

Internet Appendix for
Short-Sale Constraints and Options Trading:
Evidence from Reg SHO

Internet Appendix A: Pilot Program

Short-sale regulations in the United States were first adopted in 1938. Regulation SHO (Reg SHO), which was passed on September 7, 2004 and became effective on January 3, 2005, sought to update these regulations in light of various market developments.¹ Goals included establishment of uniform “locate” and “close-out” requirements for short sales (Rule 203) and creation of uniform order-marking requirements for the sales of all equity securities (Rule 200).² Reg SHO became an experiment that temporarily suspended the “provisions of Rule 10a-1 under the Securities Exchange Act of 1934 and any short-sale price test of any exchange or national securities association for short sales of certain securities for certain time periods” in order to “evaluate the overall effectiveness and necessity of such restrictions” (i.e., Pilot Program pursuant to Rule 202T).

The Pilot Program commenced on May 2, 2005.³ One-third of the stocks in the Russell 3000 Index (pilot stocks) were allowed to short without regard to any price test. To select pilot stocks, the Securities and Exchange Commission (SEC) first excluded the 32 securities in the Russell 3000 index as of June 25, 2004 that were not listed on Nasdaq national market securities (NNM), the American Stock Exchange (AMEX), or the New York Stock Exchange (NYSE). The reason is that short sales in these securities were not

¹ See Securities Exchange Act Release No. 50103 (July 28, 2004), 69 FR 48008 (August 6, 2004).

² The locate provision requires “a broker-dealer to have reasonable grounds to believe that the security can be borrowed so that it can be delivered on the date delivery is due before effecting a short sale order in any equity security.” The close-out requirement imposes “additional delivery requirements on broker-dealers for securities in which there are a relatively substantial number of extended delivery failures at a registered clearing agency.”

³ The Pilot Program originally was scheduled to begin on January 3, 2005, but was reset to May 2, 2005 in response to information received by the SEC from market participants (see Securities Exchange Act Release No. 50747 (November 29, 2004), 69 FR 70480 (December 6, 2004)).

subject to a price test at that time. Then it excluded issuers whose initial public offerings occurred after April 30, 2004.

The remaining securities constitute three groups: AMEX, Nasdaq, and NYSE. Each group was ranked by average daily dollar volume over the one year prior to the issuance of this order, from highest to lowest. In each group, every third stock was selected as a pilot stock.⁴ The temporary suspension was scheduled to end on April 28, 2006, but ultimately was extended to August 6, 2007. The SEC believed that the Pilot Program would allow it to gather and analyze the data necessary to study the effect of the price tests on stock prices, volatility, liquidity, and trading behavior.

Internet Appendix B: Matched Sample

The pilot and control stocks are matched by firm characteristics including listing exchanges, two-digit SIC industry code, options volume, market capitalization, stock trading volume, and implied volatility. The implied volatilities are obtained from the at-the-money call options with moneyness closest to 0. We first matched firms on October 29, 2004, the last trading day before the beginning of our sample period. Conceivably, market conditions and the matching variables might change and affect options trading volume between that matching date (October 29, 2004) and the effective date of Reg SHO (May 2, 2005), resulting in systematic differences in options trading activity between the pilot and control stocks. We then matched alternatively on January 31, 2005, a date much closer to the effective date of Reg SHO. Table A1 presents the results of

⁴ Securities Exchange Act Release No. 50104 (July 28, 2004).

options volume regressions using the matched sample by measuring the firm characteristics on October 29, 2004 and January 31, 2005.

[Table A1 to be inserted here]

The coefficients on $\text{PILOT} \times \text{REG_SHO}$ for the all put volume and the at-the-money put volume regressions are significantly negative in both settings, indicating that Reg SHO induced more reduced options trading activity in pilot puts than control puts. The results are similar to those of the unmatched sample. Table A2 shows that the effects of Reg SHO on options pricing remain very similar. IV spread, IV skew, and the probability of put-call parity violation all drop significantly after Reg SHO, whether we measure firm characteristics on October 29, 2004 or January 31, 2005.

[Table A2 to be inserted here]

It is noteworthy that the coefficients on the pilot dummy are insignificantly different from zero when we match by firm characteristics on January 31, 2005, with one exception for the in-the-money put volume regression. Systematic differences between pilot and control options during the pre-Reg SHO period seem to be eliminated with a closer matching date.

Internet Appendix C: Repeal of Price Tests for All Stocks in 2007

The SEC removed all exchange-mandated short-sale price tests for all stocks effective July 6, 2007. To study the robustness of our findings using the 2007 repeal data, consistent with the setting of the main analyses, we choose a sample period for the repeal event with a 12-month window from January 1 through December 31, 2007, and define the periods before and after July 6, 2007 as the Reg SHO and Post-Reg SHO periods,

respectively. Again, we aggregate the volume of all options on the same stock (daily total option volume [OVS]) and estimate the regression:

$$(A1) \quad OVS_{i,t} = \alpha + \beta_1 STOCK_VOLUME_{i,t} + \beta_2 STOCK_RETURN_{i,t} + \beta_3 VIX_t \\ + \beta_4 REPEAL_i + \beta_5 POST_REG_SHO_t \\ + \beta_6 (REPEAL_i \times POST_REG_SHO_t) + \mu_k + \varepsilon_{i,t},$$

where $OVS_{i,t}$ is the put (call) options volume for a given stock i on day t . Each unit of volume corresponds to a single contract written on 100 shares. $STOCK_VOLUME_{i,t}$ is total number of shares of stock i traded on day t ; $STOCK_RETURN_{i,t}$ is daily return of stock i on day t ; VIX_t is the closing value of the CBOE Volatility Index on day t ; $REPEAL_i$ is a dummy variable that equals 1 if a given stock experiences the repeal of price tests, and 0 otherwise; $POST_REG_SHO_t$ dummy variable equals 1 for observations between July 6 and December 31, 2007, and 0 otherwise; and μ_k represents unobserved industry-specific heterogeneity.

Table A3 presents the put trading volume regression results, revealing a significantly negative coefficient for the interaction term of $REPEAL$ and $POST_REG_SHO$ for put trading volume. That is, put options trading activity in stocks experiencing the repeal of price tests drops significantly after the repeal of price tests, relative to their controls. The effect of the repeal of the price tests on put open interest is similar to the effect of the volume regression. The results indicate that put options trading serves as a substitute for directly selling a stock short, especially when there are strict short-sale constraints in the equity markets.

[Table A3 to be inserted here]

We also find significant declines in IV spread and IV skew during the Post-Reg SHO period for stocks experiencing relaxation of price tests in 2007, as presented in panel A of Table A4. Because buying puts and writing calls are two alternative ways to facilitate short selling when there are equity short-sale constraints, there is less price pressure on put and call options of the non-pilot stocks after repeal of the price tests. The repeal of price tests also significantly reduces the probability of put-call parity violations, as shown in panel B of Table A4.

[Table A4 to be inserted here]

Overall, test results for the 2007 repeal event support a conclusion similar to that for the Reg SHO event and confirm our hypotheses. That is, options trading substitutes for short selling when there are short-sale constraints, so there is less trading activity in the options markets and reduced price pressure on put and call options as short-sale constraints in the stock market are relaxed.

Internet Appendix D: Additional Robustness Tests

In response to SEC Reg SHO, self-regulatory organizations must have made short sale transactions data available beginning in January 2005 through the pilot period. We thus relate the findings to the Reg SHO equity short sale data released by the NYSE and Nasdaq with a shorter sample period from January 1, 2005 through August 31, 2005, which covers four months before and during the Reg SHO period. The results are similar, showing that during the Reg SHO period, short-sale volume of the pilot stocks increases and put volume of the pilot stocks reduces compared to controls.

When we repeat all the tests using options with 10 to 150 days to expiration, which are more liquid (Figlewski and Webb (1993)) and less prone to distortions associated with market thinness, the results of subsample tests continue to be similar.

Table A1: Matched Sample Results: Put Options Volume

This table presents the results of the regressions examining the effect of Reg SHO on put options volume for matched pair samples. Pilot stocks were designated as pilot securities by Reg SHO. Possible control stocks were chosen from the remaining stocks of Russell 3000 index stocks included, requiring the same two-digit SIC code and listing on the same exchange, and then matched by market capitalization, stock trading volume, implied volatility of the most at-the-money call option, and options volume. If pairs are matched by those dimensions as of October 29, 2004 (January 31, 2005), the sample period is Nov. 1, 2004 – Oct. 31, 2005 (Feb. 1, 2005 – Jul. 31, 2005). The dependent variable is the total, in-the-money, at-the-money, and out-of-the-money put options volume for a given stock on a given date. Each unit of volume corresponds to a single contract written on 100 shares. PILOT is a dummy variable that equals 1 if stocks were designated as pilot securities by Reg SHO and 0 otherwise. REG_SHO is a dummy variable that equals 1 if the observation date is between May 2 and October 31, 2005, inclusive, and 0 otherwise. PILOT \times REG_SHO is the interaction term between PILOT and REG_SHO. Industry fixed effects are included, and the intercept is subsumed by the fixed effects. Standard errors are in parentheses. *** and ** indicate significance at the 1% and 5% levels, respectively.

Sample Period:	Nov. 1, 2004 – Oct. 31, 2005				Feb. 1, 2005 – Jul. 31, 2005			
	All Options	In-the-Money	At-the-Money	Out-of-the-Money	All Options	In-the-Money	At-the-Money	Out-of-the-Money
STOCK_VOLUME (100 shares)	0.031*** (0.000)	0.001*** (0.000)	0.026*** (0.000)	0.004** (0.000)	0.031*** (0.000)	0.001*** (0.000)	0.026*** (0.000)	0.003*** (0.000)
STOCK_RETURN	-7.790*** (0.974)	-1.592*** (0.116)	-9.199*** (0.836)	3.107*** (0.290)	-4.681*** (1.351)	-1.339*** (0.149)	-6.721*** (1.164)	3.796*** (0.395)
VIX	-6.281*** (1.270)	0.785*** (0.129)	-4.061*** (1.091)	-3.030*** (0.334)	-4.041** (1.606)	0.681*** (0.151)	-2.768** (1.384)	-1.362*** (0.416)
PILOT	-19.034*** (5.327)	-2.091*** (0.589)	-12.265*** (4.578)	-10.677*** (1.399)	-3.891 (7.362)	-1.469** (0.734)	-0.782 (6.343)	-2.917 (1.930)
REG_SHO	20.905*** (4.894)	2.924*** (0.522)	17.176*** (4.202)	-1.870 (1.273)	0.196 (6.832)	1.293 (0.683)	-1.186 (5.893)	1.068 (1.725)
PILOT \times REG_SHO	-15.979** (6.906)	-0.939 (0.737)	-14.629** (5.935)	0.145 (1.790)	-17.752** (8.482)	-0.800 (0.942)	-19.999** (8.177)	-0.174 (2.417)
R^2	0.467	0.247	0.454	0.272	0.462	0.216	0.456	0.266
No. of obs.	235,384	120,138	234,202	162,447	120,819	60,512	120,110	83,008

Table A2: Matched Sample Results: Options Pricing

This table presents the results of regressions examining the effect of Reg SHO on options pricing by using the matched pair sample. Pilot stocks were designated as pilot securities by Reg SHO. Control stocks were chosen from the remaining stocks of Russell 3000 index stocks included, requiring the same two-digit SIC code and listing on the same exchange, and then matched by market capitalization, stock trading volume, implied volatility of the most at-the-money call option, and option volume. If pairs are matched by those dimensions as of October 29, 2004 (January 31, 2005), the sample period is Nov. 1, 2004 – Oct. 31, 2005 (Feb. 1, 2005 – Jul. 31, 2005). Panel A presents the regression results examining the effect of Reg SHO on IV spread and IV skew. Panel B presents the results of the estimation of a probit model examining the effect of Reg SHO on the probability of put-call parity violations. Industry fixed effects are included, and the intercept is subsumed by the fixed effects. Standard errors are in parentheses. *** indicates significance at the 1% level.

Panel A: Effect of Reg SHO on IV Spread and IV Skew				
Sample Period:	Nov. 1, 2004 – Oct. 31, 2005		Feb. 1, 2005 – Jul. 31, 2005	
	IV_SPREAD	IV_SKEW	IV_SPREAD	IV_SKEW
PILOT ($\times 10^2$)	0.100*** (0.000)	-0.086*** (0.000)	0.004 (0.000)	-0.038 (0.000)
REG_SHO ($\times 10^2$)	0.054*** (0.000)	-0.050 (0.000)	0.018*** (0.000)	-0.025 (0.000)
PILOT \times REG_SHO ($\times 10^2$)	-0.058*** (0.000)	-0.278*** (0.000)	-0.026*** (0.000)	-0.212*** (0.001)
STOCK_VOLUME ($\times 10^6$)	-0.038*** (0.000)	-0.062*** (0.000)	-0.049*** (0.000)	-0.150*** (0.000)
STOCK_RETURN	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.000*** (0.000)
VIX ($\times 10^6$)	-0.012*** (0.000)	0.077*** (0.000)	-0.018*** (0.000)	0.199*** (0.000)
R^2	0.182	0.112	0.207	0.168
No. of obs.	1,682,782	159,442	755,960	80,819
Panel B: Effect of Reg SHO on Put-Call Parity Violation				
Sample Period:	Nov. 1, 2004 – Oct. 31, 2005		Feb. 1, 2005 – Jul. 31, 2005	
PILOT ($\times 10^2$)	-0.031*** (0.009)		-0.017 (0.012)	
REG_SHO ($\times 10^2$)	0.154*** (0.008)		-0.102*** (0.013)	
PILOT \times REG_SHO ($\times 10^2$)	-0.087*** (0.011)		-0.048*** (0.018)	
STOCK_VOLUME ($\times 10^6$)	-0.070*** (0.000)		-0.082*** (0.000)	
STOCK_RETURN	-0.017*** (0.002)		-0.019*** (0.003)	
VIX ($\times 10^6$)	-0.022*** (0.002)		-0.013*** (0.003)	
Log likelihood	198,391		77,564	
No. of obs.	1,682,052		762,898	

Table A3: Effect of Repeal of Price Tests on Put Options

This table presents the results of regressions examining the effect of the repeal of price tests on put volume and open interest. The sample period is January 1 through December 31, 2007. The dependent variables are the total put option volume and open interest for a given stock on a given date. Each unit of volume corresponds to a single contract written on 100 shares. REPEAL is a dummy variable that equals 1 if stocks experience the repeal of the price tests and 0 otherwise. POST_REG_SHO is a dummy variable that equals 1 if the observation date is between July 6 and December 31, 2007, inclusive, and 0 otherwise. REPEAL \times POST_REG_SHO is the interaction term between REPEAL and POST_REG_SHO. Industry fixed effects are included, and the intercept is subsumed by the fixed effects. Standard errors are in parentheses. *** and ** indicate significance at the 1% and 5% levels, respectively.

	Volume	Open Interest
STOCK_VOLUME (100 shares)	0.032*** (0.000)	1.187*** (0.002)
STOCK_RETURN	-4.883*** (0.889)	-64.936** (25.838)
VIX	-0.296 (0.486)	-64.815*** (14.133)
REPEAL	-6.259 (4.453)	-419.864*** (129.461)
POST_REG_SHO	-3.269 (6.297)	897.865*** (183.068)
REPEAL \times POST_REG_SHO	-17.771*** (5.824)	-648.360*** (169.306)
R^2	0.540	0.670
No. of obs.	303,333	303,332

Table A4: Effect of Repeal of Price Tests on Options Pricing

This table presents the results of regressions examining the effect of the repeal of price tests on options pricing. The sample period is January 1 through December 31, 2007. REPEAL is a dummy variable that equals 1 if stocks experience the repeal of the price tests and 0 otherwise. POST_REG_SHO is a dummy variable that equals 1 if the observation date is between July 6 and December 31, 2007, inclusive, and 0 otherwise. REPEAL \times POST_REG_SHO is the interaction term between REPEAL and POST_REG_SHO. Panel A presents the regression results examining the effect of Reg SHO on IV_SPREAD and IV_SKEW. Panel B presents the results of the estimation of a probit model examining the effect of Reg SHO on the probability of put-call parity violations. Industry fixed effects are included, and the intercept is subsumed by the fixed effects. Standard errors are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: IV Spread and IV Skew				
	IV_SPREAD	IV_SPREAD	IV_SKEW	IV_SKEW
	(1)	(2)	(3)	(4)
REPEAL ($\times 10^2$)	0.128*** (0.000)	0.128*** (0.000)	0.215*** (0.002)	0.223*** (0.000)
POST_REG_SHO ($\times 10^2$)	0.100*** (0.000)	-0.324*** (0.000)	1.297*** (0.000)	0.779*** (0.000)
REPEAL \times POST_REG_SHO ($\times 10^2$)	-0.156*** (0.000)	-0.154*** (0.000)	-0.056** (0.000)	-0.051* (0.000)
STOCK_VOLUME ($\times 10^6$)		-0.003*** (0.000)		-0.021*** (0.000)
STOCK_RETURN		0.002*** (0.001)		0.002*** (0.004)
VIX ($\times 10^6$)		-0.043*** (0.000)		0.071*** (0.000)
R^2	0.120	0.151	0.180	0.194
No. of obs.	2,482,878	2,482,875	248,571	248,571

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Table A4 – Continued

Panel B: Put-Call Parity Violation		
	(1)	(2)
REPEAL ($\times 10^2$)	0.149*** (0.008)	0.148*** (0.008)
POST_REG_SHO ($\times 10^2$)	-0.111*** (0.010)	-0.129*** (0.013)
REPEAL \times POST_REG_SHO ($\times 10^2$)	-0.185*** (0.012)	-0.184*** (0.012)
STOCK_VOLUME ($\times 10^6$)		-0.018*** (0.000)
STOCK_RETURN		-0.008*** (0.141)
VIX ($\times 10^6$)		-0.002** (0.001)
Log likelihood	207,247	207,247
No. of obs.	2,506,040	2,506,037