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Competition of the informed: Does the presence of short sellers affect insider selling?☆

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ABSTRACT

We study how the presence of short sellers affects the incentives of the insiders to trade on negative information. We show it induces insiders to sell more (shares from their existing stakes) and trade faster to preempt the potential competition from short sellers. An experiment and instrumental variable analysis confirm this causal relationship. The effects are stronger for "opportunistic" (i.e., more informed) insider trades and when short sellers' attention is high. Return predictability of insider sales only occurs in stocks with high short-selling potential, suggesting that short sellers indirectly enhance the speed of information dissemination by accelerating trading by insiders.

1. Introduction

A large body of literature shows that insiders trade on private information (e.g., Jaffe, 1974; Seyhun, 1986, 1998; Lin and Howe, 1990; Rozeff and Zaman, 1998; Lakonishok and Lee, 2001; Marin and Olivier, 2008; Jagolinzer, 2009; Cohen, Malloy, and Pomorsky, 2012). Less attention, however, has been devoted to how the trading activity of other types of "informed" investors affects insiders' trading activity. Such research is important, as any interaction with other players may accelerate the release of new information by insiders and significantly affect the way information propagates in the financial markets. In this paper, we study this issue by exploring how the presence of a particular type of informed investors—i.e., the short sellers—could alter insiders' incentives to trade on their private (negative) information.

It is well-documented that short sellers are able to identify overvalued or "suspicious" stocks (e.g., Dechow, Hutton, Meulbroek, and Sloan, 2001; Christophe, Ferri, and Angel, 2004; Desai, Krishnamurthy, and Venkataraman, 2006; Cohen, Diether, and Malloy, 2007; Christophe, Ferri, and Hsieh, 2010; Karpoff and Lou, 2010; Hirshleifer, Teoh, and Yu, 2011; Ljungqvist and Qian, 2014). In addition, short sellers intermediate a considerable amount of trade. Diether, Lee, and Werner (2009a) document that the daily shorting activity composes 24% of the NYSE and 31% of the Nasdaq share volume. Collectively, these characteristics make short

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sellers an important class of "informed" investors whose trading activity may directly and significantly affect insiders.

We propose a channel through which short selling can affect insiders: trading competition. More specifically, we argue that the presence of short sellers changes the strategic behavior of insiders by introducing potential competition in private information trading. In the absence of short sellers, insiders with access to information about a value-destroying event not yet disclosed to the market will strategically sell their shares before the information is known to the public (e.g., Kyle, 1985). However, in the presence of short sellers, insiders will fear that short sellers may obtain access to the same information and therefore compete with them in trading on the information. The presence (fear) of such trading competition will accelerate the rate at which private information is revealed to the market (e.g., Kyle, 1984; Holden and Subrahmanyam, 1992; Foster and Viswanathan, 1993), drive down the price at which insiders can sell their shares, and jeopardize the profitability of insider sales. Insiders, aware of such potential competition, will have incentives to accelerate their information processing and trading activities in order to *preempt* short sellers.[1] To the extent that corporate insiders, such as senior managers and board directors, have access to superior corporate information before the outsiders, such a preemptive strategy is both feasible and optimal.

Such a preemptive strategy requires insiders to sell more and faster, especially when potential short sellers can compete effectively in trading on the same information. As a result, the potential of effective short selling should ex ante increase the scope and speed of insider sales. By contrast, with no credible short-selling competition, insiders should sell at low volumes and over a long period of time to reduce the price impact of their trades (e.g., Kyle, 1985).

We apply this intuition to data focusing on US stocks over the 2006–2011 period and document the ex ante impact of short-selling potential on insider sales. We use *lendable* shares—the fraction of shares available for borrowing (by short sellers)—as a proxy for the potential severity of short selling (hereinafter, *short-selling potential*). Lendable shares reasonably capture the capacity of potential short-selling competition,[2] because it determines how many shares are available for borrowing (by short sellers), which directly speaks to the feasibility of the shorting activity and thus the maximum degree of trading competition that short sellers can introduce. We define insiders as directors and officers (as per Cohen, Malloy, and Pomorsky, 2012) and focus on their trading decisions: how much to sell (as a percentage of their existing stakes) and how fast to sell (i.e., the time span of their trades).[3]

We present our analysis in three steps. In the first step, we document that the occurrence (i.e., likelihood) of open market sales by insiders is strongly positively associated with the availability of lendable shares in the previous month. A one-standard-deviation increase in lendable shares raises the relative probability of insider sales by 10% when all insiders are included and 14% when only directors and officers are considered. When we differentiate, following Cohen, Malloy, and Pomorsky (2012), insider sales that are motivated by private information (i.e., opportunistic sales) from those that are uninformative (i.e., routine sales), we find that the above relationship is significant in the case of opportunistic insider sales and becomes insignificant in the case of uninformative, routine insider sales. These findings provide initial evidence that insiders tend to trade more aggressively in the presence of short sellers when their trading is motivated by private information.

Next, in the second step, we focus on the modality of insider sales. More specifically, we examine the amount and time span of insider trades. We document that, conditional on their decision to participate in open market sales, the amount that insiders sell as a fraction of their existing stakes is significantly positively associated with short-selling potential: a one-standard-deviation increase in short-selling potential is associated with a 2.4% increase in the portion of shares insiders sell out of their existing stakes in general and a 3% increase in the case of opportunistic sales in particular. If we compare these short-selling induced sales to the average portion of their existing stakes that the insiders sell in a given transaction (25% and 24% in the two cases), the economic impact is sizable. By contrast, the time span of insider sales is significantly reduced by the potential presence of short selling. A one-standard-deviation increase in lendable shares is associated with a 4.7% decrease in the number of days of net sale transactions in a given month for all insider sales and 12% fewer days for opportunistic sales.

[1] In general, insiders could observe corporate private information earlier than other market participants. Nonetheless, the recent scandal that SAC, a $14 billon hedge fund, had "engaged in insider trading on an unprecedented scale" (*Financial Times*, July 25, 2013) reveals that some short sellers may occasionally have access to private information comparable with that of insiders. Indeed, Khan and Lu (2013) document that short sellers can even front-run insiders due to information leakage, which would even further enhance the preemptive incentives for truly informed insiders in our context. The same intuition applies to positive private information. Indeed, short sellers, such as hedge funds, may also compete with insiders in trading on positive private information. However, empirically identifying their long trading capacity is difficult.

[2] If short sellers wish to trade on their negative views via options or other derivatives markets, the feasibility and cost of such trades may still be affected by the equity loan market via, for instance, market makers' hedging behavior in the options and derivatives markets. Thus, the impact of *Lendable* is not restricted to the equity market. A few recent studies suggest that the amount of lendable shares could be a binding short sale constraint (Beneish, Lee, and Nichols, 2013), which may give rise to the important externality of discouraging information acquisition (Nezafat and Wang, 2014).

[3] The first variable follows the literature (e.g., Scott and Xu, 2004; Jenter, 2005), while we construct the second variable as the maximum selling span in a given month to capture our unique prediction regarding the speed of trading. The literature also employs other variables to represent insider trades. For instance, Cohen, Malloy, and Pomorsky (2012) use the number of insider sale transactions in a month as the main proxy for insider trades. Here, we follow Scott and Xu (2004) and Jenter (2005) to scale the amount of insider sales using insiders' existing holdings, primarily to be consistent with classical portfolio theories, in which the main decision variable is the investment weight. Regarding the speed of trading, subsequent sections provide an alternative measure related to the duration of insider sales in a given month, and the main results remain unchanged.

This suggests that insiders also speed up their trades to potentially preempt short sellers.

In our third step, we provide a causal explanation of the above results by exploiting an experiment: the SHO experiment. The Regulation SHO Pilot Program, announced in 2004, randomly selected one-third of the stocks on the Russell 3000 Index to be exempt from uptick rules and other price restrictions. The relaxation of short-selling restrictions induced an exogenous change in short-selling cost (e.g., Diether, Lee, and Werner, 2009b; Grullon, Michenaud, and Weston, 2015). We thus exploit the program announcement upon which there is an exogenous shock to the perceived short-selling potential among pilot stocks and study whether it is associated with a change in insider sale activity. Using a difference-in-differences (diff-in-diff) approach, we show that, in line with our full sample results, the announcement that the short-selling restrictions were being lifted increased the propensity for insider selling among the pilot firms relative to the firms in the control group. Moreover, insiders in the pilot firms sold more of their existing stakes and reduced the time span of trading relative to the control group after the announcement. We also rule out (change in) liquidity as an alternative explanation for the observed change in insider selling activity.

The SHO test establishes a causal relationship between short-selling potential and insider trading behavior. To provide additional evidence, we also exploit information on exchange traded fund (ETF) ownership. ETFs are among the main contributors to the equity lending market. Given that ETFs are largely passive, non-information-driven investors, ETF ownership represents an instrument for an exogenous, non-informationally motivated supply shock in the lending market, which is orthogonal to the informationally motivated trades of the insiders. Instrumental variable analysis further confirms the causal link from short-selling potential to insider sale transactions.

In addition to these three main steps, we also provide a list of additional tests to extend our economic intuition. We first examine the cross-sectional dimension in greater depth and investigate the situations in which the link between short-selling potential and insider-selling behavior is stronger—when short sellers' attention is higher. We use the number of negative public news events concerning the firm and the level of realized shorting activity among industry peers to proxy for short sellers' potential attention. We find that insiders sell more of their ownership stake and do so more rapidly when both lendable shares and short sellers' potential attention are high. This result complements our main analyses in the spirit of Cohen, Diether, and Malloy (2007) that a proper combination of supply-side (*lendable*) and demand-side information (*attention*) generates the maximum impact of potential short-selling competition.

We then explore the market implications of short selling with respect to information dissemination. Specifically, we examine how short-selling potential affects the return predictability of insider trading. We document that the predictability of (opportunistic) insider sales is concentrated in stocks with high short-selling potential. In other words, in the presence of short sellers, insiders are more likely to sell when they have information of particularly high quality. By urging insiders to release new negative information into the market, short selling indirectly accelerates information dissemination for firms. This finding confirms our initial intuition that the impact of other types of informed traders on insiders will significantly affect the general process of information dissemination in the market. Finally, we demonstrate that our main results remain qualitatively unchanged when we conduct robustness checks using a matching sample analysis and alternative definitions of corporate insiders.

These results are important as they document that "informed" professional investors (e.g., short sellers) improve market efficiency not only by directly trading, but also (and possibly more importantly) by speeding up the trades of the insiders. To our knowledge, this is the first paper that addresses such an important issue with a detailed empirical analysis that links short-selling and sales by insiders. This provides new insights for regulators and policy makers in terms of the interaction between insider trading rules and restrictions on short-selling activity.

More specifically, we contribute to several strands of the literature. First, our paper is related to the literature on insider trading, which primarily focuses on assessing the informational content of insider trades and predicting cross-sectional returns (Lorie and Niederhoffer, 1968; Jaffe, 1974; Seyhun, 1986, 1998; Lin and Howe, 1990; Damodaran and Liu, 1993; Bettis, Vickery, and Vickery, 1997; Rozeff and Zaman, 1998; Lakonishok and Lee, 2001; Piotroski, and Roulstone, 2005; Marin and Olivier, 2008; Jagolinzer, 2009). More recent studies also attempt to identify information-driven insider trading based on the characteristics of insider trades (Scott and Xu, 2004; Jenter, 2005; Cohen, Malloy, and Pomorsky, 2012), events upon which insiders trade (e.g., Kahle, 2000; Ke, Huddart, and Petron, 2003; Cheng and Lo, 2006; Huddart, Hughes, Levine, Ke, and Shi, 2007), or counterparties involved in trading, such as institutional and individual investors (Sias and Whidbee, 2010). We contribute to this literature by studying the effect of short-selling potential on insider trading and its return predictability. The impact of short selling on insider trading also conforms to the general intuition advanced by Marin and Olivier (2008) that insider purchases and sales may be driven by different economic motivations.

Second, this paper is related to the literature on short selling. A number of studies demonstrate that short sellers possess superior information: they are able to identify overvalued stocks (e.g., Desai, Ramesh, Thiagarajan, and Balachandran, 2002; Cohen, Diether, and Malloy, 2007; Boehmer, Jones, and Zhang, 2008; Diether, Lee, and Werner, 2009a; Boehmer, Huszar, and Jordan, 2010) or are particularly good at processing information (e.g., Engelberg, Reed, and Ringgenberg, 2012). We extend this literature by revealing a specific channel through which short sellers expedite information discovery—by incentivizing insiders who have private information to trade. In that respect, our results are also broadly related to the literature on strategic trading with multiple informed traders (e.g., Kyle, 1984; Holden and Subrahmanyam, 1992; Foster and Viswanathan, 1993; Edmans and Manso, 2011). We contribute to this literature by demonstrating that

the presence of additional informed traders (i.e., short sellers) largely affects the ex ante strategy and behavior of other informed traders (i.e., corporate insiders).

Finally, we also contribute to the literature on the informativeness of stock prices. Existing studies in this literature focus on the institutional environment faced by firms to explain the informativeness of stock prices (e.g., Morck, Yeung, and Yu, 2000; Jin and Myers, 2006). Moreover, although short selling is well recognized to increase the efficiency of the market (e.g., Bris, Goetzmann, and Zhu, 2007; Saffi and Sigurdsson, 2011), the channels through which it achieves such efficiency are less explored. One notable exception is Boehmer and Wu (2013), which illustrates how information gets incorporated into stock price through short sellers' intraday trading. Our unique contribution is to propose and test an explicit economic channel through which short selling can (indirectly) improve the price efficiency of the economy. This indirect channel complements the direct channel of trading in affecting efficiency.

Overall, our results have important normative and policy implications, illustrating that regulations aimed at reducing short selling will also affect the informativeness of the market by reducing insider selling. Therefore, the subjects of different policies may need to be considered jointly: policies that affect shorting are likely to also affect insider trading. Moreover, our findings suggest that the effect of short selling could have been largely underestimated to date, because regulators and academic researchers have till now ignored its impact on prices through insider trades that precede the shorting trades. The remainder of the paper is organized as follows. In Section 2, we present our stylized model and two preliminary empirical patterns that are key motivations for the model. In Section 3, we describe the data and the construction of the main variables. In Section 4, we provide the main evidence. In Section 5, we address causality and endogeneity. Section 6 provides additional tests and robustness checks. A brief conclusion follows.

2. Main hypotheses

To illustrate our main intuition, we sketch a simple stylized model to lay out the relationship between insider trading and short selling. We report the model in Appendix IA (in the online appendix). Here, we lay out the main intuition.

We consider a firm in which a manager may take a private "bad action", e.g., investing in projects with negative net present values, that could benefit him but damage the shareholders. The market is aware of this but can only guess whether the manager will take such an action. In contrast, the insider can observe the action when it is taken. This information asymmetry between the insider and the public motivates the former to trade in the market before the market is made aware of it.

Let us now consider the role of the short sellers. These traders are also informed and can trade against managerial misconduct (e.g., Senchack and Starks, 1993; Asquith, Mikhail, and Au, 2005; Cohen, Diether, and Malloy, 2007; Boehmer, Jones, and Zhang, 2008), but are on average slower than the insiders. All informed traders are strategic in the sense of Kyle (1984, 1985).

In this context, the presence of short-sellers acts as a stimulus for the insiders to trade sooner and faster. The intuition is similar to Holden and Subrahmanyam (1992) with multiple informed traders. Based on the these assumptions, the impacts of short selling on the incentives for insider trading in Period 1 can be summarized in the following proposition (Appendix IA in the online appendix provides the proof).

Proposition 1. In the presence of short selling, the insider has an incentive to sell her shares before the short seller attacks the firm. The more shares that are available to short sellers, the more shares the insider wants to sell before the short sellers attack.

Proposition 1 contains two main intuitions. First, competition from short sellers reduces the profitability of insider trading if they wait. Indeed, when the insider is the only (monopoly) informed trader in the second period, his trading reveals half of his private information to the market. If, however, one or more informed short sellers compete with the insider in trading on the same piece of private information, aggregate trading demand increases relative to the case in which the insider is the only one to have access to such information. In this situation, more private information is revealed to the market. Consequently, the market price becomes more informative—but informed trading becomes less profitable with additional competitors trading in the market.

Appendix IA (in the online appendix) shows that the total fraction of lendable shares imposes a natural capacity constraint on the feasible degree of trading competition. Specifically, the greater the number of shares available to short sellers is, the higher the level of trading competition is—i.e., a larger amount of lendable shares allows more informed short sellers to potentially trade on the same private information—and the greater the degree of price efficiency is. This finding is in line with the widely observed empirical evidence that lendable shares increase price efficiency (Saffi and Sigurdsson, 2011). It also suggests that for our empirical purposes, we can use the fraction of lendable shares to proxy for the capacity for *potential* trading competition that the short-selling market may introduce. We will refer to it as *short-selling potential*.

Second, given that competition from short sellers adversely affects insider trading, the insider has an incentive to "preempt" short sellers by shifting his trades toward the first period, i.e., to sell more shares from his existing portfolio in the first period, before any short selling occurs. If short-selling competition is sufficiently severe, the insider should concentrate his trading in the first period. This intuition provides us with the first testable hypothesis regarding the impact of short-selling potential on an insider's trading behavior.

If, instead, short-selling competition does not exist, the insider's optimal strategy is to spread the trades over the two periods. In this regard, short-selling potential also shortens the effective time span for insider sales. Overall, Proposition 1 predicts that the scale and time span of

insider sales should be substantially affected by short-selling competition (i.e., short-selling potential), which can be formulated into the following two testable hypotheses:

H1. Short-selling potential increases the fraction of their existing stakes that insiders want to sell.

H2. Short-selling potential reduces the average time span of insider sales.

Before proceeding to test these predictions, we provide some information on the data we use.

3. Data, variable construction, and preliminary evidence

We now describe the sources of our data, the construction of our main variables, and some preliminary evidence.

3.1. Data sample and sources

The sample covers the period between July 2006 and November 2011. We begin with the publicly listed companies in the US. traded on the NYSE, Nasdaq, or Amex exchanges (we include only common shares and exclude non-US incorporated firms, or American depositary receipts (ADRs), ETF, and Real estate investment trusts (REITs) from our main sample, i.e., when Center for Research in Security Prices (CRSP) share code = 10 or 11). This sample is then matched with short-selling information from Data Explorers, insider data from Thomson Reuters, and data on institutional investors' stock holdings from Thomson 13F and analyst information from the Institutional Brokers' Estimate System (I/B/E/S).

More specifically, we obtain equity lending data from Data Explorers, a research company that collects equity and bond lending data directly from the security lending desks at the world's leading financial institutions. Information detailed at the stock level is available from May 2002 to November 2011. In particular, the data set has the unique feature that it provides information on not only the value of shares that are on loan but also the value of shares that are available to be lent to short sellers, which is important for the purpose of this paper. A more detailed description of the data can be found in Saffi and Sigurdsson (2011) and Jain, Jain, McInish, and McKenzie (2013). In our study, we focus on the period beginning from July 2006, when Data Explorer has a more thorough coverage of the equity lending market in the US. Extension to earlier periods does not alter our main results. We focus on the US. sample and verify that short-selling information is available for approximately 84% of the firms in our sample period, which is similar to the figure reported in Saffi and Sigurdsson (2011).

The data on insider trades are from Thomson Reuters Insider Filings (Form 4). The data contain information on each insider sale transaction and each insider's relationship to the firm. We focus on insiders' open market sales, and we exclude open market purchases and private transactions. For the bulk of our analysis, we follow the literature (Ke, Huddart, and Petron, 2003; Cohen, Malloy, and Pomorsky, 2012) and define insiders as directors and officers. As a robustness check, we also consider an alternative definition of insiders. Specifically, the insider database defines the chief executive officer, chairman of the board, chief operating officer, president, and general counsel as top level insiders (as recorded in the insider database), whom we consider to be the top five most powerful insiders in our analysis.

We follow Cohen, Malloy, and Pomorsky (2012) and identify information-driven insider trades based on a "routine" and "opportunistic" classification.[4] In our sample period, 42% of all insider sales are routine insider sales, and the rest are opportunistic insider sales. Unreported tests following their paper confirm that routine and opportunistic insider sales serve as valid proxies for non-information- and information-driven insider sales in our sample period.

We use CUSIP to combine Compustat/CRSP data with the equity lending data and insider data. We also obtain institutional holdings from the Thomson 13F database as well as analyst and earnings announcement information from I/B/E/S. Finally, penny stocks (price < \$1) and zero turnover stocks are excluded from the sample. Book-to-market, leverage, and sale variables are winsorized at the 99% and 1% levels. The final combined data have an average of 4,168 stocks per month. Our final sample is comparable to what has been reported in the literature. For instance, Boehmer, Huszar, and Jordan (2010) report an average of 4,400 stocks per month over the 1988–2005 period based on the three major stock exchanges.[5]

3.2. Main variables

The variable of interest is the amount of shares available for borrowing (*Lendable*) as a proportion of shares outstanding. It measures the capacity and potential intensity of short-selling activity. We focus on a series of important variables related to the insider trading decision. The first is *InsiderSale_FracStake*, the proxy for the fraction or amount of shares sold from existing stakes. This variable is defined as the number of open market sale shares of officers and directors divided by their initial shares owned in a given firm-month, where the initial shares owned is computed as the number of shares held by the insiders at the beginning of the month.[6] The second variable is *InsiderSale_TimeSpan*, the proxy for the speed of insider sale transactions. This variable is defined as the number of days that an insider takes to complete sale transactions in a month—i.e., equal to n if the last net sale transaction within a month for a given firm is on the n^{th} day since the first day with nonzero net sale transactions. We also study the robustness of our results using an alternative measure

[4] We require an insider to make at least one trade in each of the three preceding years to define her as either a routine or an opportunistic trader. Specifically, routine insiders are those who have traded in the same month for at least the past three consecutive years, and opportunistic insiders are everyone else. At the beginning of each year, the insiders are categorized as either routine or opportunistic based on their trading history for the past three years.

[5] If we further look into the details of our final sample, an average of 1,361 stocks per month come from NYSE during the period of Jul 2006 to Nov 2011, which is consistent with Boehmer and Wu (2013). The rest of the stocks come from Nasdaq/Amex. Our main results are robust on the subsample of stocks coming from different exchanges.

[6] Following Scott and Xu (2004), we compute initial ownership using the number of shares traded and insiders' shareholdings at the end of the trades reported on the US. Securities and Exchange Commission (SEC) forms that insiders complete for their trades.

to capture the speediness of insider sale transactions. We will discuss this alternative measure in detail in Section 6. The third variable is *Insider sell dummy*. This variable is a dummy equal to one if the officers and directors of a firm have open market sales in the current month and zero otherwise. Finally, we also construct a control variable to capture the size of the insider trades: *Total open market shares sold/shares outstanding*. This variable is defined as the number of shares sold by officers and directors in a given firm-month divided by the total number of shares outstanding at the beginning of the month. All of these variables are primarily defined to capture officers and directors as corporate insiders.

The literature also suggests that certain firm characteristics may affect the incentives for insider trades. For instance, insiders trade more actively in large stocks, in low book-to-market firms, and following positive past returns (e.g., Lakonishok and Lee, 2001; Ke, Huddart, and Petron, 2003; Rozeff and Zaman, 1998). We confirm and control for these effects by explicitly employing a set of control variables: *Market size*, defined as the market capitalization of the firm; *Book to market*, defined as the book value of equity divided by market capitalization; *Turnover*, defined as the sum of monthly trading volumes divided by shares outstanding; *Lagged 6m ret,* defined as the cumulative stock return for the last six months; and *Leverage*, defined as long-term debt issues plus current liability divided by total assets. *Sale* is gross sales (in millions), i.e., the amount of actual billings to customers for regular sales completed during the period. *Idiosyncratic volatility* is calculated as the monthly average of the standard deviation of residuals from the adjusted Fama-French daily regressions (Jiang, Xu, and Yao, 2009). *IO* is institutional ownership, which is defined as institutional ownership shares divided by adjusted shares outstanding. *ETF* denotes the percentage of ETF ownership. *Analyst coverage* is the number of analysts following the firm. *Price* is the share price at the end of the month.[7]

We report the descriptive statistics in Table 1. Panel A reports summary statistics of stock- and firm-level characteristics, and Panel B reports pair-wise correlation statistics. The average firm in the sample has a market capitalization of 3.40 billion USD, a book-to-market ratio of 0.66, a monthly turnover rate of 0.14, and 47% institutional ownership. Moreover, an average firm has 18% of its total shares outstanding in the inventory available for borrowing (*Lendable*), suggestive of an active equity lending market in the US. More importantly, the high standard deviation in the lendable shares (12%) indicates a significant amount of variation among firms across the years. In particular, the bottom 5% of the observations in our sample essentially have zero shares available for short sellers to borrow, while the top 5% of the sample have more than 39% of their total shares outstanding available for borrowing. This rich variation in the short-selling potential facilitates identification in our analysis.

In a given month, 21% of the firms have an open market insider sale (by directors and officers), and 5% of the firms have an opportunistic open market insider sale (by officers and directors). If we condition on selling, we observe that insiders sell an amount equal to 24.85% of their portfolio. On average, an insider completes his sale transactions in 7.79 days within a given month, conditional on observing an open market insider sale. Overall, the primary characteristics of firms and the distributions of insider trades are largely consistent with the insider trading literature (e.g., Cohen, Malloy, and Pomorsky, 2012).

The pair-wise correlation statistics reveal a positive relationship between *Lendable* and *Insider sale* (and *Opportunistic insider sale*). *Insider sale* is also positively correlated with *Market size*, *Turnover*, *Past return*, *Idiosyncratic volatility*, *Institutional ownership*, and *Analyst coverage* but negatively correlated with *Book to market*. Consistent with the statistics in Saffi and Sigurdsson (2011), *Lendable* is positively correlated with *Market size* and *Turnover* and negatively correlated with *Book to market*.

4. Effect of short-selling potential on insider sales

We analyze insiders' trading incentives. We first analyze how short-selling potential affects the incentive for insiders to *participate* in open market sales and then extend the analysis to analyze the two decision variables.

4.1. Insider sales and short-selling potential

We begin with a conditional logit analysis of how short-selling potential affects the incentive for insiders to *participate*. The dependent variable is the occurrence of insider sales (i.e., *Insider sell dummy*) for a firm in a given month. We consider two alternative definitions of insider sales: (1) only the sales by the officers and directors (our main measure of insiders), and (2) the sales conducted by all insiders as recorded in Form 4 of the Insider Filings (to study whether the result is generalizable). The main explanatory variable is the one-month lagged *Lendable*. All control variables are also lagged by one month. This time convention allows us to detect how short-selling potential affects corporate insiders' decisions to sell their existing shares in the near future. We include firm and year-month fixed effects and cluster the standard errors at the firm level.

We report the results in Table 2. Columns 1 and 4 show that greater short-selling potential–i.e., the existence of a higher amount of lendable shares that short sellers can potentially use—strongly drives insiders to sell their shares in the near future. The regression coefficients of lendable shares are 0.84 when all insiders are included and 1.17 when only directors and officers are considered. These numbers are not only statistically significant but also economically relevant: a one-standard-deviation increase in lendable shares (12%) increases the relative probability of insider sales by 10.1% and 14%, respectively, in these two

[7] Ownership structure, e.g., block ownership or family ownership, may be an important determinant of insider trading and simultaneously may be correlated with short-selling potential (i.e., the number of shares available for borrowing). We do not have such information for each firm in our sample to control for the ownership effect. However, we perform a robustness check by restricting the sample to the set of family-owned firms (Anderson, Duru, and Reeb, 2009; Anderson, Reeb, and Zhao, 2012). Our main analysis holds in the subsample of family-owned firms.

Table 1
Summary statistics.

This table presents time-series summary statistics of the cross-sectional means of key variables from 2006:07 to 2011:11. Panel A reports summary statistics of stock- and firm- level characteristics, and Panel B reports the pair-wise correlation among major variables. Variable definitions are in Appendix A. Penny stocks (price < $1) and zero turnover stocks are excluded from the sample. Book-to-market, leverage, and sale variables are winsorized at 99% and 1%.

Panel A

	Mean	Std. dev.	5%	25%	50%	75%	95%
Full sample							
Lendable	0.18	0.12	0.00	0.07	0.18	0.28	0.39
Market size (millions)	3,397	15,391	21	98	365	1,505	13,353
Book to market	0.66	0.64	0.06	0.28	0.51	0.85	1.79
Turnover	0.14	0.21	0.00	0.03	0.08	0.18	0.44
Lagged 6m ret	0.04	0.42	−0.59	−0.16	0.03	0.22	0.66
Leverage	0.20	0.21	0.00	0.00	0.15	0.32	0.62
Sale (millions)	2,571	6,958	7	88	410	1,644	12,124
Idiosyncratic volatility	0.02	0.02	0.01	0.01	0.02	0.03	0.06
IO	0.47	0.32	0.00	0.16	0.50	0.77	0.93
ETF	0.03	0.03	0.00	0.01	0.03	0.05	0.09
Analyst coverage	5.27	6.22	0.00	0.00	3.00	8.00	18.00
Price	49.78	1,779.27	1.76	5.92	13.97	28.14	60.82
Insider sell dummy	0.21	0.41	0.00	0.00	0.00	0.00	1.00
Opportunistic insider sell dummy	0.05	0.23	0.00	0.00	0.00	0.00	1.00
Conditional on insider sale dummy							
InsiderSale_TimeSpan	7.79	8.81	1.00	1.00	3.00	14.00	27.00
InsiderSale_FracStake (%)	24.85	24.12	0.04	5.50	16.94	37.96	76.61
Total open market shares sold/shares outstanding (%)	0.29	2.18	0.00	0.01	0.04	0.14	0.75
Conditional on opportunistic insider sale dummy							
Opportunistic InsiderSale_TimeSpan	5.24	7.21	1.00	1.00	1.00	7.00	22.00
Opportunistic InsiderSale_FracStake (%)	24.18	24.49	0.25	5.00	15.39	36.35	78.88
Average number of firms per month	4,116						
Average number of Nasdaq/Amex firms per month	2,755						
Average number of NYSE firms per month	1,361						

Panel B

Lendable	1																	
Market size	0.09	1																
Book to market	−0.06	−0.07	1															
Turnover	0.32	0.05	−0.03	1														
Lagged 6m ret	0.00	0.02	0.09	0.08	1													
Leverage	0.03	0.01	−0.02	0.12	0.02	1												
Sale	0.14	0.68	−0.03	0.14	−0.02	0.08	1											
Idiosyncratic volatility	−0.24	−0.12	0.15	0.15	−0.04	0.02	−0.14	1										
IO (%)	0.51	0.12	−0.06	0.17	0.01	0.02	0.17	−0.20	1									
ETF (%)	0.73	0.01	−0.06	0.28	0.03	0.04	0.02	−0.20	0.46	1								
Analyst coverage	0.45	0.36	−0.18	0.30	0.00	0.03	0.40	−0.20	0.36	0.36	1							
Price	−0.02	0.12	0.00	−0.01	0.00	−0.01	0.12	−0.01	−0.01	−0.02	0.00	1						
Insider sell dummy	0.21	0.10	−0.13	0.09	0.12	−0.03	0.09	−0.12	0.15	0.16	0.23	0.00	1					
Opportunistic insider sell dummy	0.15	0.08	−0.08	0.05	0.06	−0.02	0.07	−0.08	0.10	0.10	0.17	0.00	0.47	1				
InsiderSale_TimeSpan	0.15	0.08	−0.10	0.06	0.10	−0.04	0.05	−0.08	0.11	0.10	0.19	0.00	0.62	0.41	1			
Opportunistic InsiderSale_TimeSpan	0.08	0.06	−0.05	0.03	0.04	−0.02	0.04	−0.05	0.06	0.05	0.11	0.00	0.27	0.58	0.44	1		
InsiderSale_FracStake	0.14	0.07	−0.10	0.06	0.10	−0.03	0.05	−0.08	0.10	0.10	0.18	0.00	0.61	0.38	0.92	0.40	1	
Opportunistic InsiderSale_FracStake	0.09	0.06	−0.05	0.03	0.05	−0.02	0.04	−0.05	0.06	0.06	0.11	0.00	0.28	0.60	0.43	0.93	0.43	1

Table 2
Conditional logit regression of insider sales.

This table presents the results of a conditional logit regression analysis for insider sales using monthly observations between 2006:07 and 2011:11. The dependent variables are dummy variables for various types of insider sales for a firm in a given month. Please refer to Appendix A for the variable definitions. All independent variables are lagged by one month. Firm and year-month fixed effects are included in all tests, and standard errors are clustered at the firm level. We report *t*-statistics in the parentheses below coefficient estimates, and statistical significance at the 1%, 5%, and 10% levels is indicated by ***, ** and *, respectively.

	(1) Open market sell dummy	(2) Routine open market sell dummy	(3) Opportunistic open market sell dummy	(4) Insider sell dummy	(5) Routine insider sell dummy	(6) Opportunistic insider sell dummy
	All insiders (on Form 4)			Officers and directors		
Lendable	0.843***	1.378	1.232***	1.173***	0.942	1.432***
	(3.18)	(1.15)	(2.70)	(4.41)	(0.78)	(3.05)
Log(market size)	0.891***	0.953***	1.068***	0.978***	0.923***	1.090***
	(20.37)	(4.17)	(12.05)	(21.45)	(3.99)	(11.84)
Book to market	−0.058	−0.555**	−0.157*	−0.086**	−0.599***	−0.160*
	(−1.47)	(−2.54)	(−1.96)	(−2.12)	(−2.77)	(−1.89)
Lagged 6m ret	0.562***	−0.043	0.415***	0.585***	−0.029	0.447***
	(12.55)	(−0.26)	(4.87)	(12.38)	(−0.18)	(4.95)
Log(analyst coverage+1)	−0.136***	0.108	0.045	−0.120***	0.126	0.053
	(−3.34)	(0.51)	(0.62)	(−2.83)	(0.57)	(0.71)
Turnover	−0.437***	−0.669*	−1.106***	−0.359***	−0.708*	−1.072***
	(−4.35)	(−1.72)	(−6.06)	(−3.37)	(−1.77)	(−5.76)
Idiosyncratic volatility	0.381	−4.458	−0.241	−0.559	−4.227	−1.787
	(0.74)	(−1.11)	(−0.20)	(−0.69)	(−1.02)	(−1.15)
IO	−0.051	−0.147	−0.052	−0.048	−0.204	−0.046
	(−1.25)	(−0.88)	(−0.69)	(−1.16)	(−1.20)	(−0.59)
Log(sales)	−0.000**	0.000	−0.000	−0.000*	0.000	−0.000
	(−1.97)	(0.68)	(−0.60)	(−1.68)	(0.70)	(−0.26)
Leverage	0.299*	0.121	0.011	0.322*	0.236	−0.082
	(1.85)	(0.19)	(0.03)	(1.93)	(0.36)	(−0.24)
D_EA month	0.402***	0.443***	0.333***	0.416***	0.451***	0.339***
	(21.46)	(5.94)	(12.05)	(21.41)	(6.01)	(11.93)
Observations	167,710	30,916	93,924	163,385	30,069	91,329

cases.[8] Moreover, both effects are statistically significant at the 1% level. The economic and the statistical significance are higher for sales from directors and officers. These results are in line with our information-driven argument, as these insiders presumably have access to better private information and more informationally motivated sales. In addition to our main variables, the regression coefficients on our control variables, such as *Market size*, *Book to market*, and *Lagged 6m ret*, are consistent with the literature (e.g., Lakonishok and Lee, 2001; Ke, Huddart, and Petron, 2003; Rozeff and Zaman, 1998).

If we further divide insider sales into routine and opportunistic sales, we observe that the impact of *Lendable* concentrates in opportunistic sales (columns 2, 3 and 5, 6). Specifically, a one-standard-deviation increase in lendable shares increases the likelihood that opportunistic insider sales will occur by 14.8% when all insiders are included and 17.2% when only directors and officers are considered.

Overall, these results support our first hypothesis that a greater amount of lendable shares increases the insiders' incentives to sell, particularly for the information-related insider sales. In other words, the more informed the insider is, the more they wish to preempt short sellers to exploit their informational advantage. Since the results are very similar across the two different definitions of insiders, we will follow the literature and focus on officers and directors as our insiders for the rest of the analysis.

4.2. Amount and speed of insider sales and short-selling potential

Next, we examine the impact of short selling on the two main decision variables for insider trading: the amount to be sold from her existing stakes (*InsiderSale_FracStake*) and the speed of transactions (*InsiderSale_TimeSpan*). We perform a Heckman two-stage procedure. We model the decision to sell in the first stage and the choice of the quantity to sell and the speed of transactions in the second stage. Given the previous results, we focus on the open market sales made by officers and directors.

[8] The probability that insider trading occurs is $\pi(x)=(1/(1+e^{-\beta x}))$ in the logit regression, where x is the independent variable and β is the regression parameter. Since high order terms of π can be omitted (the average unconditional insider trading probability is 0.21 in our whole sample, making the π^2 term as small as 4%), an increase in the independent variable, Δx, affects π as follows: $\Delta \ln(\pi) \approx (\Delta\pi/\pi)=\beta\Delta x$, where $\Delta\pi/\pi$ represents the relative increase in the probability. For instance, a one-standard-deviation increase in lendable shares increases the relative probability of insider trading by 10% (i.e., $12\% \times 0.84$) and 14% (i.e., $12\% \times 1.17$) for all insiders and for directors and officers, respectively.

Table 3
Heckman regression of open market insider sales.

This table presents the results of a regression analysis concerning the amount of open market sales by officers and directors using Heckman's two-stage procedure with monthly observations between 2006:07 and 2011:11. The dependent variable in Panel A is *InsiderSale_FracStake*, and the dependent variable in Panel B is the natural log of *InsiderSale_TimeSpan*, which is the maximum number of days that the insider takes to make his sales in a month. For each panel, we study all open market transactions in columns 1–2 and focus on open market transactions in columns 3–4 (the control variable *Total open market shares sold/shares outstanding* refers to all open market sales in columns 1–2 of Panel B and refers to opportunistic open market sales in columns 3–4 of Panel B). In each specification, the first-stage (selection) equation studies the determinants of insider sales and includes an additional variable, *Routine sell dummy* (equal to one if there is a routine open market sale by officers and directors in the same month), as the identifying restriction. The second-stage regression uses estimates of the inverse Mills' ratio from the first-stage regression to control for selection bias. Specifically, we estimate the following equations:

$$1st\ Stage: \quad Insider\ sell\ dummy_{i,t} = \alpha + \beta \times Routine\ insider\ sell\ dummy_{i,t} + \gamma \times X_{i,t-1} + \epsilon_{i,t},$$
$$2nd\ Stage: \quad InsiderSale\_FracStake_{i,t} = a + b \times \lambda_{i,t} + c \times X_{i,t-1} + e_{i,t-1}, \quad or$$
$$Log(InsiderSale\_TimeSpan_{i,t}) = a + b \times \lambda_{i,t} + c \times X_{i,t-1} + e_{i,t-1},$$

where $X_{i,t-1}$ stacks the list of control variables and $\lambda_{i,t}$ refers to the inverse Mills' ratio estimated from the first-stage regression. Refer to Appendix A for variable definitions. Year-month fixed effects are included in all tests. We report *t*-statistics in the parentheses below coefficient estimates, and 1%, 5%, and 10% statistical significance are indicated with ***, ** and *, respectively.

Panel A	(1)	(2)	(3)	(4)
	InsiderSale_FracStake		Opportunistic InsiderSale_FracStake	
	2nd stage	1st stage	2nd stage	1st stage
Lendable	0.202***	1.062***	0.246***	1.311***
	(14.95)	(28.30)	(7.82)	(24.25)
Log(market size)	0.034***	0.183***	0.029***	0.191***
	(25.41)	(53.19)	(8.62)	(38.50)
Book to market	−0.020***	−0.220***	−0.038***	−0.273***
	(−6.87)	(−30.49)	(−5.04)	(−21.72)
Lagged 6m ret	0.056***	0.407***	0.046***	0.282***
	(14.47)	(41.97)	(4.66)	(19.75)
Log(analyst coverage+1)	−0.018***	0.027***	−0.025***	0.019***
	(−12.39)	(5.82)	(−9.04)	(2.93)
Turnover	−0.029***	−0.203***	−0.002	−0.339***
	(−4.28)	(−9.68)	(−0.11)	(−9.61)
Idiosyncratic volatility	0.012	−0.998***	0.360	−2.523***
	(0.12)	(−3.96)	(1.27)	(−4.89)
IO	−0.014***	0.009	−0.009	0.044***
	(−3.62)	(0.74)	(−1.29)	(2.65)
Log(sales)	−0.000***	−0.000***	−0.000**	−0.000***
	(−7.54)	(−20.90)	(−1.98)	(−15.23)
Leverage	−0.017***	−0.368***	0.001	−0.386***
	(−2.76)	(−21.57)	(0.06)	(−15.20)
D_EA month	0.014***	0.187***	−0.003	0.135***
	(5.10)	(22.47)	(−0.56)	(11.58)
Inverse Mills' ratio	0.045***		−0.011	
	(8.76)		(−0.72)	
Routine insider sell dummy		2.705***		0.796***
		(36.61)		(26.98)
Constant	0.037**	−1.730***	0.106**	−2.785***
	(2.49)	(−53.81)	(2.02)	(−55.75)
Fixed effects	Year-month			
Obs.	186,564		186,564	

Panel B	(1)	(2)	(3)	(4)
	Log(InsiderSale_TimeSpan)		Log(Opportunistic InsiderSale_TimeSpan)	
	2nd stage	1st stage	2nd stage	1st stage
Lendable	−0.394***	1.063***	−1.019***	1.311***
	(−5.31)	(28.30)	(−6.59)	(24.25)
Total open market shares sold /shares outstanding	3.542***		24.367***	
	(9.43)		(11.44)	
Log(market size)	−0.032***	0.183***	−0.083***	0.191***
	(−4.34)	(53.18)	(−4.96)	(38.50)
Book to market	−0.090***	−0.220***	−0.022	−0.273***
	(−5.71)	(−30.49)	(−0.60)	(−21.72)
Lagged 6m ret	0.148***	0.407***	0.142***	0.282***
	(6.96)	(41.96)	(2.92)	(19.75)
Log(analyst coverage+1)	0.020**	0.027***	0.017	0.019***

Table 3 (*continued*)

Panel B	(1)	(2)	(3)	(4)
	Log(InsiderSale_TimeSpan)		Log(Opportunistic InsiderSale_TimeSpan)	
	2nd stage	1st stage	2nd stage	1st stage
	(2.40)	(5.82)	(1.27)	(2.93)
Turnover	−0.141***	−0.203***	−0.062	−0.339***
	(−3.76)	(−9.66)	(−0.74)	(−9.61)
Idiosyncratic volatility	1.999***	−1.008***	4.005***	−2.523***
	(3.97)	(−4.00)	(2.92)	(−4.89)
IO	−0.021	0.009	0.042	0.044***
	(−1.02)	(0.76)	(1.19)	(2.65)
Log(sales)	0.000	−0.000***	0.000**	−0.000***
	(0.22)	(−20.90)	(2.37)	(−15.23)
Leverage	−0.170***	−0.368***	−0.014	−0.386***
	(−5.09)	(−21.57)	(−0.22)	(−15.20)
D_EA month	0.037**	0.187***	0.022	0.135***
	(2.49)	(22.47)	(0.83)	(11.58)
Inverse Mills' ratio	−0.628***		−0.534***	
	(−21.70)		(−6.88)	
Routine insider sell dummy		2.705***		0.796***
		(36.61)		(26.98)
Constant	2.387***	−1.730***	2.476***	−2.785***
	(28.68)	(−53.80)	(9.47)	(−55.75)
Fixed effects	Year-month			
Obs.	186,560		186,564	

In the first stage, as the identifying restriction, we employ a dummy variable equal to one if there is a routine open market sale by officers and directors in the *same* month and zero otherwise (*Routine insider sell dummy*). The intuition is that, as routine sales are unrelated to private information (Cohen, Malloy, and Pomorsky, 2012) and thus short selling (Table 2), they help to hide informed trading. Indeed, in the same spirit that informed traders only wish to trade when other noisy trading flows are present to hide their information (e.g., Kyle, 1985), we expect informed insiders to be more likely to participate in open market sales when there are concurrent liquidity-driven (or other non-informationally related) routine transactions. Consistent with our model, such transactions may help to camouflage information-driven trades. Therefore, the occurrence of routine insider sales will increase the incentives—and thus the observed probability—for informed insiders to participate in trading. It does not, however, directly affect the informed insiders' two decision variables, as these decisions should be affected by the content of private information, which is not correlated with the occurrence *dummy* of routine insider sales. This result implies that the *Routine insider sell dummy* satisfies both the inclusion and the exclusion requirements of Heckman (1979).

Then, in the second stage, we regress the informed insiders' two decision variables on *Lendable*, the previously defined set of control variables, and the inverse Mills' ratio from the first stage to correct for selection bias. Year-month fixed effects are included, and standard errors are clustered at the firm level. The overall regression model is summarized by the following equations:

$$1st\ Stage: \quad Insider\ sell\ dummy_{i,t} = \alpha + \beta \times Routine\ insider\ sell\ dummy_{i,t} + \gamma \times X_{i,t-1} + \epsilon_{i,t},$$

$$2nd\ Stage: \quad InsiderSale\_FracStake_{i,t} = a + b \times \lambda_{i,t} + c \times X_{i,t-1} + e_{i,t-1}, \quad or$$

$$Log(InsiderSale\_TimeSpan_{i,t}) = a + b \times \lambda_{i,t} + c \times X_{i,t-1} + e_{i,t-1},$$

where $X_{i,t-1}$ indexes the list of independent and control variables (all lagged by one month) and $\lambda_{i,t}$ refers to the inverse Mills' ratio estimated from the first-stage regression.

We report the results in Table 3. Panel A focuses on *InsiderSale_FracStake* as the main dependent variable in the second stage (column 1 for *InsiderSale_FracStake* and column 3 for *Opportunistic InsiderSale_FracStake*). The remaining two columns report the estimates of the first-stage selection equation (column 2 for *Insider sell dummy*; and column 4 for *Opportunistic insider sell dummy*).

We first note that the occurrence of routine insider sales significantly incentivizes overall and opportunistic insider sales, which supports our choice of the *Routine insider sell dummy* as the identifying instrument. Moreover, the second-stage regressions confirm that short-selling potential can substantially increase the amount of shares that are sold from insiders' existing holdings. The effect is statistically significant and economically relevant. Column 1 reports that a one-standard-deviation increase in *Lendable* leads insiders to sell an additional 2.4% of their existing stakes,[9] which amounts to nearly 10% of the average insider sale size of 24.85% in our sample. The economic effect is more substantial if we focus on opportunistic open market sales (column 3), with a one-standard-deviation increase in *Lendable* leading insiders to sell an additional 3% of their existing stakes. This effect,

[9] The impact of the linear regression model, $y = \beta \times x$, is estimated as $\Delta y = \beta \times \Delta x$, where Δx denotes the one-standard-deviation change of the independent variable, which amounts to $0.202 \times 12\% = 2.4\%$.

again, is sizable compared with the average opportunistic insider sale size of 24.18%. Taken together, these results are consistent with our second hypothesis that the presence of short sellers induces insiders to sell more.

The next question concerns how rapidly insiders execute their transactions. We therefore replace the decision variable of *InsiderSale_FracStake* in the second-stage regression with the log of *InsiderSale_TimeSpan*, our proxy for transaction speed. The econometric specifications and the set of control variables are the same as before.

The results are reported in Panel B with a layout similar to that of Panel A. Unlike the previous case, here, short-selling potential greatly reduces the time span of the transactions in the second stage. A one-standard-deviation increase in *Lendable* is associated with a 4.7% (or 12.2%) decrease in the average time span of insider (or opportunistic insider) transactions.[10] This result is consistent with our third hypothesis that insiders expedite their transactions in the presence of short sellers, resulting in a smaller time span to complete their transaction sequences.

5. Endogeneity checks

The previous results, while supportive of our hypotheses, may still be subject to endogeneity concerns. In this section, we address this issue using a multipronged approach. First, we consider an experiment—the Reg SHO Pilot Program—to identify the causal impact of short-selling potential on insider sales. As an additional test, we perform an instrumental variable analysis.

5.1. A quasi-experiment: the SHO Pilot Program

We now consider an exogenous change in short-selling cost using the announcement of the change in short-sale restrictions under Regulation SHO in 2004 as a natural experiment. In the US. experiment, the SEC drafted and established a pilot program exempting a third of the stocks in the Russell 3000 Index from uptick rules and other price restrictions (Diether, Lee, and Werner, 2009b; Grullon, Michenaud, and Weston, 2015). The selection of stocks was purely random. As described in SEC Release No. 50104, the regulator "sorted the securities into three groups—Amex, Nasdaq-NM, and NYSE—and ranked the securities in each group by average daily dollar volume over the one year prior to the issuance of this order from highest to lowest for the period. In each group, we then selected every third stock from the remaining stocks."[11] In doing so, the SEC effectively generated a randomized experiment that exogenously reduces short-selling restrictions for a subset of stocks.

For our purposes, the relaxation of the short-selling restrictions also causes an exogenous change in the short-selling potential perceived by insiders, which will, in turn, change insiders' incentive to sell, which leads to our identification strategy. We use a diff-in-diff methodology, using the Reg SHO Pilot Program as the natural experiment to identify the causal effect of an exogenous change in the short-selling potential on insider sales. Treatment firms are the Pilot sample firms, and control firms are the remaining Russell 3000 firms. The program was announced in September 2004 and implemented in January 2005. We study the three months pre (2004.04–2004.06) and post (2004.09–2004.11) the announcement of the Reg SHO Pilot sample.[12]

We consider the announcement window, instead of the implementation window, to capture the effect of (ex ante) short-selling potential as opposed to that of realized shorting activity. The reasons are two-fold. First, the selection of the testing period is motivated by our general intuition that insiders with superior information will not wait until the period in which short-selling competition increases (i.e., the implementation window for Pilot firms). Rather, they will act before the enforcement period and strategically sell more and faster in the announcement period. By contrast, for stocks that are not included in the Pilot pool, the incentives for insiders to sell more and faster in the announcement period are significantly weakened. In this regard, the identification power on the ex ante impact of enhanced short selling is greatest during the announcement period. Second, unlike the case in which market quality and liquidity change once the program is implemented (Diether, Lee, and Werner, 2009b), we will demonstrate that liquidity does not change during our testing period. Hence, focusing on the announcement period allows us to isolate the short-selling effect from other confounding effects, for example, due to liquidity.[13]

We perform the standard difference-in-differences regressions in this analysis. Since we include both the firm and time fixed effects, the coefficient on *Pilot* × *Post* captures the treatment group's (Pilot firms') post-program change relative to that in the control group (i.e., diff-in-diff estimate). We present the results in Table 4.

We find that lifting the short-selling restrictions increased the likelihood of insider trading among treatment firms. On average, Pilot stocks experience 2.9% greater likelihood of insider sales for the Pilot firms relative to the control firms, and the diff-in-diff coefficient is statistically significant at 5% (Model 1). In addition, insiders in Pilot firms on average sell a larger fraction of their stakes and reduce the time span of their transactions (Model 2). Interestingly, insiders in Pilot firms do not speed up their trades immediately after the announcement of the regulation, presumably because there is still plenty of time for them to sell stocks before short-selling potential is really enhanced—hence, the necessity of selling fast is greatly reduced. Overall, the results suggest that the Reg SHO program has a causal effect on insiders' incentives especially to trade more.

Next, we perform the following placebo test. Liquidity may change in the treatment firms following the announcement of the SHO Pilot Program, partly because of firms'

[10] The relative impact for the time-span regression, $\ln(T) = \beta \times x$, is estimated as $\Delta \ln(T) = \Delta T/T = \beta \times \Delta x$. Hence, the effects of a one-standard-deviation increase are $0.394 \times 12\% = 4.7\%$ and $1.019 \times 12\% = 12.2\%$ for the two cases.

[11] The details are available at http://www.sec.gov/rules/other/34-50104.htm.

[12] We exclude 2004.07 and 2004.08, when the final Pilot sample was being discussed but was not finalized (i.e., a period with uncertainty about the program).

[13] As a further robustness check, we extend the post-announcement window to nine months after announcement (i.e., until 2005.05). The results are qualitatively the same.

Table 4
Evidence from the Reg SHO experiment.

This table presents evidence from the REG SHO Pilot Program that changes the short-selling constraint for a randomly selected subset of Russell 3000 firms. The first three columns present diff-in-diff regression analysis of insider sales using observations from the three months *Pre* (2004.04–2004.06) and *Post* (2004.09–2004.11) the announcement of the Reg SHO Pilot sample (we exclude 2004.07 and 2004.08, when the final Pilot sample was being discussed but had not been finalized). Treatment firms are the Pilot sample firms, and control firms are the remaining Russell 3000 firms. The last column reports, as a falsification test, the diff-in-diff regression result on trading turnover. Please refer to Appendix A for the variable definitions. We allow the standard errors to be correlated among all the Pilot (or control) firms for each month. We report *t*-statistics in the parentheses below the coefficient estimates, and statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

	(1) Insider sell dummy	(2) InsiderSale_FracStake (%)	(3) InsiderSale_TimeSpan (# days)	(4) Turnover
Pilot × Post	0.029**	0.006***	−0.021	−0.001
	(3.00)	(3.32)	(−0.15)	(−0.29)
Constant	0.438***	0.153***	5.562***	0.127***
	(135.32)	(170.17)	(56.47)	(170.32)
Firm FE		Yes		
Year-month FE		Yes		
Obs	16,646	16,646	16,646	16,646
R^2	0.435	0.370	0.473	0.765

anticipation of reduced shorting costs and higher shorting potential afterward. To address the concern that the change in insiders' trading during the announcement period is affected by the change in the general liquidity conditions of the treatment firms, we study the difference in the monthly turnover in the treatment group in the announcement period relative to the difference in turnover among the control firms (column 4 of Table 4). We find little change in monthly turnover during the announcement period for treatment firms. More importantly, the difference in the change in turnover between the treatment and the control groups is essentially zero both economically and statistically.

Finally, although the SHO experiment does not explicitly rely on lendable shares, it is nonetheless interesting to investigate whether the regulation has also increased the number of lendable shares on Pilot firms. If Regulation SHO is expected to make short selling easier and thus more important among all trades (e.g., Diether, Lee, and Werner, 2009b), more lendable shares could be supplied to the market to meet such changes. We find evidence to support this conjecture. More specifically, we conduct a diff-in-diff analysis using 2005:05–2007:07 as the post-period and 2004:01–2005:04 as the pre-regulation period, and find a modest yet statistically significant increase (0.4%) in the lendable shares among Pilot firms relative to the change in lendable shares among the control firms after the implementation of the REG SHO Pilot Program.[14] Taken together, the findings of our analysis and the previous literature collectively support the identifying strategy of using the REG SHO Pilot Program as an exogenous shock that reinforces short-selling potential.

Overall, our results confirm the identifying assumption that the treatment and control firms are comparable both before and after the announcement of the Pilot Program. Therefore, the significant increase in insider selling after the announcement of the Pilot Program observed for the treatment firms is due to the expected increase in short-selling potential.

5.2. An instrumental variable approach

We complement the previous approach with an instrumental variable analysis. We re-estimate the previous specifications (as estimated in Table 3) using ETF ownership as the instrument for the variable *Lendable*. The use of ETF ownership as an instrument provides an additional identification to allay concerns that the relationship between lendable shares and insider trading is driven by omitted variables rather than by the effect of short selling.

On the one hand, ETFs are among the main participants in the short-selling market, making shares available that can then be used by short sellers. On the other hand, ETFs, being passive investors, do not typically engage in the active control or informed trading of firms. Thus, the fraction of shares held by ETFs is a good instrument, as it meets both the exclusion restriction (i.e., there is no reason it should be related to insider trading through any channel other than the availability of shares to be lent in the short-selling market) and the inclusion restriction (i.e., ETFs make shares available to short sellers).

Moreover, the exogenous and high growth rate of the ETF industry over the past decade suggests that the instrument is likely to be very powerful. Indeed, unreported results show that *Lendable* is strongly positively related to the fraction of ETF ownership when we regress it on ETF ownership, firm-level control variables, and firm and year-month fixed effects. The effect of ETF ownership not only is statistically significant at the 1% level but also can explain approximately 50% of the variation in lendable shares in our sample, providing strong evidence against a weak instrument critique (Staiger and Stock, 1997). Overall, these results suggest that ETF ownership is a good instrument for short-selling potential.

[14] The two periods are selected because Regulation SHO was implemented in May 2005, and ended in August 2007. Note that we do not go before 2004 because of the poorer coverage of Data Explorer in the earlier period. Furthermore, the post-period here differs from that of our insider trading test because, different from the incentives of insiders to preempt short sellers, lenders benefit from enhanced short selling.

We repeat the analysis in Table 3 using the instrumented *Lendable*. The results are reported in Table 5. Columns 1 and 2 report the impact of the instrumented *Lendable* on the two-stage Heckman regressions related to the first major decision variable for insider sales (*InsiderSale_FracStake*), while columns 3 and 4 conduct similar analyses for the second major decision variable (*Log(InsiderSale_TimeSpan)*). The results confirm the previous findings in Table 3; short-selling potential significantly incentivizes insiders to sell more of their existing holdings and expedite their sale transactions. Every 1% increase in (instrumented) *Lendable* is associated with a 0.46% increase in shares sold as a proportion of insiders' existing portfolio holdings and a 2.59% decrease in the time span of transactions. Unreported results confirm that these effects are primarily observed (and become stronger) in the opportunistic sales sample.

Of course, ETF ownership may be related to uncontrolled-for firm-specific characteristics, such as investor attention and liquidity. The economic concern is that high investor attention and liquidity may directly increase the price efficiency of firms, which effectively disciplines managers following the spirit of the previous model. Therefore, in a robustness check, we orthogonalize ETF ownership on institutional ownership, the number of analysts following the firm, and turnover. Unreported results using this orthogonalized variable provide similar results.

It may be argued that ETF affects insider trading through not only the short-selling channel—such that the instrumental test captures only a spurious correlation due to omitted variables or the direct impact of the ETF itself—but also another channel that we cannot explicitly control for; then, such an impact should be observed *independent* of the level of short-selling potential. By contrast, a lack of direct explanatory power of ETF on insider trading in the case of low short-selling potential would help to eliminate the omitted variable problem. To address this issue, we examine the impact of ETF ownership (*ETF*) on insider trading when short selling is constrained. Unreported results show that for these stocks (that have no short interest in our sample period), ETF is clearly uncorrelated with insider selling. Finally, we also find that *Lendable* affects insider trading to an even greater extent when ETF ownership is zero. Overall, these findings confirm the quality of our instrument, making the instrumental variable analysis a good complement to the test based on the SHO experiment.

6. Extensions

On average, the previous results establish that an insider is more likely to sell a higher proportion of her ownership stake and do so more rapidly when the firm's short-selling potential is higher. This section provides a list of additional tests to extend our economic intuition and assess the robustness of our main results. We first test whether a firm's short-selling potential has a greater effect on insiders' incentives when short sellers' attention is higher. We then explore the implications of our hypothesis in terms of information dissemination. Finally, we provide robustness checks using a matching sample analysis and alternative definitions of insiders.

6.1. Short sellers' attention

While, as hypothesized, short-selling potential in general affects insider sales, its impact could be more prominent when competition over trading on private information is more imminent, for instance, when the attention level of short sellers is high. In this section, we exploit firm-specific negative news events to test this additional implication. The benefit of using news events is that we can use media reports, or public attention, to proxy for the attention of short sellers. For instance, news reports may cause short sellers to pay particular attention to certain firms. Alternatively, both short sellers and the public media pay attention to the same firm when it has negative news (but short sellers' private information is more accurate than the public information available in the media). In either case, media coverage correlates with short sellers' attention, and we expect insiders to sell more and sell more rapidly shortly before unfavorable media coverage.[15]

Specifically, we focus on how (the expected) short sellers' attention affects insider selling through lendable shares by relating insider trading to the interaction between attention and *Lendable*. If high short-selling attention intensifies the competitiveness of private information trading through the improved use of existing lendable shares, we expect the interaction to induce insiders to sell more and do so more rapidly right before the attention events. We therefore collect information on news events from RavenPack News Analytics, which is a data provider (generally to hedge funds) with explanatory and predictive input derived from (public) news. For the purposes of our analysis, we focus on negative news.[16] We compute the number of negative news articles for a firm in one month, from which we subtract the average number of negative news for the same firm in the preceding three months. We define *D_neg news* as a dummy variable equal to one if the number of negative news events (in excess of the level in the previous three months) of the firm in a month is above the cross-section median for that given month. We use "*D_neg news*" in month $t+1$ to proxy for the *expected* abnormal short seller attention in month t. Then, we interact *D_neg news* in month $t+1$ with lagged *Lendable* and determine whether insiders sell in a different manner in month t conditioning on attention. The dependent variables are *InsiderSale_FracStake* and *InsiderSale_TimeSpan*. We use the

[15] Short-selling activity is known to concentrate around news events (e.g., Engelberg, Reed, and Ringgenberg, 2012; Boehmer, Jones, and Zhang, 2012).

[16] RavenPack extracts information from public news sources for tens of thousands of firms, decodes the tone of reports based on linguistic analyses, and assigns positive or negative values to the tone of news reports on a 100-point scale (the lower the score is, the more negative the coverage of the firm is), which the database calls the "sentiment score" of news. We compute the monthly "sentiment score" of a firm by averaging the scores over all news reported for the firm in a given month. We then define the abnormal sentiment score as the difference between the sentiment score in the current month and the average monthly sentiment score over the previous three months for each firm. Our negative news variable reflects news reports with negative abnormal sentiment scores.

Table 5
IV analysis.

This table reports the results of the instrumental variable (IV) regression analysis, by repeating the analysis in Table 3 using ETF ownership as the instrument for the variable *Lendable*. Specifically, we predict $\widehat{Lendable}_{i,t-1}$ from the following regression, using ETF as the instrument, with which we then estimate the Heckman regressions employing the same specification and explanatory variables as in Table 4. $Lendable_{i,t-1} = \alpha + \beta ETF_{i,t-1} + \sum \gamma_j X_{i,j,t-1} + \epsilon_{i,t-1}$. Please refer to Appendix A for the variable definitions. We also include year-month fixed effects, and standard errors are clustered at the firm level. We report *t*-statistics in the parentheses below the coefficient estimates and statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

	(1)	(2)	(3)	(4)
	InsiderSale_FracStake		Log(InsiderSale_TimeSpan)	
	2nd stage	1st stage	2nd stage	1st stage
Lendable (instrumented)	0.464***	1.786***	−2.588***	1.786***
	(7.84)	(10.62)	(−8.00)	(10.62)
Total open market shares sold/shares outstanding	1.024***		3.410***	
	(14.47)		(9.07)	
Log(market size)	0.027***	0.163***	0.015	0.163***
	(15.87)	(32.91)	(1.56)	(32.91)
Book to market	−0.015***	−0.192***	−0.096***	−0.192***
	(−5.23)	(−27.30)	(−6.22)	(−27.30)
Lagged 6m ret	0.055***	0.410***	0.119***	0.410***
	(14.06)	(41.28)	(5.51)	(41.28)
Log(analyst coverage+1)	−0.021***	0.027***	0.044***	0.027***
	(−12.72)	(5.33)	(4.89)	(5.33)
Turnover	−0.025***	−0.158***	−0.101***	−0.158***
	(−3.58)	(−7.45)	(−2.64)	(−7.45)
Idiosyncratic volatility	−0.118	−1.642***	1.769***	−1.642***
	(−1.30)	(−6.54)	(3.57)	(−6.54)
IO	−0.004	0.068***	−0.058***	0.068***
	(−1.15)	(5.73)	(−2.78)	(5.73)
Log(sales)	−0.000***	−0.000***	−0.000	−0.000***
	(−8.61)	(−24.02)	(−0.18)	(−24.02)
Leverage	−0.018***	−0.374***	−0.162***	−0.374***
	(−2.90)	(−22.16)	(−4.87)	(−22.16)
D_EA month	0.015***	0.189***	0.039**	0.189***
	(5.38)	(22.90)	(2.57)	(22.90)
Inverse Mills' ratio	0.041***		−0.632***	
	(8.18)		(−22.11)	
Routine insider sell dummy		2.703***		2.703***
		(37.56)		(37.56)
Constant	0.042***	−1.758***	2.418***	−1.758***
	(2.82)	(−55.58)	(29.27)	(−55.58)
Fixed effects	Year-month			
Obs.	189,961		189,961	

Heckman two-step procedure estimation method and include the same set of control variables as in Table 3.

We report the results in Table 6. First, the amount of lendable shares still significantly affects insider selling, as before. The regression coefficients, 0.186 for *InsiderSale_FracStake* (column 1) and −0.282 for *InsiderSale_TimeSpan* (column 3), are also comparable with those reported in Table 3. These results indicate that, irrespective of whether attention is taken into consideration, the first-order impact of short-selling potential is to incentivize insiders to sell more and faster.

More interestingly, we observe that high levels of attention largely reinforce the general impact of short selling through the interaction term—the regression parameters are 0.06 and −0.266 for the size and time span of insider sales, respectively, which are in the same direction as the regression coefficients for *Lendable*. Conditional on the same level of lendable shares, firms that would have more negative news in the subsequent month are associated with more (by 6%, column 1) and faster insider selling (by 26.6%, column 3). The magnitudes are highly statistically and economically significant.

Overall, the analyses of short sellers' attention complement our main analyses in the spirit of Cohen, Diether, and Malloy (2007): while *Lendable* measures the maximum threat of short-selling competition from the supply side of the short-selling market, attention describes its effectiveness from the demand side of the market. The combination of the two produces the maximum impact of the short-selling market on insider sales.

6.2. Implications for information dissemination

We now explore the implications of short selling by examining how it affects the return predictability of insider sales.

We partition our sample according to a firm's average level of lendable shares during the sample period. Firms with average values of *Lendable* greater than the median are placed in the High lendable (or high short-selling potential) subsample, and the rest of the firms are placed in the Low lendable subsample. The dependent variable is the monthly

Table 6
Insider selling before negative news events.

This table reports results regarding the effect of short seller potential on insider-selling behavior one month before negative news events using Heckman two-step procedures (with the same specification and explanatory variables as in Table 3). We collect information on news events from RavenPack News Analytics, which is a data provider (primarily to hedge funds) with sources of explanatory and predictive inputs derived from (public) news. RavenPack extracts information from public news sources on tens of thousands of firms and codes its content as positive or negative on a 100-point scale (the lower the score is, the more negative the information regarding the firm is). For the purposes of our analysis, we focus on the negative news events (in the form of news events with negative abnormal sentiment scores). We then compute the number of the negative news events on a firm in a given month, defined as (the logarithm of) the number of negative news events minus (the logarithm of) the number of the negative news events over the previous three months). *D_neg news* is equal to one if the number of negative news for a firm in a month is above median in the cross-section of firms at that given month. Please refer to Appendix A for the variable definitions. We report results regarding insider-selling behavior one month before the negative news event using the Heckman two-step procedures in the 2006:07–2011:11 period. In addition to the reported variables, we include the same set of control variables as in Table 3. We report *t*-statistics in the parentheses below the coefficient estimates, and statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

	(1)	(2)	(3)	(4)
	InsiderSale_FracStake		Log(InsiderSale_TimeSpan)	
	2nd stage	1st stage	2nd stage	1st stage
Lendable	0.186***	1.088***	−0.282***	1.088***
	(11.07)	(23.36)	(−3.07)	(23.36)
D_neg news	−0.013**	0.009	0.094***	0.009
	(−2.23)	(0.54)	(2.87)	(0.54)
Lendable × D_neg news	0.060***	−0.095	−0.266**	−0.095
	(2.66)	(−1.54)	(−2.19)	(−1.54)
Inverse Mills' ratio	0.044***		−0.630***	
	(8.61)		(−21.61)	
Routine insider sell dummy		2.701***		2.701***
		(36.49)		(36.49)
Fixed effects		Year-month		
Other controls		Yes		
Constant	0.034**	−1.719***	2.356***	−1.719***
	(2.27)	(−52.27)	(27.85)	(−52.27)
Observations	182,642		182,642	

return (in percentage terms) over *t*, and the key independent variables are the dummy variables for *Insider sell*, *Opportunistic insider sell*, and *Routine insider sell* in month $t-1$. Following Cohen, Malloy, and Pomorsky (2012), we include *Market size* and *Book to market* in month $t-1$, the past one month's returns ($t-1$), and past 12 months' returns ($t-2$,$t-12$), as well as month fixed effects in the regression. Similarly, standard errors are clustered at the firm level.

We report the results in Table 7. The first two columns confirm that insider sales predict negative stock returns and that this predictive power concentrates in opportunistic sales. This result is generally consistent with Cohen, Malloy, and Pomorsky (2012). The next two columns indicate that the predictive power is greatest among stocks with high lendable shares. These results identify an explicit channel through which short sellers indirectly enhance the speed of information dissemination through their impact on insiders. That is, short-selling potential incentivizes insiders to release more private information into the market. Negative information is subsequently incorporated into stock prices. The literature (e.g., Bris, Goetzmann, and Zhu, 2007; Boehmer, Jones, and Zhang, 2008; Boehmer and Wu 2013; Saffi and Sigurdsson, 2011) argues that short selling contributes to the market's informational efficiency—and our analyses confirm the existence of an explicit economic channel through which this contribution can be achieved.

6.3. Alternative interpretations

It is worth mentioning that the analysis till now has been based on lendable shares and insider shares standardized by shares outstanding. While the standardization follows the literature convention (e.g., Saffi and Sigurdsson, 2011), we consider an alternative way of standardizing our main variables based on trading volume. Our goal is twofold. The first is purely methodological, as the alternative standardization helps us to assess the robustness of our results. The second is more conceptual, as it helps to differentiate our hypothesis from an alternative information interpretation. Indeed, if both insiders and short sellers scale their orders proportionally to expected trading volume to minimize costs, which can happen in Kyle (1984) types of models (including Holden and Subrahmanyam (1992) as well as the model we presented in the Internet Appendix) especially when uninformed trading volume is time varying, stock lenders may also scale up their lending volume accordingly. In this case, the positive relationship between insider sales and lendable shares may reflect "comovement" induced by the impact of trading volume on informed trading, rather than insiders' preemptive trading due to the fear of trading competition. The standardization based on trading volume removes the potential impact of trading volume on informed trading strategies. If standardized lendable shares can still speed up similarly standardized insider selling, the former proxy clearly captures the importance of short-selling potential with respect to all trading volume rather than a comovement effect.

We therefore repeat the main analysis of Tables 2 and 3 based on trading volume-standardized insider sales and lendable shares. More specifically, we scale both variables by the contemporaneous monthly trading volume of the stock—the time convention here captures the idea that informed traders

Table 7
Return predictability of insider sales by short-selling potential.

This table reports results regarding the return predictability of insider sales between firms with high short-selling potential and firms with low short-selling potential. We partition our sample according to the average level of lendable shares for a firm over the sample period. Firms with an average value of *Lendable* greater than the median are placed in the High lendable (or high short-selling potential) subsample, and the rest of the firms are placed in the Low lendable subsample. The dependent variable is the monthly return (in percentage terms) in t, and the key independent variables are dummy variables for *Insider sell*, *Opportunistic insider sell*, and *Routine insider sell* in month $t-1$. Following Cohen, Malloy, and Pomorsky (2012), we include *Market size* and *Book to market* in month $t-1$, past one month's returns ($t-1$), and past 12 months' returns ($t-2$, $t-12$) as well as month fixed effects in the regression. Please refer to Appendix A for the variable definitions. Similarly, standard errors are clustered at the firm level. We report t-statistics in the parentheses below the coefficient estimates, and statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

Variables	(1) Return Full sample	(2) Return Full sample	(3) Return High lendable	(4) Return Low lendable
Insider sell dummy	−0.501***			
	(−6.13)			
Opportunistic insider sell dummy		−0.255**	−0.314***	0.252
		(−2.15)	(−2.62)	(0.51)
Routine insider sell dummy		−0.116	−0.062	−0.938
		(−0.47)	(−0.24)	(−0.84)
Market size	−0.004***	−0.005***	−0.004**	−0.010**
	(−2.59)	(−2.97)	(−2.55)	(−2.44)
Book to market	1.750***	1.782***	1.908***	1.616***
	(15.56)	(15.87)	(12.23)	(9.99)
Past month returns	0.035***	0.035***	0.050***	0.019*
	(6.66)	(6.64)	(8.35)	(1.96)
Past year returns	−0.009***	−0.009***	−0.010***	−0.009***
	(−10.23)	(−10.79)	(−8.91)	(−6.53)
Constant	0.188**	0.078	−0.032	0.252*
	(2.21)	(0.96)	(−0.32)	(1.75)
Observations	188,530	188,530	128,515	60,015
R^2	0.031	0.030	0.046	0.015

may increase their trading when they expect a high uninformed trading volume to occur. Next, we also take the natural logarithm of these standardized variables to alleviate the outlier effect. We then apply the tests documented in Tables 2 and 3 to these variables. In the interest of brevity, we only describe the general patterns here while tabulating the table in the Internet Appendix (Table IA.1)—all results are very similar to what we have seen in Tables 2 and 3. More explicitly, standardized lendable shares significantly increase the likelihood for insider sales in general and opportunistic open market sales in particular to occur. Furthermore, trading volume-standardized lendable shares are positively associated with insider sales and negatively associated with the time span of insider sales, where insider sales are also standardized by trading volume. All these effects are statistically significant, suggesting that lendable shares in this case nonetheless capture short-selling potential with respect to all trading volume rather than comovements induced by time-varying uninformed trading. These additional results, therefore, further support our main interpretation based on trading competition.

6.4. Robustness checks

We first provide additional evidence that high values in lendable shares introduce more trading competition to insiders using an alternative specification of the short-selling potential variable. Specifically, we construct two dummy variables *D_low lendable* and *D_high lendable*, instead of using the continuous variable of lendable shares. *D_low lendable* is a dummy equal to one if the firm's lendable shares in a month is below the bottom quartile of the cross-sectional distribution for that given month. Likewise, *D_high lendable* is a dummy equal to one if the firm's amount of lendable shares in a month is above the top quartile of the monthly cross-sectional distribution. *D_low lendable* identifies firms in months where (effective) short selling is close to infeasible as the amount of lendable shares in the inventory accounts for less than 7% of the total shares outstanding (Table 1). These are the firms where we expect the minimum impact on insiders' trading incentive from potential short sellers. On the other hand, *D_high lendable* identifies firms in months with abundant lendable shares and hence, insiders face more credible threat by short sellers. We repeat the analysis in Tables 2 and 3 and report the results in Table 8.

Panel A of Table 8 tabulates the results when we regress the likelihood of insider selling on the two dummy variables described above. The test is similar to that reported in Table 2, except that we use the two dummy variables concerning the extreme values of lendable shares rather than the variable of lendable shares itself. Panel B further explores the impact of the two dummy variables in the Heckman specification following Table 3. From Panel A, we see that firms in the top quartile of the distribution of lendable shares experience a greater likelihood of their insiders selling and the effects are statistically and economically significant. Panel B further demonstrates that, conditional on the participation of sales, insiders sell more and faster in the case of firms with extremely high values of lendable shares (*D_high lendable*=1) as compared to firms with mid-range lendable shares. Likewise, insiders sell less and slower in the case of firms with the low levels of lendable shares (*D_low lendable*=1) compared to firms with mid-range lendable shares. *F*-tests also confirm that the difference between the two coefficients (*D_high lendable*

Table 8
Alternative specifications on short-selling potential.

This table reports results from using a different specification of short-selling potential and repeating the analysis of Tables 2 and 3 in the full sample as a robustness check. *D_low lendable* is equal to one if the variable *Lendable* is below the bottom quartile of the monthly cross-sectional distribution. *D_high lendable* is equal to one if the variable *Lendable* is above the top quartile of the monthly cross-sectional distribution. Panel A repeats Table 2's conditional logit regression analysis. Panel B repeats Table 3's Heckman regression analysis of open market insider sales by the top five insiders. We include the same set of control variables in the regressions; please refer to Tables 2 and 3 for the model specification and Appendix A for the variable definitions. We report *t*-statistics in the parentheses below the coefficient estimates, and statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

Panel A: Conditional logit regressions of insider sale

	(1) Insider sell dummy	(2) Opportunistic insider sell dummy
D_low lendable	−0.004	0.012
	(−0.03)	(0.03)
D_high lendable	0.131***	0.228***
	(2.85)	(2.66)
Controls	Yes	
Fixed effects	Firm, year-month	
Observations	129,922	49,211

Panel B: Heckman analysis

	(1)	(2)	(3)	(4)
	InsiderSale_FracStake		Log (InsiderSale_TimeSpan)	
	2nd stage	1st stage	2nd stage	1st stage
D_low lendable	−0.019***	−0.212***	0.082***	−0.212***
	(−3.32)	(−15.81)	(2.72)	(−15.82)
D_high lendable	0.034***	0.147***	−0.043***	0.147***
	(13.51)	(19.18)	(−3.14)	(19.19)
Controls	Yes			
Fixed effects	Year-month			
Obs.	189,970		189,966	

and *D_low lendable*) is statistically significant. Unreported tests using different thresholds (e.g., to define the two dummy variables to represent top/bottom 10% of values of lendable shares) lead to very similar results. These observations suggest that high values of lendable shares indeed proxy for high short-selling potential, which induces more insider sales in our empirical framework.[17]

Second, we consider an alternative measure of insider trading and focus on the five most powerful insiders in the company, whom the Thomson Insider Database classifies as "level 1 insiders". These are: the chief executive officer, the chairman of the board, the chief operating officer, the president, and the general counsel. We therefore re-estimate the previous specifications using this new definition of insiders, and report the results in Table 9. Panel A repeats Table 2's conditional logit regression analysis. Panel B repeats Table 3's Heckman regression analysis. The results confirm those presented above, both in terms of statistical significance and economic relevance, as the coefficients remain statistically significant and their magnitudes are in general larger than those in Table 2. We also experiment with the top three insiders, as in Cohen, Malloy, and Pomorsky (2012), and obtain a similar result.

Third, given that the measure for the speed of trading we use is novel, we provide an alternative measure in this section to check the robustness of the related results. Specifically, we define *InsiderSale_Duration* as the weighted average of days that insiders take to complete sales in a given month, with the weights determined by the total dollar value of each day's net sales. Compared with the previous measure *InsiderSale_TimeSpan*, this measure effectively assigns a greater weight to days that have a larger volume of net insider sales. We then examine the impact of short selling on this alternative measure of trading speed.

The results are presented in Table 10, with a layout similar to that of Table 3, Panel B. The evidence confirms a negative impact of short-selling potential on the pace of insider trading. A higher level of lendable shares is associated with a decrease in the duration of insider sale transactions (as captured by *InsiderSale_Duration*), and the decrease in duration is particularly substantial for opportunistic insider sale transactions.

Finally, we address the potential concern that the occurrence of insider sales is not randomly distributed among firms. For example, the determinants of an insider sale may be correlated with other firm characteristics, differentiating the sample of firms with insider sales from that without insider sales. Such differences may bias our inference of the impact of short selling on insider sales. To address this issue, we consider a matching sample

[17] This test also addresses the potential concern that high lendable shares may not be powerful enough to capture the potential impact of short sellers because not all lendable shares are utilized in normal days. Table 8 illustrates that high values of lendable shares, regardless of their potential utilization rate, have significant power. This observation is reasonable because insiders' ex ante concern about trading competition should be more affected by the maximum amount of shares lendable to short sellers (i.e., a measure of the potential capacity to short). We also consider another short-selling potential variable that takes into account the utilization rate of the lendable shares. We exclude the utilized shares from the lendable shares, which measures the portion of the shares outstanding that are currently not on loan and thus are available for borrowing. Then we repeat the analysis in Tables 2 and 3. The results are qualitatively the same and for brevity we do not report them here.

Table 9
Alternative insider measure.

This table reports results from using a different measure for insider and repeating the analysis of Tables 2 and 3 in the full sample as a robustness check. The insiders are constrained to the five most powerful insiders in the company: the chief executive officer, the chairman of the board, the chief operating officer, the president, and the general counsel. Panel A repeats Table 2's conditional logit regression analysis. Panel B repeats Table 3's Heckman regression analysis of open market insider sales by the top five insiders. We include the same set of control variables in the regressions; please refer to Tables 2 and 3 for the model specification and Appendix A for the variable definitions. We report *t*-statistics in the parentheses below the coefficient estimates, and statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

Panel A: Conditional logit regressions of top 5 insider sale

	(1) Top5 insider sell dummy	(2) Opportunistic top5 insider sell dummy
Lendable	1.528***	2.663***
	(3.99)	(3.62)
Controls	Yes	
Fixed effects	Firm, year-month	
Observations	128,248	48,869

Panel B: Heckman analysis for top 5 insiders

	(1)	(2)	(3)	(4)
	Top5 InsiderSale_FracStake		Top5 log (InsiderSale_TimeSpan)	
	2nd stage	1st stage	2nd stage	1st stage
Lendable	0.194***	1.132***	−0.695***	1.133***
	(9.55)	(24.57)	(−6.50)	(24.58)
Controls	Yes			
Fixed effects	Year-month			
Obs.	186,571		186,569	

Table 10
Alternative measure of trading speed.

This table reports results from using a different measure of trading speed and repeating the analysis in Table 3. We replace our current measure *InsiderSale_TimeSpan* with *InsiderSale_Duration* in this analysis. *InsiderSale_Duration* is defined as the weighted average of the number of days that insiders take to complete their sales in a given month, where the weights are determined by the total dollar value of each day's net sales. We include the same set of control variables in the regressions; please refer to Table 3 for the model specification and Appendix A for the variable definitions. We report *t*-statistics in the parentheses below the coefficient estimates, and statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

	(1)	(2)	(3)	(4)
	Log(InsiderSale_Duration)		Log(Opportunistic InsiderSale_Duration)	
	2nd stage	1st stage	2nd stage	1st stage
Lendable	−0.363***	1.063***	−0.756***	1.311***
	(−6.27)	(28.30)	(−6.38)	(24.25)
Inverse Mills' ratio	−0.473***		−0.400***	
	(−21.01)		(−6.72)	
Routine insider sell dummy		2.705***		0.796***
		(36.61)		(26.98)
Constant	1.806***	−1.730***	1.791***	−2.785***
	(27.84)	(−53.80)	(8.94)	(−55.75)
Controls	Yes			
Fixed effects	Year-month			
Obs.	186,560		186,564	

procedure. We use a "P-score nearest neighbor matching" procedure based on firm size, book-to-market, lagged six-month return, turnover, sales, leverage, institutional ownership, and idiosyncratic volatility.[18] That is, for each firm-month in which we observe insider sales, we find a matching firm with similar characteristics that does not have an insider sale. The resulting sample thus contains a more homogeneous group of firms with comparable firm characteristics. We report the results in Table 11. Panel A repeats Table 2's conditional logit analysis. Panel B repeats Table 3's Heckman regression analysis.

The new tests confirm the previous results. The economic and statistical impacts are comparable. For instance,

[18] The results reported in the paper use the one-to-five matching methodology, and our findings are also robust to a one-to-one matching methodology.

Table 11
Robustness check: propensity score matching.

This table reports results of the *P*-score matching method as a robustness check for Tables 2 and 3. We match firms based on firm size, book-to-market, lagged six months' return, turnover, sales, leverage, institutional ownership, and idiosyncratic volatility. Panel A repeats Table 2's conditional logit regression analysis. Panel B repeats Table 3's Heckman regression analysis on insider sales by officers and directors. We include the same set of control variables in the regressions; please refer to Tables 2–5 for the model specification and Appendix A for the variable definitions. We report *t*-statistics in the parentheses below the coefficient estimates, and statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

Panel A: Conditional logit regressions of insider sale

	(1)	(2)	(3)	(4)	(5)	(6)
	Open market sell dummy	Routine open market sell dummy	Opportunistic open market sell dummy	Insider sell dummy	Routine insider sell dummy	Opportunistic insider sell dummy
	All insiders (on Form 4)			Officers and directors		
Lendable	1.297***	1.217	1.236**	1.378***	0.955	1.309***
	(4.23)	(1.03)	(2.54)	(4.51)	(0.81)	(2.64)
Control variables	Yes					
Fixed effects	Firm, year-month					
Observations	69,580	19,881	49,184	69,386	19,529	48,666

Panel B: Heckman analysis

	(1)	(2)	(3)	(4)
	InsiderSale_FracStake		Log (InsiderSale_TimeSpan)	
	2nd stage	1st stage	2nd stage	1st stage
Lendable	0.211***	1.153***	−0.634***	1.153***
	(14.86)	(21.98)	(−7.50)	(21.99)
Control variables	Yes			
Fixed effects	Year-month			
Obs.	73,993		73,989	

the regression coefficient of *Lendable* on *InsiderSale_FracStake* in Panel B, column 1 is 0.211 (with a *t*-statistic of 14.86). In the tests reported in Table 3, the corresponding coefficient is 0.202 (with a *t*-statistic of 14.95). Similarly, the coefficient of *Lendable* on *Log(InsiderSale_TimeSpan)* is −0.634 (with a *t*-statistic of −7.50) in column 3 of Panel B of the current table, compared with the coefficient of −0.394 (with a *t*-statistic of −5.31) reported in Panel B of Table 3. Therefore, the main findings remain very similar using a more homogeneous control group of firms with comparable characteristics.

7. Conclusion

We study how the presence of short sellers alters insiders' incentives to trade. Trading competition by short sellers incentivizes insiders to expedite their information processing and trading activities to *preempt* short sellers, enhancing both the scope and speed of insider sales.

We test this hypothesis using monthly data on US. stocks over the period from 2006 to 2011. We document that short-selling potential strongly encourages insiders to participate in open market sales. If we decompose the open market sales into routine and opportunistic sales, the impact of lendable shares concentrates in opportunistic sales. Thus, short selling primarily affects informed insiders. If we condition on insider selling, we find that with high levels of lendable shares, insiders tend to sell a higher portion of their existing stakes and expedite their sale transactions, confirming that short selling incentivizes insiders to both sell more and sell faster. Our results remain qualitatively unchanged when we conduct robustness checks using an alternative sample of firms and an alternative definition of corporate insiders.

A natural experiment based on the SHO Pilot Program that exogenously relaxes short-selling restrictions provides an opportunity to test the causal impact of short-selling potential on insider sales. Among otherwise comparable firms (both before and after announcement), we observe a significant increase in the open market insider sales of officers and directors among the Pilot stocks after the announcement, relative to the change in open market insider sales for the control firms. In addition, treatment firms' insiders sold more shares and sold them faster after the announcement of the SHO Pilot Program, relative to the control firms' insiders. The results from an instrumental variable analysis using ETF ownership as an exogenous determinant of lendable shares complement and confirm the findings in the quasi-experimental approach.

We also find that the effect of short-selling potential on insider selling is amplified when short sellers' attention is higher. Moreover, the return predictability of insider sales

is only observed among stocks with high shorting potential, suggesting that short sellers indirectly enhance the informativeness of firm's share prices via insider sales.

Overall, our results suggest that insiders' trading motivation and behavior could be substantially affected by the conditions of the shorting market. The availability of short selling introduces a competition scheme that accelerates the rate at which private information is revealed to the market via insider trading. In addition, the findings in the paper have implications concerning the unintended consequences of limiting short selling.

Appendix A. Variable definitions

Variables	Definitions
Lendable	Stock shares in the inventory available for borrowing as a proportion of shares outstanding
Market size	Market capitalization
Book to market	Book value of equity divided by market capitalization
Turnover	Sum of monthly trading volume (equal to two for Nasdaq stocks) divided by shares outstanding
Lagged 6m ret	Cumulative stock return for the last six months
Leverage	Long-term debt issues plus current liability divided by total assets
Sale	The gross sales (i.e., the amount of actual billings to customers for regular sales completed) during the period
Idiosyncratic volatility	Monthly average of the standard deviation of residuals from the adjusted Fama-French daily regressions (Jiang, Xu, and Yao, 2009)
IO	Institutional ownership, defined as institutional ownership shares divided by adjusted shares outstanding
ETF	Proportion of shares held by an ETF
Analyst coverage	Number of analysts following the firm
Price	Share price at the end of the month
D_EA month	Dummy variable equal to one if there is an earnings announcement in the month
Abnormal sentiment	We compute the monthly "sentiment score" of a firm by averaging the scores assigned by RavenPack over all news events reported in the month. We define *Abnormal sentiment* as the difference between the sentiment score in the current month and the average monthly sentiment score over the previous three months.
D_neg news	Dummy variable equal to one if the firm's number of negative news events is above the monthly median in the sample. The number of negative news is defined as (the logarithm of) the average number of news events that have a negative *Abnormal sentiment* score in a given month for each firm minus the (log of) the average number of news events that have a negative *Abnormal sentiment* score in the previous three months.
Open market sell dummy	Dummy variable equal to one if there is an open market sale by *any* insider (as recorded in Form 4 of the Insider Filings in the current month) and zero otherwise Dummy variable equal to one if directors and officers have open market sales in the current month and zero otherwise.
InsiderSale_FracStake	Number of shares sold on the open market by officers and directors as a proportion of their initial ownership in a given firm-month
InsiderSale_TimeSpan	The number of days that an insider takes to complete his sale transactions in a month (i.e., equal to n if the last net sale transaction within a month is on the n^{th} day since the first day with nonzero net sale transactions)
Insider sell/ outstanding	Total number of shares sold on the open market by officers and directors in a firm month divided by shares outstanding
Routine sell	An insider is considered a routine trader if he has been trading in the same calendar months over the prior three years. A routine sale is one made by a routine insider in the same calendar month in which the insider traded over the past three years (Cohen, Malloy, and Pomorsky, 2012). All routine-related insider sale variables are defined using this definition.
Opportunistic sell	An opportunistic insider is one for whom there is no obvious discernible pattern in the past timing of their trades over the past three years. An opportunistic sale is one made by an opportunistic insider. Opportunistic-related insider sale variables use this definition.

Appendix IA. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.jfineco.2015.08.004.

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