The Rise of the Equity Lending Market: Implications for Corporate Policies

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Abstract

We model the effect of short selling constraints on corporate policies and empirically show how the equity lending market affects corporate behavior. Firms react to increases in the supply of lendable stocks by repurchasing shares and increasing investment, consistent with the theory that managers respond to manipulative shorting threats by signaling firm value through corporate policies. Firms also save more cash and issue more debt in response to shifts in the supply of lendable stocks. These various policy responses are coordinated and are more pronounced for firms with more liquid stocks, higher growth opportunities, tighter financing constraints, and when managers' personal compensation is more sensitive to stock prices.

Keywords: Equity lending markets, short sales, corporate policies, share repurchases, investment, savings.

JEL classification: G23, G32, G35.

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1 Introduction

It is based on equity prices that managers estimate their companies' cost of capital, plan merger deals, establish payout policies, and even design employee compensation packages. Researchers have stressed that downward price manipulation by short sellers may significantly distort the allocation of corporate resources across several dimensions (see, e.g., Goldstein and Guembel (2008), Khanna and Mathews (2012), and Goldstein et al. (2013)). Corporate managers, in turn, seem concerned with the emergence of markets and practices that facilitate stock price manipulation (Edmans et al. (2015)) and often implement measures meant to obstruct the shorting of their companies' shares (Lamont (2012)).

Corporate managers cannot control stock prices, but they can influence the trading of their companies' shares. Unlike other agents, managers have near-monopoly powers over the supply of (own-)company stocks going into the market: they can issue new shares as well as repurchase existing ones under company-sponsored programs. Yet, managers' influence over their firms' stocks is limited. In particular, their ability to influence float depends on the pool of "lendable stocks" that is placed by investors in the equity lending market. These stocks can be borrowed by speculators, enabling shorting strategies. While the mechanics of equity lending and shorting have remained fairly stable over the last several years, the supply of lendable stocks has significantly increased, together with the unprecedented growth of institutional investing (see, e.g., Ferreira and Matos (2008) and Cremers et al. (2016)).

This paper is the first to show how developments in the equity lending market have influenced corporate policies involving equity float, investment, and liquidity management. Recent studies point to important links between outward shifts in the supply of lendable stocks and the relaxation of short sales constraints (e.g., Kolasinski et al. (2013) and Porras Prado et al. (2016)).[1] In what follows, we develop a model where price feedbacks engendered by manipulative shorting strategies shape financial contracts and affect various corporate policies. The relations we model are then taken to the data, which show that firms respond to shifts in the supply

[1] Kolasinski et al. (2013), for example, show that when more shares are available to lend, speculators locate them more easily and pay lower borrowing fees, facilitating shorting activity.

of lendable stocks with policies meant to shore up their defenses against shorting. Not only do firms react in reducing stock float via repurchases, but also invest more and build up cash reserves needed to sustain their float policies following increases in the supply of lendable stocks.

Our theory builds on Goldstein and Guembel (2008), who show that manipulation by short sellers can lead to underinvestment in a setting where managers make one-shot investment decisions after firm stocks are traded in financial markets. We expand the model to a more dynamic setting with ex–ante financial contracting, where managers raise funds for projects that need investment outlays before financial markets are open and may require reinvestment after stocks begin to trade. The model contributes to the literature on the effects of short sales constraints on corporate policies along two important dimensions. First, it identifies a non-linear relation between investment and short sales constraints when funds needed for reinvestment are only arranged ex–post, after investors learn about investment fundamentals from the stock market. Second, the model shows how ex–ante financial contracting induces managers to prevent manipulation by short sellers through stock repurchases, leading to the implementation of optimal investment policies. Our theory yields the novel prediction that stock repurchases and investment are *both* decreasing in short selling constraints. It also shows how these relations are modulated by features such as stock liquidity, corporate growth opportunities, managerial compensation–stock price sensitivity, and financing constraints.

Our model analysis encompasses two contracting settings. First, without ex–ante financial contracting, firms raise funds from investors that learn about fundamentals through stock prices. When constraints to short selling are sufficiently low, speculators may profit by shorting the stock even without holding private information, as lower prices are interpreted as a negative signal about firm fundamentals. This manipulative shorting strategy is profitable because investors learn from prices and may refuse to finance even value-creating reinvestment plans, further reducing share prices in the next round of trading and allowing short sellers to cover their positions at a profit. For moderate levels of shorting constraints, the potential gains from this strategy are lower and reduce the scope for manipulation. As a result, prices become more informative and reinvestment plans are only canceled under selling pressure from speculators that possess negative information about the firm. Finally, when short selling constraints are sufficiently high, shorting the stock is unprofitable even for informed speculators. In this case, prices become less informative about firm value, leading to a reduction in reinvestment funding that was not analyzed by Goldstein and Guembel (2008).

In a more complete setting featuring ex-ante financial contracting, the firm can pre-commit funds and make future refinancing contingent on stock prices. This dynamic induces managers to signal value to investors through stock repurchases when shorting constraints are low, offsetting manipulation gains and improving price informativeness and debt capacity. Notably, ex-ante contracts that allow for buybacks are not optimal when constraints on short sales are high, since in this case they may provide managers with ex-post incentives to shore up stock prices against informed shorting rather than against manipulative shorting. Inflated prices lead to the financing of value-destroying reinvestment plans, reducing firm value and debt capacity. Managers thus refrain from signing such contracts, yielding the unique prediction that investment and stock repurchases are both negatively related to short selling constraints. The model implies that the empirical evidence we present below are due to managers responding efficiently to manipulative trading.

We set out to test the various predictions of our model using novel data on the supply of lendable (shortable) stocks in U.S. stock exchanges. Our base empirical investigation builds on standard models of the determinants of stock repurchases and investment spending (e.g., Dittmar (2000), Grullon and Michaely (2002), and Baker et al. (2003)). Performing fixed-effects (FE) estimations, we first add a measure of net lendable supply (*Shortable Supply*) to empirical specifications commonly used in the literature. In every case, we find a positive, statistically significant coefficient for the lendable supply measure, consistent with our model's predictions. Estimates in this base set of tests suggest that a one-interquartile range (IQR) increase in a company's supply of lendable stocks is associated with 0.2% more repurchases and a 0.1% increase in investment (both as a fraction of total assets). These figures are equivalent to 37% and 4% of the sample's mean stock repurchases and investment spending, respectively.

We extend the analysis in several ways to verify the robustness of our results and their internal logic. We show, for example, that firms also accumulate cash and issue new debt following increases in the supply of lendable stocks. In our model, this is consistent with managerial attempts to support stock prices and signal firm quality. In that same vein, outward shifts in the supply of lendable stocks should increase the probability that firms "publicly announce" the authorization of repurchase programs. This is what we find in the data. Such dynamic is notable since these announcements enable firms to signal a response to the threat of shorting, yet do not imply that they will immediately spend resources (if at all).[2] We also show that the estimated effect of lendable supply on stock repurchases and investment varies negatively with the amount of cash the firm saves. This is consistent with the logic of a binding budget constraint that forces managers to substitute between share buybacks and cash hoarding when responding to surges in the supply of lendable stocks. In effect, firms react to a relaxation in shorting constraints by either repurchasing shares or by accumulating cash war chests that allow them to respond to shorting in a time-consistent fashion. Beyond mapping out how firms optimize resources in responding to shifts in the supply of lendable stocks, we also use an alternative, price-based measure of shorting constraints to confirm the robustness of our results.

We exploit various dimensions of cross-firm heterogeneity to shore up our conclusions. Guided by our model's framework, we show that shifts in lendable supply trigger stronger repurchase responses by firms whose stocks are more liquid and easier to trade. That is, managers take into account the ease with which investors can trade shares when deciding how their firms will respond to increases in lendable supply. Likewise, we find that stock repurchases are more sensitive to shifts in lendable supply for firms with higher growth opportunities. Consistent with agency considerations, we show that repurchase programs are particularly aggressive when managers' personal compensation is sensitive to the market price of their companies' stocks. Finally, we find that financially constrained firms are more sensitive to changes in short selling constraints. Since these firms depend more on outside financing, they are the ones that benefit the most from ex–ante contracting that allows them to signal firm value through repurchases.

[2]Simkovic (2009) shows that, on average, only 40% of the amount authorized under a buyback program is repurchased within one quarter after the announcement. The percentage of firms that fulfill their program authorization within one year of the announcement is only 44% (see also Stephens and Weisbach (1998)).

In the last part of our empirical investigation, we resort to a design-based, difference-in-differences (local) test approach to deal with concerns about endogeneity. Admittedly, while our base tests allow us to take our model's predictions to a large (general) range of the data, they are also subject to estimation biases. During our data sample period, nonetheless, a subset of firms experienced a sharp decline in their net lendable supply of stocks. As we explain in detail below, this shift followed from an extension of Regulation SHO (Reg SHO) by the Securities and Exchange Commission (SEC) in June 2007. That extension eliminated "short sales price tests" for the stocks in the Russell 3000 index that were excluded from the pilot phase of the original 2005 SEC program.[3] This alternative testing strategy, which builds upon Grullon et al. (2015), confirms our base results. In particular, using this well-identified approach, we first show how that regulatory change led to a decline in the net supply of lendable stocks for the 2,000 firms that were excluded from the Reg SHO pilot phase (relative to the 1,000 firms included in the pilot). We then verify that this shift in supply led to a relative decline in stock repurchases and investment spending for those same 2,000 firms.

The precipitous growth of the equity lending market has sparked several new research agendas related to ours. Kolasinski et al. (2013) and Porras Prado et al. (2016) describe relations between equity lending stocks, institutional ownership, and limits to arbitrage. Massa et al. (2015) provide a detailed analysis of the extent to which the threat of shorting curbs earnings management. Work by Christoffersen et al. (2007) and Aggarwal et al. (2015) investigate voting behavior around shareholder meetings using equity loans. Our paper adds to this line of research by advancing evidence on how various other dimensions of corporate decision-making are shaped by the equity lending market.

A recent theoretical literature examines the impact of short sales on stock price efficiency and firm value (see Goldstein and Guembel (2008), Khanna and Mathews (2012), Goldstein et al. (2013), and Cornelli and Yilmaz (2016)). These papers show how frictions in short selling activity (or lack thereof) distort investors' perceptions about firm fundamentals and hinder firms' ability to raise capital, prompting managers to react to speculative trading. Our

[3]The final ruling states that "no price test shall apply to short sales in any security." Please refer to `https://www.sec.gov/rules/final/2007/34-55970fr.pdf` for further details.

analysis describes how short selling constraints and the workings of the market for borrowing shares prompt firms to adopt policies meant to counter the effects of shorting. Importantly, it shows that several corporate responses (including repurchases, investment, and cash savings) seem coordinated and internally consistent with the goal of responding to shorting threats.

Our empirical analysis and results relate to recent work by Grullon et al. (2015) and Fang et al. (2016) on corporate responses to the inception of Regulation SHO in 2005. Our paper extends this literature by examining the impact of the equity lending market — a growing, yet under-studied market — on a myriad of important corporate policies, some of which have not been examined in detail (such as, stock repurchases and cash savings). While regulatory changes bear more localized, direct impacts on short sales constraints, our work focus on the general dynamics of market variables like the (shortable) lendable supply of stocks and loan fees. This is an important distinction since the analysis we propose directly looks at the *locus* in which short sellers operate; the market where they borrow the stocks they short. New to the literature, our work describes — using both theoretical and empirical analyses — how stock repurchases can be used to defend against manipulative shorting and how managerial responses are modulated by short selling constraints in a market setting.

The remainder of the paper is organized as follows. Section 2 discusses the growth of the equity lending market. Section 3 describes our model. Section 4 details our sample construction. Section 5 contains the baseline regressions that document relations between the supply of lendable stocks and corporate policies. Section 6 provides a number of tests designed to check the robustness and logic of our main results. Section 7 uses cross-firm heterogeneity to corroborate and extend our findings. Section 8 shows the results from a quasi-natural testing approach. Section 9 concludes.

2 The Equity Lending Market

The SEC defines a short sale as "*the sale of a stock that a seller does not own or a sale which is completed by the delivery of a stock borrowed by, or for the account of, the seller.*"[4] The eq-

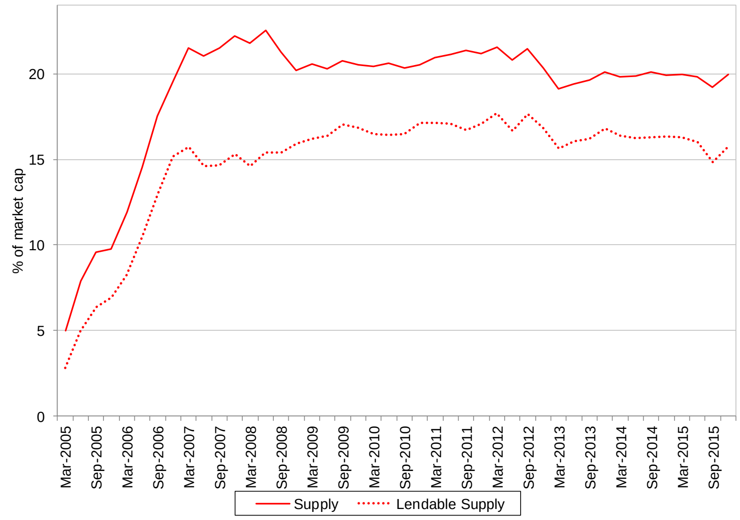
[4]Please refer to `https://www.sec.gov/answers/shortsale.htm` for additional details.

uity lending market is where investors borrow and lend shares to fulfill the delivery obligations of a short sale, which requires delivery of the securities by the seller up to three days after the transaction takes place (see D'Avolio (2002) and Saffi and Sigurdsson (2011)). Currently, the U.S. equity lending market operates over-the-counter, with lenders and borrowers being connected via intermediaries that facilitate transactions. Stocks can be borrowed for tax-arbitrage purposes (see Christoffersen et al. (2005)) and for voting in shareholder meetings (Aggarwal et al. (2015)). Yet, the vast majority of borrowed stocks is used for the implementation of short selling strategies.

Lenders in this market are typically institutional investors, such as pension funds, endowments, index funds and exchange-traded funds (ETFs). These investors often have long-term investment horizons and employ lending agents (custodians and third-party agent dealers) to manage their lending programs and temporarily transfer the ownership of securities in exchange for a fee. Borrowers are investors (e.g., hedge funds and proprietary traders) that need to locate shares for delivery, engaging with lending agents mostly through a broker/dealer. Borrowers also have to provide collateral for the transaction, which varies with the type of security involved. For equities, the average requirement corresponds to 103% of the position's size (Baklanova et al. (2016)). If the equity loan is collateralized with cash, the collateral is invested by the lending agent, who return a pre-agreed fraction of the proceeds (called the rebate rate) back to the borrower. In this case, the loan fee is defined as the difference between the reinvestment rate of the collateral and the rebate rate. For non-cash collateralized loans, the fee is set directly. Loans are usually open-ended and rolled over daily, giving both counterparties the option to terminate the transaction. In particular, SEC regulations require that investment funds that lend shares must be able to end the loan at any time and must recall shares to vote in proxies that involve a material event (e.g., a merger proposal). Furthermore, if the stock pays any dividends through the duration of the loan, the borrower is required to transfer to the lender any amount that would have been received if the stock had not been lent out. The lender also loses all voting rights for the duration of the loan.

Comprehensive data on the U.S. equity lending market are available from Markit for the 2005–2016 period. The Markit database covers over 90% of that market and contains firm-

Figure 1. Equity Lending Market Dynamics over Time

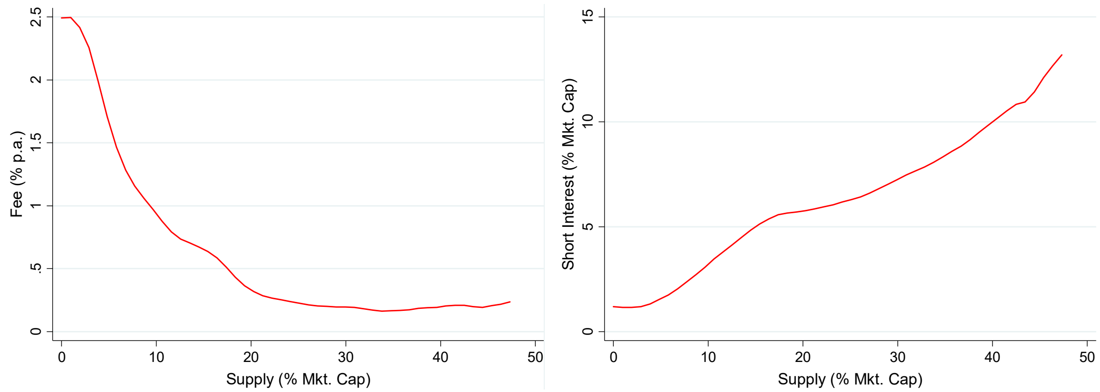


This figure shows quarterly averages of lendable supply measures of U.S. stocks. *Supply* is the number of shares available to lend as a fraction of total shares outstanding. *Shortable Supply* is the difference between shares available to lend and shares lent out as a fraction of total shares outstanding.

level information on the supply of lendable shares for the majority of stocks listed in public exchanges (see Saffi and Sigurdsson (2011)). Using this data source, we define *Supply* as the value of a firm's lendable shares divided by its market capitalization. Notably, at any point in time, some of the firm's lendable stocks might already have been lent out to other borrowers (*On Loan*), thus becoming unavailable for shorting. Using this timely, supplementary piece of information, we compute a precise measure of *net* lendable supply (*Shortable Supply*), defined as the difference between *Supply* and *On Loan*.

Figure 1 depicts the time series evolution of the supply of lendable stocks in the U.S. market. The numbers are based on stocks in the Markit dataset with information available on the Center for Research in Security Prices (CRSP). The figure shows quarterly averages of the total fraction of stocks put up for lending (*Supply*) as well as the proportion of stocks available for immediate shorting (*Shortable Supply*). *Supply* increased from 5% of market capitalization in March 2005 to a peak of 23% in June 2008, right before the Lehman Brothers bankruptcy. *Supply* reached 20% of the market capitalization at the end of 2015, or US$ 3.7 trillion. From March 2005 to December 2015, *Shortable Supply* grew from 3% to 16% of the total stock market capitalization. These series showcase the significant increase in the amount of shares

Figure 2. Supply of Lendable Shares and Short Selling Activity



This figure shows a kernel-weighted local polynomial regression of short selling activity measures (*Fee* and *Short Interest*) as a function of lendable supply (*Supply*). We use the Epanechnikov kernel to calculate estimates based on end-of-quarter stock data. *Fee* is the annualized stock loan fee and *Short Interest* is the number of shares shorted as a fraction of total shares outstanding. *Supply* is the number of shares available to lend as a fraction of total shares outstanding.

available for shorting in a ten-year period.

The growth of the equity lending market has been remarkable. The fraction of U.S. equities available in the market for lending has increased from 5% in 2005 to 20% in 2015. A key feature of this growth is related to the increase in institutional ownership. In effect, the practice of lending equity holdings to secure extra revenues has become standard for institutional investors.[5] CalPERS, for example, reports having earned $1.2 billion in revenues from security lending between 2000 and 2008; an additional 30 basis points to the pension fund's overall return performance (see also Blocher and Whaley (2015)). While stock lending is widespread among institutional investors, it is more pronounced among index funds and ETFs; vehicles that have become extraordinarily popular in recent years (see Cremers et al. (2016)). Regulators have expressed concerns about these trends and the SEC has established a series of guidelines meant to restrict the amount of lending for funds registered under the Investment Company Act. For example, registered funds cannot have more than one-third of assets under management committed to security lending loans at any point in time.

Figure 2 reveals important linkages between the supply of lendable stocks and measures of short selling activity, such as "short interest," the fraction of shares held short reported by

[5]The *Financial Times* reports that pension fund revenues from securities lending amount to more than $800 million per year ("Guide Issued on Securities Lending," Sept. 12, 2010).

Compustat. Using an Epanechnikov kernel-weighted local polynomial regression, the figure shows that higher levels of lendable supply are associated with lower loan fees (*Fee*) and more short interest (*Short Interest*). The left-hand side panel of Figure 2, in particular, highlights the accelerating decline in lending fees until a level where *Supply* is approximately equal to 20% of market capitalization. The right-hand panel depicts a positive, quasi-linear relation between lendable supply and short interest. These explicit connections are important in supporting the mechanism underlying the hypotheses discussed below: a higher supply of lendable stocks eases short sales constraints, facilitating shorting activity.

3 The Model

This section develops a model showing how feedback effects from stock prices shape financial contracts and affect corporate policies. The model builds on Goldstein and Guembel (2008), who show that price manipulation induces managers to underinvest and suggest that short selling constraints may increase investment. Our theory innovates on two dimensions relative to the existing literature. First, it explicitly shows how short selling constraints affect manipulation incentives and investment outcomes. In particular, it reveals a non-linear relation between short selling constraints and investment that had not been studied in prior literature. Second, while past models focus on financing and investment decisions that take place after the firm's shares are traded in the stock market, our model shows that ex–ante financial contracting can prevent manipulation and leads to the implementation of optimal investment policies. In particular, contracts that pre-commit funds and condition future investments on stock prices induce managers to repurchase stock and signal firm value to investors, offsetting potential manipulation by speculators. Our theory yields the key prediction that stock repurchases and investment are decreasing in short selling constraints, a prediction that we take to the data.

3.1 Set Up

The economy has four periods $t \in \{0, 1, 2, 3\}$ and a firm whose shares are in unit supply and traded in the financial market. Following Holmstrom and Tirole (1998), the firm has an investment opportunity that requires an investment of I in $t = 0$ and a reinvestment of K in $t = 3$. The value of the firm is given by $V(k, \omega)$, where $k \in \{0, K\}$ is the reinvestment policy and $\omega \in \{l, h\}$ is the state of the economy. If no reinvestment is made, the value of the firm equals $V(0, \omega) = 0$. If the firm reinvests, it is worth $V(K, l) = V^{-} > 0$ when the state is "low" and $V(K, h) = V^{+} > K > V^{-}$ when the state is "high." Both states are equally likely. The firm has no funds and must borrow from risk-neutral lenders who require an expected rate of return of at least zero. Financial contracts are signed in $t = 0$, equity trading occurs in $t \in \{1, 2\}$, and spot financing takes place in $t = 3$.

In $t = 0$, the firm's manager offers a contract $\mathcal{C}$ that maximizes firm value and yields lenders nonnegative expected returns. Conditional on the verifiable information, the contract specifies if investment is made, the amount of funds borrowed, if and when the reinvestment occurs, and the share of the firm value received by lenders. Only a fraction $\phi \in (0, 1)$ of the firm value is verifiable and thus pledgeable. This implies that the manager always want to reinvest if enough funds can be raised. One can interpret a high ϕ as an indicator that the manager's incentives are better aligned with those of shareholders. Contract terms are observable to all participants.

In $t = 1$, the state of the economy is realized and the firm's stock begins to trade in the market. There are four agents in the equity market: a risk-neutral speculator, a noise trader, the firm's manager, and a risk-neutral market maker. The manager and the speculator observe a signal $s \in \{l, h, \emptyset\}$ about the state of the world. The signal is perfectly informative ($s \in \{l, h\}$) with probability $\alpha \in (0, 1)$ and uninformative ($s = \emptyset$) with probability $1 - \alpha$. The size of order flows is fixed at a proportion $\pi \in (0, 1]$ of the firm's shares. We follow Glosten and Harris (1988) and take π as proxy for the liquidity of the firm's stock, such that a higher π reflects more illiquid stocks. The speculator submits order flows $u_t \in \{-1, 0, 1\}$, which represent, respectively, the option to short, not trade, or buy π units of the firm's stock. While buying is unconstrained, shorting faces a constraint measured by $c \geq 0$, which reflects costs such as locating stocks for borrowing and loan fees. The noise trader does not act strategically and submits serially uncorrelated random orders $n_t \in \{-1, 1\}$ with equal probability. The manager is not allowed to short sell, but may repurchase shares in the open market by submitting orders $r_t \in \{0, 1\}$.

As in Kyle (1985), orders are submitted simultaneously at each trading period to a market maker. The market maker observes only the aggregate order flow $Q_t = u_t + n_t + r_t$ and behaves competitively, setting the price p_t so as to earn zero expected profits conditional on all the public information available at t. It follows that $p_1 (Q_1, \mathcal{C}) = E[V(k, \omega) - k | Q_1, \mathcal{C}]$ and $p_2 (Q_1, Q_2, \mathcal{C}) = E[V(k, \omega) - k | Q_1, Q_2, \mathcal{C}]$. The speculator and the manager choose their trading strategies contingent on their own signals, past actions, and previously observed prices so as to maximize their payoff given the price-setting rule. Lenders only observe prices and are willing to provide funds so long as they break even in expectation.

We restrict our attention to pure-strategy equilibria. An equilibrium consists of the following: (i) a contract that maximizes firm value given the trading strategy of the speculator, the trading and reinvestment strategies of the manager, and the price-setting rule of the market maker; (ii) the speculator and manager's strategies are best responses to each other given the price-setting rule of the market maker; (iii) the price-setting rule of the market maker allows the market maker to break even given other players' strategies; (iv) the beliefs of all players are consistent with all strategies and derived from Bayes' rule whenever possible.

Finally, we make a couple of parametric assumptions to simplify the model's solution. We take that prices play an allocational role such that spot financing (i.e., reinvestment is financed after trading takes place in the stock market) is sufficiently profitable in the absence of news, but unprofitable following bad news. Put differently, the pledgeable income net of reinvestment costs is positive if the order flow does not reveal the speculator's information, but negative if they reveal that she is not informed about the high state. Notably, we take that the improvement in resource allocation is greatest when the speculator trades in the direction of her information: buying if informed about the high state, selling if informed about the low state, and not trading when uninformed.[6]

[6]These technical conditions amount to: $1 < \frac{2V^+ + 3V^-}{5K}$ and $\frac{V^+ + V^- - 2K}{V^+ - K} < \alpha < \frac{2\phi(V^+ + V^-) - 4K}{\phi(V^+ + V^-) - 2K + \phi V^+ - K}$.

3.2 Equilibrium

To highlight the implications of financial contracting for investment, we begin with a benchmark case where the firm and its lenders agree on their reinvestment arrangements in $t = 3$; after trading takes place (i.e., spot financing). Following the previous literature (e.g., Goldstein and Guembel (2008) and Goldstein et al. (2013)), we establish the relation between investment and short selling *without* the possibility of stock repurchases. Then, we investigate the role of financial contracting by allowing reinvestment arrangements to be made in $t = 0$; before markets are open. This gives managers the possibility to use funds to repurchase shares in $t = 1, 2$.

3.2.1 Investment and Short Selling Constraints *without* Ex-Ante Contracting

Because the firm has no endowed funds in $t = 0$, the manager cannot repurchase stock when reinvestment funding only takes place after markets close. Proposition 1 characterizes the outcomes for different ranges of short selling constraints, measured by the parameter c.[7]

Proposition 1 *An equilibrium in which the speculator informed about the high state buys in $t = 2$ when $p_1 < V^+ - K$ always exists. Equilibria within this class are characterized as follows:*

(i) For $c > \overline{c} \equiv \frac{V^+ - V^-}{4}$, an equilibrium exists only if no type of speculator trades in $t = 1$ and neither the uninformed speculator nor the speculator informed about the low state trades in $t = 2$. Investment occurs if $I \leq \overline{I} \equiv \phi \overline{V} - (1 - \phi) \frac{\alpha}{2} K$, where $\overline{V} \equiv \frac{\alpha}{2} (V^+ - K)$.

(ii) For $c' \equiv \frac{V^+ - K}{12} + \frac{V^+ - V^-}{6} < c < \overline{c}$, an equilibrium exists only if no type of speculator trades in $t = 1$, the uninformed speculator does not trade in $t = 2$, and the speculator informed about the low state sells in $t = 2$. Investment occurs if $I \leq I' \equiv \phi V' - (1 - \phi) \frac{4 - \alpha}{4} K$, where $V' \equiv \frac{\alpha}{4} (V^+ - K) + \frac{2 - \alpha}{2} \left(\frac{V^+ + V^-}{2} - K \right) > \overline{V}$ and $I' > \overline{I}$.

(iii) For $\widehat{c} \equiv \frac{V^+ - K}{12} < c < c'$, an equilibrium in which the speculator informed about the high state buys in $t = 1$ exists only if the uninformed speculator does not trade in $t = 1$ and the speculator informed about the low state sells in $t = 1$ and sells again

[7] All model proofs are collected in Appendix A.

in $t = 2$ *when* $p_1 > 0$. *Investment occurs if* $I \leq I^* \equiv \phi V^* - (1-\phi)\frac{8-3\alpha}{8}K$, *where* $V^* \equiv \frac{3\alpha}{8}(V^+ - K) + \frac{4-3\alpha}{4}\left(\frac{V^+ + V^-}{2} - K\right) > V'$ *and* $I^* > I'$

(iv) *For* $\underline{c} \equiv \frac{\alpha(V^+ - K)}{12} < c < \widehat{c}$, *an equilibrium exists only if no type of speculator trades in* $t = 1$, *the uninformed speculator does not trade in* $t = 2$, *and the speculator informed about the low state sells in* $t = 2$. *Investment occurs if* $I \leq I'$.

(v) *For* $c < \underline{c}$, *an equilibrium in which the speculator informed about the high state buys in* $t = 1$ *exists only if the uninformed speculator and the speculator informed about the low state sell in* $t = 1$ *and sell again in* $t = 2$ *when* $p_1 > 0$. *Investment occurs if* $I \leq \underline{I} \equiv \phi \underline{V} - (1-\phi)\frac{2+3\alpha}{8}K$, *where* $\underline{V} \equiv \frac{3\alpha}{8}(V^+ - K) + \frac{1}{4}\left(\frac{V^+ + V^-}{2} - K\right) > V'$ *and* $\underline{I} < I'$.

Proposition 1 implies that investment and firm value are highly non-monotonic functions of short selling constraints under spot financing. For sufficiently low short selling constraints ($c < \underline{c}$), both informed and manipulative short sales may occur. The latter happens when an uninformed speculator establishes a short position in $t = 1$ and then sells again in $t = 2$, when order flows in $t = 1$ do not reveal that she is not informed about the high state. The selling pressure in $t = 2$ may reduce the firm's access to financing, leading to the cancellation of reinvestment and driving firm value to zero in $t = 3$. The reason is that, when prices reveal that the speculator is not informed about the high state, investors cannot distinguish between a speculator informed about the low state and an uninformed speculator, in which case the expected pledgeable income is insufficient for financing to be arranged, $\phi\frac{V^- + (1-\alpha)V^+}{2-\alpha} < K$. Manipulation results in a loss of c to the speculator in each trading period. However, the period-1 stock price is positive, as the market expects that the period-2 stock price may reveal that the speculator is informed about the high state, allowing the firm to raise funds for reinvestment. Therefore, manipulation is profitable if short selling constraints are small enough.

As short selling constraints increase to $c \in (\underline{c}, \widehat{c})$, short sales by uninformed speculators are no longer profitable in equilibrium. Yet, when only informed speculators trade, the expected firm value is higher when the order flow in $t = 1$ does not reveal the speculator's type. As a result, the period-1 price is large enough to compensate for the costs of establishing a short position in $t = 1$, making manipulation a credible threat. Therefore, an equilibrium exists only in the absence of speculative trading in $t = 1$, in which case price informativeness and debt capacity decrease. This result suggests that the adoption of even modest short selling constraints may be enough to drive out informed trading and investment. It also highlights the relevance of a full analysis of the equilibrium consequences of short selling constraints for firm value, a point well noted but not carried out by Goldstein and Guembel (2008).

Moderate short selling constraints ($c \in (\widehat{c}, c')$) are enough to eliminate manipulation threats by uninformed speculators, but insufficient to reduce informed speculation. As a consequence, firm value and investment capacity achieve their maximum within this range. When constraints on short sales increase further to $c \in (c', \overline{c})$, short selling in $t = 1$ is not profitable in equilibrium even for speculators informed about the low state. However, if only speculators informed about the high state trade in $t = 1$, the period-1 price becomes so high that it makes informed short sales attractive. It follows that an equilibrium exists only if no speculator trades in $t = 1$, in which case firm value and investment decrease. Finally, short sales are fully deterred and firm value is lowest when shorting constraints are high ($c > \overline{c}$). In this case, prices no longer reflect the information of the speculator informed about the low state. As a result, lenders interpret order flows consistent with no trade by the speculator as negative news, since they cannot tell if the speculator is informed about the low state or uninformed. This leads to underinvestment, as funds for reinvestment can only be raised when the speculator is informed about the high state.

3.2.2 Investment and Short Selling Constraints *with* Ex-Ante Contracting

Our analysis thus far has shown that the manager's ability to finance investment after trading in financial markets depends on lenders' beliefs about the value of the firm given observed stock prices. Underinvestment occurs in high and low regions of short selling constraints, as prices are less informative relative to when short sales constraints are moderate. Informativeness is low when short selling is too constrained because prices do not reflect the information of informed speculators. It is also low when short sales are unconstrained due to manipulation by uninformed speculators. This raises the question of whether the impact of manipulation can be resolved by contracts that provide the firm with access to funding beyond investment needs, allowing the manager to repurchase stock in the market and signal firm value to investors.

Pre-committed funds are a necessary condition for contracts to implement the outcome of Proposition 1(iii) under low short selling constraints (i.e., $c < \widehat{c}$) . However, they are not sufficient. Because of the ability to divert a fraction $1 - \phi$ of the firm value, the manager always reinvests irrespective of the state of the economy. The resulting firm value equals $\widehat{V} \equiv \frac{V^{+}+V^{-}}{2} - K$, which is lower than that under manipulation since $\underline{V} - \widehat{V} = \frac{3}{8}\left[\alpha\left(V^{+} - K\right) - \left(V^{+} + V^{-} - 2K\right)\right] > 0$. The reason is that prices still play an important allocational role in the presence of manipulation, as they reflect the information of the speculator informed about the low state. It follows that the implementation of the outcome of Proposition 1(iii) requires contracts to condition reinvestment on stock prices, such that reinvestment is canceled whenever the expected pledgeable income net of investment costs is negative. Under this contingency, reinvestment is less likely to occur after manipulative selling pressure by an uninformed speculator. As a result, an uninformed manager has the incentive to signal his information by driving prices up through stock repurchases, because the manager's payoff is positive if and only if reinvestment takes place. This leads to the following proposition.

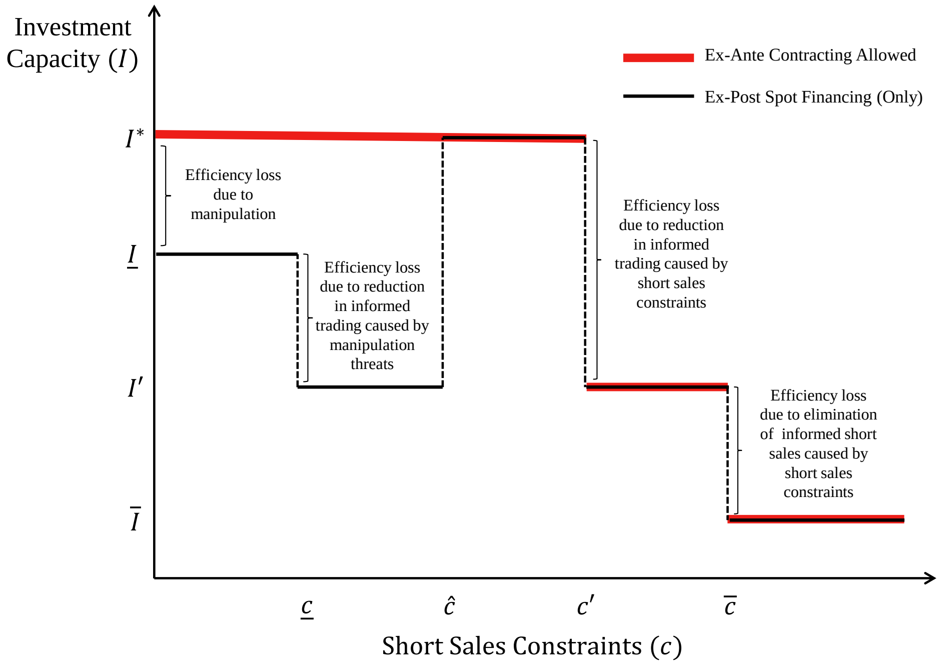
Proposition 2 *Consider the following contract: the manager borrows b_t in $t \in \{0, 3\}$ with $b_0 = 2\pi\frac{V^{+}+(1-\alpha)V^{-}-(2-\alpha)K}{2-\alpha}$ and $b_0 + b_3 = \sum_{t=1}^{2} r_t \pi p_t + k$; reinvestment occurs ($k = K$) if the pledgeable income conditional on the order flows is greater than the reinvestment outlay, $E\left[\phi V\left(K, \omega\right)|Q_1, Q_2, \mathcal{C}\right] \geq K$, and does not occur otherwise ($k = 0$); and repayments to lenders are such that they at least break even in expectation. When short selling constraints are low ($c < \widehat{c}$), there exists an equilibrium such that: the speculator informed about the high state buys in $t = 1$ and buys again in $t = 2$ when $p_1 < V^{+} - K$; the uninformed speculator does not trade in $t = 1$ and does not trade again in $t = 2$ when $p_1 > 0$; the speculator informed about the low state sells in $t = 1$ and sells again in $t = 2$ when $p_1 > 0$; and the manager trades if and only if he is uninformed about the state, in which case the manager buys in $t = 1$ and buys again in $t = 2$ when $p_1 > 0$. This equilibrium implements the investment policy and achieves the firm value specified in Proposition 1(iii).*

According to Proposition 2, there exists an equilibrium under which financial contracting induces the manager to signal firm value through stock buybacks if and only if he is uninformed. In this equilibrium, buying pressure is interpreted as the outcome of either repurchases by an uninformed manager or informed trading by a speculator informed about the hight state. Accordingly, moderate order flows are seen as resulting from short sales by a speculator informed about the low state. Therefore, manipulative short sales by an uninformed speculator counters the buying pressure from buybacks and results in moderate order flows, pushing the price down to zero. This offsets manipulation gains and efficiently boosts investment when short selling constraints are low. Moreover, the manager does not have an incentive to repurchase shares when informed about the low state. In principle, this could mitigate negative information coming through prices and enables the firm to raise funds and reinvest. If successful, such strategy would be profitable since the manager can divert a fraction $1 - \phi$ of the firm value. However, because of the selling pressure by the speculator informed about the low state, repurchases only lead to moderate order flows, driving the price down to zero and leading to the cancellation of inefficient reinvestment.

Figure 3 compares the relations between investment and short sales constraints when ex-ante contracting is allowed (red line) versus the setting when funds for reinvestment are raised only through ex-post spot financing (black line). For $c < c'$, investment is non-monotonic in short sales constraints when only spot financing is available: investment is lower when short selling constraints decline from moderate ($c \in (\widehat{c}, c')$) to low ($c \in (\underline{c}, \widehat{c})$). This happens because manipulative short sales, although unprofitable in equilibrium, still constitute a credible threat and partially drives away informed speculation. However, investment increases as constraints on short sales become sufficiently low $c < \underline{c}$, as in this case manipulation is profitable in equilibrium and, albeit inefficient, coexists with informed trading. Under the equilibrium described by Proposition 2, stock repurchases eliminate manipulative short sales and manipulation threats altogether for $c < \widehat{c}$, leading to maximum investment capacity over the entire range $c < c'$.

For $c > c'$, ex-ante contracting cannot improve upon ex-post spot financing. When $c \in (c', \overline{c})$, short sales constraints make it unprofitable to short the stock in $t = 1$ even for

Figure 3. Investment and Short Sales Constraints



This figure shows investment capacity as a function of short sales constraints (c) for the two alternative settings of the model proposed in Section 3. The red schedule shows investment capacity when ex-ante contracting is allowed (i.e., firms can make ex-ante financial arrangements for repurchase and reinvestment policies). The black schedule shows investment capacity when funds for reinvestment are raised only through ex-post spot financing.

a speculator informed about the low state, completely driving out informed trading in $t = 1$. Under spot financing, informed trading in $t = 2$ secures enough funds for reinvestment when the speculator is either informed about the high state or uninformed, and leads to the cancellation of reinvestment when the state is low with probability $\frac{\alpha}{4}$. Ex-ante contracting is innocuous in this case: repurchases by an uninformed manager result in buying pressure that is interpreted as coming either from trading by a speculator informed about the high state or from uninformed buybacks, generating enough pledgeable income for reinvestment; and repurchases by a manager informed about the low state are not advantageous since they offset the selling pressure from informed speculation and result in moderate order flows, which drive the stock price to zero and lead to certain cancellation of reinvestment. It follows that reinvestment policies and investment capacity are the same in both settings.

When $c > \bar{c}$ short sales are fully deterred, reinvestment under spot financing occurs only when the speculator is informed about the high state, generating investment capacity $\overline{I}$. In this case, it is optimal for the manager not to offer any contract in $t = 1$ that allows for repurchases. The reason is that, once investment is financed, the manager wants to maximize the probability of reinvestment (as he can divert a fraction $1 - \phi$ of the firm value). As a result, he has an incentive to use pre-committed funds and repurchase stock when informed about the low state: since there is no selling pressure from informed speculation, buybacks create buying pressure that is interpreted as trading by a speculator informed about the high state, which leads to certain reinvestment. Therefore, if a contract that allows for buybacks is signed in $t = 1$, an equilibrium exists only if the manager repurchases stocks when informed about the low state, in which case the firm always reinvests and investment capacity equals $\widehat{I} \equiv \phi\widehat{V} - (1-\phi)K < \overline{I}$.

Proposition 2 implies that ex-ante contracting that allows for stock repurchases is optimal for $c < c'$, whereas ex-post spot financing is optimal for $c > c'$. In this fashion, our model predicts that stock repurchases increase as constraints to short sales decline. Proposition 2 also implies that investment declines in short selling constraints to the extent that financial contracting is feasible; that is, when the expected pledgeable income in $t = 0$ is enough to cover the expected investment outlay and amount lent for stock repurchases. We highlight this prediction of the model via a corollary.

Corollary 1 *There exists a monotonically negative relation between investment and short selling constraints when*

$$V^* - (1-\phi)\left(V^* + \frac{8-3\alpha}{8}K\right) - I \geq (1-\alpha)\, 2\pi \frac{2\widehat{V} - \alpha\,(V^- - K)}{2-\alpha}.$$

This condition is always satisfied for $\pi \leq \frac{\phi(\widehat{V}+K)-K}{2\widehat{V}}$. *For* $\pi > \frac{\phi(\widehat{V}+K)-K}{2\widehat{V}}$, *it is satisfied if and only if* $\alpha \geq \alpha^*(\pi, \phi, V^- - K, \widehat{V}) > 0$, *where* α^* *is decreasing in* $\widehat{V}$ *and* ϕ, *and increasing in* π.

Corollary 1 identifies a number of heterogeneous impacts of short selling constraints on the feasibility of financial contracting. First, financial contracting is more likely to be feasible when stock liquidity is higher (lower π). This result is intuitive as the manager would need to repurchase fewer shares in order to offset manipulative selling orders of lower sizes, in which the firm repurchases shares more often when short sales constraints decline. Second, financial contracting should be used more often to counter manipulation threats when firms exhibit higher growth potential (the project's net present value $\widehat{V}$ is higher) and more aligned managerial incentives (higher ϕ). Intuitively, these firms can pledge more income to lenders, allowing them to more easily raise funds before financial trading. In all, these results allow us to derive a series of auxiliary predictions.

3.3 Testable Hypotheses

It is important that we flesh out the empirical implications of our model. Combining the characterization of financial contracting feasibility with Propositions 1 and 2 allows us to derive the following testable hypotheses.

Hypothesis 1: *Corporate stock repurchases and investment increase when short selling constraints decline.*

As described by Proposition 1, investment and firm value have a non-linear relation with respect to short selling constraints when only spot financing is available (i.e., no stock repurchases are allowed). They increase as constraints decline from high ($c > \bar{c}$) to moderate ($c \in (\widehat{c}, c'))$, as stock prices become more informative about fundamentals; and they go down as short selling constraints decline from moderate to sufficiently low values ($c < \underline{c}$), as manipulation distorts stock prices and leads to inefficient cancellation of investment. Critically, financial contracting and the possibility to raise funds before shares are traded can prevent manipulative short selling. According to Proposition 2, when short selling constraints are low ($c < \widehat{c}$), the ability to use funds to repurchases stock can lead to the investment and firm valuation levels observed for moderate short selling constraints ($c \in (\widehat{c}, c')$). The combination of both results yields the monotonically negative relations posited in Hypothesis 1.

Hypothesis 1 relies on an equilibrium generated by the contract in Proposition 2 that results in an efficient response to manipulation threats. This raises the question of whether the same contract yields an alternative equilibrium in which the manager inefficiently repurchases shares to offset the selling pressure coming from negatively informed speculators. As it turns out, there exists an equilibrium in which the manager never trades when informed about the high state, but always repurchases shares when uninformed or negatively informed about the state of the economy. Under this equilibrium, a speculator with private information about the high state always buys, but never trades when uninformed or privy about the low state. Notably, prices are uninformative and the firm always invests regardless of the state of the economy and degrees of short selling constraints, with firm value being equal to $\widehat{V}$. However, it follows from Proposition 1 that firm value is at least $\underline{V} > \widehat{V}$ under spot financing (i.e. without ex–ante contracting). As a result, the manager would always prefer financing an investment opportunity after trading is complete than to offer a contract that induces overinvestment. Note that investment and stock repurchases would be insensitive to short selling constraints if the manager offered such a contract, contrary to what Hypothesis 1 proposes.

We now turn to additional cross-sectional characterization of our base model results.

Hypothesis 2: *The increases in stock repurchases and investment caused by a decline in short selling constraints are more pronounced for firms with more liquid stock, higher growth potential, more aligned managerial incentives, and stronger financing constraints.*

Hypothesis 2 is a corollary of Proposition 2, except for the impact of financing constraints. Under the financial contracting arrangement of Proposition 2, lenders advance funds to the manager before trading in financial markets. This allows the uninformed manager to conduct stock repurchases and signal firm value. Such a contract is feasible so long as the expected pledgeable income, net of investment costs, is sufficient to cover the amount lent for stock repurchases. It follows that stock repurchases and investment are more likely to increase following a reduction in short selling constraints when: the stock is more liquid, as it reduces the costs of offsetting manipulative selling pressure through stock repurchases; the investment opportunity has the potential to generate more income; and managerial incentives are more aligned with those of the firm. The prediction about the asymmetrical impact of financing constraints is a direct consequence of the feedback channel between stock prices and access to external capital.

Since firms with more financial slack depend less on financing from lenders that learn from stock prices, their repurchase and investment decisions should be less responsive to the impact of manipulation on stock prices.

Hypotheses 1 and 2 form the basis of the set empirical analyses performed next. Derivative model implications, such as the use of debt financing and cash savings in association with shorting, are also examined in the data.

4 Sample Formation and Variable Construction

4.1 Sample Formation

Our Markit dataset is merged with data from CRSP and Compustat. We follow related prior literature and exclude firms that have total assets under $10 million, those that have missing entries for sales or cash holdings, and firms that have annual asset or sales growth in excess of 100%. We also remove non-profits and governmental firms. The final sample contains 113,019 firm-quarter observations from more than 4,350 unique firms.

4.2 Variables

Our data analyses start with the estimation of standard empirical models of stock repurchases and investment. This section describes the variables used in our estimations. Additional details on variable construction are given in Appendix B.

4.2.1 Outcome Variables

Our main dependent variables are a firm's stock repurchases and total investment expenditures. *Repurchases* is defined as the ratio of stock repurchases in a given quarter (Compustat's mnemonic *PRSTKC*) scaled by lagged total assets.[8] *Investment* is computed by adding up quarterly capital expenditures (*CAPX*) and R&D expenditures (*XRDQ*), scaling this sum by the firm's assets in the prior quarter. Additional tests consider firms' cash holdings (*Cash*),

[8] Our inferences are the same if we subtract the amount of shares issued from repurchases ("net repurchases").

defined as cash (*CHEQ*) divided by lagged total assets. We also examine debt issuance, defined as the change in short-term and long-term debt (*DLCQ* + *DLTTQ*) divided by lagged assets.

4.2.2 Control Variables

Following prior studies in the stock repurchase literature (e.g., Dittmar (2000) and Grullon and Michaely (2002)), our basic set of control variables includes *Size* (log of Compustat's *ATQ*), *Market-to-Book* ($(PRCC \times CSHO) \div CEQ$), and *Cash Flow* ($IBQ + DPQ$) scaled by lagged total assets. These variables are also commonly used in empirical investment models (e.g., Kaplan and Zingales (1997) and Baker et al. (2003)). Given the documented relations between equity lending, stock liquidity, and institutional ownership (e.g., D'Avolio (2002) and Porras Prado et al. (2016)), our extended control variable set also includes Amihud's (2002) stock liquidity measure (*ILLIQ*), the fraction of total institutional ownership (*Total IO*), and the fraction of ownership held by the largest five institutional investors (*Top5 IO*). Following the monitoring role of large shareholders on the firm (see, e.g., Edmans (2014)), we also include the number of institutional blockholders (*# Blockholders*), defined as those with a stake greater than 5% in the firm, as a proxy for activism. The latter three variables are taken from companies' 13F filings.

4.3 Descriptive Statistics and Variable Correlations

Table 1 reports the descriptive statistics of our sample. *Supply* and *Shortable Supply* represent, on average, about 18% and 14%, respectively, of a firm's total market capitalization. The average quarterly amount of share repurchases corresponds to 0.5% of total assets. On average, firms invest 2.7% of assets every quarter, while keeping about 20% of their total assets as cash; similar to values reported by Bates et al. (2009), among others. The statistics for the variables in our study are similar to those of related studies and we omit a detailed discussion.

TABLE 1 ABOUT HERE

Table 2 reports pairwise correlations for the main variables. Stocks with higher values for *Shortable Supply* — the main proxy for short selling constraints — are associated with larger market capitalization (*Size*) and higher institutional ownership (*Total IO*); they also are cheaper to borrow, have lower liquidity, lower *Bid-Ask* spreads, and higher stock turnover. These results are all in line with prior literature on the characteristics of the equity lending market (see, e.g., D'Avolio (2002) and Porras Prado et al. (2016)).

<u>Table 2 About Here</u>

5 Empirical Testing

5.1 Stock Repurchases and Investment: Baseline Fixed-Effects Estimations

We start our tests of Hypothesis 1 by adding the measure for the net lendable supply of stocks, *Shortable Supply*, to standard corporate stock repurchase and investment models. Our panel data specifications have the following form:

$$Y_{i,t+1} = \alpha + \beta \mathit{Shortable\ Supply}_{i,t} + \gamma' \mathbf{X}_{i,t} + \psi_i + \theta_t + \epsilon_{i,t}. \quad (1)$$

The dependent variable Y is, alternatively, *Repurchases* or *Investment* in the following quarter. The independent variable of interest, *Shortable Supply*, is our empirical proxy for short selling constraints. It captures the net supply of shares available for borrowing at the end of the current quarter. We consider several control variables in the matrix $\mathbf{X}$: *Size*, *Market-to-Book*, *Cash Flow*, *ILLIQ*, *Total IO*, *Top5 IO*, and *# Blockholders.* All estimations include firm-fixed effects, which are captured by the parameter ψ_i. One can think of our results as describing within-firm variation in corporate policies following firm-specific changes in *Shortable Supply.* The models further account for time-fixed effects via θ_t, which absorbs year-quarter-specific variation. Standard errors are double-clustered at the firm and year-quarter levels.[9]

The OLS-FE estimations reported in Table 3 point to a positive response of stock repurchase activity and investment spending to outward shifts in the supply of lendable stocks. The results are economically and statistically significant.[10] For repurchases, the 0.01 coefficient shown in column (2) implies that a one-interquartile range (IQR) change in *Shortable Supply* is associated with a 0.19% (= 0.01 × 19.39%) asset-scaled increase in stock repurchases in the following quarter, equivalent to 37% of the mean. The estimates in columns (3) and (4) point to economically significant increases in investment as well. The coefficient in column (4) implies that a one-IQR change in *Shortable Supply* is associated with a 0.1% increase in investment-to-asset ratios, equivalent to 4% of the *Investment* sample average.

Table 3 About Here

The results in Table 3 are consistent with the equilibrium considered in Hypothesis 1, which posits that firms efficiently increase repurchases to support prices and boost investment following an increase in uninformed manipulation threats. However, they could arguably be consistent with an alternative equilibrium. In particular, in an attempt to secure funding and invest at all times managers could engage in inefficient stock repurchases because of informed trading by speculators, using corporate savings to buy stocks and mitigate the effects of the negative information coming through prices. Our model shows that, because repurchases against informed shorting reduce firm value, managers would refrain from entering into contractual arrangements that lead to such repurchases. Notably, under this inferior equilibrium, managers would conduct stock buybacks both when uninformed and negatively informed about fundamentals, regardless of the degree of short selling constraints. As a result, *Repurchases* and *Investment* would be insensitive to changes in the amount of stocks available for

[9]The standard errors' calculations employ 48 year-quarter- and more than 4,300 firm-clusters. Based on the simulations in Cameron and Miller (2015), the number of clusters in our analysis is well within the range one desires to avoid the issue of over-rejection of the null.

[10]Work on panel data econometrics has emphasized the potential for estimation biases arises from the use of serially correlated variables in regression analysis (see, e.g., Bertrand et al. (2004)). The results in Table 3 are unaffected when estimated using first-differences of all variables instead of levels.

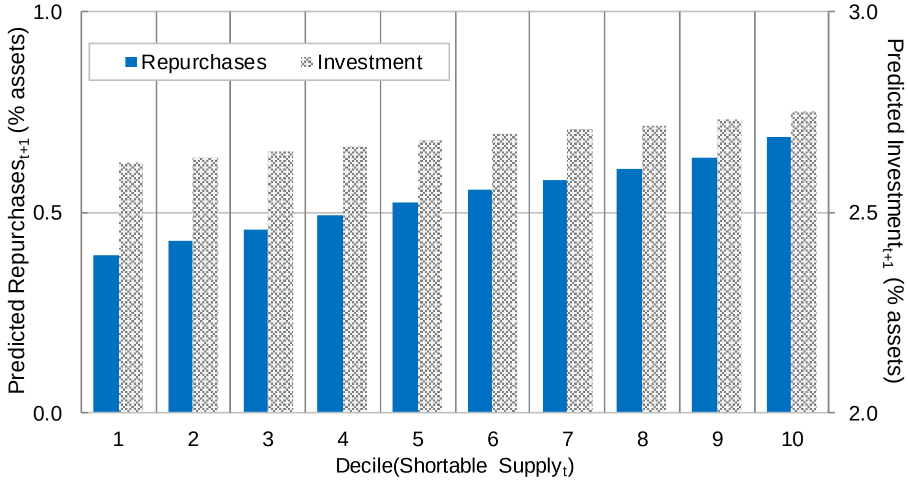
lending. Our findings therefore suggest that managers are efficiently responding to a rise in manipulative shorting threats.

We conclude our baseline tests by noting that inferences based on reported estimates are also limited by the lack of exogenous variation in the supply of lendable stocks. Later in the analysis, we strive to identify the impact of a plausibly-exogenous shift in the supply of lendable stocks on corporate repurchases and investment policies. In particular, building on Grullon et al. (2015), we study the complete repeal of "shorting price tests" — experimentally introduced by Regulation SHO to a subset of Russell 3000 stocks — that took place in July 2007.

5.2 Stock Repurchases and Investment: Monotonicity in Short Selling Constraints

The results in Table 3 conform with the theory that ex–ante financial contracting allows firms to prevent manipulation by repurchasing stocks, implying that *Repurchases* and *Investment* are monotonically decreasing in short selling constraints. However, one could argue that while the *average* responses of stock repurchases and investment to increases in the supply of lendable stocks are positive, these effects could still be *non-monotonic* when examined across the distribution of stocks available for lending. This alternative dynamic would be consistent with managers making financial arrangements ex–post, after capital providers learn about investment fundamentals from stock prices. In this case, a decline in shorting constraints would lead to an increase in the incidence of manipulative shorting, depressing stock prices and prompting lenders to reduce the supply of investment financing. To shore up inferences about the validity of our theoretical argument in the data, we examine whether the relation between corporate policies and *Shortable Supply* found in Table 3 is indeed monotonic. To do so, we estimate a regression similar to column (2) of Table 3, but allow coefficients of *Shortable Supply* to vary across each decile of this measure of stock supply.

Figure 4. Predicted Values of *Repurchases* and *Investment* Across the Distribution of *Shortable Supply*



This figure reports predicted values of *Repurchases* and *Investment* for different points of the *Shortable Supply* distribution. The predictions are based, respectively, on regression similar to columns (2) and (4) of Table 3, but allow coefficients of *Shortable Supply* to vary across each decile. The predicted value for *Repurchases* is computed from the estimated coefficients and the average for *Shortable Supply* in each decile, keeping all other covariates the same.

Figure 4 reports the difference in predicted values of *Repurchases* for different levels of the *Shortable Supply* distribution. The predicted value for *Repurchases* is computed from the estimated coefficients and the average for *Shortable Supply* in each decile, keeping all other covariates equal.[11] Across all deciles, stock repurchases increase monotonically with short selling constraints. Namely, an increase in *Shortable Supply* is associated with an ever increasing response in stock repurchases. For firms in the bottom decile, the predicted value for *Repurchases* is equal to 0.39%, while for firms in the top decile it is equal to 0.69%. Figure 4 shows similar dynamics for *Investment*, which also monotonically increases with *Shortable Supply* across deciles. These results provide further support to our theory, showing that the relations exist for any level of short selling constraints. Critically, as predicted by our model, the variation in stock repurchases is more pronounced at lower levels of short selling constraints (i.e, higher *Shortable Supply*), the region in which manipulation threats are expected to be higher. Overall, our findings suggest that firms and capital providers anticipate the adverse consequences of manipulation by entering into contractual arrangements that lead to the implementation of optimal policies.

[11] We use the "margins" command in Stata to compute predicted values after the regression estimation.

5.3 Other Corporate Policies

Our model predicts that short selling constraints also affect other corporate policies. In particular, it recognizes that firms may pre-arrange financing and keep a portion of raised funds as liquid assets for the purpose of conducting future stock repurchases. In turn, we study how firms choose between different sources of funds when financing their responses to shifts in the supply of lendable stocks. Using our baseline model, we estimate the impact of lendable supply on cash holdings and debt issuance.

Table 4 About Here

Columns (1) and (2) of Table 4 show that an increase in *Shortable Supply* is associated with a measurable increase in cash holdings. The 0.047 coefficient found for *Shortable Supply* in column (2) implies that a one-IQR increase in *Shortable Supply* is associated with a 3.5% (=0.047 × 19.4% / 26.1%) IQR increase in cash holdings. We observe analogous results when examining debt issuance. Firms are more likely to raise debt in funding their responses to increases in the supply of lendable stocks. The 0.022 coefficient reported for *Shortable Supply* in column (4) implies that a one-IQR change in *Shortable Supply* is associated with a 0.43% increase in debt issuance as a fraction of assets.

Taken altogether, results in Tables 3 through 4 are consistent with the model developed in Section 3. Managers seem to react to a decline in short sales constraints by increasing their companies' stock repurchases, investments, cash holdings, and debt. These various policies seem coordinated and internally consistent with the idea that firms significantly alter the management of their resources in responding to shifts in the supply of lendable stocks. In what follows, we present a fuller characterization of our base empirical results to show how they closely conform to finer predictions of our theory.

6 Result Characterization

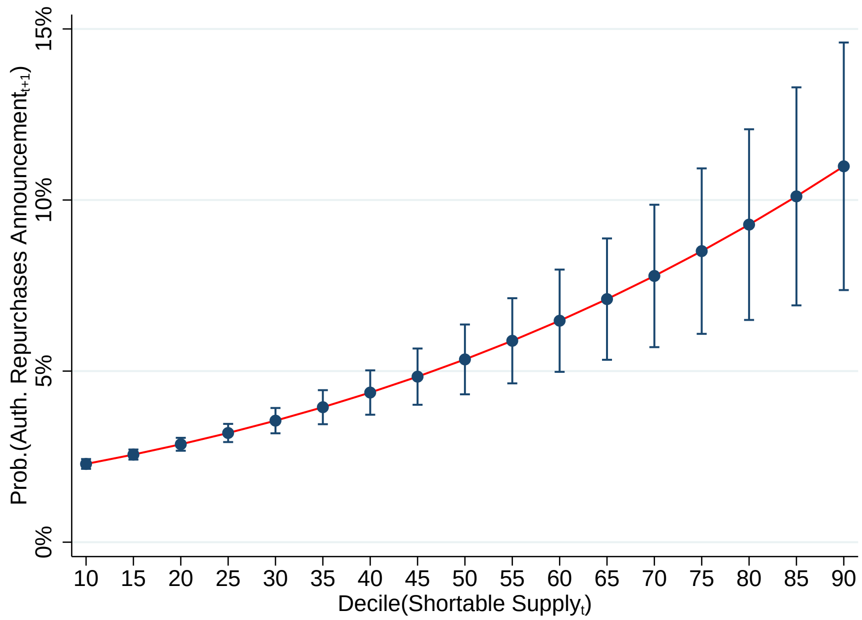
6.1 Authorization of Stock Repurchase Programs

Before a stock buyback can take place, a firm needs to set up a repurchase program, have it authorized by the board, and announced to the market. The announcement alone can act as a signal to short sellers that the firm is willing to support its stock, becoming a deterrent to shorting. While this signal is not costless, it does not require the company to immediately spend resources. Notably, the non-binding nature of program authorizations gives managers the flexibility they need to fine-tune their responses to shorting across time. According to our story, firms facing an increase in the supply of lendable stocks are expected to authorize stock repurchase programs if managers want to preempt shorting activity. We set out to test this finer data characterization in turn.

Using data from SDC Platinum, we collect the dates of all open-market stock repurchase authorizations announced for the firms in our sample. We create an indicator variable, *D(Authorized Repurchases)*, that is equal to 1 if a firm announces the authorization of a buyback program in a given quarter and 0 otherwise. On average, our sample features 310 such announcements per year. Among firms announcing buyback programs, approximately 20% (10%) report *no* repurchase activity over one quarter (year) following the announcement. Only 20% (56%) of the amount authorized under the program is ever repurchased within one quarter (year) of the announcement. These figures speak directly to the idea that while repurchase programs may at times appear to be large, they need not be binding nor fully implemented, hence not necessarily committing firm resources. Their announcement, nonetheless, gives managers the leverage they need in responding to shifts in the supply of lendable stock and sends a signal to potential manipulators about the firm's ability to defend against manipulative shorting.

In Table 5, we estimate two probit models to examine if the likelihood of announcing a repurchase program is driven by *Shortable Supply*. Columns (1) and (2) display estimates from a standard probit model and columns (3) and (4) from a population-averaged model that accounts for firm-specific effects. In all cases, coefficients for *Shortable Supply* are positive and statistically significant.

Figure 5. Probability of Authorized Repurchases



This figure shows the marginal probability of authorized repurchase program announcements in a given quarter across different values of *Shortable Supply*. The estimated probabilities are derived from the probit model estimated in column (2) of Table 5. 90% confidence intervals are shown.

Table 5 About Here

To provide economic intuition for the estimates in Table 5, we compute the marginal probability of a repurchase program announcement for various levels of *Shortable Supply* and place the results in Figure 5. The coefficients shown in column (2) imply that the marginal announcement probability for a firm in the 25^{th} percentile of *Shortable Supply* is around 3%. Firms in the 75^{th} percentile, in contrast, have marginal probabilities that are more than twice as large, around 8%. That is, managers are likely to request a preemptive authorization of share repurchase programs when their firms face an increase in lendable supply. These results are consistent with our model's hypothesis regarding how managers react to the possibility of manipulative shorting.

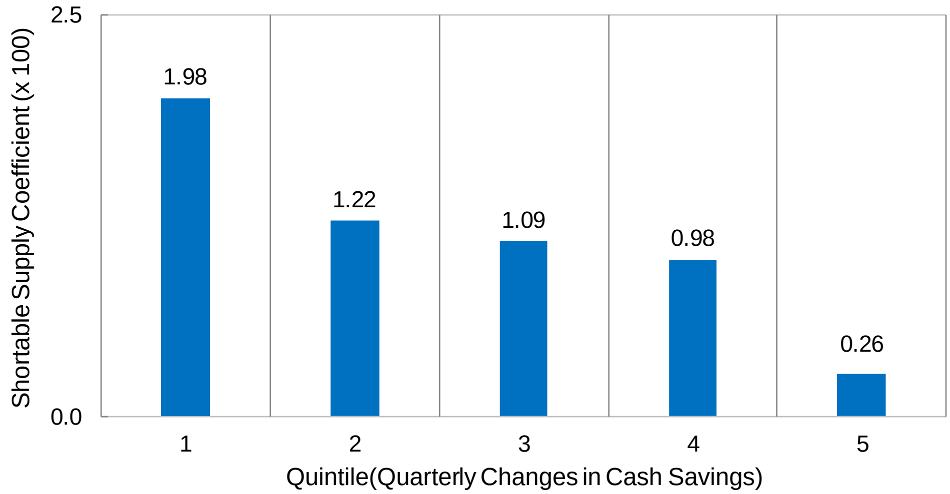
6.2 Loan Fees and Intensity of Short Sales Constraints

An alternative way to measure short sales constraints is to consider the explicit cost of borrowing shares. When shorting, investors consider not only the availability of shares to borrow, but also loan costs. As such, loan fees may contain complementary information relative to the net lendable supply proxy that our previous tests have employed. Our equity lending data contain an explicit measure of the cost to borrow shares, *Fee Score*. This variable ranges from 0 to 5; where 0 is cheapest and 5 denotes the most expensive stocks to borrow. *Fee Score* is constructed using the annualized value-weighted average loan fee of all outstanding stock loans initiated in the past 30 days relative to Markit's proprietary daily benchmark rate. Less than 25% of the stocks have a *Fee Score* greater than zero in our Markit sample, with only 6% being classified with the most expensive value (*Fee Score=5*).

Table 6 repeats our baseline regressions using an indicator variable based on the cost of borrowing shares: *D*(*High Fee*) is equal to 1 if a stock's *Fee Score* is greater than zero; and 0 otherwise. Columns (1) and (2) display results for stock repurchases. Column (1) shows that stocks with higher loan fees observe lower repurchases. In column (2), we add *Shortable Supply* and the cross-product term between *D(High Fee)* and *Shortable Supply*. The *D(High Fee)* coefficient increases from –0.09 to –0.02 and is no longer statistically significant. The negative –0.004 coefficient estimated for the cross-product term implies that an increase in *Shortable Supply* for stocks that are expensive to borrow leads to a lower increase in share repurchases compared to stocks that are cheap to borrow. Columns (3) and (4) consider *Investment*. In column (4), the coefficient for *D(High Fee)* increases relative to the estimate in column (3), but remains significant after controlling for the net lendable supply of stocks. Critically, the cross-product term shows that the impact of *D(High Fee)* on *Investment* is modulated by lendable supply, similar to the case of repurchases.

Table 6 About Here

Figure 6. Estimated *Shortable Supply* Coefficients in *Repurchases* Regressions



This figure shows the total impact of *Shortable Supply* on stock repurchases conditional on changes in cash savings. For each quintile of the distribution of quarterly changes in cash between quarters t and $t+1$, we compute the impact of $Shortable\ Supply_t$ on $Repurchases_{t+1}$ with a regression similar to column (2) of Table 3, but adding the quarterly change in cash savings and its interaction term with *Shortable Supply*.

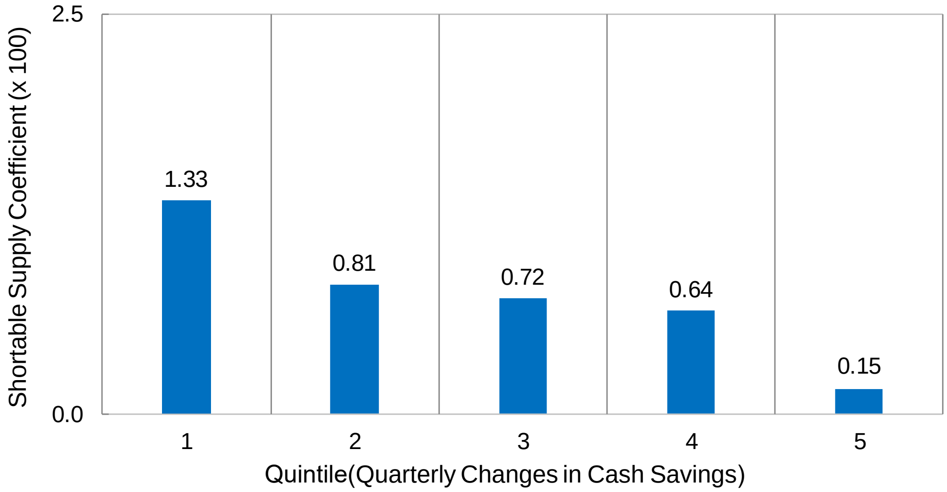
The results in Table 6 show that firms with expensive stocks to borrow not only repurchase fewer shares, but also invest less, consistent with the idea that managers are less reactive to speculative activity when short sales constraints are higher.

6.3 Policy Substitution Effects

Our results show that firms *both* repurchase stocks and save more cash following outward shifts in the lendable supply of stocks. Naturally, corporate resources are limited and, for our proposed mechanism to be warranted, repurchases and savings should show some degree of substitution in achieving a common objective. In particular, it is likely that managers substitute share buybacks with increases in cash balances to deter short sellers, leading to a differential impact of *Shortable Supply* on *Repurchases* conditional on the amount of cash the firm has saved (binding budget constraint). According to our story, an analogous substitution dynamic should also exist between *Shortable Supply* and *Investment*.

In Figure 6, we depict these policies mechanisms by plotting the coefficients of a model of *Repurchases* that is similar to that of Eq. (1), but that adds the change in cash holdings and

Figure 7. Estimated *Shortable Supply* Coefficients in *Investment* Regressions



This figure shows the total impact of *Shortable Supply* on stock repurchases conditional on changes in cash savings. For different percentiles of the distribution of quarterly changes in cash between quarters t and $t+1$, we compute the impact of $Shortable\ Supply_t$ on $Investment_{t+1}$ with a regression similar to column (4) of Table 3, but adding the quarterly change in cash savings and its interaction term with $Shortable\ Supply_t$.

its interaction term with *Shortable Supply* as additional explanatory variables. For different percentiles of the cash savings distribution, we compute the total impact of *Shortable Supply* on *Repurchases*. The figure confirms the existence of a significant substitution effect between repurchases and cash holdings. To wit, the impact of an increase in *Shortable Supply* on stock repurchases is lower for firms that register a large increase in cash balances. For firms in the bottom decile of quarterly changes in cash savings (i.e., $\Delta Cash = -5.7\%$), the estimated effect on next quarter's stock repurchases following a one-IQR increase of lendable supply is 0.3%, while the same effect for firms in tenth decile of $\Delta Cash$ is cut by more than 60%; being equal to only 0.1%. Figure 7 shows analogous substitution dynamics for investment spending. *Investment* does not change as much following an increase in *Shortable Supply* for firms with larger increases in corporate savings in the same quarter.

7 Effect Heterogeneity

We now turn to tests of Hypothesis 2, which predicts that the magnitude of the effect of a reduction in short selling constraints on firm policies depends on various firm characteristics. We investigate several dimensions by which the effects we report vary across firms: (1) stock liquidity, (2) growth opportunities, (3) CEO wealth–performance sensitivity to stock prices, and (4) financing constraints. To cut clutter, we focus on *Repurchases* as the relevant policy variable, collecting all of our results in Table 7 below.

7.1 Stock Liquidity

Hypothesis 2 predicts that the effect of a relaxation in short sales constraints on stock repurchases is stronger for firms with more liquid stocks. The reason is that higher stock liquidity reduces the cost of responding to the threat of shorting, facilitating financing arrangements that induce stock repurchases and lead to more investment. Exploring this proposed mechanism, we use measures of ex–ante liquidity to test if firms react less strongly to increases in the supply of lendable stocks when trading shares is more difficult.

Our tests capture alternative dimensions of stock illiquidity by using two alternative measures: bid-ask spreads (*Bid-Ask*) and stock turnover (*Turnover*). In each quarter, we sort firms according to a given measure in order to identify and compare those firms in the lowest and highest terciles. Accordingly, we create an indicator variable, *D(Sample Split)*, that is equal to one if the firm's stock is "illiquid" in a quarter (i.e., in the top tercile of *Bid-Ask* or in the lowest tercile of *Turnover*) and equal to zero if it is "liquid" (in the bottom tercile of *Bid-Ask* or in the top tercile of *Turnover*). We estimate a model similar to that presented in Table 3, but include *D(Sample Split)* and the *Shortable Supply*×*D(Sample Split)* interaction term as additional variables. The models we estimate can be written as:

$$
\begin{aligned}
Repurchases_{i,t+1} &= \alpha + \beta_1 Shortable\ Supply_{i,t} + \beta_2 D(Sample\ Split)_{i,t} \\
&\quad + \beta_3 Shortable\ Supply_{i,t} \times D(Sample\ Split)_{i,t} \\
&\quad + \gamma' \mathbf{X}_{i,t} + \psi_i + \theta_t + \epsilon_{i,t}. \qquad (2)
\end{aligned}
$$

Across both illiquidity measures under columns (1) and (2) in Table 7, we find that more illiquid stocks exhibit a lower sensitivity of stock repurchases to changes in the supply of lendable stocks. The results are consistent with our hypothesis that managers of illiquid firms need to repurchase relatively fewer shares to achieve a given price impact. Column (2), for example, implies that a unit increase in *Shortable Supply* increases stock repurchases by 0.015 for firms in the top tercile of stock turnover, but by only 0.004 for those in the lowest tercile. Consistent with our proposed theory, the degree by which investors can easily trade shares is taken into account by managers when deciding how to respond to changes in the supply of lendable stocks.

TABLE 7 ABOUT HERE

7.2 Growth Opportunities

We also investigate how companies' growth opportunities modulate the impact of lendable supply on firm policies. According to Hypothesis 2, growth firms will exhibit relatively larger increases in repurchases following a decrease in short sales constraints. This prediction is derived from the ability of growth firms to pledge more future income to lenders, allowing them to raise the necessary funds for stock repurchases and investment more easily. In column (3) of Table 7, we use market-to-book ratios to measure growth opportunities. The indicator variable *D(Sample Split)* in column (3) assigns the value of one (or zero) to firms in the top (bottom) tercile of the *Market-to-Book* distribution.

The *D(Sample Split)* coefficient shows that repurchases are higher when firms have high market-to-book ratios. Notably, the coefficient for the interaction between *Shortable Supply* and *D(Sample Split)* is positive and statistically significant. The effects of shifts in the supply of lendable stocks on repurchases are indeed greater for firms whose stocks are likely to be perceived as having higher growth opportunities.

7.3 Managerial Incentives

Hypothesis 2 predicts that managers are more likely to repurchase shares to support stock prices when their interests are more aligned with those of the firm. Better managerial incentives allow the firm to pledge more of its future income to lenders, increasing the firm's debt capacity and boosting its ability to conduct stock repurchases that offset selling pressure from manipulating speculators. We use the wealth–performance sensitivity measure, *CEO WPS*, proposed by Edmans et al. (2009), as a proxy for the alignment of managerial incentives. This measure is defined as the dollar change in CEO wealth for a one-percent change in firm value, divided by annual flow compensation. The *D(Sample Split)* variable is equal to one for firms in the top tercile of *CEO WPS* and zero for those in the bottom tercile. Our tests evaluate how the impact of *Shortable Supply* varies with managerial wealth sensitivity to stock prices. The estimated 0.012 coefficient for the *Shortable Supply*×*D(Sample Split)* interaction in column (4) of Table 7 is quite revealing. It implies that high (top tercile) *CEO WPS* firms repurchase more than twice as many shares than firms in the bottom tercile of *CEO WPS* following an increase in lendable supply. In other words, managers are far more likely to initiate stock repurchase programs when the value of their personal compensation packages are threatened by shorting activity that is facilitated by increases in the supply of lendable stocks.

7.4 Financing Constraints

Finally, we examine how a firm's degree of financing constraints affects its response to a change in *Shortable Supply*. Hypothesis 2 predicts that managers of financially constrained firms will repurchase more shares in response to a reduction in short selling constraints. The reason is that manipulation is more likely to affect firms whose projects depend more on external funds to be financed, since outside investors condition the provision of funds on information extracted from prices. We proxy for financing constraints using the availability of credit ratings for either corporate bonds or commercial paper issued by the firm (cf., e.g., Almeida et al. (2004)). *D(Sample Split)* is equal to one if the firm does not have an outstanding rating on those credit securities, zero otherwise. Column (5) shows that the *Shortable Supply*×*D(Sample Split)* interaction coefficient is positive and equal to 0.004. This estimate is remarkable as it implies that financially constrained firms exhibit a 40% larger reaction to an increase in shortable supply than unconstrained firms, consistent with our theoretical model. It further suggests that financially constrained firms are the ones that benefit the most from contractual arrangements that allow for the prevention of manipulation through stock repurchases.

It is worth highlighting that the results reported in this section are important to validate our proposed model along several dimensions. They show that increases in the net supply of lendable stocks lead company managers to conduct more aggressive buyback policies when their stocks are ex–ante more liquid and when firms have higher growth opportunities prior to shifts in net lendable supply of stocks. Notably, managers are also more reactive when their personal wealth is more sensitive to stock price fluctuations and when their firms have more difficulty to obtain external funds. These results help us rule in and rule out different potential explanations for our baseline findings, when empirical identification is challenging. They further provide support for our theory on a number of dimensions and add to the literature examining the channels through which short sales constraints affect corporate policies.

8 Robustness: A Design-Based Testing Strategy

In June 2004, the SEC put forth Reg SHO, changing rules governing short selling activity in the stock market (see Grullon et al. (2015) and Fang et al. (2016) for details). Before Reg SHO, a short sale could only occur at a price greater than the last trading price. Under Rule 202T, firms in the Russell 3000 Index were ranked by trading volume and every third firm was selected to take part in a pilot trial, having their shares exempt from price tests. The program started on May 2005, with a trial group of 1,000 stocks included in the pilot phase. The remaining 2,000 stocks in the Russel Index were excluded from the pilot.

In June 2007, the SEC announced that price tests would be abolished for *all* remaining stocks. This extension of Reg SHO allows us to design a quasi-randomized test strategy in checking the robustness of our base tests.[12] To wit, it was ruled that the 2,000 stocks excluded from the pilot phase would no longer be subject to price tests starting from July 2007 onwards. This sharp rule eliminated a barrier to shorting, instantaneously increasing the demand for shorting without a concomitant effect on the supply of available shares. The repeal of price tests led to a decline in the *net* lendable supply of shares (i.e., *Shortable Supply*), making it relatively more difficult for investors to locate shares for borrowing in the months following the ruling. We examine this argument in Table 8, where we report group-mean differences around the full repeal of price tests for *On Loan*, *Shortable Supply*, *Repurchases*, and *Investment*. We compute estimates for the 2,000 non-pilot firms (*Non-Reg SHO Pilot*) and the 1,000 pilot firms (*Reg SHO Pilot*) in the four quarters before and after the removal of price tests in July 2007 in our sample. For the purpose of our Reg SHO repeal test, firms in the first category (2,000 firms) are deemed as "treated," while those in the latter group (1,000 firms) can be seen as "controls."

The estimates reported in Table 8 provide the elements we need to use the full repeal of price tests as a surrogate for an exogenous shift in the supply of lendable stocks. Panel A reports cross-group comparisons of the main "shifters" of shorting. First, notice that figures for *On Loan* confirm the prior that shorting demand increased relatively more for the treatment group (*Non-Reg SHO Pilot* firms) than for the control group (*Reg SHO Pilot* firms), as the shorting constraints of the former group declined with the repeal of the price tests. Before the 2007 repeal, *On Loan* was lower for treated firms than for control firms (6.9% versus 7.3%), becoming statistically indistinguishable afterwards (9.1% versus 9.0%). The associated differences-in-differences estimate is significant at the 5% test level. Importantly for our purposes, nearly by construction, it follows from the increase in *On Loan* that *Shortable Supply* increases less for the treatment group than the control group after the repeal. That is, our set

[12] Our equity lending data begin do not fully cover the period around the beginning of Reg SHO, as such we exploit the *repeal* of price tests in July 2007. This testing strategy is also used by Grullon et al. (2015) when performing robustness tests for their 2005 Reg SHO test results.

of treated firms observe a relative decline in the net supply of lendable (shortable) stocks.

<u>Table 8 About Here</u>

According to our model, the decline in net lendable supply triggered by the end of price tests in July 2007 should lead to a relative reduction in stock repurchases and investment spending for the 2,000 treated (*Non-Reg SHO Pilot*) firms relative to the control group (*Reg SHO Pilot* firms). This is what we find in Panel B of Table 8, where we examine the effect of the repeal of of price tests on our main outcome variables. For *Repurchases*, the difference between stocks in the treatment and control groups is no longer statistically significant after the price test repeal. The differences-in-differences is equal to –0.24 and statistically significant. To give context to the dynamics represented in the table, notice that the control firms (*Reg SHO Pilot*) register a secular increase in repurchases around July 2007. But such an increase is not observed for the treated firms (*Non-Reg SHO Pilot*); hence, the relative decline of repurchases by firms in the treatment group. In an analogous fashion, we also observe a relatively higher decline in *Investment* for *Non-Reg SHO Pilot* firms, with a –0.11 differences-in-differences value.

A limitation of the univariate analysis performed in Table 8 is that it does not account for variation in other firm characteristics. The tests of Table 9, in turn, utilize a differences-in-differences-in-differences multivariate set-up to study how firm reactions to the end of shorting price tests vary with the pre-existing net supply of lendable shares. To wit, one would expect corporate reactions to the repeal of price tests to be modulated by investors' ability to locate stocks for shorting.[13] That is, the decline in repurchases and investment observed for the treatment (*Non-Reg SHO Pilot*) firms due to the decline in *Shortable Supply* after the repeal of price tests, should be relatively smaller for stocks that were easier to sell short before July 2007 — a higher ex–ante *Shortable Supply* would dampen the ex–post impact of the repeal.

[13]Duffie et al. (2002) shows that stocks with lower search costs in the equity lending market are easier and cheaper to borrow.

This conjecture motivates the following test specification:

$$
\begin{aligned}
Y_{i,t} \;=\; & \alpha + \beta_1 D(\mathit{Repeal})_t \times D(\mathit{Non\text{-}Reg\ SHO\ Pilot})_i \\
& + \beta_2 D(\mathit{Repeal})_t \times \mathit{Shortable\ Supply}_{i,June07} \\
& + \delta D(\mathit{Repeal})_t \times D(\mathit{Non\text{-}Reg\ SHO\ Pilot})_i \times \mathit{Shortable\ Supply}_{i,June07} \\
& + \gamma' \mathbf{X}_{i,t} + \psi_i + \theta_t + \epsilon_{i,t}. \qquad (3)
\end{aligned}
$$

The indicator variable *D(Repeal)* is equal to one in the four quarters after June 2007, when the uptick price test was removed for all stocks, and zero otherwise. *D(Non-Reg SHO Pilot)* is equal to one for firms in the treatment category; that is, those excluded from the Reg SHO 2005 pilot and still subject to price tests in July 2007, and zero otherwise. The variable $\mathit{Shortable\ Supply}_{June07}$ denotes the firm-specific value for net lendable supply in June 2007, the quarter-end prior to the repeal of the price test. The main parameter of interest is captured by δ, which measures how *ex–ante* shortable supply ($\mathit{Shortable\ Supply}_{June07}$) affects the magnitude by which firms in the treatment group ($D(\mathit{Non\text{-}Reg\ SHO\ Pilot}) = 1$) change their policies (Y) after price tests are removed ($D(\mathit{Repeal}) = 1$). The estimation considers data from four quarters before through four quarters after the removal of the price tests. All regressions have firm- and year-quarter-fixed effects. Note that adding firm-fixed effects make firm-invariant variables redundant (e.g., *D(Non-Reg SHO Pilot)* and $\mathit{Shortable\ Supply}_{June07}$), while adding time-fixed effects make time-invariant variables redundant (i.e., *D(Repeal)*), eliminating them from the estimation output.

TABLE 9 ABOUT HERE

The estimates under column (1) of Table 9 show that treated firms repurchased relatively fewer shares than control firms after July 2007; the $D(\mathit{Repeal}) \times D(\mathit{Non\text{-}Reg\ SHO\ Pilot})$ interaction coefficient is equal to –0.43. This result confirms the inferences drawn from Table 8. This reduction also varies with the level of net lendable supply that is observed right before the repeal of the price tests. As hypothesized, the decline in repurchases is less negative if the firm has a higher lendable supply of shares. The coefficient for the triple interaction term is equal to

0.025 and is statistically significant at the 1% test level. Its economic effect is also significant: the 25^{th} (75^{th}) percentile of the *Shortable* $Supply_{June07}$ distribution is equal to 10.9% (25.8%), implying that the relative difference in repurchases after the repeal of prices tests due to a one-IQR difference in *Shortable* $Supply_{June07}$ is equal to 0.43%. These results are consistent with our model's hypothesis that managers repurchase relatively more shares when speculators find it easier to short them. In column (2), we examine investment. Treated firms (*D(Non-Reg SHO Pilot)*) are found to invest relatively less than control firms after the repeal of price tests. Similarly to the dynamics affecting stock repurchases, the impact of removing short sales price tests on investment depends on ex–ante shorting constraints. The estimated relative decline in investment for firms in the 25^{th} percentile of *Shortable* $Supply_{June07}$ relative to those in the 75^{th} percentile is –0.18%. In columns (3) and (4), we observe analogous implications when examining cash holdings and debt issuance.

In all, results stemming from the full repeal of short sales price tests that followed from the extension of Regulation SHO in 2007 confirm our base findings that differences in the net lendable supply of a stock have measurable impacts on various corporate policies. Addressing potential biases due to endogeneity is a difficult task in our setting, yet results in Tables 8 and 9 are consistent with the model's predictions and the role of equity lending in affecting corporate behavior.

9 Concluding Remarks

This paper examines whether and how the recent surge in equity lending activity has shaped managerial actions. Our results imply that managers react to an increase in the ease of shorting shares in their companies by increasing stock repurchase activity and corporate investment, consistent with the notion of supporting share prices against speculative trading. Firms also accumulate cash and issue debt. Our results suggest that these policies seem coordinated and internally consistent with the goal of responding to speculative shorting. Our empirical findings are consistent with the hypotheses generated from a theory we advance in the paper.

Notably, the effects we document are stronger for firms whose stocks are more liquid, firms that have higher growth opportunities, tighter financing constraints, and when managers' personal compensation is more sensitive to stock prices. Our analysis uncovers important, new effects that capital markets and institutions exert on corporate policies. The equity lending market is a large — yet understudied in the corporate finance literature — source of short selling constraints. It is the *locus* in which short sellers operate, engaging with lenders who supply the stocks they want to short. Understanding the impact of this market on corporate policies is important for researchers, managers, and policymakers alike, as capital markets evolve and present new challenges to all of its participants.

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Appendix A

Proof of Proposition 1. [Proof of Proposition 1] We first analyze the optimal strategies in $t = 2$ for any reachable information set after the period-1 trade. Next we examine the optimal strategies in $t = 1$.

- Trading in $t = 2$

The possible information sets after trading takes place in $t = 1$ are as follows: (i) the order flow Q_1 perfectly reveals the speculator's information; (ii) the order flow Q_1 reveals that she is not informed about the low state; (iii) the order flow Q_1 reveals that she is not informed about the high state; (iv) the order flow Q_1 reveals that the speculator is not uninformed; and (v) the order flow does not reveal any information. Conditional on the information set, the speculator chooses u_2 to maximize her payoff, $u_1\pi E\left[V\left(k,\omega\right)-k-p_1\left(Q_1\right)|s,Q_1,u_2\right]-1_{\{u_1=-1\}}\pi c+u_2\pi E\left[V\left(k,\omega\right)-k-p_2\left(Q_1,Q_2\right)|s,Q_1,u_2\right]-1_{\{u_2=-1\}}\pi c$. Note that the speculator's strategy in $t = 2$ is independent from: (a) the order size π, such that we take $\pi = 1$ without loss of generality; and (b) the action chosen in $t = 1$ unless u_2 affects the firm value $V\left(k,\omega\right)-k$ through the investment policy k.

Case (i): The market price reflects the expected firm value given the speculator's information, $p_1\left(Q_1\right)=E\left[p_2\left(Q_1,Q_2\right)|s,Q_1,u_2\right]=E\left[V\left(k,\omega\right)-k|s,Q_1,u_2\right]$. Thus, the speculator is indifferent between buying and not trading in $t = 2$ as both yield a profit of zero. If speculator sells, there is a loss of $-c$. Therefore, she either buys or does not trade.

Case (ii): In equilibrium, the uninformed speculator does not buy and the speculator informed about the high state does not sell in $t = 2$ if $\frac{V^+-V^-}{4}-c>0$. If the speculator informed about the high state buys, the uninformed speculator sells if $\frac{\alpha}{2-\alpha}\frac{V^+-V^-}{4}>c$. Note that $E\left[\phi V\left(K,\omega\right)-K|Q_1,Q_2\right]>0$ under (ii), which implies that the firm always invests $(k=K)$ and the speculator's strategy in $t = 2$ is independent from what happened in $t = 1$. Thus, we examine only the period-2 trade profit.

Suppose by way of contradiction that the uninformed speculator buys in equilibrium. It follows that the speculator informed about the high state also buys. If she sells instead, then: with probability $\frac{1}{2}$ the order flow equals $Q_2 = 0$ and $p_2\left(\cdot,0\right)=\frac{\alpha}{2-\alpha}\left(V^+-K\right)+\frac{2(1-\alpha)}{2-\alpha}\left(\frac{V^++V^-}{2}-K\right)$; and with probability $\frac{1}{2}$ the order flow equals $Q_2=-2$ and $p_2\left(\cdot,-2\right)=V^+-K$. Therefore, her expected profit equals $\frac{p_2(\cdot,0)}{2}+\frac{p_2(\cdot,-2)}{2}-\left(V^+-K\right)-c<0$. Hence, she does not sell as she can assure a payoff of zero by not trading. If she does not trade her profit is zero, which implies she has an incentive to deviate and buy since in this case $p_2\left(\cdot,\cdot\right)=\frac{V^++V^-}{2}-K$ and her profit equals $V^+-K-p_2\left(\cdot,\cdot\right)>0$. But there cannot be an equilibrium in which both speculators buy, as the uninformed speculator loses money in this case: the period-2 price is $p_2\left(\cdot,\cdot\right)=\frac{\alpha}{2-\alpha}\left(V^+-K\right)+\frac{2(1-\alpha)}{2-\alpha}\left(\frac{V^++V^-}{2}-K\right)$ and her profit equals $\frac{V^++V^-}{2}-K-p_2\left(\cdot,\cdot\right)<0$. Hence, the uninformed speculator does not buy in equilibrium.

Suppose by way of contradiction that the speculator informed about the high state sells in equilibrium. It follows that the uninformed speculator also sells. If she buys instead, then: with probability $\frac{1}{2}$ the order flow equals $Q_2 = 0$ and $p_2\left(\cdot,0\right)=\frac{\alpha}{2-\alpha}\left(V^+-K\right)+\frac{2(1-\alpha)}{2-\alpha}\left(\frac{V^++V^-}{2}-K\right)$; and with probability $\frac{1}{2}$ the order flow equals $Q_2 = 2$ and $p_2\left(\cdot,2\right)=\frac{V^++V^-}{2}-K$. Therefore, her expected profit equals $\frac{V^++V^-}{2}-K-\left(\frac{p_2(\cdot,0)}{2}+\frac{p_2(\cdot,2)}{2}\right)<0$. Hence, she does not buy as she can assure a payoff of zero by not trading. If she does not trade her profit is zero, which implies that she has an incentive to deviate and sell, since in this case $p_2(\cdot,\cdot) = V^+ - K$ and her profit equals $p_2(\cdot,\cdot) - \left(\frac{V^+ + V^-}{2} - K\right) - c = \frac{V^+ - V^-}{2} - c > 0$. But there cannot be an equilibrium in which both speculators sell, as the speculator informed about the high state loses money in this case: the period-2 price is $p_2(\cdot,\cdot) = \frac{\alpha}{2-\alpha}(V^+ - K) + \frac{2(1-\alpha)}{2-\alpha}\left(\frac{V^+ + V^-}{2} - K\right)$ and her profit equals $p_2(\cdot,\cdot) - (V^+ - K) - c < 0$; hence, she does not sell as she can guarantee a payoff of zero by not trading.

Now suppose that the speculator informed about he high state buys in equilibrium. If the uninformed speculator sells, her profit is determined as follows: with probability $\frac{1}{2}$ the order flow is $Q_2 = 0$ and $p_2(\cdot,0) = \frac{\alpha}{2-\alpha}(V^+ - K) + \frac{2(1-\alpha)}{2-\alpha}\left(\frac{V^+ + V^-}{2} - K\right)$, generating a profit of $p_2(\cdot,0) - \left(\frac{V^+ + V^-}{2} - K\right) - c = \frac{\alpha}{2-\alpha}\frac{V^+ - V^-}{2} - c$; with probability $\frac{1}{2}$ the order flow is $Q_2 = -2$ and $p_2(\cdot,-2) = \frac{V^+ + V^-}{2} - K$, yielding a profit of $p_2(\cdot,-2) - \left(\frac{V^+ + V^-}{2} - K\right) - c = -c$; hence, her expected profit is $\frac{\alpha}{2-\alpha}\frac{V^+ - V^-}{4} - c > 0$. If she deviates and buys, then: with probability $\frac{1}{2}$ the order flow equals $Q_2 = 0$ and $p_2(\cdot,0) = \frac{\alpha}{2-\alpha}(V^+ - K) + \frac{2(1-\alpha)}{2-\alpha}\left(\frac{V^+ + V^-}{2} - K\right)$; and with probability $\frac{1}{2}$ the order flow equals $Q_2 = 2$ and $p_2(\cdot,2) = V^+ - K$; hence, her expected profit equals $\frac{V^+ + V^-}{2} - K - \left(\frac{p_2(\cdot,0)}{2} + \frac{p_2(\cdot,2)}{2}\right) < 0$, which implies she does not have an incentive to deviate and buy.

If the uninformed speculator does not trade, her profit is zero. If she deviates and buys then $p_2(\cdot,\cdot) = V^+ - K$ and her profit equals $\frac{V^+ + V^-}{2} - K - p_2(\cdot,\cdot) < 0$, which implies she does not have an incentive to deviate and buy. If she deviates and sells, then: with probability $\frac{1}{2}$ the order flow equals $Q_2 = 0$ and $p_2(\cdot,0) = V^+ - K$; and with probability $\frac{1}{2}$ the order flow equals $Q_2 = -2$ and $p_2(\cdot,-2) \geq \frac{V^+ + V^-}{2} - K$; hence her expected profit is at least $\frac{p_2(\cdot,0)}{2} + \frac{1}{2}\left(\frac{V^+ + V^-}{2} - K\right) - \left(\frac{V^+ + V^-}{2} - K\right) - c = \frac{V^+ - V^-}{4} - c > 0$, which implies she has an incentive to deviate and sell.

Now suppose that the uninformed speculator sells. If the speculator informed about the high state buys, her profit is determined as follows: with probability $\frac{1}{2}$ the order flow equals $Q_2 = 0$ and $p_2(\cdot,0) = \frac{\alpha}{2-\alpha}(V^+ - K) + \frac{2(1-\alpha)}{2-\alpha}\left(\frac{V^+ + V^-}{2} - K\right)$; and with probability $\frac{1}{2}$ the order flow equals $Q_2 = 2$ and $p_2(\cdot,2) = V^+ - K$; hence her expected profit is $V^+ - K - \left(\frac{p_2(\cdot,0)}{2} + \frac{p_2(\cdot,2)}{2}\right) > 0$. If she deviates and sells, then: with probability $\frac{1}{2}$ the order flow equals $Q_2 = 0$ and $p_2(\cdot,0) = \frac{\alpha}{2-\alpha}(V^+ - K) + \frac{2(1-\alpha)}{2-\alpha}\left(\frac{V^+ + V^-}{2} - K\right)$; and with probability $\frac{1}{2}$ the order flow equals $Q_2 = -2$ and $p_2(\cdot,-2) \leq V^+ - K$; hence, her expected payoff is at most $\frac{p_2(\cdot,0)}{2} + \frac{1}{2}(V^+ - K) - (V^+ - K) - c < 0$, which implies that she does not have an incentive to deviate and sell.

If she does not trade, her profit is zero which implies she has an incentive to deviate and buy: with probability $\frac{1}{2}$ the order flow is $Q_2 = 2$ and $p_2(\cdot,2) \leq V^+ - K$; and with probability $\frac{1}{2}$ the order flow is $Q_2 = 0$ and $p_2(\cdot,0) = \frac{V^+ + V^-}{2} - K$; hence, her expected profit is at least $V^+ - K - \left(\frac{p_2(\cdot,0)}{2} + \frac{p_2(\cdot,2)}{2}\right) > 0$, which implies that she has an incentive to deviate buy.

Case (iii): Neither the uninformed speculator nor the speculator informed about the low state sells in $t = 2$ in equilibrium if $\frac{V^+ - V^-}{4} - c > 0$, yielding to both speculators a period-2 trade payoff equal to zero. In order to see this, note that because the strategies played in $t = 2$ affect the value of the investment (as it may or may not occur), they also impact the payoffs of period-1 trades. Therefore, we split our analysis in three cases: the speculator informed about the low state (a) sells, (b) does not trade, or (c) buys in $t = 1$.

In (A), the speculator informed about the low state does not sell in $t = 2$. By way of contradiction, suppose she does. In this case, her payoff is $p_1(\cdot) - 2c$. Therefore, she is better of deviating and choosing not to trade in $t = 2$, as her payoff is at least $p_1(\cdot) - c$; her payoff is higher if the beliefs associated with $Q_2 \in \{-1, 1\}$ result in a pledgeable greater than K, as in this case investment occurs and she earns $p_1(\cdot) - (V^- - K) - c > p_1(\cdot) - c$. Thus, if (A) holds, the speculator informed about the low state does not sell in $t = 2$. In turn, this implies that the uninformed speculator does not sell as well: if she does, then the speculator informed about the low state has an incentive to deviate and sell, as this would yield a payoff of at least $p_1(\cdot) - \frac{1}{2}\left[(V^- - K) - \left(\frac{V^+ + V^-}{2} - K\right)\right] - 2c = p_1(\cdot) + \frac{V^+ - V^-}{4} - 2c > p_1(\cdot) - c$. Therefore, neither speculator sells in $t = 2$ under (a), resulting in a period-2 trade payoff of zero.

Next, we show that either (c) does not occur in equilibrium under (iii) or, when it does, neither speculator sells in $t = 2$. Suppose there exists an equilibrium in which (c) and (iii) hold simultaneously and at least one speculator sells in $t = 2$. A profile of period-1 strategies generates the information set of case (iii) with positive probability if and only if the uninformed speculator either buys or sells. If the uninformed speculator sells in $t = 1$, it must be that the speculator informed about the high state does not trade. In this case, the speculator informed of the low state can increase her payoff by adopting the following strategy: she deviates and sells in $t = 1$; if $Q_1 = -2$, she does not trade in $t = 2$; if $Q_1 = 0$, she conforms with the period-2 equilibrium strategy. This strategy yields the same period-2 equilibrium trade payoff when $Q_1 = 0$ (probability $\frac{1}{2}$), but results in a higher payoff for the period-1 trade: in the assumed equilibrium, her type is revealed when $Q_1 = 2$ (probability $\frac{1}{2}$), generating a profit of zero; the deviation earns $\frac{V^+ + V^-}{2} - K - (V^- - K) - c$ when $Q_1 = -2$ (probability $\frac{1}{2}$). Therefore, the overall profit gain from the deviation is $\frac{V^+ - V^-}{4} - c > 0$. Thus, (c) and (iii) cannot both occur in equilibrium when the uninformed speculator sells in $t = 1$.

If instead the uninformed speculator buys in $t = 1$, then in any equilibrium both the uninformed speculator and the speculator informed about the low state must choose the same strategy in $t = 2$. By way of contradiction, suppose there exists an equilibrium in which they do not. Then it follows that $p_1(\cdot) > 0$, since investment occurs when the uninformed speculator is revealed (which occurs with positive probability). In this case, the speculator informed of the low state can increase her payoff by deviating and not trading both in $t = 1$ and $t = 2$: in the proposed equilibrium she knows that investment never occurs (regardless of whether she is revealed or not in $t = 2$), such that her payoff is at most $-p_1(\cdot) < 0$; the deviation secures her a payoff of zero. Now, given that they must choose the same strategy in $t = 2$ in equilibrium, then it cannot be that both sell. If they do, investment never occurs and the overall payoff of the uninformed speculator is $-c$; however she can secure a payoff of at least zero by deviating and not trading in $t = 2$ (her payoff is higher if the beliefs associated with $Q_2 \in \{-1, 1\}$ result in a pledgeable greater than K, as in this case investment occurs and she earns $\frac{V^+ + V^-}{2} - K$). Therefore, if (a) and (iii) hold, neither speculator sells in $t = 2$.

Finally, let us consider (b). In this situation, the period-1 trades do not affect the period-2 decisions, so we can focus on the period-2 trade payoffs. It turns out that the uninformed speculator does not sell and is indifferent between buying and not trading in equilibrium. If she sells (buys) and her type is revealed, investment occurs since the pledgeable income equals $\phi\frac{V^{+}+V^{-}}{2} > K$. In this case, she makes a profit of $p_2(\cdot,\cdot) - \left(\frac{V^{+}+V^{-}}{2} - K\right) - c = -c$ $\left(\frac{V^{+}+V^{-}}{2} - K - p_2(\cdot,\cdot) = 0\right)$. If her type is not revealed, investment does not occur as the pledgeable income equals $\phi\frac{V^{-}+(1-\alpha)V^{+}}{2-\alpha} < K$. Thus, she makes a profit of $p_2(\cdot,\cdot) - 0 - c = -c$ $(0 - p_2(\cdot,\cdot) = 0)$. Hence, the speculator does not sell and is indifferent between trading and not trading.

Similarly, the speculator informed about the low state does not sell and is indifferent between buying and not trading in equilibrium. Investment never occurs since the pledgeable income is $\phi V^{-} < K$ if her type is revealed or $\phi\frac{V^{-}+(1-\alpha)V^{+}}{2-\alpha} < K$ if otherwise. When she sells (buys) her profit equals $p_2(\cdot,\cdot) - 0 - c = -c$ $(0 - p_2(\cdot,\cdot) = 0)$. Hence, she does not sell and is indifferent between buying or not trading. Therefore, none of them sells in $t = 2$ under (b), resulting in a period-2 payoff of zero.

Case (iv): The speculator informed about the high state does not sell in $t = 2$ in equilibrium if $\frac{V^{+}-V^{-}}{2} - c > 0$. Suppose by way of contradiction that she does. In this case, the speculator informed about the low state also sells in any equilibrium. Suppose instead that the speculator informed about the low state either (a) does not trade or (b) buys in $t = 2$. In (a), her profit is $-p_1(\cdot)$ if she buys in $t = 1$, zero if she does not trade, and $p_1(\cdot) - c$ if she sells; if she deviates and sells in $t = 2$ instead, her profit equals $p_2(\cdot,\cdot) - p_1(\cdot) - c = \frac{V^{+}+V^{-}}{2} - K + \frac{V^{+}-V^{-}}{2} - p_1(\cdot) - c > -p_1(\cdot)$ if she buys in $t = 1$, $p_2(\cdot,\cdot) - (V^{-} - K) - c = V^{+} - V^{-} - c > 0$ if she does not trade, and $p_1(\cdot) - (V^{-} - K) - c + p_2(\cdot,\cdot) - (V^{-} - K) - c = p_1(\cdot) - c + V^{+} - V^{-} - (V^{-} - K) - c > p_1(\cdot) - c$ if she sells. Therefore, she has an incentive to deviate and sell, which contradicts (a); hence she trades.

In (b), her profit is $\frac{V^{-}-K}{2} - p_1(\cdot) + \frac{1}{2}(0 - p_2(\cdot,2)) + \frac{1}{2}[V^{-} - K - p_2(\cdot,0)] = \frac{V^{-}-K}{2} - p_1(\cdot) - \frac{V^{+}-V^{-}}{4}$ if she buys in $t = 1$, $-\frac{V^{+}-V^{-}}{4}$ if she does not trade, and $p_1(\cdot) - \frac{V^{-}-K}{2} - c + \frac{1}{2}(0 - p_2(\cdot,2)) + \frac{1}{2}[V^{-} - K - p_2(\cdot,0)] = p_1(\cdot) - c - \frac{1}{2}\left(\frac{V^{+}+V^{-}}{2} - K\right)$ if she sells; if she deviates and sells in $t = 2$ instead, her profit equals $V^{-} - K - p_1(\cdot) + \frac{1}{2}[p_2(\cdot,0) - (V^{-} - K)] + \frac{1}{2}[p_2(\cdot,-2) - (V^{-} - K)] - c = \frac{V^{+}-V^{-}}{4} + \frac{V^{+}+V^{-}}{2} - K - p_1(\cdot) - c > \frac{V^{-}-K}{2} - p_1(\cdot) - \frac{V^{+}-V^{-}}{4}$ if she buys in $t = 1$, $\frac{V^{+}-V^{-}}{4} + \frac{V^{+}-V^{-}}{2} - c > -\frac{V^{+}-V^{-}}{4}$ if she does not trade, and $p_1(\cdot) - (V^{-} - K) - c + \frac{1}{2}[p_2(\cdot,0) - (V^{-} - K)] + \frac{1}{2}[p_2(\cdot,-2) - (V^{-} - K)] - c = p_1(\cdot) - c - (V^{-} - K) + \frac{V^{+}-V^{-}}{2} + \frac{V^{+}-V^{-}}{4} - c > p_1(\cdot) - c - \frac{1}{2}\left(\frac{V^{+}+V^{-}}{2} - K\right)$ if she sells. Therefore, she has an incentive to deviate and sell, which contradicts (b); hence she does not buy.

The results in (a) and (b) imply that, if the speculator informed about the high state sells in equilibrium, then the speculator informed about the low state also sells. However, there is no equilibrium in which both speculators sell in $t = 2$. By way of contradiction, suppose such an equilibrium exists. The payoff of the speculator informed about the high state is $p_2(\cdot,\cdot) - p_1(\cdot) - c = -c$ if she buys in $t = 1$, $p_2(\cdot,\cdot) - (V^{+} - K) - c = -\frac{V^{+}-V^{-}}{2} - c$ if she does not trade, and $-(V^{+} - V^{-}) - 2c$ if she sells; if she deviates and buys instead, her payoff is at least (it is higher if the beliefs associated with $Q_2 = 2$ result in a pledgeable greater than K, in which case investment occurs) $\frac{V^{+}-K}{2} - p_1(\cdot) + \frac{1}{2}(0 - p_2(\cdot,2)) + \frac{1}{2}(V^{+} - K - p_2(\cdot,0)) =$

$\frac{1}{4}\left[V^+ - V^- - 2\left(V^- - K\right)\right] > -c$ if she buys in $t=1$, $\frac{V^+-V^-}{4} > -\frac{V^+-V^-}{2} - c$ if she does not trade, and $p_1\left(\cdot\right) - \frac{V^+-K}{2} - c + \frac{1}{2}\left(0 - p_2\left(\cdot,2\right)\right) + \frac{1}{2}\left(V^+ - K - p_2\left(\cdot,0\right)\right) = \frac{1}{2}\left(\frac{V^++V^-}{2} - K\right) - c > -\left(V^+ - V^-\right) - 2c$. Thus, the speculator informed about the high state has an incentive to deviate and buy in $t=2$, contradicting the assumption that she sells in $t=2$ in equilibrium.

Next we show that, if the speculator informed about the high state buys in $t=2$ in equilibrium, the speculator informed about the low state trades and does not buy in $t=2$ for $\frac{V^+-V^-}{4} + \Delta - c > 0$, where $\Delta > 0$; if she either buys or sells in $t=1$, she sells in $t=2$; if she does not trade in $t=1$, she sells in $t=2$ for $\frac{V^+-V^-}{4} > c$. Suppose by way of contradiction that she does not trade. In such equilibrium, her profit is $-p_1(\cdot)$ if she buys in $t=1$, zero if she does not trade, and $p_1(\cdot) - c$ if she sells; if she deviates and sells in $t=2$ instead, her profit is at least (it is higher if beliefs are such that investment occurs when $Q_2 = -2$, which we assume does not) is $\frac{V^--K}{2} - p_1(\cdot) + \frac{1}{2}\left[p_2\left(\cdot,0\right) - \left(V^- - K\right)\right] - c = -p_1(\cdot) + \frac{V^+-K}{2} - c = -p_1(\cdot) + \frac{1}{2}\left(\frac{V^++V^-}{2} - K\right) + \frac{V^+-V^-}{4} - c > -p_1(\cdot)$ if she buys in $t=1$, $\frac{1}{2}\left[p_2\left(\cdot,0\right) - \left(V^- - K\right)\right] - c = \frac{V^+-V^-}{2} - c > 0$ if she does not trade, and $p_1(\cdot) - \frac{V^--K}{2} - c + \frac{1}{2}\left[p_2\left(\cdot,0\right) - \left(V^- - K\right)\right] - c = p_1(\cdot) - c - \left(V^- - K\right) + \frac{1}{2}\left(\frac{V^++V^-}{2} - K\right) + \frac{V^+-V^-}{4} - c > p_1(\cdot) - c$ if she sells. Therefore, in equilibrium the speculator informed about the low state trades in $t=2$. Now, suppose by way of contradiction that she buys in $t=2$. In such an equilibrium, her profit is $V^- - K - p_1(\cdot) + V^- - K - \left(\frac{V^++V^-}{2} - K\right) = V^- - K - p_1(\cdot) - \frac{V^+-V^-}{2}$ if she buys in $t=1$, $V^- - K - \left(\frac{V^++V^-}{2} - K\right) = -\frac{V^+-V^-}{2}$ if she does not trade, and $p_1(\cdot) - c - \left(\frac{V^++V^-}{2} - K\right)$ if she sells; if she deviates and sells instead, her profit is at least (it is higher if beliefs are such that investment occurs when $Q_2 = -2$, which we assume does not) is $\frac{V^--K}{2} - p_1(\cdot) + \frac{1}{2}\left[p_2\left(\cdot,0\right) - \left(V^- - K\right)\right] - c = \frac{V^--K}{2} - p_1(\cdot) + \frac{V^+-V^-}{4} - c > V^- - K - p_1(\cdot) - \frac{V^+-V^-}{2}$ if she buys in $t=1$, $\frac{V^+-V^-}{4} - c > -\frac{V^+-V^-}{2}$ if she does not trade, and $p_1(\cdot) - c - \frac{V^--K}{2} + \frac{V^+-V^-}{4} - c > p_1(\cdot) - c - \left(\frac{V^++V^-}{2} - K\right)$ if she sells. Therefore, the speculator informed about the low state does not buy in $t=2$. Now, suppose that she sells in $t=2$. In such an equilibrium, her profit is $\frac{1}{2}\left(\frac{V^++V^-}{2} - K\right) - p_1(\cdot) - c$ is she buys in $t=1$, $\frac{V^+-V^-}{4} - c$ if she does not trade, and $p_1(\cdot) - \frac{V^--K}{2} + \frac{V^+-V^-}{4} - 2c$ if she sells. If she deviates and does not trade in $t=2$, her least favorable payoff if she buys in $t=1$ is $V^- - K - p_1(\cdot)$ (her payoff is higher if the beliefs associated with $Q_2 \in \{-1,1\}$ are such that investment does not occur), her payoff is she does not trade in $t=1$ is zero, and her least favorable payoff if she sells in $t=1$ is $p_1(\cdot) - c$ (her payoff is higher and equal to $p_1(\cdot) - \left(V^- - K\right) - c$ if the beliefs associated with $Q_2 \in \{-1,1\}$ are such that investment does occurs). If she deviates and buys in $t=2$, her payoff is always lower than that when she deviates and does not trade: $V^- - K - p_1(\cdot) + \frac{1}{2}\left[V^- - K - \left(V^+ - K\right)\right] + \frac{1}{2}\left[V^- - K - \left(\frac{V^++V^-}{2} - K\right)\right] < -p_1(\cdot)$ if she buys in $t=1$, $\frac{1}{2}\left[V^- - K - \left(V^+ - K\right)\right] + \frac{1}{2}\left[V^- - K - \left(\frac{V^++V^-}{2} - K\right)\right] < 0$ if she does not trade, and $p_1(\cdot) - \frac{1}{2}\left[V^+ - K + \left(\frac{V^++V^-}{2} - K\right)\right] - c < p_1(\cdot) - c$ if she sells. Therefore, it follows speculator informed about the low state sells in $t=2$ if she does not trade in $t=1$ for $\frac{V^+-V^-}{4} - c > 0$, and sells in $t=2$ if she either buys or sells in $t=1$ for $\frac{V^+-V^-}{4} + \Delta - c > 0$, where $\Delta > 0$.

Lastly, we show that, if the speculator informed about the high state does not trade in

$t = 2$ in equilibrium, then the speculator informed about the low state does not trade in $t = 2$ if she sells in $t = 1$, and does not sell in $t = 2$ if she does not trade $t = 1$. To see this, suppose the speculator informed about the low state sells in $t = 2$ in equilibrium. In this case, her the profit is $-p_1(\cdot) - c$ if she buys in $t = 1$, $-c$ if she does not trade, and $p_1(\cdot) - 2c$ if she sells. If she deviates and does not trade in $t = 2$ instead, her profit is $V^- - K - p_1(\cdot)$ if she buys in $t = 1$, $0 > -c$ if she does not trade, and $p_1(\cdot) - (V^- - K) - c > p_1(\cdot) - 2c$ if she sells. Therefore, if she either does not trade or sells in $t = 1$, she has an incentive to deviate and not trade in $t = 2$; hence she does not sell in $t = 2$. Moreover, if she sells in $t = 1$, then she does not buy in $t = 2$: if she buys in $t = 2$, her payoff is $p_1(\cdot) - c$; if she deviates and does not trade, her payoff equals $p_1(\cdot) - (V^- - K) - c > p_1(\cdot) - c$; hence, she has an incentive to deviate and not trade. It follows that, if the speculator informed about the low state sells in $t = 1$, she does not trade in $t = 2$.

Case (v): using the same reasoning applied to case (iv), one can verify that the same results found in (iv) regarding the speculators informed about the high and low states carry through to case (v). The collection of these results imply that, in $t = 2$, either (a) the speculator informed about the high state buys while that informed about the low state sells, or (b) they both do not trade, or (c) the speculator informed about the high state does not trade and the speculator informed about the low state sells. We now turn to the behavior of the uninformed speculator

In (a), if the uninformed speculator sells in $t = 1$ in equilibrium, then she does not buy in $t = 2$ for $\frac{\alpha}{2-\alpha}\frac{V^+-V^-}{4} - c > 0$ and sells if $\frac{1}{2}\left(\frac{V^++V^-}{2} - K\right) = \frac{\alpha}{2-\alpha}\frac{V^+-V^-}{4} + \frac{(1-\alpha)V^++V^--(2-\alpha)K}{2(2-\alpha)} > c$; if she does not trade in $t = 1$, then she does not trade in $t = 2$. In order to show this, let us assume by way of contradiction that there exists an equilibrium in which she sells in $t = 1$ and buys in $t = 2$. In this case, her payoff equals $p_1(\cdot) - c - \left(\frac{p_2(\cdot,2)}{2} + \frac{p_2(\cdot,0)}{2}\right) = p_1(\cdot) - c - \frac{1}{2}\left(\frac{V^++(1-\alpha)V^-}{2-\alpha} - K + \frac{V^++V^-}{2} - K\right)$; if she deviates and sells again it equals $p_1(\cdot) - c - \frac{1}{2}\left(\frac{V^++V^-}{2} - K\right) + \frac{1}{2}\left[p_2(\cdot, 0) - \left(\frac{V^++V^-}{2} - K\right)\right] + \frac{1}{2}\left(p_2(\cdot, -2) - 0\right) - c = p_1(\cdot) - 2c - \frac{1}{2}\left(\frac{V^++V^-}{2} - K\right)$. Subtracting her payoff in the proposed equilibrium from the deviation payoff yields $\frac{1}{2}\left(\frac{V^++V^-}{2} - K\right) + \frac{\alpha}{2-\alpha}\frac{V^+-V^-}{4} - c$. Thus, in equilibrium, the uninformed speculator does not buy $t = 2$ when she sells in $t = 1$ if $\frac{\alpha}{2-\alpha}\frac{V^+-V^-}{4} - c > 0$. If she does not trade in $t = 2$ in such equilibrium, her payoff equals $p_1(\cdot) - c - \left(\frac{V^++V^-}{2} - K\right)$; if she deviates and sells again it equals $p_1(\cdot) - 2c - \frac{1}{2}\left(\frac{V^++V^-}{2} - K\right)$. Subtracting her payoff in the proposed equilibrium from the deviation payoff yields $\frac{1}{2}\left(\frac{V^++V^-}{2} - K\right) - c$. Therefore, in equilibrium, the uninformed speculator trades in $t = 2$ when she sells in $t = 1$ if $\frac{1}{2}\left(\frac{V^++V^-}{2} - K\right) - c > 0$. Now, suppose she sells in $t = 2$ when she sells in $t = 1$. In this case, her payoff equals $p_1(\cdot) - 2c - \frac{1}{2}\left(\frac{V^++V^-}{2} - K\right)$. If she deviates and buys in $t = 2$, her payoff equals $p_1(\cdot) - c - \frac{1}{2}\left[V^+ - K + \frac{V^++V^-}{2} - K\right]$. Subtracting the deviation payoff from the equilibrium payoff yields $\frac{1}{2}\left(\frac{V^++V^-}{2} - K\right) + \frac{V^+-V^-}{4} - c > 0$; hence there is no incentive to deviate and buy. If she deviates and does not trade in $t = 2$, her payoff equals $p_1(\cdot) - c$ if the beliefs associated with $Q_2 \in \{-1, 1\}$ are such that investment does not occur; if these beliefs are such that investment does not occur, her payoff equals $p_1(\cdot) - c - \left(\frac{V^+ + V^-}{2} - K\right)$. Thus, in equilibrium beliefs must me such that investment occurs (otherwise she has an incentive to deviate and not trade), in which case sells if $\frac{1}{2}\left(\frac{V^+ + V^-}{2} - K\right) - c > 0$.

Now, consider the case in which she does not trade in $t = 1$ and assume by way of contradiction that she trades in $t = 2$. If she buys, her payoff equals $\frac{V^+ + V^-}{2} - K - \left(\frac{p_2(\cdot,2)}{2} + \frac{p_2(\cdot,0)}{2}\right) = \frac{V^+ + V^-}{2} - \frac{V^+ + (1-\alpha)V^-}{2-\alpha} < 0$; if she deviates and does not trade she secures a payoff of zero; hence, she does not buy. If she sells, her payoff equals $\frac{1}{2}\left[p_2(\cdot, 0) - \left(\frac{V^+ + V^-}{2} - K\right)\right] + \frac{1}{2}\left(p_2(\cdot, -2) - 0\right) - c = -c$; if she deviates and does not trade she secures a payoff of zero; thus, she does not trade.

In (b), the uninformed speculator does not sell in $t = 2$. Suppose by way of contradiction that she does. In this case, her the profit is $\frac{V^+ + V^-}{2} - K - p_1(\cdot) - c$ if she buys in $t = 1$, $-c$ if she does not trade, and $p_1(\cdot) - \left(\frac{V^+ + V^-}{2} - K\right) - 2c$ if she sells. If she deviates and does not trade in $t = 2$ instead, her profit is $\frac{V^+ + V^-}{2} - K - p_1(\cdot) > \frac{V^+ + V^-}{2} - K - p_1(\cdot) - c$ if she buys in $t = 1$, $0 > -c$ if she does not trade, and $p_1(\cdot) - \left(\frac{V^+ + V^-}{2} - K\right) - c > p_1(\cdot) - \left(\frac{V^+ + V^-}{2} - K\right) - 2c$ if she sells. Therefore, she has an incentive to deviate and not trade $t = 2$ regardless of her trade in $t = 1$; hence she does not sell in $t = 2$.

In (c), the uninformed speculator does not sell in $t = 2$. Suppose by way of contradiction that she does. In this case, her the profit is $-p_1(\cdot) - c$ if she buys in $t = 1$, $-c$ if she does not trade, and $p_1(\cdot) - 2c$ if she sells. If she deviates and does not trade in $t = 2$ instead, her profit is $\frac{V^+ + V^-}{2} - K - p_1(\cdot) > -p_1(\cdot) - c$ if she buys in $t = 1$, $0 > -c$ if she does not trade, and $p_1(\cdot) - \left(\frac{V^+ + V^-}{2} - K\right) + \left[V^+ - K - \left(\frac{V^+ + V^-}{2} - K\right)\right] - 2c = p_1(\cdot) - (V^- - K) - 2c > p_1(\cdot) - 2c$ if she sells. Therefore, she has an incentive to deviate and not trade $t = 2$ regardless of her trade in $t = 1$; hence she does not sell in $t = 2$.

- Trading in $t = 1$

We start by showing that, if $\frac{V^+ - V^-}{4} - c > 0$, there is no equilibrium in which the speculator informed about the high state sells in $t = 1$. Suppose by way of contradiction that she does sell in $t = 1$ in equilibrium. In such an equilibrium, the speculator informed about the low state sells. To see this, suppose instead that she either (a) buys or (b) does not trade. Under (a), with probability $\frac{1}{2}$ the order flow equals $Q_1 = 2$. In this case, her type is revealed if the uninformed speculator either does not trade or sells, resulting in a profit of zero. If the uninformed speculator buys, the optimal strategies in $t = 2$ imply that her profit from the period-2 trade is zero, such that her overall profit is at most $-p_1(2) \leq 0$. With probability $\frac{1}{2}$ the order flow equals $Q_1 = 0$. If the speculator informed about the high state does not trade in $t = 2$, her profit from the period-2 trade is at most zero (it equals $-c$ when she sells). Thus, her overall profit is at most $-p_1(0) < 0$ (the period-1 price is positive as it reflects the positive probability that the period-2 price does not reveal that the speculator is not informed about the high state). If the speculator informed about the high state buys in $t = 2$, her overall profit equals $\frac{V^- - K}{2} - p_1(0) - c < 0$. Therefore, the overall expected profit of the speculator informed about low state is always negative, such that she has an incentive to deviate and not trade in both periods, securing a payoff of zero. This contradicts (a).

Under (b), the order flow $Q_1 \in \{-1, 1\}$. In this case, her type is revealed if the uninformed speculator either buys or sells, resulting in a profit of zero. If the uninformed speculator does not trade, the optimal strategies in $t = 2$ imply that her profit from the period-2 trade is zero, such that her overall profit is also zero. If she deviates and sells in $t = 1$ instead, with probability $\frac{1}{2}$ the order flow equals $Q_1 = 0$. If the uninformed speculator does not trade in $t = 1$, then $p_1(0) = V^+ - K$. In this case, she can profit by not trading in $t = 2$, receiving an overall payoff of at least $V^+ - K - c = \frac{V^+ + V^-}{2} - K + \frac{V^+ - V^-}{2} - c > 0$ (her payoff is higher if beliefs conditional of $Q_2 \in \{-1, 1\}$ are such that investment occurs). If the uninformed speculator either buys or sells, then $p_1(0) = \frac{\alpha}{2-\alpha}(V^+ - K) + \frac{2(1-\alpha)}{2-\alpha}\left(\frac{V^+ + V^-}{2} - K\right)$. In this case, she can profit by following the strategy of the uninformed speculator in $t = 2$, which yields her a profit from the period-2 trade of at least zero (her profit is higher if $\frac{\alpha}{2-\alpha}\frac{V^+ - V^-}{4} > c$, in which case the uninformed speculator sells while the speculator informed about the high state buys in $t = 2$). Her overall profit is therefore at least $p_1(0) - (V^- - K) = \frac{V^+ - V^-}{2} + \frac{\alpha}{2-\alpha}\frac{V^+ - V^-}{2} - c > 0$. With probability $\frac{1}{2}$ the order flow equals $Q_1 = -2$. If the uninformed speculator either buys or does not trade, then $p_1(-2) = V^+ - K$. In this case, she can profit by not trading in $t = 2$, receiving an overall payoff of at least $V^+ - K - c = \frac{V^+ + V^-}{2} - K + \frac{V^+ - V^-}{2} - c > 0$ (her payoff is higher if beliefs conditional of $Q_2 \in \{-1, 1\}$ are such that investment occurs). If the uninformed speculator sells, then $p_1(-2) = \frac{\alpha}{2-\alpha}(V^+ - K) + \frac{2(1-\alpha)}{2-\alpha}\left(\frac{V^+ + V^-}{2} - K\right)$. In this case, she can profit by following the strategy of the uninformed speculator in $t = 2$, which yields her a profit from the period-2 trade of at least zero (her profit is higher if $\frac{\alpha}{2-\alpha}\frac{V^+ - V^-}{4} > c$, in which case the uninformed speculator sells while the speculator informed about the high state buys in $t = 2$). Her overall profit is therefore at least $p_1(-2) - (V^- - K) = \frac{V^+ - V^-}{2} + \frac{\alpha}{2-\alpha}\frac{V^+ - V^-}{2} - c > 0$. It follows from the analysis above that the speculator informed about the low state trades, contradicting (b).

Therefore, in any equilibrium in which the speculator informed about the high state sells in $t = 1$, the speculator informed about the low state also sells in $t = 1$. However, in this case the speculator informed about the high state has an incentive to deviate. To see this, note that in such an equilibrium the order flow equals $Q_1 = -2$ and $Q_1 = 0$ with equal probability. First, let us consider the situation in which the uninformed speculator buys in $t = 1$. In this case the speculator informed about the high state can profit by buying in $t = 1$, following the uninformed speculator's equilibrium strategy in $t = 2$ if $Q_1 = 2$ (probability $\frac{1}{2}$), and conforming with her period-2 equilibrium strategy if $Q_1 = 0$ (probability $\frac{1}{2}$). Since this deviation and the equilibrium strategy yield the same payoff if $Q_1 = 0$, it suffices to show that the deviation payoff if $Q_2 = 2$ is higher than the equilibrium payoff when $Q_1 = -2$. If $Q_1 = -2$, her equilibrium profit is $p_1(-2) - (V^+ - K) - c < 0$ if she does not trade in $t = 2$, and $p_1(-2) - c - \left(\frac{p_2(-2,2)}{2} + \frac{p_2(-2,0)}{2}\right) = \frac{1}{4}(V^+ - K) + \frac{1}{2}\left(\frac{V^+ + V^-}{2} - K\right) - c - \left[\frac{1}{2}(V^+ - K) + \frac{1}{2}\left(\frac{V^+ + V^-}{2} - K\right)\right] < 0$ if she buys. If $Q_1 = 2$, her deviation strategy yields at least $V^+ - K - p_1(2) = V^+ - K - \left(\frac{V^+ + V^-}{2} - K\right) > 0$ (her payoff is higher if the uninformed speculator buys in $t = 2$). Therefore, the speculator informed about the high state has an incentive to deviate.

Let us now turn to the situations in which the uninformed speculator either does not trade or sells in $t = 1$. If the speculator informed about the high state does not trade in $t = 2$ in such an equilibrium, her payoff is $p_1(\cdot) - (V^+ - K) - c < 0$. In this case, she can deviate and not trade in periods $t = 1, 2$, securing herself a payoff of zero. If she buys in $t = 1$, her payoff is $p_1(\cdot) - \left(\frac{p_2(\cdot,2)}{2} + \frac{p_2(\cdot,0)}{2}\right) - c = \frac{V^+ - K}{4} + \frac{1}{2}\left(\frac{V^+ + V^-}{2} - K\right) - \frac{1}{2}\left[V^+ - K + \left(\frac{V^+ + V^-}{2} - K\right)\right] - c < 0$. In this case, she can also profit by deviating and not trading in periods $t = 1, 2$, securing herself a payoff of zero.

Therefore, there is no equilibrium in which the speculator informed about the high state sells in $t = 1$. Now let us assume that the speculator informed about the high state buys in equilibrium in $t = 1$. We next show that in such an equilibrium, the speculator informed about the low state sells in $t = 1$. To see this, suppose instead that she either (a) buys or (b) does not trade. Under (a), if the speculator informed about the high state does not trade in $t = 2$, her profit from the period-2 trade is at most zero (it equals $-c$ when she sells). Thus, her overall profit is at most $-p_1(\cdot) \leq 0$. In this case, she can profit by selling in $t = 1$ and not trading in $t = 2$. This deviation yields a profit of at least (her profit is higher if beliefs conditional on $Q_1 = -2$ are such that investment occurs, which we assume otherwise) $\frac{1}{2}[p_1(0) - (V^- - K)] - c = \frac{V^+ - V^-}{4} - c > 0$. If the speculator informed about the high state buys, her profit is $\left(\frac{p_2(\cdot,0)}{2} + \frac{p_2(\cdot,-2)}{2}\right) - p_1(\cdot) - c = \frac{1}{2}\left(\frac{V^+ + V^-}{2} - K\right) - \left[\frac{V^+ - K}{4} + \frac{1}{2}\left(\frac{V^+ + V^-}{2} - K\right)\right] - c < 0$. In this case, the speculator informed about the low state can profit by selling in $t = 1$, not trading in $t = 2$ if $Q_1 = -2$, and conforming with her period-2 equilibrium strategy if $Q_1 = 0$. This deviation generates a profit of at least (her profit is higher if beliefs conditional on $Q_1 = -2$ are such that investment occurs with positive probability, which we assume otherwise) $\frac{1}{2}\left\{p_1(0) - \frac{V^- - K}{2} + \frac{1}{2}\left[\frac{V^+ + V^-}{2} - K - (V^- - K)\right] - c\right\} - c = \frac{1}{2}(\frac{V^+ - K}{4} + \frac{V^+ - V^-}{4} - c) + \frac{V^+ - V^-}{4} - c > 0$. This contradicts (a).

Under (b), the order flow $Q_1 \in \{-1, 1\}$. If the uninformed speculator either buys or sells, her type is revealed, resulting in a profit of zero. In this case, she can profit selling in $t = 1$, not trading in $t = 2$ if $Q_1 = -2$, and following the equilibrium strategy of the uninformed speculator in $t = 2$ if $Q_1 = 0$. For $Q_1 = 0$, we have $p_1(0) = \frac{\alpha}{2-\alpha}(V^+ - K) + \frac{2(1-\alpha)}{2-\alpha}\left(\frac{V^+ + V^-}{2} - K\right)$, in which case this deviation yields her a profit from the period-2 trade of at least zero (her profit is higher if $\frac{\alpha}{2-\alpha}\frac{V^+ - V^-}{4} > c$, in which case the uninformed speculator sells while the speculator informed about the high state buys in $t = 2$), and an overall profit of at least $p_1(0) - (V^- - K) = \frac{V^+ - V^-}{2} + \frac{\alpha}{2-\alpha}\frac{V^+ - V^-}{2} - c$. For $Q_1 = -2$, this deviation generates a profit of at least $-c$ (her payoff is higher if beliefs conditional of $Q_2 \in \{-1, 1\}$ are such that investment occurs with positive probability, which we assume otherwise). Therefore, the expected profit from the deviation is at least $\frac{V^+ - V^-}{4} + \frac{\alpha}{2-\alpha}\frac{V^+ - V^-}{4} - c > 0$.

If the uninformed speculator does not trade, the optimal strategies in $t = 2$ imply that her profit from the period-2 trade is zero, such that her overall profit is also zero. In this case, she can profit by selling in $t = 1$ and not trading in $t = 2$. For $Q_1 = 0$, we have $p_1(0) = V^+ - K$, in which case this deviation yields her a payoff of at least $V^+ - K - c = \frac{V^+ + V^-}{2} - K + \frac{V^+ - V^-}{2} - c > 0$ (her payoff is higher if beliefs conditional of $Q_2 \in \{-1, 1\}$ are such that investment occurs with positive probability, which we assume otherwise). For $Q_1 = -2$, this deviation generates a profit of at least $-c$ (her payoff is higher if beliefs conditional of $Q_2 \in \{-1, 1\}$ are such that investment occurs with positive probability, which we assume otherwise). Therefore, the expected profit from the deviation is at least $\frac{V^+ - K}{2} - c = \frac{1}{2}\left(\frac{V^+ + V^-}{2} - K\right) + \frac{V^+ - V^-}{4} - c > 0$. This contradicts (b).

Therefore, for $\frac{V^+-V^-}{4}-c>0$, if the speculator informed about the high state buys in equilibrium in $t=1$, the speculator informed about the low state sells in $t=1$. Let us now consider the class of equilibria in which the speculator informed about the high state buys in $t=2$ if her type is not revealed by the period-1 trade. Let us further assume that $\frac{1}{2}\left(\frac{V^++V^-}{2}-K\right)=\frac{\alpha}{2-\alpha}\frac{V^+-V^-}{4}+\frac{(1-\alpha)V^++V^--(2-\alpha)K}{2(2-\alpha)}>c$. We next show that if the speculator informed about the high state buys in equilibrium in $t=1$, then the uninformed speculator does not buy $t=1$. Suppose by way of contradiction that the uninformed speculator buys in $t=1$. The order flow equals $Q_1=2$ with probability $\frac{1}{2}$, in which case her period-2 trade profit is $\frac{1}{2}\left[p_2(2,0)-\left(\frac{V^++V^-}{2}-K\right)\right]=\frac{1}{2}\left[\frac{\alpha}{2-\alpha}(V^+-K)+\frac{2(1-\alpha)}{2-\alpha}\left(\frac{V^++V^-}{2}-K\right)-\left(\frac{V^++V^-}{2}-K\right)\right]-c$. Her period-1 trade profit is $\frac{V^++V^-}{2}-K-p_1(2)=\frac{V^++V^-}{2}-K-\left[\frac{\alpha}{2(2-\alpha)}(V^+-K)+\frac{p_2(2,0)}{2}\right]$. Thus, her overall when $Q_1=2$ is $\frac{1}{2}\left[\frac{V^++V^-}{2}-K-\frac{\alpha}{2-\alpha}(V^+-K)\right]-c<0$.[14] With probability $\frac{1}{2}$ the order flow equals $Q_1=0$. In this case, her profit from the period-2 trade is $-c$. Her period-1 trade profit equals $\frac{V^++V^-}{2}-K-p_1(0)=-\frac{\alpha}{4}(V^+-K)<0$. Thus, her overall profit when $Q_1=0$ is also negative. This implies that the uniformed speculator has an incentive to deviate and not trade in both periods $t=1,2$, securing herself a payoff of zero. It follows that in equilibrium the uninformed speculator does not buy in $t=1$.

Next we show that, if the speculator informed about the high state buys in $t=1$, the uninformed speculator trades for $c<\frac{V^+-K}{12}=\frac{1}{2}\left(\frac{V^++V^-}{2}-K\right)-\frac{5}{12}\left(\frac{2}{5}V^++\frac{3}{5}V^--K\right)$. Suppose now that the uninformed speculator does not trade in $t=1$. In this case, she also does not trade in $t=2$, which results in a payoff of zero. Consider a deviation in which she sells in $t=1$ and conforms with the strategy of the speculator informed about the low state in $t=2$. The order flow equals $Q_1=-2$ with probability $\frac{1}{2}$, in which case her profit from the period-2 trade is zero. Her profit from the period-1 trade is $p_1(-2)-0-c=-c$. Thus, her overall profit when $Q_1=-2$ is $-c$. With probability $\frac{1}{2}$, the order flow equals $Q_1=0$, in which case her profit from the period-2 trade is $-c$; her profit from the period-1 trade is $p_1(0)-\frac{1}{2}\left(\frac{V^++V^-}{2}-K\right)-c=\frac{V^+-K}{4}+\frac{1}{2}\left(\frac{V^++V^-}{2}-K\right)-\frac{1}{2}\left(\frac{V^++V^-}{2}-K\right)-c=\frac{V^+-K}{4}-c$; therefore, her overall profit is $\frac{1}{2}\left(\frac{V^+-K}{4}-c\right)-c>0$. Thus, the uninformed speculator has an incentive to deviate, from which it follows that in equilibrium the uninformed speculator trades in $t=1$.

Now, let us take c to be even smaller, $c<\alpha\frac{V^+-K}{12}$. If the uninformed speculator sells in $t=1$, then $Q_1=-2$ with probability $\frac{1}{2}$, in which case her profit from the period-2 trade is zero. Her profit from the period-1 trade is $-c$, since it equals $p_1(-2)-\left(\frac{V^++V^-}{2}-K\right)-c=-c$ if her strategy and that of the speculator informed about the low state in $t=2$ are different, and $p_1(-2)-0-c=-c$ if their strategies in $t=1$ are the same. Thus, her overall profit when $Q_1=-2$ is $-c$. With probability $\frac{1}{2}$, the order flow equals $Q_1=0$. If the speculator informed about the high state buys in $t=2$, her profit from the period-2 trade is $-c$; her profit from the period-1 trade is $p_1(0)-\frac{1}{2}\left(\frac{V^++V^-}{2}-K\right)-c=\frac{\alpha}{4}(V^+-K)+\frac{1}{2}\left(\frac{V^++V^-}{2}-K\right)-\frac{1}{2}\left(\frac{V^++V^-}{2}-K\right)-c=$

[14] This becomes evident from $\frac{V^++V^-}{2}-K=\frac{\alpha}{2-\alpha}(V^+-K)-\frac{\alpha}{2-\alpha}\left(\frac{V^++V^-}{2}-K\right)+\frac{(1-\alpha)V^++V^--(2-\alpha)K}{2-\alpha}<\frac{\alpha}{2-\alpha}(V^+-K)$.

$\frac{\alpha}{4}(V^+ - K) - c$; therefore, her overall profit is $\frac{1}{2}\left[\frac{\alpha}{4}(V^+ - K) - c\right] - c > 0$.

The collection of the previous results implies the following. For $c < \frac{\alpha}{12}(V^+ - K)$, there exists an equilibrium in which the speculator informed about the high state buys in $t = 1$ if and only if the uninformed speculator and the speculator informed about the low state sell in $t = 1$, and sell again in $t = 2$ when their types are not revealed by the period-1 trade. For $\frac{\alpha}{12}(V^+ - K) < c$, there is no equilibrium in which the speculator informed about the high state buys in $t = 1$; if $\frac{\alpha}{12}(V^+ - K) < c < \frac{V^+ - K}{12}$, an equilibrium exists if and only if neither type of speculator trades in $t = 1$, in which case the uninformed speculator does not trade in $t = 2$ while the speculator informed about the low state sells. For $\frac{V^+ - K}{12} < c$, an equilibrium in which the speculator informed about the high state buys in $t = 1$ exists only if the uninformed speculator does not trade in $t = 1$; if $\frac{V^+ - K}{12} < c < \frac{V^+ - K}{12} + \frac{V^+ - V^-}{6}$, an equilibrium in which the speculator informed about the high state buys in $t = 1$ exists if and only the uninformed speculator does not trade in $t = 2$, while the speculator informed about the low state sells in $t = 1$ and sells again in $t = 2$ when the period-1 trade does not reveal her type. For $\frac{V^+ - K}{12} + \frac{V^+ - V^-}{6} < c$, there is no equilibrium in which the speculator informed about the high state buys in $t = 1$; if $\frac{V^+ - K}{12} + \frac{V^+ - V^-}{6} < c < \frac{V^+ - V^-}{4}$, an equilibrium exists if and only if neither type of speculator trades in $t = 1$, the uninformed speculator does not trade in $t = 2$, and the speculator informed about the low state sells in $t = 2$. Finally, for $c > \frac{V^+ - V^-}{4}$, an equilibrium exists if and only not type of speculator trades in $t = 1$ and neither the uninformed speculator nor the speculator informed about the low state does trade in $t = 2$. ■

Proof of Corollary 1. From the definition $\widehat{V} \equiv \frac{V^+ + V^-}{2} - K$, it follows that $\phi\frac{V^+ + V^-}{2} - K = \phi(\widehat{V} + K) - K$ and $\phi V^+ - K = 2[\phi(\widehat{V} + K) - K] - (\phi V^- - K)$. Using these to rewrite the condition of the corollary yields:

$$-\frac{3\alpha}{8}(\phi V^- - K) + \phi(\widehat{V} + K) - K - 2\pi\left[(1 - \alpha)\frac{2\widehat{V} - \alpha(V^- - K)}{2 - \alpha}\right] \geq 0. \qquad \text{(A.1)}$$

The derivative of the term inside the brackets of A.1 with respect to α is $-\frac{2\widehat{V} - \left(V^- - K\right)\left(-\alpha^2 + 4\alpha - 2\right)}{(2-\alpha)^2}$. This derivative is negative since the numerator is at least $2\widehat{V} + (V^- - K) > 0$; this follows from our parametric assumptions $2\widehat{V} + (V^- - K) > 0$ and $\alpha > \frac{V^+ + V^- - 2K}{V^+ - K}$, which imply that $\alpha > \frac{1}{3}$; hence $(-\alpha^2 + 4\alpha - 2) > -1$. Therefore, the left-hand side of A.1 is increasing in α. As a result, A.1 is violated if and only if $\pi > \frac{\phi(\widehat{V} + K) - K}{2\widehat{V}}$ and α is sufficiently small. Let $\pi > \frac{\phi(\widehat{V} + K) - K}{2\widehat{V}}$. Since A.1 holds for α close to 1, there exists α^* large enough such that the equality obtains. Write this equality as

$$-\alpha^*\left(V^- - K\right)\left[\frac{3\phi}{8} - \frac{2(1 - \alpha^*)\pi}{2 - \alpha^*}\right] + 2\widehat{V}\left[\frac{\phi}{2} - \frac{2(1 - \alpha^*)\pi}{2 - \alpha^*}\right] = (1 - \phi)K\left(1 - \frac{3\alpha^*}{8}\right).$$

Note that the second term on the left-hand side of the equality must be positive; if it were negative then the first term would also be negative, violating the equality. Thus, it is easy to see (and simple comparative statics can be used for verification) that α^* is increasing in π, and decreasing in ϕ and $\widehat{V}$. ■

Proof of Proposition 2. Let $c < \frac{V^+-K}{12}$. Consider the folowing strategies profile: the speculator informed about the high state buys in $t=1$ and buys again in $t=2$ if $p_1 < V^+ - K$; the uninformed speculator does not trade in $t=1$ and does not trade in $t=2$ if $p_1 > 0$; the speculator informed about the low state sells in $t=1$ and sells again in $t=2$ if $p_1 > 0$; the manager buys in $t=1$ if and only if he is uninformed and buys in $t=2$ if $p_1 > 0$ if and only if he is uninformed; beliefs assign probability one to the speculator being informed about the low state for the trade histories $\{\{Q_1\}, \{Q_1, Q_2\}\}$ for $Q_1 \in \{-2,-1,1,3\}$ and $Q_2 \in \{-3,-2,-1,0,1,2,3\}$, and $\{Q_1 = 2, Q_2\}$ for $Q_2 \in \{-2,-1,1,3\}$.

The payoff of the uninformed speculator under the proposed equilibrium is 0. If she deviates and sells in $t=1$, the order flow equals $Q_1 \in \{-1,1\}$: her profit from the period-1 trade is $-c$; her period-2 trade profit is at most 0 (it is $-c$ if she sells); hence, she does not have an incentive to deviate and sell. If she deviates and buys, the order fow equals $Q_1 \in \{1,3\}$: her profit from the period-1 trade is 0; her profit from the period-2 trade is at most 0 (it is $-c$ if she sells); hence, she does not have an incentive to buy. Therefore, she does not have an incentive to deviate from her strategy in the proposed equilibrium.

If the speculator informed about the low state deviates and does not trade the order flow equals $Q_1 \in \{-1,1\}$: her profit from the period-1 trade is 0; her period-2 trade profit is at most 0 (it is $-c$ if she sells); hence, her overall profit is at most 0. If she deviates and buys in $t=1$, then with probability $\frac{1}{2}$ the order flow equals $Q_1 = 2$: in this case, $p_1(2) = p_2(2, Q_2 \in \{2,0\}) = \frac{\alpha}{2-\alpha}(V^+ - K) + \frac{2(1-\alpha)}{2-\alpha}\left(\frac{V^+ + V^-}{2} - K\right)$; if she buys in $t=2$, her profit equals $2(V^- - K) - p_1(2) - p_2(2, Q_2 \in \{2,0\}) < 0$; if she does not trade in $t=2$, then $Q_2 \in \{-1,1\}$ and her profit equals $-p_1(2) < 0$; and if she sells in $t=2$, her profit equals $\frac{p_2(2,0)}{2} - p_1(2) - c < 0$. With probability $\frac{1}{2}$ the order flow equals $Q_1 = 0$: in this case, $p_2(0,2) = p_2(2, Q_2 \in \{2,0\})$, $p_2(0,0) = \frac{V^+ + V^-}{2} - K$, and $p_1(0) = \frac{2-\alpha}{4} p_2(2, Q_2 \in \{2,0\}) + \frac{1}{2}\left(\frac{V^+ + V^-}{2} - K\right)$; if she buys in $t=2$, her profit equals $2(V^- - K) - p_1(0) - \frac{p_2(0,2)}{2} - \frac{p_2(0,0)}{2} < 0$; if she does not trade in $t=2$, then $Q_2 \in \{-1,1\}$ and her profit equals $-p_1(0) < 0$; and if she deviates and sells her profit is $-\frac{p_2(0,0)}{2} - p_1(0) - c < 0$. It follows that her overall profit if she deviates from her strategy in the proposed equilibrium is at most 0, which implies that she does not have an incentive to deviate since in the proposed equilibrium she makes a profit of $\frac{1}{2}\left[p_1(0) + \frac{p_2(0,0)}{2} - (V^- - K) - c\right] - c = \frac{1}{2}\left(\frac{V^+ + (1-\alpha)V^- - (2-\alpha)K}{4} + \frac{V^+ - V^-}{2} - c\right) - c > 0$.

The payoff of the speculator informed about the high state in the proposed equilibrium is $\frac{1}{2}\left[2(V^+ - K) - p_1(2) - \left(\frac{p_2(2,2)}{2} + \frac{p_2(2,0)}{2}\right)\right] + \frac{1}{2}\left[2(V^+ - K) - p_1(0) - \left(\frac{p_2(0,2)}{2} + \frac{p_2(0,0)}{2}\right)\right]$. If she deviates and does not trade the order flow equals $Q_1 \in \{-1,1\}$: her profit from the period-1 trade is 0; her period-2 trade profit is at most 0 (it is $-c$ if she sells); hence, she does not have an incentive to deviate and not trade. If she deviates and sells in $t=1$ the order flow equals $Q_1 = -2$ with probability $\frac{1}{2}$: her profit from the period-1 trade is $-c$ and her period-2 trade profit is at most 0 (it is $-c$ if she sells). With probability $\frac{1}{2}$ the order flow equals $Q_1 = 0$: if she buys in $t=2$, her profit equals $p_1(0) - \left(\frac{p_2(0,2)}{2} + \frac{p_2(0,0)}{2}\right) - c < 0$; if she does not trade in $t=1$, her profit equals $p_1(0) - c$; and if she sells her profit equals $p_1(0) + \frac{1}{2}\left(\frac{V^+ + V^-}{2} - K\right) - (V^+ - K) - 2c$. It follows that her overall profit when she deviates and sells in $t=1$ is at most $\frac{p_1(0)}{2} - c$. Subtrating the best deviation payoff from her payoff in the proposed equilibrium yields $\frac{1}{2}\left[2\left(V^{+}-K\right)-p_1\left(2\right)-\left(\frac{p_2(2,2)}{2}+\frac{p_2(2,0)}{2}\right)\right]+\frac{1}{2}\left[\left(V^{+}-K\right)-\frac{(2-\alpha)\left(V^{-}-K\right)}{2}-\left(\frac{p_2(0,2)}{2}+\frac{p_2(0,0)}{2}\right)\right]+c>0$. It follows that she does not have an incentive to deviate and sell. Therefore, she does not have an incentive to deviate from her strategies in the proposed equilibrium.

Lastly, we consider the deviation incentives of the manager. Because the manager can divert a fraction $1-\phi$ of the firm value, once the project is financed in $t=0$ he has an incentive to change his repurchases strategy if and only if it leads to an increase in the probability of reinvestment in $t=2$. If the manager is either informed about the high state or uninformed, reinvestment always occurs under the proposed equilibrium; hence he has no incentive to deviate. If the manager is informed about the low state, reinvestment does no occur when $Q_1=-2$ and when $\{Q_1=0,Q_2=-2\}$. If he deviates and buys, the order flow equals $Q_1\in\{-1,1\}$. In this case, beliefs assign probability one to the speculator being informed about the low state, which implies that investment does not occur. Therefore, he does not have an incentive to deviate and change his repurchase strategy. ■

Appendix B

Variable	Definition
Supply	End-of-quarter fraction of market capitalization available to lend
On Loan	End-of-quarter fraction of market capitalization effectively lent out
Shortable Supply	*Supply* – *On Loan*
Fee	Value-weighted loan fee at the end of the quarter (annualized %)
Fee Score	Fee score computed by Markit. Ranges from 0 (cheapest) to 5 (hardest)
Repurchases	Purchase of Common and Preferred Stock ÷ Lagged Book Assets
Investment	(Capital Expenditures + R&D Expenses) ÷ Lagged Book Assets
Cash	Cash & Short-Term Equivalents ÷ Lagged Book Assets
Debt Issuance	Quarterly changes of Short- and Long-Term Debt ÷ Lagged Book Assets
Size	Logarithm of Firm Assets in US$ Billions
Market-to-Book (MB)	Market Value ÷ Book Value of Common Shares
Cash Flow	(Income Before Extraordinary Items + Deprec. & Amort.) ÷ Lagged Book Assets
ILLIQ	Daily absolute return divided by dollar volume averaged over a quarter
Total IO	Fraction of the firm held by institutional investors (computed from 13F files)
Top5 IO	Fraction of the firm held by the largest 5 institutional investors (from 13F files)
# Blockholders	Number of blockholders holding shares in the firm (from 13F files)
Bid-Ask	Bid-ask spread at the end of a trading day averaged over a quarter
Turnover	Quarterly average of daily shares traded divided by total outstanding
CEO WPS	Edmans et al.'s (2009) wealth-performance sensitivity; given by the dollar change in CEO wealth for a 1% change in firm value, divided by annual flow compensation

Table 1
Descriptive Statistics
This table reports quarterly descriptive statistics of the main variables used in the analysis. Equity lending data are provided by Markit, price data come from CRSP, ownership data from SEC's 13F holdings, and accounting data from Compustat. The variable definitions are in Appendix B.

Variable	Mean	Median	St. Dev.	25th Pct.	75th Pct.	Obs.
Supply (% mktcap)	17.57%	17.90%	12.20%	5.97%	27.49%	113,305
On Loan (% mktcap)	3.94%	1.82%	5.29%	0.40%	5.23%	113,305
Shortable Supply (% mktcap)	13.61%	12.73%	11.05%	3.32%	22.71%	113,305
Fee (% p.a.)	0.77%	0.12%	2.25%	0.07%	0.23%	109,428
Fee Score (0 to 5)	0.62	0.00	1.39	0.00	0.00	107,087
Repurchases (% assets)	0.54%	0.00%	1.51%	0.00%	0.12%	113,305
Investment (% assets)	2.68%	1.74%	3.01%	0.76%	3.40%	113,305
Cash (% assets)	20.40%	11.78%	22.80%	3.56%	29.61%	113,305
Debt Issuance (% assets)	0.15%	0.00%	5.94%	–0.96%	0.58%	108,547
Size	6.40	6.32	2.00	4.91	7.76	113,305
Market-to-Book	2.94	2.05	3.06	1.28	3.46	113,254
Cash Flow (% assets)	0.99%	1.98%	5.21%	0.59%	3.28%	110,199
ILLIQ	3.97	0.08	20.48	0.01	0.85	113,305
Total IO (% mktcap)	62.02%	69.23%	29.01%	39.31%	86.20%	113,305
Top5 IO (% mktcap)	27.19%	27.31%	11.69%	19.91%	34.46%	113,299
# Blockholders	2.33	2.00	1.71	1.00	3.00	113,305
Bid-Ask (%)	0.64%	0.14%	1.66%	0.05%	0.49%	113,280
Turnover (%)	0.19%	0.14%	0.18%	0.07%	0.24%	113,305
CEO WPS	59.38	5.91	509.79	2.31	13.77	28,930

Table 2
Variable Correlations

This table reports pairwise correlations for the main variables used in the analysis. Equity lending data are provided by Markit, price data come from CRSP, ownership data from SEC's 13F holdings, and accounting data from Compustat. The variable definitions are in Appendix B.

Variable	$Corr(\downarrow, \rightarrow)$	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Supply (% mktcap)	(1)	1																		
On Loan (% mktcap)	(2)	0.43	1																	
Shortable Supply (% mktcap)	(3)	0.89	–0.02	1																
Fee (% p.a.)	(4)	–0.25	0.17	–0.36	1															
Fee Score (0 to 5)	(5)	–0.32	0.22	–0.46	0.79	1														
Repurchases (% assets)	(6)	0.15	0.05	0.14	–0.07	–0.09	1													
Investment (% assets)	(7)	–0.09	0.07	–0.14	0.14	0.18	–0.04	1												
Cash (% assets)	(8)	–0.11	0.04	–0.13	0.11	0.15	0.02	0.43	1											
Debt Issuance (% assets)	(9)	0.01	0.02	0.00	0.02	0.02	0.02	0.02	–0.03	1										
Size	(10)	0.47	0.12	0.47	–0.28	–0.36	0.15	–0.23	–0.36	–0.02	1									
Market-to-Book	(11)	0.00	0.09	–0.04	0.06	0.05	0.16	0.25	0.22	0.01	–0.02	1								
Cash Flow (% assets)	(12)	0.21	–0.03	0.24	–0.32	–0.36	0.16	–0.38	–0.31	–0.08	0.32	–0.07	1							
ILLIQ	(13)	–0.22	–0.13	–0.18	0.08	0.12	–0.06	–0.04	–0.04	0.00	–0.24	–0.10	–0.10	1						
Total IO (% mktcap)	(14)	0.72	0.38	0.61	–0.35	–0.42	0.17	–0.09	–0.10	0.00	0.58	0.07	0.26	–0.29	1					
Top5 IO (% mktcap)	(15)	0.42	0.30	0.31	–0.24	–0.25	0.05	–0.04	–0.02	0.00	0.21	–0.02	0.09	–0.19	0.73	1				
# Blockholders	(16)	0.47	0.34	0.35	–0.19	–0.2	0.04	–0.05	–0.02	0.00	0.13	–0.05	0.07	–0.15	0.65	0.78	1			
Bid-Ask (%)	(17)	–0.33	–0.18	–0.27	0.15	0.22	–0.09	0.00	0.00	0.00	–0.38	–0.13	–0.16	0.59	–0.42	–0.23	–0.19	1		
Turnover (%)	(18)	0.31	0.52	0.08	0.11	0.10	0.08	0.11	0.10	0.01	0.22	0.11	0.01	–0.17	0.36	0.13	0.14	–0.23	1	
CEO WPS	(19)	–0.03	–0.02	–0.02	0.02	0.01	0.04	0.03	0.09	–0.01	0.07	0.07	0.05	0.01	–0.06	–0.06	–0.07	0.03	0.03	1

Table 3
Equity Lending, Stock Repurchases, and Investments: OLS-FE Regressions
This table reports regressions of stock repurchases and corporate investment in quarter *t+1* as a function of equity lending in quarter *t*. The variable definitions are in Appendix B. We report standard errors double-clustered at the firm and year-quarter levels in brackets. All regressions have firm- and year-quarter-fixed effects.

Dep. Var.:	$Repurchases_{i,t+1}$		$Investment_{i,t+1}$	
	(1)	(2)	(3)	(4)
$Shortable\ Supply_{i,t}$	0.011***	0.010***	0.009***	0.005***
	[0.002]	[0.002]	[0.002]	[0.002]
$Size_{i,t}$	0.065**	0.063**	–0.981***	–0.988***
	[0.026]	[0.028]	[0.064]	[0.067]
$Market\text{-}to\text{-}Book_{i,t}$		0.010***		0.071***
		[0.004]		[0.007]
$Cash\ Flow_{i,t}$		0.013***		–0.022***
		[0.002]		[0.005]
$ILLIQ_{i,t}$		0.002***		–0.002***
		[0.000]		[0.000]
$Total\ IO_{i,t}$		0.002**		0.012***
		[0.001]		[0.002]
$Top5\ IO_{i,t}$		–0.438***		–1.331***
		[0.154]		[0.234]
$\#\ Blockholders_{i,t}$		–0.016**		–0.015
		[0.007]		[0.010]
Time FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
Obs.	113,019	109,851	113,019	109,851
R^2	0.01	0.01	0.04	0.06

*** p-value<0.01, ** p-value<0.05, * p-value<0.10

Table 4
Other Corporate Policies
This table reports regressions of alternative firm policy variables in quarter *t+1* as a function of equity lending in quarter *t*. The variable definitions are in Appendix B. We report standard errors double-clustered at the firm and year-quarter levels in brackets. All regressions have firm- and year-quarter-fixed effects.

Dep. Var.:	$Cash_{i,t+1}$		$Debt\ Issuance_{i,t+1}$	
	(1)	(2)	(3)	(4)
$Shortable\ Supply_{i,t}$	0.097***	0.047***	0.034***	0.022***
	[0.014]	[0.015]	[0.006]	[0.007]
$Size_{i,t}$	–4.346***	–4.958***	–2.999***	–3.305***
	[0.358]	[0.371]	[0.222]	[0.235]
$Market\text{-}to\text{-}Book_{i,t}$		0.287***		–0.070***
		[0.046]		[0.025]
$Cash\ Flow_{i,t}$		0.089***		–0.121***
		[0.022]		[0.022]
$ILLIQ_{i,t}$		–0.018***		–0.005***
		[0.004]		[0.002]
$Total\ IO_{i,t}$		0.114***		0.048***
		[0.011]		[0.006]
$Top5\ IO_{i,t}$		–7.034***		–2.989***
		[1.616]		[0.741]
$\#\ Blockholders_{i,t}$		–0.228***		0.008
		[0.063]		[0.036]
Time FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
Obs.	113,019	109,851	111,701	108,665
R^2	0.02	0.04	0.01	0.02

*** p-value<0.01, ** p-value<0.05, * p-value<0.10

Table 5
Equity Lending and Authorized Stock Repurchases Announcements
This table reports coefficients from probit regression models of stock repurchases authorizations in quarter *t+1* as a function of equity lending at quarter *t*. The dependent variable, *D(Authorized Repurchases)*, is equal to one if the firm makes an announcement of a stock repurchase program in a given quarter, zero otherwise. Columns (1) and (2) are based on a standard probit model. Columns (3) and (4) are based on a firm-averaged probit. The variable definitions are in Appendix B. We report standard errors double-clustered at the firm and year-quarter levels in brackets. All regressions have year-quarter-fixed effects.

Dep. Var.:	$D(Authorized\ Repurchases)_{i,t+1}$			
Probit Type:	Standard		Firm Avg. (Firm FE)	
	(1)	(2)	(3)	(4)
$Shortable\ Supply_{i,t}$	0.016***	0.010***	0.015***	0.009***
	[0.001]	[0.001]	[0.001]	[0.001]
$Size_{i,t}$	0.073***	0.048***	0.076***	0.047***
	[0.006]	[0.008]	[0.006]	[0.007]
$Market\text{-}to\text{-}Book_{i,t}$		0.001		–0.005
		[0.004]		[0.004]
$Cash\ Flow_{i,t}$		0.035***		0.030***
		[0.003]		[0.003]
$ILLIQ_{i,t}$		–0.000		0.000
		[0.001]		[0.001]
$Total\ IO_{i,t}$		0.004***		0.005***
		[0.001]		[0.001]
$Top5\ IO_{i,t}$		–0.427**		–0.527***
		[0.168]		[0.159]
$\#\ Blockholders_{i,t}$		–0.006		–0.003
		[0.009]		[0.008]
Time FE	Y	Y	Y	Y
Obs.	103,536	100,486	103,536	100,486
$LR\ \chi^2\ Statistic$	963***	1,051***	938***	1,009***

*** p-value<0.01, ** p-value<0.05, * p-value<0.10

Table 6
OLS-FE Regressions: Exploiting Information from Equity Loan Fees
This table reports regressions of stock repurchases and investment in quarter $t+1$ as a function of equity lending in quarter t. *D(High Fee)* is equal to one if Fee is bigger than 1% p.a.; zero otherwise. The variable definitions are in Appendix B. We report standard errors double-clustered at the firm and year-quarter levels in brackets. All regressions have firm- and year-quarter-fixed effects.

Dep. Var.:	$Repurchases_{i,t+1}$		$Investment_{i,t+1}$	
	(1)	(2)	(3)	(4)
$D(High\ Fee)_{i,t}$	–0.088***	–0.023	–0.148***	–0.091*
	[0.023]	[0.029]	[0.042]	[0.052]
$Shortable\ Supply_{i,t}$		0.010***		0.004*
		[0.002]		[0.002]
$D(High\ Fee)_{i,t} \times Shortable\ Supply_{i,t}$		–0.004*		–0.008*
		[0.002]		[0.005]
$Size_{i,t}$	0.072**	0.064**	–1.008***	–1.012***
	[0.029]	[0.029]	[0.069]	[0.068]
$Market\text{-}to\text{-}Book_{i,t}$	0.011***	0.011***	0.069***	0.068***
	[0.004]	[0.004]	[0.007]	[0.007]
$Cash\ Flow_{i,t}$	0.014***	0.014***	–0.022***	–0.022***
	[0.002]	[0.002]	[0.005]	[0.005]
$ILLIQ_{i,t}$	0.002***	0.002***	–0.002***	–0.002***
	[0.000]	[0.000]	[0.000]	[0.000]
$Total\ IO_{i,t}$	0.004***	0.002*	0.012***	0.012***
	[0.001]	[0.001]	[0.002]	[0.002]
$Top5\ IO_{i,t}$	–0.678***	–0.459***	–1.495***	–1.411***
	[0.163]	[0.157]	[0.233]	[0.243]
$\#\ Blockholders_{i,t}$	–0.012*	–0.014**	–0.010	–0.011
	[0.007]	[0.007]	[0.010]	[0.010]
Time FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
Obs.	103,845	103,843	103,843	103,843
R^2	0.01	0.01	0.06	0.06

*** p-value<0.01, ** p-value<0.05, * p-value<0.10

Table 7
OLS-FE Regressions: Effect Heterogeneity

This table reports estimates of stock repurchases in quarter *t+1* as a function of equity lending in quarter *t*. In column (1), *D(Sample Split)* is equal to one if the stock is in the highest tercile of *Spread*; zero for those in the lowest tercile. In column (2), *D(Sample Split)* is equal to one for stocks in the lowest tercile of *Turnover*; zero for those in the highest tercile. In columns (3) and (4), *D(Sample Split)* is equal to one, respectively, if the stock is in the highest tercile of *Market-to-Book* and in the highest tercile of the CEO pay-sensitivity (*CEO WPS*) from Edmans et al. (2009); zero for those in the lowest tercile. In column (5), *D(Sample Split)* is equal to one for firms without a credit rating on its corporate bonds and commercial paper; zero otherwise. Regressions include the same set of control variables used in column (2) of Table 3. We report standard errors double-clustered at the firm and year-quarter levels in brackets. All regressions have firm- and year-quarter-fixed effects.

	Dep. Var.: Repurchases				
Heterogeneity Criteria	*High*	*Low*	*High*	*High*	*No*
D(Sample Split) $_{i,t}$ *=1* if:	*Bid-Ask*	*Turnover*	*MB*	*CEO WPS*	*Credit Rating*
	(1)	(2)	(3)	(4)	(5)
D(Sample Split) $_{i,t}$	–0.044	0.108***	0.008	–0.052	0.135**
	[0.028]	[0.028]	[0.038]	[0.063]	[0.055]
Shortable Supply $_{i,t}$	0.014***	0.015***	0.007***	0.008***	0.010***
	[0.003]	[0.003]	[0.002]	[0.003]	[0.002]
Shortable Supply $_{i,t}$ $\times$ *D(Sample Split)*	–0.006**	–0.011***	0.012***	0.012***	0.004*
	[0.003]	[0.003]	[0.003]	[0.004]	[0.002]
Firm Controls	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y
Obs.	64,937	65,029	64,976	16,654	109,851
R^2	0.01	0.01	0.01	0.01	0.01

*** p-value<0.01, ** p-value<0.05, * p-value<0.10

Table 8
Validity Tests using the July 2007 Price Test Repeal: Univariate Analysis
This table examines equity lending markets and firm policies in the four quarters around the repeal of the uptick rule in July 2007. Panel A reports statistics for *On Loan* and *Shortable Supply.* Panel B reports statistics for our main outcome variables: *Repurchases* and *Investment. Reg SHO Pilot* denotes the Russell stocks included in the SHO pilot program of May 2005 that form the control group (C). *Non-Reg SHO Pilot* denotes firms excluded from the May 2005 pilot, but that had price tests removed after July 2007; they form the treatment group (T). We compare means in the four quarter-ends before price tests were removed for all stocks (*Pre*) and after (*Post*).

Panel A: *On Loan* and *Shortable Supply*

	On Loan (% mktcap)			*Shortable Supply (% mktcap)*		
	Pre	*Post*	*Post–Pre*	*Pre*	*Post*	*Post–Pre*
Non-Reg SHO Pilot (T)	6.87	9.02	2.15***	16.17	17.02	0.85
Reg SHO Pilot (C)	7.25	9.10	1.85***	16.24	17.41	1.17*
(T) – (C)	–0.38***	–0.08		–0.07	–0.39*	
Diff.-in-Diff.			0.30**			–0.32*

Panel B: *Repurchases* and *Investment*

	Repurchases			*Investment*		
	Pre	*Post*	*Post–Pre*	*Pre*	*Post*	*Post–Pre*
Non-Reg SHO Pilot (T)	0.98	1.06	0.08	2.95	2.70	–0.26**
Reg SHO Pilot (C)	0.84	1.16	0.32***	2.75	2.61	–0.14
(T) – (C)	0.14*	–0.09		0.21***	0.09***	
Diff.-in-Diff.			–0.24**			–0.11***

*** p-value<0.01, ** p-value<0.05, * p-value<0.10

Table 9

Validity Tests using the 2007 Price Test Repeal: Multivariate Analysis

This table examines firm policies in the four quarters around the repeal of the uptick rule in July 2007. *D(Repeal)* is equal to one in the four quarters after the uptick price test was removed for all U.S. stocks in July 2007; zero otherwise. *D(Non-Reg SHO Pilot)* is equal to one for stocks originally excluded from the Reg SHO pilot in 2005, but still subject to price tests in July 2007; zero otherwise. $Shortable\ Supply_{June07}$ is the value for shortable supply in the quarter immediately before the repeal of price tests. We report robust-cluster standard errors. All regressions have firm- and year-quarter-fixed effects.

Dep. Var.:	$Repurchases_{i,t}$ (1)	$Investment_{i,t}$ (2)	$Cash_{i,t}$ (3)	$Debt\ Issuance_{i,t}$ (4)
$D(Repeal)_t \times D(Non\text{-}Reg\ SHO\ Pilot)_i$	–0.433***	–0.243*	–2.184**	–0.731
	[0.136]	[0.138]	[0.912]	[0.531]
$D(Repeal)_t \times Shortable\ Supply_{i,June07}$	0.004**	0.001*	0.022*	0.048**
	[0.002]	[0.007]	[0.012]	[0.021]
$D(Repeal)_t \times D(Non\text{-}Reg\ SHO\ Pilot)_i \times Shortable\ Supply_{i,June07}$	0.025***	0.011**	0.017**	0.005*
	[0.006]	[0.006]	[0.008]	[0.002]
$Size_{i,t}$	–0.564***	–0.483***	3.768**	–3.153
	[0.139]	[0.154]	[1.568]	[1.995]
$Market\text{-}to\text{-}Book_{i,t}$	0.042**	0.021	0.211**	0.123
	[0.019]	[0.016]	[0.106]	[0.113]
$Cash\ Flow_{i,t}$	0.018***	–0.064***	0.190***	–0.068
	[0.007]	[0.014]	[0.059]	[0.048]
$ILLIQ_{i,t}$	–0.003	0.005***	–0.019	0.020
	[0.003]	[0.002]	[0.021]	[0.021]
$Total\ IO_{i,t}$	–0.018***	0.010***	0.072***	0.017
	[0.005]	[0.004]	[0.025]	[0.024]
$Top5\ IO_{i,t}$	–0.246	–1.979***	–9.235***	1.865
	[0.729]	[0.459]	[3.298]	[3.352]
$\#\ Blockholders_{i,t}$	0.061*	0.019	–0.046	–0.021
	[0.036]	[0.017]	[0.108]	[0.125]
Time FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
Obs.	10,681	10,681	10,681	10,216
R^2	0.03	0.04	0.05	0.01

*** p-value<0.01, ** p-value<0.05, * p-value<0.10