04	2.41E-03***	3.68
-4	4.18E-03	6.51E-04	3.53E-03***	5
-3	4.12E-03	8.73E-04	3.24E-03***	4.39
-2	7.34E-03	1.36E-03	5.98E-03***	7.42
-1	1.03E-02	3.45E-03	6.82E-03***	7.7
0	-4.57E-02	-5.06E-02	4.97E-03***	7.23
1	3.26E-03	2.57E-04	3.00E-03***	4.41
2	1.06E-03	-4.10E-04	1.47E-03**	2.24
3	2.47E-03	1.85E-03	6.26E-04	0.91
4	9.34E-04	9.21E-04	1.30E-05	0.02
5	1.24E-03	9.32E-04	3.08E-04	0.47
6	7.94E-04	8.86E-04	-9.00E-05	-0.15
7	1.44E-03	1.47E-03	-3.00E-05	-0.05
8	6.77E-04	-6.20E-04	1.30E-03**	2.25
9	1.06E-03	8.46E-04	2.09E-04	0.34
10	6.46E-04	6.36E-04	1.00E-05	0.02

Cumulative daily abnormal returns

CAR Window	No Options mean	With Options mean	Mean Diff	T-Value
(-10, -1)	3.74E-02	7.73E-03	2.97E-02***	13.74
(-1, 1)	-3.21E-02	-4.69E-02	1.48E-02***	12.12
(1, 5)	8.94E-03	3.54E-03	5.40E-03***	3.85
(1, 10)	1.35E-02	6.74E-03	6.78E-03***	3.63
(1, 30)	3.17E-02	9.00E-03	2.27E-02***	7.4
(1, 60)	5.85E-02	1.17E-02	4.68E-02***	10.83

Table 2

Abnormal returns and cumulative abnormal returns for Control Sample firms (no short sale restrictions in place)

The table reports the average Abnormal returns and the average cumulative abnormal returns around event days for the control sample period: Oct 10, 2008 till Aug 2, 2009. Event days are identified as days in which a firm experiences a 10% intraday drop in stock price, which would have triggered a short sale restriction if Rule 201 was effective and in full compliance. We estimate the abnormal returns using the Carhart four-factor model (Carhart (1997)). The figures represent the final sample that resulted in after applying all the options related filters. *, **, *** represents significance at 10%, 5%, and 1% respectively

Panel A: Stocks with Traded Options

Daily abnormal returns

Days	NOBS	Mean	Median	T-Value	SD
-10	22,376	-3.60E-04	-4.77E-03	-0.6	8.83E-02
-9	22,376	-7.10E-04	-3.68E-03	-1.24	8.48E-02
-8	22,377	-1.20E-03*	-4.42E-03	-1.89	9.45E-02
-7	22,377	-2.30E-04	-4.30E-03	-0.36	9.61E-02
-6	22,375	-6.00E-05	-3.81E-03	-0.1	9.10E-02
-5	22,375	3.71E-03***	-7.41E-04	5.03	1.10E-01
-4	22,372	4.05E-03***	-1.09E-03	6	1.01E-01
-3	22,373	2.59E-03***	-3.15E-03	3.62	1.07E-01
-2	22,374	6.26E-03***	-2.14E-03	8.21	1.14E-01
-1	22,375	6.13E-03***	-2.07E-03	8.23	1.11E-01
0	22,377	-9.23E-02***	-8.03E-02	-176.76	7.81E-02
1	22,343	5.90E-03***	2.36E-03	8.08	1.09E-01
2	22,315	2.05E-03***	-2.90E-03	2.66	1.15E-01
3	22,297	3.00E-03***	-2.52E-03	4.34	1.03E-01
4	22,279	2.88E-03***	-2.31E-03	4.13	1.04E-01
5	22,264	5.92E-03***	-2.16E-04	8.87	9.97E-02
6	22,246	4.12E-03***	-1.03E-03	6.33	9.69E-02
7	22,232	3.86E-03***	-2.39E-03	4.69	1.23E-01
8	22,218	2.00E-03***	-3.19E-03	2.69	1.11E-01
9	22,201	4.50E-03***	-7.29E-04	5.58	1.20E-01
10	22,187	4.29E-03***	-8.93E-04	6.92	9.23E-02

Cumulative daily abnormal returns

CAR Window	Mean	T-value	Median
(-10, -1)	2.02E-02***	10.04	1.39E-03
(-1, 1)	-8.02E-02***	-73.1	-6.94E-02
(1, 5)	1.97E-02***	13.16	1.01E-02
(1, 10)	3.84E-02***	18.43	2.56E-02
(1, 30)	1.21E-01***	38.5	8.46E-02
(1, 60)	2.16E-01***	53.47	1.65E-01

Table 2

Abnormal returns and cumulative abnormal returns for Control Sample firms (no short sale restrictions in place)

The table reports the average Abnormal returns and the average cumulative abnormal returns around event days for the control sample period: Oct 10, 2008 till Aug 2, 2009. Event days are identified as days in which a firm experiences a 10% intraday drop in stock price, which would have triggered a short sale restriction if Rule 201 was effective and in full compliance. We estimate the abnormal returns using the Carhart four-factor model (Carhart (1997)). *, **, *** represents significance at 10%, 5%, and 1% respectively

Panel B: Stocks Without Traded Options

Daily abnormal returns

Days	NOBS	Mean	Median	T-Value	SD
-10	31,283	3.40E-03***	-3.81E-03	3.16	1.90E-01
-9	31,285	1.80E-03**	-4.55E-03	2.54	1.25E-01
-8	31,286	4.26E-03***	-3.21E-03	4.12	1.83E-01
-7	31,284	4.64E-03***	-2.79E-03	6.15	1.33E-01
-6	31,285	3.61E-03***	-4.31E-03	3.32	1.93E-01
-5	31,286	5.17E-03***	-2.89E-03	6.74	1.36E-01
-4	31,289	4.21E-03***	-4.01E-03	4.21	1.77E-01
-3	31,286	7.85E-03***	-2.34E-03	9.81	1.42E-01
-2	31,285	1.22E-02***	-2.44E-03	9.65	2.24E-01
-1	31,286	4.02E-02***	9.89E-03	35.1	2.03E-01
0	31,293	-1.38E-01***	-1.25E-01	-302.41	8.08E-02
1	31,219	4.05E-02***	1.81E-02	35.57	2.01E-01
2	31,169	1.04E-02***	-9.51E-04	9.57	1.92E-01
3	31,118	6.42E-03***	-1.49E-03	8.57	1.32E-01
4	31,073	5.05E-03***	-2.64E-03	5.93	1.50E-01
5	31,022	8.53E-03***	-5.99E-04	11.55	1.30E-01
6	30,986	7.34E-03***	-1.15E-03	6.4	2.02E-01
7	30,923	8.22E-03***	-1.78E-03	7.88	1.83E-01
8	30,876	6.08E-03***	-2.42E-03	6.36	1.68E-01
9	30,843	6.52E-03***	-1.15E-03	8.85	1.29E-01
10	30,810	5.07E-03***	-2.23E-03	7.09	1.25E-01

Cumulative daily abnormal returns

CAR Window	Mean	T-value	Median
(-10, -1)	8.74E-02***	31.18	3.69E-02
(-1, 1)	-5.75E-02***	-38.2	-6.60E-02
(1, 5)	7.08E-02***	38.68	4.41E-02
(1, 10)	1.04E-01***	41.72	6.15E-02
(1, 30)	2.24E-01***	53.34	1.43E-01
(1, 60)	4.02E-01***	72.55	2.81E-01

Table 2

Difference in the AR and CAR for the Control Sample (no short sale restrictions in place).

The table reports the average Abnormal returns and the average cumulative abnormal returns around the short sale restriction day for the stocks without traded options during the control sample period. The control sample spans from Oct 10, 2008 till Aug 2, 2009. Firm in this sample are identified as having more than 10% intraday drop in stock price. A behavior that would have triggered a short sale restriction if Rule 201 was effective and in full compliance. We estimate the abnormal returns using the Carhart four-factor model (Carhart '1997'). *, **, *** represents significance at 10%, 5%, and 1% respectively. Difference in the AR and CAR for the sample that was affected by short sale constrains for stocks with traded options versus stock with no traded options. We estimate the abnormal returns using the Carhart four-factor model (Carhart '1997'). *, **, *** represents significance at 10%, 5%, and 1% respectively.

Panel C: Stocks with options vs. stocks with no options.

Daily abnormal returns

Days	No Options mean	With Options mean	Mean Diff	T-Value
-10	3.40E-03	-3.60E-04	3.75E-03***	2.75
-9	1.80E-03	-7.10E-04	2.50E-03***	2.6
-8	4.26E-03	-1.20E-03	5.46E-03***	4.09
-7	4.64E-03	-2.30E-04	4.87E-03***	4.66
-6	3.61E-03	-6.00E-05	3.67E-03***	2.65
-5	5.17E-03	3.71E-03	1.46E-03	1.33
-4	4.21E-03	4.05E-03	1.57E-04	0.12
-3	7.85E-03	2.59E-03	5.26E-03***	4.68
-2	1.22E-02	6.26E-03	5.99E-03***	3.67
-1	4.02E-02	6.13E-03	3.41E-02***	22.82
0	-1.38E-01	-9.23E-02	-4.59E-02***	-65.74
1	4.05E-02	5.90E-03	3.46E-02***	23.37
2	1.04E-02	2.05E-03	8.35E-03***	5.79
3	6.42E-03	3.00E-03	3.42E-03***	3.23
4	5.05E-03	2.88E-03	2.17E-03*	1.86
5	8.53E-03	5.92E-03	2.60E-03**	2.5
6	7.34E-03	4.12E-03	3.22E-03**	2.21
7	8.22E-03	3.86E-03	4.35E-03***	3.08
8	6.08E-03	2.00E-03	4.08E-03***	3.16
9	6.52E-03	4.50E-03	2.02E-03*	1.83
10	5.07E-03	4.29E-03	7.78E-04	0.78

Cumulative daily abnormal returns

CAR Window	No Options mean	With Options mean	Mean Diff	T-Value
(-10, -1)	8.74E-02	2.02E-02	6.72E-02***	18.04
(-1, 1)	-5.75E-02	-8.02E-02	2.28E-02***	11.35
(1, 5)	7.08E-02	1.97E-02	5.11E-02***	20.37
(1, 10)	1.04E-01	3.84E-02	6.53E-02***	19.06
(1, 30)	2.24E-01	1.21E-01	1.03E-01***	18.35
(1, 60)	4.02E-01	2.16E-01	1.87E-01***	25.24

Table 3.

Sample Descriptive Statistics

This table reports the average daily total option volume per stock (OVS) and Options Spread (SRO) for all the stock that were affected by a short sale ban in our sample. The sample consists of stocks that triggered a Circuit Breaker and it spans from Feb 28, 2011 till Dec 10, 2016. Daily OVS is the aggregate volume of all call/put options on the same stock in the same day. This table also reports the SRO for all the options in our sample and the average daily stock volumes, returns and spreads. Options data is obtained from OptionMetrics whereas Stock data is obtained from CRSP.

Panel A. Rule 201 Full Compliance Period					
Option Volume (OVS)					
	N	Average	St. dev	Min	Max
Call Option Volume	499,876	299.03	1,704.28	0	196,221
Put Option Volume	493,787	204.76	1,284.05	0	195,897
Panel B. Option Spread (SRO)					
	Average	St. dev	Min	Max	
Call Option SRO	20.806	13.032	0.154	50	
Put Option SRO	20.597	13.111	0.147	50	
Panel C. Stock Daily Volume, Returns, and Spreads.					
	Average	St. dev	Min	Max	
Stock Daily Volume in Millions	1.437	4.242	0.001	246.000	
Stock Daily Return (in %)	0.039	4.376	-67.382	170.774	
Stock Daily Spread	1.239	1.835	0.010	126	

Table 3.

Sample Descriptive Statistics

This table reports the average daily total option volume per stock (OVS) and Options Spread (SRO) for all the stock that were supposed to be affected by a short sale ban in our control sample. The Sample spans from Oct 10, 2008 till Aug 2, 2009. Firm in this sample are identified as having more than 10% intraday drop in stock price. A behavior that would have triggered a short sale restriction if Rule 201 was effective and in full compliance. Daily OVS is the aggregate volume of all call/put options on the same stock in the same day. This table also reports the SRO for all the options in our sample and the average daily stock volumes, returns and spreads. Options data is obtained from OptionMetrics whereas Stock data is obtained from CRSP.

Panel B: Control Sample (Rule 201 is not in effect)					
Option Volume (OVS)					
	N	Average	St. dev	Min	Max
Call Option Volume	289,340	295.61	1,548.79	0	155,355
Put Option Volume	298,968	335.69	1,691.37	0	117,479
	Average	St. dev	Min	Max	
Call Option SRO	19.53	12.16	0.37	50	
Put Option SRO	20.11	12.71	0.34	50	
	Average	St. dev	Min	Max	
Stock Daily Volume in Millions	2.780	7.604	0.003	780.718	
Stock Daily Return (in %)	-0.106	7.503	-63.524	625.926	
Stock Daily Spread	1.606	1.617	0.029	57.859	

Table 4

Effect of Circuit Breakers on Put and Call Option Spread

The below table presents the results of the regression of Option Spread (SRO) on the day in which the circuit breaker was activated for the stock. Our dependent variable, spread on put (SRO) is defined following Gundy et al. (2012) according to the below equation: $SRO = \frac{Best\ offer - Best\ bid}{(Best\ offer - Best\ bid)/2\ - \max[Intrinsic\ Value, PV(forward)]} \times 100$. D is a dummy variable equal one if S > K and zero otherwise. Moneyness is estimated following Grundy et al. (2012) as: $Moneyness = \frac{\ln\left(\frac{S}{K}\right)}{\sigma_{ATM}\sqrt{t}}$. The circuit breaker Rule 201 data spans from 28th of February 2011 which is the day in which the circuity breaker rule became in full compliance till the 10th of December 2016. The control sample data spans from the 10th of October 2008 that is one day after the short sale ban till the 2nd of August 2009 that is one day before the circuit breaker pre-approval period. *, **, *** represent significance at 10%, 5%, and 1% respectively. Huber-White heteroskedasticity-corrected standard errors t-stat are presented in parenthesis.

	Circuit Breaker Rule 201 is in Full Compliance		Control Sample – Rule 201 not Applicable	
	Put SRO	Call SRO	Put SRO	Call SRO
Intercept	14.849***(587.58)	17.751***(621.9)	4.28***(122.73)	10.641***(222.74)
D x Moneyness	2.65***(333.15)	2.225***(209.39)	3.74***(411.22)	1.883***(106.12)
[D x Moneyness]^2	-0.11***(-153.21)	-0.075***(-85.93)	-0.14***(-178.66)	-0.006***(-4.03)
(D-1) x Moneyness	0.278***(10.09)	-0.645***(-21.16)	1.02***(33.36)	-1.95***(-43.87)
[(D-1) x Moneyness]^2	-0.229***(-24.09)	0.024**(2.27)	-0.15***(-15.84)	0.639***(45.73)
(Day to Maturity)$^{-1}$	253.146***(270.21)	158.973***(159.81)	462.31***(371.33)	284.029***(195.83)
VIX	-0.048***(-52.62)	-0.082***(-81.02)	0.08***(142.27)	0.052***(82.89)
D-5	-0.106**(-2.16)	-0.07 (-1.39)	0.32***(5.66)	0.202***(3.03)
D-4	-0.138***(-2.84)	0.026 (0.52)	0.28***(4.8)	0.25***(3.73)
D-3	-0.044 (-0.89)	0.021 (0.42)	0.05 (0.8)	0.022 (0.32)
D-2	0.117**(2.4)	0.123**(2.45)	-0.23***(-3.8)	-0.327***(-4.78)
D-1	0.384***(7.95)	0.396***(7.9)	-0.05 (-0.89)	0.105 (1.57)
D0	0.59***(11.96)	0.806***(14.66)	-0.38***(-6.4)	-0.191***(-2.61)
D+1	0.414***(8.58)	0.323***(6.13)	-0.44***(-7.65)	-0.717***(-10.27)
D+2	0.313***(6.51)	0.328***(6.27)	-0.64***(-11.19)	-0.694***(-10.21)
D+3	0.152***(3.16)	0.219***(4.22)	-0.43***(-7.33)	-0.588***(-8.52)
D+4	0.132***(2.76)	0.176***(3.43)	-0.45***(-7.88)	-0.545***(-8.17)
D+5	0.08*(1.67)	0.092*(1.79)	-0.41***(-7.27)	-0.257***(-3.88)
Adj-R square	0.1017	0.0891	0.2487	0.1678
N	4,027,364	3,713,705	2,280,063	1,746,691

Table 5

Effect of Circuit Breakers on Put and Call Daily Option Volumes

The below table presents the results of the regression of Option Volumes (OVS) on the day in which the circuity breaker was activated for the stock. Our dependent variable, OVS is equal to the sum of all put options' volume on the stock for the corresponding day. Each single option contract is written on 100 shares. D_0 is a dummy variable that takes a value of 1 for the day in which the circuit breaker was applied and zero otherwise. D_i is a dummy variable that takes a value of 1 for day 'i' around the day in which the circuit breaker was applied and zero otherwise. We limited our sample to 30 days around the day in which the circuit breaker is applied. Stock volume and stock returns correspond to the stock daily traded volumes in millions and daily percentage return respectively as reported in CRSP database. Market Capitalization is estimated by multiplying the stock price by the number of shares outstanding for the corresponding day expressed in millions. The circuit breaker Rule 201 data spans from 28th of February 2011 which is the day in which the circuity breaker rule became in full compliance till the 10th of December 2016. The control sample data spans from the 10th of October 2008 that is one day after the short sale ban till the 2nd of August 2009 that is one day before the circuit breaker pre-approval period. *, **, *** represent significance at 10%, 5%, and 1% respectively. Huber-White heteroskedasticity-corrected standard errors t-stat are presented in parenthesis.

	Circuit Breaker Rule 201 is in Full Compliance		Control Sample – Rule 201 not Applicable	
	Put Volume	Call Volume	Put Volume	Call Volume
Intercept	-109.33***(-14.08)	-25.35***(-3.39)	-75.01***(-6.85)	219.64***(23.21)
Stock Volume	140.97***(32.94)	202.89***(38.02)	129.18***(17.78)	127.16***(22.82)
Stock Return	-17.65***(-19.6)	18.72***(15.64)	-12.31***(-15.6)	10.25***(9.99)
Market Capitalization	0.02***(12.76)	0.04***(13.94)	0.02***(5.95)	0.01***(3.69)
VIX	2.69***(10.22)	-2.87***(-9.47)	0.19 (0.8)	-6.04***(-27.37)
D-5	-1.88 (-0.17)	17.42 (1.05)	34.98 (1.44)	-24.95 (-1.31)
D-4	-13.21 (-1.62)	13.64 (1.18)	-24.52 (-1.47)	25.24 (1.06)
D-3	-4.89 (-0.47)	-0.02 (0)	1.06 (0.06)	-4.18 (-0.28)
D-2	-11.04 (-1.15)	4.96 (0.41)	33.9*(1.65)	49.07***(3.07)
D-1	6.1 (0.47)	0.99 (0.06)	27.84 (1.07)	92.68***(2.6)
D0	5.77 (0.25)	-70.42***(-3.74)	55.8 (1.6)	63.67***(2.62)
D+1	24.9*(1.86)	-25.55 (-1.19)	27.72 (1.26)	-57.78***(-2.9)
D+2	-2.63 (-0.2)	-51.47***(-4.08)	-4.13 (-0.25)	-15.21 (-0.92)
D+3	-8.21 (-0.76)	-62.43***(-5.85)	-11.21 (-0.7)	9.86 (0.65)
D+4	5.36 (0.43)	-35.63***(-2.83)	12.98 (0.55)	-10.42 (-0.61)
D+5	-3.5 (-0.32)	-11.39 (-0.61)	22.41 (1.34)	27.28*(1.75)
Adj-Rsquare	0.3717	0.4294	0.3998	0.4261
N	493,787	499,876	298,968	289,340

Table 6
Effect of Circuit Breakers on Call and Put Option Spread – 2SLS

The below table presents the results of the regression of Option Spread (SRO) on the day in which the circuit breaker was activated for the stock. Our dependent variable, spread on put (SRO) is defined following Gundy et al. (2012) according to the below equation: $SRO = \frac{Best\ offer - Best\ bid}{(Best\ offer - Best\ bid)/2\ - \max[Intrinsic\ Value, PV(forward)]} \times 100$. D is a dummy variable equal one if S > K and zero otherwise. Moneyness is estimated following Grundy et al. (2012) as: $Moneyness = \frac{\ln\left(\frac{S}{K}\right)}{\sigma_{ATM}\sqrt{t}}$. The circuit breaker Rule 201 data spans from 28th of February 2011 which is the day in which the circuity breaker rule became in full compliance till the 10th of December 2016. The control sample data spans from the 10th of October 2008 that is one day after the short sale ban till the 2nd of August 2009 that is one day before the circuit breaker pre-approval period. Fitted Option Volumes is obtained through regression option volumes on all exogenous variable. *, **, *** represent significance at 10%, 5%, and 1% respectively. Huber-White heteroskedasticity-corrected standard errors t-stat are presented in parenthesis.

	Circuit Breaker Rule 201 is in Full Compliance		Control Sample – Rule 201 not Applicable	
	Put SRO	Call SRO	Put SRO	Call SRO
Intercept	14.282***(568.43)	17.803***(625.61)	4.354***(127.51)	11.15***(231.55)
D x Moneyness	2.451***(306.04)	2.101***(192.33)	3.528***(370.43)	1.831***(102.11)
[D x Moneyness]^2	-0.097***(-135.02)	-0.069***(-76.27)	-0.13***(-159.3)	-0.006***(-3.78)
(D-1) x Moneyness	0.911***(33.49)	-0.019 (-0.62)	1.547***(50.24)	-1.077***(-23.35)
[(D-1) x Moneyness]^2	-0.376***(-40.16)	-0.159***(-15.07)	-0.292***(-30.96)	0.417***(29.38)
(Day to Maturity)$^{-1}$	396.779***(310.7)	274.665***(210.74)	581.754***(291.39)	414.103***(159.92)
VIX	-0.02***(-22.13)	-0.083***(-84.31)	0.076***(146.4)	0.031***(44.71)
Fitted Option Volumes	-0.059***(-158.74)	-0.033***(-137.95)	-0.026***(-73.16)	-0.021***(-59.1)
D-5	-0.063 (-1.3)	0.05 (1.01)	0.587***(10.5)	0.36***(5.52)
D-4	-0.187***(-3.9)	0.097**(1.96)	0.261***(4.59)	0.486***(7.38)
D-3	-0.013 (-0.27)	0.043 (0.87)	0.148***(2.59)	0.093 (1.4)
D-2	0.239***(4.98)	0.251***(5.05)	-0.287***(-4.9)	-0.238***(-3.57)
D-1	1.008***(21.03)	0.907***(18.24)	0.066 (1.17)	0.413***(6.27)
D0	3.205***(62.74)	2.011***(36.66)	0.945***(15.26)	0.321***(4.39)
D+1	1.096***(23.16)	0.834***(16.15)	-0.154***(-2.71)	-0.341***(-4.94)
D+2	0.627***(13.3)	0.521***(10.09)	-0.509***(-8.87)	-0.397***(-5.84)
D+3	0.215***(4.56)	0.231***(4.53)	-0.426***(-7.4)	-0.37***(-5.39)
D+4	0.222***(4.73)	0.193***(3.82)	-0.445***(-7.91)	-0.428***(-6.56)
D+5	0.046 (0.97)	0.114**(2.27)	-0.404***(-7.27)	-0.122*(-1.89)
Adj-Rsquare	0.1309	0.1152	0.2784	0.2036
N	4,027,364	3,713,705	2,280,063	1,746,691

Table 7
Effect of Circuit Breakers on Put and Call Option Volume – 2SLS
The below table presents the results of the regression of Option Volumes on the day in which the circuity breaker was activated for the stock. Our dependent variable, is the individual option volume. Each single option contract is written on 100 shares. D_0 is a dummy variable that takes a value of 1 for the day in which the circuit breaker was applied and zero otherwise. D_i is a dummy variable that takes a value of 1 for day 'i' around the day in which the circuit breaker was applied and zero otherwise. We limited our sample to 30 days around the day in which the circuit breaker is applied. Stock volume and stock returns correspond to the stock daily traded volumes in millions and daily percentage return respectively as reported in CRSP database. Market Capitalization is estimated by multiplying the stock price by the number of shares outstanding for the corresponding day expressed in millions. The circuit breaker Rule 201 data spans from 28th of February 2011 which is the day in which the circuity breaker rule became in full compliance till the 10th of December 2016. The control sample data spans from the 10th of October 2008 that is one day after the short sale ban till the 2nd of August 2009 that is one day before the circuit breaker pre-approval period. Fitted Option SRO is obtained through regression option SRO on all exogenous variable. *, **, *** represent significance at 10%, 5%, and 1% respectively. Huber-White heteroskedasticity-corrected standard errors t-stat are presented in parenthesis.

	Circuit Breaker Rule 201 is in Full Compliance		Control Sample – Rule 201 not Applicable	
	Put Volume	Call Volume	Put Volume	Call Volume
Intercept	41.124***(62.06)	88.86***(87.78)	46.834***(43.93)	94.387***(69.15)
Stock Volume	3.952***(45.96)	7.27***(62.68)	6.577***(26.65)	9.628***(24.99)
Stock Return	-1.515***(-27.23)	2.555***(24.77)	-1.415***(-27.87)	1.723***(13.15)
Market Capitalization	0***(2.6)	0***(-8.61)	0***(3.35)	-0.001***(-5.45)
VIX	0.228***(11.66)	-0.5***(-18.68)	0.312***(17.71)	-0.537***(-23.97)
Fitted Option SRO	-1.691***(-55.47)	-3.022***(-71.27)	-2.635***(-62.01)	-3.169***(-47.7)
D-5	-0.128 (-0.12)	2.499*(1.73)	5.503***(2.65)	-1.996 (-0.88)
D-4	-1.185 (-1.61)	2.234*(1.93)	-2.255 (-1.42)	4.815 (1.51)
D-3	-0.598 (-0.56)	0.715 (0.56)	1.535 (0.88)	1.561 (0.81)
D-2	0.153 (0.18)	3.391***(2.74)	2.215 (1.17)	3.593*(1.76)
D-1	4.89***(5.14)	7.453***(5.65)	1.83 (0.86)	13.922***(3.77)
D0	18.353***(11.49)	23.861***(14.14)	14.775***(4.66)	20.381***(5.81)
D+1	7.33***(7.54)	6.394***(2.86)	4.147**(2.01)	-8.199***(-3.05)
D+2	2.403**(2.42)	-1.889 (-1.38)	-1.32 (-0.7)	-2.532 (-1.11)
D+3	-0.375 (-0.47)	-4.05***(-4.01)	-1.704 (-1)	-0.273 (-0.12)
D+4	1.156 (1.28)	-1.994*(-1.8)	0.067 (0.03)	-3.055 (-1.46)
D+5	-1.19 (-1.46)	-0.578 (-0.28)	0.231 (0.14)	1.321 (0.57)
Adj-Rsquare	0.0244	0.0412	0.054	0.077
N	4,027,364	3,713,705	2,280,063	1,746,691

Table 8

Descriptive Statistics for the put-call parity sample

This table reports the descriptive statistics for the put-call parity subsample. The circuit breaker Rule 201 data spans from 28th of February 2011 which is the day in which the circuity breaker rule became in full compliance till the 10th of December 2016. The control sample data spans from the 10th of October 2008 that is one day after the short sale ban till the 2nd of August 2009 that is one day before the circuit breaker pre-approval period. The put-call parity related variables takes a value of 1 if the put-call parity relationship is violated: $P + S > C + K + PV(div)$. The Potential decoupling variable is constructed out of closing midpoint prices for stock and options whereas the violation arbitrage is constructed out of closing ask prices for call options and closing bid prices for both put options and share prices. Present value of dividend is equal to the sum of the PV of all dividend that falls within the option maturities. Discounting dividend is done using interpolated continuously compounded interest rates obtained from OptionMetrics. Options data is obtained from OptionMetrics whereas Stock data is obtained from CRSP.

Panel A - During Rule 201 Full Compliance Period					
	Average	Median	St. dev	Minimum	Maximum
Potential decoupling	0.521	1	0.5		
Violation arbitrage	0.085	0	0.279		
Put price	3.252	2.2	3.893	0.225	122.75
Call price	3.702	2.325	5.065	0.2	135.45
Put volume	25.516	0	246.725	0	29,918
Call volume	33.847	0	244.347	0	36,526
Call open interest	553.272	119	1,778.216	1	71,757
Put open interest	667.962	152	2,114.33	1	154,606
Present value of dividend	0.029	0	0.184	0	5.997
Stock price	29.644	18.515	46.088	4.94	1,414.46
Strike price	29.087	17.500	45.25	4	1400
Panel B - for the Control Sample (Rule 201 is not in effect)					
	Average	Median	St. dev	Minimum	Maximum
Potential decoupling	0.377	0	0.485		
Violation arbitrage	0.047	0	0.211		
Put price	3.173	2.55	2.375	0.215	46.1
Call price	3.438	2.6	2.905	0.23	43.55
Put volume	58.354	0	425.054	0	57,625
Call volume	43.677	0	312.075	0	48,824
Call open interest	107,4.759	196	417,4.528	1	241,851
Put open interest	753.219	124	265,7.635	1	114,415
Present value of dividend	0.058	0	0.174	0	4.522
Stock price	19.489	15.005	16.316	4.49	290.5
Strike price	19.164	15	15.939	4	300

Table 9.
Put-Call parity violations
This table reports the results of the estimation of a probit model where the dependent variable is the put-call parity violation variable. The circuit breaker Rule 201 data spans from 28th of February 2011 which is the day in which the circuity breaker rule became in full compliance till the 10th of December 2016. The control sample data spans from the 10th of October 2008 that is one day after the short sale ban till the 2nd of August 2009 that is one day before the circuit breaker pre-approval period. The put-call parity related variables takes a value of 1 if the put-call parity relationship is violated: P + S > C + K + PV(div). The Potential decoupling variable is constructed out of closing midpoint prices for stocks and options whereas the violation arbitrage is constructed out of closing ask prices for call options and closing bid prices for both put options and share prices following the work of Grundy et al. (2012). Present value of dividend is equal to the sum of the PV of all dividend that falls within the option maturities. Discounting dividend is done using interpolated continuously compounded interest rates obtained from OptionMetrics. D_i is a dummy variable that takes a value of 1 for day 'i' around the day in which the circuit breaker was applied and zero otherwise. We limited our sample to 30 days around the day in which the circuit breaker is applied. Stock volume and stock returns correspond to the stock daily traded volumes in millions and daily percentage return respectively as reported in CRSP database. Market Capitalization is estimated by multiplying the stock price by the number of shares outstanding for the corresponding day expressed in millions. Options data is obtained from OptionMetrics whereas Stock data is obtained from CRSP. *, **, *** represent significance at 10%, 5%, and 1% respectively. Huber-White heteroskedasticity-corrected standard errors t-stat are shown in parenthesis.

	Circuit Breaker Rule 201 is in Full Compliance		Control Sample – Rule 201 not Applicable	
	Potential Decoupling	Violation Arbitrage	Potential Decoupling	Violation Arbitrage
Intercept	0.126*** (19.64)	-1.342*** (-153.02)	-0.032*** (-3.2)	-1.563*** (-95.64)
Stock Volume	0.005*** (5.83)	0.026*** (14.95)	0 (0.09)	0.009*** (3.34)
Stock Return	0.068*** (72.34)	0.013*** (16.4)	0.031*** (70.54)	0.005*** (6.84)
Market Capitalization	0*** (-13.83)	0*** (-7.18)	0*** (-34.2)	0*** (-7.38)
VIX	-0.002*** (-6.59)	-0.003*** (-7.06)	-0.004*** (-19.51)	-0.002*** (-5.28)
D-5	0.004 (0.26)	0.003 (0.13)	0.024 (1.17)	0.055* (1.66)
D-4	0 (0)	0.021 (0.95)	0.017 (0.86)	0.009 (0.25)
D-3	0.019 (1.23)	0.005 (0.24)	0.055*** (2.72)	0.042 (1.23)
D-2	0.003 (0.2)	-0.003 (-0.13)	0.088*** (4.15)	0.006 (0.17)
D-1	0.006 (0.39)	-0.024 (-1.06)	0.116*** (5.71)	0.005 (0.15)
D0	0.298*** (16.01)	0.029 (1.17)	0.105*** (4.4)	-0.014 (-0.34)
D+1	-0.027 (-1.64)	-0.028 (-1.23)	0.135*** (6.37)	0.003 (0.08)
D+2	-0.023 (-1.45)	-0.02 (-0.89)	-0.092*** (-4.29)	-0.031 (-0.85)
D+3	-0.003 (-0.16)	-0.002 (-0.07)	0.04* (1.87)	-0.027 (-0.75)
D+4	0.007 (0.42)	0.007 (0.29)	0.049** (2.4)	-0.021 (-0.59)
D+5	-0.024 (-1.53)	-0.005 (-0.23)	0.073*** (3.52)	0 (0.01)
Pseudo-Rsquare	0.0550	0.0086	0.0582	0.0029
N	402,176	402,176	250,784	250,784

Table 10.
Synthetic Shorts to Synthetic Short to Stock Price Ratio

This table shows the ratio of synthetic short to stock price for days around the event (halt) day (Event Day 0). The circuit breaker Rule 201 data spans from 28th of February 2011 which is the day in which the circuity breaker rule became in full compliance till the 10th of December 2016. The control sample data spans from the 10th of October 2008 that is one day after the short sale ban till the 2nd of August 2009 that is one day before the circuit breaker pre-approval period. Synthetic short is created by being long put option, short call option using the following formula: synthetic short = put – call - K – PV(div). K is the strike price and PV(div) is the present value of all dividend falling within the options maturities. Panel A reports the synthetic short to stock ratio calculated by dividing the synthetic short by the stock end of day mid-price, In panel B, Daily Put Best Offer, and Call Best Bid are used. Here, the synthetic short to stock ratio is obtained by dividing the synthetic short by the stock best bid.

Panel A. Mid-Price Based

Event Day	Synthetic Short to Price Ratio – Full Compliance Period	Synthetic Short to Price Ratio – Control Period	Mean Diff – Full Compliance Period vs. Control Period
-5	0.9945 (-20.27)	0.9987 (-4.48)	-0.0042 (***)
-4	0.9945 (-20.07)	0.9986 (-4.54)	-0.00411 (***)
-3	0.9942 (-21.39)	0.9986 (-4.72)	-0.0044 (***)
-2	0.9947 (-19.45)	0.9975 (-8.25)	-0.00283 (***)
-1	0.9945 (-20.28)	0.9981 (-6.44)	-0.00361 (***)
0	0.9955 (-16.11)	1.0032 (10.74)	-0.00763 (***)
1	0.995 (-18.25)	0.9969 (-10.54)	-0.00198 (***)
2	0.9948 (-18.9)	0.9994 (-2.05)	-0.00456 (***)
3	0.994 (-22.07)	0.9985 (-5.48)	-0.00444 (***)
4	0.9943 (-21.02)	0.9977 (-7.99)	-0.00339 (***)
5	0.9944 (-20.26)	0.998 (-7.18)	-0.00363 (***)

Panel B: Synthetic Short = Put (Best Offer) – Call (Best Bid) Strike – PV(div)

Event Day	Synthetic Short to Price Ratio – Full Compliance Period	Synthetic Short to Price Ratio – Control Period	Mean Diff – Full Compliance Period vs. Control Period
-5	0.9698 (-80.01)	0.9732 (-60.81)	-0.00337 (***)
-4	0.9699 (-80.19)	0.9728 (-60.77)	-0.00293 (***)
-3	0.9695 (-81.06)	0.9729 (-61.48)	-0.00338 (***)
-2	0.9697 (-80.41)	0.9729 (-60.69)	-0.00317 (***)
-1	0.9696 (-80.07)	0.9733 (-59.97)	-0.00372 (***)
0	0.9701 (-79.3)	0.977 (-58.89)	-0.00695 (***)
1	0.97 (-78.47)	0.9714 (-62.13)	-0.00136 (***)
2	0.9699 (-79.27)	0.9746 (-58)	-0.0047 (***)
3	0.9693 (-80.1)	0.9736 (-62.56)	-0.00439 (***)
4	0.9699 (-79.53)	0.9731 (-61.82)	-0.00327 (***)
5	0.9697 (-78.04)	0.9728 (-63.59)	-0.00304 (***)