



# Back to the Futures: When Short Selling is Banned

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# Background: The 2008 Short-Selling Ban

- On September 19, 2008, the SEC issued a temporary ban on short selling of 799 financial stocks.

Sep 15 (Mon)	Sep 16 (Tue)	Sep 19 (Fri)	Sep 22 (Mon)	Oct 8 (Wed)
<ul style="list-style-type: none"><li>• Bank of America agreed to purchase Merrill Lynch for \$50 billion.</li><li>• Lehman Brothers filed for bankruptcy-court protection.</li></ul>	<ul style="list-style-type: none"><li>• The Federal government bailed out American International Group (AIG).</li></ul>	<ul style="list-style-type: none"><li>• The SEC announced a temporary ban on short selling of 799 financial stocks.</li></ul>	<ul style="list-style-type: none"><li>• NYSE and Nasdaq added more than 130 non-financial stocks to the short-selling ban list.</li><li>• These stocks include General Electrics, General Motors, and IBM.</li></ul>	<ul style="list-style-type: none"><li>• The short-selling ban was lifted.</li></ul>

*“This emergency action should prevent short selling from being used to drive down the share prices of issuers even where there is no fundamental basis for a price decline other than general market conditions.” – The SEC*

## Background (cont'd): Which stocks were banned in 2008?

- Most stocks on the initial list are financial stocks. They include:
  - (Large): Bank of America, Wells Fargo, JP Morgan, Goldman Sachs, etc...
  - (Small/regional): Capital Source, Prologis, Cape Bancorp, Horizon Bancorp, etc...
- Stocks on the additional list are firms with financial services or subsidiaries. They include:
  - (Large): General Motors, General Electric, IBM, Moody's, American Express, etc...
  - (Small): KBW Corp., Legg Mason, Doral Financial, Invesco, etc...

# The Literature & Purpose of This Paper

Several studies have examined the effects of the ban on stock and options markets:

- **Battalio and Schultz (2011)** and **Grundy, Lim, and Verwijmeren (2012)** examine the options markets during the ban period, and find that liquidity in options markets dried up during the ban period.
  - Trading costs of options increased. One explanation: options underwriters were unable to short underlying banned stocks to hedge their position during the ban period.
- **Boehmer, Jones, and Zhang (2013)** find that market quality of banned stocks deteriorated dramatically during the ban period.

Relatively less attention has been devoted to **the single-stock futures (SSFs)** market.

- ⇒ We examine the role played by SSFs trading, particularly its contribution to price discovery and market quality of underlying banned stocks during the ban period.
- ⇒ What are SSFs?

# What are Single-Stock Futures (SSFs)?

- Single-stock futures (SSFs) are standard futures contracts: an agreement to buy or sell a specified quantity of an underlying stock at a specified time in the future.
- SSFs began trading in Australia and Hong Kong in early 1990's and in Europe (mainly in the UK) in 2000.
  - Some exchanges were already trading SSFs on US stocks.
- Trading SSFs were prohibited in the US, as part of the Shad-Johnson Accord of 1982.
  - The Shad-Johnson Accord is an agreement reached between then chairman of the SEC (John S. R. **Shad**) and then chairman of the Commodity Futures Trading Commission (Phil **Johnson**).
- The Commodity Futures and Modernization Act (CFMA) repealed the prohibition and trading SSFs became legal since 2000 in the US.

## Why legalizing SSFs in the US?

- There was the need for the US markets to stay competitive with other markets (Esau, 2002).
- Alan Greenspan noted:  
*Already the largest futures exchange in the world is no longer in the American heartland; instead, it is now in the heart of Europe. To be sure, no U.S. exchange has yet to lose a major contract to a foreign competitor. But it would be a serious mistake for us to wait for such unmistakable evidence of a loss of international competitiveness before acting.*
- After the legalization of SSFs trading, two exchanges, OneChicago and Nasdaq-Liffe (NQLX), were founded and started trading SSFs in November 2003.
- OneChicago and NQLX initially listed 86 SSFs, including:
  - Apple, Boeing, Coca-Cola, Dell, Exxon Mobil, Ford, General Motors, etc...
- Only OneChicago survived to date, with currently over 1,800 listings.
- By 2016, the US SSFs market was still ranked outside of the top 10 exchanges by number of SSFs contracts traded (World Federation of Exchanges IOMA Derivatives Report, 2016).

# Research Questions

- #1. Did trading activities and particularly trading volume of single-stock futures (SSFs) on banned stocks, increase during the 2008 short-selling ban period?
- #2. What are the effects of SSFs trading on price discovery of underlying banned stocks during the ban period?
- #3. What are the effects of SSFs trading on the market quality of underlying banned stocks during the ban period?

Considering the fact that **trading of SSFs in US is still lagging behind other markets**, it is important to understand the roles of SSFs trading in financial markets and answers to these questions are essential to our understanding of the importance of SSFs.

# Motivation (RQ1)

#1. Did trading activities and particularly trading volume of single-stock futures (SSFs) on banned stocks increase during the 2008 short-selling ban period?

## One key question:

*Where did bearish investors and market participants with hedging demand go during the short-selling ban period?*

### 1. Trading options?

- A theoretical model by **Easley, O'Hara, and Srinivas (1998)** predicts that when short selling is constrained, informed traders are more likely to trade options.
  - The options market can be an alternative when short selling is prohibited.
- In fact, **Grundy, Lim, and Verwijmeren (2012)** find evidence that options trading volume did not increase for banned stocks during the ban period.
  - Put options underwriters need to take an offsetting short position in underwriting stocks to hedge their positions, but short selling was prohibited during the ban period.

## Motivation (RQ1, cont'd)

### 2. Trading single-stock futures (SSFs)?

- Trading SSFs can be considered as a substitute for short selling (**Danielsen, Van Ness, and Warr, 2009**):
  - Shorting SSFs and short selling underlying stocks share the same linear payoff function.
  - Trading SSFs requires lower margin requirements than short selling does.
  - It is easier to execute SSFs trading, because there is no uptick rule or necessity to borrow shares to short when shorting SSFs.
- During the UK short-selling ban period (September 18, 2008 – January 16, 2009), SSFs trading volume increased for banned stocks in the London market (**Benzennou, Gwilym, and Williams, 2017**).
- **Grundy, Lim, and Verwijmeren (2012)** perform a preliminary examination on SSFs trading volume during the ban period, but the evidence presented is largely inconclusive.

# Motivation (RQ1, cont'd)

Why trading SSFs during the ban period?

➤ Advantages of trading SSFs over short-selling:

- Lower initial margin requirements (as set by **the SEC [Release No. 34 – 44853] on September 7, 2004**):
  - SSFs (20%) vs Stocks (50%)
- Less costly to initiate a short position:
  - No uptick rule
  - No need to borrow shares to short

➤ Advantages over trading options:

- Lower initial margin requirements (as set by **the SEC [Release No. 34 – 44853] on September 7, 2004**):
  - SSFs (20%) vs Options (20% + 100% of options premium)
  - The margin requirement for a short position in an ATM option is 100 percent of the option proceeds plus 20 percent of the underlying security.
- Shorting SSFs is a more direct and efficient way of hedging: **sport-futures parity**.
- It is more costly to use options to replicate a synthetic future.
  - For example, to create a synthetic short, investors must buy a call and sell a put with identical strike prices and maturity. (⇒ Twice the transaction cost.)

## Motivation (RQ2)

#2. What are the effects of SSFs trading on price discovery of underlying banned stocks during the ban period?

Existing literature has examined the extent to which SSFs trading contributes to price discovery of underlying stocks.

- Although the SSFs market is small in the US, SSFs prices are informative:
  - **Shastri, Thirumalai, and Zutter (2008)** analyze 137 SSFs traded on the OneChicago Exchange, and find that SSFs trading contributes 24% of the price discovery for underlying stocks during the January 2003 – July 2005 period.
- Is SSFs trading informative during the ban period?

## Motivation (RQ2, cont'd)

During the ban period, SSFs have the potential to help the discovery of underlying stock prices:

- Short sellers are typically considered as informed traders (**Diamond and Verrechia, 1987**).
- **Danielsen, Van Ness, and Warr (2009)** propose SSFs as a low cost substitute for short-selling. Analyzing data on 111 stocks that had SSFs during the November 2002 – December 2003 period, they find that after SSFs are introduced, short-selling in the underlying security declined significantly.
- Options traders can also be considered as informed traders, as the higher leverage available in the options market attracts informed investors to trade options (**Black, 1975**).
- However, during the short-selling ban period, short-selling in banned stocks was prohibited and options trading also declined dramatically (**Grundy, Lim, and Verwijmeren (2012)**).
- There is the potential that the ban induced more informed traders to migrate to the SSFs market.
- If the trading volume of SSFs indeed increased during the ban period, we expect SSFs trading's contribution to price discovery for banned stocks to be larger.

## Motivation (RQ3)

**#3.** What are the effects of SSFs trading on stocks' market quality during the ban period?

- **Boehmer, Jones, and Zhang (2013)** examine the effect of the ban on market quality of banned stocks.
    - They find that market quality of banned stocks deteriorated dramatically during the ban period, especially stocks in the largest market cap quartiles.
- ⇒ For banned stocks with SSFs trading during the ban period, SSFs trading may mitigate the negative effect of the ban on market quality.

# Main Findings

## RQ#1:

- First, we witnessed a sharp increase in the number of SSFs listings on the OneChicago exchange during the ban period. Prior to the ban, only 64 banned stocks had SSFs. During the ban, the exchange introduced SSFs on 275 additional banned stocks.
- Second, we find SSFs trading volume increased significantly by 9.9 percent for banned stocks during the ban period.
  - ⇒ Our results support the argument that SSFs trading and short selling are substitutes, and suggest that SSFs trading served as an alternative to short selling during the ban period.

## Main Findings (cont'd)

**RQ#2:** The contribution of SSFs trading to price discovery of banned stocks increased significantly during the ban period.

- Compared to the pre-ban period (before September 1, 2008), the contribution of SSFs trading to price discovery is significantly higher during the period covering the ban.
- The result is robust to the inclusion of stock-level characteristics such as market cap, trading volume, and return of underlying stocks.

**RQ#3:** SSFs trading helped mitigate the negative effect of the ban on market quality of banned stocks during the ban period.

- Consistent with **Boehmer, Jones, and Zhang (2013)**, we find that market quality of banned stocks worsened significantly during the ban period.
- During the ban period, banned stocks with SSFs had significantly better (less negative) market quality than those without SSFs.

⇒ Together, our results suggest that SSFs plays an important role when short-selling is constrained.

## Main Findings- Further Analysis

We test the robustness of our results by:

1. Controlling for options trading of banned stocks, because we can view trading options as an alternative to short-selling during the ban period.
2. Comparing banned stocks to non-banned stocks to test whether the results are specific to the banned stock sample using a difference-in-differences approach.

We find that our results are robust when controlling for options trading and when compared to non-banned stocks.

# Data

- Main data used in our study comprise 976 stocks that were subject to the 2008 short-selling ban.
  - 339 banned stocks had SSFs contracts during the ban period.
- Main sample period is from June 1, 2008 – January 31, 2009.
  - Ban period: September 19 – October 8, 2008.
- The list of banned stocks is obtained from the SEC, NYSE, and Nasdaq websites.
- Information on SSFs listings is from the OneChicago Exchange.
- We use:
  - Daily data on underlying stocks (including stock price and volume) from the CRSP.
  - Daily data on SSFs contracts (including price and volume) from Bloomberg.
  - Intraday data on underlying stocks (including bid and ask prices) from the TAQ database.
  - Daily data on options contracts from the OptionMetrics.
  - Annual data on underlying stocks accounting information from the Compustat.

# Table 1: Number of Banned Stocks and Stocks with SSFs

		# of stocks with SSFs prior to the ban	# of stocks with SSFs introduced during the ban period
<b># of banned stocks</b>			
Total	976		
With SSFs	339	64	275
Without SSFs	637	-	-
<b># of non-banned stocks</b>			
With SSFs	474	451	23

# Empirical Analysis

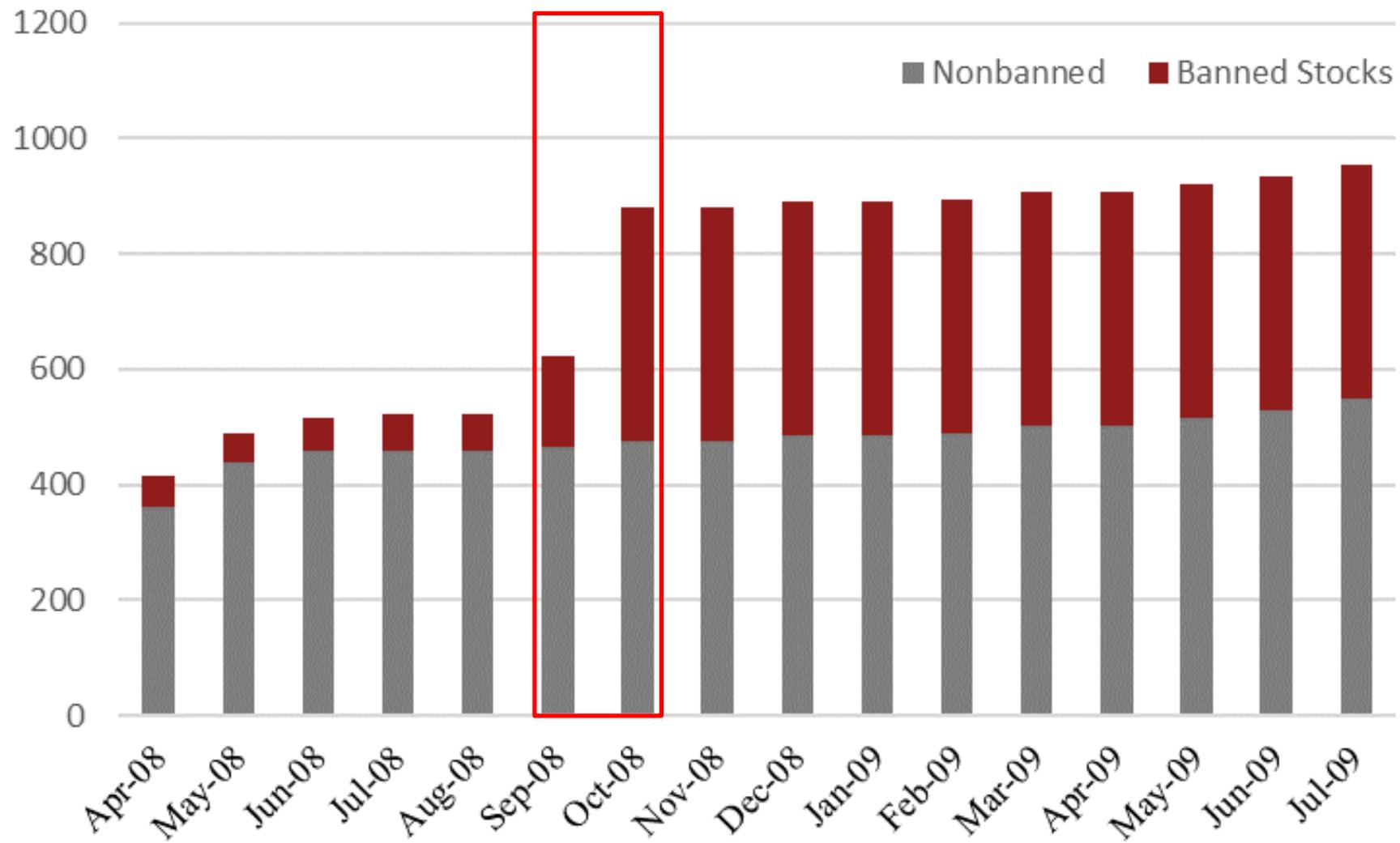
# Empirical Analysis- RQ1

#1. Did trading activities and particularly trading volume of single-stock futures (SSFs) on banned stocks increase during the 2008 short-selling ban period?

## What We Do:

- We analyze stocks with SSFs listed on the OneChicago exchange, and examine the exchange's listing activities around the short-selling ban period.
  - We examine changes in SSFs trading volume of banned stocks between the ban and non-ban periods.
- ⇒ Perform a more thorough analysis to compliment preliminary results presented in **Grundy, Lim, and Verwijmeren (2012)**.

# Figure 1: Cumulative SSFs Listings Around the Short-Selling Ban Period



# Table 2 Panel A: Characteristics of banned stocks with SSFs

	N	Mean	Median
<b>Group 1: Banned stocks with SSFs listed prior to the ban</b>			
<i>Size</i>	64	22.80	23.05
<i>Price</i>	64	3.555	3.678
<i>Illiquidity</i>	64	0.007	0.0004
<i>BM</i>	64	1.066	0.822
<i>Turnover</i>	64	0.272	0.213
<i>Momentum</i>	64	0.054	0.056
<i>Volatility</i>	64	0.019	0.016
<b>Group 2: Banned stocks with SSFs listed during the ban period</b>			
<i>Size</i>	274	20.46	20.35
<i>Price</i>	274	3.134	3.066
<i>Illiquidity</i>	274	0.039	0.011
<i>BM</i>	273	0.857	0.742
<i>Turnover</i>	274	0.116	0.058
<i>Momentum</i>	274	0.03	0.031
<i>Volatility</i>	274	0.019	0.018
<b>Difference (Group 2 - Group 1)</b>			
<i>Size</i>		-2.34*** (-14.77)	-2.701*** (-7.20)
<i>Price</i>		-0.421*** (-4.88)	-0.612*** (-5.27)
<i>Illiquidity</i>		0.032*** (4.72)	0.011*** (6.93)
<i>BM</i>		-0.208*** (-2.82)	-0.079 (-1.13)
<i>Turnover</i>		-0.156*** (-5.59)	-0.156*** (-6.65)
<i>Momentum</i>		-0.024*** (-2.64)	-0.025*** (-3.48)
<i>Volatility</i>		0.0003 (0.38)	0.002 (1.39)

## Table 2 Panel B:

# How many banned stocks would have had SSFs introduced, had there not been the short-selling ban?

$$\text{Probit (SSFs listing)} = -17.22 + 0.76 \text{ Size} - 0.23 \text{ Price} - 1.41 \text{ Illiquidity} + 0.09 \text{ BM} + 0.78 \\ \text{Turnover} - 0.70 \text{ Momentum} + 23.59 \text{ Volatility}$$

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### Probability of SSFs listing if there were no short-selling ban:

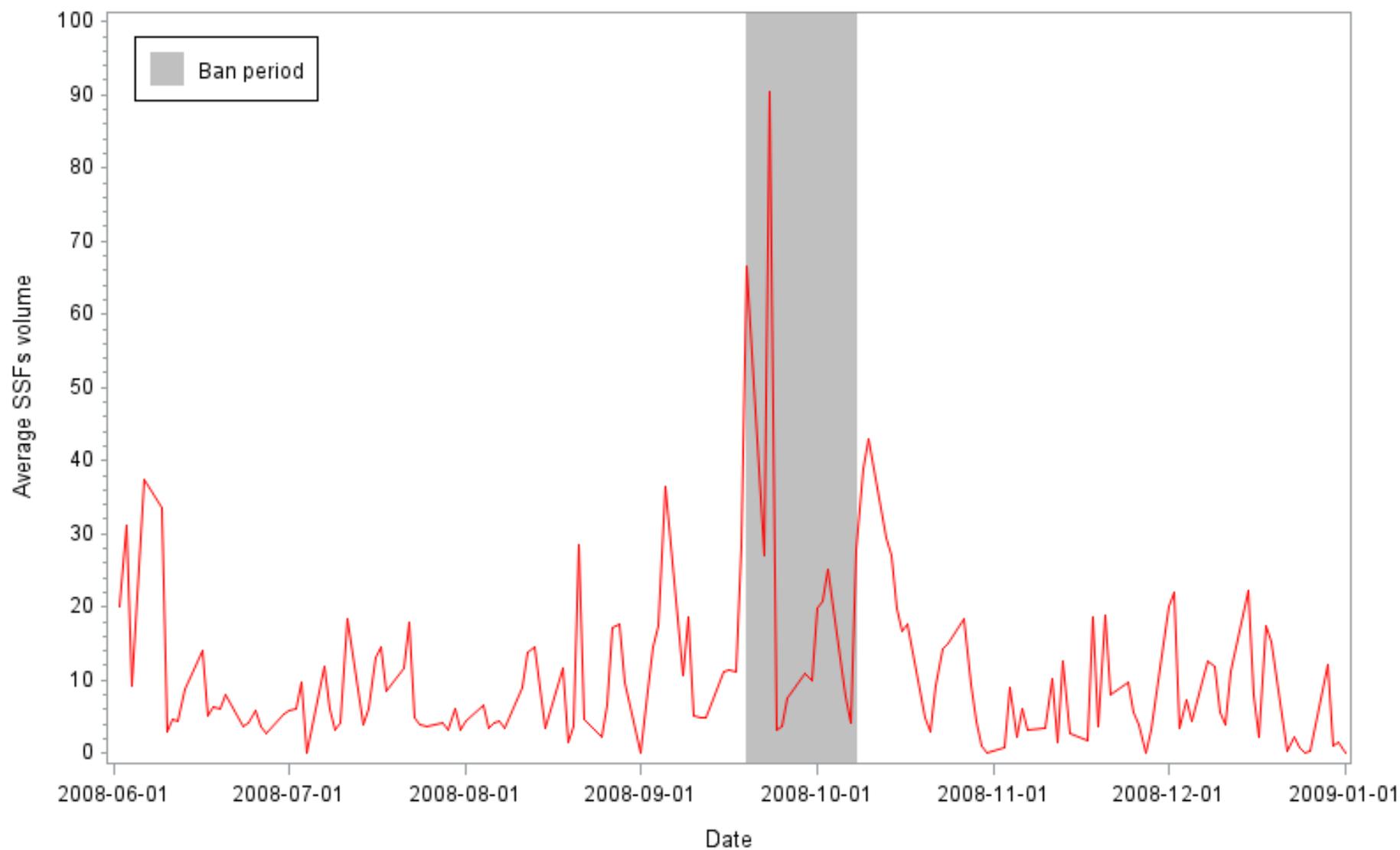
N	274
Mean	7.25%
Median	2.96%

### Number (percentage) of banned stocks with a given probability:

75 - 100%	4	(1.46%)
50 - 75%	1	(0.36%)
25 - 50%	11	(4.01%)
10 - 25%	49	(17.88%)
< 10%	209	(76.28%)
Total	274	(100%)

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# Figure 2: Average Daily SSFs Trading Volume Around the Short-Selling Ban Period



## Table 3: Average Daily SSFs Trading Volume

	Pre	Ban	Post	Difference (t-value)			
				Ban - Pre		Ban - Post	
<b>Panel A (Time window: April 1, 2008 - January 31, 2009)</b>							
<b>Banned stocks with SSFs</b>							
# of stocks	64	336	336				
Average daily SSFs trading volume	1778.1	971.4	135.3	-806.7	(-1.27)	836.1***	(9.07)
<b>Banned stocks with SSFs prior to the ban period</b>							
# of stocks	64	64	64				
Average daily SSFs trading volume	1778.1	2318.5	848.0	540.4	(0.54)	1470.5***	(4.11)
<hr/>							
	Pre	Ban	Post	Difference (t-value)			
				Ban - Pre		Ban - Post	
<b>Panel B (Time window: June 1, 2008 - January 31, 2009)</b>							
<b>Banned stocks with SSFs</b>							
# of stocks	64	336	336				
Average daily SSFs trading volume	1107.18	971.4	135.2709	-135.8	(-0.43)	836.1	(9.07)
<b>Banned stocks with SSFs prior to the ban period</b>							
# of stocks	64	64	64				
Average daily SSFs trading volume	1107.2	2318.5	848.0	1211.3***	(2.49)	1470.5***	(4.11)

## Table 3 (cont'd):

	Pre	Ban	Post	Difference (t-value)			
				Ban - Pre		Ban - Post	
<b>Panel C (Time window: June 1, 2008 - January 31, 2009 with two-week gaps)</b>							
<b>Banned stocks with SSFs</b>							
# of stocks	64	336	336				
Average daily SSFs trading volume	1059.4	971.4	102.2	-88.1	(-0.26)	869.1***	(9.85)
<b>Banned stocks with SSFs prior to the ban period</b>							
# of stocks	64	64	64				
Average daily SSFs trading volume	1059.4	2318.5	646.2	1259.1***	(2.38)	1672.3***	(4.86)

- Pre-ban period is April 7, 2008 – September 18, 2008 (Panel A); June 1, 2008 – September 18, 2008 (Panel B); June 1, 2008 – August 31, 2008 (Panel C)
- Ban period is September 19, 2008 – October 8, 2008.
- Post-ban period is October 9, 2008 – January 31, 2009 (Panels A and B); November 1, 2008 – January 31, 2009 (Panel C)

# Regression Analysis

We analyze 64 banned stocks with SSFs (prior to the ban period) to examine whether SSFs trading volume increased for banned stocks during the ban period.

- Multivariate regression:

$$SSF\ volume_{it} = \alpha_i + \beta_1 Ban\ period_{it} + \boldsymbol{\theta}' \mathbf{X}_{it} + \varepsilon_{it}$$

- $SSF\ volume_{it}$ : Log of SSFs trading volume of stock  $i$  on day  $t$ .
- $Ban\ period_{it}$ : A dummy variable that is equal to 1 for observations made during the ban period (September 19, 2008 – October 8, 2008), and zero otherwise.
- $X_{it}$ : Control variables:
  - $Stock\ return_{it}$ : Daily return on underlying stock  $i$  on day  $t$ .
  - $Turnover_{it}$ : Daily trading volume of underlying stock  $i$ , divided by shares outstanding on day  $t$ .
  - $VIX_t$ : The level of the CBOE S&P500 Volatility Index on day  $t$ .

## Table 4: Regression Results

Variables	(1)*	(2)**
<b>Ban period<sub>it</sub></b>	0.093** (0.044)	0.099** (0.045)
<b>Stock return<sub>it</sub></b>	0.096 (0.116)	0.188 (0.123)
<b>Turnover<sub>it</sub></b>	0.302*** (0.067)	0.395*** (0.150)
<b>VIX<sub>t</sub></b>	-0.000 (0.001)	0.000 (0.001)
<b>Firm FE</b>	Yes	Yes
<b>N</b>	10,181	8,274
<b>Adj.R<sup>2</sup></b>	0.407	0.399

\*Time window: June 1, 2008 – January 31, 2009

\*\* Time window: June 1, 2008 – January 31, 2009 with two-week gaps before and after the ban period.

# Empirical Analysis- RQ2

# Empirical Analysis- RQ2

#2. What are the effects of SSFs trading on price discovery of underlying banned stocks during the ban period?

## What We Do:

- We examine changes in the contribution of SSFs trading to underlying stock price discovery before, during, and after the ban period.
- We use the **Hasbrouck's (1995)** vector error correction model (VECM) approach to estimate SSFs' trading's contribution to price discovery over 4 different time periods around the short-selling ban period.

# Methodology: Measuring Price Discovery

- Consider the case where stock ( $S_t$ ) and SSFs ( $F_t$ ) prices of the same underlying security share the efficient price, denoted as  $m$ , and suppose that  $m$  follows a random walk:

$$m_t = m_{t-1} + \mu_t, \text{ where } E(\mu_t) = 0; E(\mu_t^2) = \sigma^2.$$

- Then price vector  $P_t$  can be expressed as:  $P_t = \begin{bmatrix} S_t \\ F_t \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix} m_t + \begin{bmatrix} \varepsilon_{S,t} \\ \varepsilon_{F,t} \end{bmatrix}$
- Following **Hasbrouck's (1995)** general vector error correction model (**VECM**) specification,  $P_t$  can be expressed in terms of an error correction model of order N as:

$$\Delta p_t = \phi_1 \Delta p_{t-1} + \phi_2 \Delta p_{t-2} + \dots + \beta(z_{t-1} - b) + \epsilon_t,$$

where  $z_{t-1} - b$  is an error correction term with  $z_{t-1} = S_{t-1} - F_{t-1}$  and  $b = E(z_t)$ .

## Methodology: Measuring Price Discovery (cont'd)

- Alternatively, the price vector can be expressed as a VMA model:

$$\Delta p_t = \epsilon_t + \psi_1 \epsilon_{t-1} + \psi_2 \epsilon_{t-2} + \dots,$$

where  $\epsilon_t = [\epsilon_{S,t} \quad \epsilon_{F,t}]'$  is a vector process, where the two components reflect the innovations revealed in the stock and SSFs markets, and  $\psi_i$ 's are  $(2 \times 2)$  matrices, and  $Var(\epsilon_t) = \Omega$ .

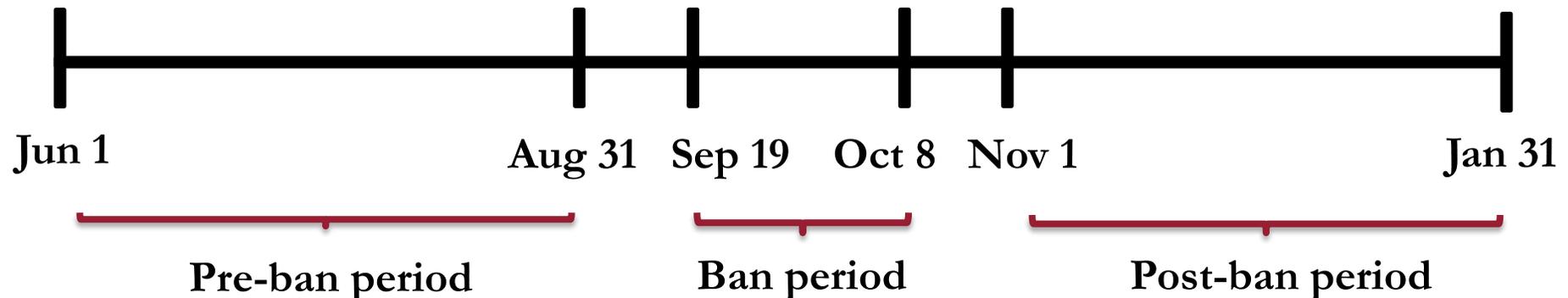
- The sum of the MA coefficients, defined as  $\psi(1) = I + \psi_1 + \psi_2 + \dots$ , has identical rows  $\psi$ , and  $\psi$  reflects the impact of innovation on the permanent price component.
- The total variance of price innovations can be calculated as  $\psi\Omega\psi'$ , and we decompose the total variance by using the Cholesky decomposition to obtain each market's contribution to price discovery.
- Therefore, SSFs market's contribution to price discovery can be measure by:

$$Contribution = \frac{\psi_F^2 \Omega_{FF}}{\psi \Omega \psi'}$$

# Event Windows

To ensure that we have sufficient number of observations to estimate the VECM model, we estimate price discovery variable *Contribution* over 4 different estimation windows:

- **Pre-ban period:** June 1, 2008 – August 31, 2008
- **Pre-ban + Ban period:** June 1, 2008 – October 8, 2008 (with a two-week gap prior to the ban's initiation date)
- **Post-ban + Ban period:** September 19, 2008 – January 31, 2009 (with a two-week gap after the ban's lifting date)
- **Post-ban period:** November 1, 2008 – January 31, 2009



**Table 5: Contribution of SSFs Trading to Price Discovery around the Short-Selling Ban**

**Panel A: Pre-ban and ban periods**

	<b>Pre (A)</b>	<b>Pre + Ban (B)</b>	<b>Difference (t-value) B-A</b>	
<b>Number of stocks</b>	61	58		
<b>Mean</b>	0.175	0.271	0.096***	(2.58)
<b>Median</b>	0.095	0.212	0.117***	(2.24)

**Panel B: Post-ban and ban periods.**

	<b>Post (A)</b>	<b>Post + Ban (B)</b>	<b>Difference (t-value) B-A</b>	
<b>Number of stocks</b>	59	61		
<b>Mean</b>	0.235	0.280	0.044	(0.95)
<b>Median</b>	0.182	0.215	0.033	(1.02)

# Regression Analysis

- We analyze 64 banned stocks with SSFs (prior to the ban period) to examine whether SSFs trading contributes to price discovery significantly more during the ban period.
- Multivariate regression:

$$\text{Contribution}_{it} = \alpha_i + \beta_1 \text{Ban period}_{it} + \boldsymbol{\theta}' \mathbf{X}_{it} + \varepsilon_{it}$$

$\mathbf{X}_{it}$ : Control variables including: *Market cap, Trading volume, and Stock return.*

## Table 6: Regression Results

Comparison:	<u>Pre-Ban and Ban Periods</u>	<u>Post-ban and Ban period</u>
	(1)	(2)
<i>Ban period<sub>it</sub></i>	0.092** (0.040)	0.044 (0.049)
<i>Market cap<sub>it</sub></i>	-0.029** (0.014)	-0.003 (0.021)
<i>Trading Volume<sub>it</sub></i>	0.038** (0.016)	0.020 (0.022)
<i>Stock return<sub>it</sub></i>	(1.213) (4.188)	-0.628 (3.945)
<i>Constant</i>	0.064 (0.187)	-0.034 (0.213)
N	119	120
Adj. R <sup>2</sup>	0.070	-0.013

# Empirical Analysis- RQ3

# Empirical Analysis- RQ3

#3. What are the effects of SSFs trading on stocks' market quality during the ban period?

## What We Do:

- We examine how SSFs trading affected market quality of banned stocks during the ban period.
- ⇒ We follow **Boehmer, Jones, and Zhang (2013)** to construct market quality measures, and examine whether market quality of banned stocks with SSFs trading differs from that of banned stocks without SSFs trading during the ban period.

# Variable Construction

1. Relative quoted spread:  $RQS_{it} = \frac{Ask_{it} - Bid_{it}}{M_{it}}$ 
  - RQS measures the cost of immediacy; it captures how costly it is to buy and sell at the best quoted prices simultaneously.
2. Relative effective spread:  $RES_{it} = \frac{2D_{it}(P_{it} - M_{it})}{M_{it}}$ 
  - RES incorporates hidden orders information by using the NBBO midpoint to account for transactions made within the quoted bid and ask prices
3. Relative realized spread:  $RRS5_{it} = \frac{2D_{it}(P_{it} - M_{it+5})}{M_{it}}$ 
  - RRS measures the profit earned by the liquidity supplier between time  $t$  and  $t+5$  if the position is held for five minutes.
4. 5-minute price impact:  $RPI5_{it} = \frac{D_{it}(M_{it+5} - M_{it})}{M_{it}}$ 
  - RPI5 measures how much a given trade at time  $t$  tends to push the price at  $t+5$  (over the next five minutes).

These market quality measures are used by **Boehmer, Jones, and Zhang (2013)** and **Brogaard, Hendershott, and Riordan (2017)**

## Variable Construction (cont'd)

- Trade direction,  $D_{it}$ , takes value of : +1 (-1) for a buyer (seller) initiated trade according to the **Lee and Ready (1991)** algorithm.
- The **LR** algorithm classifies a transaction by a combination of:
  - 1) classifying a trade according to the quote rule: A buy (sell) if the trade price is above (below) the midpoint.
  - 2) classifying a mid-point transaction by the tick rule: A buy (sell) if the trade price is above (below) the previous price.
- **Bessenbinder (2003)** analyzes 300 stocks from NYSE and Nasdaq before and after the 2001 decimalization, and shows that the decimalization in 2001 resulted in narrower bid-ask spreads and thus reduced trade execution costs.
- Narrower spreads as a result of decimalization may make prices closer to the midpoint, leading to a potential misclassification of the LR trading direction.
- We follow **Holden (2014)** to construct these market quality variables adjusted for these potential misclassification problems.

## Table 7: Market Quality of Banned Stocks Around the Short-Selling Ban Period

	Pre-ban	Ban	Post-ban	Difference			
				Ban - Pre-ban (t-value)		Ban - Post-ban (t-value)	
<b>All banned stocks</b>							
Number of stocks	957	957	957				
Relative quoted spread	1.720%	2.821%	2.894%	1.095%***	(28.54)	0.077%	(-1.40)
Relative effective spread	1.459%	2.777%	2.598%	1.311%***	(36.85)	0.171%***	(3.19)
Relative realized spread	0.979%	1.882%	1.699%	0.090%***	(27.95)	0.185%***	(3.91)
5-minute price impact	0.484%	0.869%	0.882%	0.386%***	(22.56)	-0.013%	(-0.51)
<b>Banned stocks with SSFs prior to the ban period</b>							
Number of stocks	64	64	64				
Relative quoted spread	0.116%	0.225%	0.249%	0.109%***	(15.94)	-0.024%***	(-2.15)
Relative effective spread	0.141%	0.335%	0.303%	0.193%***	(12.79)	0.031%	(1.42)
Relative realized spread	0.064%	0.161%	0.152%	0.096%***	(6.92)	0.008%	(0.40)
5-minute price impact	0.074%	0.168%	0.149%	0.093%***	(11.96)	0.018%	(1.08)

# Regression Analysis

We analyze 957 banned stocks to examine the effect of SSFs trading on market quality during the ban period.

- The following panel regression with firm-fixed effects is estimated:

$$\text{Eq. 1: } \text{Market quality}_{it} = \alpha_i + \beta_1 \text{SSF}_{it} + \beta_2 \text{Ban period}_{it} + \beta_3 (\text{Ban period}_{it} \times$$

$$\text{Eq. 2: } \text{Market quality}_{it} = \alpha_i + \beta_1 \text{SSF}_{it} + \beta_2 \text{Ban period}_{it} + \beta_3 (\text{Ban period}_{it} \times$$

## Indicator variables

- $\text{Ban period}_{it}$
- $\text{SSF}_{it}$
- $\text{Active SSF}_{it}$ ,

Equal to one if stock  $i$  had SSF trading on day  $t$ , and zero otherwise.

## Firm-level control variables

- $\text{MCAP}_{it}$ : Market capitalization
- $\text{DVOL}_{it}$ : Dollar trading volume
- $\text{VWAP}_{it}$ : Intraday value-weighted average price
- $\text{RVOL}_{it}$ : Intraday price range,

computed by:  $\frac{|\text{Price}_{\text{highest}} - \text{Price}_{\text{lowest}}|}{\text{VWAP}_{it}}$

## Table 8: Regression Results (Panel A)

Variables	RQS <sub>it</sub> (1)	RES <sub>it</sub> (2)	RRS <sub>it</sub> (3)	RPI5 <sub>it</sub> (4)
SSF <sub>it</sub>	-0.054* (0.030)	-0.210*** (0.030)	-0.166*** (0.027)	-0.037** (0.016)
Ban period <sub>it</sub>	0.476*** (0.041)	0.668*** (0.041)	0.507*** (0.041)	0.143*** (0.024)
SSF <sub>it</sub> × Ban period <sub>it</sub>	-0.566*** (0.046)	-0.786*** (0.049)	-0.598*** (0.046)	-0.165*** (0.028)
MCAP <sub>it</sub>	0.697*** (0.168)	0.271 (0.193)	0.828*** (0.200)	-0.392*** (0.116)
DVOL <sub>it</sub>	-0.378*** (0.019)	-0.357*** (0.020)	-0.430*** (0.021)	0.0585*** (0.013)
VWAP <sub>it</sub>	-1.17*** (0.174)	-0.509** (0.205)	-0.890*** (0.217)	0.239** (0.122)
RVOL <sub>it</sub>	7.66*** (0.333)	10.2*** (0.364)	6.24*** (0.345)	3.78*** (0.218)
N	52,415	52,422	52,394	52,392
Adj. R <sup>2</sup>	0.701	0.592	0.426	0.191

## Table 8: Regression Results (Panel B)

Variables	$RQS_{it}$ (5)	$RES_{it}$ (6)	$RRS_{it}$ (7)	$RPI5_{it}$ (8)
$SSF_{it}$	-0.057* (0.030)	-0.212*** (0.031)	-0.167*** (0.027)	-0.038** (0.016)
<b>Ban period<sub>it</sub></b>	0.476*** (0.041)	0.668*** (0.041)	0.508*** (0.041)	0.142*** (0.024)
$SSF_{it} \times \text{Ban period}_{it}$	-0.549*** (0.046)	-0.774*** (0.049)	-0.593*** (0.047)	-0.157*** (0.028)
<b>Active <math>SSF_{it}</math></b>	0.0209 (0.046)	-0.0133 (0.052)	0.0452 (0.034)	-0.0526** (0.024)
<b>Active <math>SSF_{it}</math> <math>\times \text{Ban period}_{it}</math></b>	-0.188*** (0.067)	-0.130 (0.087)	-0.0591 (0.070)	-0.0845** (0.037)
$MCAP_{it}$	0.697*** (0.168)	0.271 (0.193)	0.829*** (0.200)	-0.391*** (0.116)
$DVOL_{it}$	-0.378*** (0.019)	-0.356*** (0.020)	-0.430*** (0.021)	0.0586*** (0.013)
$VWAP_{it}$	-1.17*** (0.174)	-0.510** (0.205)	-0.891*** (0.218)	0.239** (0.122)
$RVOL_{it}$	7.66*** (0.333)	10.2*** (0.364)	6.24*** (0.345)	3.78*** (0.218)
N	52,415	52,422	52,394	52,392
Adj. R <sup>2</sup>	0.701	0.592	0.426	0.191

# Summary of Main Results

## **RQ#1:**

- During the ban period, OneChicago exchange introduced 275 new SSFs listings underlying banned stocks. Prior to the ban, only 64 banned stocks had SSFs listings.
- SSFs trading volume increased significantly for banned stocks during the ban period.

**RQ#2:** The contribution of SSFs trading to price discovery of banned stocks increased significantly during the ban period.

**RQ#3:** SSFs trading helped mitigate the negative effect of the ban on market quality of banned stocks during the ban period.

# Further Analysis

# Further Analysis

We perform further analysis to:

1. Control for the effect of options trading.
2. Examine the effect of SSFs trading on banned stocks relative to non-banned stocks using difference-in-differences tests.

## Further Analysis #1: Controlling for Options Trading

- Since trading options could be viewed as substitutes for short-selling or trading SSFs, does options trading affect our results?

### What We Do:

#### 1. Effect on the contribution of SSFs trading to price discovery:

- Because all 64 banned stocks in our subsample had options trading during the ban period, we focus on the effect of active options trading.
- We use dummy variable *Active options trading*, which equals one for banned stocks if the total options trading volume over the sample period was higher than median of the sample stocks, and zero otherwise.

#### 2. Effect on market quality:

- Because some stocks on the ban list did not have listed options, we use dummy variable *Options*, which equal one for banned stocks with listed options during the sample period, and zero otherwise.

## Table 9: Effect of SSFs Trading on Price Discovery

$$\text{Contribution}_{it} = \alpha_i + \beta_1 \text{Ban period}_{it} + \beta_2 \text{Active options trading}_{it} + \beta_3 (\text{Ban period}_{it} \times \text{Active options trading}_{it}) + \theta' X_{it} + \varepsilon_{it}$$

Comparison:	Pre-Ban and Ban Periods		Post-Ban and Ban Periods	
	(1)	(2)	(3)	(4)
<i>Ban period<sub>it</sub></i>	0.142** (0.060)	0.147** (0.057)	0.042 (0.061)	0.042 (0.063)
<i>Active options trading<sub>it</sub></i>	0.001 (0.045)	-0.069 (0.049)	0.056 (0.065)	0.039 (0.075)
<i>Ban period<sub>it</sub> × Active options trading<sub>it</sub></i>	-0.083 (0.077)	-0.093 (0.075)	0.016 (0.095)	0.017 (0.096)
<i>Market cap<sub>it</sub></i>		-0.025* (0.013)		-0.004 (0.022)
<i>Stock volume<sub>it</sub></i>		0.059*** (0.018)		0.013 (0.023)
<i>Stock return<sub>it</sub></i>		-0.104 (4.172)		0.190 (4.238)
Constant	0.176*** (0.034)	-0.296 (0.202)	0.204*** (0.043)	0.080 (0.260)
N	115	115	118	118
Adj. R <sup>2</sup>	0.051	0.109	-0.001	-0.025

## Table 10: Effect of SSFs Trading on Market Quality

Variables	RQS <sub>it</sub>	RES <sub>it</sub>	RRS <sub>it</sub>	5PI <sub>it</sub>
	(1)	(2)	(3)	(4)
<i>Ban period</i> <sub>it</sub>	0.769*** (0.039)	1.025*** (0.038)	0.799*** (0.037)	0.21*** (0.022)
<i>SSF</i> <sub>it</sub>	-0.542*** (0.062)	-0.548*** (0.06)	-0.356*** (0.059)	-0.184*** (0.035)
<i>SSF</i> <sub>it</sub> × <i>Ban period</i> <sub>it</sub>	-0.649*** (0.151)	-0.868*** (0.146)	-0.64*** (0.144)	-0.234*** (0.084)
<i>Options</i> <sub>it</sub>	0.653*** (0.043)	0.548*** (0.042)	0.671*** (0.041)	-0.121*** (0.024)
<i>Ban period</i> <sub>it</sub> × <i>Options</i> <sub>it</sub>	-1.271*** (0.07)	-1.375*** (0.068)	-1.094*** (0.067)	-0.266*** (0.039)
<i>SSF</i> <sub>it</sub> × <i>Options</i> <sub>it</sub>	0.657*** (0.077)	0.545*** (0.075)	0.394*** (0.074)	0.149*** (0.043)
<i>Ban period</i> <sub>it</sub> × <i>SSF</i> <sub>it</sub> × <i>Options</i> <sub>it</sub>	0.905*** (0.18)	0.998*** (0.175)	0.771*** (0.172)	0.244** (0.101)
<i>MCAP</i> <sub>it</sub>	0.456*** (0.014)	0.401*** (0.014)	0.428*** (0.014)	-0.015* (0.008)
<i>DVOL</i> <sub>it</sub>	-1.000*** (0.009)	-0.852*** (0.009)	-0.732*** (0.009)	-0.127*** (0.005)
<i>VWAP</i> <sub>it</sub>	-0.121*** (0.015)	-0.160*** (0.015)	-0.123*** (0.015)	-0.037*** (0.009)
<i>RVOL</i> <sub>it</sub>	10.263*** (0.177)	11.917*** (0.172)	7.348*** (0.17)	4.399*** (0.10)
Firm FE	Yes	Yes	Yes	Yes
N	52,386	52,386	52,386	52,386
Adj. R <sup>2</sup>	0.458	0.416	0.292	0.134

# Summary of Further Analysis 1

- The contribution of SSFs trading to price discovery increased significantly during the period covering the short-selling ban, after controlling for the effect of active options trading.
  - Active options trading appears to have little effect on the contribution of SSFs trading to price discovery during the ban period.
- Banned stocks with SSFs had significantly better market quality during the ban period than those without SSFs, even after controlling for the effect of options trading.
  - The results are consistent across all market quality measures.

# Further Analysis #2: Difference-in-Differences (DID) Tests

## What We Do:

- We examine whether the effect of SSFs trading is stronger or weaker for banned stocks relative to non-banned stocks.
- We construct a matched sample of non-banned stocks with SSFs, and examine whether the results are specific to the banned stock sample.
- Stocks are matched with replacement based on:
  - **Size:** Market capitalization
  - **Volatility:** Idiosyncratic volatility (**Ang, Hodrick, Xing, and Zhang, 2009**)
  - **Liquidity:** Amihud (2002) illiquidity
  - **SSFs trading volume**

**Table 11:**

**Effect of SSFs Trading on Price Discovery during the Ban Period (DID)**

$$PD_{it} = \alpha_i + \beta_1 Ban\ period_{it} + \beta_2 (Ban\ period_{it} \times Banned\ stock_{it}) + \theta' X_{it} + \varepsilon_{it}$$

Comparison:	Pre-Ban and Ban Periods	Post-Ban and Ban Periods
	(1)	(2)
Ban period <sub>it</sub>	-0.011 (0.036)	-0.084** (0.040)
Banned stock <sub>it</sub>	-0.004 (0.032)	-0.042 (0.044)
Ban period <sub>it</sub> × Banned stock <sub>it</sub>	0.109** (0.049)	0.129** (0.061)
Market cap <sub>it</sub>	-0.018* (0.011)	-0.019 (0.015)
Stock volume <sub>it</sub>	0.031** (0.013)	0.021 (0.017)
Stock return <sub>it</sub>	0.773 (3.681)	-0.404 (3.505)
Constant	-0.007 (0.140)	0.243 (0.155)
N	223	223
Adj. R <sup>2</sup>	0.059	0.010

Table 12:

## Effect of SSFs Trading on Market Quality during the Ban Period (DID)

- **Difference-in-Differences Model:**

$$\begin{aligned} \text{Market quality}_{it} = & \alpha_i + \beta_1 \text{Ban period}_{it} + \beta_2 (\text{Ban period}_{it} \times \text{Banned stock}_{it}) \\ & + \beta_3 \text{Active SSF}_{it} + \beta_4 (\text{Active SSF}_{it} \times \text{Ban period}_{it}) \\ & + \beta_5 (\text{Active SSF}_{it} \times \text{Ban period}_{it} \times \text{Banned stock}_{it}) \\ & + \theta' X_{it} + \varepsilon_{it} \end{aligned}$$

- The US SSFs market is not a liquid market; having a SSFs listing does not mean that there is SSFs trading every day for a given stock.
- In this DID test, we focus on the effect of active SSF trading, particularly banned stocks which not only had SSFs listing but also SSFs trading during the sample period.
- $\text{Active SSF}_{it}$  is equal to one if stock  $i$  had SSFs trading on day  $t$ , and zero otherwise.

Variables	RQS <sub>it</sub>	RES <sub>it</sub>	RRS <sub>it</sub>	5PI <sub>it</sub>
	(1)	(2)	(3)	(4)
<i>Ban period</i> <sub>it</sub>	0.012*** (0.003)	0.012*** (0.003)	-0.117 (0.088)	0.005** (0.003)
<i>Ban period</i> <sub>it</sub> × <i>Banned stock</i> <sub>it</sub>	0.047*** (0.007)	0.043*** (0.007)	0.177** (0.088)	0.020*** (0.007)
<i>Active SSF</i> <sub>it</sub>	0.010*** (0.002)	0.008*** (0.002)	0.004 (0.029)	0.004 (0.003)
<i>Ban period</i> <sub>it</sub> × <i>Active SSF</i> <sub>it</sub>	-0.011* (0.006)	-0.016*** (0.005)	-0.115 (0.170)	-0.014*** (0.005)
<i>Ban period</i> <sub>it</sub> × <i>Banned stock</i> <sub>it</sub> × <i>Active SSF</i> <sub>it</sub>	-0.024*** (0.009)	-0.022*** (0.008)	0.086 (0.171)	-0.003 (0.009)
<i>MCAP</i> <sub>it</sub>	0.185*** (0.046)	0.201*** (0.046)	-0.696** (0.315)	0.152*** (0.043)
<i>DVOL</i> <sub>it</sub>	-0.033*** (0.005)	-0.021*** (0.004)	0.068* (0.040)	-0.016*** (0.003)
<i>VWAP</i> <sub>it</sub>	-0.310*** (0.047)	-0.318*** (0.047)	0.619** (0.305)	-0.211*** (0.044)
<i>RVOL</i> <sub>it</sub>	0.335*** (0.046)	0.423*** (0.041)	-0.641* (0.344)	0.416*** (0.041)
Firm FE	Yes	Yes	Yes	Yes
N	7,606	7,606	7,606	7,512
Adj. R <sup>2</sup>	0.834	0.845	0.003	0.648

## Summary of Further Analysis 2

- The effect of SSFs trading on underlying stock price discovery is significantly stronger for banned stocks than for non-banned stocks.
- SSFs trading helps improve market quality of underlying stocks, again the effect is stronger for banned stocks than for non-banned stocks.
  - The results strengthen our main finding that SSFs trading does help mitigate the negative effect of the ban on market quality of banned stocks.

# Conclusion

- We use the 2008 short-selling ban to examine the role of SSFs trading.
  - There was a sharp increase in the number of new SSFs contracts introduced during the ban period.
  - We find that SSFs trading volume of banned stocks increased significantly when the short-selling ban was in effect.
- We further examine the effect of SSFs trading on price discovery and market quality of underlying banned stocks.
  - The contribution of SSFs trading to underlying stock price discovery increased significantly during the ban period.
  - SSFs trading helped mitigate the negative effect of the ban on market quality; banned stocks with SSFs trading had significantly better market quality than those without.
- Our results are robust when:
  - We compare banned stocks to non-banned stocks using a difference-in-differences approach.
  - We control for options trading, which can be a substitute for short-selling or SSFs.

# Appendix

# Appendix 1: Probit Analysis

- We perform a probit analysis to examine what kind of stock-level characteristics determine a stock's probability of having a SSFs listing.
- Sample:
  - 530 stocks (banned and non-banned) with SSFs prior to August 2008
  - All other stocks that never had SSFs prior to August 2008 (stocks with share price below \$5 are excluded)
- Sample period: January 2003 – August 2008
  - Covers most of the lifespan of the SSFs market in the US before the ban.

## Appendix 1: Probit Analysis (cont'd)

- The following probit model is estimated:

$$\text{Probit}(SSFs_i) = \beta' \mathbf{X}_i + \varepsilon_i, \text{ where}$$

- ***Probit(SSFs<sub>i</sub>)***: Probability of having a SSFs listing, which takes a value of 1 if stock *i* had SSFs during the sample period, and zero otherwise.
- ***X<sub>i</sub>***: Stock-level characteristics:
  - ***Size***: Market capitalization
  - ***Price***: Share price
  - ***Illiquidity***: The Amihud (2003) illiquidity measure
  - ***Book-to-market ratio***
  - ***Turnover***
  - ***Momentum***: past 6 month return
  - ***Volatility***: Idiosyncratic volatility relative to the Fama-French (1993) model

# Table A1: Probit Model Result

	Probability of having SSFs listing
<i>Constant</i>	-17.224*** (-23.211)
<i>Size</i>	0.761*** (23.157)
<i>Price</i>	-0.226*** (-3.700)
<i>Illiquidity</i>	-1.407* (-1.946)
<i>BM</i>	0.088*** (2.708)
<i>Turnover</i>	0.785*** (5.312)
<i>Momentum</i>	-0.701** (-2.372)
<i>Volatility</i>	23.591*** (5.096)
N	6,108
Pseudo R <sup>2</sup>	0.369

## Appendix 2:

### Constructing a Matched Sample for Difference-in-Differences Test

- In Further Analysis, we compare banned stocks to non-banned stocks by performing difference-in-differences tests.
- We match a treatment group of 64 banned stocks with SSFs prior to the ban with a group of non-banned stocks with SSFs and similar stock-level characteristics.
- Stocks are matched based on:
  - *Size*: Market capitalization
  - *Illiquidity*: The Amihud (2003) measure
  - *Volatility*: Idiosyncratic volatility relative to the Fama-French (2003) model
  - *SSFs trading volume*
- Stocks are matched with replacement.
- We follow **Ang, Hodrick, Xing, and Zhang (2006)** to construct the idiosyncratic volatility measure.

## Table A2: Descriptive Statistics for Matching Variables

<b>Group</b>	<b>Variable</b>	<b>Mean</b>	<b>SD</b>	<b>Min</b>	<b>Max</b>
Treatment	Size	22.722	1.815	17.922	26.356
Control	Size	22.733	1.821	17.809	26.241
	Difference	-0.01			
	t-value	(-0.03)			
Treatment	Volatility	0.028	0.024	0.008	0.129
Control	Volatility	0.023	0.012	0.010	0.078
	Difference	0.005			
	t-value	(1.51)			
Treatment	Liquidity	0.002	0.005	0.000	0.032
Control	Liquidity	0.002	0.012	0.000	0.098
	Difference	<-0.001			
	t-value	(-0.43)			
Treatment	SSFs volume	0.500	0.762	0.000	4.272
Control	SSFs volume	0.477	0.748	0.000	4.074
	Difference	0.023			
	t-value	(0.17)			