Does High Frequency Market Manipulation Harm Market Quality?*

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Abstract: Manipulation of financial markets has long been a concern. With the automation of financial markets, the potential for high frequency market manipulation has arisen. Yet, such behavior is hidden within vast sums of order book data, making it difficult to define and to detect. We develop a tangible definition of one type of manipulation, spoofing. Using proprietary user-level identified order book data, we show the determinants of spoofing. Exploiting SEC Litigation Releases that exogenously reduce spoofing, we show causal evidence that spoofing increases return volatility, increases trading costs, and decreases price efficiency. The findings indicate that spoofing harms liquidity and price discovery.

JEL classification: G10, G12, G14

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1. Introduction

Modern financial markets are largely automated. With the increased automation, market participants can potentially distort markets to profitably induce short term price movements. One such high-frequency manipulation method is spoofing, which is defined as "bidding or offering with the intent to cancel the bid or offer before execution."[1] In September 2020, JPMorgan was fined $920 million for spoofing metals and U.S. Treasury futures, where it was suggested that spoofing is a common practice.[2,3] The frequency of spoofing activity in financial markets is an empirical question. In addition, the fact that spoofing should be unrelated to real information and therefore does not contribute to price discovery raises the question of how spoofing affects market quality. This paper quantifies the frequency of spoofing and tests whether it harms market quality.

Theory on the impact market manipulation should have on market quality is mixed. Skrzypacz and Williams (2021) address the determinants and market quality impacts of spoofing. They theoretically show that increased spoofing activity leads to slower price discovery, higher return volatility, and wider bid-ask spreads. A spoofing strategy impedes price discovery by driving prices away from fundamental values. Because deviations from fundamentals can be corrected, spoofing price movements induce reversals which then increase return volatility. At the same time, if spoofing drives prices away from fundamentals, adverse selection increases and market-makers are forced to raise spreads to remain profitable.

Some theoretical work argues against manipulation being feasible or that it can even improve market quality. Jarrow (1992) shows that when prices do not exhibit momentum,

[1] 2010 Dodd-Frank Act
[2] https://www.reuters.com/article/jp-morgan-spoofing-penalty-idINKBN26K325
[3] https://fortune.com/2022/07/20/former-jpmorgan-trader-reveals-how-his-mentor-taught-him-to-place-and-cancel-bogus-spoof-trades-manipulate-markets/

manipulation is not possible. Cherian and Jarrow (1995) show that a symmetric price response to manipulation renders it unprofitable. Other studies show that manipulation may be associated with improved market quality. Hanson and Oprea (2009) model a manipulator as a noise trader and show that the manipulation strategy encourages information acquisition as the profits to informed traders increase, thereby improving price accuracy. We empirically test these conflicting theories on the existence and effect of market manipulation.

We study Canadian equity markets using the proprietary IIROC dataset, which has trade and quote data with trader identification. We identify potential spoofing orders by applying six tractable filters to the data. We then examine the prevalence and determinants of spoofing in Canadian equity markets. We find that the median stock-day observation has 64 attempted spoofing orders, with 3 successful. We exploit variation in spoofing from SEC Litigation Releases to estimate the causal effect of spoofing on market quality. Our results are consistent with the theoretical predictions of Skrzypacz and Williams (2021). Spoofing leads to higher return volatility, higher transaction costs, and slower price discovery.

To discourage spoofing activity regulators strategically make the definition ambiguous. While is it not possible to perfectly identify spoofing orders, we draw from recent spoofing court cases[4] to develop a six-step filtering approach that identifies trade and order behavior consistent with spoofing. First, all spoofing orders are eventually deleted. Second, spoofing buy (sell) order prices must be greater (less) than or equal to one tick below (above) the prevailing NBB (NBO). We match potential spoofing orders to genuine orders, which are orders in the opposite direction from the same trader. Third, spoofing orders must be placed within one second of the genuine order. Fourth, the spoofing order volume must be higher than the genuine order volume. Fifth, the

[4] For example, *United States v. Coscia* and *United States v. Bases et al.*

spoofing orders must be cancelled within one second after genuine orders are executed or cancelled. Lastly, we require that during the second a spoofing order is placed, the trader does not actually trade in the same direction as the spoofing order. As it is very challenging to empirically distinguish market making from spoofing manipulation, we purposely use strict criteria that can distinguish between the two. A limitation of such a strict definition is that we likely undercount the true spoofing activity.

We begin the empirical analysis by documenting the prevalence and determinants of spoofing activity. Plotting spoofing against lagged market quality characteristics, we find that spoofing is most prevalent in stock-days with intermediate levels of transaction costs, intermediate levels of return volatility, and high levels of price efficiency.

Motivated by the theoretical predictions from Skrzypacz and Williams (2021), we next focus on the relationship between spoofing and market quality. We estimate OLS panel regressions of market quality measures on the attempted spoofing order volume scaled by trading volume, while controlling for lagged dollar spread, lagged price, lagged inverse price, absolute return, log of dollar volume, Amihud (2002) illiquidity, and stock and date fixed effects. Spoofing is positively associated with 1- and 5-minute return volatility, effective spreads, realized spreads, variance ratios, and the Hasbrouck (1993) pricing error. We also find that quoted spreads and price impact are negatively associated with spoofing activity.

There is a strong endogeneity problem. Spoofing traders likely endogenously select certain stocks and dates to spoof. For instance, Skrzypacz and Williams (2021) predict that spoofers endogenously choose to spoof when markets are not so illiquid that their spoofing orders can be identified by market makers but not so liquid that their spoofing orders are unable to move markets. We document a similar pattern. If spoofing activity is correlated with a stock's ex-ante liquidity, then our OLS estimates suffer from omitted variable bias, as ex-ante liquidity likely predicts market quality.

To overcome the endogeneity concern, we exploit SEC Litigation Releases as shocks to spoofing activity. We interpret market manipulation-related SEC Litigation Releases as positive shocks to the ex-ante legal risk of spoofing for stocks subject to SEC jurisdiction. In the three days after a release, spoofing in US cross-listed stocks decreases relative to stocks that are only listed on Canadian exchanges. Because SEC Litigation Releases predict spoofing activity but likely do not affect market quality directly, we instrument for spoofing with a difference in difference regression comparing the effect of SEC Litigation Releases on US cross-listed and Canada only stocks. The instrumental variables estimation shows that spoofing causes increased return volatility, increases variance ratios, and increases the Hasbrouck (1993) pricing error volatility. We also find weak evidence that spoofing raises transaction costs.

We show that spoofing is associated with worsened market quality at the intraday level. We regress 30-minute market quality measures on spoofing, intraday controls, and stock-day and 30-minute interval fixed effects. While not causal, the strict fixed effects allow us to study the relation between spoofing and market quality *within* stock-day, which helps alleviate several endogeneity concerns. The results indicate that spoofing is strongly positively associated with intraday return volatility, and quoted spread. Spoofing is negatively associated with realized spreads and increases price impact, which suggests that spoofing activity may harm liquidity providers. Spoofing also is correlated with larger intraday variance ratio and Hasbrouck (1993) pricing error σ, which is evidence that spoofing is negatively correlated with price efficiency at the intraday level.

To alleviate concerns that our spoofing detection process captures legitimate orders and cancellations placed by market makers, we conduct a falsification test. We rely on key differences between spoofing and legitimate market making by HFTs. First, spoofing trading activity is one-sided, while market making trading is typically two-sided to provide liquidity. Second, spoofing strategies require that spoofing orders are cancelled quickly, while market makers place orders to maintain a two-sided market. For each stock-day, we measure market making activity as the proportion of orders from traders who have at least one outstanding order on each side of the limit order book at the end of each minute and place buy orders between 40% to 60% of the time. In OLS regressions of our market quality measures on market making activity, we find that market making activity is associated with improved market quality. This suggests that our spoofing measure does not capture legitimate market making.

Finally, we conduct a variety of robustness tests. We re-estimate our baseline IV results using alternative definitions of spoofing, such as the successful and failed spoofing order volume. Across the varying robustness checks the results remain economically consistent. We also re-estimate the IV results across different subsamples and exclude options settlement dates to address concerns that SEC litigation releases may also affect other types of manipulation.

This paper contributes to the extant literature on market manipulation (See Putnins, 2012 for a survey) and more specifically to the newer literature on high frequency market manipulation. There is a nascent theoretical literature on spoofing. In general, it is challenging to model limit order book dynamics (Parlour, 1998; Rosu, 2009). Theory has incorporated spoofing behavior into the equilibrium order book behavior. Skrzypacz and Williams (2021) provide an equilibrium model showing that spoofing behavior can harm liquidity, slow price discovery, and elevate volatility. Wang, Hoang, Vorobeychik, and Wellman (2021) also show that the presence of spoofers in an order book that is otherwise informative results in a decrease in investor welfare. Cartea, Jaimungal, and Wang (2020) model how spoofing can be used to increase an investor's revenue, and how potential legal fines can deter spoofing behavior. Using simulated limit order books, Withanawasam, Whigham, and Crack (2018) examine where manipulators may be more prevalent. Our study provides empirical tests of the theoretical implications of spoofing on market quality and confirms that spoofing harms market quality.

Legal scholars have argued more generally about the impact of spoofing. Fischel and Ross (1991) provide a framework for how the legal community analyzes manipulation in markets. They argue that it is difficult to identify manipulation without knowing trader intent. They propose that no trades should be considered manipulative, while behavior that gives a false sense of trading activity (i.e. wash trading or matched orders) is manipulative. McNamara (2016) tackles the ethical and legal implications of high frequency trading, which covers spoofing and other limit order based manipulation strategies. Miller and Shorter (2016) survey the literature on high frequency trading and market manipulation and discuss the regulatory and legislative reaction to crack down on behaviors such as spoofing. Canellos et al. (2016) provide an overview of spoofing cases that have occurred before and after Dodd-Frank. Fox, Glosten, and Guan (2021) provide a framework to consolidate the varying interpretations of what is and is not considered spoofing. Montgomery (2016) argues that spoofing may in fact improve the liquidity of financial markets. Dalko, Michael, and Wang (2020) argue that spoofing as a manipulative practice only arises because of behavioral biases of investors and microstructural systems.

The empirical work on spoofing is limited. The reason for the paucity of work on the topic is that it typically requires order book data with trader identifying information. That said, Tao, Day, Ling, and Drapeau (2022) have crafted a strategy to detect spoofing from public order books.

Two other papers have identifying account information and study spoofing. Lee, Eom, and Park (2013) use data from Korea and show a positive correlation among spoofing and volatility and a negative correlation with market capitalization. Wang (2019) uses data from Taiwan futures and shows that spoofing is profitable and is correlated with higher volume, bid-ask spreads, and volatility. This paper makes two contributions to the empirical literature. First, we provide another tractable spoofing detection method that aims to be orthogonal to genuine market-making activity. Second, we are the first to provide causal evidence that spoofing negatively impacts market quality.

2. Data and Variable Construction

Our primary data source is the proprietary Investment Industry Regulatory Organization of Canada (IIROC) dataset. The data consists of trade and quote data for 137 Canadian stocks from May 3, 2010 to July 19, 2011. The sample is a volume stratified sample of Toronto Stock Exchange (TSX) stocks plus the TSX60 index constituents. Penny stocks and stocks with less than 20 active days are excluded. 46% of the firms in the sample are cross-listed in the US. We observe trades and quotes on the Toronto Stock Exchange. We also observe Alternative Trading System (ATS) activity through the Alpha (ALF), Chi-X (CHX), Omega (OMG), Pure (PTX), and MATCH Now (TCM) platforms.

The trade and quote data are timestamped at the 10-millisecond level and contain order submissions, amendments, cancellations, and executions. Importantly, trades and orders in the data have unmasked trader IDs that allow us to track individual trader positions and strategies across time. For each event, we observe trader ID, order ID, price, volume, NBB, NBO, exchange, and other information. Each order is assigned an order ID that can be used to track the status of an order over time. This is crucial for spoofing identification, as it allows us to track an individual trader's cancellations and amendments with precision. We require that each stock-day has at least \$1 million in trading volume to remove very illiquid stocks. For intraday analysis, we require that each stock-day-30-minute interval has nonzero trading volume. We drop observations with quoted spreads above 5% to remove potential data errors. We also ignore the 99th percentile of the variance ratio and Hasbrouck (1993) pricing error σ, as the right tails have extreme outliers. However, our results are robust to including the dropped observations.[5]

2.1 Market Quality Measures

We construct liquidity and market quality measures from the IIROC data. We measure liquidity with time-weighed quoted spreads, volume-weighted effective spreads, volume-weighed realized spreads, volume-weighed price impact, and Amihud (2002) illiquidity. We measure volatility with 1- and 5-minute return volatility, and market quality with variance ratios and Hasbrouck (1993) pricing error σ.

We compute time-weighted quoted spreads by weighting $\frac{NBO-NBB}{NBBO\ midpoint}$ by the time each spread prevails for a given stock-day. We compute volume-weighted effective spreads by weighing $2 \times \frac{D_k(Price_k - NBBO\ midpoint_k)}{NBBO\ midpoint_k}$ by the volume at each trade, k, where D_k is a trade sign indicator equal to 1 if the trade was buyer initiated and -1 if the trade was seller initiated. To approximate liquidity provision revenue, we compute volume-weighted realized spreads by weighing $2 \times \frac{D_k(Price_k - NBBO\ midpoint_{k,t+5})}{NBBO\ midpoint_k}$ by the volume at each at each trade, k, where $NBBO\ midpoint_{k,t+5}$ is the NBBO midpoint five minutes after trade k. Price impact is computed

[5] More details about the IIROC dataset can be found in the internet appendix for *The Competitive Landscape of High-Frequency Trading Firms* by Boehmer, Li, and Saar (2018).

as the difference between the effective spread and realized spread. Amihud (2002) illiquidity is computed as the absolute value of daily returns divided by dollar volume for each stock day, multiplied by 10^6.

Return volatilities are computed at the 1- and 5-minute levels and are the standard deviation of returns using trading prices. We compute Lo and MacKinlay (1988) variance ratios with 1- and 30-minute return variances with $\left|1 - 30 \times \frac{Var_{1\ minute}(ret)}{Var_{30\ minute}(ret)}\right|$, a timing choice also used in Rösch, Subrahmanyam, and van Dijk (2016). We compute 1- and 30-minute returns with trade prices. Lastly, we compute the Hasbrouck (1993) pricing error σ. Similar to Boehmer and Kelley (2009), we estimate the VAR system with five lags and include four variables: log returns, trade sign indicator equal to 1 if the trade was buyer initiated and -1 if the trade was seller initiated, signed volume computed as the trade sign times the number of shares traded, and root signed volume computed as the trade sign times the square root of the number of shares traded. We set lagged variables to zero at the beginning of each day. Table 1 Panel A reports liquidity and market quality summary statistics at the stock-day level, while Panel B reports liquidity and market quality summary statistics at the 30-minute level.

INSERT TABLE 1 ABOUT HERE

2.2 **Spoofing Measures**

As the official definition of spoofing is likely strategically ambiguous, it is difficult to empirically measure the prevalence of spoofing activity. We draw our criteria from the following example of a trader who successfully executes a sell spoofing strategy: suppose a trader wants to buy shares of a stock. The NBB and NBO are currently $99 and $100, respectively. The trader wants to buy at a price less than $99 and will manipulate prices down. First, the trader places a buy order for the shares he wants to buy at $98.75, which is less than the prevailing NBO. He then rapidly places a high-volume limit sell order at a price lower than $100 (but higher than $99 to avoid immediate execution) to mimic selling pressure. The market responds to the false selling pressure by adjusting the NBB and NBO down. However, the trader immediately cancels the limit sell order before it can be executed. Because the market responds to the selling pressure, the NBB decreases and falls below $98.75, which results in the trader's buy order executing. Figure 1 describes this strategy graphically.

INSERT FIGURE 1 ABOUT HERE

Our example yields a more general definition. A trader who is spoofing the market will initially place a bona fide "genuine" buy limit order at a price lower than the current best bid price. After placing the genuine order, the trader will enter "spoofing" sell orders that will create the impression that the market is facing selling pressure. This will drive prices down and lead to the genuine order being executed. Finally, the spoofer will cancel the spoofing sell order. The same story holds with genuine sell orders and spoofing buy orders. We develop six filters to classify orders as potential spoofing orders.

We separately identify buy and sell spoofing orders. We also require that spoofing activity occurs during the trading hours of 9:30 AM to 4 PM. We describe the procedure for identifying spoofing buy orders in detail.[6] The spoofing identification procedure relies on visible trader IDs to track spoofing strategies.

We first search for spoofing orders without considering the other side's genuine orders. The first filter requires that spoofing orders are eventually deleted. As spoofing strategies consist of rapid entrance and cancellation of orders in the same direction, we expect that a spoofer will cancel a vast majority of their spoofing orders. Our spoofing detection strategy implicitly assumes that spoofing orders are not executed. Although it is likely that some spoofing orders are unintentionally executed, it is difficult to disentangle an executed spoofing order from a non-spoofing order. Second, if a spoofing order is to induce a market response, it must be somewhat aggressive. We require that buy spoofing order prices are greater than or equal to one tick below the previous NBB.

We match each potential buy spoofing order to potential sell (genuine) orders from the same trader ID.[7] Our third criteria requires that spoofing orders occur within one second after the genuine order is placed. This is consistent with a spoofing trader first entering a reasonable genuine order and then subsequently spoofing the market to induce a price response. For there to be a price effect, spoofing orders again must be sufficiently aggressive. Our fourth filter captures this by requiring that each spoofing buy order's volume must be greater than the genuine order's volume. Spoofing occurs at high frequencies. Our fifth and most aggressive filter requires that spoofing orders are cancelled within one second after genuine orders are either cancelled or executed. Lastly, our sixth filter requires that for a given spoofing buy order, the trader ID must not have

[6] The procedure to identify spoofing sell orders is nearly identical to the procedure used to identify buy orders. Switching "buy" with "sell" and changing the second filter to require that the spoofing sell order must be less than the NBO yields the spoofing sell order identification procedure.
[7] Note that our matching procedure can match multiple spoofing orders to a single genuine order. Our spoofing detection algorithm can therefore also capture layering activity, which regulators often use interchangeably with spoofing. Layering can be viewed as spoofing, but with multiple non-bona fide orders at different prices.

executed a buy order in the same second. This is consistent with the one-sided nature of spoofing. If a trader is trying to manipulate prices in one direction, it is unlikely that they will trade on their spoofing orders (and if they did, then the spoofing strategy would be much less profitable).

We define three types of spoofing: attempted, successful, and failed. Successful spoofing orders are spoofing orders with executed genuine orders, while failed spoofing orders have cancelled genuine orders. Attempted spoofing orders are the sum of the successful and failed spoofing orders. Our main measure of spoofing is the attempted spoofing order volume scaled by trading volume.

Table 1 Panel C presents the stock-day level summary statistics for spoofing activity. In our sample, the median stock-day has 64 attempted spoofing orders and 3 successful spoofing orders. Table 1 Panel D presents 30-minute level summary statistics for spoofing. The median number of attempted spoofs for a stock in a 30-minute interval is 1, while the median number of successful spoofs is 0. In untabulated results, we find that for a given stock-day, the median spoofer places three attempted spoofing orders. For a given trader-day, the median trader spoofs four stocks. High frequency traders place 57% of the average stock-day's spoofing orders.

We explore the characteristics of spoofing traders. We classify a trader as a spoofer if they make at least one attempted spoofing order in the sample. 9.4% of the traders in the sample place at least one attempted spoofing order, while 6.3% place at least one successful spoofing order. Spoofers tend to be large traders. The mean non-spoofer trades $275 million in the sample period, while the mean spoofer trades $3.2 billion (which is greater than the 95th percentile of trader-volume). Conditioning on large traders who trade over $500 million in the sample, 38% of traders place at least one attempted spoofing order and 31% place at least one successful spoofing order.

Spoofing activity is right skewed, which suggests that spoofing may be heavily concentrated within certain time periods or stocks. We disaggregate successful and attempted spoofs into the buy and sell types and find that on average, selling spoofing activity is slightly more common than buying spoofing activity. This suggests that traders who wish to manipulate the market by spoofing tend to do so with downward price pressure.

2.3 Market-making Measure

A concern with our spoofing identification method is that we are measuring orders and cancellations associated with market making or liquidity provision activity. We generate a measure of liquidity provision to show that our results are likely not driven by market making. A trader-minute is considered market making if the proportion of buy orders is between 40% to 60% and the trader has at least one order outstanding at the end of the minute on each side of the market. Our market making measure is defined as the standardized percent of order associated with market-making activity for each stock day.

2.4 Microstructure Controls

We compute average dollar spread, average price, and inverse price as microstructure controls in regression tests. Average price is computed as the dollar trading volume divided by share trading volume, and inverse price is equal to 1 divided by the average price. Average dollar spread is computed by multiplying the quoted spread by the average price.

3. Spoofing Activity

We begin by examining the determinants of spoofing activity graphically. We compute the average number of attempted spoofing orders for 15 lagged market quality quantiles. Skrzypacz and

Williams (2021) predict that spoofing activity should be most active in markets with moderate liquidity. We measure liquidity with quoted spread, effective spread, realized spread, and price impact. We also show the relation between spoofing and lagged volatility and price efficiency measures. The results are shown in Figure 2.

INSERT FIGURE 2 ABOUT HERE

Panel A shows that spoofing tends to occur in stocks with lower ex-ante quoted spreads. However, spoofing is most prevalent in stock-days with intermediate ex-ante effective spreads, price impact, and realized spreads. This is consistent with the Skrzypacz and Williams (2021) prediction that spoofing should be the most prevalent in markets with intermediate levels of liquidity, as spoofers target sufficiently liquid markets to avoid being caught, while targeting sufficiently illiquid markets to be able to effectively influence prices.

Panel B presents results for ex-ante volatility. Spoofing occurs the most in stock-days with moderate levels of intraday return volatility. Spoofing in periods of low return volatility may lead to higher chances of being caught, while spoofing in periods of high return volatility is less likely to move prices in the desired direction. Panel C shows that spoofing occurs the most in stocks with lower inverse market quality levels. That is, spoofing is more prevalent when prices are more efficient. This is likely because spoofers target periods where their spoofing orders are more likely to be falsely impounded into prices as new information, such as when algorithmic trading is prevalent.

We validate the spoofing measure by examining spoofing activity around the passage of the Dodd-Frank act. Namely, we observe a decrease in spoofing in US cross-listed stocks relative to stocks that are only listed on Canadian exchanges because of the more stringent anti-fraud provisions in Dodd-Frank that only apply to US cross-listed stocks. Because only US cross-listed stocks are subject to US regulations, Dodd-Frank should not affect spoofing in Canada-only stocks. In untabulated results, we use a difference-in-difference approach where the treatment group is the set of US cross-listed stocks, and the time-series shock is the passage of Dodd-Frank. After Dodd-Frank is passed, the treatment group experiences a decline in spoofing relative to the control group. The results suggest that increases in the ex-ante legal risk of spoofing can deter spoofing activity. Furthermore, the results validate the spoofing measure. If the true level of spoofing falls because of Dodd-Frank, then a valid proxy for the true level of spoofing should also fall.

4. Relation between Spoofing and Market Quality

Guided by the theoretical predictions in Skrzypacz and Williams (2021), we examine the relation between spoofing activity and market quality. Namely, increased spoofing activity should be associated with higher return volatility, higher bid-ask spreads, and slower price discovery. We measure return volatility with 1 and 5-minute return volatility. We measure spreads with time-weighted quoted spread, volume-weighted effective spread, volume-weighted realized spread, and volume-weighted price impact. We measure price discovery with the variance ratio and Hasbrouck (1993) pricing error σ. All market quality variables except for the variance ratio are expressed in basis points. For ease of interpretation, we take the natural log of the variance ratio and Hasbrouck (1993) pricing error σ. For each market quality measure, we estimate regressions of the following form:

$$Market\ Quality_{i,t} = \beta_1 Attempted\ Spoofing_{i,t} + \boldsymbol{\beta} X + \gamma_t + \zeta_i + \epsilon_{i,t}$$

Where $Attempted\ Spoofing_{i,t}$ is the standardized attempted spoofing order volume scaled by trading volume, and X is a vector of controls that includes lagged average dollar spread, lag average price, lag inverse price, absolute return, log of trading volume, and Amihud (2002) illiquidity. We denote date and stock fixed effects with γ_t and ζ_i, respectively.

We scale spoofing order volume by trading volume to more easily compare across stock-days with different levels of trading activity, as 500 shares of spoofing volume may have a different effect on market quality in a stock-day with 1 million vs 100 million shares of trading volume.

We include several microstructure and liquidity controls because the decision to spoof likely depends on a stock's ex-ante level of market quality (as shown in Figure 2). We include the lag of average price, inverse price, and average dollar spread. This is because spoofing may be easier to implement in stocks that are less tick constrained. However, we lag the microstructure variables to avoid controlling for a downstream affect, as spoofing may also directly affect price and dollar spread (Angrist and Pischke 2009).

Our controls for log dollar volume and Amihud (2002) illiquidity help control for contemporaneous liquidity, while the daily return control alleviates concerns that spoofing traders might tend to target stocks with high or low return magnitudes. For interpretability, we standardize all control variables in all specifications. Stock fixed effects sweep out time-invariant stock-specific variation, such as industry. Day fixed effects sweep out marketwide time variation, such as marketwide liquidity shocks.

INSERT TABLE 2 ABOUT HERE

The results in Table 2 show a positive relation between spoofing activity and most of the inverse market quality measures. Because the spoofing variable is standardized, the interpretation of β_1 is that a one standard deviation increase in scaled attempted spoofing orders is associated with a β_1 unit change in the dependent variable.

Spoofing is associated with higher return volatility. We find that a one standard-deviation increase in successful spoofing orders is associated with a 0.29 and 0.39 basis point increase in 1- and 5-minute return volatility, respectively.

Spoofing is positively associated with effective and realized bid-ask spreads but is associated with decreased quoted spreads and price impact. A one standard-deviation increase in successful spoofing orders is associated with a 0.1 basis point increase in the volume-weighted effective spread and 0.39 basis point increase in the volume-weighted realized spread. However, the spoofing coefficient on effective spreads is statistically insignificant. We find that spoofing is strongly negatively associated with quoted spreads: a one standard-deviation increase in successful spoofing orders is associated with a 0.16 basis point decrease in the quoted spread. Spoofing is negatively related to price impact: a one standard-deviation increase in spoofing is associated with a 0.27 basis point decrease in price impact.

Lastly, spoofing is associated with slowed price discovery. Because we take the natural logarithm of the variance ratio and Hasbrouck (1993) pricing error σ, the specification has a log-linear interpretation. A one standard-deviation increase in successful spoofing orders is associated with a 2% increase in the variance ratio and a 5% increase in the Hasbrouck (1993) pricing error σ.

A potential shortcoming in our spoofing identification approach is that we cannot determine a trader's true intent and thus may be instead measuring genuine market-making activity. It is unlikely that genuine market-making activity will manifest in our measures because of our sixth filter: a trader must not place a spoofing order in the same second that they trade in that direction. Our sixth filter likely removes much market-making activity as market-making liquidity providers are more likely (or are required) to have balanced strategies. For example, the TSX appoints market makers who are required to maintain a two-sided market. Furthermore, if our spoofing variable measures market-making activity, then the results would contradict the existing literature on market-making. Market making should decrease spreads and improve market quality, which is the opposite of what we find. This suggests that our measure does not capture market-making activity. We provide further evidence that our results are not driven by market making with our analysis in Section 7.2.

Although we control for likely confounders and include stock and day fixed effects, it is possible that there are time-varying stock-specific unobservable or omitted variables that may bias our estimates. Thus, the results in this section can be viewed as associations between spoofing and market quality and are largely consistent with existing theoretical and empirical studies. Our finding that effective and realized spreads widen is consistent with Wang (2019), and the finding that return volatility is higher is consistent with Lee, Eom, and Park (2013). However, to our knowledge, we are the first to relate spoofing activity directly to price discovery measures such as variance ratios and Hasbrouck (1993) pricing errors.

5. Causal Effect of Spoofing on Market Quality

The results in Table 2 may suffer from omitted variable bias or reverse causality, as it is likely that spoofing traders endogenously respond to current liquidity or market quality conditions that may make spoofing strategies more profitable or effective. We exploit variation in spoofing induced by SEC litigation releases. The SEC issues litigation releases for its civil lawsuits in federal court. The press releases range from initial charges filed by the SEC to final judgement announcements. We focus specifically on market manipulation related press releases that occur in the sample as shocks to spoofing activity.

SEC litigation releases likely affect the trading behavior of manipulative traders. We interpret litigation releases as positive shocks to the ex-ante legal risk of spoofing. Because regulators study limit order book data in market manipulation cases, a larger regulator presence increases the probability that manipulation is identified. If a spoofing trader observes that the SEC has begun or completed an investigation on market manipulation, the trader may infer heightened regulatory attention and thus a higher chance of being caught spoofing. The trader will thus reduce spoofing activity to reduce the chance of being caught.

We search the SEC Litigation Releases database for market manipulation releases.[8] A release is considered market manipulation if it contains the keyword "manipulation" and refers to stock price manipulation. For example, on September 24, 2010, the SEC charged four individuals with manipulating microcap stock prices. The traders allegedly engaged in a scheme to inflate two microcap stock prices and give a false sense of market liquidity in the stocks. Such events create a sense of heightened regulatory attention on market manipulation and should therefore discourage spoofing activity. We identify 22 SEC litigation releases on market manipulation in the sample period. To identify only the most severe shocks to the ex-ante legal risk of spoofing, we filter the

[8] https://www.sec.gov/litigation/litreleases.htm

list of releases to only include charges, allegations, sentences, and final judgements. The final list consists of 12 SEC releases. Figure 3 plots the litigation days in the sample.

INSERT FIGURE 3 ABOUT HERE

Because we study the trading activity of cross-listed firms on Canadian exchanges, the analysis is only economically valid if SEC litigation releases can affect trading on Canadian markets. This is achieved through the Exchange Act of 1934's section on foreign securities exchanges.[9] Specifically, the provision on Foreign Securities Exchanges bans brokers and dealers from violating SEC regulations when trading on international exchanges if the stocks are "organized under the laws of" the United States. Because cross-listed stocks must comply with U.S. regulations, their stocks are likely protected from manipulation by U.S. and Canadian traders, even on Canadian exchanges. This is consistent with recent litigation. In *Harrington Global Opportunity Fund v CIBC World Markets Corporation,* U.S. and Canadian traders spoofed shares of Concordia International Corporation, a company cross listed in Canada (TSX) and the U.S. (NASDAQ), in 2016. The court acknowledged that a share of Concordia stock is the same whether it is traded on a U.S. or Canada exchange. Therefore, the court argued that it had jurisdiction over Canadian traders spoofing on Canadian exchanges because manipulating shares of Concordia would affect prices on NASDAQ.

We exploit the differential effect of SEC litigation releases on spoofing by comparing US cross-listed and Canada-only stocks. Because SEC litigation risk does not apply to Canada-only

[9] 15 U.S. Code § 78dd

stocks, there should be a larger reduction in spoofing in US cross-listed stocks relative to Canada-only stocks. We use the differential effect of SEC litigation releases on spoofing in US cross-listed and Canada-only stocks to instrument for spoofing activity.

Our first stage estimate is the difference-in-differences regression of the standardized attempted spoofing order volume scaled by trading volume on the interaction between $US\ Listed_i$, which is an indicator equal to 1 if the stock is cross-listed in the US, and $Litigation_t$, which is an indicator equal to 1 if day t is one to three days after a SEC litigation release on market manipulation. We choose a short period for $Litigation_t$ to avoid capturing slower moving reductions in manipulation which may plausibly improve market quality, such as insider trading or corporate misconduct. We include controls for lagged average dollar spread, lag average price, lag inverse price, absolute return, log of trading volume, and Amihud (2002) illiquidity. We also include stock and date fixed effects and cluster standard errors by stock. The first-stage results are presented in Table 3. The instrument is valid if it satisfies both the relevance and exclusion restrictions.

INSERT TABLE 3 ABOUT HERE

The first-stage results in Table 3 show that the instrument is powerful. The coefficient on $US\ Listed_i \times Litigation_t$ shows that in the three days after a SEC litigation release, US cross-listed stocks experience a 0.19 standard deviation decline in spoofing relative to Canada-only stocks. This is consistent with the hypothesis that SEC litigation releases cause spoofing activity to decrease in US cross-listed stocks, as traders reduce their spoofing activity in response to heightened legal risk. The T-statistic on $SEC_t \times Treat_i$ is -5.39 and the Kleibergen-Paap rk Wald F statistic (shown in Table 4) is greater than 28. The highly significant coefficient on the instrument and large Kleibergen-Paap rk Wald F statistic suggest that the relevance condition is satisfied. Figure 4 shows this relation graphically. For ease of comparison, we demean stock-day spoofing levels with stock fixed effects.

INSERT FIGURE 4 ABOUT HERE

The exclusion restriction requires that $US\ Listed_i \times Litigation_t$ only affects market quality through spoofing. Threats to exclusion would have to be correlated with both $US\ Listed_i \times Litigation_t$ and market quality and orthogonal to the second stage controls. While it cannot be empirically tested, it is challenging to think of alternative possible channels by which SEC litigation releases affect market quality other than through lowering market manipulation activity. One potential concern is that the IV affects high frequency market manipulation other than spoofing, such as short selling manipulation, settlement manipulation, and wash trading. To alleviate these concerns, we conduct robustness tests that suggest that the results are not driven by short selling manipulation or settlement manipulation. Furthermore, other types of manipulation such as wash trading create a false impression of liquidity. Therefore, if we observe that spoofing harms market quality, this would be despite any decreases in wash trading which may have otherwise improved short term market quality.

The second stage estimates are shown in Table 4. We regress the market quality measures from Table 2 on the predicted standardized spoofing values from the first stage estimate in Table

4. We again control for lagged average dollar spread, lag average price, lag inverse price, absolute return, log of trading volume, and Amihud (2002) illiquidity. We also include stock and date fixed effects and cluster standard errors by stock.

INSERT TABLE 4 ABOUT HERE

The results show that instrumented spoofing has a positive relation with return volatility. A one standard-deviation increase in spoofing causes a 2.1 basis point and 2.9 basis point increase in 1-minute and 5-minute return volatility, respectively. This is consistent with the idea that spoofing can move prices. If a spoofing trader can induce a temporary mispricing, then the process of inducing and correcting the manipulation will mechanically cause return volatility to increase.

Spoofing has a statistically weak positive relation with quoted spread, effective spread, realized spread, and price impact. Although weak, the results are consistent with the Skryzpacz and Williams (2021) argument that spoofing magnifies the adverse selection problem and therefore forces market makers to raise spreads.

Spoofing causes higher variance ratios and Hasbrouck σ. A one standard-deviation increase in spoofing leads to a 28% increase in the variance ratio and a 28% basis point increase in Hasbrouck σ, which is evidence that spoofing harms price discovery, although the coefficient on the variance ratio is statistically weak. As the variance ratio measure increases, the ratio of 30 1-minute volatilities and 30-minute volatility deviates more from 1. This is evidence that increased spoofing activity drives price movements away from a random walk process, which suggests impeded price efficiency. The Hasbrouck (1993) procedure decomposes stock returns into random walk (efficient) and stationary (pricing error) components. Hasbrouck σ measures the variance of the pricing errors. Larger dispersion in pricing errors suggests a less efficient price process that tends to deviate more from true prices. Thus, the Hasbrouck σ result suggests that spoofing is also associated with lower price efficiency.

6. Intraday Spoofing and Market Quality

We turn to the intraday relation between spoofing and market quality. In daily-level tests, we document an economically strong relation between spoofing and volatility and price discovery measures. However, it is likely that spoofing has a stronger intraday effect given its high frequency and fast time to completion. We measure spoofing at 30-minute intervals as the sum of attempted spoofing order volume scaled by trading volume. We again standardize the spoofing measure for ease of interpretation. We measure market quality with 1 and 5-minute return volatility, time-weighted quoted spread, volume-weighted effective spread, volume-weighted realized spread, volume-weighted price impact, log of variance ratio, and log of Hasbrouck (1993) pricing error σ.

To estimate the intraday relation between spoofing and market quality, we estimate the following regression equation for each market quality measure:

$$Market\ Quality_{i,t,j} = \beta_1 Attempted\ Spoofing_{i,t,j} + \boldsymbol{\beta} X + \theta_{i,t} + \phi_j + \epsilon_{i,t,j}$$

Where $Attempted\ Spoofing_{i,t,j}$ is the standardized attempted spoofing order volume scaled by trading volume for stock i on day t during 30-minute interval j, and X is a vector of controls that includes the lag of average dollar spread, lag of average price, lag of inverse price, absolute return, log of trading volume, and Amihud (2002) illiquidity. We include stock-day fixed effects with $\theta_{i,t}$ and 30-minute interval fixed effects with ϕ_j, respectively. Results are presented in Table 5.

INSERT TABLE 5 ABOUT HERE

Because there are multiple observations for each stock-day, we are able to apply an aggressive set of controls to help mitigate several endogeneity concerns. However, we acknowledge that the results are not causal. We first include within-stock-day controls to help alleviate concerns that spoofers may target periods with different levels of trading volume, return magnitude, liquidity, or ex-ante microstructure characteristics. We also include stock-day and 30-minute interval fixed effects.

The stock-day fixed effects sweep out any time varying (at the daily level) and firm specific characteristics. The coefficient on spoofing is therefore a within-stock-day estimate of spoofing on market quality. In other words, we compare the market quality and spoofing levels between a stock-day's 30-minute intervals. The stock-day fixed effects can alleviate concerns that stock-specific and time-varying (at the daily level) confounders affect both spoofing and market quality. For example, the fixed effects sweep out potential endogeneity driven by firm specific news, macroeconomic events, and idiosyncratic stock-day liquidity shocks.

The 30-minute interval fixed effects mitigate concerns that spoofing and market quality may be higher or lower during different times of day (Lee, Eom, and Park 2013). For example, a within stock-day analysis may be confounded by the fact that markets face more spoofing and higher volatility during the open and close, which would drive a positive relation between spoofing and volatility. The 30-minute interval fixed effects alleviate this concern because they remove the time-of-day effect on both market quality and spoofing.

Thus, potential confounders would have to be time varying within stock-day, orthogonal to the intraday controls, orthogonal to time-of-day fixed effects, and affect both the spoofing and market quality measures. The aggressive fixed effects allow us to examine the effects of spoofing on market quality while mitigating many potential endogeneity concerns. However, because we do not exploit exogenous variation in intraday spoofing, we can not make causal claims in this section. We are unable to use the SEC Litigation Release IV because stock-day fixed effects are perfectly multicollinear with the instrument.

Consistent with the daily results, an increase in intraday spoofing is associated with significant increases in return volatility. A one standard-deviation increase in 30-minute spoofing is associated with a 0.69 basis point increase in 1-minute volatility and a 1.28 basis point increase in 5-minute volatility. Spoofing is also positively associated with spreads. A one standard-deviation increase in 30-minute spoofing is associated with a 0.23 basis point increase in quoted spread, but has an insignificant effect on the effective spread. Consistent with the idea that spoofing targets liquidity providers, a one standard-deviation increase in spoofing is associated with a 1.10 basis point decrease in realized spread and a one basis point increase in price impact. This suggests that spoofing activity is associated with a heightened adverse selection problem that liquidity providers face and lower profits to liquidity provision. Finally, intraday spoofing is associated with impeded price efficiency. A one standard-deviation increase in spoofing is associated with a 6% increase in the variance ratio and 3% increase in the Hasbrouck (1993) pricing error σ. The results suggest that spoofing is associated with worsened market quality at the intraday level.

7. Robustness

We apply a battery of robustness tests to ensure that our results are not driven by market-making activity or our choice of spoofing measure and support the exclusion restriction assumption in the IV analysis.

7.1 Market Making

One potential concern is that the spoofing detection filters pick up bona fide market making activity. We conduct a falsification test to show that unlike spoofing, market-making activity improves market quality.

We rely on key differences between spoofing and legitimate market making by HFTs. First, spoofing trading activity is one-sided, while market making trading is typically two-sided to provide liquidity. Second, spoofing strategies require that spoofing orders are cancelled quickly, while market makers place orders to maintain a two-sided market. For each stock-day, we measure market making activity as the proportion of orders from traders who have at least one outstanding order on each side of the limit order book at the end of each minute and place buy orders between 40% to 60% of the time.

We repeat the OLS estimations from Table 2 with market-making activity instead of spoofing. The market-making variable is defined as the standardized percentage of orders associated with market-making activity (as defined in Section 2.3).

INSERT TABLE 6 ABOUT HERE

Table 6 shows that market-making activity has no clear relation with return volatility, has no clear relation with quoted and effective spreads but a negative relation with realized spreads, and is negatively associated with the variance ratio and Hasbrouck σ. These results are generally consistent with the existing literature that increased algorithmic trading improves liquidity and price discovery (Hendershott, Jones, and Menkveld, 2011; Brogaard, Hendershott, and Riordan, 2014). However, the relation between market making and price impact is positive. This may be because in equilibrium, informed traders endogenously select to trade when there is the most liquidity provision available. Overall the marking making results suggest that the spoofing measures are likely not capturing genuine market-making activity.

7.2 Alternative Spoofing Definitions

The main results measure spoofing as the standardized attempted spoofing volume scaled by trading volume. We show that the results are robust to alternate definitions of spoofing at the daily and intraday levels. Namely, we turn to successful and failed spoofs.

We define successful spoofing orders as attempted spoofing orders that also result in the genuine side being executed. We define failed spoofing orders as attempted spoofing orders that result in the genuine side being cancelled. We again scale each measure by trading volume and standardize the measure for interpretation. For each alternative spoofing measure, we re-estimate the daily SEC litigation release IV approach and intraday regression approach.

The SEC litigation IV results are robust across the two different spoofing measures. Table 7 presents first stage estimates of the SEC litigation IV across the two alternate measures. The first stage coefficients on $US\ Listed_i \times Litigation_t$ show that SEC litigation releases cause spoofing to fall in US cross-listed stocks relative to Canada-only stocks. The Kleibergen-Paap rk Wald F statistic (shown in Table 8) is greater than 5 for successful spoofs and is greater than 23 for failed spoofs. This indicates that the first stage is weaker for successful spoofing activity.

INSERT TABLE 7 ABOUT HERE

Table 8 presents the second stage estimates for the SEC litigation IV. Panel A presents results for successful spoofing, while Panel B presents results for failed spoofing. The successful spoofing results in Panel A are statistically weaker than in Table 4, which is likely a result of the lower variation in successful spoofing activity. Although statistically weak, spoofing tends to increase return volatility and Hasbrouck σ. The failed spoofing results in Panel B show a similar pattern. The coefficients in Panel A are all larger in magnitude than the corresponding coefficients in Panel B, which suggests that successful spoofing activity may have a larger effect on market quality relative to failed spoofing.

INSERT TABLE 8 ABOUT HERE

We also repeat the intraday analysis with successful and failed spoofing. We reestimate the regression specification from Table 5 but replace the attempted spoofing measure with either the scaled order volume from successful spoofing or the scaled order volume from failed spoofing. Table 9 presents the results.

INSERT TABLE 9 ABOUT HERE

Table 9 Panel A presents results for successful spoofing. The results provide strong evidence that spoofing is associated with higher volatility, quoted spread, variance ratio, and price impact. Again, spoofing is associated with significantly lower realized spreads. Panel B presents the results for attempted spoofing and yields similar conclusions. The magnitudes on successful spoofing are larger, except for the variance ratio and Hasbrouck (1993) pricing error σ, which again indicates that successful spoofing activity may have a larger adverse effect on market quality.

7.3 Exclusion Restriction Robustness

The exclusion restriction requires that our instrument only affects market quality through spoofing activity. Because there are other types of market manipulation that may be affected by SEC litigation releases and correlated with spoofing activity, we make two modifications to our IV specification to mitigate this concern.

First, SEC litigation releases may lead to a decrease in short selling manipulation. If short selling manipulation is correlated with our spoofing measure, then the results may be biased. Because sell spoofs may be correlated with short selling manipulation, the results may be contaminated with changes in short selling manipulation. We therefore re-estimate the IV specification results using buy spoofs only and sell spoofs only and find that the results are economically consistent with the estimates in Table 4. We also split the sample on above and below median lagged Amihud (2002) illiquidity. The IV results are economically similar in each of the two subsamples, although statistically weaker. Because it is likely more difficult to manipulate with short selling in illiquid stock-days, the concern of short selling manipulation is lessened in the illiquid subsample.

Second, SEC litigation releases may lead to a decrease on settlement manipulation around options expirations dates. Because Canadian equity options expire on the third Friday of each month, traders may manipulate spot prices to profitably trade options. We remove the third Fridays of each month and find that our results are again unchanged.

8. **Conclusion**

We document evidence of spoofing behavior in Canadian equity markets and provide causal evidence that spoofing harms market quality. Consistent with the theoretical predictions in Skrzypacz and Williams (2021), spoofing increases return volatility, increases transaction costs, and slows price discovery.

We develop a tractable six-step filtering process to identify spoofing orders and study the prevalence of spoofing. Consistent with Skrzypacz and Williams (2021), we show that spoofing activity is single-peaked in liquidity when measured with spreads and volatility.

OLS regressions show that on average, spoofing activity is associated with worse market quality. Using SEC Litigation Releases, we exploit the variation in spoofing in US-Canada cross-listed and Canada-only stocks in an instrumental variables framework to provide causal evidence that spoofing harms market quality. We estimate the relation between spoofing and market quality within stock-day and show similar results.

This paper makes two contributions to the literature. First, we provide another tractable spoofing detection method that aims to be orthogonal to genuine market-making activity. Second, motivated by the theoretical predictions in Skrzypacz and Williams (2021), we are the first to provide causal evidence that spoofing harms market quality.

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Appendix

Table A1. Variable definitions

Variable	Definition
Spoofing measures	
Attempted spoofs	Order volume from attempted spoofing orders as defined by the procedure in Section 2.2, scaled by trading volume. Includes both successful and unsuccessful spoofs, meaning that the associated genuine order does not have to be executed.
Successful spoofs	Order volume from successful spoofing orders as defined by the procedure in Section 2.2, scaled by trading volume. Includes only successful spoofs, meaning that the associated genuine order must be executed.
Failed spoofs	Order volume from failed spoofing orders as defined by the procedure in Section 2.2, scaled by trading volume. Includes only unsuccessful spoofs, meaning that the associated genuine order must be cancelled.
Market characteristics	
1-minute return volatility	Standard deviation of 1-minute returns.
5-minute return volatility	Standard deviation of 5-minute returns.
Quoted spread	Time-weighted quoted spread, where each quoted spread is $\frac{NBO - NBB}{NBBO\ midpoint}$.
Effective spread	Volume-weighted effective spread, where each effective spread is $2 \times \frac{D_k(Price_k - NBBO\ midpoint_k)}{NBBO\ midpoint}$. D_k is a trade sign indicator equal to 1 if the trade was buyer-initiated, and -1 if the trade was seller-initiated.
Realized spread	Volume-weighted realized spread, where each realized spread is $2 \times \frac{D_k(Price_k - NBBO\ midpoint_{k,t+5})}{NBBO\ midpoint_k}$. D_k is a trade sign indicator equal to 1 if the trade was buyer-initiated, and -1 if the trade was seller-initiated. $NBBO\ midpoint_{k,t+5}$ is the NBBO midpoint five minutes after trade k occurs.
Variance ratio	Lo and MacKinlay (1988) variance ratios using 1 and 30-minute return variances: $\left|1 - 30 \times \frac{Var_{1\ minute}(ret)}{Var_{30\ minute}(ret)}\right|$.
Hasbrouck σ	Standard deviation of pricing errors from VAR system with five lags and four variables: log returns, trade sign indicator equal to 1 (-1) if the trading price is buyer (seller) initiated, signed volume computed as the trade sign times the number of shares traded, and root signed volume computed as the trade sign times the square root of the number of shares traded.
Dollar trading volume	Total trading volume.
Absolute return	Absolute value of return for the trading day.

Market-making	Percent of order volume associated with market-making activity. As defined in Section 2.3, market-making trader-minutes must have proportion of buy orders between 40% to 60% and must have an outstanding order at the end of the minute for each side.
Microstructure Controls	
Average price	Dollar trading volume divided by share trading volume.
Inverse price	1 / Average price
Dollar spread	Average price × quoted spread

Appendix A2: Spoofing Court Cases

This section describes several seminal spoofing court cases. For each case, we summarize the spoofing case, describe the court's definition of spoofing, and describe additional analysis from regulators or expert witnesses.

A2.1: *United States v. Coscia* (2017)

Background

In the first spoofing case in the United States, Michael Coscia was charged and sentenced to prison for violating the anti-spoofing provision in the Commodities Exchange Act. In *United States v. Coscia* (2017), Coscia appealed, arguing that the regulations were too vague and that there was a lack of evidence that supported his guilt. The court rejected the appeal, arguing that the anti-spoofing provision was not unconstitutionally vague, and that there was sufficient evidence to convict Coscia.

Michael Coscia owned and operated the high-frequency trading firm Panther Energy Trading, LLC. In the initial trial in 2015, Michael Coscia was accused of spoofing in the commodities futures market in 2011. To facilitate the spoofing strategy, Coscia hired Jeremiah Park to create two trading programs, Flash Trader and Quote Trader. Park's testimony revealed that the programs would bait the algorithmic traders with large spoofing orders and move prices in one direction, while at the same time profitably executing small genuine orders. The trading strategy yielded Coscia $1.4 million in a three month period. Coscia was ordered to return the $1.4 million in addition to a $1.4 million fine, and was sentenced to three years in prison.

Court's definition of spoofing (United States v. Coscia, 807 F.3d 610 (7th Cir. 2017))

> In practice, spoofing, like legitimate high-frequency trading, utilizes extremely fast trading strategies. It differs from legitimate trading, however, in that it can be employed to artificially move the market price of a stock or commodity up and down, instead of taking advantage of natural market events (as in the price arbitrage strategy discussed above). This artificial movement is accomplished in a number of ways, although it is most simply realized by placing large and small orders on opposite sides of the market. The small order is placed at a desired price, which is either above or below the current market price, depending on whether the trader wants to buy or sell. If the trader wants to buy, the price on the small batch will be lower than the market price; if the trader wants to sell, the price on the small batch will be higher. Large orders are then placed on the opposite side of the market at prices designed to shift the market toward the price at which the small order was listed. (p. 5-6)

Expert witness analysis

Professor Hank Bessembinder was an expert witness for the U.S. Government during the Coscia trial. While he did not provide a formal definition of spoofing, he provided ex-post evidence for why Coscia's trading behavior was suggestive of spoofing behavior[10]. First, the fill rates on the genuine orders were high relative to both the spoofing orders and HFT orders in general. Professor Bessembinder is quoted as saying that "there were more than 10 times as many contracts traded on the small orders as compared to the large orders". Second, Coscia had a large imbalance in large and small orders that differed from other HFTs. Professor Bessembinder

[10] The Bessembinder expert witness details are from two sources. The first point on fill rates is found in the 2016 U.S. v. Coscia case (United States v. Coscia, 177 F. Supp. 3d 1087 (N.D. Ill. 2016)), while the latter points are found in the 2021 U.S. v. Coscia case (United States v. Coscia, 4 F.4th 454 (7th Cir. 2021)).

stated that Coscia "was entering over 60 percent of his orders as large orders, whereas, the other high-frequency traders were entering only about a quarter of one percent of their orders as large orders." Lastly, Coscia had a high order cancellation rate, particularly in the large spoofing orders. Professor Bessembinder stated that Coscia cancelled "a little over 97 percent" of large orders within a second, while the percentages was under 35 percent for other HFTs.

A2.2: U.S. Commodity Futures Trading Commission v. Nav Sarao Futures Limited PLC and Navinder Singh Sarao (2017)

Background

Navinder Singh Sarao was accused and convicted of spoofing E-mini S&P 500 futures in 2009 to 2015. Based in his parents' home in London, Sarao used a combination of manual spoofing and algorithmic spoofing to manipulate E-mini prices. Importantly, Sarao's spoofing activity is considered one of the contributors to the May 6, 2010 Flash Crash. Sarao was arrested in 2015 and paid $12.8 million to the U.S. government.[11]

Court's definition of layering (Case No. 15-cv-3398)

> More specifically, Defendants placed thousands of orders to buy or to sell E-mini S&P futures contracts that they did not intend to execute at the time the orders were placed (Spoof Orders). Defendants' intent in placing these Spoof Orders was to create a materially false and misleading impression of supply (when placing sell-side Spoof Orders) and demand (when placing buy-side Spoof Orders) in order to induce other

[11] https://www.bbc.co.uk/news/business-37932250

> market participants to react to the false Spoof Order information and to buy or sell E-mini S&P futures contracts at prices, quantities, and/or times that, but for Defendants' Spoof Orders, they would not otherwise have traded. (p.6)

Regulatory analysis[12]

The regulatory complaint included several metrics that were used to argue that Sarao's layering orders were different from typical E-mini orders. First, Sarao's layering algorithm had extremely high cancellation rates, with a cancellation rate of over 99%. However, the cancellation rate from other traders for orders of similar sizes was 49%. Second, Sarao's layering algorithm order size was 504 contracts on average, while the order size was 7 contracts on average for other traders. Third, Sarao's layering algorithm had a higher amendment rate, with 161 amendments on average per order, while orders from other traders averaged only 1 modification per order.

A2.3: Securities and Exchange Commission v. Lek Securities Corporation, et al (2019)

Background

On March 20, 2017, the SEC sued Lek Securities Corporation for market manipulation. Lek Securities is a New York-based broker-dealer firm. Avalon Securities used the Lek broker-dealer services to trade in the U.S. The SEC accused Avalon Securities of market manipulation, and argued that Lek Securities profited from Avalon's manipulative activity. The jury verdict in 2019 was in favor of the SEC, which resulted in fines for Lek and Avalon.

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[12] We use the regulatory analysis from the CFTC's complaint: https://www.cftc.gov/sites/default/files/idc/groups/public/@lrenforcementactions/documents/legalpleading/enfsaraocomplaint041715.pdf

The jury found that the defendants were guilty of layering and cross-market spoofing. From 2012 to 2016, the defendants had over 675,000 cases of layering and 668 cases of cross-market spoofing, which yielded over $21 million from layering and over $21 million from cross-market spoofing.

Court's definition of layering (612 F. Supp. 3d 287 (S.D.N.Y. 2020))

> The first manipulative scheme, referred to as "layering," involved placing multiple orders to buy (or sell) a given stock at increasing (or decreasing) prices, to move the price of the security without intending to execute those orders. These are referred to as the loud-side orders. The loud-side orders created the appearance of an artificially inflated level of demand (or supply) for a stock. In conjunction with the loud-side orders, the trader would place a smaller number of orders on the opposite side of the market to sell (or buy) the same stock. These are referred to as the quiet-side orders. Once the stock reached the desired price, the trader canceled the loud-side orders.

Expert witness analysis (370 F. Supp. 3d 384 (S.D.N.Y. 2019))

Professors Terrence Hendershott and Neil Pearson provided expert witness testimony. Because the defendants moved to exclude the expert testimony in trial, the court described the testimonies in detail. We focus on Professor Hendershott's "layering loop" analysis. Below is an excerpt from the court opinion (p.4).

> Hendershott applied five criteria to identify groups of orders, cancellations, and executions consistent with layering. First, Hendershott considered only instances where a trader places both buy and sell orders in a single stock, because layering is a strategy that involves a trader placing orders on both sides of the market. Second, Hendershott only

considered instances where the orders were entirely resolved through cancellation or execution within 60 seconds, even though it is possible for traders to engage in a layering scheme through transactions that last longer than 60 seconds. The parties refer to these groupings as "Loops."

Third, Hendershott required both the number of visible orders and the number of shares in those orders on the Loud side of a Loop to be greater than both the orders and shares on the Quiet side by at least two to one (the "Order Imbalance"). Approximately 2 million Loops from the Avalon Trade Data met Hendershott's first three criteria.

Fourth, Hendershott eliminated Loops where the ratio of executed shares on the Quiet side to the Loud side was less than three to one (the "Execution Imbalance"), even though the Loud-side shares were more numerous. Hendershott contends that considering only Loops with an Execution Imbalance of at least three to one eliminates trading strategies such as market making from the Loops.

Fifth, Hendershott eliminated Loops if a Loud-side order was placed more than one second after the last Quiet-side execution or cancellation. He reasoned that this was consistent with a layering strategy, which typically involves placing Loud-side orders to achieve favorable execution prices for Quiet-side orders. Hendershott explains that, together, these five criteria create a conservative data set reflecting patterns of layering activity. Applying these criteria yielded a total of 675,504 Loops that Hendershott found to be consistent with layering (the "Layering Loops"). Of those, 663,994 occurred after March 12, 2012.

In addition to the layering definition, Hendershott's testimony provides additional analysis that suggests that Avalon's activity is layering. First, he shows that the layering orders are cancelled within seconds of the genuine order executions, which he states "is consistent with a layering strategy which tries to minimize the execution rate of Loud-side orders" (p. 4). Second, Hendershott provides evidence that suggests that Avalon's activity has no economic rationale. He shows that the realized spread associated with the genuine-side orders tends to be positive, while the realized spread associated with the layering orders tends to be negative. This is evidence that the layering orders did not have an "economic rationale." (p. 5)

A2.4: Harrington Global Opportunity Fund v. CIBC World Markets Corp

Background

Harrington Global Opportunity Fund owned shares of Concordia, a pharmaceutical company that is cross-listed on NASDAQ and TSX. From January 27, 2016 to November 15, 2016, the price of a Concordia share fell from $28.03 to $3.13. Defendants are traders from both the U.S. and Canada, whom Harrington accused of manipulative spoofing and short-selling.

Because there were defendants from both the U.S. and Canada, the court had to determine whether it had jurisdiction over the Canadian traders. The court argued that under the "effects test," it had jurisdiction over the Canadian traders, even if they did not manipulate Concordia on U.S. exchanges. This is because manipulating the price of Concordia listed on the TSX will also affect the price of shares on the NASDAQ. The court dismissed the manipulative short-selling claims in February of 2022, while the spoofing claims remained (585 F. Supp. 3d 405 (S.D.N.Y. 2022)).

Court’s definition of spoofing (585 F. Supp. 3d 405 (S.D.N.Y. 2022))

> Nonetheless, when looking to indicia that distinguish spoofing from legitimate market activity, courts tend to examine (1) the passage of time between placement and canceling of orders (usually in milliseconds), (2) cancellation of orders when large baiting orders are partially filled or legitimate small orders are completely filled, (3) parking baiting orders behind smaller legitimate orders placed by other traders and (4) large disparities in the volume of baiting orders on one side of the market and legitimate orders placed by the spoofer. (p. 7)

A2.5: U.S. Commodity Futures Trading Commission v. Oystacher et al.

Background

The CFTC accused Igor Oystacher and 3Red Trading LLC of spoofing from on over 51 days from December 2011 to January 2014. The defendants were accused of spoofing E-Mini S&P 500 futures, crude oil and natural gas futures, copper futures, and VIX futures.[13] The CFTC and defendants settled in 2016, resulting in a $2.5 million civil fine and trading limitations for the defendants.

Expert witness analysis (No. 15-CV-9196)

Professor Hendrik Bessembinder was hired by the CFTC as an expert witness. His analysis is detailed in the court’s Memorandum Opinion and Order. To identify instances of spoofing, Bessembinder first identified “flipping patterns.” In particular, he stated that “[a] flip refers to

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[13] https://www.cftc.gov/PressRoom/PressReleases/7264-15

[the] cancellation of an order followed by an opposite side order entry within 0.005 seconds and at the same or better price." (p.46).

Professor Bessembinder then used the following four criteria to further narrow down the flip orders (p.46-47). Flip orders were included if they:

1. Were "placed and cancelled in less than a second"
2. "At least doubled the quantity of contracts that was already in the limit order book at the relevant prices"
3. "Were placed at an existing price—i.e., did not establish a new best bid or offer"
4. "Were fully visible to the market—i.e., not iceberg orders"

Figure 1: Spoofing Example

Figure 1 provides a graphical representation of the sell spoofing example described in Section 2.2.

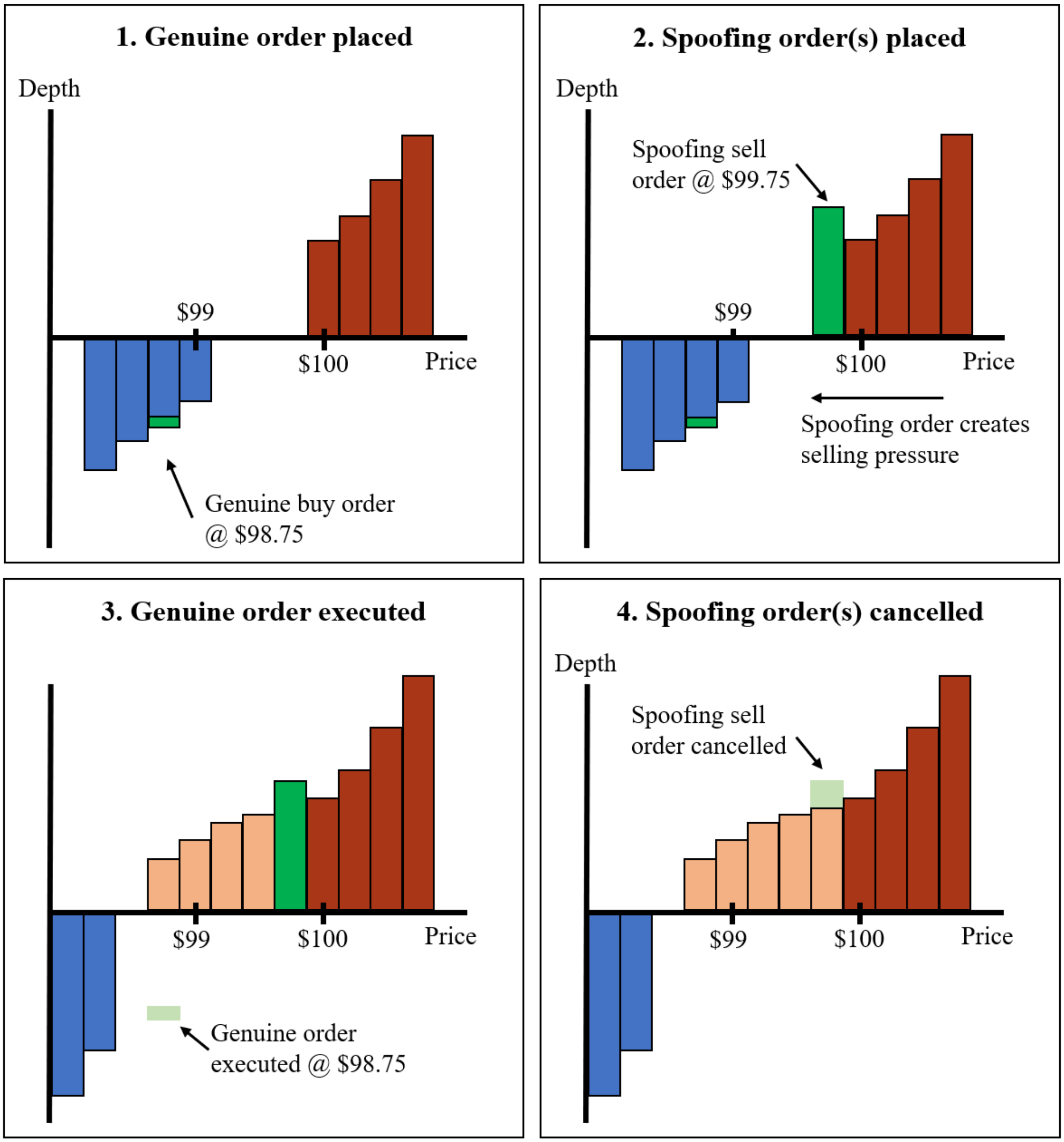
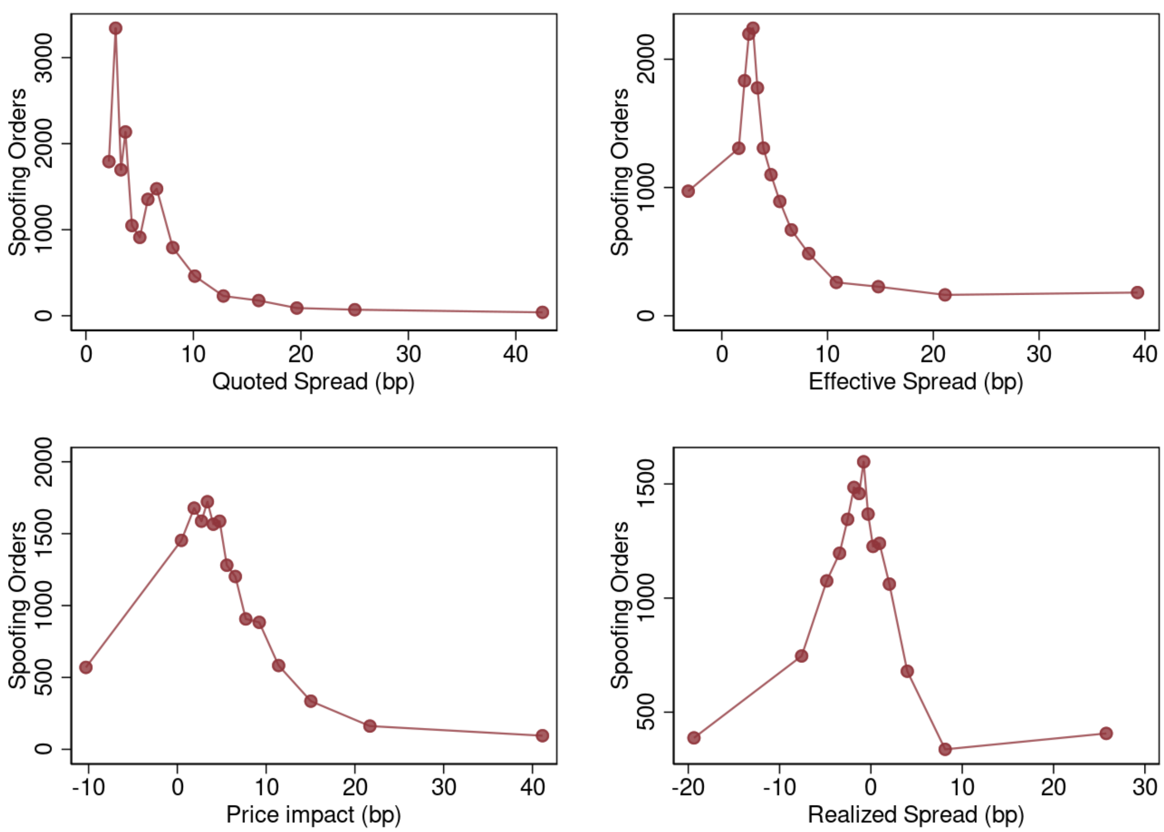


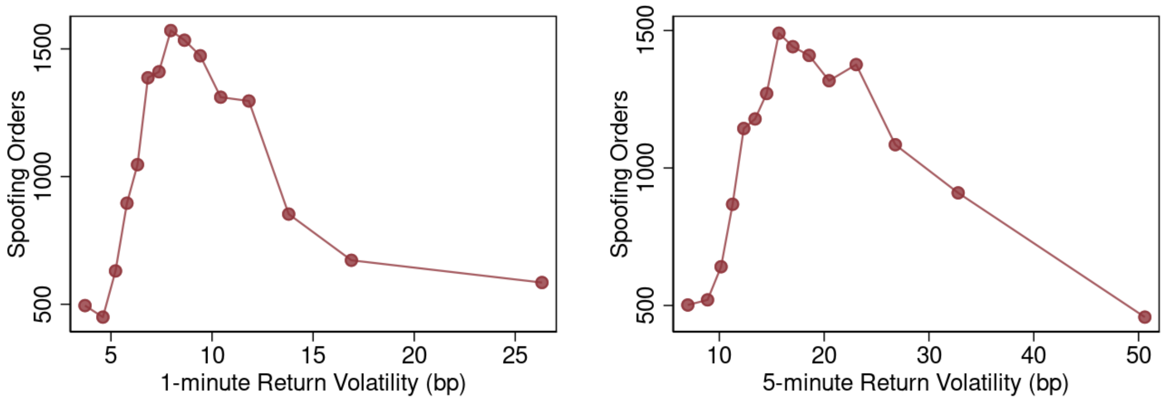
Figure 2: Spoofing and Market Quality

Figure 2 plots spoofing activity given lagged market quality quantiles. The vertical axis shows spoofing, measured as the number of attempted spoofing orders for a given stock-day. The horizontal axis represents different market quality measures. Panel A plots the average level of spoofing for each transaction cost quantile, where transaction costs are measured with time-weighted quoted spread, volume-weighted effective spread, volume-weighted price impact, and volume-weighted realized spread. Panel B plots the average level of spoofing given volatility quantiles, where volatility is measured with 1 and 5-minute return volatility. Panel C plots the average level of spoofing given price efficiency quantiles, where price efficiency is measured with the variance ratio and Hasbrouck (1993) pricing error σ.

Panel A: Spoofing and Lagged Transaction Costs



Panel B: Spoofing and Lagged Volatility



Panel C: Spoofing and Lagged Price Efficiency

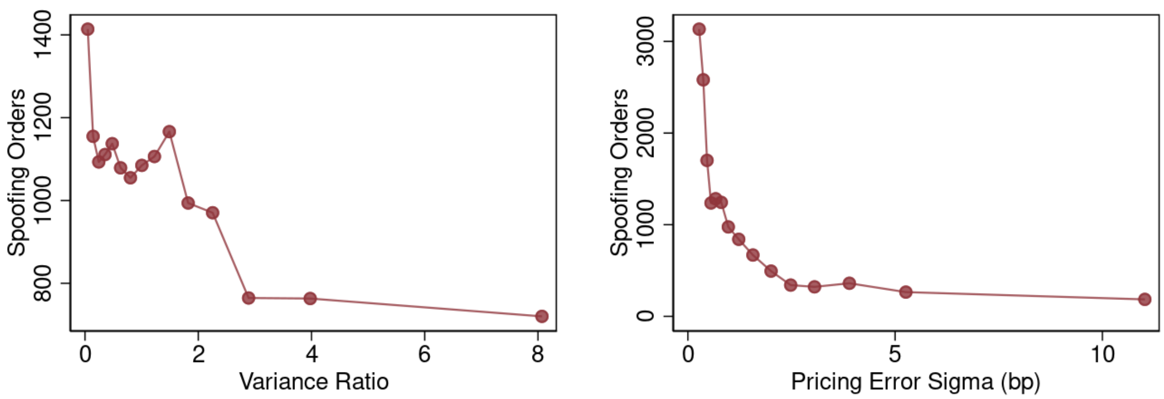


Figure 3: SEC Litigation Releases

Figure 3 plots the 12 SEC litigation releases in the sample period. The sample of SEC litigation releases consists of charges, allegations, sentences, and final judgements that are related to trade or order-based market manipulation. Litigation days are defined as those in the three days following an SEC litigation release.

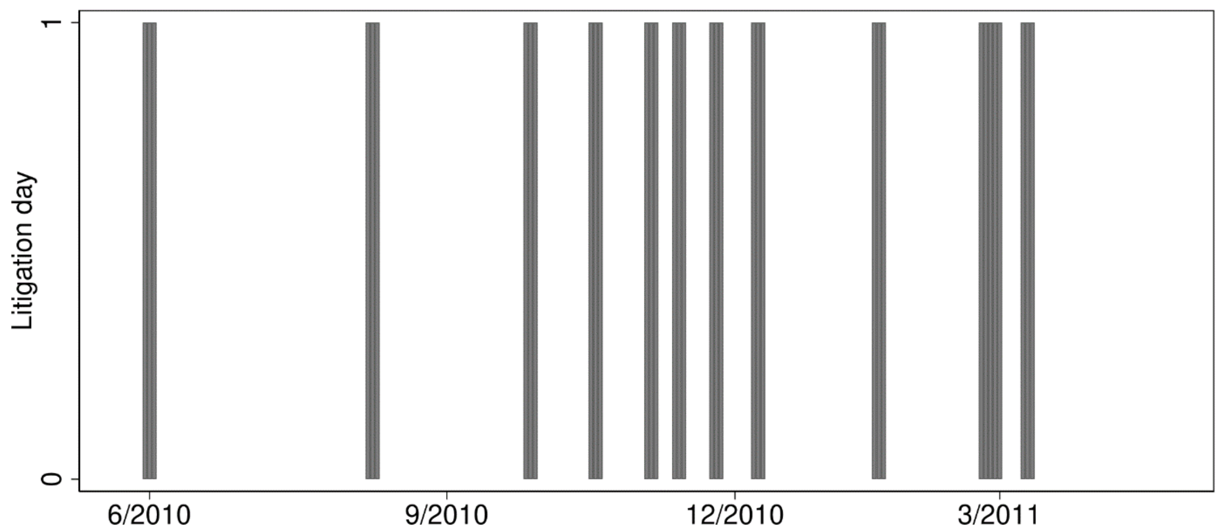


Figure 4: SEC Litigation Releases and Spoofing Activity

Figure 4 plots the average daily spoofing activity for US cross-listed and Canada-only stocks during litigation and non-litigation periods. Stock-day spoofing levels are demeaned with stock fixed-effects. Litigation periods are defined as the three days after a significant SEC litigation release on trade or order-based market manipulation. Spoofing is measured as the order volume from attempted spoofing scaled by trading volume.

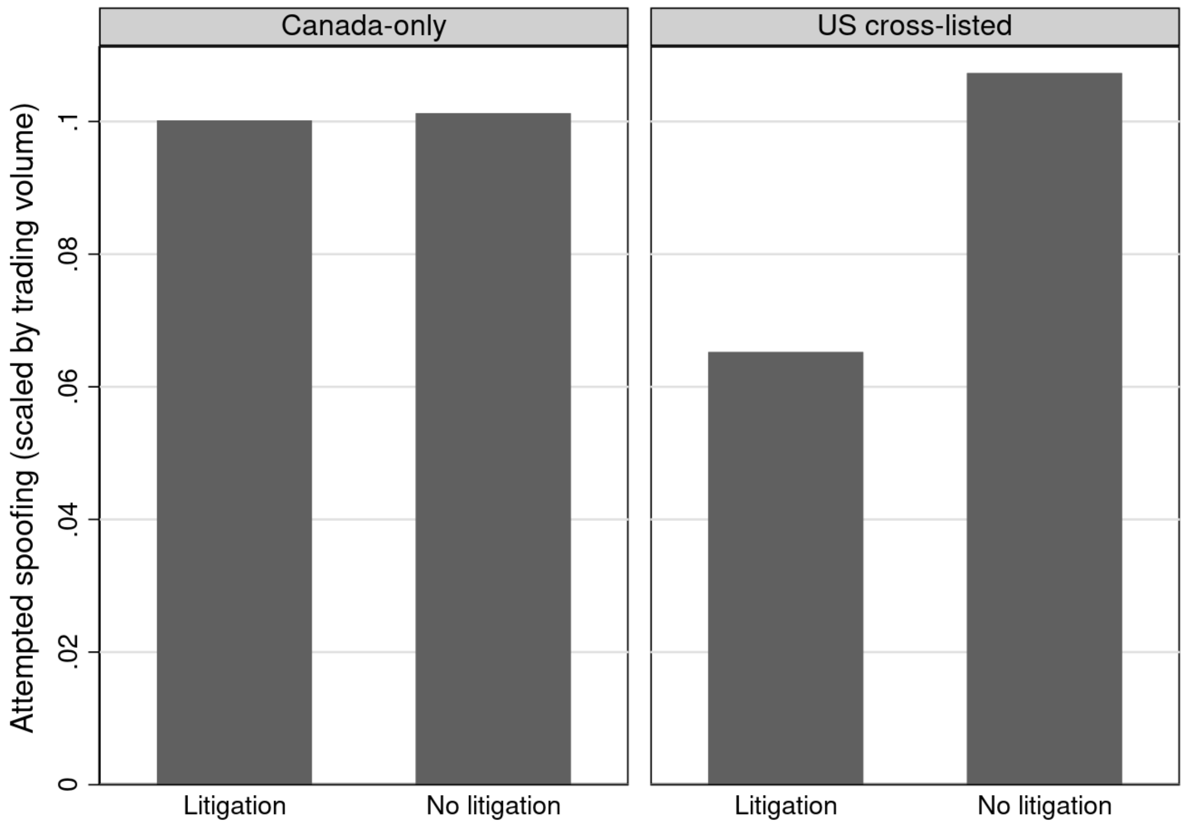


Table 1: Summary Statistics

Panel A presents stock-day level summary statistics for market quality measures. All Panel A variables except for the variance ratio, daily return, and dollar volume are reported in basis points. Panel B presents 30-minute level summary statistics for market quality measures. All Panel B variables except for variance ratio are reported in basis points. Panel C presents stock-day level summary statistics for spoofing activity. Panel D presents 30-minute level summary statistics for spoofing activity. Spoofing variables in percentages are defined as the spoofing order volume scaled by the level of total trading volume. All variables are winsorized at the 1% and 99% levels.

Panel A: Stock-Day Market Quality

	Mean	SD	p10	Median	p90	N
1-minute volatility (bp)	9.99	6.18	4.64	8.14	17.53	21,415
5-minute volatility (bp)	19.49	11.98	8.97	16.04	34.14	21,415
Quoted spread (bp)	12.61	13.24	2.82	7.04	28.34	21,415
Effective spread (bp)	9.21	12.34	1.61	4.89	23.47	21,415
Realized spread (bp)	0.25	11.35	-7.85	-0.76	9.13	21,415
Price impact (bp)	8.91	13.11	0.43	5.73	23.47	21,415
Variance ratio	1.69	2.15	0.14	1	3.93	21,396
Hasbrouck σ (bp)	2.61	3.52	0.38	1.35	5.88	21,306

Panel B: 30-Minute Market Quality

	Mean	SD	p10	Median	p90	N
1-minute volatility (bp)	10.11	9.72	2.61	7.25	20.54	365209
5-minute volatility (bp)	19.61	19.9	3.82	13.73	41.5	363425
Quoted spread (bp)	31.16	55.15	2.83	11.47	76.58	369105
Effective spread (bp)	22.89	53.98	0.16	6.14	63.2	368987
Realized spread (bp)	11.4	50.2	-14.93	.88	45.99	368987
Price impact (bp)	11.12	30.62	-4.13	4.16	35.76	368987
Variance ratio	1.11	2.1	0.04	.37	2.79	342590
Hasbrouck σ (bp)	3.75	6.18	0.40	1.49	8.78	262135

Panel C: Stock-Day Spoofing

	Mean	SD	p10	Median	p90	N
Attempted spoofs (% volume)	10.10	22.06	0.00	1.59	28.22	21,415
Successful spoofs (% volume)	0.18	0.25	0.00	0.08	0.52	21,415
Failed spoofs (% volume)	9.92	21.91	0.00	1.43	27.78	21,415
Attempted spoofs (#)	985.58	2403.68	0.00	64	2840	21,415
Attempted buy spoofs (#)	486.24	1202.33	0.00	31	1376	21,415
Attempted sell spoofs (#)	499.34	1252.21	0.00	31	1384	21,415
Successful spoofs (#)	24.3	50.49	0.00	3	74	21,415
Successful buy spoofs (#)	12.04	25.73	0.00	1	37	21,415
Successful sell spoofs (#)	12.26	26.43	0.00	2	37	21,415

Panel D: 30-Minute Spoofing

	Mean	SD	p10	Median	p90	N
Attempted spoofs (% volume)	10.99	30.96	0.00	.29	27.34	369105
Successful spoofs (% volume)	5.38	15.85	0.00	0	13.01	369105
Failed spoofs (% volume)	5.6	17.84	0.00	0	12.92	369105
Attempted spoofs (#)	63.52	259.12	0.00	1	133	369105
Attempted buy spoofs (#)	31.33	139.01	0.00	0	64	369105
Attempted sell spoofs (#)	32.19	147.84	0.00	0	63	369105
Successful spoofs (#)	1.51	5.85	0.00	0	4	369105
Successful buy spoofs (#)	.75	3.27	0.00	0	2	369105
Successful sell spoofs (#)	.76	3.3	0.00	0	2	369105

Table 2: Spoofing and Market Quality

Table 2 presents results of the following regression equation: $Market\ Quality_{i,t} = \beta_1 Attempted\ Spoofing_{i,t} + \boldsymbol{\beta}X + \gamma_t + \zeta_i + \epsilon_{i,t}$, where $MarketQuality_{i,t}$ is 1-minute return volatility, 5-minute return volatility, time-weighted quoted spread, volume-weighted effective spread, volume-weighted realized spread, volume-weighted price impact, log of variance ratio, or log Hasbrouck (1993) pricing error σ. $Attempted\ Spoofing_{i,t}$ is the standardized attempted spoofing order volume scaled by trading volume. X represents standardized controls for the lag of average dollar spread, lag of average price, lag of inverse price, absolute return, log of trading volume, and Amihud (2002) illiquidity. We include stock and date fixed effects with γ_t and ζ_i, respectively. T-statistics are reported in parentheses and standard errors are clustered by stock.

	(1) 1-minute volatility	(2) 5-minute volatility	(3) Quoted spread	(4) Effective spread	(5) Realized spread	(6) Price impact	(7) Variance ratio	(8) Hasbrouck σ
$Attempted\ Spoofing_{i,t}$	0.29***	0.39***	-0.16**	0.10	0.39***	-0.27***	0.02	0.05***
	(3.62)	(2.77)	(-2.44)	(1.28)	(3.28)	(-3.51)	(1.42)	(5.68)
$Average\ Dollar\ Spread_{i,t-1}$	0.98***	1.93***	2.47***	1.52***	0.59**	0.96***	0.08**	0.19***
	(7.25)	(9.06)	(6.63)	(5.08)	(2.49)	(2.82)	(2.47)	(8.90)
$Average\ Price_{i,t-1}$	-1.08***	-2.16***	-0.97**	-0.71*	-0.15	-0.46	0.03	-0.04
	(-3.84)	(-4.07)	(-1.98)	(-1.75)	(-0.45)	(-0.94)	(0.75)	(-0.98)
$Inverse\ Price_{i,t-1}$	3.41***	5.42***	10.29***	6.88***	5.94***	1.04	0.17***	0.29***
	(7.37)	(6.11)	(11.34)	(9.21)	(7.48)	(1.37)	(2.90)	(7.17)
$Absolute\ Return_{i,t}$	0.90***	2.10***	-0.10	0.52***	-0.83***	1.30***	-0.15***	0.00
	(11.87)	(13.93)	(-1.42)	(3.55)	(-4.83)	(7.40)	(-9.31)	(0.32)
$\ln(Dollar\ Volume)_{i,t}$	2.37***	4.47***	-0.38**	-2.59***	1.79***	-4.01***	-0.07	-0.20***
	(10.39)	(10.83)	(-2.31)	(-9.10)	(2.89)	(-7.23)	(-1.56)	(-8.52)
$Amihud\ Illiquidity_{i,t}$	0.16	0.44*	1.30***	1.05***	-0.91***	1.93***	-0.02	0.03***
	(1.34)	(1.88)	(5.76)	(4.04)	(-3.47)	(5.90)	(-1.20)	(2.70)
Stock FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Date FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	20,155	20,155	20,155	20,155	20,155	20,155	20,144	20,095
Adjusted R-squared	0.722	0.699	0.903	0.573	0.088	0.354	0.143	0.563

Table 3: First Stage Litigation IV Estimate

Table 3 presents results for the following regression equation: $Attempted\ Spoofing_{i,t} = \beta_1 Litigation_t \times Treat_i + \boldsymbol{\beta} X + \gamma_t + \zeta_i + \epsilon_{i,t}$, where $Attempted\ Spoofing_{i,t}$ is the standardized attempted spoofing order volume scaled by trading volume for stock i on day t, $Litigation_t$ is an indicator variable equal to 1 if the date t is one to three days after a SEC litigation release on market manipulation, and $Treat_i$ is an indicator variable equal to 1 if stock i is cross-listed on a U.S. exchange. X represents standardized controls for the lag of average dollar spread, lag of average price, lag of inverse price, absolute return, log of trading volume, and Amihud (2002) illiquidity. We include stock and date fixed effects with γ_t and ζ_i, respectively. T-statistics are reported in parentheses and standard errors are clustered by stock.

	(1) Attempted Spoofing
$US\ Listed_i \times Litigation_t$	-0.19***
	(-5.39)
$Average\ Dollar\ Spread_{i,t-1}$	0.03
	(0.65)
$Average\ Price_{i,t-1}$	-0.13
	(-0.74)
$Inverse\ Price_{i,t-1}$	-0.40***
	(-4.80)
$Absolute\ Return_{i,t}$	-0.01
	(-0.41)
$\ln(Dollar\ Volume)_{i,t}$	-0.17**
	(-2.52)
$Amihud\ Illiquidity_{i,t}$	-0.01
	(-0.39)
Stock FE	Yes
Date FE	Yes
Observations	20,155
Adjusted R-squared	0.526

Table 4: Second Stage Litigation IV Estimate

Table 4 presents results for the following regression equation $Market\ Quality_{i,t} = \beta_1 \widehat{Attempted\ Spoofing}_{i,t} + \boldsymbol{\beta}X + \gamma_t + \zeta_i + \epsilon_{i,t}$, where $MarketQuality_{i,t}$ is 1-minute return volatility, 5-minute return volatility, time-weighted quoted spread, volume-weighted effective spread, volume-weighted realized spread, volume-weighted price impact, log of variance ratio, or log of Hasbrouck (1993) pricing error σ. $\widehat{Spoofing}_{i,t}$ is the predicted standardized attempted spoofing volume scaled by trading volume for stock i on day t from the first-stage IV regression in Table 3. X represents standardized controls for the lag of average dollar spread, lag of average price, lag of inverse price, absolute return, log of trading volume, and Amihud (2002) illiquidity. We include stock and date fixed effects with γ_t and ζ_i, respectively. T-statistics are reported in parentheses and standard errors are clustered by stock.

	(1) 1-minute volatility	(2) 5-minute volatility	(3) Quoted spread	(4) Effective spread	(5) Realized spread	(6) Price impact	(7) Variance ratio	(8) Hasbrouck σ
$Attempted\ Spoofing_{i,t}$	2.09**	2.88*	0.56	3.73*	0.64	2.02	0.28	0.28**
	(2.59)	(1.96)	(0.59)	(1.83)	(0.33)	(1.03)	(1.02)	(2.50)
$Average\ Dollar\ Spread_{i,t-1}$	0.93***	1.86***	2.44***	1.41***	0.58**	0.89**	0.08*	0.18***
	(4.96)	(6.56)	(6.45)	(3.75)	(2.32)	(2.39)	(1.91)	(6.32)
$Average\ Price_{i,t-1}$	-0.85**	-1.83***	-0.88	-0.24	-0.12	-0.16	0.07	-0.01
	(-2.16)	(-3.06)	(-1.65)	(-0.29)	(-0.24)	(-0.24)	(0.81)	(-0.17)
$Inverse\ Price_{i,t-1}$	4.12***	6.42***	10.57***	8.33***	6.04***	1.95*	0.27**	0.39***
	(6.96)	(6.03)	(11.06)	(7.03)	(5.54)	(1.78)	(2.04)	(5.78)
$Absolute\ Return_{i,t}$	0.91***	2.11***	-0.09	0.53***	-0.82***	1.31***	-0.15***	0.00
	(11.91)	(14.01)	(-1.32)	(3.48)	(-4.82)	(7.22)	(-9.00)	(0.45)
$\ln(Dollar\ Volume)_{i,t}$	2.67***	4.88***	-0.26	-1.98***	1.83***	-3.62***	-0.02	-0.16***
	(8.33)	(9.08)	(-1.11)	(-3.98)	(2.87)	(-5.63)	(-0.34)	(-4.56)
$Amihud\ Illiquidity_{i,t}$	0.18	0.47*	1.31***	1.08***	-0.91***	1.95***	-0.02	0.03**
	(1.33)	(1.86)	(5.72)	(3.81)	(-3.44)	(5.66)	(-1.04)	(2.56)
Stock FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Date FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	20,155	20,155	20,155	20,155	20,155	20,155	20,144	20,095
Kleibergen-Paap F-statistic	29.08	29.08	29.08	29.08	29.08	29.08	28.97	29.34

Table 5: Intraday Relation Between Spoofing and Market Quality

Table 5 presents results of the following regression equation: $Market\ Quality_{i,t,j} = \beta_1 Attempted\ Spoofing_{i,t,j} + \boldsymbol{\beta}X + \theta_{it} + \phi_j + \epsilon_{i,t,j}$, where $MarketQuality_{i,t,j}$ is 1-minute return volatility, 5-minute return volatility, time-weighted quoted spread, volume-weighted effective spread, volume-weighted realized spread, volume-weighted price impact, log of variance ratio, or log of Hasbrouck (1993) pricing error σ for stock i on day t in the 30-minute interval j. $Attempted\ Spoofing_{i,t,j}$ is the standardized attempted spoofing order volume scaled by trading volume. X represents standardized controls for the lag of average dollar spread, lag of average price, lag of inverse price, absolute return, log of trading volume, and Amihud (2002) illiquidity. We include stock-day fixed effects with θ_{it} and 30-minute interval fixed effects with ϕ_j. T-statistics are reported in parentheses and standard errors are clustered by stock.

	(1) 1-minute volatility	(2) 5-minute volatility	(3) Quoted spread	(4) Effective spread	(5) Realized spread	(6) Price impact	(7) Variance ratio	(8) Hasbrouck σ
$Attempted\ Spoofing_{i,t,j}$	0.69***	1.28***	0.23***	-0.11	-1.10***	1.00***	0.06***	0.03***
	(12.42)	(11.47)	(3.17)	(-1.18)	(-4.88)	(5.25)	(2.78)	(2.74)
$Average\ Dollar\ Spread_{i,t,j-1}$	0.67***	1.12***	9.51***	3.41***	3.19***	0.24	0.02	0.14***
	(8.11)	(7.62)	(7.50)	(6.68)	(6.46)	(1.45)	(0.79)	(9.19)
$Average\ Price_{i,t,j-1}$	-6.81***	-20.80***	3.14	6.00	-10.28	15.16**	-0.24	-0.51***
	(-4.47)	(-5.22)	(0.87)	(0.88)	(-1.48)	(2.37)	(-0.46)	(-3.07)
$Inverse\ Price_{i,t,j-1}$	4.60**	12.32***	13.26	-32.61**	-19.45	-13.93	-0.92	0.18
	(2.12)	(3.30)	(1.36)	(-2.56)	(-1.53)	(-1.43)	(-0.97)	(1.18)
$\ln(Dollar\ Volume)_{i,t,j}$	4.78***	9.38***	-0.42**	-0.58	-5.72***	5.32***	1.12***	-0.44***
	(22.21)	(21.89)	(-2.38)	(-1.13)	(-9.22)	(8.50)	(10.43)	(-18.30)
$Absolute\ Return_{i,t,j}$	3.07***	6.83***	1.93***	6.06***	-1.15***	6.77***	0.04*	0.03***
	(20.62)	(24.70)	(8.32)	(10.04)	(-2.82)	(20.64)	(1.87)	(7.09)
$Amihud\ Illiquidity_{i,t,j}$	0.38***	0.74***	1.24***	2.58***	5.64***	-2.96***	-0.45***	0.02
	(4.55)	(4.13)	(4.82)	(6.56)	(12.62)	(-12.74)	(-8.60)	(0.13)
Stock-day FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
30-minute interval FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	318,711	317,597	320,427	320,349	320,349	320,349	304,418	238,783
Adjusted R-squared	0.596	0.549	0.858	0.484	0.368	0.199	0.178	0.790

Table 6: Market Making Falsification

Table 6 presents results of the following regression equation: $Market\ Quality_{i,t} = \beta_1 Market\ Making_{it} + \boldsymbol{\beta} X + \gamma_t + \zeta_i + \epsilon_{i,t}$, where $MarketQuality_{i,t}$ is 1-minute return volatility, 5-minute return volatility, time-weighted quoted spread, volume-weighted effective spread, volume-weighted realized spread, volume-weighted price impact, log of variance ratio, or log of Hasbrouck (1993) pricing error σ. $MarketMaking_{i,t}$ is the standardized percent of order volume associated with market-making activity. X represents standardized controls for the lag of average dollar spread, lag of average price, lag of inverse price, absolute return, log of trading volume, and Amihud (2002) illiquidity. We include stock and date fixed effects with γ_t and ζ_i, respectively. T-statistics are reported in parentheses and standard errors are clustered by stock.

	(1) 1-minute volatility	(2) 5-minute volatility	(3) Quoted spread	(4) Effective spread	(5) Realized spread	(6) Price impact	(7) Variance ratio	(8) Hasbrouck σ
$Market\ Making_{it}$	-0.02	0.02	0.03	-0.01	-0.22*	0.24**	-0.04**	-0.02***
	(-0.32)	(0.24)	(0.35)	(-0.09)	(-1.69)	(2.26)	(-2.45)	(-2.69)
$Average\ Dollar\ Spread_{i,t-1}$	1.00***	1.96***	2.45***	1.56***	0.66***	0.95***	0.09**	0.19***
	(7.65)	(9.46)	(6.58)	(5.15)	(2.75)	(2.75)	(2.51)	(9.81)
$Average\ Price_{i,t-1}$	-1.13***	-2.23***	-0.95*	-0.75*	-0.23	-0.44	0.03	-0.05
	(-3.76)	(-3.97)	(-1.95)	(-1.82)	(-0.67)	(-0.91)	(0.70)	(-1.05)
$Inverse\ Price_{i,t-1}$	3.28***	5.25***	10.30***	6.93***	5.74***	1.29*	0.15**	0.27***
	(6.92)	(5.80)	(11.38)	(9.02)	(7.11)	(1.70)	(2.58)	(6.52)
$Absolute\ Return_{i,t}$	0.90***	2.11***	-0.09	0.52***	-0.82***	1.29***	-0.15***	0.00
	(11.81)	(13.91)	(-1.37)	(3.53)	(-4.82)	(7.43)	(-9.34)	(0.31)
$\ln(Dollar\ Volume)_{i,t}$	2.30***	4.38***	-0.36**	-2.63***	1.67***	-3.93***	-0.08*	-0.21***
	(10.05)	(10.62)	(-2.22)	(-9.23)	(2.68)	(-7.04)	(-1.76)	(-9.12)
$Amihud\ Illiquidity_{i,t}$	0.14	0.40*	1.30***	1.04***	-0.96***	1.94***	-0.02	0.03**
	(1.17)	(1.73)	(5.64)	(3.93)	(-3.67)	(5.91)	(-1.19)	(2.54)
Stock FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Date FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	20,140	20,140	20,140	20,140	20,140	20,140	20,132	20,086
Adjusted R-squared	0.721	0.699	0.904	0.573	0.086	0.356	0.122	0.815

Table 7: Alternate Spoofing Measures Litigation First Stage

Table 7 presents results for the following regression equation: $Spoofing_{i,t} = \beta_1 SEC_t \times Treat_i + \boldsymbol{\beta} X + \gamma_t + \zeta_i + \epsilon_{i,t}$, where $Spoofing_{i,t}$ is the standardized spoofing measure for stock i on day t. Columns 1 and 2 measure spoofing with the order volume from successful spoofing and order volume from failed spoofing, respectively. Before standardization, spoofing measures are scaled by trading volume. SEC_t is an indicator variable equal to 1 if the date t is one to three days after a SEC litigation release on market manipulation, and $Treat_i$ is an indicator variable equal to 1 if stock i is cross-listed on a U.S. exchange. X represents standardized controls for the lag of average dollar spread, lag of average price, lag of inverse price, absolute return, log of trading volume, and Amihud (2002) illiquidity. We include stock and date fixed effects with γ_t and ζ_i, respectively. T-statistics are reported in parentheses and standard errors are clustered by stock.

	(1) Successful Spoofing	(2) Failed Spoofing
$US\ Listed_i \times Litigation_t$	-0.07**	-0.18***
	(-2.42)	(-4.81)
$Average\ Dollar\ Spread_{i,t-1}$	0.02	0.07
	(0.55)	(1.04)
$Average\ Price_{i,t-1}$	-0.14	-0.14
	(-1.29)	(-0.76)
$Inverse\ Price_{i,t-1}$	-0.40***	-0.37***
	(-6.97)	(-4.42)
$Absolute\ Return_{i,t}$	0.01	-0.00
	(0.87)	(-0.30)
$\ln(Dollar\ Volume)_{i,t}$	-0.11***	-0.15**
	(-2.93)	(-2.56)
$Amihud\ Illiquidity_{i,t}$	-0.00	-0.01
	(-0.30)	(-0.30)
Stock FE	Yes	Yes
Date FE	Yes	Yes
Observations	20,155	20,155
Adjusted R-squared	0.496	0.425

Table 8: Alternate Spoofing Measures Litigation Second Stage

Table 8 presents results for the following regression equation: $Market\ Quality_{i,t} = \beta_1 \widehat{Spoofing}_{i,t} + \boldsymbol{\beta} X + \gamma_t + \zeta_i + \epsilon_{i,t}$, where $MarketQuality_{i,t}$ is 1-minute return volatility, 5-minute return volatility, time-weighted quoted spread, volume-weighted effective spread, volume-weighted realized spread, volume-weighted price impact, log of variance ratio, or log of Hasbrouck (1993) pricing error σ. $\widehat{Spoofing}_{i,t}$ is the predicted standardized spoofing measure for stock i on day t from the first-stage IV regressions in Table 7. Panels A and B measure $\widehat{Spoofing}_{i,t}$ with instrumented standardized successful spoofing order volume and failed spoofing order volume. Both measures of spoofing are scaled by trading volume before standardization in the first stage. X represents standardized controls for the lag of average dollar spread, lag of average price, lag of inverse price, absolute return, log of trading volume, and Amihud (2002) illiquidity. We include stock and date fixed effects with γ_t and ζ_i, respectively. T-statistics are reported in parentheses and standard errors are clustered by stock.

Panel A: Successful Spoofing

	(1) 1-minute volatility	(2) 5-minute volatility	(3) Quoted spread	(4) Effective spread	(5) Realized spread	(6) Price impact	(7) Variance ratio	(8) Hasbrouck σ
$Successful\ Spoofing_{i,t}$	5.52*	7.62	1.47	9.86	1.70	5.34	0.75	0.74*
	(1.80)	(1.50)	(0.57)	(1.61)	(0.33)	(0.99)	(0.93)	(1.69)
$Average\ Dollar\ Spread_{i,t-1}$	0.90***	1.82***	2.44***	1.36***	0.57**	0.86**	0.07	0.18***
	(3.99)	(5.44)	(6.31)	(3.00)	(2.12)	(2.26)	(1.55)	(5.07)
$Average\ Price_{i,t-1}$	-0.36	-1.16	-0.75	0.63	0.03	0.31	0.13	0.06
	(-0.52)	(-1.12)	(-1.10)	(0.44)	(0.04)	(0.30)	(0.85)	(0.58)
$Inverse\ Price_{i,t-1}$	5.53***	8.36***	10.94***	10.83***	6.47***	3.31	0.46	0.57***
	(4.25)	(3.91)	(8.46)	(4.03)	(2.93)	(1.43)	(1.35)	(2.98)
$Absolute\ Return_{i,t}$	0.85***	2.04***	-0.11	0.44**	-0.84***	1.25***	-0.15***	-0.00
	(9.94)	(13.18)	(-1.56)	(2.38)	(-4.78)	(6.70)	(-8.37)	(-0.36)
$\ln(Dollar\ Volume)_{i,t}$	2.93***	5.25***	-0.19	-1.51*	1.92**	-3.37***	0.01	-0.13*
	(5.76)	(6.57)	(-0.55)	(-1.77)	(2.51)	(-4.17)	(0.11)	(-1.96)
$Amihud\ Illiquidity_{i,t}$	0.19	0.48*	1.31***	1.10***	-0.91***	1.95***	-0.02	0.03**
	(1.19)	(1.75)	(5.74)	(3.51)	(-3.41)	(5.56)	(-0.96)	(2.11)
Stock FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Date FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	20,155	20,155	20,155	20,155	20,155	20,155	20,144	20,095
Kleibergen-Paap F-statistic	5.837	5.837	5.837	5.837	5.837	5.837	5.816	6.051

Panel B: Failed Spoofing

	(1) 1-minute volatility	(2) 5-minute volatility	(3) Quoted spread	(4) Effective spread	(5) Realized spread	(6) Price impact	(7) Variance ratio	(8) Hasbrouck σ
$Failed\ Spoofing_{i,t}$	2.25**	3.11*	0.60	4.02*	0.69	2.18	0.30	0.30**
	(2.51)	(1.94)	(0.59)	(1.80)	(0.33)	(1.02)	(1.02)	(2.43)
$Average\ Dollar\ Spread_{i,t-1}$	0.84***	1.74***	2.42***	1.26***	0.55*	0.81*	0.06	0.17***
	(3.75)	(5.13)	(6.28)	(2.70)	(1.89)	(1.97)	(1.44)	(5.02)
$Average\ Price_{i,t-1}$	-0.80*	-1.77***	-0.86	-0.16	-0.10	-0.12	0.07	-0.00
	(-1.88)	(-2.77)	(-1.60)	(-0.18)	(-0.20)	(-0.17)	(0.80)	(-0.06)
$Inverse\ Price_{i,t-1}$	4.12***	6.41***	10.57***	8.32***	6.04***	1.95*	0.27**	0.39***
	(6.96)	(6.04)	(11.06)	(7.05)	(5.55)	(1.78)	(2.05)	(5.78)
$Absolute\ Return_{i,t}$	0.91***	2.11***	-0.09	0.53***	-0.83***	1.30***	-0.15***	0.00
	(11.74)	(13.84)	(-1.33)	(3.46)	(-4.83)	(7.23)	(-9.13)	(0.40)
$\ln(Dollar\ Volume)_{i,t}$	2.66***	4.87***	-0.26	-2.00***	1.83***	-3.63***	-0.02	-0.16***
	(8.46)	(9.21)	(-1.14)	(-4.12)	(2.88)	(-5.69)	(-0.38)	(-4.65)
$Amihud\ Illiquidity_{i,t}$	0.18	0.46*	1.31***	1.08***	-0.91***	1.94***	-0.02	0.03**
	(1.27)	(1.81)	(5.71)	(3.72)	(-3.45)	(5.61)	(-1.04)	(2.42)
Stock FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Date FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	20,155	20,155	20,155	20,155	20,155	20,155	20,144	20,095
Kleibergen-Paap F-statistic	23.11	23.11	23.11	23.11	23.11	23.11	23.06	23.32

Table 9: Alternate Intraday Spoofing Measures

Table 9 presents results of the following regression equation: $Market\ Quality_{i,t,j} = \beta_1 Spoofing_{itj} + \boldsymbol{\beta} X + \theta_{it} + \phi_j + \epsilon_{i,t,j}$, where $MarketQuality_{i,j,t}$ is 1-minute return volatility, 5-minute return volatility, time-weighted quoted spread, volume-weighted effective spread, volume-weighted realized spread, volume-weighted price impact, log of variance ratio, or log of Hasbrouck (1993) σ for stock i on day t in the 30-minute interval j. Panels A and B measure spoofing with successful and failed spoofs, respectively. $Successful\ Spoofing_{i,t,j}$ is the standardized successful spoofing order volume scaled by trading volume. $Failed\ Spoofing_{i,t,j}$ is the standardized failed spoofing order volume scaled by trading volume. X represents standardized controls for the lag of average dollar spread, lag of average price, lag of inverse price, absolute return, log of trading volume, and Amihud (2002) illiquidity. We include stock-day fixed effects with θ_{it} and 30-minute interval fixed effects with ϕ_j. T-statistics are reported in parentheses and standard errors are clustered by stock.

Panel A: Successful Spoofing

	(1) 1-minute volatility	(2) 5-minute volatility	(3) Quoted spread	(4) Effective spread	(5) Realized spread	(6) Price impact	(7) Variance ratio	(8) Hasbrouck σ
$Successful\ Spoofing_{i,t,j}$	0.55***	0.98***	0.20***	-0.02	-0.83***	0.81***	0.05***	0.02***
	(15.65)	(14.22)	(3.43)	(-0.25)	(-4.44)	(5.76)	(3.21)	(3.42)
$Average\ Dollar\ Spread_{i,t,j-1}$	0.67***	1.12***	9.51***	3.44***	3.20***	0.25	0.03	0.14***
	(8.26)	(7.76)	(7.50)	(6.73)	(6.46)	(1.54)	(0.99)	(9.18)
$Average\ Price_{i,t,j-1}$	-6.90***	-20.98***	3.18	6.06	-10.15	15.08**	-0.26	-0.50***
	(-4.66)	(-5.42)	(0.89)	(0.89)	(-1.47)	(2.37)	(-0.48)	(-3.03)
$Inverse\ Price_{i,t,j-1}$	4.91**	12.89***	13.31	-32.48**	-19.78	-13.48	-0.84	0.19
	(2.29)	(3.47)	(1.37)	(-2.54)	(-1.55)	(-1.38)	(-0.90)	(1.24)
$\ln(Dollar\ Volume)_{i,t,j}$	4.95***	9.61***	-0.20	0.61	-5.39***	6.05***	1.39***	-0.51***
	(25.22)	(24.57)	(-1.10)	(1.10)	(-9.30)	(11.04)	(13.90)	(-17.18)
$Absolute\ Return_{i,t,j}$	2.98***	6.67***	1.91***	5.91***	-1.11***	6.60***	0.00	0.04***
	(21.27)	(25.61)	(8.28)	(9.96)	(-2.72)	(20.23)	(0.23)	(7.73)
$Amihud\ Illiquidity_{i,t,j}$	0.77***	1.47***	1.28***	2.86***	5.33***	-2.39***	-0.28***	-0.12
	(9.61)	(8.56)	(4.79)	(7.24)	(11.71)	(-9.64)	(-5.20)	(-0.93)
Stock-day FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
30-minute FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	318,711	317,597	320,427	320,349	320,349	320,349	304,418	236,340
Adjusted R-squared	0.601	0.552	0.858	0.484	0.368	0.200	0.181	0.790

Panel B: Failed Spoofing

	(1) 1-minute volatility	(2) 5-minute volatility	(3) Quoted spread	(4) Effective spread	(5) Realized spread	(6) Price impact	(7) Variance ratio	(8) Hasbrouck σ
$Failed\ Spoofing_{i,t,j}$	0.44***	0.84***	0.15***	-0.02	-0.70***	0.68***	0.05***	0.02**
	(10.09)	(9.27)	(3.03)	(-0.21)	(-4.34)	(4.61)	(2.93)	(2.49)
$Average\ Dollar\ Spread_{i,t,j-1}$	0.67***	1.12***	9.51***	3.44***	3.20***	0.25	0.03	0.14***
	(8.27)	(7.77)	(7.50)	(6.73)	(6.47)	(1.54)	(0.98)	(9.17)
$Average\ Price_{i,t,j-1}$	-7.06***	-21.26***	3.12	6.07	-9.91	14.85**	-0.27	-0.51***
	(-4.68)	(-5.33)	(0.87)	(0.90)	(-1.44)	(2.35)	(-0.51)	(-3.06)
$Inverse\ Price_{i,t,j-1}$	4.69**	12.48***	13.24	-32.47**	-19.46	-13.80	-0.87	0.18
	(2.19)	(3.39)	(1.36)	(-2.54)	(-1.53)	(-1.41)	(-0.93)	(1.14)
$\ln(Dollar\ Volume)_{i,t,j}$	4.93***	9.58***	-0.21	0.62	-5.37***	6.02***	1.39***	-0.51***
	(25.18)	(24.57)	(-1.16)	(1.10)	(-9.23)	(10.99)	(13.98)	(-17.24)
$Absolute\ Return_{i,t,j}$	2.99***	6.68***	1.91***	5.91***	-1.12***	6.61***	0.01	0.04***
	(21.37)	(25.72)	(8.29)	(9.95)	(-2.75)	(20.25)	(0.26)	(7.75)
$Amihud\ Illiquidity_{i,t,j}$	0.76***	1.46***	1.28***	2.86***	5.33***	-2.40***	-0.29***	-0.12
	(9.53)	(8.46)	(4.79)	(7.24)	(11.75)	(-9.68)	(-5.21)	(-0.90)
Stock-day FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
30-minute FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	318,711	317,597	320,427	320,349	320,349	320,349	304,418	236,340
Adjusted R-squared	0.600	0.552	0.858	0.484	0.368	0.200	0.181	0.790