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The Market for Corporate Control as a Limit to Short Arbitrage

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Abstract

We hypothesize that corporate takeover markets create significant constraints for short sellers. Both short sellers and corporate bidders often target firms with declining economic prospects. Yet, a target firm's stock price generally increases upon a takeover announcement, resulting in losses for short sellers. Therefore, short sellers should require higher rates of return when the takeover likelihood is higher. Consistent with this prediction, the return predictability of monthly short interest increases with industry-level takeover probability and decreases as takeover defenses are implemented. Our results suggest that efficient takeover markets create trading frictions for short sellers and can therefore inhibit overall market efficiency.

I. Introduction

In corporate finance, the market for corporate control is an important governance mechanism. Bidding firms and corporate raiders often target firms considered to have poor prospects under current management, expecting that they can increase firm value by improving firm performance or identifying synergies

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(i.e., Devos, Kadapakkam, and Krishnamurthy (2009), Hoberg and Phillips (2010), Erel, Liao, and Weisbach (2012), and Erel, Jang, and Weisbach (2015)). Further, takeover targets generally experience large positive announcement returns upon the announcement of a takeover bid, as a premium is normally required to attract the marginal investor for majority ownership of the target firm (e.g., Lang, Stulz, and Walkling (1989), Servaes (1991), Schwert (1996), and Schwert (2000)). Similarly, short sellers have an important governance role, as they often target overvalued firms considered to be poorly managed and increase their profits as the stock price falls. Although the short seller's motive is to make trading profits, such behavior imposes a type of external governance on corporate executives (Edmans (2009), Massa, Zhang, and Zhang (2015), and Fang, Huang, and Karpoff (2016)).

Our study considers the tension between these two governance mechanisms. Specifically, if short sellers correctly target a mismanaged and overvalued firm and the firm's stock price begins to decline, the firm is also more likely to become the target of a subsequent takeover attempt (Edmans, Goldstein, and Jiang (2012)). Upon realization of a takeover bid, the target firm's stock price experiences a sudden, discrete jump. Therefore, an increase in the likelihood that a firm becomes a takeover target poses a significant risk to informed short sellers who take under-diversified positions in order to exploit an arbitrage opportunity (Shleifer and Vishny (1997), Wurgler and Zhuravskaya (2002)). We explore these two competing effects and investigate the role of the market for corporate control as a source of arbitrage risk to short sellers. Such risk should result in a risk premium demanded by short sellers, leading to return predictability.[1,2] Such return predictability obtains because if informed short sellers anticipate the risk of a potential takeover ex ante, they demand higher returns to their arbitrage positions for bearing this risk (De Long, Shleifer, Summers, and Waldmann (1990), Shleifer and Vishny (1997)). Higher takeover probability should therefore lead to more negative future stock returns for firms with large amounts of short interest (e.g., Engelberg, Reed, and Ringgenberg (2018)).

Our evidence supports this prediction. We document a stronger negative relation between short interest and future stock returns in portfolios with the highest ex ante takeover risk, as measured by the number of recent takeover attempts in

[1]We illustrate this risk with a recent example. On Aug. 7, 2018, Tesla's CEO and founder, Elon Musk, announced that he had secured private outside funding to buy the company at $420 per share. In 24 hours, Tesla's stock price went from $343.84 to $369.09. Three days later, a short seller named Kalman Isaacs filed a lawsuit against Musk, claiming that the announcements were false and designed to hurt investors holding short positions in Tesla. Isaacs further claimed that he had to buy 3,000 shares of Tesla at inflated prices to cover his short positions (https://www.cnbc.com/2018/08/11/lawsuits-accuse-teslas-musk-of-fraud-over-going-private-proposal.html).

[2]The recent takeover of Kite Pharma by Gilead Sciences illustrates the adverse effect of a takeover on short sellers' profits. As of Aug. 15, 2017, Kite Pharma had an outstanding short interest of 8.1 million shares (14.2% of shares outstanding) as investors questioned the prospects of its new technology, CART therapy. On Aug. 28, Gilead Sciences announced the acquisition of Kite Pharma for $11.9 billion. Gilead agreed to pay $180 per share, which represented a 29% premium over the market price. Wedbush biotechnology analyst David Nierengarten admitted that he was wrong on the price forecast, commenting that "the hazard of having an underperform rating on a company that's about to launch is that it can get acquired before the launch."

the same industry. Our results, therefore, suggest that increases in takeover risk generate limits to arbitrage. Although the market for corporate control and short selling are both individually important for market efficiency, they appear to crowd out one another in equilibrium.

We show that the economic effect of takeover risk on the return predictability of short interest is comparable to that of other factors that limit arbitrage activities, such as idiosyncratic risk (Pontiff (2006)), institutional ownership (Asquith, Pathak, and Ritter (2005)), size, and stock illiquidity (Amihud (2002), Brunnermeier and Pedersen (2009)). Our results are also robust to controlling for the availability of lendable shares. The average return from short-selling stocks with takeover risk appears to outweigh the expected loss from short-selling stocks that actually receive takeover bids. Consistent with the intuition that takeover risk induces market inefficiencies by limiting informed short selling, we find that a mispricing-based trading strategy is more profitable when takeover risk is higher (Stambaugh, Yu, and Yuan (2015)).

Although our empirical tests are designed to explore the effect of takeover risk on short sellers, we also note that heavy short selling may itself increase the probability of a takeover attempt. Edmans, Goldstein, and Jiang (2015) formalize this intuition and theoretically show that when real decision makers such as corporate managers or activist investors learn from stock prices, they can make better-informed decisions and improve real efficiency. Although these corrective actions can improve firms' fundamental values, they also reduce the trading profits of short sellers who convey this negative information via their trades. In our context, the role of market-based corrective action falls to the potential acquirer and hence reverse causality may arise due to the informational feedback loop. Even without this feedback loop between short sellers and firm's managers, the increase in the likelihood of a takeover attempt and the decrease in short interest could be driven jointly by unobserved positive fundamental information about the firm. In other words, it is possible that the relation between short selling and takeover risk is endogenously determined. Therefore, we must identify exogenous variation in takeover likelihood in order to establish a plausibly causal relation between takeover risk and limits to short arbitrage.

We address the potential endogeneity of takeover probability in our empirical tests in two ways. First, we use the passage of business combination laws to generate staggered, state-level variation in ex ante takeover risk. Second, we consider exogenous firm-level variation in takeover risk using instrumented measures of firms' anti-takeover defenses developed by Gompers, Ishii, and Metrick (2003) and Karpoff, Schonlau, and Wehrly (2017). The results of these better-identified tests continue to suggest that increases in takeover risk generate limits to short arbitrage.

Our study contributes to the extensive academic literature on the limits to arbitrage (see Gromb and Vayanos (2010) for a survey). Theoretical studies argue that risk exposure due to potential changes in firms' fundamentals (Shleifer and Vishny (1990), Campbell and Kyle (1993)) and noise trading (De Long et al. (1990)) create significant holding costs for arbitrageurs (Pontiff (2006)). Limits to arbitrage due to risk exposure have been empirically examined in various

contexts of market inefficiency, such as the closed-end fund discount (Pontiff (1996)), long-term seasoned equity offering returns (Pontiff and Schill (2002)), merger arbitrage (Mitchell and Pulvino (2001)), and situations where a firm's value is less than the sum of its subsidiaries' values (Mitchell, Pulvino, and Stafford (2002)).[3] Our findings contribute to this literature by identifying the threat of a potential takeover as a specific source of risk that causally limits informed short selling.

The empirical literature on short-selling constraints generally documents that short interest can predict stock returns. This return predictability manifests in both cross-sectional and time-series data.[4] Much of the extant literature focuses on transaction costs created by the stock lending market or short-selling regulations (Gromb and Vayanos (2010), Reed (2013)). For example, Jones and Lamont (2002) show that stocks that are expensive to short have lower subsequent returns. Asquith et al. (2005) and Nagel (2005) show that institutional ownership, as a proxy for the supply of lendable shares, is related to short-selling constraints. Engelberg et al. (2018) document that the risk of future variation in stock borrowing costs constrains short sellers. Boehmer et al. (2013), Boehmer and Wu (2013), Lin and Lu (2016), and Chu, Hirshleifer, and Ma (2020) examine the effect of short-selling restrictions on market efficiency. In contrast to these studies, the friction that we investigate arises naturally from the market for corporate control. Hence, informed short-selling may be limited even without short-selling regulations or frictions in the stock lending market. Interestingly, takeover markets themselves are considered important governance mechanisms in corporate finance and are generally viewed as improving economic efficiency (Jensen and Ruback (1983), Bertrand and Mullainathan (2003), Gompers et al. (2003), and Bebchuk, Cohen, and Ferrell (2009)). However, by showing that active takeover markets also generate limits to arbitrage for short sellers, our evidence suggests that an active market for corporate control also has the unintended effect of inducing stock market frictions.

Finally, our study contributes to the literature on the interaction between short sellers and other market participants. Specifically, our findings are consistent with the results of Massa, Qian, Xu, and Zhang (2015)). Massa et al. (2015) show that the presence of short sellers induces corporate insiders to sell more and trade faster, because insiders face the risk of losing the value of private negative information if short sellers trade on the same information ahead of them. Consistent with the argument by Massa et al., short sellers in our setting also have the incentives to trade ahead of potential acquirers, because they face the risk of losing the value of private negative information if the same information induces an acquisition before they finish the trades. Nevertheless, in our setting, it is possible for both informed parties

[3]More recent studies show that individual short sellers can mitigate limits to arbitrage by publicly revealing their information and attracting other investors to follow, for example, through short campaigns (Ljungqvist and Qian (2016), Kovbasyuk and Pagano (2022)).

[4]See, for example, Figlewski (1981), Chen and Singal (2003), Asquith et al. (2005), Boehme, Danielsen, and Sorescu (2006), Boehmer, Huszar, and Jordan (2010), and Boehmer, Jones, and Zhang (2013) for evidence on the cross-sectional return predictability of short interest. See Seneca (1967) and Rapach, Ringgenberg, and Zhou (2016) for the time-series return predictability of aggregate short interest.

(i.e., short sellers and bidders) to make trading profits. Specifically, short sellers profit from shorting before the negative information they discovered becomes public and from subsequently buying back shares after the negative information becomes public but before potential acquirers make a move. On the other hand, a bidder can benefit by making an offer at a lower price after the negative information the short sellers revealed is incorporated into the market price. Bidders can further increase their gain by enhancing the target's fundamental value using their control rights (e.g., by changing corporate strategies, improving governance, or creating synergies, among others) post-acquisition. Therefore, it is feasible for both informed parties to profit from the same negative information if they strategically time their trades, that is, short sellers accelerate their trades while acquirers delay their offers, such that their trades do not overlap. Supportive of the condition for a win–win situation to be feasible and the hypothesis by Massa et al. (2015), we find that short-selling activities increase significantly 15 weeks before takeover announcements. We further discuss the interaction between short sellers and potential acquirers in Section IV.F.

II. Hypothesis Development and Empirical Identification

A. Hypothesis Development

We first develop our hypothesis about the role of takeover risk in creating limits to short arbitrage and about the effect of takeover risk on the relation between a stock's short interest and future returns. We also provide an illustrative model based on the work of Wurgler and Zhuravskaya (2002) and Gromb and Vayanos (2010) in the Supplementary Material.

Consider a short-selling arbitrageur who takes an under-diversified position to exploit a potential mispricing opportunity. The arbitrageur bears the risk that the price will deviate further from the expected value either due to changes in fundamentals or noise trading (De Long et al. (1990), Shleifer and Vishny (1990), Campbell and Kyle (1993), Shleifer and Vishny (1997), and Pontiff (2006)). To the extent that this risk cannot be fully hedged, short sellers will not bear this risk unless the expected arbitrage return is sufficiently high (Wurgler and Zhuravskaya (2002)). Consistent with the risk-return tradeoff in short arbitrage, the extant literature documents that monthly short interest negatively predicts future stock returns (e.g., Figlewski (1981), Chen and Singal (2003), Asquith et al. (2005), Boehme et al. (2006), and Boehmer et al. (2010)).

We argue that the likelihood of a takeover represents a source of arbitrage risk for informed short sellers. A takeover attempt is often accompanied by a substantial price jump in the target stock price around the announcement, because acquirers typically pay significant premia to obtain control of target firms (e.g., Barclay and Holderness (1989)). Following a takeover attempt, short sellers may even have to cover their positions in response to the price jump and realize trading losses (Hong, Kubik, and Fishman (2012)). Given the ex post potential losses when a takeover attempt induces a short squeeze, a rational short seller demands a higher ex ante return in exchange for this increased risk. Thus, the relation between monthly short

interest, reflecting informed short sellers' positions, and future stock returns should be more negative when takeover risk is higher.[5]

Hypothesis 1. Ex ante takeover risk enhances the negative relation between monthly short interests and future stock returns.

B. Identification Strategy

Our study focuses on how increases in takeover probability cause short sellers to demand higher expected returns for their trades (and therefore more negative stock returns). Using standard asset pricing methodologies, we first estimate cross-sectional relations among takeover risk, short interest, and future stock returns consistent with our hypothesis.

We next note that this relation could be endogenously determined. For example, the model in Edmans et al. (2015) shows that short sellers could reveal information via their trades. Therefore, by observing short sellers' behavior, managers can take corrective actions if they believe that short sellers identify areas for improvement. Similarly, in our setting, outsiders can make takeover bids by observing information revealed by short sellers' trades. Even if potential acquirers do not directly learn from short sellers' trades, the increase in takeover likelihood and the decline in short interest could be driven by positive information about the firm's fundamentals which acquirers and short sellers independently discover. In sum, the main concern is that the link between short selling and takeovers may be endogenously determined, either through reverse causality (short selling triggering takeover attempts) or a spurious correlation relating to the firm's economic fundamentals.

We therefore attempt to identify variation in takeover risk orthogonal to a firm's fundamentals using staggered changes in state-level takeover laws and instrumented G-Index. We describe these empirical strategies in detail in Section IV.E.

III. Data and Summary Statistics

A. Data

Our study utilizes several standard finance databases. We extract stock price information from CRSP and accounting and short interest data from Compustat. We collect data on takeover attempts for U.S. firms from 1984 to 2018 from the Securities Data Company (SDC), and data on lendable shares utilization and stock borrowing cost from the Markit Securities Finance Buyside Analytics database.

We start with U.S. common stocks traded on the NYSE, AMEX, or NASDAQ exchanges from 1985 to 2018, and we require that both CRSP and Compustat cover

[5]Our hypothesis argues that short sellers refrain from trading on their information or demand a higher risk premium if they do trade, when takeover risk is higher. However, one could also argue that higher ex ante takeover risk may discourage short sellers from searching for information about the stock in the first place. This argument does not contradict our proposed mechanism. Both the risk premium and the information production hypotheses suggest that a marginal increase in short selling has a stronger predictability for future stock returns when takeover risk is higher ex ante.

each stock.[6] We exclude stocks below 5 dollars per share at the portfolio formation date to reduce the concern that small and illiquid stocks drive our results. To ensure that our analysis captures the ex ante threat of a potential acquisition, we exclude stocks that have been takeover targets within the past 12 months. After merging data from the above sources, we have an unbalanced panel data set with 815,065 firm-month observations for 8,932 companies that we use for our main analysis. We use different sample periods when conducting tests using state antitakeover laws, G-index, and stock lending data, due to the availability of those variables. We provide detailed discussions of the samples in the corresponding sections.

B. Variable Definitions

1. Takeover Intensity

We measure the potential takeover threat for each firm using the number of takeover attempts within the firm's industry over the past 6 months. We motivate the use of industry-level takeover risk by the well-established observation that merger waves typically cluster within industries (Mitchell and Mulherin (1996), Harford (2005)). For each stock month, we count the number of announcements of takeover attempts (i.e., including both completed and unsuccessful attempts) that target private and public firms in the same 2-digit SIC industry over the previous 6 months. We follow Edmans et al. (2012) and exclude acquisitions of partial stakes, minority squeeze-outs, buybacks, recapitalizations, and exchange offers. Additionally, we only retain bids where the acquirers had a stake of under 50% before the acquisition attempt and are bidding for a final ownership of over 50%. We standardize the number of takeover announcements by the number of stocks in the same 2-digit SIC industry. For our regression analysis, we create a binary variable that equals 1 if the takeover intensity ratio is in the top tercile at the portfolio formation date. Consistent coverage of M&A activity in SDC begins in 1984, so we are able to use this variable for portfolio sorting starting in Jan. 1985.

2. Short Interest

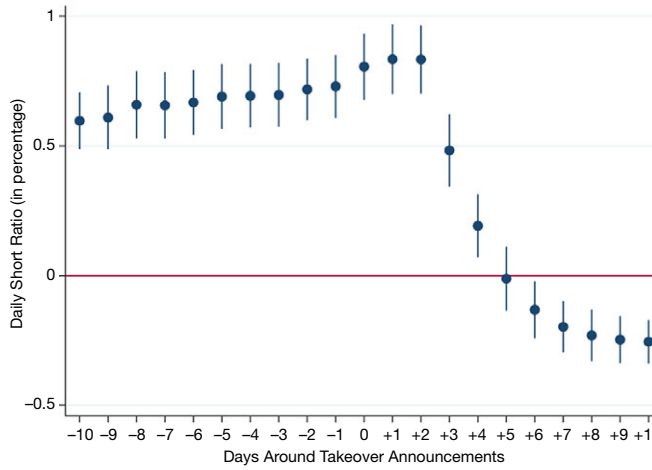
We collect short-interest data for individual stocks from Compustat. Historically, U.S. exchanges compile short interest in each stock as of the 15th of each month and publicly report the data 4 business days later. After Sept. 2007, Compustat reports short interest data twice per month. We only retain the mid-month short interest throughout the sample to ensure that the short interest we use is publicly observable to investors as of the end of each month. Compustat reports historical short-interest data back to 1973, which allows us to conduct our analysis using a relatively long time series. Following the extant literature (e.g., Asquith et al. (2005), Rapach et al. (2016)), we calculate the short interest ratio (SR) as the ratio of the number of shares sold short to the total number of shares outstanding. For Figure 1, we compute the daily short ratio (DAILY_SR) by dividing the daily short interest variable provided by Markit (SHORT_LOAN_QUANTITY) by the total shares outstanding (from CRSP).

[6]We begin our stock price data in 1985 because we lag our takeover data.

FIGURE 1

Short Selling Around Acquisition Announcements

Figure 1 presents coefficient estimates from a regression estimating changes in short-selling activity around takeover announcements. The sample consists of stock-day observations from 2007 to 2018. The dependent variable is DAILY_SR, measured as daily number of shares on loan divided by the number of shares. The independent variables are binary variables indicating days around takeover announcements. We also include firm × quarter and day-of-the-week fixed effects to control for time-varying firm characteristics and seasonality. The vertical lines indicate the 90% confidence intervals, with standard errors adjusted for firm clustering and year-quarter clustering.



3. Stock Lending Utilization

We collect data on lendable shares utilization and stock borrowing cost from the Markit database. Markit collects detailed data on stock lending from their client hedge funds. In our analysis, we use the variable DAILY_UTILIZATION, defined as the ratio of shares on loan to the number of lendable shares. The data on DAILY_UTILIZATION are available beginning in 2002. Further, we use SHORT_FEE, which is the fee paid by the borrower on a new loan, and DCBS, a relative measure of the cost of borrowing estimated by Markit. Finally, following Engelberg et al. (2018), we estimate SHORT_RISK to capture the risk of changing lending market conditions.[7]

4. Control Variables

Following the extant literature, we include the following control variables (all defined in the Supplementary Material). We control for firm characteristics by using the book-to-market ratio (BM), market capitalization (ME), idiosyncratic volatility (IVOL), and institutional ownership (IO). We further include variables that have

[7]Our measure of short risk is slightly different from Engelberg et al. (2018) because their measure is computed using sell-side fees. We use IHS Markit buy-side data, which provides INDICATIVE_FEE, Markit's estimate of the expected borrowing cost for a new loan paid by the ultimate borrower of the stock (SHORT_FEE in our regressions). We compute SHORT_RISK as the predicted value from the following regression: $\text{var(SHORT\_FEE)}_{t+1} = \alpha + \beta_1\text{UTILIZATION} + \beta_2\text{TAILUTILIZATION} + \beta_3\log(\text{VOLUME}) + \beta_4\log(\text{BID\_ASK}) + \beta_5\log(\text{MARKEP\_CAP}) + \beta_6\text{SHORT\_FEE} + \beta_7\log(\text{RETURN\_VOLATILITY}) + \beta_8\text{DIVIDEND\_FLAG} + \beta_9\text{OPTION\_FLAG} + \beta_{10}\text{IPO\_FLAG}$ (all variable definitions are in the Supplementary Material).

historically explained returns, such as lagged monthly stock returns to measure short-term reversal (REV), and the compounded 11-month stock return to measure momentum (MOM). We also examine stock illiquidity (ILLIQ) as an additional proxy variable measuring limits to arbitrage.

C. Summary Statistics

Panel A of Table 1 reports the summary statistics used in our data analysis. The short interest ratio (SR) has a mean of 3.5% and a standard deviation of 4.7%, consistent with other recent studies (e.g., Li and Zhu (2022)). Based on the stock lending data reported by Markit, on average only 16.4% of the lendable shares are shorted, with a standard deviation of 19%, while the fee paid by the borrower for new loans is on average 0.9% with a standard deviation of 2%.

TABLE 1

Summary Statistics

Panel A of Table 1 presents summary statistics of the variables used in our baseline tests. Panel B presents the average stock characteristics for each takeover intensity tercile. The sample runs from Jan. 1985 to Dec. 2018. We winsorize all variables at the 1st and 99th percentiles. All variables are defined in the Supplementary Material.

Panel A. Overall Summary Statistics

	N	Mean	P25	P50	P75	Std. Dev.
TAKEOVER	815,065	0.863	0.356	0.563	1.008	1.153
SR	815,065	0.035	0.004	0.018	0.046	0.047
REV	815,017	0.014	−0.046	0.009	0.068	0.112
MOM	777,361	0.175	−0.087	0.109	0.338	0.451
ln(BM)	761,906	−0.706	−1.145	−0.620	−0.188	0.773
ln(ME)	799,454	13.552	12.300	13.487	14.725	1.788
IVOL	813,640	0.020	0.011	0.017	0.025	0.013
IO	815,065	0.564	0.335	0.594	0.802	0.292
ln(ILLIQ)	814,983	−5.012	−7.034	−5.262	−3.217	2.815
1_MONTH_COMP_RETURN	4,739,944	0.006	−0.051	0.007	0.063	0.122
1_DAY_PREMIUM	791,420	0.318	0.189	0.275	0.392	0.731
DAILY_SR	8,407,263	3.830	0.347	1.713	5.121	5.203
LENDABLE_SHARES_SUPPLY	8,322,523	19.050	7.706	20.524	28.698	12.300
DAILY_UTILIZATION	4,739,944	16.434	2.889	8.950	22.936	19.068
SHORT_FEE	4,739,944	0.009	0.004	0.004	0.005	0.020
DCBS	4,739,944	1.257	1.000	1.000	1.000	1.020
SHORT_RISK	4,739,944	−14.879	−16.336	−14.813	−13.636	4.741

Panel B. Summary Statistics by Terciles of Takeover Risk

Takeover Terciles	Average *N*	TAKEOVER	SR	SR (Std. Dev.)	ln(BM)	ln(ME)	IVOL	IO
1	267,309	0.285	0.032	0.045	−0.649	13.285	0.020	0.509
2	268,554	0.616	0.036	0.048	−0.658	13.750	0.019	0.589
3	267,503	1.689	0.038	0.049	−0.814	13.618	0.020	0.595

Panel C. Summary Statistics by Deciles of Short Ratio

SR Deciles	Average *N*	SR	SR (Std. Dev.)	TAKEOVER	ln(BM)	ln(ME)	IVOL	IO
1	79,430	0.000	0.000	0.695	−0.290	12.099	0.020	0.313
2	79,549	0.003	0.003	0.839	−0.446	12.382	0.021	0.364
3	80,000	0.005	0.008	0.871	−0.651	13.724	0.018	0.504
4	80,313	0.008	0.013	0.887	−0.695	13.920	0.018	0.559
5	80,701	0.012	0.019	0.902	−0.739	13.983	0.018	0.590
6	80,485	0.016	0.025	0.901	−0.758	14.005	0.018	0.619
7	80,699	0.020	0.034	0.894	−0.793	13.997	0.019	0.643
8	80,630	0.026	0.047	0.888	−0.825	13.955	0.020	0.660
9	80,767	0.036	0.069	0.873	−0.879	13.842	0.022	0.676
10	80,793	0.064	0.136	0.884	−0.955	13.539	0.025	0.712

Panels B and C of Table 1 report the mean values of the main regression variables by takeover risk terciles and short ratio deciles, respectively. Statistics in Panel B show that firms with higher takeover risk exhibit on average a higher short ratio. This is consistent with the intuition that firms that are heavily shorted tend to become targets of potential acquirers.

Finally, our intuition requires short sellers to hold positions long enough for expected takeovers to affect them. In other words, we expect compensation for longer-run takeover risk to be less relevant for short-term traders. In our data (unreported), on average, short positions are outstanding for 83 days. The data, therefore, suggest that the average short seller in our sample is an investor with longer-term exposure.

IV. Empirical Results

A. Testing the Underlying Assumptions

Our hypothesis is that takeover risk represents a limit to short selling because a takeover attempt can cause substantial losses to short sellers. To verify the underlying assumptions of our hypothesis, we first examine whether short sellers scale back their short positions in reaction to takeover announcements. We use daily data on stock returns and short-selling activities and regress DAILY_SR on binary variables for each day of the $[-10, +10]$ window around the M&A announcements. We also include day-of-the-week fixed effects and the interaction between firm and year-fixed effects to control for seasonality and time-varying firm characteristics, respectively. The standard errors are clustered by both firm and year-quarter. We plot the coefficient estimates and the corresponding 90% confidence intervals for the day dummies in Figure 1. The level of a short position is significantly higher than the sample average prior to a takeover announcement. This is consistent with our conjecture that acquirers and short sellers tend to target the same stocks. Importantly, there is a significant drop in short interest after the announcement. This suggests that short sellers try to close their positions after the M&A bid, likely because of the typical post-bid positive price shock to the target firm (Lang et al. (1989), Servaes (1991)).

Our hypothesis also assumes that short sellers update their priors about takeover likelihoods by observing takeover behavior in the industry. To test this underlying assumption, we regress DAILY_SR on binary variables that take a value of 1 when a matched peer firm in the same 2-digit SIC industry is the target of a takeover attempt from day $t - 5$ to $t + 5$.[8] Table 2 reports the results. In column 1, we document that short interest begins to decline from day $t + 1$ to $t + 4$ after peers' takeover news. In contrast, in column 2, we find that there is no significant change in daily lendable share supply during the same period, indicating that the reduction in short selling is not driven by supply-side constraints. These results are consistent with the intuition that short sellers respond to takeover attempts against

[8]We identify takeover announcements of peers that are in the same 2-digit SIC industry and matched by size (2 groups), book-to-market (3 groups), and momentum (3 groups).

TABLE 2

Short Sellers' Responses to Peers' Takeover Announcements

The sample in Table 2 consists of stock-day observations from 2007 to 2018. The dependent variable in column 1 is DAILY_SR, measured as daily number of shares on loan divided by the number of shares. The dependent variable in column 2 is LENDABLE_SHARES_SUPPLY, defined as daily number of lendable shares divided by number of shares outstanding. The independent variables are binary variables indicating days around peers' takeover announcements. We identify takeover announcements of peers that are in the same 2-digit SIC industry and matched by size (2 groups), book-to-market (3 groups), and momentum (3 groups). We also include firm × quarter and day-of-the-week fixed effects to control for time-varying firm characteristics and seasonality. We report standard errors adjusted for firm clustering and year-quarter clustering. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	DAILY_SR	LENDABLE_SHARES_SUPPLY
	1	2
$t-5$	−0.011	0.019
	(−1.42)	(0.82)
$t-4$	−0.01	0.019
	(−1.27)	(0.80)
$t-3$	−0.01	0.021
	(−1.23)	(0.88)
$t-2$	−0.014	0.015
	(−1.49)	(0.68)
$t-1$	−0.008	0.021
	(−1.01)	(1.28)
0	−0.012	0.024
	(−1.50)	(1.32)
$t+1$	−0.011	0.02
	(−1.51)	(1.13)
$t+2$	−0.017**	0.009
	(−2.55)	(0.53)
$t+3$	−0.016**	0.005
	(−2.27)	(0.27)
$t+4$	−0.015**	0.00
	(−2.47)	(−0.01)
$t+5$	−0.008	0.01
	(−1.34)	(0.82)
R^2	0.969	0.992
No. of obs.	8,407,263	8,322,523
Firm × quarter FE	Yes	Yes
Day-of-the-week FE	Yes	Yes

peer firms in the same industry by scaling back their short positions, indicating that they are cognizant of potential takeover risks.

B. Portfolio Strategies Based on Industry Takeover Intensity and Short Interest

Next, we investigate our main hypothesis that short interest should more strongly predict future stock returns when takeover risk is higher ex ante. We start this analysis by creating 30 portfolios by first sorting stocks into terciles of takeover intensity and then, within each tercile, further sorting stocks into deciles of short ratio. For each portfolio, we follow Engelberg et al. (2018) and compute the equal-weighted average monthly returns and Carhart (1997) 4-factor alphas 1 month ahead of TAKEOVER and SR.

We present these results in Table 3. As predicted, and consistent with existing studies such as Figlewski (1981), Asquith et al. (2005), and Boehme et al. (2006)), portfolios in the bottom decile of SR significantly outperform portfolios in the top decile of SR in most cases. Further, consistent with our intuition that takeover risk limits short selling ex ante, the highest tercile of takeover intensity displays stronger

TABLE 3

Two-Way Sorts on Takeover Intensity and Stock Short Ratio

Panel A of Table 3 reports equal-weighted monthly average returns and Carhart (1997) 4-factor alphas (in percentages) sorted by takeover intensity and stock's short ratio. The sample runs from Jan. 1985 to Dec. 2018. At the beginning of each month, we first sort all the stocks into terciles based on takeover intensity at the 2-digit SIC industry level, and within each tercile, we sort the stocks further into deciles based on their short ratios in the past month. The time-series average of portfolio size is 66 stocks. In Panel B, we partition the sample into small stocks and large stocks based on the 50th percentile of NYSE size breakpoints. All variables are defined in the Supplementary Material. We report Newey–West adjusted *t*-statistics in parentheses. For the long-short portfolios, *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Whole Sample

	Returns (EW)				Carhart 4-Factor Alphas (EW)			
	Short Ratio Deciles				Short Ratio Deciles			
Takeover Terciles	1	5	10	1–10	1	5	10	1–10
	1	2	3	4	5	6	7	8
1	0.97	1.09	0.75	0.22	0.23	0.09	−0.34	0.57***
	(4.46)	(4.74)	(2.52)	(1.21)	(1.89)	(0.94)	(−2.59)	(3.42)
2	1.18	1.18	0.65	0.52***	0.31	0.16	−0.42	0.73***
	(4.91)	(5.78)	(2.15)	(2.90)	(2.24)	(1.40)	(−2.54)	(3.49)
3	1.29	1.12	0.58	0.71***	0.40	0.08	−0.54	0.94***
	(5.20)	(4.66)	(1.83)	(4.36)	(3.22)	(0.72)	(−3.78)	(5.43)
3–1	0.32***	0.03	−0.17	0.49***	0.17	−0.01	−0.20	0.37**
	(2.70)	(0.28)	(−1.07)	(3.21)	(1.31)	(−0.07)	(−1.24)	(2.37)

Panel B. Subsample by Size

Value-Weighted Portfolios of Small Stocks

	Returns (VW)				Carhart 4-Factor Alphas (VW)			
	Short Ratio Deciles				Short Ratio Deciles			
Takeover Terciles	1	5	10	1–10	1	5	10	1–10
	1	2	3	4	5	6	7	8
1	0.85	1.28	0.82	0.03	−0.01	0.24	−0.39	0.38
	(3.38)	(4.69)	(2.80)	(0.13)	(−0.03)	(1.49)	(−2.69)	(1.62)
2	1.28	0.99	0.46	0.81***	0.38	−0.04	−0.68	1.05***
	(4.97)	(4.16)	(1.41)	(3.51)	(2.47)	(−0.27)	(−3.07)	(4.36)
3	1.25	1.21	0.60	0.65***	0.32	0.12	−0.59	0.91***
	(4.30)	(4.11)	(1.92)	(3.23)	(1.84)	(0.63)	(−3.39)	(3.74)
3–1	0.40**	−0.08	−0.22	0.62***	0.33	−0.13	−0.20	0.53**
	(1.98)	(−0.33)	(−1.25)	(2.70)	(1.42)	(−0.55)	(−1.04)	(2.25)
Value-Weighted Portfolios of Large Stocks								
1	0.75	1.30	1.06	−0.31	−0.27	0.34	0.13	−0.40*
	(2.68)	(6.37)	(3.24)	(−1.18)	(−2.01)	(2.93)	(0.73)	(−1.80)
2	0.83	0.90	0.71	0.11	−0.12	−0.03	−0.38	0.26
	(3.65)	(3.94)	(2.23)	(0.62)	(−0.89)	(−0.13)	(−2.35)	(1.51)
3	0.99	0.95	0.97	0.02	−0.01	−0.08	−0.10	0.08
	(4.25)	(3.33)	(3.31)	(0.10)	(−0.11)	(−0.57)	(−0.71)	(0.49)
3–1	0.24	−0.35*	−0.09	0.33	0.26	−0.42**	−0.23	0.49*
	(1.30)	(−1.79)	(−0.43)	(1.31)	(1.28)	(−2.18)	(−1.14)	(1.90)

outperformance (underperformance) for stocks with low (high) short interest, resulting in a significantly higher return in the long-short portfolio. Specifically, in the top tercile of takeover intensity, the long-short portfolio based on SR generates an average of 71 basis-point return and 94 basis-point Carhart alpha per month,

whereas in the bottom tercile of takeover intensity the long-short portfolio produces only a 22 basis-point return and 57 basis-point Carhart alpha per month. The difference in performance is statistically significant at the 1% level ($t = 3.21$) in the base case, passing the hurdle of a 3.0 t-statistic suggested by Harvey, Liu, and Zhu (2016). The difference in performance is also statistically significant at the 5% level ($t = 2.37$) for the Carhart tests. Consistent with our hypothesis, Table 3 documents that the return predictability generated by short interest is stronger when the firm's takeover risk is higher. In turn, this suggests that the likelihood of a takeover bid represents an implicit limit to arbitrage opportunities.

Interestingly, we also note that stocks in the bottom decile of short ratio exhibit significantly positive abnormal returns in the month following portfolio formation, particularly in the highest tercile of takeover intensity. This result is consistent with Boehmer et al. (2010), who document a positive abnormal return in stocks with low short interest and interpret this result as evidence that short sellers can not only identify overvalued stocks to short sell, but also identify undervalued stocks to avoid short selling or even to long.[9]

As documented by extant studies (e.g., Engelberg et al. (2018)), we expect that the return predictability of short interest will manifest more frequently in small stocks. Short-selling large stocks are less costly because they are typically more liquid and have a larger supply of lendable shares by institutional investors. Importantly, our proposed mechanism should also apply more to small stocks because large firms are less likely to become takeover targets (Comment and Schwert (1995)). In order to properly account for size differences, we follow Engelberg et al. (2018) by partitioning the sample into small and large stocks based on the 50th percentile of NYSE size breakpoints (Fama and French (2008)), and by using value-weighted portfolio returns. We perform the 3-by-10 portfolio sort separately among small and large stocks and estimate the value-weighted performance of these portfolios. Consistent with existing studies, our results in Panel B of Table 3 show that the return predictability of short interest generally exists in the sample of smaller firms. Moreover, the differential performance between the top/bottom takeover-intensity terciles is statistically significant among small stocks. When we consider the performance of value-weighted portfolios among large stocks, we still observe a greater positive (negative) performance of lightly (heavily) shorted stocks in the industries with higher takeover likelihood, although now the difference in performance between high/low takeover-intensity tercile is not statistically significant. Since smaller firms are more likely affected by takeover risk, our remaining analyses focus on the performance of equal-weighted portfolios.

C. Multivariate Regressions of Future Stock Returns on Industry Takeover Intensity and Short Interest

Next, we investigate the role of takeover likelihood as a limit to short sellers' arbitrage opportunities in a multivariate setting. Panel A of Table 4 reports the estimates of Fama and MacBeth (1973) regressions of the following model:

[9]Both long and short positions could reflect a short seller's private information. Unfortunately, we cannot observe the long positions held by short sellers, as they are not required to report them.

TABLE 4

Fama–MacBeth Regressions on Takeover Intensity, Short Ratio, and the Cross Section of Stock Returns

Panel A of Table 4 reports the estimates from the Fama and MacBeth (1973) regression of monthly stock returns for the period from Jan. 1985 to Dec. 2018. Panel B reestimates the model in Panel A including alternative measures of limits to arbitrage. Control variables are included in the regression but omitted from Panel B for brevity. All variables are defined in the Supplementary Material. We report Newey–West adjusted *t*-statistics in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	1	2	3	4
Panel A. Baseline Model				
SR	−0.033**	−0.035***	−0.026**	−0.033***
	(−2.32)	(−2.62)	(−2.11)	(−2.69)
SR × HIGH_TAKEOVER	−0.037**	−0.035**	−0.038**	−0.037**
	(−2.36)	(−2.32)	(−2.50)	(−2.47)
HIGH_TAKEOVER	0.001	0.001	0.001	0.001
	(1.34)	(0.95)	(1.16)	(0.94)
ln(BM)	0.001**	0.001**	0.001*	0.001
	(2.07)	(2.06)	(1.70)	(1.61)
ln(ME)	0.000	0.000	−0.000	−0.001*
	(0.97)	(0.47)	(−1.00)	(−1.82)
REV		−0.025***	−0.024***	−0.024***
		(−5.97)	(−5.69)	(−5.89)
MOM		0.004**	0.005**	0.005**
		(2.14)	(2.48)	(2.56)
IVOL			−0.170***	−0.169***
			(−3.79)	(−3.74)
IO				0.004**
				(2.39)
No. of obs.	761,906	755,795	754,479	754,479
R^2	0.023	0.041	0.047	0.051

Panel B. Additional Proxies for Limits to Arbitrage					
SR	−0.021	−0.019	−0.016	−0.033**	−0.003
	(−1.50)	(−1.26)	(−1.05)	(−2.53)	(−0.21)
HIGH_TAKEOVER	0.001	0.001	0.001	0.001	0.001
	(0.79)	(1.10)	(1.07)	(1.12)	(1.14)
SR × HIGH_TAKEOVER	−0.033**	−0.035**	−0.038**	−0.040**	−0.034**
	(−2.19)	(−2.30)	(−2.51)	(−2.55)	(−2.13)
HIGH_IVOL	−0.002*				−0.002*
	(−1.67)				(−1.68)
SR × HIGH_IVOL	−0.032***				−0.026*
	(−2.59)				(−1.80)
LOW_IO		−0.001			−0.000
		(−0.82)			(−0.34)
SR × LOW_IO		−0.055***			−0.055***
		(−2.87)			(−2.83)
LOW_ME			0.002**		0.002**
			(2.27)		(1.99)
SR × LOW_ME			−0.049***		−0.037**
			(−3.60)		(−1.98)
HIGH_ILLIQ				−0.001	−0.002**
				(−1.12)	(−2.03)
SR × HIGH_ILLIQ				−0.036*	0.011
				(−1.78)	(0.40)
No. of obs.	754,479	754,479	754,479	754,472	754,472
R^2	0.049	0.051	0.050	0.053	0.050

$$(1)\quad \mathrm{RET}_{i,t+1} = \alpha + \beta_1 \mathrm{SR}_{i,t} + \beta_2 \mathrm{HIGH\_TAKEOVER}_{i,t} + \beta_3 \mathrm{SR}_{i,t} \times \mathrm{HIGH\_TAKEOVER}_{i,t} + \beta_4 \ln(\mathrm{BM})_{i,t} + \beta_5 \ln(\mathrm{ME})_{i,t} + \beta_6 \mathrm{REV}_{i,t} + \beta_7 \mathrm{MOM}_{i,t} + \beta_8 \mathrm{IVOL}_{i,t} + \beta_9 \mathrm{IO}_{i,t} + \varepsilon_{i,t}.$$

For each firm i at month t, SR is the short interest ratio, HIGH_TAKEOVER is an indicator variable equal to 1 if TAKEOVER is in the top tercile for that month, with other variables defined in the Supplementary Material. If a higher threat of a takeover limits short selling and generates stronger return predictability, we expect subsequent returns to be lower for stocks that have high short interest and are also in the highest tercile of TAKEOVER. Thus, we expect a negative coefficient on β_3.

The results in Table 4 are consistent with this hypothesis. The coefficient on the interaction term SR × HIGH_TAKEOVER is significantly negative in all specifications, implying that short-selling activities more strongly predict future stock returns when firms face higher takeover threats. Based on the estimates in column 4, a 10 percentage point increase in short ratio for firms with lower takeover risk implies a 33 basis points reduction in stock return the following month. By contrast, for firms in the top tercile of takeover risk, a 10 percentage point increase in short ratio implies a 70 basis points decrease in returns in the following month. Thus, the magnitude of the effect of the short ratio on the next month's stock return more than doubles in industries with top-tercile level of takeover risk. The return predictability of short interest in the top tercile of takeover risk is comparable to the return predictability implied by other prominent anomalies, such as short-term reversal, momentum (Jegadeesh and Titman (1993)), and idiosyncratic volatility (Ang, Hodrick, Xing, and Zhang (2006)). For example, the estimates in column 4 suggest that a 1-standard-deviation increase in SR is related to a 32.9-basis-point decrease in stock return next month, whereas a 1-standard-deviation change in REV, MOM, and IVOL imply a change in the next-month stock return by 26.88, 22.55, and 21.97 basis points, respectively.[10]

In Panel B of Table 4, we reestimate the models in Panel A but further control for several other factors known to limit arbitrage activities in the extant literature (see, e.g., Asquith et al. (2005), Duan, Hu, and McLean (2010)). We include the interaction between SR and binary variables that indicate firms with top-tercile level of arbitrage friction, proxied by idiosyncratic volatility (IVOL), institutional ownership (IO), market capitalization (ME), and illiquidity (ILLIQ). All control variables from Panel A are included in the regression but omitted from the table for brevity. Our results are consistent with the extant literature in that all 4 proxies for limits to arbitrage are related to greater return predictability of short interest. Importantly, the coefficient on SR × HIGH_TAKEOVER remains significant after the inclusion of the other factors known to generate limits to arbitrage. Further, the economic effect of takeover risk on the return predictability of short interest is comparable to that of other proxies of limits to arbitrage.

[10]The coefficient estimate on HIGH_TAKEOVER is not statistically significant. Thus, for the average stock, higher ex ante takeover risk does not predict a negative stock return. Our interpretation is that takeover risk does not represent a first-order limit of arbitrage except for the highly shorted stocks.

We perform a battery of robustness tests for the main results in Tables 3 and 4. Specifically, our main finding on takeover risk and return predictability of short interest is robust to i) alternative asset-pricing models such as the CAPM, Fama and French (2016), (2017)), 5-factor model, Carhart (1997), 4-factor model plus Pástor and Stambaugh (2003), liquidity factor, Hou, Xue, and Zhang's (2015)), Q-factor model, and industry-adjusted returns; ii) alternative sorting methods, such as 5-by-5 and 5-by-10; iii) alternative measures of takeover risk such as 3-digit SIC level takeover intensity and firm-level predicted takeover risk (e.g., Cremers, Nair, and Kose (2009)); iv) predicting returns up to 3 months in the future; and v) controlling for industry fixed effects in the Fama–MacBeth regressions. For brevity, we report and discuss these empirical results in the Supplementary Material.

D. Supply-Side Constraints

The stock lending markets can also create friction for short sellers (see, e.g., Beneish, Lee, and Nichols (2015), Porras Prado, Saffi, and Sturgess (2016), and Engelberg et al. (2018)). A concern in the above tests may be that stocks in high takeover intensity industries are also more difficult to borrow. Therefore, rather than the proposed takeover channel, a spurious correlation created by known short-selling constraints such as low supply of lendable shares or high borrowing costs could be generating the return predictability that we document. To address this concern, we estimate a panel OLS regression of the 1-month compounded return using daily data on stock lending and stock returns. We include the following measures of borrowing costs: DAILY_UTILIZATION, the ratio of shares on loan to the number of lendable shares; DCBS, a categorical variable provided by Markit that indicates the relative cost of borrowing and has a range from 1 (low cost) to 10 (high cost); SHORT_FEE, Markit's estimate of the expected borrowing cost; and SHORT_RISK, a measure of short selling risk similar to the one developed in Engelberg et al. (2018). The regressions include day-fixed effects.[11]

The estimates in Table 5 show that our results hold even when we control for a variety of costs associated with short selling, as the coefficient for the interaction term DAILY_SR × HIGH_TAKEOVER is significantly negative in all columns. Although our results are consistent with the extant evidence, takeover risk appears to limit short sellers beyond the limits already imposed by stock lending frictions.

E. Identifying the Effect of Takeover Risk on the Limits to Short Arbitrage

1. Implementation of Antitakeover Legislation

Our above tests use recent industry-level takeover activity to proxy for a short seller's ex ante risk of future takeover. Although industry merger waves are likely beyond the control of any single firm or investor, we cannot interpret our tests as causal because they cannot rule out a spurious correlation between unobservable

[11]Note that our Markit data begins in 2002, resulting in a shorter time period for these tests.

TABLE 5

OLS Regression: Controlling for Stock Lending Characteristics

Table 5 reports the estimates from the OLS regression of the 1-month compounded return for the period from Jan. 1985 to Dec. 2018. The regression includes day-fixed effects. All variables are defined in the Supplementary Material. We report firm-clustered *t*-statistics in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	1_MONTH_COMP_RETURN					
	1	2	3	4	5	6
DAILY_SR	0.021**	−0.011**	−0.012**	−0.022***	−0.000	−0.013
	(2.25)	(−2.00)	(−2.07)	(−3.71)	(−0.02)	(−1.21)
DAILY_SR × HIGH_TAKEOVER	−0.020**	−0.019**	−0.019**	−0.018*	−0.019**	−0.017*
	(−2.08)	(−1.97)	(−1.98)	(−1.84)	(−2.02)	(−1.75)
HIGH_TAKEOVER	0.000	−0.000	−0.000	0.000	−0.000	−0.000
	(0.31)	(−0.13)	(−0.09)	(0.18)	(−0.10)	(−0.87)
DAILY_UTILIZATION	−0.000***				−0.000	−0.000
	(−5.97)				(−1.59)	(−1.14)
DCBS		−0.003***			−0.004***	−0.004***
		(−8.72)			(−2.73)	(−2.61)
SHORT_FEE			−0.135***		0.060	0.056
			(−8.56)		(0.89)	(0.83)
SHORT_RISK				−0.000***	0.000	0.000
				(−4.81)	(0.53)	(1.05)
ln(BM)						−0.001**
						(−2.22)
ln(ME)						−0.000
						(−1.19)
REV						−0.045***
						(−13.56)
MOM						−0.000
						(−0.42)
IVOL						0.038
						(1.21)
IO						0.003***
						(3.35)
No. of obs.	4,739,944	4,739,944	4,739,944	4,739,944	4,739,944	4,739,944
R^2	0.235	0.235	0.235	0.235	0.235	0.235

industry characteristics and other limits to short arbitrage. Additionally, short selling may create an endogenous feedback loop that triggers corrective actions, such as takeovers (Edmans et al. (2012), (2015)). Therefore, we consider two identification strategies to exploit plausibly exogenous variation in ex ante takeover risk.

We use the introduction of state-level antitakeover laws in the U.S. as an exogenous shock to a given firm's likelihood of receiving a takeover bid in its state of incorporation.[12] Given that antitakeover laws make takeovers more difficult, they reduce the likelihood that a firm with high short interest will become the target of a takeover.[13] We therefore expect return predictability associated with short interest to decrease following the passage of an antitakeover law. We estimate the following difference-in-differences model[14]:

[12]See Karpoff and Wittry (2018) for a comprehensive list of papers using the introduction of antitakeover laws as a natural experiment.

[13]Further, the introduction of state-level antitakeover laws is unlikely to be driven by short sellers' incentives.

[14]We do not estimate the difference-in-differences regressions using the Fama–MacBeth method because the binary variable BC captures time-series variations in takeover risk.

$$(2)\quad \mathrm{RET}_{i,t+1} = \alpha + \beta_1 \mathrm{SR}_{i,t} + \beta_2 \mathrm{BC}_{i,t} + \beta_3 \mathrm{SR}_{i,t} \times \mathrm{BC}_{i,t} + \beta_4 \ln(\mathrm{BM})_{i,t} + \beta_5 \ln(\mathrm{ME})_{i,t} + \beta_6 \mathrm{REV}_{i,t} + \beta_7 \mathrm{MOM}_{i,t} + \beta_8 \mathrm{IVOL}_{i,t} + \beta_9 \mathrm{IO}_{i,t} + \varepsilon_{i,t}.$$

For each firm i in month t, BC_t is a binary variable that equals 1 for stock-month observations if the state where the firm is incorporated has passed business combination laws. We focus on the implementation of business combination laws, based on Bertrand and Mullainathan (2003).[15] We predict that the coefficient on the interaction term SR × BC is positive if antitakeover laws reduce limits to short arbitrage and hence the return predictability of short interest.[16] We follow the methodology of Bertrand and Mullainathan (2003) and estimate equation (2) using stock-month observations from 1976 to 1995.[17]

Table 6 reports the estimates of the difference-in-differences model. In column 1, the coefficient estimate for SR is −0.054, suggesting that a 10 percentage point increase in short ratio is related to a 54-basis-point lower stock return next month. In columns 2–6, we include the interaction between SR and BC. In column 6, we also include industry and year-month fixed effects, thereby controlling for time-invariant, unobserved characteristics at the industry level as well as time trends in short selling. The coefficient on the interaction term SR × BC is significantly positive in all models. Hence, we continue to document that takeover risk limits short sellers, as legislation that reduces takeover risk also reduces the return predictability of short interest.

In column 7, we identify the timing of the effect of business combination laws on short-selling activities. The estimates show that, in the year prior to the passage, the return predictability of short interest is stronger. Importantly, the relation between short interest and future stock return significantly weakens only 2 years after the passage of business combination laws. This is consistent with business combination laws reducing limits to short arbitrage.

2. Instrumented G-Index as a Measure of Firm-Level Takeover Defenses

We next consider a firm-level measure of takeover probability. We focus on the index of antitakeover defenses in a firm's corporate charter developed by Gompers et al. (2003), the G-Index. We collect the G-Index of U.S. public firms from 1991 to 2006 from Andrew Metrick's website and examine whether firms with stronger antitakeover defenses exhibit lower short-selling frictions and hence lower return predictability of short interest.[18]

[15]Business combination laws impose a 3–5 year moratorium on M&A transactions between the firm and the large shareholders who obtain more than a specified percentage of shares. This moratorium imposes costs on acquirers as it impedes them from using the target's assets to repay the debt raised for the acquisition.

[16]Since we do not use the TAKEOVER measure in this test (and therefore do not use SDC data), we can extend our sample prior to 1984.

[17]We follow the corporate governance literature (e.g., Bertrand and Mullainathan (2003), Karpoff and Wittry (2018)) and use observations from 1976 to 1995 because most business combination laws became effective between 1980 and 1990.

[18]The data on takeover provision after 2006 are collected by RiskMetrics. As noted by Karpoff et al. (2017), there have been significant changes to the format and scope of the data compared to the IRRC

TABLE 6

Business Combination Laws, Short Interest, and Monthly Stock Returns

Table 6 reports estimates from a panel regression of monthly stock returns for the period from Jan. 1976 to Dec. 1995. All variables are defined in the Supplementary Material. We report *t*-statistics using firm-clustered standard errors in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	1	2	3	4	5	6	7
SR	−0.054***	−0.222***	−0.233***	−0.221***	−0.230***	−0.143***	−0.129***
	(−3.00)	(−5.40)	(−5.87)	(−5.63)	(−5.52)	(−4.04)	(−3.12)
SR × BC		0.197***	0.211***	0.207***	0.213***	0.121***	
		(4.31)	(4.77)	(4.74)	(4.63)	(3.07)	
BC		−0.001**	−0.001**	−0.001**	−0.002***	0.000	
		(−2.29)	(−2.33)	(−2.26)	(−3.25)	(0.03)	
SR × BC_{-3}							0.054
							(0.50)
SR × BC_{-2}							0.093
							(0.86)
SR × BC_{-1}							−0.167**
							(−2.23)
SR × BC_0							−0.106
							(−1.23)
SR × BC_1							0.039
							(0.58)
SR × BC_{2+}							0.125***
							(2.80)
ln(BM)	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***
	(9.95)	(10.83)	(10.45)	(9.78)	(8.60)	(9.39)	(9.47)
ln(ME)	−0.001***	−0.000**	−0.000**	−0.001***	−0.001***	−0.001***	−0.001***
	(−4.19)	(−2.22)	(−2.14)	(−4.20)	(−4.63)	(−4.34)	(−4.40)
REV	0.004		0.002	0.003	0.012***	−0.025***	−0.025***
	(1.34)		(0.66)	(1.26)	(4.14)	(−8.90)	(−8.97)
MOM	0.002***		0.002***	0.002***	0.001	0.009***	0.009***
	(3.05)		(3.09)	(3.13)	(0.96)	(13.83)	(13.68)
IVOL	−0.138***			−0.135***	−0.141***	−0.245***	−0.244***
	(−4.40)			(−4.30)	(−4.33)	(−7.71)	(−7.69)
IO					0.009***		
					(7.01)		
BC_{-3}							0.003**
							(2.45)
BC_{-2}							0.000
							(0.19)
BC_{-1}							0.004***
							(2.73)
BC_0							0.002*
							(1.72)
BC_1							0.004***
							(2.83)
BC_{2+}							−0.000
							(−0.26)
R^2	0.001	0.001	0.001	0.002	0.002	0.218	0.218
No. of obs.	213,660	215,046	213,691	213,660	188,453	213,472	213,472
Industry FE						Yes	Yes
Year-month FE						Yes	Yes

The raw G-Index potentially contains an endogenous component since firms might incorporate more takeover defenses in their charters when the likelihood of receiving takeover bids is higher ex ante. We therefore follow Karpoff et al. (2017)

version before 2006. To ensure consistency of the variable, we only use the G-index based on the IRRC data which ends in 2006. We thank Andrew Metrick for making this data available.

and use two types of instruments for the G-Index: geography-based instruments and IPO-cohort-based instruments. These instruments are designed to capture the influence of peers through shared legal services or through social interactions. Additionally, these geography-based instruments and cohort-based takeover defenses are unlikely to be correlated with stock returns other than through takeover probabilities, thereby satisfying the exclusion restriction. We use the instrumented G-Index (G) in our main regressions and interact this variable with SR.[19]

We present the estimates in Table 7. The geography-based instruments and IPO-cohort-based instruments appear to satisfy the relevance condition, as they are significantly correlated with the firms' G-Index. In the second-stage estimates, the coefficient on the interaction term SR $\times$ G is significantly positive, consistent with our main hypothesis. Specifically, the negative relation between short interest and future stock returns is significantly weaker when (instrumented) takeover defenses are stronger. These results are consistent with our hypothesis – that takeover risk creates friction for short sellers. In other words, when a takeover is less likely due to stronger takeover defenses, it becomes safer to short-sell stocks. When short sellers demand less compensation for arbitrage risk, the return predictability of short interest is muted.[20]

F. Short Sellers and Potential Acquirers

In this section, we further investigate the interaction between short sellers and potential bidders. Both are informed parties that can benefit from the negative information about a firm/potential target: short sellers profit by taking a short position before the negative information is revealed and closing the position after the information is incorporated into the price but *before* a bidder makes an offer, while a bidder benefits by making an offer at a lower price *after* the negative information is incorporated into the market price. Subsequently, the bidder can make a profit by enhancing the target's fundamental value using its control rights post-acquisition.

In Figure A1 in the Supplementary Material, we find that the level of short interest on a target firm's stock starts to significantly increase 15 weeks before a takeover announcement. The level of short interest increases until the week of the takeover announcement, suggesting that some short sellers failed to time

[19]Karpoff et al. (2017) show that anti-takeover provisions, after addressing endogeneity, do affect takeover probability. Thus, the relevance condition for the instruments hold. For the exclusion condition to hold, any effect of anti-takeover provisions on limits to short selling should occur only through the effect on takeover probability. Consistent with the validity of the exclusion condition, many previous studies, such as Gompers et al. (2003), Dittmar and Mahrt-Smith (2007), Harford, Mansi, and Maxwell (2008), Bates, Kahle, and Stulz (2009), Bebchuk et al. (2009), and Chava, Livdan, and Purnanandam (2009), rely on the same premise when they use takeover provision to directly proxy for the probability of takeover and examine its effect on firm valuation, cashing holding, and cost of capital, among others.

[20]We note that although our setting is different from the critiques of Karpoff et al. (2017) and Karpoff and Wittry (2018), we believe that their instruments are still appropriate in our setting. Specifically, we only require that such endogeneity corrections to takeover probability are unrelated to subsequent short-selling behavior.

TABLE 7

IV Regressions: Takeover Defenses, Short Interest, and Stock Returns

Table 7 reports the estimates from 2SLS regressions of monthly stock returns from 1991 to 2006. We use two types of instruments for the G-Index: geography-based instruments and IPO-cohort-based instruments. Following Karpoff et al. (2017), we make 2 adjustments to both instruments to strengthen the exclusion condition. First, we exclude firms in the same industry from the peer group. Second, we calculate the instruments based on the peer firms' average G-Index as of i) 5 years before the analysis ("5yr"); ii) 1990, which is the earliest data reported by IRRC ("static-1990"); and iii) the earliest year before 1990 that are either reported by IRRC or Cremers and Ferrell (2014). By using a lagged value and excluding firms in the same industry from the instruments, we can separate the effect of the instrument from any confounding local economic factors and industry-level shocks. Control variables such as those in Table 4 are included in the estimation but unreported for brevity. Columns 1 and 2, 4 and 5, and 7 and 8 report first-stage estimates of SR and G, while columns 3, 6, and 9 report second-stage estimates of monthly returns. All variables are defined in the Supplementary Material. We report the *F*-statistic of weak-instrument test for the first-stage models. We also present *t*-statistics using firm-clustered standard errors in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Model	2SLS								
Stage	1st	1st	2nd	1st	1st	2nd	1st	1st	2nd
Dependent Variable	SR × G	G	RETURN	SR × G	G	RETURN	SR × G	G	RETURN
	1	2	3	4	5	6	7	8	9
SR	0.283 (0.18)	−25.475* (−1.75)	−0.395** (−2.15)	2.366 (1.22)	−21.714 (−1.19)	−0.399** (−2.03)	5.621*** (3.04)	−31.380** (−2.02)	−0.416** (−2.09)
SR × G			0.039** (1.97)			0.040* (1.91)			0.041* (1.93)
G			−0.002** (−2.57)			−0.001 (−0.97)			−0.002* (−1.78)
SR × GEO_5YR	0.424*** (3.26)	1.335 (1.07)							
GEO_5YR	−0.001 (−0.40)	0.311*** (3.54)							
SR × IPO_5YR	0.565*** (3.74)	1.058 (0.94)							
IPO_5YR	0.002 (0.50)	0.604*** (7.59)							
SR × GEO_1990				0.587*** (3.81)	2.762* (1.90)				
GEO_1990				−0.002 (−0.85)	0.286*** (2.59)				
SR × IPO_1990				0.162 (1.07)	−0.945 (−0.71)				
IPO_1990				−0.001 (−0.43)	0.250** (2.42)				
SR × GEO_PRE_1990							0.597*** (2.76)	2.781 (1.61)	
GEO_PRE_1990							−0.006 (−1.46)	0.161 (1.24)	
SR × IPO_PRE_1990							−0.134 (−1.27)	0.615 (0.67)	
IPO_PRE_1990							−0.002 (−0.74)	−0.288*** (−3.83)	
F-stat.	34.47	44.25		8.51	9.56		5.66	8.20	
No. of obs.	110,034	110,034	110,034	144,255	144,255	144,255	144,255	144,255	144,255
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

their trades and were squeezed by acquirers. Nevertheless, the observed time gap between the initiation of abnormal short-selling activities and takeover announcements suggests that at least some informed short sellers could feasibly time their trades and exit prior to potential takeover bids. Meanwhile, the downward pressure on the target price created by short sellers prior to a takeover announcement is beneficial to the acquirer, who enjoys a lower offer price and cost of acquisition as the short selling reduces the market price. Informed acquirers could even strategically delay their offer and let the market price fully reflect short sellers' negative information. Such a strategic motive also

potentially explains the observed time gap between short sellers' and acquirers' activities.[21]

Our evidence shows that short-selling stocks with takeover risk are compensated with additional return. Based on our estimates from column 4 of Table 4, a firm in the top tercile of industry takeover intensity that experiences a 10 percentage points increase in short ratio exhibits a decrease of 70 basis points in stock returns the following month.[22] However, since target firms normally receive a premium in an average takeover attempt, short sellers stand to suffer a substantial loss if a firm they have shorted receives a takeover bid. Therefore, one may question whether short sellers are adequately compensated for the risk they take by investing in high-takeover risk firms.

To gauge the relative benefits and costs of short-selling stocks with takeover risk, we estimate the stock returns in actual takeover announcements. In Table 8, we present estimates of OLS regressions where the dependent variable is stock return in month t and the independent variables are SR and firm control variables in month $t-1$. We include the interaction between SR and ANNOUNCEMENT, a binary variable that equals 1 if the firm receives a takeover bid in month t. In column

TABLE 8

Takeover Announcement, Short Ratio, and the Cross-Section of Stock Returns

Table 8 reports the estimates from OLS regressions of monthly stock returns for the period from Jan. 1985 to Dec. 2018. ANNOUNCEMENT is a binary variable that equals 1 if the firm received a takeover bid in month t. All variables are defined in the Supplementary Material. We report t-statistics based on firm-clustered standard errors in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	1	2	3	4
SR	−0.039***	−0.039***	−0.033***	−0.043***
	(−9.98)	(−10.03)	(−8.42)	(−10.19)
SR × ANNOUNCEMENT	0.323***	0.316***	0.316***	0.316***
	(3.26)	(3.17)	(3.18)	(3.18)
ANNOUNCEMENT	0.196***	0.198***	0.198***	0.198***
	(41.36)	(41.49)	(41.54)	(41.53)
ln(BM)	0.001***	0.001***	0.001***	0.001***
	(6.06)	(5.67)	(4.56)	(4.26)
ln(ME)	0.000***	0.000***	−0.000	−0.000***
	(5.25)	(4.70)	(−0.15)	(−4.37)
REV		−0.021***	−0.019***	−0.019***
		(−11.80)	(−10.64)	(−10.65)
MOM		0.005***	0.005***	0.005***
		(11.11)	(11.74)	(11.63)
IVOL			−0.148***	−0.142***
			(−8.49)	(−8.22)
IO				0.005***
				(8.82)
No. of obs.	761,906	755,795	754,479	754,479
R^2	0.023	0.041	0.047	0.051

[21]A caveat of this analysis is that we only observe the aggregate level of short interest but not the position of each individual short seller. Due to the data limitation, we cannot empirically verify whether and which short sellers exit their short position during the 15-week period prior to the announcement. Therefore, our only claim is that 15 weeks is a sufficiently long time window for an informed short seller to feasibly make trading profit and exit before a takeover event takes place.

[22]$(-0.033 - 0.037) \times 0.10 = 70$ basis points.

4, the estimated coefficient on ANNOUNCEMENT is 0.198, suggesting a return of 19.8 percentage points in the month of the takeover announcement. The estimated coefficient on SR × ANNOUNCEMENT is 0.316 and statistically significant. This is consistent with the intuition that takeover announcements force short sellers to cover their short positions and that the increased demand from short covering increases the already-positive price shock created by the announcement (e.g., Hong et al. (2012), Jiang, Liu, Schrowang, and Xu (2022)). The estimates from Table 8 suggest that when a firm's short ratio increases by 10 percentage points, the firm's stock return increases on average by 22.96 percentage points in the month the takeover announcement occurs, which is consistent with the large takeover premium usually offered by acquirers.[23] In our sample with the top tercile level of industry takeover intensity, the probability that a takeover attempt occurs in a firm-month observation is 0.6 percentage points. Therefore, a well-diversified short seller's expected loss from a takeover announcement is 22.96 × 0.006 = 13.78 basis points, which is lower than the average monthly return of 70 basis points from the short positions. Since short sellers can build their positions 15 weeks before an actual announcement, as Figure A1 in the Supplementary Material shows, the estimated return for short-selling stocks with takeover risk is more than sufficient to compensate for the expected loss from an actual takeover.[24] Furthermore, short sellers can require higher returns for their positions if they anticipate a higher level of takeover premium offered by potential acquirers. Consistent with this conjecture, Table 9 shows that the long-short portfolio based on short ratio is significantly more profitable in the subsample with a higher prevailing takeover premium in the same

TABLE 9

Two-Way Sorts on One-Day Premium and Stock Short Ratio

Table 9 reports equal-weighted average returns and Carhart (1997) 4-factor alphas sorted by 1-day premium and stock's short ratio. The sample runs from Jan. 1985 to Dec. 2018. At the beginning of each month, we first sort all the stocks into terciles based on the offer 1-day premium aggregated at the 2-digit SIC industry level, and within each tercile, we sort the stocks further into deciles based on their short ratios in the past month. All variables are defined in the Supplementary Material. We report Newey–West adjusted *t*-statistics in parentheses. For the long-short portfolios, *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Returns				Carhart 4-Factor Alphas			
	Short Ratio Deciles				Short Ratio Deciles			
One-Day Premium Terciles	1	5	10	1–10	1	5	10	1–10
	1	2	3	4	5	6	7	8
1	1.08 (4.29)	0.96 (3.92)	0.77 (2.35)	0.31* (1.70)	0.23 (1.71)	−0.09 (−0.85)	−0.37 (−2.72)	0.60*** (3.09)
2	1.15 (5.09)	1.22 (5.83)	0.74 (2.47)	0.41** (2.15)	0.34 (3.13)	0.21 (1.98)	−0.37 (−2.45)	0.72*** (3.91)
3	1.30 (5.15)	1.18 (5.28)	0.60 (2.11)	0.70*** (4.28)	0.45 (3.28)	0.17 (1.50)	−0.47 (−3.07)	0.92*** (4.82)
3–1	0.21** (2.13)	0.23* (1.78)	−0.17 (−1.15)	0.39** (2.15)	0.22** (2.22)	0.26* (1.77)	−0.10 (−0.56)	0.32* (1.65)

[23] $0.198 + 0.316 \times 0.10 = 22.96$ percentage points.

[24] Table A6 in the Supplementary Material shows that the return predictability of short ratio is significant up to 3 months in the future, supporting the claim that short sellers can build their position several months before a takeover announcement.

2-digit SIC industry. Therefore, short sellers appear prudent when shorting stocks with takeover risk.

The above analysis applies to a well-diversified short seller who shorts a portfolio of stocks. For a specialized short seller who takes an undiversified position in a stock with takeover risk, the break-even threshold for a profitable short arbitrage is necessarily higher. Recent studies (e.g., Ljungqvist and Qian (2016)) show that some highly skilled short sellers, such as activist hedge funds which combine private information with public short campaigns, can achieve a monthly return of 7.5%. Combined with the fact that abnormal short selling occurs 15 weeks ahead of takeover announcements, it is feasible for this type of short sellers to make trading profits from an undiversified position in stocks with takeover bids.

To summarize, our evidence shows that while short sellers could experience significant losses in the event of a takeover announcement, on average they profit from taking short positions in stocks with a high takeover risk. Moreover, potential acquirers can benefit from short sellers' trades which reduce the market price and thus the cost of acquisition. As such, both informed parties could gain from the same negative information if they strategically time their trades, that is, short sellers accelerate their trades while acquirers delay their offers, such that their trades do not overlap (e.g., see Massa et al. (2015)). The observed long time gap between short-selling activities and takeover announcements appears to support this condition.

G. Takeover Intensity, Short Interest, and Stock Mispricing

In order to further investigate the role of takeovers as an implicit limit to short-selling arbitrage, we examine the relation between takeover risk and stock mispricing. We form long-short portfolios using the mispricing factor developed by Stambaugh, Yu, and Yuan (2012) and Stambaugh et al. (2015), which is a composite score based on a broad set of anomaly variables, including NET_STOCK_ISSUES, COMPOSITE_EQUITY_ISSUES, ACCRUALS, NET_OPERATING_ASSETS, ASSET_GROWTH, INVESTMENT_TO_ASSETS, DISTRESS, O_SCORE, MOMENTUM, GROSS_PROFITABILITY, and RETURN_ON_ASSETS, that are related to mispricing due to market sentiment. We create 30 portfolios by first sorting stocks into terciles of takeover intensity and then, within each tercile, further sorting stocks into deciles by the mispricing factor. Since the momentum factor is included in the composite score, for this test we compute the alpha of each portfolio using a 3-factor model rather than the 4-factor model used up to this point. Thus, for each portfolio, we follow Stambaugh et al. (2012) and Chu et al. (2020) and compute the average monthly return and the Fama–French 3-factor alpha.

Results in Table 10 show that returns and alphas for the long-short portfolio based on mispricing factor are larger in the high takeover risk subsample. Although the difference across takeover samples is not significant for monthly raw returns, it is significant at the 10% level using the Fama–French 3-factor alpha (Fama and French (1993)). Takeover risk, therefore, appears to increase the profitability of mispricing-based trading strategies. This result is consistent with Chu et al. (2020), supporting the intuition that a higher likelihood of a takeover bid limits short sellers' arbitrage activities. These results suggest that takeover risk is related to greater mispricing, consistent with the intuition that takeover risk limits the arbitrage activities of short sellers.

TABLE 10

Takeover Intensity and Mispricing Factor

Table 10 reports equal-weighted monthly average returns and Fama and French (1993) 3-factor alphas (in percentages) sorted by takeover intensity and stock's MISPRICE (defined as in Stambaugh et al. (2015)). The sample runs from Jan. 1985 to Dec. 2016. At the beginning of each month, we first sort all the stocks into terciles based on takeover intensity at the 2-digit SIC industry level, and within each tercile, we sort the stocks further into deciles based on MISPRICE in the past month. The time-series average of portfolio size is 64 stocks. All variables are defined in the Supplementary Material. We report Newey–West adjusted *t*-statistics in parentheses. For the long-short portfolios, *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Returns (EW)				Fama–French 3-Factor Alphas			
	Misprice Score Deciles				Misprice Score Deciles			
Takeover Terciles	1	5	10	1–10	1	5	10	1–10
1	1.68	1.36	0.11	1.57***	0.72	0.38	−1.04	1.76***
	(6.84)	(5.55)	(0.34)	(8.96)	(6.85)	(3.35)	(−7.32)	(10.45)
2	1.53	1.23	−0.01	1.54***	0.58	0.17	−1.24	1.82***
	(6.49)	(4.77)	(−0.02)	(6.56)	(5.49)	(2.09)	(−7.40)	(9.44)
3	1.57	1.24	−0.24	1.81***	0.62	0.14	−1.52	2.15***
	(6.42)	(4.48)	(−0.56)	(6.03)	(6.48)	(1.71)	(−7.79)	(9.20)
3–1	−0.11	−0.12	−0.35	0.24	−0.09	−0.25*	−0.48**	0.39*
	(−1.11)	(−0.85)	(−1.40)	(1.00)	(−0.94)	(−1.95)	(−2.16)	(1.83)

V. Conclusion

We hypothesize that the risk of a takeover bid represents an implicit limit to short sellers' arbitrage activities. The empirical results support this hypothesis, as we find that the return predictability associated with short interest is higher when takeover risk is higher, consistent with the intuition that takeover risk represents a limit to informed short selling. In addition to using historical industry-level takeover activity to proxy for takeover risk, our empirical methodology also utilizes staggered, state-level variation in business combination laws that exogenously change firms' takeover risk. These results suggest that exogenous reductions in takeover risk also reduce the return predictability of short interest. Further tests indicate that higher takeover risk appears related to more mispricing, which is consistent with the intuition that takeover risk represents a limit to short sellers' arbitrage opportunities.

We note that most of the literature considers limits to short arbitrage in the context of regulations or market frictions such as limited supply of lendable shares and high stock borrowing costs. In contrast, the limit to short arbitrage documented here can arise naturally from competitive markets for corporate control, rather than short-selling regulations or frictions in the stock lending markets. Our results are surprising because takeovers are considered important mechanisms for disciplining managers and improving corporate governance. In contrast, our evidence suggests that efficient markets for corporate control also have the unintended effect of inducing stock market inefficiencies via limiting arbitrage opportunities for short sellers.

Supplementary Material

To view supplementary material for this article, please visit http://doi.org/10.1017/S0022109022001302.

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