This Draft: September 15, 2009
Preliminary and Incomplete: Please do not quote

Hastily Implementing Rules that are not Well Thought Out: The Impact of the 2008 Short Sale Ban on Equity Option Markets

Robert Battalio
241 College of Business Administration
University of Notre Dame
Notre Dame, IN 46530
(574) 631-9428
rbattali@nd.edu

Paul Schultz
260 College of Business Administration
University of Notre Dame
Notre Dame, IN 46530
(574) 631-3338
pschultz@nd.edu

Abstract. We examine how the confusion and regulatory uncertainty generated by the imposition of draconian short sale restrictions in September 2008 impacted equity option markets. We uncover four primary findings. First, investors seeking short exposure in financial stocks did not migrate to the option market to avoid the short sale ban. Second, the short sale restrictions are associated with increased bid ask spreads for options on banned stocks that are not solely attributable to inflated bid ask spreads on the underlying stocks. Indeed, on September 19th, we estimate that liquidity demanding investors trading December 2008 expiration puts and calls encountered bid ask spreads that were $1.20 wider (24% larger) than the bid ask spreads of options on comparable stocks with no short sale restrictions. Third, synthetic share prices for banned stocks become significantly lower than actual share prices. Finally, we find the short sale ban increased the number of apparent arbitrage opportunities that involve the buying of synthetic shares and shorting of actual shares. Together, our results suggest trading costs in option markets increase dramatically and option and stock prices decouple when option market makers are not able to hedge easily and investors are unable to purchase short exposure. Our results also provide a reminder of the costs of allowing politicians to hastily implement rules that are not well thought out in financial markets.

Acknowledgments: We thank an anonymous firm for providing the option data used in our analysis, the Options Clearing Corporation for providing early exercise and open interest data, the S3 Corporation and an anonymous retail broker for providing retail order and rebate rate data, and the ISE for providing data on trades that open or close trading positions. We gratefully acknowledge comments from Peter Bottini, Michael Doherty, Rob Neal, Jerry O'Connell, Gavin Rowe, and Rod Taylor.

"This ban is terrible for option market makers. It will kill options trading because you cannot price options fairly. You cannot buy a call or sell a put and hedge them."

- Joe Kinahan, derivatives strategist at the Thinkorswim Group, September 19, 2008.[1]

Early in the morning on September 19, 2008, the United States Securities and Exchange Commission (SEC) issued a surprise directive banning short selling in 797 financial stocks. The ban, which remained in effect until October 8, 2008, was intended to prevent short sellers from manipulating prices of financial stocks. Proponents of the ban argued it would prevent a 'death spiral' in which short sellers could force down prices, which would lead depositors to withdraw funds from financial institutions, which would put further downward pressure on financial stock prices, and so on. While the initial ban clearly permitted short sales as part of legitimate equity market making activity, it only allowed option market makers to go short when hedging their positions on September 19th, a triple witching day.

In this paper, we examine the impact of the short sale ban on the options market. The ban provides a unique opportunity to see what happens when market makers are confused about their ability to hedge. Initially, there was uncertainty about whether options market makers would be allowed to short for hedging purposes for the duration of the ban, and whether stock needed to be borrowed before shorting. Even after September 25th, when options market makers' regulatory standing had been clarified, hedging was difficult. A number of institutions, like CALPERS, stopped lending stock. In addition, trading costs increased sharply for financial stocks in the equity markets.

In this paper we address four questions. First, we examine whether the options market was used to avoid the short selling restrictions. Short selling restrictions are ineffective if investors can circumvent them by selling short synthetically in the options market. Harris, Namvar, and Phillips (2009) provide indirect evidence of a migration of shorting to the options market by showing that prices of stocks with options were

[1]Doris Frankel (2008).

affected less by the ban than other stocks. However, the SEC ban, as amended shortly after 12:00am on the morning of September 22nd, only allowed market makers to sell short if they knew the customer or counterparty was not increasing a net economic short position.[2]

We find the ratio of option-to-stock volume is comparable for banned and control stocks throughout our sample period. Given the coarse nature of trade data, we next examine whether investors trading on the ISE and on the CBOE opened more long put positions and more short call positions in options on financial stocks during the ban. Surprisingly, we find little evidence that investors moved from the stock to the option market to gain short exposure in financial stocks. Together, our evidence suggests investors did not migrate in mass to the option market to obtain short exposure in financial stocks.

Inflated trading costs may at least partially explain why investors do not seem to have migrated to the options market to obtain short exposure in the banned stocks. The second issue we examine is the impact of the short-selling ban on trading costs and liquidity in the options market. Our multivariate analysis reveals that on the first day of the ban, puts and calls on banned stocks with December 2008 expirations have quoted spreads that are more than \$1.10 wider than the quoted spreads of options on our control stocks. This translates into a difference of 24% in relative spreads on September 19th. On the morning of September 22nd, when there was still confusion regarding the ability of option market makers to hedge, relative quoted spreads remain elevated for options on financial stocks. From September 22nd through October 8th, the last day of the ban, we find the relative quoted spreads are an average of 10% higher for options on banned stocks than for options on control stocks. After the ban is removed, the difference in relative quoted spreads falls to around 4%. Inflated bid ask spreads on the banned stocks explain much of the disruption in the option market, but they are unable to explain the extreme rise in relative spreads on September 19th.

---

[2] See "Options Market Makers get Relief from SEC Ban on Short-Selling," published in Traders Magazine Online News on September 22, 2008.

Our analysis of intraday quotes suggests that the SEC's imposition of severe penalties on option market makers who failed to deliver shorted shares in a timely fashion affected the relative spreads of options on both banned and control stocks. For example, on September 17th, relative intraday quoted spreads averaged 10% for both sets of stocks. During the first hour of trading on September 19th, the intraday relative spread for puts on control stocks averaged more than 20%. We also find evidence suggesting that regulatory uncertainty led to wider bid ask spreads for all options, especially in the mornings, in the days following the short sale ban.

Finally, order data provided by a retail options broker suggests that, on average, liquidity demanding investors paid more than the quoted spread during the short sale ban. This suggests our analysis of quoted spreads understates the impact of the short sale ban on the cost of immediacy in the option market when the short sale ban was imposed.

The third question we address is whether biases in option prices emerge during the short sale ban. We measure bias as the difference between the price of a synthetic and an actual share of stock. The price of a synthetic share of stock can fall relative to the price of an actual share for two reasons. First, since the short sale ban and the pre-borrow requirements made it difficult for options market makers to hedge long positions in puts and short positions in calls, we might expect option market makers to discourage the sale of puts and the writing of calls by raising their offer prices for puts and lowering their bid prices for calls. Together, this asymmetric adjustment of quotes for puts and calls decreases the price of selling a share of stock synthetically, which is done by writing a call, purchasing a put, and selling a riskless asset. Second, the ban could inflate the prices of the actual shares of stock while leaving the prices of options unaffected. For October expiration options with a stock-to-strike price ratio between 80% and 120%, we find no difference in bid/ask spread midpoints for synthetic and actual shares prior to September 19th. On the day that the ban is instituted, the synthetic bid/ask spread midpoint is an average of $0.18 per share lower than the actual bid/ask spread midpoint. After the first few days of the ban, this difference falls to around $0.05 per share and when the short sale ban ends, the midpoints of the synthetic and actual bid/ask spread converge.[3] Since short sale constraints on option market makers became widely known toward the end of the week of September 22nd, and since these constraints did not change when the ban was lifted on October 8th, the fact that the difference in spread midpoints becomes statistically indistinguishable from zero only when the ban ends provides support for the argument that the short sale ban led to inflated stock prices.

The fourth and final question we address in this paper is whether or not the short sale ban produced price discrepancies that would allow arbitrage profits to be earned. It is widely believed that prices of equivalent or similar assets diverge significantly when short sales are restricted. We test whether the ban increased the likelihood that synthetic ask prices were less than contemporaneous bid prices of actual shares. In normal circumstances, arbitrageurs would exploit these price discrepancies by buying shares synthetically and shorting the stock itself. With the short-sale ban, arbitrage of this type became impossible and, as a result, prices may have diverged more than usual.

Our evidence suggests that the frequency of "buy synthetic/sell actual" and the frequency of "sell synthetic/buy actual" apparent arbitrage opportunities are similar for banned and control stocks prior to September 19th. During the ban, apparent arbitrage opportunities in which a synthetic share is sold and an actual share is purchased are actually more likely in control stocks than in banned stocks This likely reflects the fact that bid/ask spreads for options on banned stocks were wider than bid/ask spreads for options on control stocks. Conversely, arbitrage opportunities involving the sale of an actual share and the purchase of a synthetic share are more prevalent in banned stocks after the short sale ban. Consistent with our analysis of actual and synthetic spread midpoints, we find that the short sale ban allowed stock prices to become high relative to options prices as investors could not sell short to take advantage of the put call parity violations.

---

[3]We obtain similar, but stronger results for December expiration options.

The remainder of this paper is organized as follows. In Section I we discuss how events around the shorting ban impacted the equity options market. Section II provides a brief description of related literature. In Section III we describe our data. In Section IV we examine whether investors seeking short interest migrated to the equity options market after the imposition of the short sale ban. In Section V we investigate the impact of the short sale ban on liquidity in the options market. Section VI investigates the impact of the short sale ban on the linkage between the equity and equity options markets. Section VII concludes.

I. The Shorting Ban

Stock prices for banks and other financial institutions declined steeply during the summer of 2008. Some regulators feared a potential death spiral in which short sales drove down prices, leading depositors and creditors to withdraw funds from banks, driving prices down further and attracting more short selling. The SEC first attempted to limit short selling in 19 financial stocks with a July 21st directive banning "naked shorting," that is shorting without actually borrowing the shares. This ban remained in effect until August 12th. The ban's effectiveness was limited. The two stocks that had served as catalysts for the SEC's directive, Fannie Mae and Freddie Mac, continued their declines, falling 40% and 41% over the life of the naked shorting ban.

In September of 2008, as prices of financial stocks plunged, the SEC came under additional pressure to limit short sales. New York State Attorney General Andrew Cuomo announced an investigation into short selling. Former Morgan Stanley CEO Phillip Purcell called for a short sale ban. Senators Hillary Clinton and Chuck Schumer pressured SEC commissioner Christopher Cox to ban short sales. Meanwhile, the U.K.'s Financial Services Authority banned short selling in financial stocks in great Britain until January.

On September 18th, the SEC adopted Temporary Rule 204T, which imposed "enhanced delivery requirements on the sales of all equities securities" in the United States.[4] If a broker dealer failed to deliver

[4]See SEC Release 34-58572, September 18, 2008.

shares by 9:30 on the morning after the settlement date (three days after the trade date), its clearing firm and any broker dealer for which it clears (including option market makers) would be prohibited from executing additional short sales for itself or its customers without pre-borrowing the shares. This penalty would remain in effect until the failed trade was settled. The SEC had been tolerant of failures to deliver. This, in contrast, was a stiff penalty. In a December 19, 2008 letter to the SEC, the seven options exchanges and the OCC express concern that complying with Temporary Rule 204T "has caused, and will continue to cause, market volatility, increased borrowing costs, and wider bid/ask spreads."

On the evening of September 18th, SEC commissioners met to discuss short selling and other issues. In the early morning hours of September 19th, the SEC issued a ban, effective immediately, on short selling for 797 financial stocks.[5] The ban was set to expire in 10 days, but could be extended to 30 days at the SEC's discretion. "Registered market makers, block positioners, or other market makers obligated to quote in the over-the-counter market" were exempted from the ban for short sales that occurred as part of their market making activity. An exception was also granted for "...automatic exercise or assignment of an equity option held prior to effectiveness of this Order due to expiration of the options." This was interpreted by some to mean that options could not be exercised early. Finally, to facilitate the expiration of options on September 20th, a triple witching day, the SEC granted an exception to option market makers "when selling short as part of bona fide market making and hedging activities related directly to bona fide market making in derivatives" on the 797 financial stocks until 11:59 p.m. on September 19th. Presumably, option market makers would be unable to sell short for any reason during the remainder of the short sale ban.

By midday on September 19th, several options market makers threatened to stop trading if they were not allowed to hedge by shorting stock. Bill Easley, vice chairman of the Boston Options Exchange, "explained to the SEC [on Friday] that the ban meant the options market makers wouldn't function come Monday." Nina

[5]See SEC Release 34-58592, September 19, 2008.

Mehta, a reporter for Traders Magazine, noted that "by mid-afternoon Friday, the SEC's Division of Trading and Markets had issued a statement noting that Commission staff would recommend modifying the short-selling ban to extend the exception to options market makers' hedging activities."

In the early hours of Monday, September 22nd, the SEC confirmed that the exception for market makers for options and other derivatives would remain in place. The SEC did not, however, want investors to use the options market to circumvent short selling restrictions. So, they added a provision that market makers could not short if they knew a customer or counterparty was increasing an "economic net short position in the shares of that stock." The vague prohibition against shorting if the market maker *knew* the trade would create an economic net short position seemed to give market makers an incentive to avoid knowing what their customers were doing.

The SEC's original list of 797 banned stocks did not include all the relevant financial stocks. This is hardly surprising since the list was drawn up overnight and without industry comment. On Monday September 22nd, the SEC announced that decisions on which companies to add to the short sale ban would be left to the exchanges. The New York Stock Exchange added an additional 71 stocks after the market close on Monday, September 22nd. Over the next few days, the list of banned stocks increased to about 1,000. Some of the stocks, like CVS Caremark and IBM are financial stocks only when the financial sector is defined very broadly. Other financial companies like Diamond Hill Investment and JMP group asked to be dropped from the list because they did not agree with the idea that short sales should be banned.

The emergency actions taken on September 18th and 19th were both sudden and not well understood by industry participants. In a May 2009 report, the Government Accountability Office (GAO) notes that, "industry officials stated that due to the rushed nature of the September emergency order and the temporary rule, there was a lot of uncertainty and confusion related to the scope and application of the new requirements."[6] The seven options exchanges and the OCC argue in a December 19, 2008 letter to the SEC that "with respect to the emergency actions overall, imposing significant requirements without advance warning or input from the exchanges and market participants, but which must be complied with immediately, was and still is extremely disconcerting to all market participants. Adjustments to trading strategies and compliance systems that would be difficult, but possible, with reasonable advance notice become, in some situations, nearly impossible."[7]

Confusion over the emergency actions is evidenced by a series of regulatory circulars put out by the CBOE during the week of September 22nd. CBOE Regulatory Circular RG08-117, issued on September 24th, notes that "yesterday evening, the SEC Staff issued guidance in the form of an FAQ on the emergency order that adopted Temporary Rule 204T, which pertains to the delivery of securities." The FAQ attempted to answer three questions. First, the FAQ suggested that a clearing firm can allocate responsibility for Temporary Rule 204T's close-out requirement to the broker-dealer that is responsible for the fail position, rather than to the clearing firm and all of its customers. Second, there was confusion about whether firms had to close out their short positions on the settlement date or whether they could close them out earlier. The FAQ suggested that "a broker-dealer may receive credit for purchasing securities prior to the beginning of regular trading hours on the settlement day..." Finally, the FAQ suggested that "any Market Maker to which a fail to deliver position at a registered clearing agency is attributable must attest in writing to the market on which it is registered that the fail to deliver position at issue was established solely for the purpose of meeting its bona fide market making obligations."

On September 25th, the CBOE issued another regulatory circular conveying the SEC Staff's guidance on close-out and pre-borrow requirements under Temporary Rule 204T. This circular states that option market

---

[6]See GAO-09-483.

[7]See December 19, 2008 letter from option exchanges to the SEC.

makers must now close out their short positions by the beginning of regular trading hours on the morning of the sixth trading day following the transaction. The circular also confirmed that the option market makers could short shares of a security even when customer of its clearing agency has a fail to deliver in that security as long as “the Market Maker can show that it does not have an open fail to deliver position at the time of any additional short sales.”

The shorting ban was set to expire on October 2nd if it was not extended. The SEC did extend the ban until the earlier of October 17th, or three business days after the $700 billion financial rescue legislation was passed into law. Shorting resumed on October 9th, but as noted in the December 19, 2008 letter from the seven options exchanges and the OCC to the SEC, “even when an emergency action ends, its impact lingers.” Table 1 characterizes the various regulatory events and clarifications.

To summarize, there were several ways in which SEC actions limited the ability of option market makers to hedge. Beginning on September 18th, Temporary Rule 204T limited market makers ability to hedge by penalizing failures to deliver. This rule affected all options. On September 19th, it was not at all clear if options market makers would be able to hedge by shorting banned stocks at all after that day. This issue was resolved on September 22, as it was made clear that options market makers would be able to sell short for hedging purposes. There were still, however, special obstacles for market makers that wanted to hedge by shorting banned stocks. Market makers were not allowed to sell banned stocks short if the net result was to create an economic short position in the stock for a customer. In addition, unusually wide spreads on banned stocks made it costly for market makers to hedge using underlying shares. Finally, borrowing banned stocks became more difficult as a number of institutions, like CALPERS, stopped lending hem.

II. Literature Review

For the most part, financial economists view short selling restrictions as counterproductive. Miller (1977) argues that short sale restrictions keep pessimistic from being impounded in stock prices, thus resulting in overpriced shares. Consistent with Miller's hypothesis, Figlewski (1981), Figlewski and Webb (1993), and Dechow et al. (2001) find stocks with high short interest have low subsequent returns and Jones and Lamont (2002) find evidence that stocks which are expensive to short have high valuations and low subsequent returns. Ofek and Richardson (2003) suggest that inability to short led to high prices for internet stocks in 1999 and 2000, and the relaxation of constraints on borrowing shares for shorting led to the eventual collapse of prices for these stocks.

Diamond and Verrecchia (1987) model the impact of short sale restrictions on asset prices and conclude that short sale restrictions need not lead to overpriced assets. Investors will be aware that short sale restrictions prevent selling by pessimistic investors and will adjust their valuations accordingly. Even if prices are unbiased though, they will be less accurate than if short selling was unconstrained. Investors may take into account that pessimistic traders are shut out of the market, but that is not the same as knowing when pessimistic traders are selling. Bris, Goetzmann, and Zhu (2007) provide some empirical support for the idea that markets with short selling restrictions are less efficient. Using a number of markets around the world, they show that short sale restrictions lead to slower impounding of negative information.

Jones (2008) uses a series of regulatory changes in the U.S. during the 1930's that made shorting more difficult to explore the impact of short sale restrictions on liquidity and asset prices. During the thirties, short sales were banned for two days, versions of the uptick rule were introduced, and brokers were required to get authorization before using their customers' shares for shorting. Jones finds evidence suggesting that each of these events made shorting more costly. He also finds the affected stocks have average returns around these events that are significantly positive. Jones interprets these results as being "consistent with the limits-to-arbitrage notion that when there are restrictions on shorting, optimists have more influence on pricing." Finally, Jones (2008) shows that bid ask spreads tighten when versions of the uptick rule are introduced. This result likely reflects the fact that the uptick rule requires short sellers to supply liquidity to get their orders executed. Conversely, Diether, Lee, and Werner (2009) find the spreads widen when the uptick rule is removed.

The July 2008 Emergency Order and the September 2008 shorting ban provide sudden and drastic changes in short selling restrictions with which to test the impact of shorting restrictions in today's electronic markets. The SEC's Office of Economic Analysis (OEA) produced a memorandum in January 2009 analyzing impact of the pre-borrowing requirement on the market. Relative to a sample of control stocks, the OEA found that stocks subject to the Emergency Order had "large and statistically significant drops in short selling volume" and "dramatic, but temporary, initial increases in stock lending rates followed by rates still higher than before the Order." The OEA found little change in quoted spreads, quoted depths, short interest, option trading volume, open interest, or stock trading volume. Finally, they did not find a significant migration of order flow in cross-listed stocks to London.

Recent studies document several ways in which the September 2008 short sale ban affected equity markets. First, the short-sale ban dramatically reduced short selling. Boehmer, Jones, and Zhang (2009) find that on average, short sales made up 21.75% of trading volume for banned stocks in the six weeks leading up to the ban but only 7.72% during the ban itself. Presumably, these remaining short sales were made by market makers. Over the same period, the proportion of trading volume from short sales declined from 20.38% to 19.32% for control stocks. Gurliacci, Jeria, and Sofianos (2008) use proprietary Goldman Sachs electronic order flow (algorithmic and direct market access) to examine short-seller activity in S&P 500 stocks initially impacted by the short sale ban. In May 2008, they find short selling in the banned stocks was 23% of executed value, while buying was 51% of value. On October 8th, the last day of the ban, they find short selling is 4% of value, which they attribute to exempt market making activity, and buying is 48% of value. Finally, on October 9th, Gurliacci et al. find shorting activity returns to 23% of value and buying activity remains at 48% of value. Gagnon and Witmer (2008) report a substantial migration of trading volume to Canada for banned stocks that also traded there.

The ban appears to have increased the costs of trading financial stocks. Boehmer, Jones, and Zhang (2009) report that median effective spreads for banned stocks increased from 42 basis points in the six weeks before the ban to 145 basis points while the ban was in effect. Over the same period, the increase in the median effective bid-ask spreads for control stocks was much smaller: from 35 basis points to 57 basis points. Other measures of market quality, like price impact and volatility, also deteriorated for financial stocks during the short sale ban. Kolasinksi, Reed, and Thornock (June 2009) find market quality, as measured by R^2, falls during the ban.

There is also evidence that prices of financial stocks were artificially inflated during the ban. Boehmer, Jones, and Zhang (2009) document large gains in prices of banned stocks when the ban was announced that were gradually surrendered over the ban period. Of course, other factors, like the status of the TARP bill before congress could explain the returns of financial stocks. Harris, Namvar, and Phillips (2009) refute this by estimating a factor analytic model of stock price changes around the ban. Among the factors are the returns on a value-weighted index of the banned stocks and a TARP index. After adjusting for common factors, Harris, Namvar, and Phillips report that banned stocks earned positive abnormal returns of about 10.5% during the ban period and find that these returns were concentrated in stocks without listed options. Harris, Namvar, and Phillips (2009) conjecture that returns could be less for banned stocks with listed options because investors may have been able to construct synthetic short positions in the options market in these stocks.[8]

III. Data

As in Battalio and Schultz (2006), we use option market data collected under the Options Price Reporting Authority (OPRA) Plan for Reporting of Consolidated Last Sale Reports and Quotation Information. We obtain OPRA data from a large options market maker. These data, which average approximately 100

---

[8]Kolasinksi, Reed, and Thornock (June 2009) find short sales become more informative following each of these actions, especially for stocks with listed options. They interpret this as evidence that informed investors move to the options market to obtain short exposure when the cost of short selling becomes more expensive.

gigabytes per day in 2008 and are as large as 450 gigabytes in the last two weeks of September 2008, are also available from the International Securities Exchange (ISE) and the Chicago Board Options Exchange (CBOE).

The OPRA quote records contains the date, the to-the-millisecond time, the option and underlying stock symbols, the exchange on which the record is generated, bid and ask prices, and bid and ask messages. The quote messages indicate whether the quotes are regular way quotes, non-firm, part of the opening rotation, eligible for automatic execution, or whether they contain customer trading interest. The OPRA trade records contain the date, the to-the-second time, the option class and series symbols, the exchange on which the trade is reported, the trade price, and the trade message. Among other things, the trade message indicates whether the trade was a regular transaction, whether it was cancelled, whether it was executed electronically, and whether it was reported with delay. Our dataset contains all quotes and trades for all equity options traded each day from August 1, 2008 through October 21, 2008 with two exceptions. Our daily OPRA files containing data for August 14th and August 26th are corrupt. We narrow our analysis down to options on stocks for which shorting is banned in the original SEC order and to options on a sample of control stocks. The control stock sample is chosen by matching each banned stock with the non-banned stock with the smallest sum of the squared percentage difference in price at the beginning of the sample period, and the squared percentage difference in capitalization.

Even with a short sample period, the size of the data set makes it difficult to use. A single stock will have puts and calls with perhaps ten exercise prices, and five expiration dates, for a total of 100 options per stock. For some stocks on some days, the number of options is much larger. In addition, options on a particular stock may be quoted on as many as seven options exchanges. To reduce the data set to a manageable size, we create a NBBO quote for each option at the end of each minute by taking the highest firm bid and the lowest firm offer price across the exchanges. For the underlying equity market, we obtain end-of-minute NBBO quote records from the New York Stock Exchange's (NYSE) Daily Trade and Quote (TAQ) database. The file that contains all of the equity option transactions that occur during our 55-day sample period is only 1.33 gigabytes and is therefore much more manageable.

We obtain a file of all marketable orders in our sample and control option classes that were executed via a large retail broker in September 2008. Among other things, for each order these data provide an indication of whether the order is a market or a marketable limit order, a limit price if the order is a marketable limit order, a buy/sell indicator, the order submission date and time, the execution date and time, the order size, the trade size, the trade price, and the order-receipt-time NBBO.

Our initial dataset consists of 58,590 trades. We eliminate 8,141 trades resulting from orders received prior to 9:45a.m. since we are not interested in trades that occur in the opening rotation. We eliminate 509 trades resulting from orders received after 3:51p.m. to avoid trades executed in closing rotations. We eliminate one order as a data error because the order receipt date is different from the execution date. Our analysis requires a valid order receipt time (ORT) quote. We eliminate 352 trades with a NBBO of zero and 42 trades with an ORT National Best Bid that is greater than its ORT National Best offer. Finally, we eliminate 21 trades with relative bid/ask spreads that exceed 5% as data errors. Our final sample contains 49,524 trades, or 84.5% of our original sample.

Finally, we obtain data sets indicating the number of contracts contained in trades that open and close buy positions and open and close sell positions from the ISE and the CBOE. These exchanges, which account for more than 57% of the average daily trading volume of all options in 2008, are the only ones that make these data available for purchase. These data include the number of trades and the volume of contracts involved in transactions in which customers and market professionals opened and closed buy and sell positions on each of these exchanges for each series, for each day during August and September 2008.

Table 2 provides a description of the sample. Panel A summarizes the distribution of price and market capitalization for banned and control stocks as of July 31, 2008 - the date when matching stocks are determined. There are a total of 330 banned stocks with options that trade at that time. Each is matched with a control stock. Following Davies and Kim (2009), our match is the stock that was not banned that minimizes the sum of the squared percentage difference between the banned stock and control stock prices, plus the squared percentage difference between the banned stock and control stock market capitalizations. No control stock is used twice. If the control stock does not have options quoted for any day of the sample period, the second best match (or third best if needed) is used.

Prices and sizes of the control stocks closely match those of the banned stocks. The mean capitalization of both bank and control stocks is $8.7 billion. The mean price of the banned stocks is $30.76 and the mean price of the control stocks is also $30.76. The medians and quartiles of the prices are also very similar for banned and control stocks.

Panel B reports the distribution, across days, of the number of options contracts quoted on each stock. The banned stocks have a mean of 29,678 options quoted per day with a range of 27,434 to 34,088. For the sample of control stocks, the mean number of options quoted on a day is 32,619. The number of options on control stocks quoted on any specific day ranges from 30,540 to 38,072. For each expiration month from August through December 2008, there are at least 1,500 options quoted on control stocks and at least 1,000 options quoted on banned stocks. The last three rows of the table report the number of options for which the stock price is 20% below the exercise price, the proportion with a stock price within 20% of the exercise price, and the proportion with a stock price at least 20% greater than the exercise price. For both the banned stocks and the control stocks, there are more options quoted with a stock price at least 20% less than the exercise price than with a stock price at least 20% greater than the exercise price. This is symptomatic of falling stock prices over the prior months. In some of the tests to follow, we use only options with exercise prices within 20% of the stock price, so it is more significant that there are always at least 7,000 options trading in the in-the-money category.

Panel C reports the average daily contract and share volume in our sample of banned and control stocks in August, September, and October 2008. The average daily volume of calls traded on banned stocks climbs from 1.18 million contracts in August to 1.3 million contracts in October. Over this same time interval, the average daily volume of puts traded on banned stocks rises from 1.06 million contracts to 1.45 million contracts. While the average daily volume of option contracts traded is roughly comparable for control and banned stocks in August and October, there is a marked difference in September where the average daily volume of options traded is 3.22 million contracts for control stocks and 2.61 million contracts for banned stocks. The data presented in Panel C suggest the short sale ban did have an affect on the relative volume of options traded on banned stocks. However, the daily share volume in control stocks exceeds the daily share volume in banned stocks by an average of 967 million shares per day in September 2008. This suggests that the ratio of option-to-stock trading volume may not be much different for banned and control stocks.

We explore this further in Figure 1, which plots the ratio of option-to-stock volume in banned and control stocks for each of the days in our sample period. Each day, we first multiply the volume of put and call contracts traded on banned stocks by 100 since each contract contains options on 100 shares of stock. We then divide this product by the number of shares traded in the underlying banned stocks on that day. The ratio of option-to-stock volume for control stocks is computed analogously. Figure 1 suggests that the ratio of option-to-stock volume averages around 15% per day for banned and control stocks. This ratio does not appear to be affected at all by the ban, thus providing no support for the idea that short sellers migrated to the options market. In untabulated results, similar patterns emerge when this ratio is computed separately for puts and for calls and when we use multivariate regressions to analyze the data. Together, the evidence in Figure 1 and in Panel C of Table 1 suggest that investors did not move to the option market when short selling was banned in the equity market. In the next section, we use an alternative dataset to investigate this issue more fully.

IV. Did Investors Seeking Short Exposure Move to the Options Market?

There are many reasons investors trade options. In this section we more fully examine whether investors seeking short exposure migrated to the option market during the short sale ban. On September 19, 2008 investors were prohibited from shorting shares of financial stocks but they could buy puts and write calls on these stocks in the option market. For the remainder of the ban, options market makers were prohibited from providing liquidity to investors seeking a synthetic short position in stocks in which short selling was banned.

As we have seen in Figure 1, there is little evidence in the OPRA data that shifted to the options market. In this section we use the Open/Close Trade Profile obtained from the CBOE and the ISE to investigate how customers and firms used options to change their exposure to underlying financial stocks. Unlike OPRA trade data, these data allow us to track the actual opening and closing of positions. However, they only cover positions initiated and/or closed on the CBOE and the ISE.

We obtain daily records of trading activity for all options traded on the CBOE and on the ISE for August and September 2008. These records, which decompose daily trading volume into four trade types and at least two investor classes, are similar to those used by Pan and Poteshman (2006). The four trade types are "open-buys", "open-sells", "close-buys", and "close-sells". "Open-buys" ("open-sells") are trades that are initiated by buyers (sellers) to open a position and "close-buys" ("close-sells") are trades that are initiated by buyers (sellers) to close a position. The OCC assigns one of three origin codes to each option trade: public customer, firm proprietary trader, or market maker. Our data contains the positions of customers and firm proprietary traders. Pan and Poteshman (2006) note that customer trades include clients of brokers such as E-Trade and Merrill Lynch. The ISE's website also indicates that they include trades placed by institutions and hedge funds. Firm proprietary trades include trades executed on the behalf of an exchange member's own account and on the behalf of another broker dealer that is not a member of the exchange. For our purposes, the primary advantages of these data over the OPRA trade records are that we know whether the initiator of observed volume is opening a new position or closing one that was already outstanding and whether the initiator was a customer or a firm.

Each day, for each customer type, we compute the change in short exposure on these two exchanges separately for options on banned and control stocks as follows:

Change in Short Exposure $_t$ = (Put Open-Buy + Call Open-Sell) - (Put Close-Buy + Call Close-Sell).

We compute Short Exposure separately for October, November, and December expiration options and for customers and firm proprietary traders. Figure 2 contains plots the time series of short exposure by customer type and expiration month. The top two plots contain Short Exposure in October expiration options, the middle two plots contain Short Exposure in November expiration options, and the bottom two plots contain Short Exposure in December expiration options. As can be seen in each of these plots, there appears to be little difference in the aggregate short exposure accumulated by customers trading put options on banned and control stocks. In untabulated results, we obtain similar results when we examine Net Put Buys and Net Put Sells separately. These results are consistent with the conclusions reached from the OPRA trading data – there is little evidence that investors migrated from the equity market to the option market to gain short exposure in stocks subject to the September 19th short sale ban.[9]

V. The Impact of the Short Sale Ban on Bid-Ask Spreads in the Options Market

A. Quoted Spreads

For each option, we compute the National Best Bid and Offer (NBBO) by taking the highest valid bid and the lowest valid offer posted at any of the seven venues currently trading equity options in the United States. Next, we calculate an average percentage spread, *Pct Spread*, each day by taking the average of the NBBO (divided by the midpoint) at the end of each of the 390 minutes of the trading day. A direct comparison of the trading costs for options on banned stocks with options on control stocks is problematic. The financial stocks that fell under the short sale ban were very volatile at the time. In addition, prices of these stocks had fallen dramatically, leaving many put options deep in the money and many call options deep out of the money.

[9]We also examine put exercise as a proportion of open interest. We examine exercise of puts that sell for less than their intrinsic value and find that the short sale ban did not have a differential impact on the ability of investors to exercise puts on financial stocks early.

To see how bid-ask spreads were affected we run the following cross-sectional regression each day from August 1, 2008 through October 21, 2008, with standard errors clustered by underlying stock:

$$Pct\ Spread_i = \alpha_0 + \alpha_1 Banned_i + \alpha_2 \left(S/X\right)_i + \alpha_3 \left(S/X\right)_i^2 + \alpha_4 \left(S/X\right)_i^{1/2} + \alpha_5 ISD_i + \alpha_6 ISD_i^2 + \alpha_7 ISD_i^{1/2} + \alpha_8 \left(S/X\right)_i ISD_i + \alpha_9 Penny_i + \varepsilon_i \quad (1)$$

where $Banned_i$ takes a value of one if option I is on a stock with banned short selling and zero otherwise, $(S/X)_I$ is the average ratio of the stock price to the exercise price computed using the 390 end-of-minute observations on day t, $(S/X)_t^2$ and $(S/X)_t^{1/2}$ are the square and square root of the average value of (S/X) for day t, ISD_i is the mean implied standard deviation for option I on day t calculated from calls with the same exercise price and expiration date, ISD_t^2 and $ISD_t^{1/2}$ are square and square root of the average implied standard deviation for day t, and *Penny* is one if the option is part of the SEC's Penny Pilot and zero otherwise.[10]

Figure 3 plots the daily estimates of the coefficient on Banned from regressions using put options that expired on December 20, 2008 while Table 3 provides a more detailed description of our regression results. Up to September 15th, the coefficients on the banned variable are close to zero. After adjusting for volatility and moneyness, bid-ask spreads for puts on stocks that were later banned are indistinguishable from bid-ask spreads on other stocks. The coefficient jumps to 9% on September 18th when Temporary Rule 204T is put into place. This may reflect the fact that it was more costly to borrow shares of financial stocks. When the short sale ban is enacted on September 19th, the coefficient estimate jumps to 25%. So, if the bid ask spread on a non-financial stock put was 5%, the bid-ask spread on a similar put on a banned stock would be 30% of the price. The short sale ban is in effect until October 8th. The coefficient on the banned dummy variable decreases slowly while the ban is in effect, but remains significantly positive, suggesting that either the short sale ban,

[10] During our sample period, 63 stocks were part of the SEC's Penny Pilot. The tick size for options on these stocks is \$0.01 if the option is worth less than \$3.00 and is \$0.05 if the option has a value of \$3.00 or more. Options on stocks that are not part of the Penny Pilot have a tick size of \$0.05 if the option is worth less than \$3.00 and a tick size of \$0.10 if the option is worth more than \$3.00. Ten of our banned stocks and thirteen of our control stocks are in the Penny Pilot.

Temporary Rule 204T, or both had lingering impacts on the cost of providing liquidity in puts on banned stocks.

Figure 4 plots the daily coefficient estimates for Banned from regressions using call options expiring on December 20, 2008 and Table 4 provides a more detailed description of our regression results. The regressions include all call options with all strike prices that expired in December. As in the put regressions, standard errors are clustered on the underlying stock. Figure 4 reveals that, after adjustment for moneyness and volatility, the percentage spread for calls on banned stocks is about five percent higher than the percentage spread for calls on control stocks between August 1st and September 15th. As is the case with puts, this difference in percentage spreads increases by around 9% on the day that Temporary Rule 204T is put into place. When the short sale ban is instituted on September 19th, the difference in percentage spreads for calls on banned and control stocks is around 28%, which is around 23% higher than it was between August 1st and September 15th. After the short sale ban is lifted on October 8th, the difference in percentage spreads remains higher than it was prior to September 15th. Together, the information in Figures 3 and 4 and in Tables 3 and 4 suggest the short sale ban had similar effects on the relative spreads of puts and calls on financial stocks. The regressions discussed so far use the percentage spread, that is bid-ask spread divided by the average of the bid and ask prices, as the dependent variable. To insure that the changes in spreads are not due to changes in the options prices, we reestimate (1) each day using the dollar bid-ask spread rather than the percentage spread as the dependent variable. Standard errors are clustered by stock. Daily coefficient estimates for the banned variable are plotted in Figure 5 for put and call options with December expirations.

The difference between quoted spreads of options on banned and control stocks is similar for puts and calls. This suggests that option market makers made similar adjustments to put and call bid ask spreads when the short sale ban was instituted. The impact of the short sale ban on quoted spreads is striking. In the six weeks prior to the ban, the coefficient on the banned variable was between \$0.10 and \$0.20. Dollar spreads were a little wider for financial stocks, but not much wider. On September 19th, the first day of the ban, the spread differences jump to over \$1.20. The spread differences remain over \$0.40 for the duration of the ban and then slowly decline toward pre-ban levels.

Regressions using options with other expiration months yield very similar results. It is clear that it became much more expensive to trade either puts or calls when the ban on shorting the underlying stock was implemented. Options market makers routinely hedge their positions by trading the underlying stock. When the ban was announced in the early morning hours of September 19th, shorting by options market makers was to be banned along with other short selling. The CBOE successfully lobbied the SEC to allow market makers to short for hedging purposes at least for September 19th, but it was uncertain if market makers would be able to short in succeeding days. On the morning of that day, there was still some confusion though as to whether the market makers would need to pre-borrow the stock before shorting it. These factors may explain why spreads became so large on September 19th.

Other factors are likely to explain the difference in banned and control stocks after September 19th. First, market makers were still prohibited from transactions that would create an economic short position for an investor. Also, even if options market makers were allowed to hedge with short sales, the market for the underlying stocks was less liquid. A number of institutions, like CALPERS, who had been active participants in the equity lending market stopped lending shares. In additions, Boehmer, Jones, and Zhang (2009) report a sharp increase in bid-ask spreads for financial stocks during the banned period. Even if hedging was still possible, it was more expensive.

We next include the underlying stock spread in our analysis of percentage spreads for December 2008 expiration puts to determine whether the behavior of spreads in the option market can be explained by increased costs of hedging exposure in financial stocks in the underlying equity market. To do this, we first compute the average percentage bid ask spread at the end of each of the 390 minutes in the trading day. Then, we add the average percentage bid ask spread for the underlying stock to equation (1) and estimate this regression each day from August 1, 2008 through October 21, 2008, clustering standard errors by stock. Table 5 contains the results of these regressions.

Comparisons of Tables 3 and 5 reveal that most of the control variables are significant regardless of whether or not the underlying stock's percentage spread is included in the spread regressions. Not surprisingly, the coefficient on the percentage spread of the underlying stock is significant each day. While the coefficient on the variable indicating whether the option was on a banned stock is significantly positive each day from September 16th through October 21st when we do not include the stock's spread in the spread regressions, it is only significant on September 19th when the stock's percentage spread is included. After accounting for the percentage bid ask spreads on the underlying stocks, our results indicate that if the bid ask spread on a non-financial stock put was 5%, the bid-ask spread on a similar put on a banned stock on September 19th would be 21% of the price. We obtain similar results when the relative spread for the underlying stock is included in our analysis of call relative spreads, and when examining relative spreads for puts and calls that expire in other months. These results suggest that the increase in relative spreads for stocks subject to the short sale ban are not solely responsible for the massive increase in relative spreads for options on those stocks on September 19th.

While the short sale ban was relaxed for option market makers on September 22nd, the increased costs of hedging associated with the onset of Temporary Rule 204T remained for options on all stocks – even those for which short sales were permitted. To the extent high relative spreads in the underlying stock are indicative of low rebate rates, this may explain why the banned indicator variable is largely insignificant when the underlying percentage spread is included in our cross sectional regressions. Additionally, the high correlation between the average daily relative bid/ask spread of the underlying stock and the banned indicator variable may explain why the coefficient on the banned indicator variable is only significant on the first day of the short sale ban when we include the underlying stock's relative spread in our regressions. For this reason, we next estimate our modified relative spread regressions with the underlying stock's relative spread included as an explanatory variable for December expiration puts on a minute-by-minute basis each day of our sample period. Since these regressions are run each minute, *(S/X)* is the end of minute ratio of the stock price to the exercise price and ISD is the end of minute implied ISD computed using calls with the same exercise price and expiration date. Standard errors are clustered at the stock level.

Figure 6 plots the coefficient estimates for the banned indicator variable obtained from the 390 minute-by-minute regressions run each day of our sample period. A comparison of Figure 6 with Figure 3, which contains the daily plot of the coefficient estimates for the banned indicator variable obtained from the daily spread regressions for December expiration puts *without* the underlying stock spread as a control variable, reveals striking similarities. Prior to September 17th, the coefficient on the banned indicator variable is largely insignificant for both specifications. On September 18th, the day that Temporary Rule 204T is enacted, the coefficient estimate for the banned indicator variable is 9% in the daily regressions while it ranges from 5% early in the morning to around 20% in the last ten minutes of trading. On September 19th the banned indicator variable's coefficient is 25% in the daily regressions and the average of the 390 coefficients from the minute-by-minute regressions is 29%. A close inspection of Figure 6 reveals that the relative spreads of put options on banned stocks on the mornings of September 23rd and 24th were inflated. This result is likely due to the fact options market participants were confused over the requirements of the short sale ban and Temporary Rule 204T.

After controlling for the underlying stock's relative spread, an inspection of the data used to construct Figure 6 suggests that the relative spreads of December expiration puts on banned stocks were significantly higher than the spreads of December expiration puts on controlled stocks for 99.2% of the 5,460 minutes that the short sale ban was in place. As is the case with the daily put regressions that do not have the underlying stock spread as an explanatory variable, the coefficient on the banned indicator variable largely becomes insignificant at the 95% level after the ban expires. These results suggest the inflated bid ask spreads for options on banned stocks during the short sale ban are not solely attributable to the inflated bid ask spreads of the underlying stocks.

While our cross sectional regression analyses allow us to assess the marginal impact of the events associated with the 2008 short sale ban on bid/ask spreads of banned stocks relative to control stocks, they do not reveal how the short sale ban affected the level of bid ask spreads in the options market. For this reason, we next examine intraday relative quoted spreads for puts on banned and control stocks.

We compute relative quoted spreads for October expiration puts with implied volatilities between 0.7 and 1.0 and with a stock-to-strike price ratio between 80% and 120% by dividing the difference between the National Best Offer and the National Best Bid by the midpoint of the NBBO at the end of each minute. Next, we compute the arithmetic average of the relative spreads at the end of each minute separately for put options on banned and control stocks and plot them for different days or sets of days. These plots are presented in Figure 7.

Intraday relative spreads for puts on banned and control stocks on August 11th, a typical day in August 2008, provide a useful benchmark to evaluate spreads during the short sale ban. Relative spreads are 5% of the NBBO midpoint for puts on both sets of stocks throughout the day on August 11th. While there is little difference in the relative spreads of puts on banned and control stocks on September 17th, intraday relative spreads are elevated to nearly 10% of the option value. This implies that a put with a NBBO midpoint of $1.00 had a bid/ask spread of $0.10. Intraday spreads for puts on banned and control stocks begin to diverge around noon on September 18th, the day that Temporary Rule 204T was enacted. This likely reflects the fact that Temporary Rule 204T had a bigger impact on financial stocks.

The confusion associated with the announcement of the short sale ban at 12:01am on September 19th is clearly evidenced in the plots of intraday relative spreads on that day. Even the spreads of options on control stocks are affected by the announcement of the short sale ban. Conversations with industry participants suggest that spreads of options on stocks that were not subject to the ban increased because of the uncertainty as to whether more emergency orders were yet to come. Relative spreads for puts on banned stocks averaged around 20% throughout the afternoon of September 19th, likely reflecting the uncertainty as to whether option market makers would be allowed to short shares of banned stocks during the remainder of the ban.

The SEC announced at 12:01am on Monday, September 22nd that option market makers would be allowed to short shares of stock in order to hedge positions resulting from normal market making. It is likely, however, that many option market makers were unable to recalibrate their option pricing models to reflect the ability to short shares of banned stocks. This conjecture is consistent with the plots of relative spreads for puts on banned and control stocks on the September 22nd. At the start of trading on September 22nd, relative spreads for puts on banned stocks are around 60% higher than relative spreads for puts on control stocks. By 11am, average relative spreads for puts on banned and control stocks converge, and for the remainder of the trading day relative spreads on banned and control stocks are comparable.

Figure 7 also plots intraday average relative spreads each day from September 22nd through September 26th and the across day average intraday relative spreads for September 29th through October 8th, the last day of the short sale ban. Relative spreads for puts on banned stocks are inflated relative to relative spreads for puts on control stocks in the first half hour of trading each day during the week of September 22nd, which is consistent with the argument that option market makers were confused during this period. With the exception of the first hour of trading, average intraday relative spreads for puts on control stocks average around 10% for the remainder of the ban, which is similar to the average intraday relative spreads for puts on control stocks prior to the SEC's implementation of Temporary Rule 204T on September 17th. Consistent with our regression results, average intraday relative spreads for puts on banned stocks appear to be higher than comparable spreads for puts on control stocks over this time period.

To determine whether the high spreads documented in the OPRA quote data translate into higher effective spreads for investors, we obtain order data from a large options broker. Because we have order data, we know whether the order is a buy or a sell, whether it is a market or a marketable limit order, and perhaps most importantly, when the order was received. This allows us to use the order receipt time (ORT) quotes to compute effective spreads. As a result, we do not have to worry about delays associated with trade reporting during periods of high trading activity.

For buy orders, effective spreads are twice the difference between the trade price and the midpoint of the ORT bid ask spread. For sell orders, effective spreads are twice the difference between the midpoint of the ORT bid ask spread and the trade price. Relative effective spreads are computed by dividing the effective spread by the midpoint of the ORT bid ask spread. Relative quoted spreads are computed by dividing the ORT bid ask spread by the midpoint of the ORT bid ask spread. We compute the contract-weighted ratio of effective-to-realized spread for each option class each day. We then compute the across-class average of these spreads separately for option classes on stocks in which short sales are banned on September 19, 2008 and for option classes on our set of control stocks. We present these averages in Figure 8.

Over the first two weeks of September, the average ratio of relative effective to relative quoted spread for options on banned stocks is around 100%, indicating the average liquidity demanding round-trip trade executed via our broker paid 100% of the quoted bid/ask spread. Liquidity demanding investors seeking to trade options on our control stocks paid 98.4% of the quoted relative bid/ask spread on a round-trip trade over this same interval. On September 18th, the day on which the SEC adopted Temporary Rule 204T, the ratio of effective-to-quoted relative bid/ask spreads grew to 109% for options on banned stocks. On September 19th, this ratio rises to 137% for options on stocks for which short sales were restricted. The ratio remains elevated for options on banned stocks on September 22nd, and then returns to an average of 99.8% for the remainder of the month. Excluding September 19th, the ratio of effective-to-quoted spreads for options on control stocks averaged 97.8%. Overall, the statistics presented in Figure 8 suggest that if anything, our analysis of quoted spreads understates the impact of the short sale ban on investors seeking to trade options on banned stocks during the short sale ban.

To summarize, the SEC's actions had a dramatic impact on quoted spreads in the options market. While the impact is most severe for options on banned stocks, other options are also affected. For a put option with a value of $1.00, the failure to include an option market maker exemption for the entirety of the short sale ban in the initial order caused quoted spreads for put options on banned stocks with a December 2008 expiration to be $0.25 wider than the quoted spreads for put options on control stocks. Data obtained from a retail broker suggest that investors were lucky if they paid the quoted spread on September 19th, suggesting that our analysis understates the cost of the short sale ban on liquidity demanding investors. Our analysis of intraday spreads suggests that confusion over the requirements of Temporary Rule 204T and the short sale ban led to inflated relative spreads, especially during the first hour of trading. Overall, our analysis suggests that the inflated spreads in the option market were not solely attributable to the elevated bid ask spreads of banned stocks. Rather, they likely are the result of regulatory uncertainty and increases in the cost of shorting shares brought on by Temporary Rule 204T.

VI. Biases in Prices Arising from the Short Sale Ban

We next examine the impact of the ban on the difference in prices of synthetic shares created from options and the price of the underlying shares. There are two reasons why the price of synthetic shares may fall relative to the price of actual shares. First, the stock may be overpriced if the short sale ban results in stock prices held to artificially high levels. Harris, Namvar, and Phillips (2009) provide evidence that suggests that prices were held artificially high for stocks that were included in the short sale ban. Second, synthetic share prices may have fallen as the result of option market makers' inability to hedge. A synthetic short position in a stock is created by writing a call and buying a put. If market makers were unable to hedge investors' sales of calls by shorting stock, they may decrease the price they pay for calls to reflect the risks that they are taking. Similarly, if market makers were unable to hedge investors' purchases of puts by shorting stock, they might increase the price of puts to reflect these risks. Either or both of an increase in put prices or a decrease in call prices would mean a fall in synthetic share prices.

We calculate synthetic buy and sell prices at the end of each minute of each day during the sample period using all pairs of call and put options with the same exercise price and expiration date. The cost to buy a share of stock synthetically is

$$Synthetic\ Stock^{Ask} = C^{Ask} + e^{-rT}X - P^{Bid} + EEP + \sum_{j=1}^{J} e^{-rt_j} D_j \quad (2)$$

where C^{ask} is the ask price of a call, r is the riskless rate, T is the time to expiration for the call and put, X is the exercise price, P^{Bid} is the bid price of a put with the same exercise price and expiration date as the call, EEP is the early exercise premium in the put price, t_j is the time until the stock pays its jth dividend before the option expires, and D_j is the amount of the jth dividend. We approximate the dividends expected to be paid over the life of the option with the actual dividends from CRSP for 2008, and with the previous quarter's dividend for 2009. The early exercise premium for the put is calculated as in Barone-Adesi and Whaley (1987).

Similarly, the proceeds to be received from selling a share synthetically are given by

$$Synthetic\ Stock^{Bid} = C^{Bid} + e^{-rT}X - P^{Ask} + EEP + \sum_{j=1}^{J} e^{-rt_j} D_j \quad (3)$$

To examine biases in option prices we compare the average of the synthetic bid and ask with the bid-ask midpoint of the underlying stock. For every day from August 1, 2008 through October 17, 2008, we calculate the mean difference between the synthetic bid-ask midpoint and the actual stock bid-ask midpoint using all options expiring in October 2008, clustering standard errors by the underlying stock. In order to minimize the impact of data errors, we discard all instances when the difference between synthetic and actual bid ask midpoints is \$2 or more in absolute value. The daily mean differences for banned stocks are plotted in Panel A of Figure 9 while the daily mean differences for control stocks are plotted in Panel B of Figure 9. Prior to the introduction of Temporary Rule 204T and short sale ban, the mean difference between the synthetic bid-ask midpoint and the actual midpoint is close to zero for banned and control stocks. When Temporary Rule 204T is enacted on September 18th, the synthetically implied midpoint is, on average, \$0.05 per share lower than the actual midpoint. With the advent of the short sale ban on September 19th, the difference falls sharply to -\$0.37 for options on banned stocks. That is, synthetic shares of stock were priced an average of \$0.37 lower than the shares themselves. For control stocks, the difference only falls to -\$0.08. The price discrepancy between the synthetic and actual stock bid-ask midpoint of banned stocks declines steadily but remains statistically negative until the short sale ban ended. This is not surprising, since the only day during the ban on which option investors could legally purchase short exposure was September 19th. The relationship between the synthetic and actual stock bid-ask midpoint of control stocks returns to parity on September 22nd, where it more or less remains for the remainder of the short sale ban.

Figure 10 is similar to Figure 9, but presents average price differences between the prices of synthetic and actual shares using options that expire in December. Here again, the price of synthetic shares is very close to the price of actual shares before the short sale ban for control and banned stocks. When the ban is initiated, prices of synthetic shares of banned stock fall sharply relative to actual share prices. On September 19th, synthetic prices average about \$0.36 less than actual prices. This difference is narrowed, but remains significantly negative for the duration of the short selling ban.

Given the potential differences in the characteristics of banned and control stocks, we run the following cross-sectional regression each day of our sample period using October and December expiration options create synthetically implied stock midpoints:

$$Bias_i = \alpha_0 + \alpha_1 Banned_i + \alpha_2 \left(S/X\right)_i + \alpha_3 \left(S/X\right)_i^2 + \alpha_4 \left(S/X\right)_i^{1/2}$$
$$+\alpha_5 ISD_i + \alpha_6 ISD_i^2 + \alpha_7 ISD_i^{1/2} + \alpha_8 \left(S/X\right)_i ISD_i + \alpha_9 Penny_i + \varepsilon_i \quad (4)$$

where $Bias_i$ is the average difference in the midpoints of the synthetically implied and the underlying stock's actual bid ask spread computed using the 390 end-of-minute observations on day t that are not greater than \$2.00 in absolute value and the remaining explanatory variables are identical to those used in the daily spread regressions. Standard errors are clustered by stock.

Table 6 contains the results for the regressions that use October 2008 expiration options to create synthetic bid ask spread midpoints and Table 7 contains the results for the regressions that use December 2008 expiration options. Panel A of Table 6 and Table 7 suggest that the differences in bias for banned and control stocks are not statistically different from one another at the 1% level on most days prior to September 18th. On September 18th, the bias for banned stocks computed using October 2008 expiration options becomes about \$0.077 lower than the bias for control stocks. As suggested by the plots in Figure 9, this divergence in bias is largely driven by the fact that the synthetically implied bid ask spread midpoint for banned stocks falls relative to the actual bid ask spread midpoint. The difference in the bias computed using December 2008 expiration options for banned and control stocks on September 18th is not statistically significant at the 1% level. Consistent with the evidence presented in Figures 9 and 10, the difference between the bias for banned and control stocks is statistically different at the 1% level for the entire short sale ban (see Panels B and C of Tables 6 and 7). After the ban ends, there are few days on which the bias for banned and control stocks are statistically different from one another at the 1% level.

Differences between synthetic and actual stock prices during the shorting ban do not provide arbitrage opportunities. Inability to short makes it impossible to directly arbitrage between stock and option markets. In addition, even if shares could be shorted, recall that bid-ask spreads were wide for both stocks and options during the ban. Finally, misestimating the early exercise premia or failing to properly account for the cost of shorting stock may create the appearance of arbitrage opportunities where none actually exist. It is possible, however, that price discrepancies that would have allowed apparent arbitrage opportunities in the absence of short sale restrictions became more frequent with the short sale ban.

We examine two types of potential arbitrages. The first is when a synthetic share of stock could be sold for more than it would cost to buy an actual share. That is,

$$Synthetic\ Stock^{Bid} = C^{Bid} + e^{-rT}X - P^{Ask} + EEP + \sum_{j=1}^{J} e^{-rt_j} D_j > S^{Ask} \quad (5)$$

The second type of arbitrage opportunity is when a synthetic share of stock could be purchased for a lower price than would be received if an actual share of stock was sold at the bid price. Or,

$$Synthetic\ Stock^{Ask} = C^{Ask} + e^{-rT}X - P^{Bid} + EEP + \sum_{j=1}^{J} e^{-rt_j} D_j < S^{Bid} \quad (6)$$

For each minute of every day during the sample period, we calculate synthetic bid and ask prices for each pair of put and call options with the same strike price and expiration date using all expiration dates. We then count the number of each type of apparent arbitrage opportunity for each option pair each day. Figure 11 provides a plot of the average percentage of minutes each day that banned and control stocks have share prices and option prices that create apparent arbitrage opportunities of at least \$0.05 (two figures on the left) and at least \$0.10 (two figures on the right).

The graph on the upper left hand corner (upper right hand corner) of Figure 11 plots the percentage of end-of-minute stock and option quotes that imply that an investor could have sold an actual share of stock and purchased a synthetic share of stock and earned at least \$0.05 per share (\$0.10 per share) for both banned and control stocks. There is very little difference in these two plots, suggesting that most apparent buy synthetic/sell actual arbitrage opportunities generated at least \$0.10 per share in profit.

Prior to September 12th, the daily percentage of end-of-minute quotes creating apparent arbitrage opportunities generating at least \$0.05 per share is around 4%. On September 19th, the prevalence of apparent buy synthetic/sell actual arbitrage opportunities jumps to around 6.5% for banned stocks and is around 2.3% for control stocks. Apparent buy synthetic/sell actual arbitrage opportunities generating at least \$0.05 per share remain more prevalent in banned stocks until September 29th, after which there is little difference. The elevation of apparent buy synthetic/sell actual arbitrage opportunities for banned stocks during the initial portion of the short sale ban is consistent with the argument that the inability of investors to short shares of banned stocks led to inflated bid prices for shares of those stocks.

The graph on the lower left hand corner of Figure 11 plots the percentage of end-of-minute stock and option quotes that imply that an investor could have purchased an actual share of stock and sold a synthetic share of stock and earned at least \$0.05 per share for both banned and control stocks. As is the case with the apparent buy synthetic/sell actual arbitrage opportunities, around 4% of the end-of-minute stock and option quotes imply apparent sell synthetic/buy actual arbitrage opportunities for both banned and control stocks. Beginning on September 11th, apparent sell synthetic/buy actual arbitrage opportunities become more prevalent in control stocks. Indeed, on September 17th, 7% of the intraday stock and option quotes for control stocks imply this type of apparent arbitrage, versus 4% for banned stocks. The graph on the lower right hand corner of Figure 11 suggests that apparent sell synthetic/buy actual arbitrages were more prevalent for control stocks throughout the short sale ban. This likely reflects the fact that the bid ask spreads of options on and shares of banned stocks were inflated during the short sale ban. While the magnitude of the differences is lower, similar conclusions are reached when our analysis is restricted to apparent sell synthetic/buy actual arbitrages generating at least \$0.10 per share.

Differences in arbitrage opportunities for control and banned stocks may reflect differences in volatility and moneyness. Hence, each day we estimate the following Probit model to examine the marginal impact of the short sale ban on the frequency of apparent arbitrage opportunities:

$$Pct\ Arb_t = \alpha_0 + \alpha_1 Banned + \alpha_2 \left(S/X\right)_t + \alpha_3 \left(S/X\right)_t^2 + \alpha_4 \left(S/X\right)_t^{1/2} + \alpha_5 ISD_t + \alpha_6 ISD_t^2 + \alpha_7 ISD_t^{1/2} + \alpha_8 \left(S/X\right)_t ISD_t + \alpha_9 Penny_t + \varepsilon_t \quad (7)$$

where $Pct\ Arb_t$ is the proportion of minutes during day t where an arbitrage bound is violated and the remaining explanatory variables are identical to those used in the daily spread regressions. Standard errors are clustered by stock. The regressions are run separately for the percentage of minutes where the synthetic bid exceeds the actual ask, and for the percentage of minutes where the synthetic ask is less than the actual bid.

Table 8 reports probit estimates for October expiration options when the dependent variable is the percentage of minutes that the synthetic bid price exceeds the actual ask price. We restrict the sample to option pairs where $0.8 < S/X < 1.2$. Our main concern in these regressions is the sign and significance of the banned variable. Prior to the shorting ban, it is typically slightly negative but insignificant. From September 19th, the day the ban is initiated, until September 26th, $Banned_t$ is significantly negative at the 1% level each day. Banned stocks were less likely to present arbitrage opportunities that involves buying the stock and shorting synthetically than were controls stocks.

Table 9 reports estimates of probit regressions where the dependent variable is the proportion of minutes in the day where the synthetic ask is less than the actual bid price. This table again reports results when the sample is option pairs that expire in October and for which $0.8 < S/X < 1.2$ In this table we see that for days before the ban, the coefficient on $Banned_t$ was statistically insignificant. For days after the ban is initiated, the coefficient on $Banned_t$ is positive and significant. All else equal, arbitrage opportunities that involved buying shares synthetically and selling short actual shares became more common for banned stocks than others.

This is not surprising. Banned stocks couldn't be sold short, so arbitrage opportunities that required a short sale of the actual shares could not be exploited. Following the short sale ban, inability to arbitrage loosened the normally tight connections between option and stock prices and allowed stocks to float to higher prices than options.

Table 10 repeats the analysis of Table 8 with options that expire in December. Here again we see that the likelihood of a synthetic bid price exceeding an actual ask price was not significantly different for banned stocks than others before the ban. For days after the ban was initiated, the coefficient on $Banned_t$ is consistently negative and significant. With the imposition of the ban, the probability that synthetic bid prices exceeded actual ask prices declined significantly.

Table 11 is similar to Table 9, but reports probit regressions for December options when the dependent variable is the proportion of minutes where the actual bid price exceeds the synthetic ask. As with October options, $Banned_t$ is positive and significant after the short sale ban takes effect. Again, the effect of the ban is to allow stock prices to become high relative to options prices. Arbitrage requires selling stock when the stock is overpriced, hence it cannot bring prices into line after the short sale ban.

Some caution should be used in drawing inferences from these results. Even in the absence of short sale restrictions, it is not clear if these seeming arbitrage opportunities could be exploited in practice. We considered any case where the synthetic ask (bid) was less (greater) than the actual bid (ask) to be an arbitrage opportunity regardless of the size of the difference. In some cases commissions would wipe out any arbitrage profits. In other cases, even short delays in executing either trade could eliminate any gains. Finally, even though dividends and the early exercise premium are typically small, errors in estimation of either of these components of the synthetic price could make it appear that there were arbitrage opportunities when none existed.

Nevertheless, the arbitrage results are strikingly clear. When short sales were banned, arbitrage opportunities that involved buying synthetic shares and selling actual shares increased. Option and share prices had become uncoupled.

VII. Conclusions.

Confusion generated by the directive banning short selling in 797 financial stocks announced in the early hours of September 19th and over the requirements of Temporary Rule 204T had severe ramifications for equity option markets. First, trading costs for options increased sharply when the ban was initiated. This made options trading less attractive to investors who were attempting to lay off risk or to speculate on a rebound in bank stock prices. Second, a bias in relative prices of options and stock appeared with the ban. Synthetic shares of stock became cheap relative to the actual shares. This could be because stock prices were to high, or because it was more difficult for market makers to hedge customers' long positions in puts or short positions in calls and they therefore increased ask prices of puts and lowered bid prices of calls. Third, the short sale ban increased the number of apparent arbitrage opportunities that involve buying synthetic shares and shorting actual shares.

We draw two larger lessons from our study of the short sale ban. First, options market makers need to be able to hedge. If they cannot hedge easily and cheaply, trading costs in options markets increase dramatically and option and stock prices decouple. Second, financial regulators need to be shielded from political pressures. The SEC came under tremendous pressure from politicians to ban short selling in September 2008. The result was a hastily-crafted, ill-conceived rule that sowed chaos in the options and equity markets and injected regulatory uncertainty that still lingers in these markets.

References

Barone-Adesi, Giovanni, and Robert Whaley, 1987, Efficient Analytic Approximation of American Option Values, Journal of Finance 42, 301-320.

Battalio, Robert, and Paul Schultz, 2006, Options and the Bubble, Journal of Finance 61, 2071-2102.

Boehmer, Ekkehart, Charles Jones, and Xiaoyan Zhang, 2009, Shackling Short Sellers: The 2008 Shorting Ban, Working paper, Columbia Business School.

Bris, Arturo, William Goetzmann, and Ning Zhu, 2007, Efficiency and the Bear: Short Sales and Markets Around the World, Journal of Finance 62, 1029-1079.

CBOE Regulatory Circular RG08-117, September 24, 2008.

CBOE Regulatory Circular RG08-118, September 25, 2008.

Comment letter from Options Exchanges to Florence E. Harmon, Acting Secretary, SEC, December 19, 2008.

Davies, Ryan, and Sang Soo Kim, 2009, Using Matched Samples to Test for Differences in Trade Execution Costs, Journal of Financial Markets 12, 173-202.

Dechow, Patricia, Amy Hutton, Lisa Meulbroek, and Richard Sloan, 2001, Short-Sellers, Fundamental Analysis and Stock Returns, Journal of Financial Economics 61, 77-106.

Diamond, W.D. and D. Verrecchia, 1987, Constraints on Short-Selling and Asset Price Adjustment to Private Information, Journal of Financial Economics 18, 277-311.

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

Division of Trading and Markets: Guidance Regarding the Commission's Emergency Order Concerning Rules to Protect Investors against "Naked" Short Selling Abuses, http://www.sec.gov/divisions/marketreg/204tfaq.htm, September 23, 2008.

Figlewski, Stephen, 1981, The Informational Effects of Restrictions on Short Sales: Some Empirical Evidence, Journal of Financial and Quantitative Analysis 16, 463-476.

Figlewski, Stephen, and Gwendolyn Webb, 1993, Options, Short Sales, and Market Completeness, Journal of Finance 48, 761-777.

Frankel, Doris, October 7, 2008, RPT-Short-Sale Ban Worries U.S. Options Markets, Reuters News.

Gagnon, Louis, and Jonathan Winter, 2008, Short Changed? The Market's Reaction to the Short Sale Ban of 2008, Working paper, Queen's University.

References (continued)

GAO Report to Congressional Requestors, May 2009, Regulation SHO – Recent Actions Appear to Have Initially Reduced Failures to Deliver, but More Industry Guidance is Needed, GAO-09-483.

Gurliacci, Mark, David Jeria, and George Sofianos, October 14, 2008, The Short-Sell Ban and Quoted Spreads, Street Smart 34.

Harris, Lawrence, Ethan Namvar, and Blake Phillips, 2009, Price Inflation and Wealth Transfer During the 2008 SEC Short-Sale Ban, Working paper, University of Southern California.

Jones, Charles, 2008, Shorting Restrictions: Revisiting the 1930s, Columbia University Working Paper.

Jones, Charles, and Owen Lamont, 2002, Short Sale Constraints and Stock Returns, Journal of Financial Economics 66, 207-239.

Kolasinksi, Adam, Adam Reed, and Jacob Thornock, 2009, Prohibitions versus Constraints: The 2008 Short Sales Regulations, University of North Carolina working paper.

Mehta, Nina, September 19, 2008, SEC's Visible Hand Controls Market, Traders Magazine Online News.

Mehta, Nina, September 22, 2008, Options Market Makers get Relief from SEC Ban on Short-Selling, Traders Magazine Online News.

Miller, Edward, 1977, Risk, Uncertainty, and Divergence of Opinion, Journal of Finance 32, 1151-1168.

Ofek, Eli, and Matthew Richardson, 2003, DotCom Mania: The Rise and Fall of Internet Stock Prices, Journal of Finance 58, 1113-1138.

Office of Economic Analysis Memorandum, January 14, 2009, Analysis of the July Emergency Order Requiring a Pre-Borrow on Short Sales, http://www.sec.gov/spotlight/shortsales/oeamemo011409.pdf.

Pan, Jun, and Allen Poteshman, 2006, The Information in Option Volume for Future Stock Prices, Review of Financial Studies 19, 871-908.

SEC, September 18, 2008, Emergency Order Pursuant to Section 12(k)(2) of the Securities Exchange Act of 1934 Taking Temporary Action to Respond to Market Developments, Release 34-58572.

SEC, September 19, 2008, Emergency Order Pursuant to Section 12(k)(2) of the Securities Exchange Act of 1934 Taking Temporary Action to Respond to Market Developments, Release 34-58592.

SEC, October 17, 2008, Amendments to Regulation SHO, Release 34-58773.

Table 1. Relevant regulatory events and clarifications.

Date	Event	How action impacted option market participants
September 18th	Adopted temporary Rule 204T	• If a broker dealer fails to deliver shares within three days of a trade, its clearing firm and any broker dealer and/or option market maker for which it clears must pre-borrow shares before entering into a short sale. This penalty remains in effect until trade is settled. Temporary Rule 204T was made permanent on October 17, 2008 (see SEC Release 34-58773).
September 19th	Short sale ban	• Option market makers only allowed to sell short pursuant to bona fide market making and hedging activities until 11:59pm on September 19th.
September 22nd	Extension of option market maker exemption	• Option market makers allowed to sell short pursuant to bona fide market making and hedging for the remainder of the short sale ban.
September 23rd	SEC clarification of Rule 204T	• Only the firm that fails to deliver shares must pre-borrow shares if it fails to deliver shorted shares within three days of a trade. • Firms do not have to cover their short position exactly three days after a transaction – they can do this anytime during the three days after the transaction. • Market makers failing to deliver must provide a document attesting that the failure to deliver position was established while performing bona fide market making obligations.
September 24th	SEC clarification of Rule 204T	• Option market makers must now close out their short positions within five days of a trade. • Confirmation that option market makers could short shares even when another member of its clearing agency had failed to deliver.
October 8th	Short sale ban ends	

Table 2. Summary Statistics.

Panel A. Distribution of the price and market capitalization for the 330 stocks with exchange traded options that came under the initial short sale ban banned stocks on July 31, 2008 and their matching control stocks.

	Price		Market Capitalization ($ Millions)	
	330 Banned Stocks	330 Control Stocks	330 Banned Stocks	330 Control Stocks
Mean	$30.76	$30.76	8,727	8,716
25th Percentile	$12.69	$12.77	818	1.177
Median	$23.75	$22.00	2,314	2,948
75th Percentile	$39.38	$38.28	5,763	6,721

Panel B. The distribution across days from August 1, 2008 through October 21, 2008 of the number of options quoted on banned and control stocks.

	Banned Stocks			Control Stocks		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
All Options	29,678	27,434	34,088	32,619	30,540	38,072
August Exp.	4,875	4,600	4,920	5,287	5,026	5,338
September Exp.	5,194	4,776	5,388	5,885	5,558	6,080
October Exp.	4,653	2,368	5,984	4,812	2,174	6,310
November Exp.	2,651	1,036	5,678	3,165	1,514	6,344
December Exp.	2,622	2,248	4,846	2,996	2,678	6,118
Expire After 2008	15,919	12,422	21,156	17,262	13,580	23,732
S/X < 0.8	11,572	8,107	20,930	13,232	9,530	23,254
0.8 < S/X < 1.2	9,663	7,084	10,286	12,295	8,482	13,362
1.2 < S/X	8,443	4,660	12,712	7,091	3,650	9,054

Table 2 (continued)

Panel C. Average daily trading volume.

	Banned			Control		
	Puts (contracts)	Calls (contracts)	Stock (shares)	Puts (contracts)	Calls (contracts)	Stock (shares)
August	1,060,620	1,182,536	1,131,035,112	1,022,102	1,010,101	1,399,967,568
September	1,360,579	1,251,039	1,561,408,951	1,706,065	1,509,402	2,528,752,454
October	1,448,395	1,306,088	1,829,735,132	1,486,937	1,400,710	2,256,674,540

Notes. Banned includes the 330 optionable stocks for which short selling is banned on September 19th, 2008. Control refers to the set of optionable stocks not subject to the short sale ban that we match to the set of banned stocks. Our daily OPRA files containing data for August 14th and August 26th are corrupt so we have no data for these days. Our sample period ends on October 21, 2008.

Table 3
Daily percentage spread regressions for December 2008 expiration puts

Panel A. August 1, 2008 through September 19, 2008.

	20080801 - 20080912								
	Min	Median	Max	Days p≤0.01	915	916	917	918	919
Constant	-137.79%	-122.20%	-93.59%	28	-126.59%	-100.70%	-122.46%	-72.12%	46.23%
S/X	96.91%	125.67%	145.20%	28	148.02%	134.22%	135.66%	105.10%	66.37%
$(S/X)^2$	-11.89%	-9.45%	-5.12%	28	-8.72%	-9.49%	-4.37%	-6.37%	-5.13%
$(S/X)^{-1}$	28.50%	39.77%	47.45%	28	42.02%	32.09%	36.68%	24.34%	38.05%
ISD	-51.82%	-19.20%	11.16%	13	-32.50%	-41.26%	-20.76%	-10.81%	-9.62%
ISD^2	-7.83%	6.89%	22.53%	6	17.74%	19.67%	15.36%	-3.14%	1.56%
$(ISD)^{-1}$	-0.02%	0.01%	0.17%	10	0.04%	0.02%	0.03%	0.01%	0.03%
(S/X)(ISD)	-14.54%	-8.01%	1.42%	14	-22.32%	-16.18%	-31.22%	-11.73%	-2.12%
Put Price	-0.56%	-0.29%	-0.11%	17	-0.68%	-0.67%	-0.64%	-1.27%	-1.46%
$(\text{Put Price})^2$	0.00%	0.00%	0.00%	15	0.00%	0.00%	0.00%	0.01%	0.01%
Penny	-22.64%	-17.19%	-12.80%	28	-25.64%	-22.67%	-24.98%	-25.34%	-47.31%
Banned	-1.48%	0.51%	3.04%	0	3.88%	6.06%	5.23%	9.26%	24.44%
R^2	45.10%	51.05%	53.78%		51.16%	51.23%	48.14%	48.95%	55.05%
N	1,798	1,874	1,918		1,811	1,829	1,790	1,814	1,878

Notes: Shading indicates variable has a p-value that is less than 0.01.

Table 3 (continued)
Daily percentage spread regressions for December 2008 expiration puts

Panel B. September 22, 2008 through October 3, 2008.

	922	923	924	925	926	929	930	1001	1002	1003
Constant	-35.00%	-15.68%	-41.17%	-55.81%	-42.94%	-41.06%	-53.39%	-42.92%	-39.03%	-45.02%
S/X	99.75%	78.72%	94.73%	97.67%	97.29%	105.52%	108.61%	95.43%	92.93%	101.42%
$(S/X)^2$	-6.84%	-5.41%	-6.62%	-6.89%	-7.16%	-6.48%	-6.42%	-6.21%	-4.76%	-5.58%
$(S/X)^{-1}$	-2.88%	-5.57%	9.27%	16.65%	7.76%	14.17%	18.64%	14.73%	13.85%	16.09%
ISD	-11.21%	-24.41%	-28.33%	-29.28%	-25.08%	-35.99%	-44.49%	-35.40%	-36.58%	-42.49%
ISD^2	4.67%	3.48%	6.72%	6.98%	6.98%	10.19%	13.84%	10.04%	9.04%	9.83%
$(ISD)^{-1}$	0.02%	0.00%	0.02%	-0.01%	0.02%	-0.04%	-0.03%	-0.02%	-0.02%	0.02%
(S/X)(ISD)	-9.57%	-1.42%	-4.75%	-5.36%	-7.12%	-10.43%	-13.67%	-11.25%	-10.00%	-10.35%
Put Price	-0.85%	-0.80%	-1.22%	-1.00%	-1.18%	-1.46%	-0.95%	-1.04%	-0.77%	-0.71%
$(\text{Put Price})^2$	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.00%	0.00%
Penny	-42.10%	-38.66%	-35.38%	-31.19%	-34.16%	-39.71%	-33.06%	-29.00%	-31.67%	-31.37%
Banned	13.43%	12.27%	10.56%	9.72%	10.69%	13.32%	10.24%	9.29%	8.59%	9.37%
R^2	49.60%	46.69%	47.47%	48.72%	49.96%	53.15%	51.99%	48.21%	48.48%	51.02%
N	1,900	1,894	1,879	1,882	1,810	1,808	1,778	1,803	1,822	1,787

Notes: Shading indicates variable has a p-value that is less than 0.01.

Table 3 (continued)
Daily percentage spread regressions for December 2008 expiration puts

Panel C. October 6, 2008 through October 21, 2008.

				20081009 - 20081021			
	1006	1007	1008	Min	Median	Max	Days p≤0.01
Constant	-62.26%	-75.44%	-53.72%	-101.31%	-54.83%	-39.08%	9
S/X	114.38%	117.65%	99.41%	94.11%	97.26%	131.34%	9
$(S/X)^2$	-5.28%	-7.77%	-4.76%	-11.47%	-5.96%	-3.48%	9
$(S/X)^{-1}$	28.11%	31.98%	21.86%	15.45%	22.16%	35.24%	9
ISD	-44.68%	-42.87%	-27.51%	-37.56%	-25.88%	-19.47%	9
ISD^2	12.35%	9.22%	7.20%	3.38%	6.39%	11.29%	0
$(ISD)^{-1}$	-0.03%	-0.04%	0.00%	0.04%	-0.01%	0.04%	7
(S/X)(ISD)	-16.20%	-9.43%	-14.82%	-17.61%	-12.01%	-0.72%	9
Put Price	-0.79%	-0.77%	-0.81%	-0.97%	-0.69%	-0.44%	9
$(Put Price)^2$	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	9
Penny	-27.01%	-25.53%	-21.61%	-28.64%	-21.86%	-18.03%	5
Banned	7.43%	9.20	7.62%	1.96%	4.11%	5.92%	9
R^2	51.90%	51.92%	51.87%	44.26%	47.14%	49.64%	
N	1,744	1,760	1,728	1,657	1,815	3,622	

Notes: Shading indicates variable has a p-value that is less than 0.01.

Table 3 (continued)

Daily percentage spread regressions for December 2008 expiration puts

Notes. For each put option I expiring on December 20, 2008, we compute the National Best Bid and Offer (NBBO) by taking the highest valid bid and the lowest valid offer posted at one of the seven venues currently trading equity options in the United States. Next, we calculate an average percentage spread, $Pct\ Spread_i$, each day by taking the average of the NBBO (divided by the midpoint) at the end of each minute of the day. We run the following cross-sectional regression each day from August 1, 2008 through October 21, 2008, with standard errors clustered by underlying stock:

$$Pct\ Spread = \alpha_0 + \alpha_1 Banned_i + \alpha_2 \left(S/X\right)_i + \alpha_3 \left(S/X\right)_i^2 + \alpha_4 \left(S/X\right)_i^{1/2} + \alpha_5 ISD_i + \alpha_6 ISD_i^2 + \alpha_7 ISD_i^{1/2} + \alpha_8 \left(S/X\right)_i ISD + \alpha_9 Penny_i + \varepsilon_i$$

where $Banned_i$ takes a value of one if option I is on a stock with banned short selling and zero otherwise, $(S/X)_I$ is the ratio of the stock price to the exercise price over the 390 end-of-minute observations on day t, $(S/X)_t^2$ and $(S/X)_t^{1/2}$ are the square and square root of the average value of (S/X) for day t, ISD_i is the mean implied standard deviation for option I on day t calculated from calls with the same exercise price and expiration date, ISD_t^2 and $ISD_t^{1/2}$ are square and square root of the average implied standard deviation for day t, and *Penny* is one if the option is part of the SEC's Penny Pilot and zero otherwise. The regressions examine the spreads of options on the 330 optionable stocks for which short selling is banned on September 19th, 2008 and options on a set of stocks not subject to the short sale ban that we match to the set of banned stocks. Our daily OPRA files containing data for August 14th and August 26th are corrupt so we have no data for these days. Shading indicates variable has a p-value that is less than 0.01.

Table 4
Daily percentage spread regressions for December 2008 expiration calls

Panel A. August 1, 2008 through September 19, 2008.

	20080801 - 20080912								
	Min	Median	Max	Days p≤0.01	915	916	917	918	919
Constant	-105.46%	-70.95%	68.76%	24	-60.88%	-43.65%	-56.21%	-4.76%	-19.55%
S/X	6.54%	41.89%	81.93%	25	47.55%	44.46%	55.22%	25.46%	20.84%
$(S/X)^2$	-15.04%	-3.97%	-2.00%	28	-4.00%	-3.83%	-3.19%	-2.21%	-2.37%
$(S/X)^{-1}$	52.49%	82.86%	102.32%	28	88.92%	91.06%	92.43%	79.30%	96.04%
ISD	-129.28%	-74.23%	-47.40%	28	-96.34%	-133.60%	-118.46%	-141.82%	-101.06%
ISD^2	4.71%	20.585	36.11%	25	31.52%	47.54%	45.90%	49.17%	23.61%
$(ISD)^{-1}$	0.00%	0.09%.	0.26%	22	0.12%	0.06%	0.01%	0.02%	0.07%
(S/X)(ISD)	1.98%	8.77%	93.81%	16	2.30%	2.02%	-6.50%	5.69%	13.22%
Call Price	-7.57%	-0.98%	-0.69%	28	-1.17%	-1.20%	-1.17%	-1.76%	-1.94%
$(\text{Call Price})^2$	0.01%	0.01%	0.03%	28	0.01%	0.01%	0.01%	0.02%	0.01%
Penny	-22.85%	-17.50%	-13.84%	28	-21.73%	-20.48%	-22.23%	-25.00%	-34.25%
Banned	2.47%	6.22%	8.30%	27	7.34%	10.58%	8.90%	14.84%	28.45%
R^2	41.23%	48.15%	56.98%		49.42%	59.78%	50.67%	58.66%	60.19%
N	1,798	1,877	1,918		1,811	1,829	1,790	1,814	1,878

Notes: Shading indicates variable has a p-value that is less than 0.01.

Table 4 (continued)
Daily percentage spread regressions for December 2008 expiration calls

Panel B. September 22, 2008 through October 3, 2008.

	922	923	924	925	926	929	930	1001	1002	1003
Constant	-29.51%	-37.00%	-48.20%	-46.99%	-37.03%	-6.13%	-16.40%	-14.22%	-15.32%	-1.66%
S/X	31.45%	27.65%	32.87%	30.11%	22.87%	29.17%	23.98%	18.25%	31.92%	32.02%
$(S/X)^2$	-2.37%	-2.44%	-2.70%	-2.72%	-1.99%	-2.82%	-2.97%	-2.44%	-4.31%	-3.15%
$(S/X)^{-1}$	78.24%	87.58%	91.90%	92.50%	88.08%	80.61%	84.97%	82.27%	83.12%	72.92%
ISD	-73.99%	-93.45%	-85.55%	-92.50%	-88.29%	-112.25%	-112.51%	-108.45%	-124.99%	-116.39%
ISD^2	19.50%	20.82%	19.68%	21.39%	19.64%	25.21%	23.60%	22.64%	26.83%	27.70%
$(ISD)^{-1}$	0.11%	0.12%	0.13%	0.08%	0.02%	0.07%	0.09%	0.07%	0.08%	0.03%
(S/X)(ISD)	2.97%	7.48%	4.79%	7.79%	9.37%	7.30%	11.77%	14.96%	13.02%	6.15%
Call Price	-3.46%	-1.24%	-1.16%	-1.09%	-1.11%	-1.78%	-1.29%	-1.19%	-1.24%	-2.82%
$(\text{Call Price})^2$	0.05%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.05%
Penny	-27.40%	-26.57%	-24.65%	-25.84%	-29.12%	-36.67%	-27.60%	-31.98%	-19.19%	-31.20%
Banned	22.56%	20.02%	16.48%	15.22%	17.47%	19.28%	15.60%	15.68%	15.38%	17.97%
R^2	54.03%	56.27%	53.56%	52.58%	48.49%	57.65%	56.09%	53.29%	56.25%	58.49%
N	1,900	1,894	1,879	1,883	1,810	1,808	1,778	1,803	1,822	1,787

Notes: Shading indicates variable has a p-value that is less than 0.01.

Table 4 (continued)
Daily percentage spread regressions for December 2008 expiration calls

Panel C. October 6, 2008 through October 21, 2008.

	1006	1007	1008	20081009 - 20081021 Min	Median	Max	Days p≤0.01
Constant	24.77%	15.11%	52.22%	-33.52%	28.22%	94.57%	7
S/X	27.94%	21.29%	4.61%	-4.45%	12.96%	31.56%	4
$(S/X)^2$	-3.55%	-2.19%	-1.76%	-6.15%	-3.19%	-1.78%	8
$(S/X)^{-1}$	67.98%	66.71%	59.19%	50.47%	64.74%	79.80%	9
ISD	-137.21%	-116.10%	-131.75%	-138.49%	-98.17%	-69.81%	9
ISD^2	31.18%	26.06%	26.89%	7.31%	13.51%	26.51%	9
$(ISD)^{-1}$	0.07%	0.04%	0.07%	0.02%	0.11%	0.23%	8
(S/X)(ISD)	8.77%	5.91%	15.45%	10.86%	15.32%	18.74%	9
Put Price	-1.56%	-1.12%	-1.03%	-3.05%	-1.33%	-1.13%	9
$(\text{Put Price})^2$	0.01%	0.01%	0.01%	0.01%	0.01%	0.05%	9
Penny	-27.84%	-26.34%	-29.68%	-33.82%	-31.07%	-22.31%	9
Banned	15.76%	17.81%	16.23%	11.71%	14.00%	16.79%	9
R^2	58.51%	56.26%	59.75%	49.93%	59.90%	63.80%	
N	1,744	1,760	1,728	1,657	1,815	3,622	

Table 4 (continued)

Daily percentage spread regressions for December 2008 expiration calls

Notes. For each call option I expiring on December 20, 2008, we compute the National Best Bid and Offer (NBBO) by taking the highest valid bid and the lowest valid offer posted at one of the seven venues currently trading equity options in the United States. Next, we calculate an average percentage spread, *Pct Spread*$_i$, each day by taking the average of the NBBO (divided by the midpoint) at the end of each minute of the day. We run the following cross-sectional regression each day from August 1, 2008 through October 21, 2008, with standard errors clustered by underlying stock:

$$Pct\ Spread_i = \alpha_0 + \alpha_1 Banned_i + \alpha_2 \left(\frac{S}{X}\right)_i + \alpha_3 \left(\frac{S}{X}\right)_i^2 + \alpha_4 \left(\frac{S}{X}\right)_i^{1/2} + \alpha_5 ISD_i + \alpha_6 ISD_i^2 + \alpha_7 ISD_i^{1/2} + \alpha_8 \left(\frac{S}{X}\right)_i ISD_i + \alpha_9 Penny_i + \varepsilon_i$$

where $Banned_i$ takes a value of one if option I is on a stock with banned short selling and zero otherwise, $(S/X)_I$ is the ratio of the stock price to the exercise price over the 390 end-of-minute observations on day t, $(S/X)_t^2$ and $(S/X)_t^{1/2}$ are the square and square root of the average value of (S/X) for day t, ISD_i is the mean implied standard deviation for option I on day t for the call, ISD_t^2 and $ISD_t^{1/2}$ are square and square root of the average implied standard deviation for day t, and *Penny* is one if the option is part of the SEC's Penny Pilot and zero otherwise. The regressions examine the spreads of options on the 330 optionable stocks for which short selling is banned on September 19th, 2008 and options on a set of stocks not subject to the short sale ban that we match to the set of banned stocks. Our daily OPRA files containing data for August 14th and August 26th are corrupt so we have no data for these days. Shading indicates variable has a p-value that is less than 0.01.

Table 5
Daily percentage spread regressions for December 2008 expiration puts with the underlying stock's percentage spread as an explanatory variable

Panel A. August 1, 2008 through September 19, 2008.

	20080801 - 20080912								
	Min	Median	Max	Days p≤0.01	915	916	917	918	919
Constant	-137.17%	-120.76%	-90.25%	28	-123.10%	-97.71%	-118.28%	-75.51%	39.99%
S/X	96.71%	126.18%	143.63%	28	145.70%	131.07%	136.01%	101.87%	63.63%
$(S/X)^2$	-12.94%	-9.77%	-5.44%	27	-8.89%	-9.39%	-4.70%	-6.38%	-5.13%
$(S/X)^{-1}$	25.49%	36.11%	44.72%	27	36.14%	27.12%	33.18%	18.29%	-42.01%
ISD	-63.80%	-33.73%	-5.93%	8	-48.65%	-48.88%	-29.38%	-15.52%	-10.96%
ISD^2	-3.75%	10.47%	25.70%	0	21.20%	19.80%	15.74%	-4.91%	0.09%
$(ISD)^{-1}$	-0.02%	0.02%	0.16%	9	0.04%	0.02%	0.03%	0.01%	0.02%
(S/X)(ISD)	-12.72%	-5.88%	4.44%	0	-19.84%	-14.12%	-29.34%	-8.81%	0.34%
Put Price	-8.00%	-0.15%	0.05%	4	-45.00%	-0.51%	-0.43%	-0.94%	-1.18%
$(Put\ Price)^2$	0.00%	0.00%	0.00%	4	0.00%	0.00%	0.00%	0.01%	0.01%
Stock Spread	3017.46%	7366.55%	10385.69	25	7279.25%	5401.00%	8982.18%	9083.86%	7348.95%
Penny	-17.67%	-12.90%	2.98%	27	-17.40%	-16.63%	-15.68%	-14.63%	-36.37%
Banned	-2.66%	-0.90%	2.35%	0	1.84%	4.32%	2.84%	5.96%	16.28%
R^2	48.00%	53.17%	57.13%		54.08%	53.61%	51.64%	52.18%	59.75%
N	1,798	1,876	1,918		1,811	1,829	1,790	1,814	1,878

Notes: Shading indicates variable has a p-value that is less than 0.01.

Table 5 (continued)
Daily percentage spread regressions for December 2008 expiration puts with the underlying stock's percentage spread as an explanatory variable

Panel B. September 22, 2008 through October 3, 2008.

	922	923	924	925	926	929	930	1001	1002	1003
Constant	-35.74%	-18.66%	-44.11%	-56.70%	-50.63%	-51.77%	-57.50%	-47.90%	-41.32%	-56.08%
S/X	97.33%	78.02%	93.07%	96.54%	96.63%	106.21%	108.38%	95.57%	91.39%	101.85%
$(S/X)^2$	-6.78%	-5.44%	-6.63%	-6.85%	-7.22%	-6.74%	-6.69%	-6.37%	-4.99%	-5.83%
$(S/X)^{-1}$	-7.94%	-8.21%	5.78%	13.90%	2.91%	12.21%	15.12%	11.58%	10.74%	14.42%
ISD	-16.11%	-26.64%	-30.06%	-28.26%	-29.09%	-32.71%	-46.75%	-39.19%	-40.42%	-43.39%
ISD^2	5.01%	3.75%	6.76%	6.40%	7.19%	8.75%	13.21%	10.32%	9.22%	9.60%
$(ISD)^{-1}$	0.02%	0.00%	0.02%	0.00%	0.02%	-0.06%	-0.04%	-0.02%	-0.02%	0.02%
(S/X)(ISD)	-8.18%	-0.68%	-3.64%	-4.97%	-5.47%	-9.26%	-12.02%	-9.94%	-8.04%	-9.07%
Put Price	-0.59%	-64.00%	-1.01%	-0.87%	-0.77%	-1.08%	-0.68%	-0.76%	-0.57%	-0.47%
$(\text{Put Price})^2$	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.00%	0.01%	0.00%	0.00%
Stock Spread	6400.84%	4382.09%	5521.13%	2672.85%	9482.87%	3861.29%	5134.24%	5774.68%	5001.65%	6554.56%
Penny	-33.02%	-31.81%	-27.03%	-27.26%	-19.75%	-27.74%	-24.24%	-20.14%	-23.59%	-18.09%
Banned	6.69%	7.31%	4.33%	6.88%	-1.10%	2.65%	2.93%	2.69%	2.97%	-0.24%
R^2	53.72%	48.95%	50.32%	50.56%	55.36%	59.04%	55.98%	52.72%	51.28%	56.16%
N	1,900	1,894	1,870	1,883	1,810	1,808	1,778	1,803	1,822	1,787

Notes: Shading indicates variable has a p-value that is less than 0.01.

Table 5 (continued)

Daily percentage spread regressions for December 2008 expiration puts with the underlying stock's percentage spread as an explanatory variable

Panel C. October 6, 2008 through October 21, 2008.

				20081009 - 20081021			
	1006	1007	1008	Min	Median	Max	Days p≤0.01
Constant	-70.39%	-88.01%	-61.52%	-110.57%	-69.06%	-49.37%	9
S/X	112.36%	116.81%	99.46%	90.88%	99.57%	133.39%	9
$(S/X)^2$	-5.73%	-8.01%	-5.05%	-11.93%	-6.42%	-4.21%	9
$(S/X)^{-1}$	25.66%	28.93%	20.43%	14.53%	21.36%	32.61%	9
ISD	-45.19%	-42.98%	-29.04%	-46.02%	-27.95%	-19.68%	9
ISD^2	11.32%	8.45%	6.88%	3.79%	6.46%	10.10%	9
$(ISD)^{-1}$	-0.03%	-0.04%	-0.01%	-0.06%	-0.02%	0.04%	1
(S/X)(ISD)	-13.41%	-7.56%	-13.16%	-14.21%	-9.50%	0.10%	1
Put Price	-0.58%	-0.42%	-0.59%	-0.64%	-0.44%	-0.11%	6
$(Put\ Price)^2$	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6
Stock Spread	5726.83%	7048.78%	3645.84%	611.00%	6120.16%	9613.03%	9
Penny	-15.02%	-10.64%	-12.38%	-18.86%	-10.73%	-6.56%	8
Banned	-0.48%	0.15%	1.25%	-2.18%	-0.45%	0.73%	0
R^2	56.64%	58.19%	56.06%	51.03%	54.64%	56.70%	
N	1,744	1,760	1,728	1657	1815	3622	

Notes: Shading indicates variable has a p-value that is less than 0.01.

Table 5 (continued)

Daily percentage spread regressions for December 2008 expiration puts with the underlying stock's percentage spread as an explanatory variable

Notes. For each put option I expiring on December 20, 2008, we compute the National Best Bid and Offer (NBBO) by taking the highest valid bid and the lowest valid offer posted at one of the seven venues currently trading equity options in the United States. Next, we calculate an average percentage spread, *Pct Spread*$_i$, each day by taking the average of the NBBO (divided by the midpoint) at the end of each minute of the day. We run the following cross-sectional regression each day from August 1, 2008 through October 21, 2008, with standard errors clustered by underlying stock:

$$Pct\ Spread = \alpha_0 + \alpha_1 Banned_i + \alpha_2\left(S/X\right)_i + \alpha_3\left(S/X\right)_i^2 + \alpha_4\left(S/X\right)^{1/2} + \alpha_5 ISD + \alpha_6 ISD_i^2 + \alpha_7 ISD^{1/2} + \alpha_8\left(S/X\right)_i ISD + \alpha_9 Penny + \alpha_{10}\ Stock\ Spread + \varepsilon$$

where *Banned*$_i$ takes a value of one if option I is on a stock with banned short selling and zero otherwise, $(S/X)_I$ is the ratio of the stock price to the exercise price over the 390 end-of-minute observations on day t, $(S/X)_t^2$ and $(S/X)_t^{1/2}$ are the square and square root of the average value of (S/X) for day t, ISD_i is the mean implied standard deviation for option I on day t calculated from calls with the same exercise price and expiration date, ISD_t^2 and $ISD_t^{1/2}$ are square and square root of the average implied standard deviation for day t, *Penny* is one if the option is part of the SEC's Penny Pilot and zero otherwise, and *Stock Spread* is the relative spread of the underlying stock. The regressions examine the spreads of options on the 330 optionable stocks for which short selling is banned on September 19th, 2008 and options on a set of stocks not subject to the short sale ban that we match to the set of banned stocks. Our daily OPRA files containing data for August 14th and August 26th are corrupt so we have no data for these days. Shading indicates variable has a p-value that is less than 0.01.

Table 6

Difference in the midpoint of the bid ask spread synthetically created from October 2008 expiration puts and the actual bid ask spread midpoint

Panel A. August 1, 2008 through September 12, 2008.

	20080801 - 20080912								
	Min	Median	Max	Days p≤0.01	915	916	917	918	919
Banned	-\$0.0632	-\$0.0328	\$0.0027	3	-\$0.0336	-\$0.0415	-\$0.0280	-\$0.0773	-\$0.2688
S/X	-\$0.1626	-\$0.0095	\$0.0336	9	-\$0.0987	-\$0.1556	-\$0.1276	-\$0.1415	-\$0.0737
$(S/X)^2$	-\$0.0551	-\$0.0177	\$0.0031	11	\$0.0010	\$0.0033	\$0.0016	-\$0.0029	-\$0.0038
$(S/X)^{-1}$	-\$0.1467	-\$0.0316	\$0.0770	3	-\$0.0414	-\$0.0548	-\$0.0217	\$0.0402	0.3206
ISD	-\$0.0010	\$0.0696	\$0.1884	6	\$0.0366	\$0.0284	-\$0.0049	\$0.0226	-0.0718
ISD^2	-\$0.1649	-\$0.0704	\$0.0244	5	\$0.0007	-\$0.0124	-\$0.0003	-\$0.0218	\$0.0015
$(ISD)^{-1}$	-\$0.0020	-\$0.0001	\$0.0002	5	-\$0.0002	\$0.0001	\$0.0000	\$0.0000	\$0.0005
(S/X)(ISD)	\$0.0049	\$0.0781	\$0.2225	15	\$0.0243	\$0.0480	-\$0.0358	\$0.0675	\$0.0693
Penny	\$0.0037	\$0.0545	\$0.1249	0	\$0.0374	\$0.0566	\$0.0170	\$0.0379	\$0.0103
Constant	-\$0.0944	\$0.0346	\$0.2771	4	\$0.1588	\$0.1865	\$0.2026	\$0.0862	-\$0.3090
Psuedo R^2	2.69%	6.32%	12.60%		4.64%	4.09%	3.22%	7.38%	14.96%
N	1,529	3,331	3,424		3,312	3,328	3,237	3,348	3,413

Note: Shading indicates p≤0.01.

Table 6 (continued)

Difference in the midpoint of the bid ask spread synthetically created from October 2008 expiration puts and the actual bid ask spread midpoint

Panel B. September 22, 2008 through October 3, 2008.

	922	923	924	925	926	929	930	1001	1002	1003
Banned	-$0.2280	-$0.1922	-$0.1736	-$0.1417	-$0.1392	-$0.1252	-$0.1386	-$0.1357	-$0.1479	-$0.1329
S/X	-$0.0991	-$0.0952	-$0.1179	-$0.0527	-$0.1269	-$0.2424	-$0.0771	-$0.1004	-$0.1882	-$0.1166
$(S/X)^2$	$0.0009	-$0.0026	-$0.0029	-$0.0010	$0.0022	$0.0054	$0.0012	-$0.0017	$0.0032	$0.0006
$(S/X)^{-1}$	$0.0747	$0.0622	$0.1159	$0.0885	$0.0784	$0.0465	$0.0758	$0.0430	$0.0057	$0.1051
ISD	$0.0972	$0.1679	$0.1405	$0.1766	$0.1666	$0.0457	$0.0839	$0.1238	$0.1420	$0.1840
ISD^2	-$0.0099	-$0.0667	-$0.0524	-$0.0377	-$0.0628	-$0.0194	-$0.0239	-$0.0505	-$0.0508	-$0.0548
$(ISD)^{-1}$	$0.0000	$0.0002	-$0.0002	$0.0000	$0.0000	-$0.0001	-$0.0001	$0.0003	$0.0002	$0.0000
(S/X)(ISD)	$0.0347	$0.0701	$0.0733	$0.0347	$0.0718	$0.0640	$0.0274	$0.0632	$0.0669	$0.0530
Penny	$0.0304	$0.0589	$0.0968	$0.1076	$0.1093	$0.0852	$0.1380	$0.1152	$0.0736	$0.0787
Constant	-$0.0159	-$0.0778	-$0.1002	-$0.1624	-$0.0851	$0.1480	-$0.1037	-$0.0606	$0.0972	-$0.1253
Psuedo R^2	12.25%	12.01%	14.17%	11.61%	13.00%	10.51%	10.26%	10.61%	12.15%	12.30%
N	3,494	3,462	3,354	3,360	3,233	3,179	3,103	3,145	3,119	3,080

Note: Shading indicates $p \leq 0.01$.

Table 6 (continued)
Difference in the midpoint of the bid ask spread synthetically created from October 2008 expiration puts and the actual bid ask spread midpoint

Panel C. October 6, 2008 through October 17, 2008.

				20081009 - 20081017			
	1006	1007	1008	Min	Median	Max	Days p≤0.01
Banned	-$0.1138	-$0.0961	-$0.0619	-$0.0779	-$0.0394	-$0.0200	2
S/X	-$0.1532	-$0.1915	-$0.2752	-$1.5157	-$0.2550	-$0.1735	5
$(S/X)^2$	$0.0068	$0.0090	$0.0150	$0.0146	$0.0258	$0.3596	6
$(S/X)^{-1}$	$0.0429	$0.0802	-$0.0044	-$0.2478	$0.0727	$0.1112	0
ISD	$0.0707	$0.1266	-$0.0171	-$0.0340	$0.0330	$0.0638	1
ISD^2	-$0.0077	-$0.0281	-$0.0044	-$0.0124	-$0.0012	$0.0083	0
$(ISD)^{-1}$	$0.0002	$0.0003	-$0.0004	$0.0000	$0.0003	$0.0010	1
(S/X)(ISD)	$0.0249	$0.0420	$0.0600	-$0.0005	$0.0182	$0.0737	2
Penny	$0.0677	$0.0257	$0.0555	-$0.0207	$0.0209	$0.0532	1
Constant	$0.0266	$0.0061	$0.1943	-$0.1040	$0.1126	$1.3023	1
Psuedo R^2	7.31%	10.15%	8.37%	7.20%	9.35%	15.36%	
N	2,894	2,845	2,792	1,636	1,631	2,687	

Note: We run the following cross-sectional regression each day of our sample period using October expiration options create synthetically implied stock midpoints:

$$Bias_i = \alpha_0 + \alpha_1 Banned_i + \alpha_2 \left(S/X\right)_i + \alpha_3 \left(S/X\right)_i^2 + \alpha_4 \left(S/X\right)_i^{1/2}$$
$$+\alpha_5 ISD_i + \alpha_6 ISD_i^2 + \alpha_7 ISD_i^{1/2} + \alpha_8 \left(S/X\right)_i ISD_i + \alpha_9 Penny_i + \varepsilon_i$$

where $Bias_i$ is the average difference in the midpoints of the synthetically implied and the underlying stock's actual bid ask spread computed using the 390 end-of-minute observations on day t that are not greater than $2.00 in absolute value, $Banned_i$ takes a value of one if option I is on a stock with banned short selling and zero otherwise, $(S/X)_I$ is the ratio of the stock price to the exercise price over the 390 end-of-minute observations on day t, $(S/X)_t^2$ and $(S/X)_t^{1/2}$ are the square and square root of the average value of *(S/X)* for day t, ISD_i is the mean implied standard deviation for option I on day t calculated from calls with the same exercise price and expiration date, ISD_t^2 and $ISD_t^{1/2}$ are square and square root of the average implied standard deviation for day t, and *Penny* is one if the option is part of the SEC's Penny Pilot and zero otherwise. The regressions examine the spreads of options on the 330 optionable stocks for which short selling is banned on September 19th, 2008 and options on a set of stocks not subject to the short sale ban that we match to the set of banned stocks. Our daily OPRA files containing data for August 14th and August 26th are corrupt so we have no data for these days. Shading indicates variable has a p-value that is less than 0.01.

Table 7
Difference in the midpoint of the bid ask spread synthetically created from December 2008 expiration puts and the actual bid ask spread midpoint

Panel A. August 1, 2008 through September 19, 2008.

	20080801 - 20080912								
	Min	Median	Max	Days p≤0.01	915	916	917	918	919
Banned	\$0.0074	\$0.0397	\$0.1081	0	\$0.0733	\$0.0601	\$0.0415	-\$0.0142	-\$0.2580
S/X	-\$0.3301	-\$0.1507	\$0.0197	7	-\$0.2704	-\$0.3373	-\$0.4032	-\$0.3699	-\$0.1492
$(S/X)^2$	-\$0.0858	-\$0.0260	\$0.0143	8	-\$0.0251	\$0.0109	-\$0.0327	\$0.0057	-\$0.0062
$(S/X)^{-1}$	-\$0.1276	\$0.0039	\$0.1300	0	\$0.0100	-\$0.0807	-\$0.1228	-\$0.0496	\$0.4058
ISD	-\$0.1315	\$0.1785	\$0.6600	2	\$0.6132	\$0.4620	\$0.2489	\$0.3016	\$0.2776
ISD^2	-\$1.0218	-\$0.6945	-\$0.2254	16	-\$0.8645	-\$0.6670	-\$0.6026	-\$0.4833	-\$0.2977
$(ISD)^{-1}$	-\$0.0006	-\$0.0001	\$0.0001	6	-\$0.0001	\$0.0000	-\$0.0002	-\$0.0002	\$0.0004
(S/X)(ISD)	\$0.2062	\$0.4414	\$0.6303	24	\$0.4323	\$0.2880	\$0.4434	\$0.2821	\$0.1740
Penny	-\$0.2218	-\$0.1033	-\$0.0071	0	-\$0.1168	-\$0.0694	-\$0.1227	-\$0.0779	-\$0.1391
Constant	-\$0.2315	\$0.0361	\$0.3357	0	\$0.0369	\$0.2386	\$0.5452	-\$0.4462	-\$0.4462
Psuedo R^2	4.13%	8.36%	12.57%		8.20%	7.62%	6.57%	8.82%	18.86%
N	1,731	1,804	1,840		1,746	1,754	1,712	1,744	1,737

Note: Shading indicates p≤0.01.

Table 7 (continued)

Difference in the midpoint of the bid ask spread synthetically created from December 2008 expiration puts and the actual bid ask spread midpoint

Panel B. September 22, 2008 through October 3, 2008

	922	923	924	925	926	929	930	1001	1002	1003
Banned	-\$0.2232	-\$0.2310	-\$0.2517	-\$0.2401	-\$0.1763	-\$0.1646	-\$0.1398	-\$0.1827	-\$0.1667	-\$0.1420
S/X	-\$0.1695	-\$0.0351	-\$0.1816	-\$0.1429	-\$0.1974	-\$0.3320	-\$0.1505	-\$0.1999	-\$0.1475	-\$0.1519
$(S/X)^2$	\$0.0004	-\$0.0160	\$0.0042	\$0.0012	\$0.0074	\$0.0023	-\$0.0083	\$0.0010	-\$0.0286	-\$0.0133
$(S/X)^{-1}$	\$0.0864	\$0.1613	\$0.0475	\$0.0408	\$0.0183	-\$0.0010	\$0.0484	-\$0.0040	\$0.0746	\$0.1209
ISD	\$0.2052	\$0.3226	\$0.4360	\$0.5383	\$0.3588	\$0.1310	\$0.2271	\$0.4970	\$0.4470	\$0.4537
ISD^2	-\$0.1847	-\$0.2986	-\$0.2617	-\$0.3903	-\$0.4065	-\$0.2078	-\$0.2803	-\$0.4227	-\$0.4478	-\$0.3649
$(ISD)^{-1}$	\$0.0004	\$0.0004	\$0.0002	\$0.0003	\$0.0000	\$0.0004	-\$0.0002	\$0.0003	\$0.0004	\$0.0003
(S/X)(ISD)	\$0.1323	\$0.1660	\$0.1279	\$0.1458	\$0.1927	\$0.1990	\$0.1807	\$0.1857	\$0.2716	\$0.2088
Penny	-\$0.0785	-\$0.0205	\$0.0163	\$0.0650	\$0.0269	-\$0.0205	\$0.0322	\$0.0289	\$0.0160	-\$0.0104
Constant	-\$0.0199	-\$0.2630	-\$0.0488	-\$0.1192	-\$0.0023	\$0.2638	-\$0.0485	-\$0.0230	-\$0.0747	-\$0.1858
Psuedo R^2	9.61%	12.47%	13.67%	13.26%	10.22%	11.50%	10.71%	12.86%	11.69%	13.06%
N	1,777	1,758	1,770	1,786	1,689	1,702	1,658	1,687	1,687	1,691

Note: Shading indicates $p \leq 0.01$.

Table 7 (continued)
Difference in the midpoint of the bid ask spread synthetically created from December 2008 expiration puts and the actual bid ask spread midpoint

Panel C. October 6, 2008 through October 21, 2008.

				20081009 - 20081021			
	1006	1007	1008	Min	Median	Max	Days p≤0.01
Banned	-\$0.0941	-\$0.0597	-\$0.0237	-\$0.0728	-\$0.0338	\$0.0246	0
S/X	-\$0.3686	-\$0.2520	-\$0.3522	-\$0.5748	-\$0.3045	-\$0.0956	7
$(S/X)^2$	-\$0.0105	\$0.0080	-\$0.0039	-\$0.0558	-\$0.0009	\$0.0121	1
$(S/X)^{-1}$	-\$0.0005	\$0.0499	-\$0.0269	-\$0.0663	-\$0.0391	\$0.1101	1
ISD	\$0.1560	\$0.2691	\$0.2652	-\$0.1231	\$0.1414	\$0.2944	2
ISD^2	-\$0.2126	-\$0.2277	-\$0.2604	-\$0.3212	-\$0.2189	-\$0.0103	5
$(ISD)^{-1}$	\$0.0001	\$0.0002	\$0.0004	-\$0.0005	\$0.0005	\$0.0007	2
(S/X)(ISD)	\$0.2464	\$0.1636	\$0.2387	\$0.0694	\$0.1897	\$0.4046	7
Penny	-\$0.0378	-\$0.0880	-\$0.0070	-\$0.0615	\$0.0168	\$0.1003	0
Constant	\$0.2466	\$0.0396	\$0.1126	\$0.0061	\$0.1637	\$0.5009	1
Psuedo R^2	9.72%	7.69%	8.43%	2.42%	6.12%	8.41%	
N	1,630	1,658	1,616	1,565	1,745	3,550	

Note: We run the following cross-sectional regression each day of our sample period using November expiration options create synthetically implied stock midpoints:

$$Bias_i = \alpha_0 + \alpha_1 Banned_i + \alpha_2\left(S/X\right)_i + \alpha_3\left(S/X\right)_i^2 + \alpha_4\left(S/X\right)_i^{1/2}$$
$$+\alpha_5 ISD_i + \alpha_6 ISD_i^2 + \alpha_7 ISD_i^{1/2} + \alpha_8\left(S/X\right)_i ISD_i + \alpha_9 Penny_i + \varepsilon_i$$

where $Bias_i$ is the average difference in the midpoints of the synthetically implied and the underlying stock's actual bid ask spread computed using the 390 end-of-minute observations on day t that are not greater than \$2.00 in absolute value, $Banned_i$ takes a value of one if option I is on a stock with banned short selling and zero otherwise, $(S/X)_I$ is the ratio of the stock price to the exercise price over the 390 end-of-minute observations on day t, $(S/X)_t^2$ and $(S/X)_t^{1/2}$ are the square and square root of the average value of *(S/X)* for day t, ISD_i is the mean implied standard deviation for option I on day t calculated from calls with the same exercise price and expiration date, ISD_t^2 and $ISD_t^{1/2}$ are square and square root of the average implied standard deviation for day t, and *Penny* is one if the option is part of the SEC's Penny Pilot and zero otherwise. The regressions examine the spreads of options on the 330 optionable stocks for which short selling is banned on September 19th, 2008 and options on a set of stocks not subject to the short sale ban that we match to the set of banned stocks. Our daily OPRA files containing data for August 14th and August 26th are corrupt so we have no data for these days. Shading indicates variable has a p-value that is less than 0.01.

Table 8
Probit analysis of the frequency of arbitrage opportunities generated purchasing actual shares and using October 2008 expiration options to sell synthetic shares

Panel A. August 1, 2008 through September 19, 2008.

	20080801 - 20080912								
	Min	Median	Max	Days $p \leq 0.01$	915	916	917	918	919
Banned	-0.4889	-0.1511	0.0295	4	-0.2667	-0.2412	-0.1957	-0.1994	-0.3730
S/X	-198.7280	-6.4304	162.2683	0	33.1965	-45.7807	-182.5179	-129.7058	-44.8467
$(S/X)^2$	-56.1330	1.2924	64.2545	0	-15.9676	10.1815	55.6493	8.1347	13.3732
$(S/X)^{-1}$	-71.2621	-6.5154	48.5530	0	0.8250	-26.0153	-71.5399	-53.2040	-16.2516
ISD	-8.6763	1.9660	9.1466	5	1.1242	2.7052	3.3338	1.3707	-0.2245
ISD^2	-0.9515	0.0352	2.6524	1	-0.1681	-0.0191	0.0752	0.1196	-0.1235
$(ISD)^{-1}$	-0.0245	-0.0003	0.2737	0	0.0000	-0.0042	-0.0267	-0.0047	-0.0007
(S/X)(ISD)	-11.2536	-0.8851	4.0338	2	-0.4333	-2.1752	-3.1640	-1.0893	1.0342
Penny	0.7632	1.6503	2.2903	24	1.5296	1.8486	1.6060	1.8508	0.8539
Constant	-154.1676	10.4462	205.5833	0	-18.8260	60.6571	197.7046	143.7543	47.0780
Psuedo R^2	3.05%	11.21%	24.19%		8.90%	14.13%	11.75%	15.31%	5.61%
N	732	1,958	2,029		1,934	1,948	1,871	1,866	1,855

Note: Shading indicates $p \leq 0.01$.

Table 8 (continued)
Probit analysis of the frequency of arbitrage opportunities generated purchasing actual shares and using October 2008 expiration options to sell synthetic shares

Panel B. September 22, 2008 through October 3, 2008

	922	923	924	925	926	929	930	1001	1002	1003
Banned	-0.6675	-0.6629	-0.6158	-0.6379	-0.4775	-0.2215	-0.1234	-0.2087	-0.4511	-0.0784
S/X	1.5666	37.6267	245.4000	23.6773	-288.9303	-239.8155	19.4992	-0.5194	-161.2822	-234.2005
$(S/X)^2$	-6.1811	-18.5112	76.1285	-15.7738	89.1076	71.2252	-12.2090	-7.8228	47.4209	69.9571
$(S/X)^{-1}$	-9.6335	0.6531	-92.0866	-8.1266	-109.1468	-94.3786	-5.2862	-16.1337	-63.3366	-89.6839
ISD	-1.6055	1.3429	1.1203	-1.0388	0.7001	1.0400	1.6621	1.1053	-0.3674	-1.7678
ISD^2	0.2985	-0.2618	0.1816	0.4874	0.5814	-0.0889	0.1350	0.2604	0.0164	0.2239
$(ISD)^{-1}$	-0.0084	-0.0026	-0.0012	-0.0063	-0.0375	0.0001	-0.0056	-0.0028	-0.0035	-0.0005
(S/X)(ISD)	1.6427	-0.4955	-0.8588	0.7998	-0.9751	0.0840	-1.3470	-0.8907	0.9551	2.0067
Penny	1.5702	1.6446	2.0901	2.0395	1.8406	2.0377	2.0069	1.8859	1.9264	1.9401
Constant	13.2541	-20.9636	260.1809	-0.7342	308.0676	261.3031	-3.7070	22.7988	175.8145	252.1979
Psuedo R^2	17.75%	18.13%	23.46%	24.35%	20.76%	22.05%	24.84%	25.04%	21.93%	24.22%
N	1,937	1,935	1,902	1,924	1,862	1,847	1,809	1,817	1,802	1,774

Note: Shading indicates $p \leq 0.01$.

Table 8 (continued)
Probit analysis of the frequency of arbitrage opportunities generated purchasing actual shares and using October 2008 expiration options to sell synthetic shares

Panel C. October 6, 2008 through October 17, 2008

				20081009 - 20081017			
	1006	1007	1008	Min	Median	Max	Days p≤0.01
Banned	-0.1879	-0.0508	-0.0612	-0.1504	0.1095	0.3359	0
S/X	-272.7769	-185.0220	-37.2715	-534.5871	-216.1933	49.7552	2
$(S/X)^2$	86.9837	56.3657	7.389	-22.5846	52.0000	173.2536	2
$(S/X)^{-1}$	-93.3106	-67.3516	-20.1671	-180.6796	-34.6031	33.0000	2
ISD	-0.2945	-0.3982	-0.1910	-89.3643	-1.2028	0.3578	0
ISD^2	0.0847	-0.0067	-0.0667	-0.2333	-0.0865	0.0547	0
$(ISD)^{-1}$	-0.0035	-0.0037	-0.0031	-0.4085	-0.0016	0.0006	0
(S/X)(ISD)	0.6453	1.3345	0.6783	0.0005	1.4414	2.5794	1
Penny	1.8945	1.9632	2.0292	0.5698	1.2970	1.7205	7
Constant	277.5098	194.2641	48.3289	-37.5764	89.6969	539.4010	2
Psuedo R^2	19.68%	19.49%	18.86%	9.29%	14.81%	20.19%	
N	1594	1577	1522	912	1298	1494	

Note: Shading indicates p<0.01. For each minute of every day during the sample period, we calculate synthetic bid prices at the end of each minute of each day during the sample period using all pairs of call and put options with October expirations, the same exercise price, and $0.8 < S/X < 1.2$. The proceeds generated by selling a share of stock synthetically are

$$Synthetic\ Stock^{Bid} = C^{Bid} + e^{-rT}X - P^{Ask} + EEP + \sum_{j=1}^{J} e^{-rt_j} D_j \quad .$$

where C_{bid} is the bid price of a call, r is the riskless rate, T is the time to expiration for the call and put, X is the exercise price, P^{Ask} is the ask price of a put with the same exercise price and expiration date as the call, EEP is the early exercise premium in the put price, t_j is the time until the stock pays its jth dividend before the option expires, and D_j is the amount of the jth dividend. We count the number of each type of arbitrage opportunity for each option pair each day. We then estimate the following Probit model for each trading day:

$$Pct\ Arb_t = \alpha_0 + \alpha_1 Banned + \alpha_2\left(\frac{S}{X}\right)_t + \alpha_3\left(\frac{S}{X}\right)_t^2 + \alpha_4\left(\frac{S}{X}\right)_t^{1/2} + \alpha_5 ISD_t + \alpha_6 ISD_t^2 + \alpha_7 ISD_t^{1/2} + \alpha_8\left(\frac{S}{X}\right)_t ISD_t + \alpha_9 Penny_t + \varepsilon_t$$

where $Pct\ Arb_t$ is the proportion of minutes during day t where the it the synthetic bid price exceeded the actual ask price of a share the stock , $Banned_t$ takes a value of one if the stock was included in the short sale ban and zero otherwise, $(S/X)_t$ is the average ratio of stock price to exercise price over day t, $(S/X)_t^2$ and $(S/X)_t^{1/2}$ are the square and square root of the average value of (S/X) for day t, ISD_t is the mean implied standard deviation for the call for day t, and ISD_t^2 and $ISD_t^{1/2}$ are square and square root of the average implied standard deviation for day t, and $Penny_t$ is one if the option was quoted in pennies, zero otherwise. Errors are clustered at the stock level. Two days are missing because either banned=1 predicts perfectly (813) or penny=0 predicts perfectly (827).

Table 9
Probit analysis of the frequency of arbitrage opportunities generated selling actual shares and using October 2008 expiration options to purchase synthetic shares.

Panel A. August 1, 2008 through September 19, 2008.

	20080801 - 20080912								
	Min	Median	Max	Days p≤0.01	915	916	917	918	919
Banned	-0.1571	0.0265	0.2020	0	0.0753	0.0860	0.1444	0.3780	0.1061
S/X	-177.5550	-23.2829	281.4118	0	-29.1189	11.7336	16.7464	164.8134	0.6776
$(S/X)^2$	-98.5669	5.5183	60.8753	0	7.1395	-6.5182	-8.1930	-60.5359	-5.4223
$(S/X)^{-1}$	-51.4553	-9.7267	85.5885	0	-14.0334	-0.7378	0.8736	44.3070	-0.3107
ISD	-8.6102	-0.7242	3.6628	2	1.1105	1.8566	1.3298	-0.0424	2.0768
ISD^2	-1.1769	0.2457	2.0165	0	-0.1888	-0.5710	-0.2800	0.0380	-0.8260
$(ISD)^{-1}$	-0.0034	0.0003	0.1164	3	0.0006	0.0008	0.0009	-0.0001	-0.0005
(S/X)(ISD)	-2.5501	1.3516	7.8194	1	0.4435	0.4994	0.2441	1.0427	-0.1069
Penny	0.0531	0.5345	1.0475	2	0.9650	1.2378	0.9576	0.9198	1.2690
Constant	-270.9200	26.3330	164.7279	0	33.6450	-6.6614	-11.9491	-150.6100	-4.8790
Psuedo R^2	1.82%	5.24%	12.51%		10.30%	11.86%	11.24%	12.49%	7.20%
N	732	1,958	2,029		1,934	1,948	1,871	1,866	1,855

Note: Shading indicates p≤0.01.

Table 9 (continued)
Probit analysis of the frequency of arbitrage opportunities generated selling actual shares and using October 2008 expiration options to purchase synthetic shares

Panel B. September 22, 2008 through October 3, 2008

	922	923	924	925	926	929	930	1001	1002	1003
Banned	0.9313	0.7580	0.8065	0.7453	0.8450	0.5473	0.5895	0.5444	0.5241	0.6688
S/X	-64.1856	-105.8033	-114.2017	-145.8673	-183.5550	-29.9042	93.2151	-44.3977	183.2219	191.5300
$(S/X)^2$	14.6741	31.5150	34.1556	44.6552	57.7609	6.5724	-35.6028	8.2306	-64.9784	-68.6707
$(S/X)^{-1}$	-33.1175	-40.7397	-46.0817	-56.7670	-68.2280	-16.5659	21.1184	-27.6969	52.7575	52.9811
ISD	2.5756	0.0792	4.2911	4.6083	3.3362	1.5512	2.8399	2.3362	1.7203	1.9219
ISD^2	-0.5675	0.1223	-0.3119	-0.0145	0.3323	-0.1360	-0.0421	-0.2336	-0.2561	-0.1758
$(ISD)^{-1}$	0.0013	0.0004	0.0003	0.0000	0.0002	0.0014	0.0016	0.0014	0.0004	0.0001
(S/X)(ISD)	-0.3113	0.7958	-2.8212	-3.6141	-2.7902	-0.4431	-1.5182	-0.6977	-0.0874	-0.5285
Penny	1.1917	1.0293	0.7975	0.7611	0.8017	1.1322	0.6639	0.9259	0.7054	0.7845
Constant	80.1903	113.1719	123.9423	156.0266	192.0158	37.7042	-80.8921	61.5737	-173.5245	-178.2035
Psuedo R^2	19.34%	13.35%	13.12%	12.49%	14.80%	12.27%	15.05%	15.19%	13.71%	14.26%
N	1,937	1,935	1,902	1,924	1,862	1,847	1,809	1,817	1,802	1,774

Note: Shading indicates $p \leq 0.01$.

Table 9 (continued)
Probit analysis of the frequency of arbitrage opportunities generated selling actual shares and using October 2008 expiration options to purchase synthetic shares

Panel C. October 6, 2008 through October 17, 2008.

				20081009 - 20081017			
	1006	1007	1008	Min	Median	Max	Days p≤0.01
Banned	0.4847	0.5843	0.3305	0.1535	0.2373	0.5173	2
S/X	5.4872	10.6270	-42.7190	-36.5374	147.8885	434.3277	1
$(S/X)^2$	-6.1228	-7.0744	13.3815	-153.2310	-53.2652	4.4813	1
$(S/X)^{-1}$	-4.9822	-4.1929	-16.4765	-22.2333	38.4002	128.2392	0
ISD	1.2619	1.6096	2.6667	-1.0547	0.5619	1.3201	0
ISD^2	-0.1445	-0.1086	-0.1189	-0.4533	-0.0547	0.0068	1
$(ISD)^{-1}$	0.0008	0.0019	0.0010	-0.0013	0.0004	0.0013	0
(S/X)(ISD)	0.1026	-0.6923	-1.4167	-0.6061	0.6852	2.3574	0
Penny	1.1397	1.0419	1.0229	0.9328	1.3875	1.7726	7
Constant	3.0332	-1.7688	43.3304	-411.7319	-130.6465	52.6683	0
Psuedo R^2	15.71%	11.59%	14.06%	8.79%	13.64%	18.19%	
N	1594	1577	1522	912	1298	1494	

Note: Shading indicates p≤0.01. Note: Shading indicates p≤0.01. For each minute of every day during the sample period, calculate synthetic ask prices at the end of each minute of each day during the sample period using all pairs of call and put options with October expirations, the same exercise price, and 0.8 < S/X < 1.2. The cost of buying a share of stock synthetically is

$$Synthetic\ Stock^{Ask} = C^{Ask} + e^{-rT}X - P^{Bid} + EEP + \sum_{j=1}^{J} e^{-rt_j} D_j \quad .$$

where C_{ask} is the ask price of a call, r is the riskless rate, T is the time to expiration for the call and put, X is the exercise price, P^{Bid} is the bid price of a put with the same exercise price and expiration date as the call, EEP is the early exercise premium in the put price, t_j is the time until the stock pays its jth dividend before the option expires, and D_j is the amount of the jth dividend. We count the number of each type of arbitrage opportunity for each option pair each day. We then estimate the following model using a Probit for each trading day

$$Pct\ Arb_t = \alpha_0 + \alpha_1 Banned + \alpha_2\left(S/X\right)_t + \alpha_3\left(S/X\right)_t^2 + \alpha_4\left(S/X\right)_t^{1/2} + \alpha_5 ISD_t + \alpha_6 ISD_t^2 + \alpha_7 ISD_t^{1/2} + \alpha_8\left(S/X\right)_t ISD_t + \alpha_9 Penny_t + \varepsilon_t$$

where $Pct\ Arb_t$ is the proportion of minutes during day t where the it the actual bid price exceeded the synthetic ask price of a share the stock , $Banned_t$ takes a value of one if the stock was included in the short sale ban and zero otherwise, $(S/X)_t$ is the average ratio of stock price to exercise price over day t, $(S/X)_t^2$ and $(S/X)_t^{1/2}$ are the square and square root of the average value of (S/X) for day t, ISD_t is the mean implied standard deviation for the call for day t, and ISD_t^2 and $ISD_t^{1/2}$ are square and square root of the average implied standard deviation for day t, and $Penny_t$ is one if the option was quoted in pennies, zero otherwise. Errors are clustered at the stock level. Two days missing because either banned=1 predicts perfectly (813) or penny=0 predicts perfectly (827).

Table 10
Probit analysis of the frequency of arbitrage opportunities generated purchasing actual shares and using December 2008 expiration options to sell synthetic shares

Panel A. August 1, 2008 through September 19, 2008.

	20080801 - 20080912								
	Min	Median	Max	Days p≤0.01	915	916	917	918	919
Banned	-0.5081	-0.3755	-0.2045	3	-0.3294	-0.3475	-0.2473	-0.5054	-0.7534
S/X	-152.7166	2.1762	115.7651	0	-127.7924	-99.4428	-61.2098	-122.2113	-165.5612
$(S/X)^2$	-39.0726	-0.7513	52.3700	0	42.5931	34.1900	20.8067	40.8518	52.8289
$(S/X)^{-1}$	-49.3054	-1.0104	36.3437	0	-42.6851	-33.1900	-19.3469	-40.0138	-56.4646
ISD	-8.0234	0.3086	3.9259	0	-0.3193	3.828	-2.2175	0.2750	-2.8223
ISD^2	-0.9415	0.5578	4.1915	0	0.8231	1.0727	1.1733	0.1072	-0.0362
$(ISD)^{-1}$	-0.9327	-0.0291	0.0014	1	-0.0492	-0.0874	-0.3246	-0.0197	-0.0357
(S/X)(ISD)	-8.2968	-1.0951	3.2363	1	-0.9987	-5.6223	-0.7340	-0.3303	3.2007
Penny	-0.5569	0.0925	0.8293	0	-0.1549	-0.0355	-0.3715	-0.1277	0.6075
Constant	-113.4361	0.9463	150.8105	0	128.1550	98.9264	61.6070	121.2762	168.9167
Psuedo R^2	1.77%	3.78%	5.64%		2.64%	3.41%	2.79%	3.66%	9.10%
N	802	844	869		824	825	792	771	811

Note: Shading indicates p≤0.01.

Table 10 (continued)
Probit analysis of the frequency of arbitrage opportunities generated purchasing actual shares and using December 2008 expiration options to sell synthetic shares

Panel B. September 22, 2008 through October 3, 2008.

	922	923	924	925	926	929	930	1001	1002	1003
Banned	-0.9965	-1.1502	-1.0678	-0.9142	-0.9614	-0.8780	-0.9226	-1.0368	-1.0092	-0.9851
S/X	-250.3181	-143.0372	49.1656	-60.2605	-166.0412	-32.9649	39.7582	37.1518	-21.6752	-130.2380
$(S/X)^2$	80.8981	47.8812	-17.2295	17.8683	54.9942	10.9635	-13.4068	-11.4849	5.5827	42.1471
$(S/X)^{-1}$	-87.9723	-47.3319	13.5881	-24.3048	-57.0891	-12.1978	10.2536	13.1827	-9.9624	-46.4972
ISD	-0.8432	-0.8425	-0.0452	-0.2604	4.1332	2.7627	3.1541	0.4483	0.6444	2.5417
ISD^2	1.6402	2.0272	1.2502	1.3914	0.8303	0.2313	0.7169	0.8263	0.1537	0.6738
$(ISD)^{-1}$	-0.1600	-0.3205	-0.3498	-0.1864	-0.0229	-0.0160	-0.0145	-0.0786	-0.0063	-0.0472
(S/X)(ISD)	-2.0956	-3.0032	-2.6850	-2.0146	-5.0538	-2.7268	-4.2930	-1.6561	-0.4980	-3.8266
Penny	0.1486	0.0066	0.0356	0.1153	0.3463	0.5039	0.6612	0.5111	1.0365	0.4261
Constant	258.1486	144.1343	-44.0753	67.3896	167.7998	33.4611	-36.9593	-39.0319	25.5075	134.5665
Psuedo R^2	14.19%	16.52%	14.56%	12.24%	13.06%	11.15%	13.97%	14.52%	16.51%	15.09%
N	831	834	849	839	824	815	803	798	787	772

Note: Shading indicates $p \leq 0.01$.

Table 10 (continued)
Probit analysis of the frequency of arbitrage opportunities generated purchasing actual shares and using December 2008 expiration options to sell synthetic shares

Panel C. October 6, 2008 through October 21, 2008.

	1006	1007	1008	20081009 - 20081021 Min	Median	Max	Days p≤0.01
Banned	-0.8493	-0.7840	-0.8748	-0.8526	-0.6457	-0.3595	5
S/X	-30.0431	110.0348	19.3939	-196.6390	-83.1639	92.6464	0
$(S/X)^2$	10.2158	-38.1980	-5.0723	-32.3706	26.8006	66.2253	0
$(S/X)^{-1}$	-8.2542	31.5406	9.7201	-63.8071	-27.7934	28.6855	0
ISD	-2.4108	0.2398	-1.8812	-4.1960	-1.1759	1.1705	0
ISD^2	0.5324	0.9650	0.6555	0.3901	0.4905	0.6920	0
$(ISD)^{-1}$	-0.1563	-0.2016	-0.0324	-0.2235	-0.0670	-0.0106	0
(S/X)(ISD)	1.2468	-2.7559	0.5397	-2.4489	0.4837	2.3530	0
Penny	0.5847	0.7684	1.0759	0.8251	0.9572	1.6826	1
Constant	28.2566	-102.5467	-24.2629	-89.3389	8.9862	193.6959	0
Psuedo R^2	12.77%	14.45%	16.07%	9.52%	12.21%	14.30%	
N	698	709	672	536	658	708	

Note: Shading indicates p<0.01. For each minute of every day during the sample period, we calculate synthetic bid prices at the end of each minute of each day during the sample period using all pairs of call and put options with December expirations, the same exercise price, and 0.8 < S/X < 1.2. The proceeds generated by selling a share of stock synthetically are

$$Synthetic\ Stock^{Bid} = C^{Bid} + e^{-rT}X - P^{Ask} + EEP + \sum_{j-1}^{J} e^{-rt_j} D_j \quad .$$

where C_{bid} is the bid price of a call, r is the riskless rate, T is the time to expiration for the call and put, X is the exercise price, P^{Ask} is the ask price of a put with the same exercise price and expiration date as the call, *EEP* is the early exercise premium in the put price, t_j is the time until the stock pays its jth dividend before the option expires, and D_j is the amount of the jth dividend. We count the number of each type of arbitrage opportunity for each option pair each day. We then estimate the following model using a Probit for each trading day:

$$Pct\ Arb_t = \alpha_0 + \alpha_1 Banned + \alpha_2\left(\tfrac{S}{X}\right)_t + \alpha_3\left(\tfrac{S}{X}\right)_t^2 + \alpha_4\left(\tfrac{S}{X}\right)_t^{1/2} + \alpha_5 ISD_t + \alpha_6 ISD_t^2 + \alpha_7 ISD_t^{1/2} + \alpha_8\left(\tfrac{S}{X}\right)_t ISD_t + \alpha_9 Penny_t + \varepsilon_t$$

where $Pct\ Arb_t$ is the proportion of minutes during day t where the it the synthetic bid price exceeded the actual ask price of a share the stock , $Banned_t$ takes a value of one if the stock was included in the short sale ban and zero otherwise, $(S/X)_t$ is the average ratio of stock price to exercise price over day t, $(S/X)_t^2$ and $(S/X)_t^{1/2}$ are the square and square root of the average value of (S/X) for day t, ISD_t is the mean implied standard deviation for the call for day t, and ISD_t^2 and $ISD_t^{1/2}$ are square and square root of the average implied standard deviation for day t, and $Penny_t$ is one if the option was quoted in pennies, zero otherwise. Errors are clustered at the stock level.

Table 11
Probit analysis of the frequency of arbitrage opportunities generated selling actual shares and using December 2008 expiration options to purchase synthetic shares

Panel A. August 1, 2008 through September 19, 2008.

	20080801 - 20080912								
	Min	Median	Max	Days p≤0.01	915	916	917	918	919
Banned	-0.2541	0.0217	0.3203	0	-0.0048	-0.1115	-0.1203	0.0598	0.0883
S/X	-280.0790	-14.2552	251.9522	0	164.7577	-28.8015	-88.7722	166.1039	-81.1287
$(S/X)^2$	-88.2283	5.3805	94.6422	1	-57.1114	8.3243	31.1266	-57.7077	26.5720
$(S/X)^{-1}$	-91.4122	-7.3477	74.0363	1	48.0498	-11.6948	-29.0350	47.0873	-27.0975
ISD	1.5214	3.5614	6.8126	7	3.3381	2.7322	6.8966	5.7380	2.2671
ISD^2	-0.5865	0.2870	1.1141	0	0.5566	-0.3981	0.4296	0.2196	-1.1736
$(ISD)^{-1}$	-0.0014	0.0017	0.0940	4	-0.0002	0.0003	0.0001	0.0007	0.0006
(S/X)(ISD)	-7.6008	-3.0465	-0.9736	2	-3.6684	-0.9632	-6.9488	-5.5786	-0.1665
Penny	1.0920	1.7372	2.0683	25	2.0126	2.1218	2.0127	2.0359	2.0581
Constant	-238.4407	14.9212	275.6842	0	-156.9226	30.4500	85.1204	-156.9101	80.5060
Psuedo R^2	5.64%	14.52%	19.44%		19.42%	16.23%	22.60%	20.74%	9.50%
N	802	846	869		824	825	792	771	811

Note: Shading indicates p≤0.01.

Table 11 (continued)
Probit analysis of the frequency of arbitrage opportunities generated selling actual shares and using December 2008 expiration options to purchase synthetic shares

Panel B. September 22, 2008 through October 3, 2008.

	922	923	924	925	926	929	930	1001	1002	1003
Banned	0.6428	0.6821	0.5437	0.6742	0.6775	0.4148	0.5832	0.5307	0.4249	0.4915
S/X	6.5413	-104.0354	-187.3733	44.8519	12.6997	-75.1160	-88.3488	-123.4550	22.6453	-181.1292
$(S/X)^2$	-2.3522	33.5501	63.1256	-15.4058	-5.7011	22.6815	27.8406	41.4227	-9.0356	60.5501
$(S/X)^{-1}$	1.3729	-35.8351	-60.9691	12.6206	0.9076	-29.7214	-32.3159	-40.3646	1.9161	-58.8016
ISD	2.3167	-0.0090	2.9928	2.5623	1.2670	2.8088	1.3457	2.2146	4.7252	0.5585
ISD^2	-0.2226	-0.1687	-0.4347	-0.0313	-0.2988	-0.0558	-0.0020	-0.3597	0.0489	-0.0218
$(ISD)^{-1}$	-0.0008	-0.0005	0.0007	-0.0070	0.0000	-0.0020	0.0020	-0.0008	0.0010	-0.0001
(S/X)(ISD)	-1.7907	0.3073	-1.9026	-2.4773	-0.5247	-2.2926	-1.0917	-1.1165	-4.5650	-0.3826
Penny	1.8801	1.7565	1.8700	1.7948	1.7314	1.6263	1.6169	1.7265	0.8760	1.6638
Constant	-6.9692	105.0619	183.5062	-43.2832	-9.4322	80.7478	91.4645	120.5768	-16.8325	178.0108
Psuedo R^2	14.33%	12.88%	13.83%	13.91%	13.55%	11.81%	12.16%	13.47%	6.54%	11.39%
N	831	834	849	839	824	815	803	798	787	772

Note: Shading indicates $p \leq 0.01$.

Table 11 (continued)
Buy synthetic sell actual arbitrage probit regressions using December expiration options

Panel C. 20081006 through 20081021

				20081009 - 20081021			
	1006	1007	1008	Min	Median	Max	Days p≤0.01
Banned	0.1677	0.2731	0.4320	0.1720	0.3481	0.4509	0
S/X	190.5507	87.0985	44.5622	-75.4207	119.0432	246.8916	0
$(S/X)^2$	-66.6640	-31.4002	-14.1534	-84.4047	-39.8487	23.5060	0
$(S/X)^{-1}$	56.0979	22.9420	13.6823	-28.5064	37.9812	75.7155	0
ISD	1.1433	1.9430	2.8198	0.2550	1.2753	1.8118	0
ISD^2	-0.0404	-0.0710	0.0481	-0.1050	-0.0243	0.0678	0
$(ISD)^{-1}$	0.0013	0.0018	0.0000	-0.0023	0.0001	0.0134	0
(S/X)(ISD)	-0.9166	-1.6730	-2.9483	-1.4529	-1.0634	0.0429	0
Penny	1.3968	1.5287	1.3328	1.1713	1.5255	1.6674	4
Constant	-181.2513	-79.9998	-45.3358	-239.5465	-118.5214	78.6371	0
Psuedo R^2	8.16%	9.96%	7.37%	4.99%	9.35%	10.04%	
N	698	709	672	536	658	708	

Note: Shading indicates p≤0.01. Note: Shading indicates p≤0.01. For each minute of every day during the sample period, calculate synthetic ask prices at the end of each minute of each day during the sample period using all pairs of call and put options with December expirations, the same exercise price, and 0.8 < S/X < 1.2. The cost of buying a share of stock synthetically is

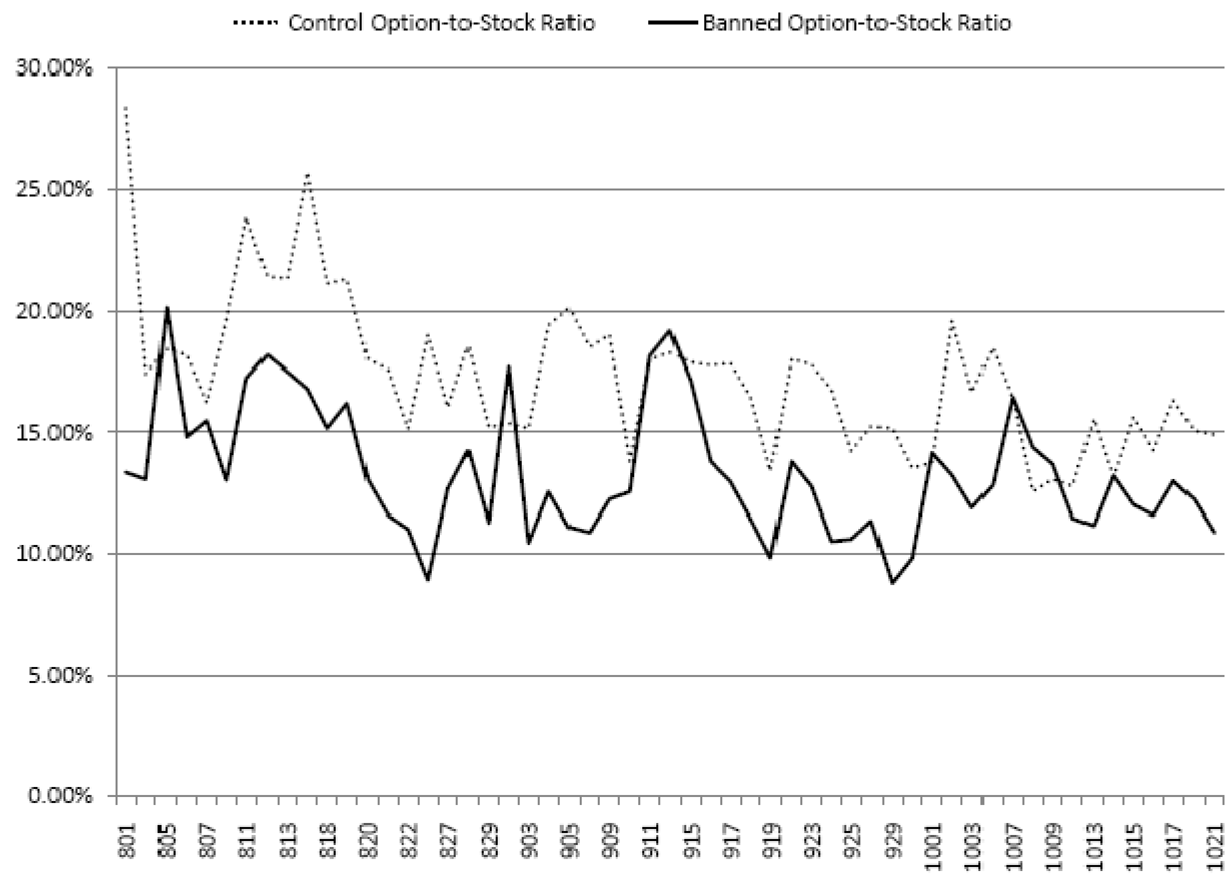
$$Synthetic\ Stock^{Ask} = C^{Ask} + e^{-rT}X - P^{Bid} + EEP + \sum_{j=1}^{J} e^{-rt_j} D_j \quad .$$

where C_{ask} is the ask price of a call, r is the riskless rate, T is the time to expiration for the call and put, X is the exercise price, P^{Bid} is the bid price of a put with the same exercise price and expiration date as the call, EEP is the early exercise premium in the put price, t_j is the time until the stock pays its jth dividend before the option expires, and D_j is the amount of the jth dividend. We count the number of each type of arbitrage opportunity for each option pair each day. We then estimate the following model using a Probit for each trading day

$$Pct\ Arb_t = \alpha_0 + \alpha_1 Banned + \alpha_2\left(\frac{S}{X}\right)_t + \alpha_3\left(\frac{S}{X}\right)_t^2 + \alpha_4\left(\frac{S}{X}\right)_t^{1/2} + \alpha_5 ISD_t + \alpha_6 ISD_t^2 + \alpha_7 ISD_t^{1/2} + \alpha_8\left(\frac{S}{X}\right)_t ISD_t + \alpha_9 Penny_t + \varepsilon_t$$

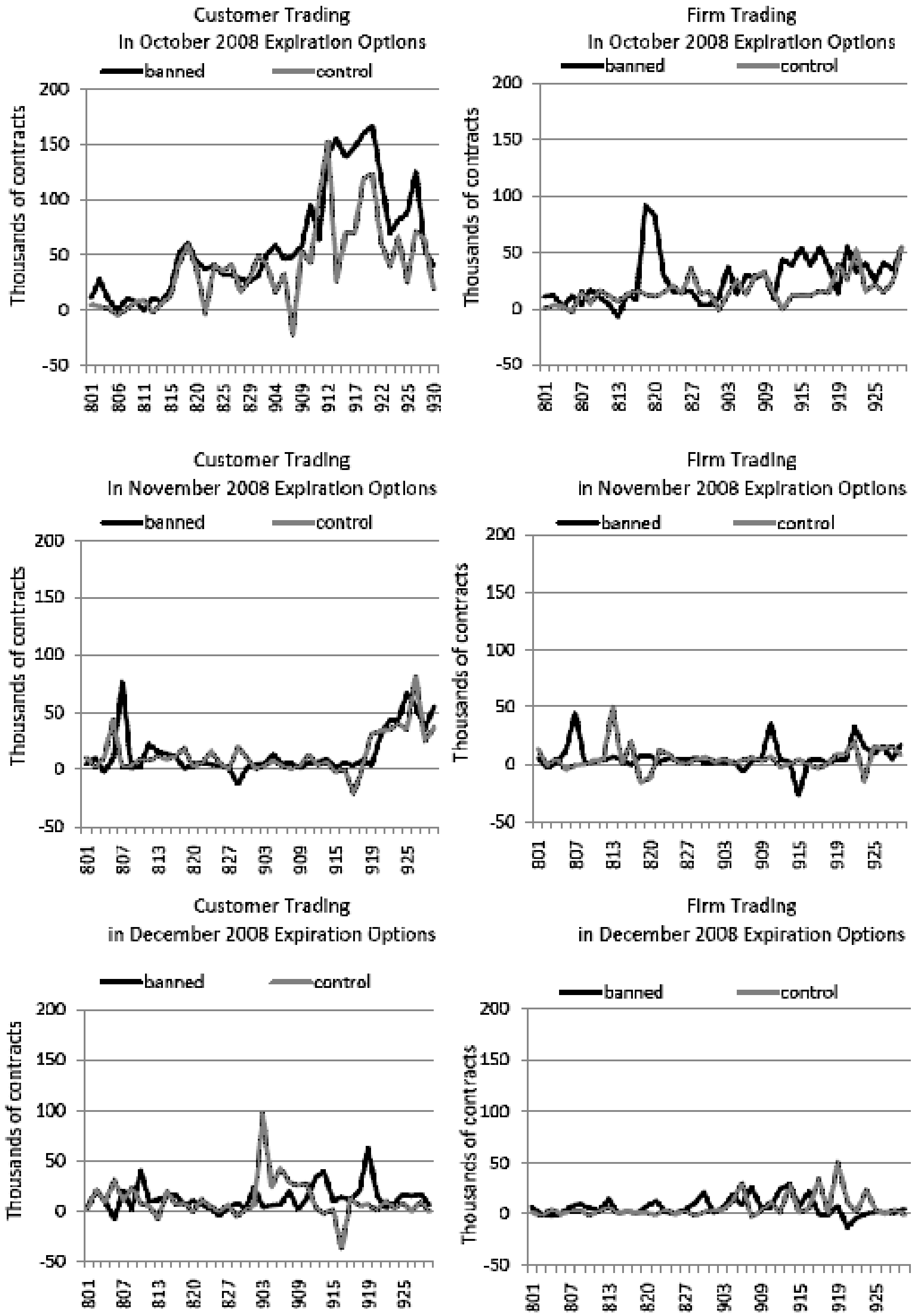
where $Pct\ Arb_t$ is the proportion of minutes during day t where the it the actual bid price exceeded the synthetic ask price of a share the stock , $Banned_t$ takes a value of one if the stock was included in the short sale ban and zero otherwise, $(S/X)_t$ is the average ratio of stock price to exercise price over day t, $(S/X)_t^2$ and $(S/X)_t^{1/2}$ are the square and square root of the average value of (S/X) for day t, ISD_t is the mean implied standard deviation for the call for day t, and ISD_t^2 and $ISD_t^{1/2}$ are square and square root of the average implied standard deviation for day t, and $Penny_t$ is one if the option was quoted in pennies, zero otherwise. Errors are clustered at the stock level.

Figure 1. Daily ratio of option-to-stock trading volume in August, September, and October 2008.



Notes. Each day, we first multiply the volume of put and call contracts traded on banned stocks by 100 since each contract contains options on 100 shares of stock. We then divide this product by the number of shares traded in the underlying banned stocks on that day. The ratio of option-to-stock volume for control stocks is computed analogously. Banned includes the 330 optionable stocks for which short selling is banned on September 19th, 2008. Control refers to the set of optionable stocks not subject to the short sale ban that we match to the set of banned stocks. Our daily OPRA files containing data for August 14th and August 26th are corrupt so we have no data for these days. Our sample period ends on October 21, 2008.

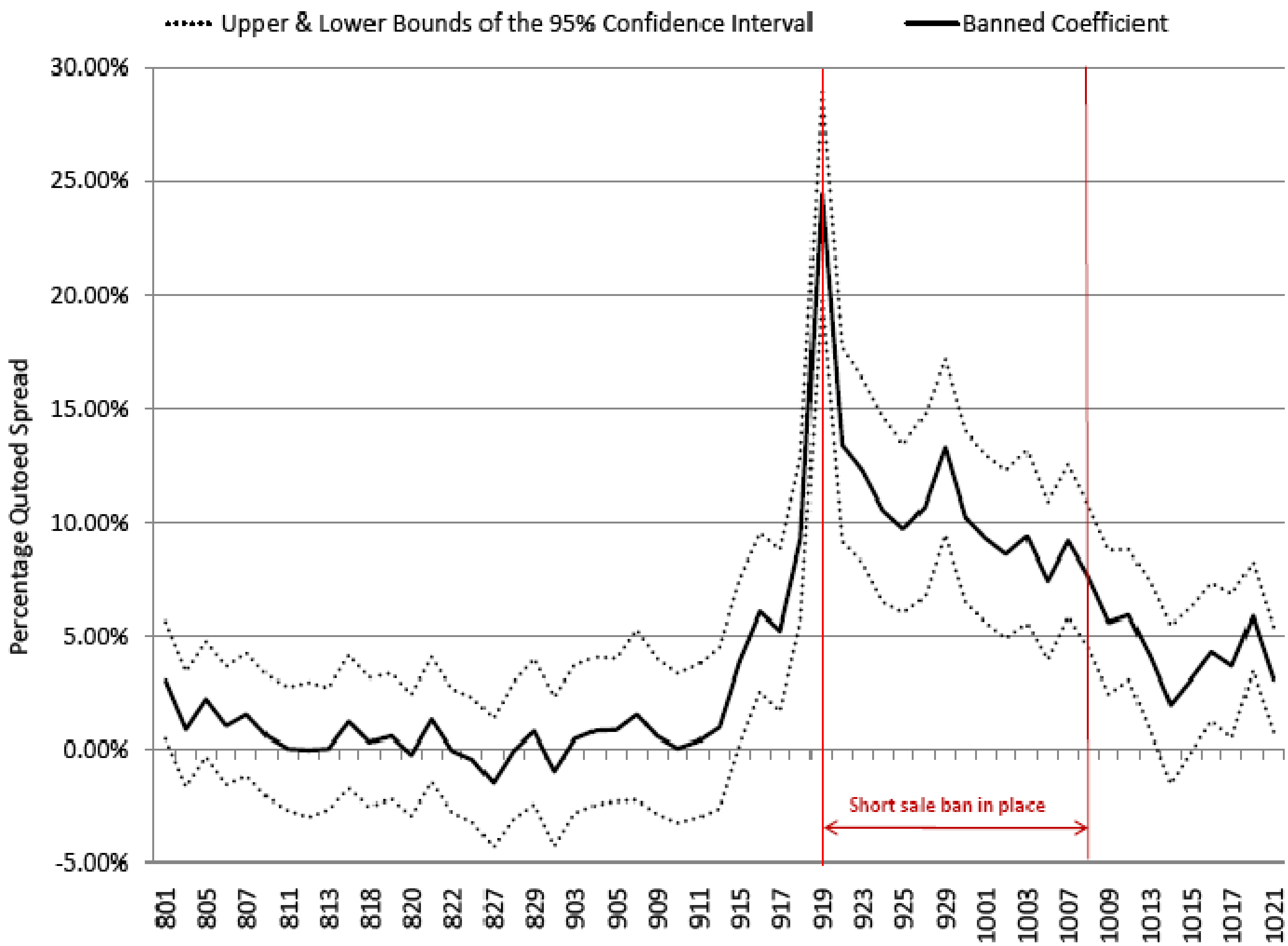
Figure 2. Daily changes in short exposure on the CBOE and ISE in August and September 2008.



Notes: Banned includes the 330 optionable stocks for which short selling is banned on September 19th, 2008. Control refers to the set of optionable stocks not subject to the short sale ban that we match to the set of banned stocks. Each day, the CBOE and the ISE identify the number of contracts involved in trades by customers and firm proprietary traders that either "open-buys", "open-sells", "close-buys", or "close-sells". Each day, for each customer type, we compute the short exposure on these two exchanges separately for options on banned and control stocks as follows:

Changes in Short Exposure$_t$ = (Put Open-Buy + Call Open-Sell) - (Put Close-Buy + Call Close-Sell).

Figure 3. Marginal impact of the short sale ban on the relative bid/ask spreads of December 2008 expiration puts on banned stocks.

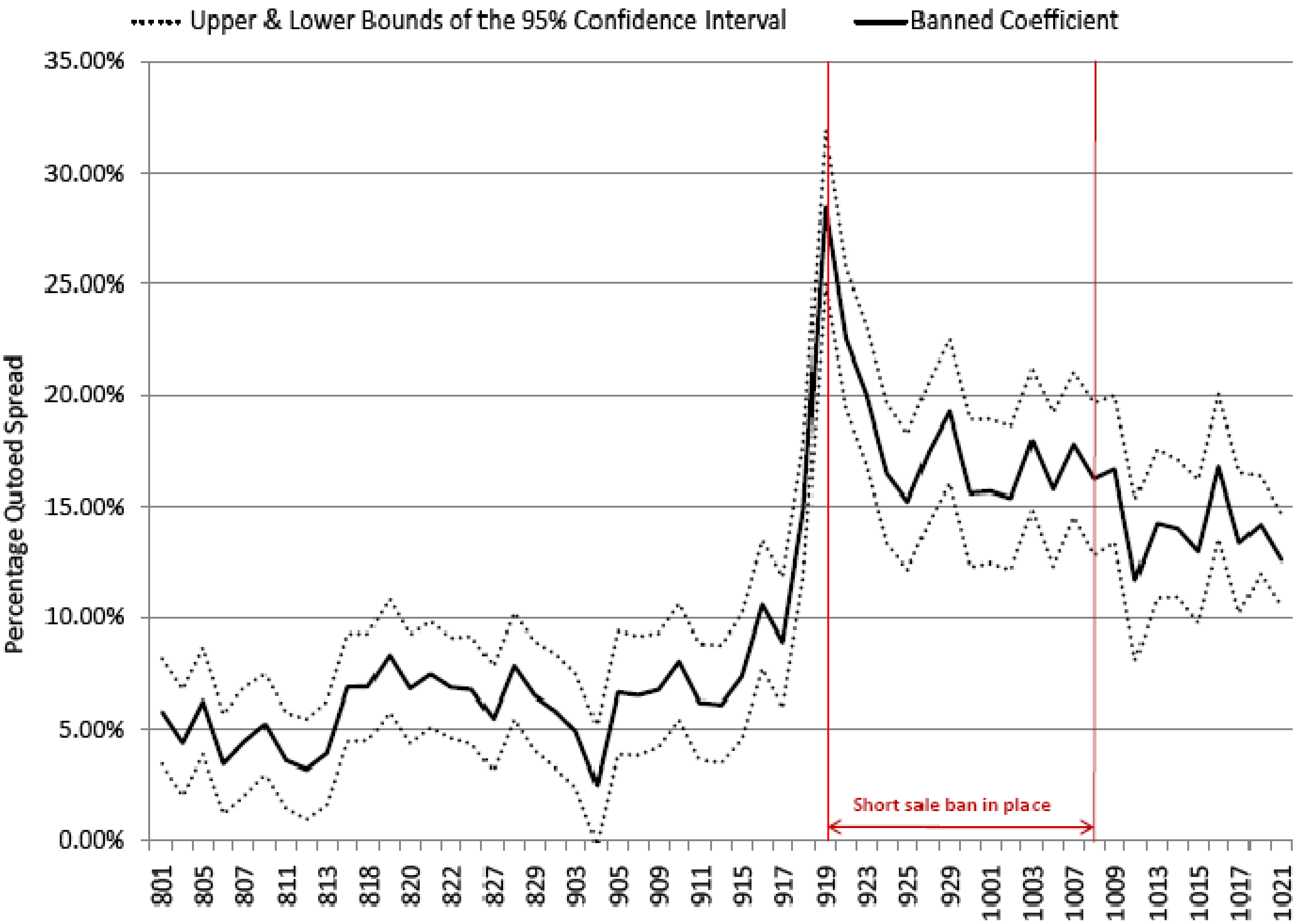


Notes. For each put option I expiring on December 20, 2008, we compute the National Best Bid and Offer (NBBO) by taking the highest valid bid and the lowest valid offer posted at one of the seven venues currently trading equity options in the United States. Next, we calculate an average percentage spread, *Pct Spread$_i$*, each day by taking the average of the NBBO (divided by the midpoint) at the end of each of the 390 minutes of the trading day. We run the following cross-sectional regression each day from August 1, 2008 through October 21, 2008, with standard errors clustered by underlying stock:

$$Pct\ Spread_i = \alpha_0 + \alpha_1 Banned_i + \alpha_2\left(S/X\right)_i + \alpha_3\left(S/X\right)_i^2 + \alpha_4\left(S/X\right)_i^{1/2} + \alpha_5 ISD_i + \alpha_6 ISD_i^2 + \alpha_7 ISD_i^{1/2} + \alpha_8\left(S/X\right)_i ISD_i + \alpha_9 Penny_i + \varepsilon_i$$

where *Banned$_i$* takes a value of one if option I is on a stock with banned short selling and zero otherwise, $(S/X)_I$ is the ratio of the stock price to the exercise price over the 390 end-of-minute observations on day t, $(S/X)_t^2$ and $(S/X)_t^{1/2}$ are the square and square root of the average value of *(S/X)* for day t, ISD_i is the mean implied standard deviation for option I on day t calculated from calls with the same exercise price and expiration date, ISD_t^2 and $ISD_t^{1/2}$ are square and square root of the average implied standard deviation for day t, and *Penny* is one if the option is part of the SEC's Penny Pilot and zero otherwise. The regressions examine the spreads of options on the 330 optionable stocks for which short selling is banned on September 19th, 2008 and options on a set of stocks not subject to the short sale ban that we match to the set of banned stocks. Our daily OPRA files containing data for August 14th and August 26th are corrupt so we have no data for these days.

Figure 4. Marginal impact of the short sale ban on the relative bid/ask spreads of December 2008 expiration calls on banned stocks.

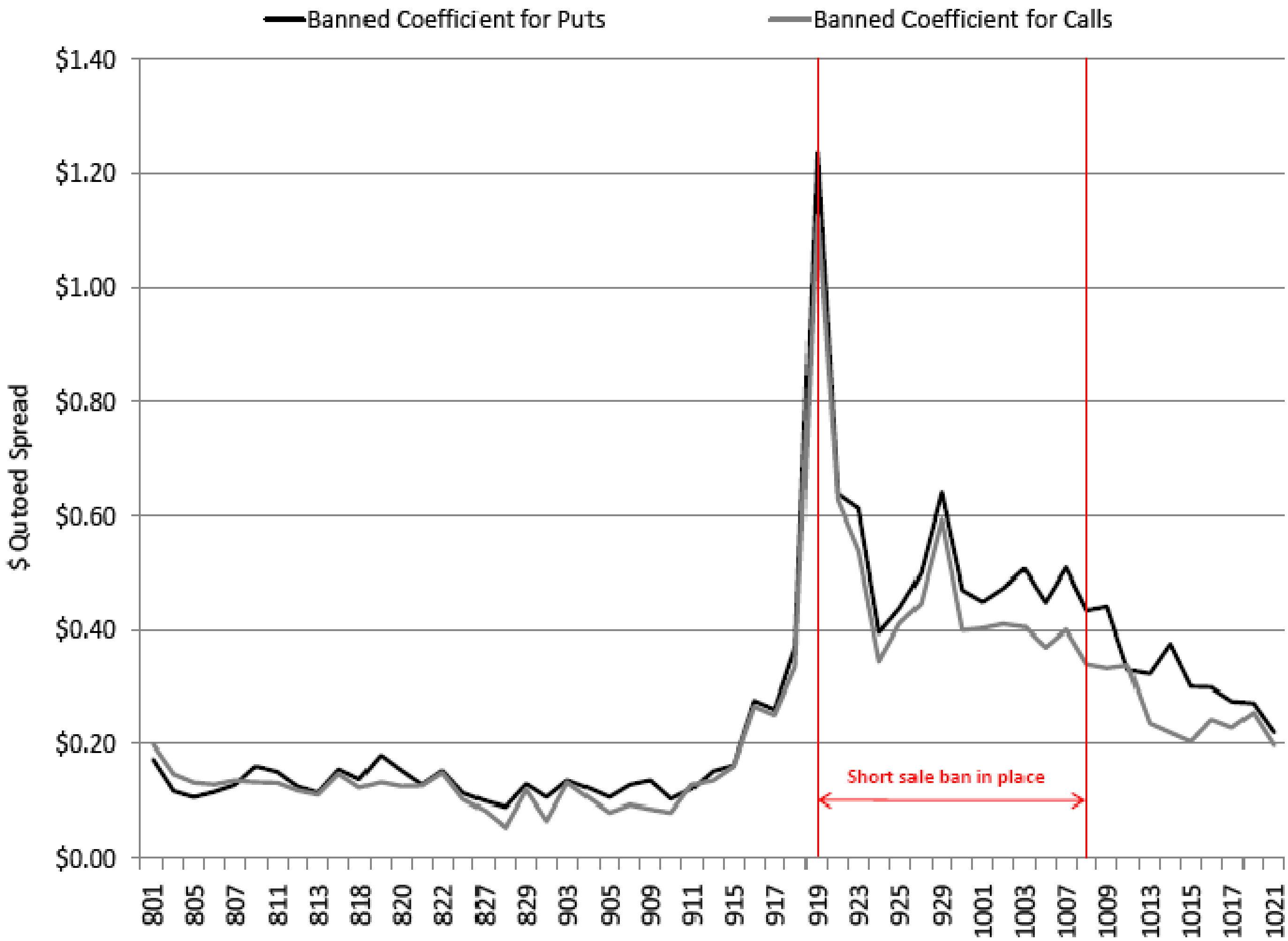


Notes. For each call option I expiring on December 20, 2008, we compute the National Best Bid and Offer (NBBO) by taking the highest valid bid and the lowest valid offer posted at one of the seven venues currently trading equity options in the United States. Next, we calculate an average percentage spread, *Pct Spread$_i$*, each day by taking the average of the NBBO (divided by the midpoint) at the end of each minute of the day. We run the following cross-sectional regression each day from August 1, 2008 through October 21, 2008, with standard errors clustered by underlying stock:

$$Pct\ Spread_i = \alpha_0 + \alpha_1 Banned_i + \alpha_2\left(S/X\right)_i + \alpha_3\left(S/X\right)_i^2 + \alpha_4\left(S/X\right)_i^{1/2} + \alpha_5 ISD_i + \alpha_6 ISD_i^2 + \alpha_7 ISD_i^{1/2} + \alpha_8\left(S/X\right)_i ISD_i + \alpha_9 Penny_i + \varepsilon_i$$

where *Banned$_i$* takes a value of one if option I is on a stock with banned short selling and zero otherwise, $(S/X)_t$ is the ratio of the stock price to the exercise price over the 390 end-of-minute observations on day t, $(S/X)_t^2$ and $(S/X)_t^{1/2}$ are the square and square root of the average value of *(S/X)* for day t, ISD_i is the mean implied standard deviation for option I on day t for the call, ISD_t^2 and $ISD_t^{1/2}$ are square and square root of the average implied standard deviation for day t, and *Penny* is one if the option is part of the SEC's Penny Pilot and zero otherwise. The regressions examine the spreads of options on the 330 optionable stocks for which short selling is banned on September 19th, 2008 and options on a set of stocks not subject to the short sale ban that we match to the set of banned stocks. Our daily OPRA files containing data for August 14th and August 26th are corrupt so we have no data for these days.

Figure 5. Marginal impact of the short sale ban on the quoted bid/ask spreads of December 2008 expiration puts and calls on banned stocks.

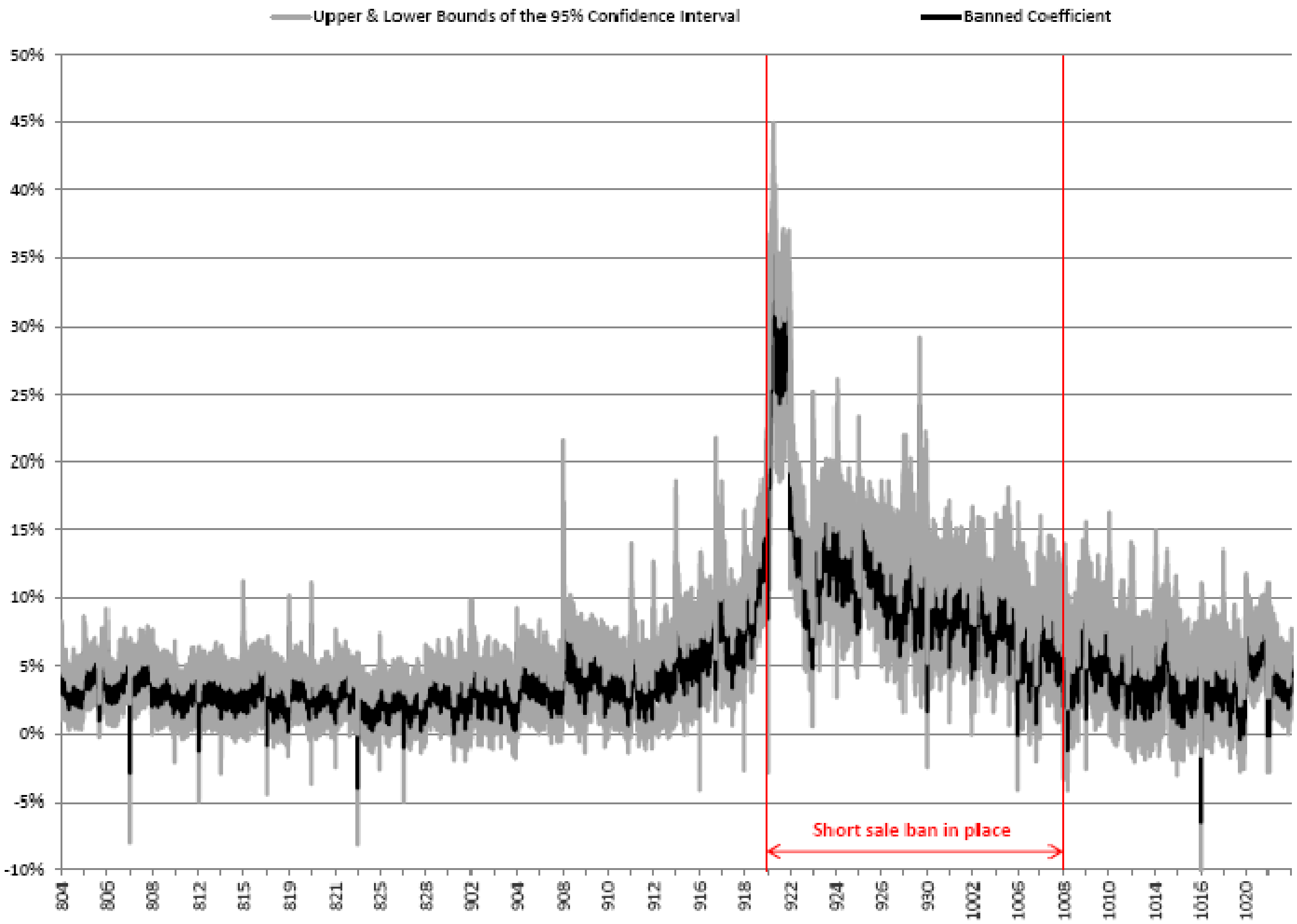


Notes. For each option I expiring on December 20, 2008, we compute the National Best Bid and Offer (NBBO) by taking the highest valid bid and the lowest valid offer posted at one of the seven venues currently trading equity options in the United States. Next, we calculate an average quoted spread, *Qte Spread$_i$*, each day by taking the average of the NBBO at the end of each of the 390 minutes of the trading day. We run the following cross-sectional regression each day from August 1, 2008 through October 21, 2008 separately for puts and calls, with standard errors clustered by underlying stock:

$$Qte\ Spread_i = \alpha_0 + \alpha_1 Banned_i + \alpha_2 \left(S/X\right)_i + \alpha_3 \left(S/X\right)_i^2 + \alpha_4 \left(S/X\right)_i^{1/2} + \alpha_5 ISD_i + \alpha_6 ISD_i^2 + \alpha_7 ISD_i^{1/2} + \alpha_8 \left(S/X\right)_i ISD_i + \alpha_9 Penny_i + \varepsilon_i$$

where *Banned$_i$* takes a value of one if option I is on a stock with banned short selling, *$(S/X)_I$* is the ratio of the stock price to the exercise price, *ISD$_i$* is the implied standard deviation for option I (for puts, the ISD is calculated from calls with the same exercise price and expiration date), and *Penny* is one if the option is part of the SEC's Penny Pilot. We plot the daily estimate of α_1 for puts (black) and calls (grey). The regressions examine the spreads of options on the 330 optionable stocks for which short selling is banned on September 19th, 2008 and options on a set of stocks not subject to the short sale ban that we match to the set of banned stocks. Our daily OPRA files containing data for August 14th and August 26th are corrupt so we have no data for these days. Plots with the 95% confidence are available from the authors upon request.

Figure 6. Intraday marginal impact of the short sale ban on the relative bid/ask spreads of December 2008 expiration puts on banned stocks.



Notes. For each put option I expiring on December 20, 2008, we compute the National Best Bid and Offer (NBBO) by taking the highest valid bid and the lowest valid offer posted at one of the seven venues currently trading equity options in the United States. Next, we calculate an average percentage spread, *Pct Spread*$_i$, each day by taking the average of the NBBO (divided by the midpoint) at the end of each minute of the day. We run the following cross-sectional regression at the end of each minute, each day from August 1, 2008 through October 21, 2008, with standard errors clustered by underlying stock:

$$Pct\ Spread_i = \alpha_0 + \alpha_1 Banned_i + \alpha_2 \left(S/X\right)_i + \alpha_3 \left(S/X\right)_i^2 + \alpha_4 \left(S/X\right)_i^{1/2} + \alpha_5 ISD_i$$
$$+ \alpha_6 ISD_i^2 + \alpha_7 ISD_i^{1/2} + \alpha_8 \left(S/X\right)_i ISD_i + \alpha_9 Penny_i + \alpha_{10}\ Stock\ Spread + \varepsilon_i$$

where *Banned*$_i$ takes a value of one if option I is on a stock with banned short selling and zero otherwise, $(S/X)_I$ is the ratio of the stock price to the exercise price over the 390 end-of-minute observations on day t, $(S/X)_t^2$ and $(S/X)_t^{1/2}$ are the square and square root of the average value of *(S/X)* for day t, ISD_i is the mean implied standard deviation for option I on day t calculated from calls with the same exercise price and expiration date, ISD_t^2 and $ISD_t^{1/2}$ are square and square root of the average implied standard deviation for day t, *Penny* is one if the option is part of the SEC's Penny Pilot and zero otherwise, and *Stock Spread* is the relative spread of the underlying stock. The regressions examine the spreads of options on the 330 optionable stocks for which short selling is banned on September 19th, 2008 and options on a set of stocks not subject to the short sale ban that we match to the set of banned stocks. Our daily OPRA files containing data for August 14th and August 26th are corrupt so we have no data for these days.

Figure 7. Average minute-by-minute relative spreads for puts on banned and control stocks.

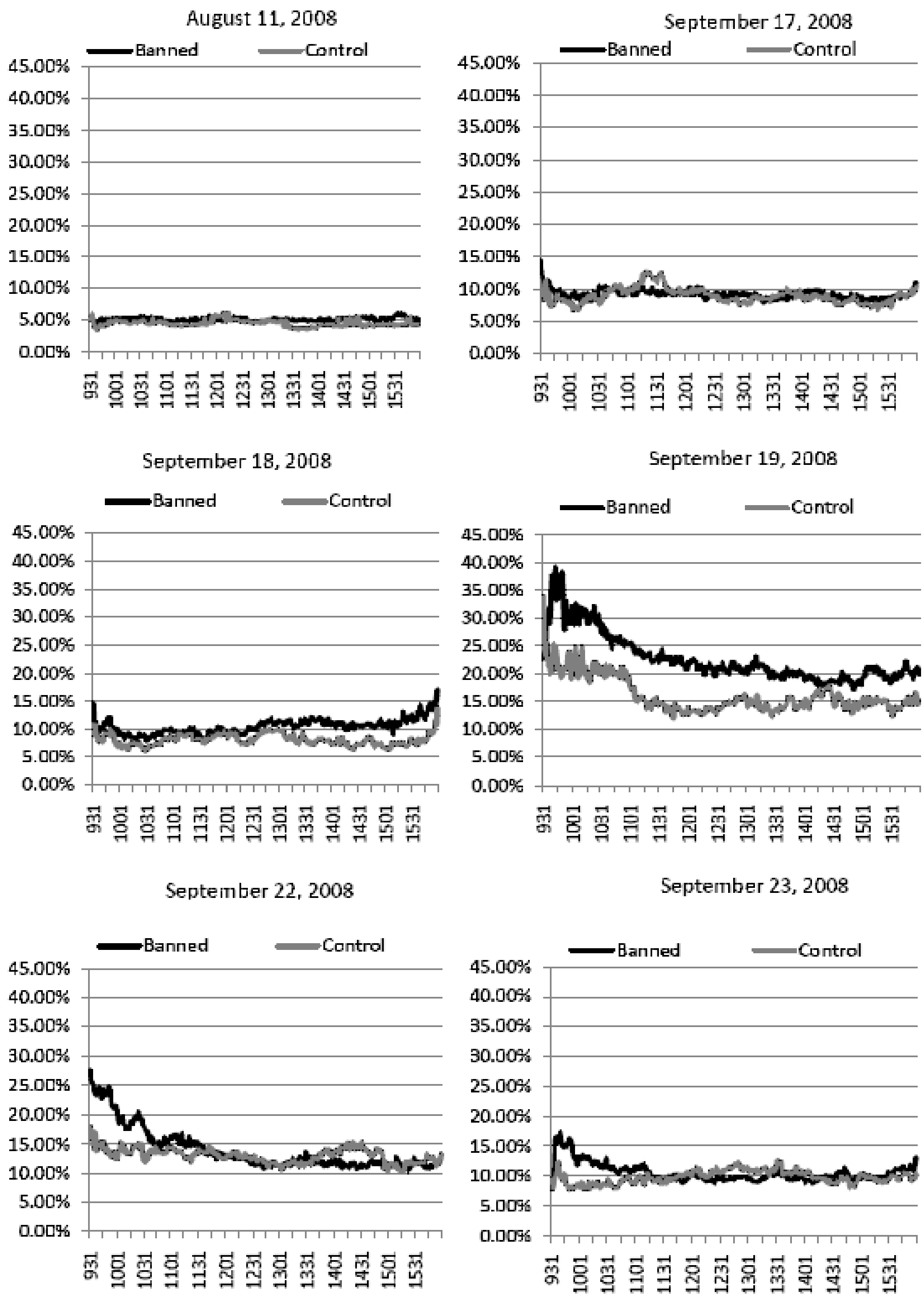
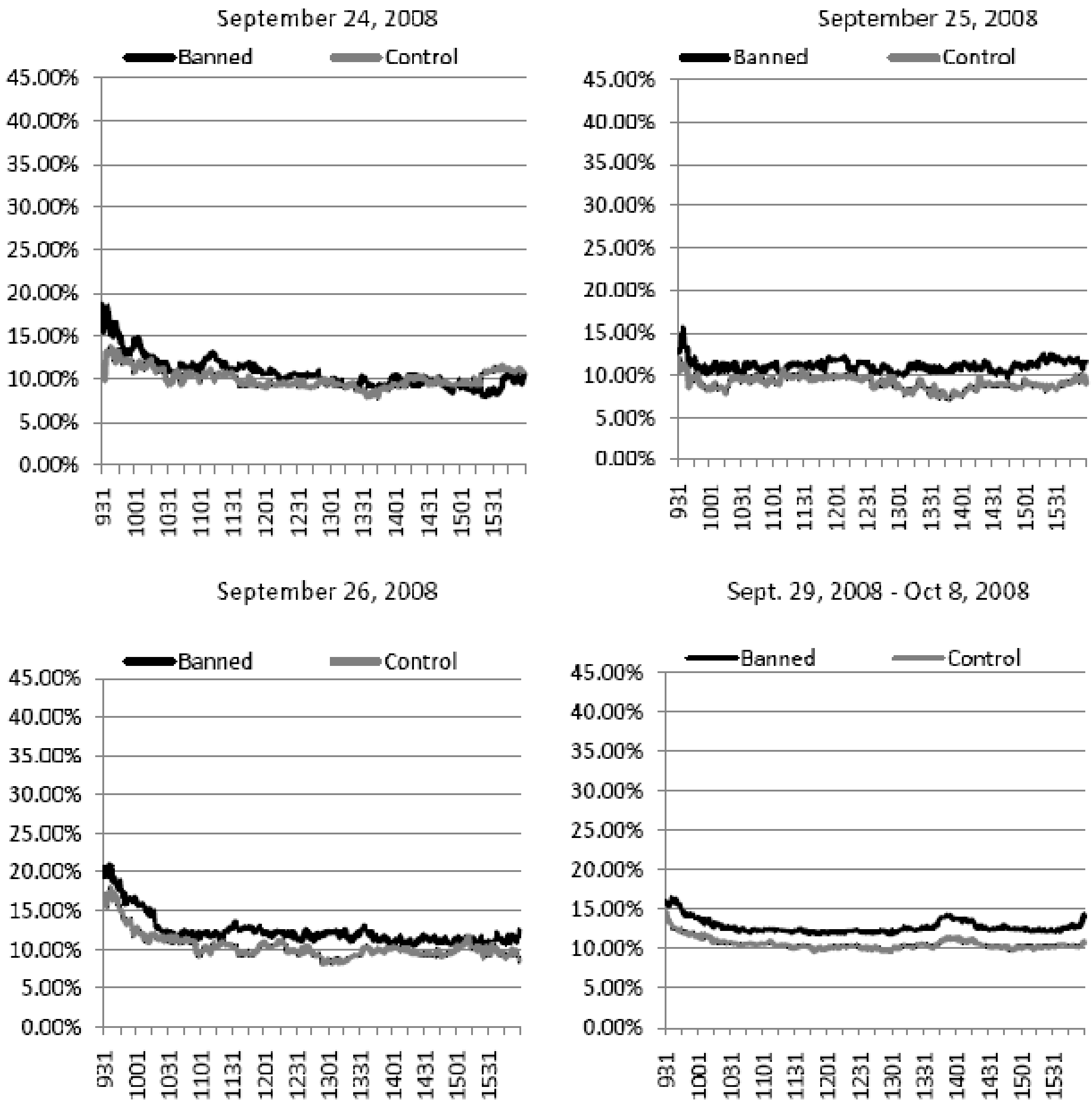
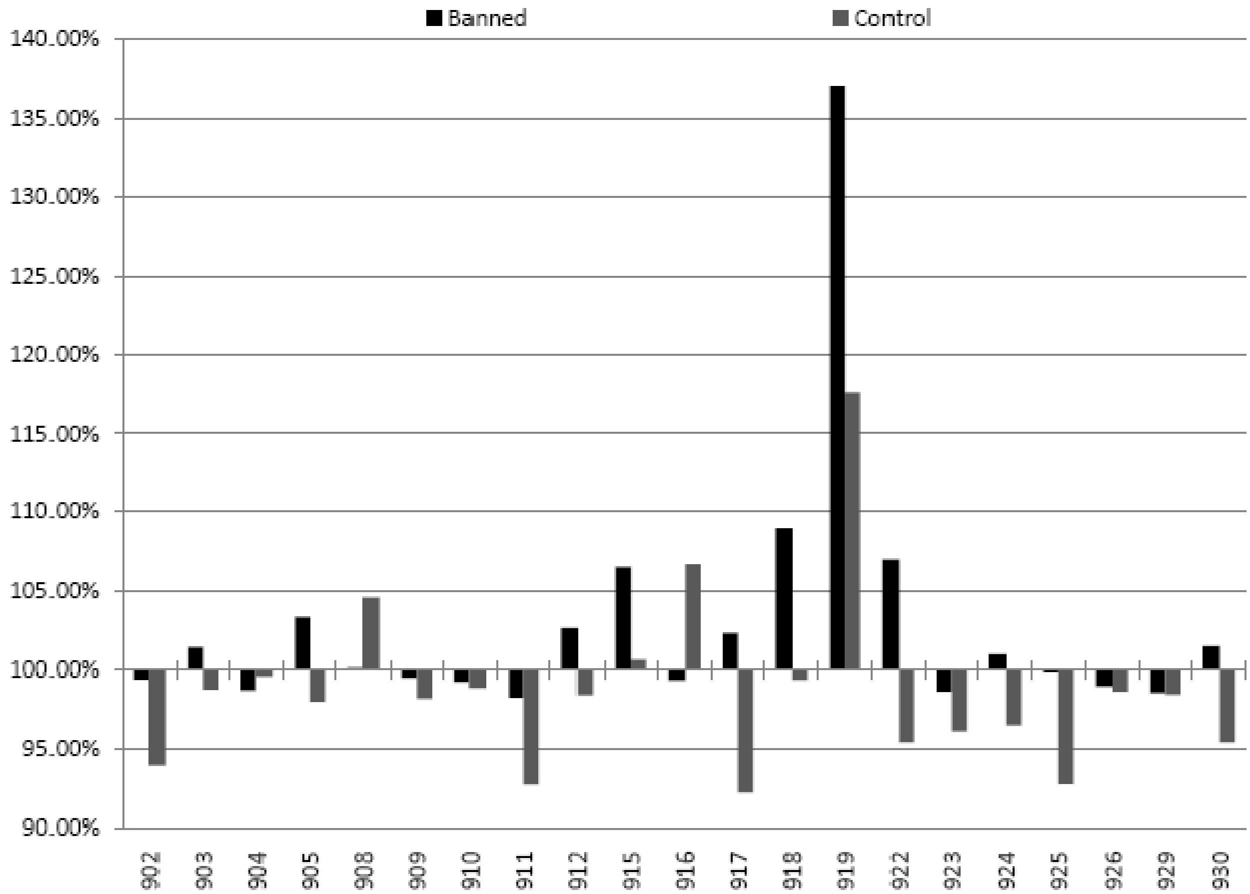


Figure 7 (continued). Average minute-by-minute relative spreads for puts on banned and control stocks.



Notes. Figures are constructed using October expiration puts with implied volatilities between 0.7 and 1.0 and with a stock-to-strike price ratio between 80% and 120%. We compute the National Best Bid and Offer (NBBO) by taking the highest valid bid and the lowest valid offer posted at one of the seven venues currently trading equity options in the United States. Next, for each put option we compute a relative spread by dividing the difference between the National Best Offer and the National Best Bid by the midpoint of the NBBO at the end of each minute. We compute the arithmetic average of these relative spreads at the end of each minute separately for put options on banned and control stocks and plot them for different days or sets of days. Banned includes the 330 optionable stocks for which short selling is banned on September 19th, 2008. Control refers to the set of optionable stocks not subject to the short sale ban that we match to the set of banned stocks.

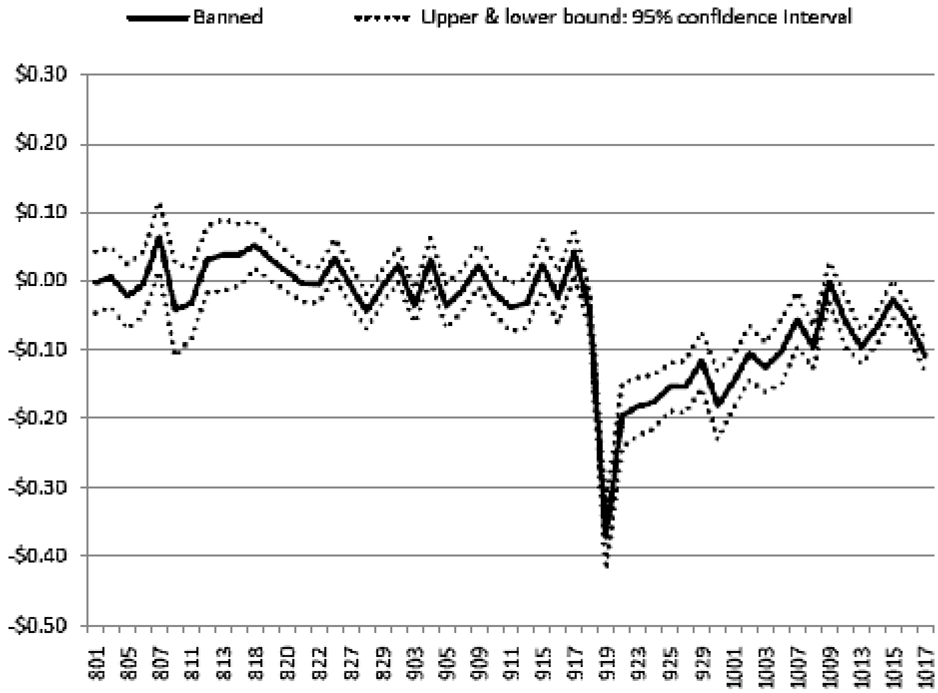
Figure 8. Ratio of the relative effective-to-relative quoted bid/ask spread for marketable orders placed with a major retail broker in September 2008.



Notes. We obtain 58,590 trades initiated by marketable orders for puts and calls on stocks for which short sales are banned on September 19, 2008 and on a set of control stocks from a retail broker during the month of September 2008. After imposing several data screens, we are left with 49,524 trades. For buy orders, effective spreads are twice the difference between the trade price and the midpoint of the order-receipt time (ORT) bid ask spread. For sell orders, effective spreads are twice the difference between the midpoint of the ORT bid ask spread and the trade price. Relative effective spreads are computed by dividing the effective spread by the midpoint of the ORT bid ask spread. Relative quoted spreads are computed by dividing the ORT bid ask spread by the midpoint of the ORT bid ask spread. We compute the contract-weighted ratio of effective-to-realized spread for each option class each day. We then compute the across-class average of these spreads separately for option classes on stocks in which short sales are banned on September 19, 2008 and for option classes on our set of control stocks and present these averages.

Figure 9. Average daily differences between synthetic spread midpoints implied by October 2008 expiration options and actual stock spread midpoints.

Panel A. Average daily difference for banned stocks.



Panel B. Average daily difference for control stocks.

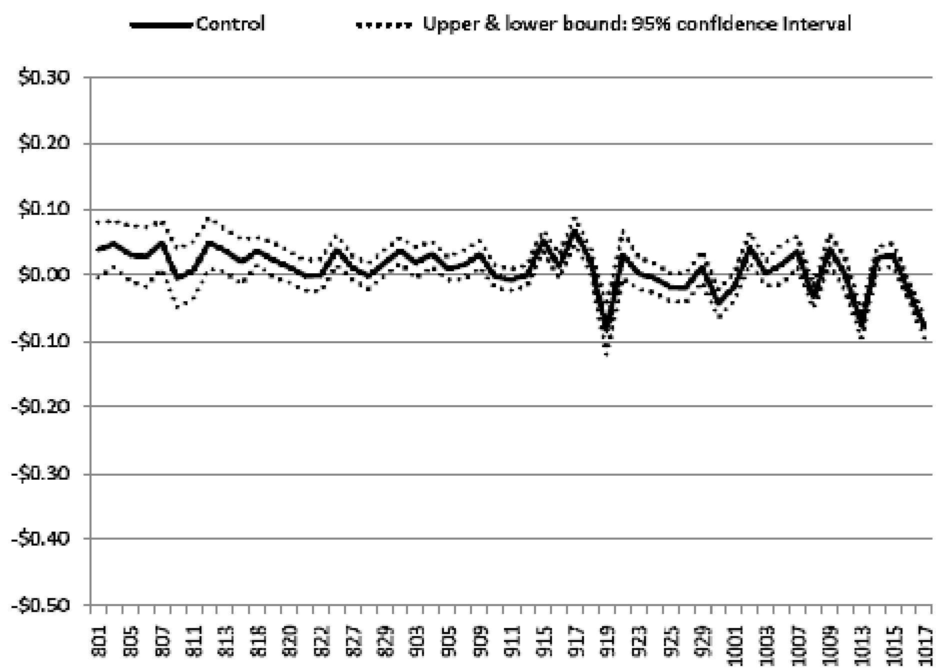


Figure 9 (continued)

Notes. Banned includes the 330 optionable stocks for which short selling is banned on September 19th, 2008. Control refers to the set of optionable stocks not subject to the short sale ban that we match to the set of banned stocks. We calculate synthetic buy and sell prices at the end of each minute of each day during the sample period using all pairs of call and put options with the same exercise price and expiration date. The cost to buy a share of stock synthetically is

$$Synthetic\ Stock^{Ask} = C^{Ask} + e^{-rT}X - P^{Bid} + EEP + \sum_{j=1}^{J} e^{-rt_j} D_j \quad .$$

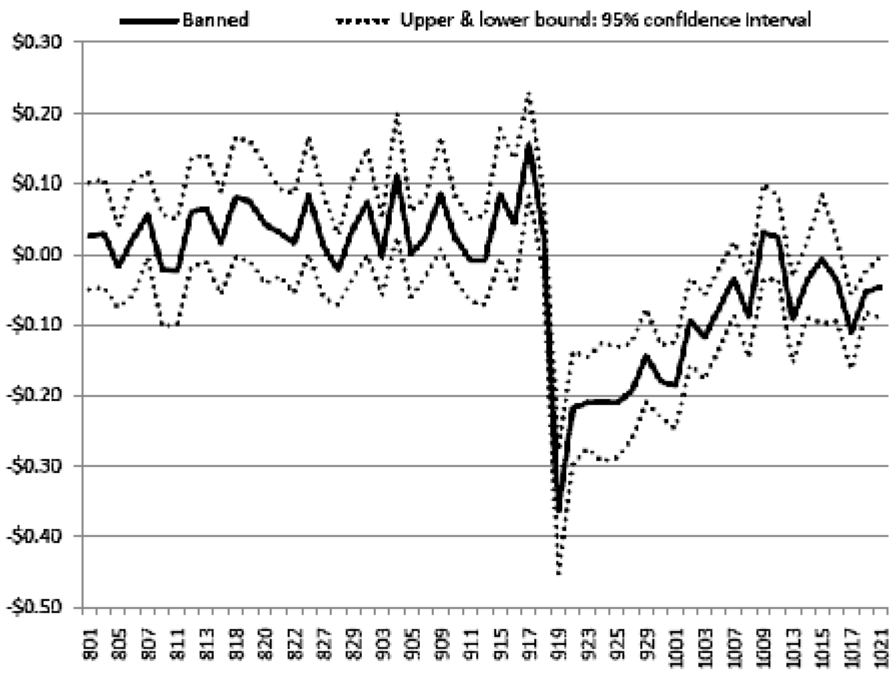
where Cask is the ask price of a call, r is the riskless rate, T is the time to expiration for the call and put, X is the exercise price, P^{Bid} is the bid price of a put with the same exercise price and expiration date as the call, EEP is the early exercise premium in the put price, t_j is the time until the stock pays its jth dividend before the option expires, and D_j is the amount of the jth dividend. We approximate the dividends expected to be paid over the life of the option with the actual dividends from CRSP for 2008, and the previous quarter's dividend for 2009. The early exercise price for the put is calculated using the method of Barone-Adesi and Whaley (1987). Similarly, the proceeds generated by selling a share of stock synthetically is

$$Synthetic\ Stock^{Bid} = C^{Bid} + e^{-rT}X - P^{Ask} + EEP + \sum_{j=1}^{J} e^{-rt_j} D_j \quad .$$

For every day from August 1, 2008 through October 17, 2008, we calculate the mean difference between the synthetic bid-ask midpoint and the actual stock bid-ask midpoint using all options expiring in October 2008 with a bias that is no greater than $2.00 in absolute value. Averages are computed with clustered standard errors.

Figure 10. Average daily differences between synthetic spread midpoints implied by December 2008 expiration options and actual stock spread midpoints.

Panel A. Average daily difference for banned stocks.



Panel B. Average daily difference for control stocks.

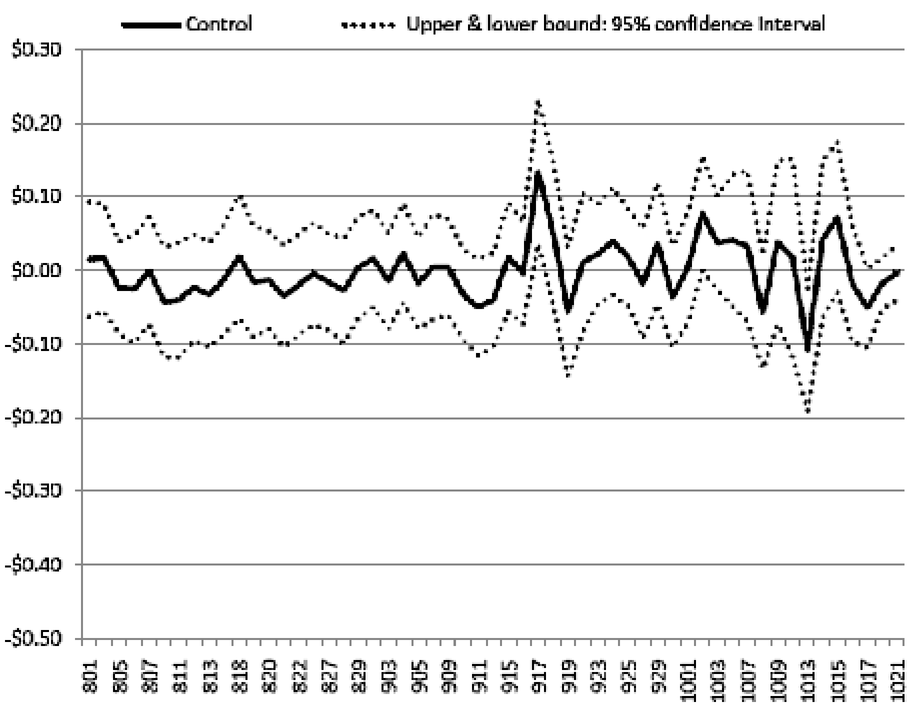


Figure 10 (continued)

Notes. Banned includes the 330 optionable stocks for which short selling is banned on September 19th, 2008. Control refers to the set of optionable stocks not subject to the short sale ban that we match to the set of banned stocks. We calculate synthetic buy and sell prices at the end of each minute of each day during the sample period using all pairs of call and put options with the same exercise price and expiration date. The cost to buy a share of stock synthetically is

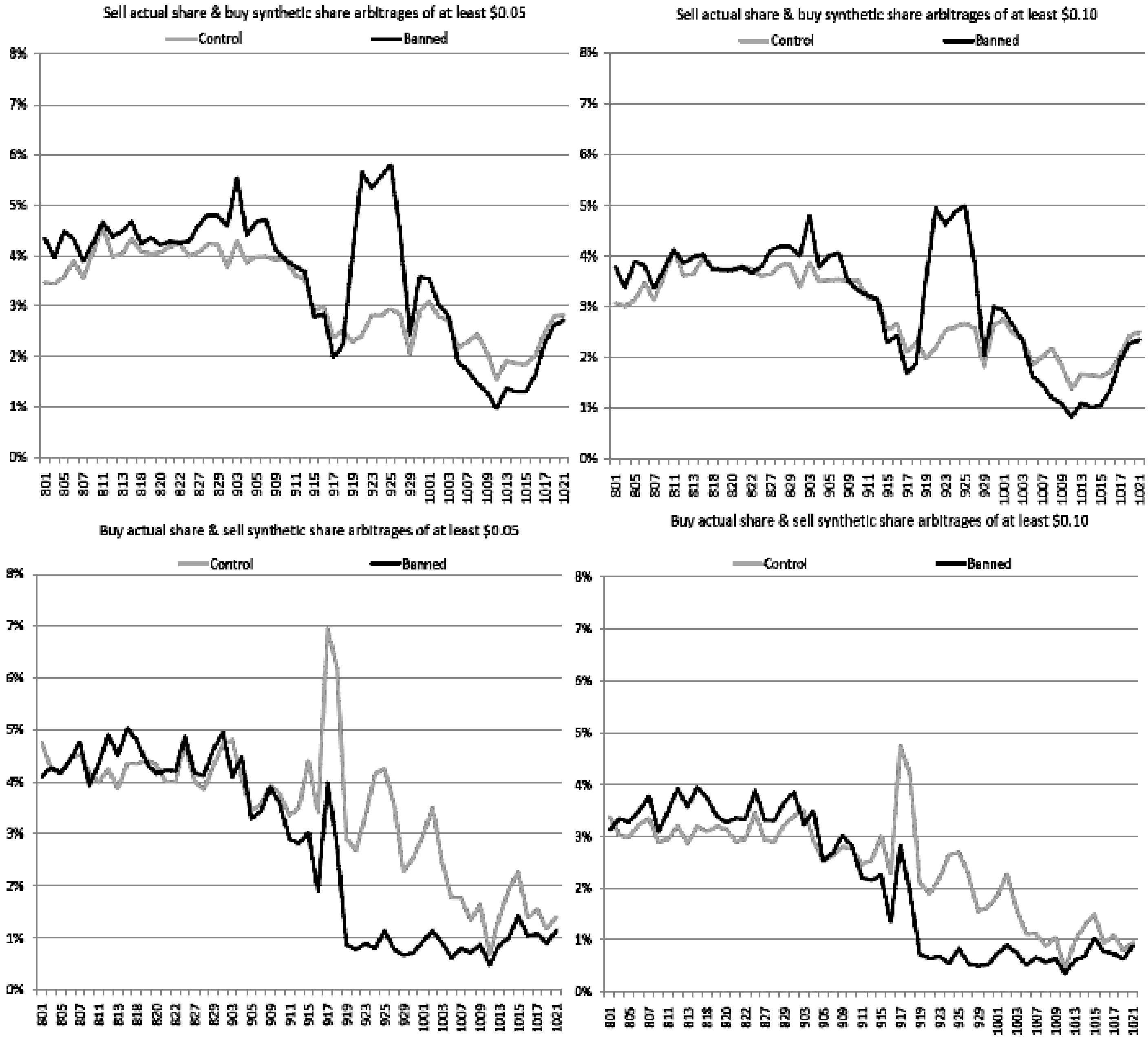
$$Synthetic\ Stock^{Ask} = C^{Ask} + e^{-rT}X - P^{Bid} + EEP + \sum_{j=1}^{J} e^{-rt_j} D_j \quad .$$

where Cask is the ask price of a call, r is the riskless rate, T is the time to expiration for the call and put, X is the exercise price, P^{Bid} is the bid price of a put with the same exercise price and expiration date as the call, EEP is the early exercise premium in the put price, t_j is the time until the stock pays its jth dividend before the option expires, and D_j is the amount of the jth dividend. We approximate the dividends expected to be paid over the life of the option with the actual dividends from CRSP for 2008, and the previous quarter's dividend for 2009. The early exercise price for the put is calculated using the method of Barone-Adesi and Whaley (1987). Similarly, the proceeds generated by selling a share of stock synthetically is

$$Synthetic\ Stock^{Bid} = C^{Bid} + e^{-rT}X - P^{Ask} + EEP + \sum_{j=1}^{J} e^{-rt_j} D_j \quad .$$

For every day from August 1, 2008 through October 17, 2008, we calculate the mean difference between the synthetic bid-ask midpoint and the actual stock bid-ask midpoint using all options expiring in December 2008 with a bias that is no greater than $2.00 in absolute value. Averages are computed with clustered standard errors.

Figure 11. Average daily frequency of apparent arbitrage opportunities during the trading day



Notes: