Short-Sales Constraints and Aftermarket IPO Pricing*

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Abstract

It is well established that initial public offerings (IPOs) tend to experience positive first-day returns followed by underperformance, especially around the expiration of lockup agreements. Miller's (1977) theory offers a unified explanation based on divergence of investor opinion about fundamental value combined with short-sales constraints. Our paper provides a test of Miller's explanation by analyzing detailed data from the securities lending market. While prior research is inconclusive with respect to the importance of Miller's theory in the IPO setting, our paper finds evidence that the combination of heterogeneous investor opinions with short-sales constraints is key to explaining aftermarket IPO pricing.

Keywords: divergence of opinion; short-sales constraints; IPO pricing; IPO share lockups.

Data Availability: Data are publicly available from sources indicated in the text.

Initial public offerings (IPOs) provide two of the greatest asset pricing puzzles in finance. First, IPOs tend to experience positive first-day returns in that, on average, the offering price is substantially below the closing price on the first trading day (e.g., Logue 1973; Ibbotson 1975). Second, IPOs tend to have poor stock returns relative to seasoned securities in the years following the offering (e.g., Ritter 1991; Loughran and Ritter 1995), and especially around the expiration of IPO share lockups (e.g., Field and Hanka 2001; Brav and Gompers 2003).

A unified theory for explaining these phenomena is proposed in Miller (1977) and subsequently formalized in Duffie et al. (2002). Within the context of this theory, investors with relatively optimistic opinions buy the stock in the immediate aftermarket, while investors with relatively pessimistic opinions are unable to register their negative views due to short-sales constraints. The theory predicts that the aftermarket price will exceed the consensus valuation of the stock and the magnitude of this overpricing will be increasing in the combined effects of divergence of investor opinion and short-sales constraints.

This theory also predicts that IPO firms will subsequently underperform seasoned firms. This is because (i) the resolution of valuation uncertainty and (ii) the loosening of short-sales constraints due to increases in the supply of tradeable shares, should cause price to revert toward the consensus valuation. This process should be accelerated at the expiration of IPO lockup agreements, as these expirations result in a dramatic increase in float, thereby significantly relaxing short-sales constraints. This prediction distinguishes Miller's theory from a variety of theories of deliberate premarket discounting (e.g., Rock's 1986 winner's curse explanation), which presume that the immediate aftermarket price is an unbiased estimate of fundamental value and are silent with respect to long-term underperformance, especially around the lockup expiration.

While Miller's theory provides an intuitive explanation for aftermarket IPO pricing, existing evidence is inconclusive with respect to the importance of short-sales constraints in the IPO setting. Geczy et al. (2002) find that most IPOs are available to short in the immediate aftermarket and that short-selling costs do not appear to be sufficient to explain IPO pricing puzzles. Similarly, Edwards and Hanley (2010) find evidence of active short selling in the IPO setting and conclude that such evidence is inconsistent with the notion that short-sales constraints explain first-day returns. Kaplan et al. (2013) examine the impact of short selling by conducting a randomized stock lending experiment among high loan fee stocks. While IPOs are not the focus of their study, they nevertheless do not find evidence consistent with Miller's (1977) prediction that supply increases in the securities lending market generate negative stock price pressure.

Our paper provides a test of Miller's explanation for aftermarket IPO pricing by analyzing detailed data from the securities lending market. To identify IPOs that are ex ante expected to have high divergence of investor opinion about fundamental value and more binding short-sales constraints, we develop a composite "*Miller Score*" using a parsimonious set of characteristics from the offering prospectus, including pre-IPO sales growth, operating earnings, investments in intangible assets, and the offering size, i.e., the number of shares offered in the IPO relative to the total number of shares outstanding in the company.

The idea underlying our composite score is that investors will form more divergent opinions about the fundamental value of a new issuer with high sales growth, negative operating earnings, and high intangible intensity, i.e., large investments in R&D and advertising relative to reported sales. With respect to the offering size, we observe that shares outstanding in the company that are not offered in the IPO are typically subject to lockup agreements that prohibit the sale or loan of the shares for 180 days following the offering. The combination of small offering size with

lockup agreements on the remaining shares outstanding in the company restricts the supply of lendable shares and makes short-sales constraints more binding prior to the lockup expiration. On the flip side, IPOs with large offering size are less likely to face binding restrictions on the supply of lendable shares.

Our composite score (standardized to range from zero to one) offers a simple way to identify IPOs that are more likely to become overpriced in the immediate aftermarket. Top-score IPOs are ex ante expected to have high divergence of investor opinion about fundamental value and more limited supply of lendable shares. Even though top-score IPOs are stocks for which both conditions for Miller's overvaluation story are more likely to be *simultaneously* satisfied, a composite score of zero does not necessarily imply the absence of divergence of investor opinion and short-sales constraints. Thus, aftermarket pricing distortions are possible even for IPOs with a *Miller Score* of zero. Such pricing distortions, however, are predicted to be higher for top-score IPOs. Following this argument, our analyses mostly focus on differences across portfolios of IPOs with composite scores of zero and one.

Consistent with Miller's overvaluation story, we find that IPOs with a top *Miller Score* are associated with more positive first-day returns and more negative abnormal returns around the lockup expiration. The economic magnitudes of our results are quite striking. The average first-day return increases with our composite score, ranging from 9% for IPOs with a zero *Miller Score* to as high as 32% for IPOs with a top *Miller Score*. In addition, the average market-adjusted return

around the lockup expiration decreases from effectively 0% for IPOs with a zero *Miller Score* to as low as -9% for IPOs with a top *Miller Score*.[1]

We next analyze detailed data from the securities lending market, including stock loan fees, rebate rates, and active supply utilization. The evidence confirms that IPOs with a high *Miller Score* are more difficult and costly to short sell. On average, top-score IPOs have stock loan fees of 7% per annum, corresponding to rebate rates below -6% per annum, with active supply utilization of 66%, while zero-score IPOs have stock loan fees of 1% per annum, corresponding to rebate rates of 0% per annum, with active supply utilization of 27%.[2]

A hypothetical trading strategy that short sells IPOs prior to the lockup expiration is indicative of significant abnormal returns. Additional analysis, however, reveals that the premium for short selling IPO share lockups likely reflects compensation for the unique costs and risks facing short sellers, including the cost of borrowing, the cost of locating stock in the securities lending market, the idiosyncratic risk from targeting IPOs, the risk that stock loans are recalled, and the risk that stock loans become more expensive. Indeed, our analysis suggests that short

[1] Prior research has used analyst forecast dispersion as a measure of divergence of investor opinion for the general population of stocks (e.g., Diether et al. 2002). Analyst coverage of IPOs typically starts only after 40 calendar days following the IPO day, which coincides with the end of the quiet period (e.g., Bradley et al. 2003). As a result, analyst forecast dispersion is determined endogenously and simultaneously with IPO pricing. In additional analysis (Table 10), we explore variation in lockup returns with analyst forecast dispersion and find consistent results. IPOs with low analyst forecast dispersion and large offering size do not experience significant abnormal lockup returns, which is consistent with evidence of 0% abnormal lockup returns for zero *Miller Score* IPOs. In contrast, IPOs with high analyst forecast dispersion and small offering size tend to experience negative lockup returns of -8.75%, which is consistent with evidence of significantly negative abnormal lockup returns of for top *Miller Score* IPOs.

[2] As an example, we consider Twitter Inc. (NYSE: TWTR)—a top *Miller Score* IPO in our sample. In the last fiscal year prior to its IPO that ended on December 31, 2012, TWTR reported sales growth of nearly 200%, an operating loss of $77 million, and a high intangible intensity ratio of 38 cents in R&D and advertising per dollar of sales. TWTR offered 13% of its shares outstanding at its IPO. The 87% of the shares outstanding that were not offered in the IPO were subject to a 180-day lockup agreement. On November 7, 2013, trading opened at $45.10 and closed at $44.90, up 73 percent from the $26 offering price per share. First-day trading volume was 170% of the number of shares offered in the IPO. TWTR's lockup agreement expired on May 6, 2014, sending the stock price down by 18% and wiping out $4 billion of market value. Prior to the lockup expiration, short sellers were actively targeting TWTR with the active supply utilization peaking at 99% and stock loan fees hovering at 9% per annum.

selling around the lockup expiration is particularly costly and risky for IPOs with a top *Miller Score*, which are precisely the stocks with the greatest back-tested returns.

Overall, our paper provides evidence that the combination of heterogeneous investor opinions with short-sales constraints is key to explaining aftermarket IPO pricing consistent with Miller's overvaluation story. Our evidence is also consistent with analytical models on the implications of sentiment investors and short-sales constraints in the immediate aftermarket for IPO pricing (e.g., Ljungqvist et al. 2006; Cornelli et al. 2006). More generally, our paper adds to ongoing research on the importance of short-sales constraints for asset pricing (e.g., Harrison and Kreps 1978; Jarrow 1980; Figlewski 1981; Diamond and Verrecchia 1987; Chen et al. 2001; Duffie et al. 2002; Hong and Stein 2003; Scheinkman and Xiong 2003; Nagel 2005; Hong et al. 2006; Chang et al. 2007; Cen et al. 2013; Kaplan et al. 2013; Drechsler and Drechsler 2014; Beneish et al. 2015; Cornelli and Yilmaz 2015; Engelberg et al. 2015; Hong and Sraer 2016).

Our paper is organized as follows. Section 1 reviews prior research and provides our empirical predictions. Section 2 describes our sample and research design. Section 3 presents our empirical results. Section 4 concludes.

1. Prior Literature and Predictions

The pricing of IPOs provides two of the most enduring capital market puzzles. First, the shares of IPOs are generally offered at a price that is substantially below the closing price on the first trading day. For example, Ritter (2016) reports an average first-day return of 17.9% for over 8,000 IPOs between 1980 and 2014. Second, the subsequent stock returns of IPOs are typically lower than the returns of seasoned securities. For example, Ritter (2016) reports an average 3-year buy-and-hold market-adjusted return of -17.8% for over 8,000 IPOs from 1980 to 2014. Prior

research indicates that underperformance is particularly pronounced around the expiration of IPO share lockups. Lockup agreements prohibit pre-IPO shareholders from selling or lending their shares for a specified period of time. The typical lockup period lasts for 180 days and covers most of the shares that are not sold in the IPO. Brav and Gompers (2003) examine a sample of 2,794 IPOs from 1988 to 1996 and find an average buy-and-hold market-adjusted return of -2% from ten trading days before to ten trading days after the lockup expiration.[3]

Miller's (1977) theory offers one of the earliest and most intuitive explanations for aftermarket IPO pricing. Miller's explanation hinges on the combination of heterogeneous investor opinions with short-sales constraints.[4] Divergence of investor opinion is expected to be particularly pronounced for IPOs because they are often high growth companies with a limited operating history for which it is difficult to forecast future cash flows and valuation uncertainty is high (e.g., Miller 1977; Kim and Ritter 1999). With divergent investor opinions about fundamental value and a limited supply of tradeable shares, the stock price will reflect the valuation estimates of the most optimistic investors who participate in the immediate aftermarket, which will be above the consensus stock valuation. As the stock becomes more seasoned, the reduction in valuation uncertainty along with the increase in the supply of tradeable shares should cause its price to fall toward the consensus valuation.

[3] Field and Hanka (2001) report that the fraction of new issuers with a 180-day lockup period increased from 43% in 1988 to 91% in 1996. Brav and Gompers (2003) find lockup agreements in 99% of new issuers.

[4] Diether et al. (2002) note that Miller's theory implicitly assumes "bounded rationality" in the sense that investors are either over-confident about their own valuation estimates or they make inaccurate inferences about others' valuation estimates. Miller's overvaluation story would disappear if investors learned to perfectly discount their valuations to account for the possibility that they ended up holding stock largely because others did not want it, as in Diamond and Verrecchia's (1987) rational expectations framework. Cornelli and Yilmaz (2015) extend Diamond and Verrecchia's (1987) rational expectations framework to include uncertainty about the number of informed investors in the market and show that, as long as the signal observed by the informed investors is not too precise, significant short-sales constraints will not allow prices to converge to the fundamental value.

Miller explicitly identifies IPOs as a prime setting for overvaluation, stating that "*the prices of new issues, as of all securities, are set not by the appraisal of the typical investor, but by the small minority who think highly enough of the investment merits of the new issue to include it in their portfolio.*" Miller also suggests a non-strategic explanation for the underpricing of new issues by underwriters based on the marginal investor viewpoint: "*…if underwriters…price new issues on the basis of their own best estimates of the prices of comparable seasoned securities, they will typically underprice new issues. The mean of their appraisals will resemble the mean appraisal of the typical investor, and this will be below the appraisals of the most optimistic investors who actually constitute the market for the security.*"

A key requirement of Miller's overvaluation story is that short-sales constraints are sufficient to prevent pessimistic investors from registering their views via short sales in the immediate aftermarket for new issuers. Such short sales would effectively increase the stock supply, causing price to fall toward the consensus valuation.

While evidence related to short-sales constraints for IPOs is sparse, the existing evidence is inconclusive with respect to the importance of such constraints in the IPO setting. Geczy et al. (2002) examine short-selling activity for a sample of 311 IPOs between October 28, 1998 and October 26, 1999 using a proprietary database provided by a large securities lender. They find that most stocks are available to be sold short and that short-selling costs seem to be too small to explain the IPO pricing puzzles. Building on this evidence, Edwards and Hanley (2010) examine short-selling activity for 388 IPOs from January 1, 2005 to December 31, 2006 using Regulation SHO pilot data. They find that short selling is prevalent in the immediate aftermarket and that IPOs with more positive first-day returns experience a greater volume of short selling. In addition, they argue that there is no evidence that short sellers systematically engage in "naked" short selling in IPOs

and, therefore, no indication that too few shares are available to be borrowed in time for settlement.[5] Overall, Edwards and Hanley (2010) conclude that short selling is an integral part of the IPO aftermarket and that other factors may be responsible for evidence of positive first-day returns.

Even though prior evidence confirms the existence of short selling around IPOs, it does not directly address the question of whether the combination of heterogeneous investor opinions with short-sales constraints can explain variation in first-day returns and subsequent underperformance, especially around the lockup expiration. We use a comprehensive database from the securities lending market to examine the role of short-sales constraints in aftermarket IPO pricing. We begin by testing the basic prediction of Miller's (1977) hypothesis that divergence of investor opinion about fundamental value combined with a limited supply of lendable shares lead to positive first-day returns:

Prediction 1: *IPOs with a combination of high divergence of investor opinion and more limited supply of lendable shares experience more positive first-day returns.*

Miller's explanation also predicts that IPOs with high divergence of investor opinion and more limited supply of shares will subsequently underperform. This is because the resolution of investor uncertainty along with the relaxation of short-sales constraints due to increases in the supply of lendable shares should cause price to fall toward the consensus valuation. This process should be accelerated around the lockup expiration as pre-IPO shareholders are allowed to sell

[5] A "naked" short sale is a short sale where the seller does not borrow or arrange to borrow the securities in time to make delivery to the buyer within the standard three-day settlement period and, as a result, the short seller fails to deliver securities to the buyer when settlement is due.

their shares, thereby increasing the supply of lendable shares and loosening short-sales constraints. This discussion leads to our second prediction:

Prediction 2: *IPOs with a combination of high divergence of investor opinion and more limited supply of lendable shares experience more negative returns around the lockup expiration.*

It should be noted that Prediction 2 holds even though the lockup parameters, i.e., the lockup period length and the number of locked-up shares, are known at the time of the IPO. Importantly, Prediction 2 distinguishes Miller's theory from a variety of theories, which presume that the immediate aftermarket price is an unbiased estimate of fundamental value and attribute evidence of positive first-day returns to premarket discounting (see Ritter 1998 for a comprehensive review).

For example, an important rationale for evidence of positive first-day returns is Rock's (1986) winner's curse explanation. Rock (1986) presents a model with two groups of investors: the informed investors, who have perfect information about the value of the offering, and the uninformed investors, who have homogeneous expectations about the distribution of the value of the offering. If the new shares are priced at their expected value, the informed investors crowd out the uninformed investors when good issues are offered and withdraw when bad issues are offered. The new issuer must price the shares at a discount in order to guarantee that the uninformed investors are sufficiently compensated for the adverse selection problem in the allocation process to purchase the issue. Rock's (1986) model presumes that the immediate aftermarket price is an unbiased estimate of fundamental value and predicts that premarket discounting is more pronounced for IPOs with high information asymmetry. Rock's (1986) model, however, is silent with respect to the long-run underperformance of IPOs, especially around the lockup expiration.

Relatedly, Benveniste and Spindt (1989) view premarket discounting as compensation to investors for revealing information about the IPO valuation to the underwriters during the book-building procedure, which can then be used to assist in pricing the issue. This market-feedback hypothesis is geared towards explaining deliberate discounting in the underwriting process and while it generates predictions with respect to variation in first-day returns, it is silent with respect to the long-run underperformance of IPOs, especially around the lockup expiration. Aggarwal et al. (2002) develop a model in which managers strategically underprice IPOs to maximize personal wealth from selling shares at lockup expiration. Their model predicts that more positive first-day returns generate information momentum, which leads to a higher stock price at the lockup expiration. Their model, however, is silent with respect to the implications of heterogeneous investor opinions and short-sales constraints on aftermarket IPO pricing.

We next examine variation in short-selling costs across IPOs. Specifically, we predict that divergence of investor opinion combined with a limited stock supply available for lending lead to a higher cost of borrowing in the securities lending market. Our prediction is consistent with the model of Duffie et al. (2002). In particular, Duffie et al. (2002) build a dynamic model of the determinants of stock prices, stock loan fees, and short interest where agents trade because of differences of opinion and would-be short sellers must search for security lenders and bargain over the stock loan fees. Within the context of their model, Duffie et al. (2002) find that stock loan fees increase when there is a high degree of divergence of investor opinion and a small float, i.e., a small number of tradeable shares, as in the case of IPOs offering a small fraction of their number of shares outstanding. Our third prediction is summarized as follows:

Prediction 3: *IPOs with a combination of high divergence of investor opinion and more limited supply of lendable shares are more difficult and costly to short sell.*

2. Sample and Research Design

2.1 Sample Selection

Our sample selection period begins in 2007 because this is the first year in which we have detailed securities lending data available on a daily basis from Markit Securities Finance Data (formerly known as Data Explorers). We start with an initial sample of 688 IPOs listed on NYSE, NASDAQ, and AMEX over the period from 2007 to 2014 obtained from the Securities Data Company (SDC) database that have Markit coverage. Following prior research (e.g., Ritter and Welch 2002), our initial sample excludes IPOs with an offering price below $5 per share and IPOs by American depository receipts (ADRs), unit offerings, real estate investment trusts (REITs), special purpose acquisition companies (SPACs), and closed-end funds.[6] We reviewed all cases with missing pre-IPO financial accounting data from Compustat and hand-collected data directly from the offering prospectuses available from the SEC's EDGAR database.[7] To obtain our final sample, we exclude 23 IPOs with no lockup agreements and 36 IPOs with lockup agreements expiring sooner or later than 180 days after the IPO day.[8]

Our final sample includes 629 IPOs over eight years from 2007 to 2014 with aggregate offer proceeds of $167.2 billion. Our sample ends in 2014 because this is the last year for which

[6] We thank Jay Ritter for providing a list of corrections to the SDC database, all of which we have incorporated in this study. The corrections are located at https://site.warrington.ufl.edu/ritter/ipo-data/.

[7] A company undertaking an IPO discloses required information in the registration statement, typically on Form S-1. Form S-1 and its amendments are filed with the SEC and are publicly available through the SEC's EDGAR database. Most of the Form S-1 is comprised of the offering prospectus, which contains at least two years of audited financial statements. After a company's IPO registration has been declared effective, the company will typically file a final prospectus, which is usually identified as a 424B3 or 424B4 filing in the EDGAR database. For the average new issuer, the last fiscal year prior to the IPO ended 191 calendar days prior to the IPO day.

[8] Our results are not sensitive when we include IPOs with lockup agreements expiring sooner or later than 180 days after the IPO day. Our analysis and presentation of results is simplified, however, by focusing on IPOs with 180-day long lockup agreements (see, e.g., Figure 1 and 2).

we can track IPOs for at least 180 days after the IPO day. Table 1, Panel A, reports the distribution of our sample by year. The number of IPOs ranges over time from a minimum of 16 for 2008 to a maximum of 155 for 2014, which was the most active year since 2000.

2.2 Ex Ante Determinants of Divergence of Opinion and Short-Sales Constraints

Miller (1977) emphasizes valuation uncertainty as the key determinant of divergent investor opinions since "*the very concept of uncertainty implies that reasonable men may differ in their forecasts*." Miller also identifies IPOs as a prime setting for valuation uncertainty, stating that "*the divergence of opinion about a new issue are [sic] greatest when the stock is issued*." Miller goes on to identify "*uncertainty about the success of new products or the profitability of a major business expansion*" as key sources of valuation uncertainty for IPOs and argues that "*over time this uncertainty is reduced as the company acquires a history of earnings or lack of them, and the market indicates how it will value these earnings*."

To identify ex ante determinants of divergence of investor opinion due to valuation uncertainty, we rely on a parsimonious set of pre-IPO characteristics measured using financial accounting data from the offering prospectus, including (i) sales growth, (ii) the sign of operating earnings, and (iii) the level of R&D and advertising spending per dollar of sales—a measure of new product uncertainty. The idea underlying this parsimonious set of variables is simple. Uncertainty about future operating performance and, therefore, divergence of investor opinion should be higher for high growth new issuers experiencing operating losses, while making larger investments in intangibles.[9] We also consider other pre-IPO characteristics including (i) firm size,

[9] Consistent with this idea, prior research provides evidence from the general population of stocks that uncertainty over fundamental value is higher when pricing fast-growing firms and intangible-intensive firms experiencing losses (e.g., Lakonishok et al. 1994; Chan et al. 2001; Darrough and Ye 2007; Balakrishnan et al. 2010).

(i) firm age measured from the incorporation date to the IPO date, (iii) the existence of venture-capital investment, and (iv) tech-industry membership. We find, however, that variation in aftermarket pricing with these additional characteristics is subsumed by variation with sales growth, operating losses, and intangible intensity.

With respect to the securities lending market, a key determinant of the supply of lendable shares and, therefore, of short-sales constraints is the offering size, i.e., the number of shares offered in the IPO relative to the total number of shares outstanding in the company. Shares outstanding that are not offered in the IPO are typically subject to lockup agreements that prohibit the sale or loan of the shares for 180 days following the offering. Effectively, IPO share lockups represent a stringent form of short-sales constraint and lockup expirations are equivalent to loosening of this constraint (e.g., Ofek and Richardson 2003).

Clearly, the combination of small offering size with lockup agreements on the remaining shares outstanding in the company restricts the supply of lendable shares in the securities lending market. It follows that IPOs with small offering size are more likely to experience a binding short-sales constraint during the lockup period and a greater loosening of this constraint around the lockup expiration. On the flip side, IPOs with large offering size are less likely to face binding restrictions on the supply of lendable shares. Given that all IPOs in our sample have a lockup agreement, we identify the number of shares offered in the IPO relative to the total number of shares outstanding in the company as the key ex ante determinant of short-sales constraints.

2.3 Introducing the Miller Score

To simultaneously examine variation in the ex ante determinants of divergence of investor opinion and short-sales constraints, we introduce a four-point scoring method. Specifically, an IPO

scores one point for each of the following four criteria: (i) it has above median sales growth, (ii) it reports an operating loss, (iii) it has above median intangible intensity, and (iv) it has below median offering size. All four inputs are measured using information from the offering prospectus as of the most recent fiscal year prior to the IPO.

We obtain a composite score, which we refer to as the *Miller Score*, by summing up the points and dividing by four to standardize the score to range between zero (low) and one (high). The possible intermediary values of our composite score are 0.25, 0.50, and 0.75. To illustrate, a top *Miller Score* of one indicates that the IPO has above median sales growth and intangible intensity, reported an operating loss, and has below median offering size. Conversely, a low *Miller Score* of zero indicates that the IPO has below median sales growth and intangible intensity, reported an operating profit, and has above median offering size.

Top-score IPOs are ex ante expected to have high divergence of investor opinion and more limited supply of lendable shares. Even though top-score IPOs are stocks for which both conditions for Miller's overvaluation story are more likely to be *simultaneously* satisfied, a composite score of zero does not necessarily imply the absence of divergence of investor opinion and short-sales constraints. Thus, aftermarket pricing distortions are possible even for IPOs with a *Miller Score* of zero. Such pricing distortions, however, are predicted to be more pronounced for top-score IPOs. Following this argument, our analyses mostly focus on differences across portfolios of IPOs with composite scores of zero and one.[10]

[10] We note that our scoring method assigns the same weight of 1/4 to each of the four pre-IPO characteristics considered. In additional analysis, we find similar results using an alternative scoring method that assigns a weight of 1/6 to each of the three ex ante determinants of divergence of opinion (i.e., high sales growth, pre-IPO operating loss, and high intangible intensity) and weighs the offering size by 1/2. Using this alternative scoring method, the possible intermediary values of the composite score are 0.17, 0.33, 0.50, 0.67, and 0.83. This alternative scoring method affects

2.4 Timeline of Research Design

Appendix 1 illustrates the timeline of our research design. We measure the ex ante determinants of divergence of investor opinion, including sales growth, the operating loss indicator, and intangible intensity, using financial accounting data from the offering prospectus as of the most recent fiscal year prior to the IPO. From the offering prospectus, we also measure the offering size as the number of shares offered in the IPO (excluding the exercise of the overallotment option) divided by the number of shares outstanding in the company immediately after the IPO.[11] At the end of the first day of trading, we measure the return from the IPO offering price per share to the closing price per share, and offer turnover as the number of shares traded on the first trading day divided by the number of shares offered in the IPO. Around the lockup expiration, we measure buy-and hold market-adjusted returns, as well as average stock loan fees, rebate rates, and active supply utilization using daily values available from Markit's securities lending market database.

2.5 Descriptive Statistics

Before presenting our empirical results, we discuss the descriptive statistics. Appendix 2 provides all variable definitions. Table 1, Panel B, summarizes the empirical distributions of key variables. The average new issuer reports sales growth of 102% in the year prior to the offering and invests nearly 92 cents in R&D and advertising per dollar of reported sales. To mitigate the

only the composition of the intermediary *Miller Score* portfolios, while the composition of the bottom and top *Miller Score* portfolios remains unchanged. Our analyses mostly focus on comparisons across the extreme *Miller Score* portfolios and, therefore, our inferences remain unchanged using this alternative scoring method.

[11] For new issuers with dual-class ownership structure (60 cases in our sample), we measure the offering size as the number of Class A shares offered in the IPO divided by the number of shares outstanding in the company immediately after the IPO. This is because Class B shares typically do not enter the supply of tradeable shares prior to the IPO lockup expiration.

effect of skewness in sales growth and intangible intensity, the portfolio partitions used in our subsequent empirical tests are based on the median values of pre-IPO characteristics. Operating losses are reported by 34% of our sample. The average offering size accounts for nearly 30% of the number of shares outstanding, which indicates that the average fraction of locked-up shares is 70%. The average offering price is $15.60 per share, while 72% of IPOs in our sample have offering prices between $10 and $20, which is in line with prior evidence on the distribution of IPO prices (e.g., Ritter 1998).[12]

Consistent with prior research dating back to Logue (1973), we find evidence of positive first-day returns. The average first-day return is 16.4% with a standard deviation in excess of 25%. Consistent with prior research (e.g., Field and Hanka 2001; Brav and Gompers 2003), we also find evidence of negative abnormal returns around the lockup expiration. The average market-adjusted return cumulated from ten trading days before to twenty trading days after the lockup expiration is -3.54% with a standard deviation in excess of 18%.

Turning to the securities lending market, we measure stock loan fees, rebate rates, and active supply utilization using daily data available from Markit. Markit sources its data from a consortium of institutional lenders that collectively account for the vast majority of loanable equity inventory in the U.S. market. Markit provides a daily cost of borrowing score (DCBS) for each security. The DCBS is a number from one to ten indicating the cost of borrowing in the securities lending market, where one is cheapest and ten is most expensive. We use the mean stock loan fees

[12] Under the book-building method used in the U.S., IPO underwriters first come up with a suggested range for the offering price. After setting the range for the offering price, the underwriters collect investors' indications of interest during the book-building process and determine the final offering price. For a description of the book-building procedure see Cornelli and Goldreich (2001, 2003). In additional analysis, we find that high *Miller Score* IPOs are associated with a wider offering price range relative to the final offering price.

and rebate fees of securities with the same DCBS on the same trading day to obtain measures of implied stock loan fees and rebate rates. We measure active supply utilization as the quantity of current inventory on loan from beneficial owners divided by the quantity of current inventory available from beneficial owners. Consistent with Beneish et al. (2015), we classify IPOs as hard-to-borrow or "special" stocks if the average DCBS is higher than two and as easy-to-borrow or "general collateral" stocks otherwise.

Returning to the empirical distributions in Table 1, Panel B, we find that around the lockup expiration 83% of IPOs experience negative rebates with an average rebate rate of -2.38% per annum, which corresponds to an average stock loan fee of 3.13% per annum. Around the lockup expiration, hard-to-borrow IPOs account for 26.4% of our sample, while the average active supply utilization is hovering at 41%. In contrast, only a small fraction of stocks in the general population is on special, experiencing negative rebate rates at any given point in time (e.g., D'Avolio 2002; Asquith et al. 2005; Reed 2013; Beneish et al. 2015). Indeed, Table 1, Panel C, shows that the average rebate rate for the general population is 0.24% per annum, which corresponds to an average stock loan fee of 0.81% per annum, with active supply utilization of 16%, and only 6.42% of all stocks being on special.[13] These differences are even more striking when we consider value-weighted averages for the general population. On a value-weighted basis, the average rebate rate for the general population is 0.53% per annum, which corresponds to an average stock loan fee of 0.35% per annum, with active supply utilization of 6.78%, and "specialness" of 0.99%.

With respect to the pairwise correlations in Table 1, Panel D, we first confirm that our composite *Miller Score* is positively correlated with sales growth, operating losses, and intangible

[13] The general population includes U.S. firms listed on NYSE, AMEX, and NASDAQ, excluding IPOs, penny stocks, micro-cap stocks, ADRs, unit stocks, closed-end funds, and REITs over the period from 2007 to 2014.

intensity, while it is negatively correlated with offering size. The pairwise correlations also confirm that the ex ante determinants of divergence of opinion share a common component with sell-side analyst forecast dispersion—a measure of divergence of investor opinion that has been used for the general population of stocks (e.g., Diether et al. 2002; Nagel 2005; Boehme et al. 2006).

The correlation matrix also offers preliminary evidence supporting our three predictions based on Miller's overvaluation story. The *Miller Score* is positively correlated with first-day returns, while it is negatively correlated with lockup returns. In addition, the *Miller Score* is positively correlated with stock loan fees and active supply utilization. The pairwise correlations also indicate that high *Miller Score* IPOs tend to have lower rebate rates and are more likely to be on special. Finally, the negative correlation between first-day returns and lockup returns suggests that some of the initial IPO pricing reflects overpricing in the immediate aftermarket that is corrected six months later, around the lockup expiration.

3. Empirical Results

3.1 Evidence from the First Trading Day

Table 2 examines variation in first-day returns with pre-IPO characteristics. The portfolio results in Table 2, Panel A, provide evidence that first-day returns are higher for IPOs that are ex ante expected to have high divergence of investor opinion and more limited supply of lendable shares. Specifically, the average first-day return is significantly higher for IPOs with above median sales growth, operating losses, above median intangible intensity, and below median offering size. Importantly, Table 2, Panel B, shows that arranging IPOs in portfolios based on the *Miller Score* yields an even bigger spread in first-day returns. The average first-day return increases with our composite score and it ranges from 9.23% for IPOs with a zero *Miller Score* to 32.01% for IPOs

with a top *Miler Score*. The difference of 22.78% in the first-day returns across the extreme portfolios is economically important and statistically significant. The OLS regression results in Table 2, Panel C, provide consistent evidence of a significantly positive association between first-day returns and our composite *Miller Score* after controlling for year fixed effects and underwriter fixed effects.[14]

Table 3 examines variation in first-day offer turnover (i.e., the ratio of the number of shares traded on the first trading day divided by the number of shares offered in the IPO) and provides additional insights into investor behavior on the trading debut of newly listed firms. Consistent with a positive link between divergence of opinion and trading volume (e.g., Harris and Raviv 1993), we find evidence that on the first trading day offer turnover is higher for IPOs with high sales growth, high intangible intensity, and negative operating earnings.[15] In addition, offer turnover is significantly higher for IPOs with below median offering size. Across portfolios formed based on our composite *Miller Score*, we find that offer turnover increases from 62% for zero-score IPOs to nearly 100% for top-score IPOs.

Overall, the evidence supports our first prediction that IPOs that are ex ante expected to have high divergence of investor opinion and more limited supply of lendable shares experience

[14] The year fixed effects control for variation in the IPO aftermarket with overall market conditions. Prior research dating back to Ibbotson and Jaffe (1975) finds evidence of cycles in the IPO market, with periods of high average first-day returns known as "hot issue" markets. Fama and French (2004) emphasize the importance of the IPO market as a bellwether for the general population of stocks. More recently, Lowry et al. (2010) document a positive relation between average first-day returns and the cross-sectional standard deviation of first-day returns. With respect to the underwriter fixed effects, we identify the managing underwriter for each IPO as the lead underwriter of the new issue. If there is more than one managing underwriter, we identify the one who underwrites the highest number of shares as the lead underwriter. Then, we classify the lead underwriter as first, second, or third tier using Loughran and Ritter's (2004) underwriter reputation rankings.

[15] Harris and Raviv (1993) provide a model where trading is generated by differences of opinion regarding the value of the asset being traded. In their model, the differences of opinion result from different interpretations of public information announcements. Although all traders are rational, some view others as being irrational. Given this lack of common knowledge of rationality, all behavior in their model is maximizing.

more positive first-day returns. Our evidence extends prior studies on the relation between heterogeneous investor opinions due to valuation uncertainty and first-day returns (e.g., Beatty and Ritter 1986; Houge et al. 2001; Cook et al. 2006; Gao et al. 2006). Even though the evidence is consistent with Miller's overvaluation story, we do not preclude deliberate premarket discounting as a non-mutually exclusive explanation for positive first-day returns. Theories of deliberate premarket discounting, however, presume that the immediate aftermarket price is an unbiased estimate of fundamental value and are silent with respect to long-term underperformance, especially around the IPO share lockup expiration.

3.2 Evidence from IPO Share Lockups

IPO lockup agreements are intended to keep pre-IPO shareholders from immediately selling stock when a company raises public capital, creating unique supply constraints in the securities lending market. A key prediction based on Miller's (1977) theory is that IPOs with high valuation uncertainty and a restricted supply of lendable shares are more likely to become overpriced in the immediate aftermarket and to experience a price correction around the lockup expiration when an increased stock supply comes to the market. As we explain in Section 2, this prediction distinguishes Miller's overvaluation story from theories that attribute positive first-day returns to deliberate premarket discounting and make no predictions concerning returns around the lockup expiration (e.g., Rock's 1986 winner's curse explanation).

Table 4 examines variation in stock returns around IPO share lockups. We measure market-adjusted returns over the window from ten trading days before to twenty trading days after the lockup expiration. We use the CRSP value-weighted index including distributions to proxy for the stock market portfolio. Brav and Gompers (2003) document negative abnormal returns over the

window from ten trading days before to ten trading days after the lockup expiration. We extend Brav and Gompers' (2003) return measurement window forward by ten additional trading days to capture more of the post-lockup drift.

While IPOs tend to experience negative abnormal returns around the lockup expiration, we find evidence of predictable variation in lockup returns with ex ante determinants of divergence of investor opinion and short-sales constraints. Specifically, Table 4, Panel A, shows that lockup returns are significantly more negative for IPOs with high sales growth, negative operating earnings, high intangible intensity, and small offering size. Arranging IPOs based on our composite *Miller Score* yields a strong negative relation with lockup returns. The portfolio results in Table 4, Panel B, show that abnormal lockup returns decrease from -0.87% for zero-score IPOs to -9.15% for top-score IPOs. Evidence of insignificant abnormal lockup returns for zero-score IPOs suggests that investors have correctly anticipated the number of shares sold around the lockup expiration for this subset of new issuers. On the flip side, evidence of significantly negative abnormal lockup returns for top-score IPOs suggests that investors have been surprised by the number of shares sold around the lockup expiration for this subset of IPOs. The OLS regression results in Table 4, Panel C, provide consistent evidence of a significantly negative association between abnormal lockup returns and our composite *Miller Score* after controlling for year fixed effects and underwriter fixed effects.

Taken together, the evidence supports our second prediction that IPOs that are ex ante expected to have high divergence of investor opinion and more limited supply of lendable shares are more likely to become overpriced in the immediate aftermarket and experience more negative abnormal returns around the lockup expiration. Although consistent with Miller's overvaluation story, our evidence of predictably negative abnormal lockup returns for top *Miller Score* IPOs is

inconsistent with predictions based on rational expectations models. Within the context of such models, on average, investors should correctly anticipate the number of shares sold around the lockup expiration and abnormal lockup returns should be zero (e.g., Allen and Postlewaite 1984).

3.3 Short-Run and Long-Run IPO Performance

Figure 1 provides additional evidence with respect to variation in the aftermarket performance of IPOs. Panel A plots average market-adjusted stock returns cumulated forward starting from the IPO day (day 0) to 270 calendar days after the trading debut of (i) all IPOs (solid black line), (ii) IPOs with top *Miller Score* (dotted red line), and (iii) IPOs with zero *Miller Score* (dashed green line). The vertical line indicates the lockup expiration on the 180th calendar day after the IPO day.

Focusing first on our full sample, Figure 1, Panel A, clearly shows a price jump relative to the offering price on the first trading day, which is consistent with longstanding evidence of positive first-day returns, followed by a price drop six months later around the lockup expiration, which is consistent with prior evidence of negative abnormal lockup returns. Separating new issuers based on the *Miller Score*, the figure clearly shows that top-score IPOs are associated with significantly more positive first-day returns and more negative abnormal lockup returns, while zero-score IPOs exhibit no evidence of abnormal returns around the lockup expiration.

Figure 1, Panel B, plots average market-adjusted stock returns cumulated from ten trading days before to twenty trading days after the lockup expiration. By centering on the lockup expiration (day 0), the figure provides a closer look into the lockup returns across *Miller Score* portfolios. Focusing on top-score IPOs, evidence of negative abnormal returns prior to the 180th calendar day after the IPO day suggests that short-selling activity increases over the days leading

up to the lockup expiration. Consistent with this conjecture, we provide direct evidence from the securities lending market in the next section. In turn, evidence of a downward post-lockup drift is consistent with a gradual incorporation of the views of more pessimistic investors and a gradual reversion toward the consensus valuation. Turning to the zero-score portfolio, the figure confirms evidence of no abnormal returns around the lockup expiration for this subset of IPOs.

3.4 Evidence from the Securities Lending Market

Our findings so far provide evidence that IPOs that are ex ante expected to have high divergence of investor opinion and more limited supply of lendable shares become overpriced in the immediate aftermarket and experience a significant price correction around the lockup expiration. Next, we analyze the detailed data from the securities lending market to test whether such IPOs are also more difficult and costly to short sell around the lockup expiration.

3.4.1 Variation in Stock Loan Fees and Rebate Rates

Stock loan fees are determined by both supply and demand in the securities lending market and reveal how much investors are willing to pay to gain short exposure.[16] Prior research has focused on the level of short interest, measured as the ratio of shares shorted to shares outstanding. The problem with short interest is that a low value can reflect either low demand or limited supply of shares in the securities lending market. Indeed, as noted by Chen et al. (2002), a low or zero value of short interest may simply indicate that a stock is difficult or costly to borrow and sell short. Stock loan fees, in contrast, provide a direct measure of the cost of short selling.

[16] For detailed discussions of the mechanics of the securities lending market, see D'Avolio (2002); Jones and Lamont (2002); Duffie et al. (2002); Cohen et al. (2007); Reed (2013).

Table 5 provides evidence on the relation between pre-IPO characteristics and stock loan fees around the lockup expiration. The univariate portfolio results in Table 5, Panel A, show that stock loan fees are significantly higher for IPOs with high sales growth, negative operating earnings, and high intangible intensity, i.e., IPOs that are ex ante expected to have high divergence of investor opinion. Stock loan fees are also higher for IPOs with small offerings, i.e., IPOs for which the stock supply in the securities lending market is ex ante expected to be constrained. Arranging our sample in portfolios based on the *Miller Score* in Table 5, Panel B, shows that stock loan fees increase from 1.26% per annum for zero-score IPOs to 7.03% per annum for top-score IPOs. The spread in stock loan fees across *Miller Score* portfolios is important in terms of both magnitude and statistical significance. The OLS regression results in Table 5, Panel C, provide consistent evidence of a significantly positive association between the *Miller Score* and stock loan fees after controlling for year fixed effects and underwriter fixed effects.

Table 6 explores variation in rebate rates and provides additional insights into the costs of short selling IPOs. The rebate rate is the cash interest rate on collateral received by the short seller net of the stock loan fee. The loan fee is not bounded by the cash interest rate and thus negative rebate rates can and do occur. A negative rebate rate is consistent with a tight stock supply in the securities lending market and can be interpreted as a signal of binding short-sales constraints (see, e.g., Ofek et al. 2004).

Our results using rebate rates mirror those using stock loan fees. Rebate rates are significantly more negative for IPOs that are ex ante expected to have high divergence of investor opinion and more limited supply of shares in the securities lending market. Arranging IPOs in portfolios based on the *Miller Score* yields a negative relation with rebate rates. Moving across portfolios, the average value of rebate rates drops from effectively 0% per annum for zero-score

IPOs to -6.36% per annum for top-score IPOs. The OLS regression results in Table 6, Panel C, provide consistent evidence of a significantly negative association between the *Miller Score* and rebate rates after controlling for year fixed effects and underwriter fixed effects.

Following Beneish et al. (2015), we next classify IPOs as hard-to-borrow or "special" stocks when Markit's average DCBS around the lockup expiration is higher than two. We classify all other IPOs as easy-to-borrow or "general collateral" stocks. Table 7 provides evidence of variation in specialness with pre-IPO characteristics. Table 7, Panel A, shows that the frequency of on-special status is higher for IPOs with high sales growth, operating losses, high intangible intensity, and small offering size. Arranging IPOs based on our composite *Miller Score* in Table 7, Panel B, reveals that the frequency of on-special status increases by nearly six times, from 8.9% for zero-score IPOs to 52.6% for top-score IPOs. The probit regression results in Table 7, Panel C, confirm that as moving from a *Miller Score* of zero to a *Miller Score* of one, the odds of a stock being on special increase by nearly six times.

3.4.2 Variation in Active Supply Utilization

Next, we obtain Markit data on active supply utilization measured as the quantity of current inventory on loan from beneficial owners divided by the quantity of current inventory available from beneficial owners. Beneish et al. (2015) argue that active supply utilization—effectively the percentage of lendable shares that are actually on loan—measures the "supply slack" in the securities lending market, thereby offering a good instrumental variable for the otherwise unobservable *marginal* cost of borrowing in the securities lending market.

Table 8 examines variation in active supply utilization around the lockup expiration and corroborates our evidence of variation in stock loan fees and rebate rates with pre-IPO

characteristics. The evidence shows that active supply utilization is higher for IPOs that are ex ante expected to have high divergence of investor opinion and more limited supply of lendable shares, i.e., new issuers with high sales growth, negative operating earnings, and high intangible intensity, offering a small fraction of the number of shares outstanding in the company. Arranging IPOs based on our composite *Miller Score*, we find that active supply utilization increases from 27.4% for zero-score IPOs to over 66% for top-score IPOs, consistent with a decrease in the supply slack across portfolios.[17] The OLS regression results in Table 8, Panel C, provide consistent evidence of a significantly positive association between the *Miller Score* and active supply utilization after controlling for year fixed effects and underwriter fixed effects.

To summarize, the evidence supports our third prediction that IPOs that are ex ante expected to have high divergence of investor opinion and more limited supply of lendable shares are not only more likely to become overpriced in the immediate aftermarket but they are also more difficult and expensive to short around the lockup expiration, as indicated by more positive stock loan fees, more negative rebate rates, and higher active supply utilization. Next, we probe the dynamics of the securities lending market in the IPO aftermarket.

3.4.3 IPO Short-Sales Constraint Dynamics

Figure 2 provides evidence with respect to the dynamics of the securities lending market starting shortly after the IPO day. The figure plots average values of stock loan fees (Panel A) and rebate rates (Panel B) for (i) all IPOs (solid black line), (ii) IPOs with top *Miller Score* (dotted red line), and (iii) IPOs with zero *Miller Score* (dashed green line). The measurement window stretches

[17] Beneish et al. (2015) note that recall risk, i.e., the risk of the stock being recalled by the lender before the borrower is prepared to close out his position, is a reason why supply utilization may not reach 100%.

from one week after the IPO day to 270 calendar days after. We omit the first week in the aftermarket to ensure that newly listed shares have time to make their way to custodian banks where they are made available to borrow (e.g., Reed 2013). The vertical line indicates the lockup expiration 180 calendar days after the IPO.

Starting with Figure 2, Panel A, we find that stock loan fees for top-score IPOs hover around 4% per annum over the first three months of trading, trend upwards for the subsequent three months reaching a peak at 10% per annum just prior to the lockup expiration, and fall back to 4% per annum in the three months after the lockup expiration. In contrast, stock loan fees for zero-score IPOs hover around 1.3% per annum and do not exhibit significant variability in the IPO aftermarket. The evidence for rebate rates in Figure 2, Panel B, mirrors the evidence for stock loan fees. Even though rebate rates are consistently more negative for top-score IPOs, there is significant variability in the aftermarket. The rebate rates for top-score IPOs hover around -3% per annum over the first three months of trading, trend downwards over the subsequent three months reaching a nadir of -9% just prior to the lockup expiration, and revert to -3% in the three months after the lockup expiration. In contrast, the rebate rates for zero-score IPOs hover around 0% and do not exhibit significant variability in the aftermarket.

Overall, the evidence in Figure 2 illustrates that IPOs that are ex ante expected to become overpriced in the immediate aftermarket are associated with higher cost of borrowing in the securities lending market. We hasten to note that evidence of a sharp increase in stock loan fees, accompanied by a sharp decrease in rebate rates, just prior to the lockup expiration of top-score IPOs is consistent with increased short-selling activity targeting IPOs that are more likely to be overpriced. In addition, evidence of a sharp decline in stock loan fees, accompanied by a sharp

increase in rebate rates, after the lockup expiration of top-score IPOs is consistent with a relaxation of stock supply constraints in the securities lending market.

3.4.4 Short Selling IPO Lockups in Practice: A Risky Business

In what follows, we provide evidence on the investment returns available to short sellers targeting IPO lockups. Our hypothetical trading strategy involves borrowing at the risk free rate, taking a long position in the stock market index, and taking an offsetting short position that equal-weights across overlapping IPO share lockups, i.e., IPOs that are within the 31-day window centered on each lockup expiration.[18] This strategy yields a payoff approximating the rebate rate minus the market-adjusted lockup return minus the risk-free rate.

Table 9, Panel A, reports the mean and standard deviation of the daily returns to our hypothetical trading strategy, along with the corresponding annualized Sharpe ratios. We implement the strategy by pooling across all IPOs and for portfolios constructed using only IPOs with the same *Miller Score*. On trading days with multiple overlapping lockup expiration windows, we measure the equal-weighted payoff across overlapping IPO lockups. On trading days that are not spanned by any IPO lockup windows, we set the payoff to zero. As a passive benchmark, we also report the mean and standard deviation of the daily stock market index return in excess of the risk free rate, which corresponds to the payoff from a trading strategy that takes a long position in the stock market index and is financed by borrowing at the risk free rate. We use the CRSP value-weighted index including distributions to proxy for the market portfolio and the one-month T-bill rate to proxy for the risk free return.

[18] We also considered a trading strategy that takes a short position in IPO lockups but does not hedge out the market return. This strategy results in lower Sharpe ratios.

We find that the average daily payoffs to short sellers increase across *Miller Score* portfolios. Focusing on the top-score IPOs, the average daily payoff is 0.23% or 78% per annum, and comes with an annualized Sharpe ratio of 1.18. In comparison, the passive trading strategy that buys the stock market index and is financed by borrowing at the risk free yields an average daily payoff of 0.03% or 8% per annum, corresponding to an annualized Sharpe ratio of 0.36. The difference in the Sharpe ratios suggests that there is a premium from short selling IPO lockups. In additional analysis, we find that evidence of a shorting premium for targeting IPO lockups is not explained by variation in risk-factor loadings based on Fama and French's (1993) three-factor model and Fama and French' (2015) five-factor model.

The premium from targeting IPO lockups, however, may not be attainable in practice. This is because our payoff calculation ignores (i) the possibility that short sellers are unable to actually locate shares to borrow at the rates quoted on Markit; (ii) the possibility that a stock loan is recalled and that another loan cannot be located to replace it; and (iii) the requirement that short sellers post additional collateral if prices rise. As discussed in Lamont and Thaler (2003) and Mitchell et al. (2002), the stock lending market is a fragmented over-the-counter market and, therefore, the existence of a transaction on Markit does not imply a liquid market at the quoted rates. In addition, the combination of small active supply with high utilization, especially for top-score IPOs, implies that the stock lending market may be too thin for short-selling operations at a large scale.

Recall risk is a particularly pernicious risk of short selling. Most institutional lenders in the U.S. maintain the right to terminate a stock loan at any time. If the lender recalls the borrower's loan, it is the borrower's responsibility to return shares to the lender by either buying shares in the market or borrowing shares from another lender. If the borrower fails to return the shares, the lender can institute a "buy-in" using the borrower's collateral to buy shares to cover the loan. Loan

recalls can force borrowers to unwind their trading positions sub-optimally and can expose borrowers to the possibility of being "squeezed" at an unattractive price.[19]

With respect to the risk that stock loans become more expensive, D'Avolio (2002) proposes that a short seller is concerned not only with the level of fees, but also with fee variance. More recently, Engelberg et al. (2015) interpret a stock loan recall as an extremely high loan fee and argue that recall risk and fee changes are manifestations of the same underlying event, namely changes in lending conditions, and therefore are not independent risks. Engelberg et al. (2015) introduce the variance of rebate rates and stock loan fees as proxies for short-selling risk and find evidence that stocks with high short-selling risk have lower future returns, decreased price efficiency, and lower short-selling activity by arbitrageurs.

Table 9, Panel B, explores variation in short-selling risk. Following Engelberg et al. (2015), we measure short-selling risk as the standard deviation of stock loan fees and rebate rates. Focusing on the window from ten trading days before to twenty trading days after the lockup expiration, we find that short-selling risk is higher for IPOs that are ex ante expected to have high divergence of investor opinion and more limited supply of lendable shares in the aftermarket. Arranging our sample based on the *Miller Score* effectively separates IPOs with high variance in rebate rates and stock loan fees. The last column shows that high *Miller Score* IPOs also tend to have more volatile stock prices.

[19] Mitchell et al. (2002) empirically examine arbitrage activity for situations in which the market value of a company is less than its subsidiary and find that short-selling risk can limit arbitrage activity. They specifically discuss recall risk, noting that "*the possibility of being bought-in at an unattractive price provides a disincentive for arbitrageurs to take a large position*."

Table 9, Panel C, reports the average frequency distribution of the number of IPOs with overlapping lockup windows on any given trading day across *Miller Score* portfolios. The evidence highlights the diversification restrictions that short sellers targeting IPO lockups would experience. Focusing on the top-score IPOs, the evidence shows that on any given trading day arbitrageurs would have been able to target more than five overlapping IPO lockups for only 3% of the 2,028 trading days in our sample period. Clearly, targeting IPO lockups entails poorly diversified portfolios with substantial idiosyncratic risk.

It should also be noted that arbitrageurs' ability to construct synthetic short positions in the options market by buying puts and writing calls is limited when targeting IPO lockups. This is because several IPOs do not have tradable options prior to lockup expiration. In addition, given that the cost of buying puts depends on the put writers' cost of hedging their synthetic long positions by shorting the stock, the cost of synthetic shorts moves hand-in-hand with the cost of borrowing the stock in the securities lending market (see, e.g., Grundy et al. 2012; Reed 2013).[20]

Overall, we conclude that the premium for short selling IPO share lockups likely reflects compensation for the unique costs and risks facing short sellers, Indeed, our analysis provides evidence that short selling IPO lockups is especially costly and risky when targeting IPOs with a

[20] Relatedly, Li and Zhu (2016) argue that arbitrageurs may use exchange-traded funds (ETFs) to create synthetic short positions. We are aware of only one ETF offering exposure to a portfolio of new issuers listed in the U.S. throughout our sample period: the First Trust U.S. IPO Index Fund (NYSE ARCA: FPX), which was incepted on 04/12/2006. Short selling the FPX, however, would not offer a close substitute for short-selling high *Miller Score* IPOs. This is because the fund targets mid- and large-cap IPOs during the first 1,000 trading days and is not tilted toward IPOs that are ex ante expected to be overpriced in the immediate aftermarket. In addition, using Markit data we find that the FPX has been mostly on special in the securities lending market since its inception.

high *Miller Score*, i.e., when targeting IPOs that are ex ante expected to become overpriced in the immediate aftermarket and subsequently underperform.[21]

3.5 Additional Analysis Using Analyst Forecast Dispersion Data

Prior research has used analyst forecast dispersion as a measure of divergence of investor opinion for the general population of stocks (e.g., Diether et al. 2002; Nagel 2005; Boehme et al. 2006).[22] Analyst coverage of IPOs typically starts only after 40 calendar days following the IPO day, which coincides with the end of the quiet period (e.g., Bradley et al. 2003). As a result, analyst forecast dispersion is determined endogenously and simultaneously with IPO pricing. By focusing on ex ante determinants of divergence of opinion using information from the offering prospectus, we alleviate issues of simultaneity and endogeneity in our empirical tests.

In our final analysis, we use sell-side analyst coverage data from IBES to explore variation in lockup returns with analyst forecast dispersion. We measure analyst forecast dispersion as the standard deviation of one-year-out earnings per share (EPS) forecasts scaled by total assets per share. To measure dispersion, we require coverage by at least three analysts as of ten trading days prior to the lockup expiration. Our restricted sample excludes 40 IPOs from our full sample of 629 IPOs for which we do not have sufficient analyst coverage data.

We stratify our sample as of ten trading days prior to the lockup expiration and compare two groups. The first group consists of IPOs with below median analyst forecast dispersion and

[21] Our evidence of a shorting premium for targeting IPO lockups complements Drechsler and Drechsler's (2014) evidence of positive abnormal returns for their cheap-minus-expensive-to-short portfolio of stocks in the general population, which they interpret as compensation for the costs and risks associated with short selling.

[22] Cao et al. (2016) use proprietary information about institutional bidding dispersion for a sample of Chinese IPOs as an alternative measure of divergence of investor opinion.

above median offering size. The second group consists of IPOs with above median analyst forecast dispersion and below median offering size. This second group of high analyst forecast dispersion and small offering size IPOs includes stocks for which both conditions for Miller's overvaluation story are more likely to be *simultaneously* satisfied, i.e., stocks for which divergence of opinion is more likely to be high and short selling is more likely to be constrained. The prediction that follows is that the second group should experience more negative abnormal returns around the lockup expiration.

Table 10 supports this prediction. Indeed, evidence of variation in lockup returns across groups is qualitatively and quantitatively similar to that based on our composite *Miller Score*. Specifically, we find that IPOs with low analyst forecast dispersion and large offering size do not experience significant abnormal lockup returns, which is consistent with evidence of 0% abnormal lockup returns for zero *Miller Score* IPOs. In contrast, IPOs with high analyst forecast dispersion and small offering size tend to experience significantly negative abnormal lockup returns of -8.75%, which is consistent with evidence of significantly negative abnormal lockup returns of -9.15% for top *Miller Score* IPOs. The lockup-return spread of -8.08% across the two groups is significantly different from zero and nearly three times as large as the spread across partitions based only on the offering size (see Table 4).[23]

[23] We note that Table 10 also corroborates the evidence from the correlation matrix in Table 1 that the ex ante determinants of divergence of opinion and short-sales constraints underlying our composite Miller Score vary predictably with analyst forecast dispersion. Pre-IPO sales growth, operating loss frequency, intangible intensity, and short-selling costs are all significantly higher for the high analyst forecast dispersion group.

4. Conclusion

Focusing on a parsimonious set of characteristics available from the offering prospectus, we find evidence that IPOs that are ex ante expected to have high divergence of investor opinion about fundamental value and more limited supply of lendable shares become overpriced in the immediate aftermarket and experience a significant price correction around the lockup expiration. Using detailed data from the securities lending market, we also provide direct evidence that such IPOs are more difficult and expensive to short sell. While prior research is inconclusive with respect to the importance of Miller's theory in the IPO setting, we provide evidence that the combination of heterogeneous investor opinions with short-sales constraints is key to explaining aftermarket IPO pricing.

Recent research suggests that restrictions on short selling have the potential to explain a broader set of anomalous returns (e.g., Drechsler and Drechsler 2014; Beneish et al. 2015). Miller's overvaluation story is particularly well suited to the IPO setting, since new issuers are subject to significant valuation uncertainty and a limited supply of lendable shares. More generally, however, we expect restrictions on short-selling to explain overpricing in settings where divergence of investor opinion is high and the supply of lendable shares is limited. One potential such setting is Fama and French's (2015) finding of unusually low stock returns for small firms that invest a lot despite low profitability.[24]

[24] In additional tests, we confirm that IPOs with a high *Miller Score* tend to have Fama and French's (2015) "lethal combination" of small size, high investment, and low profitability.

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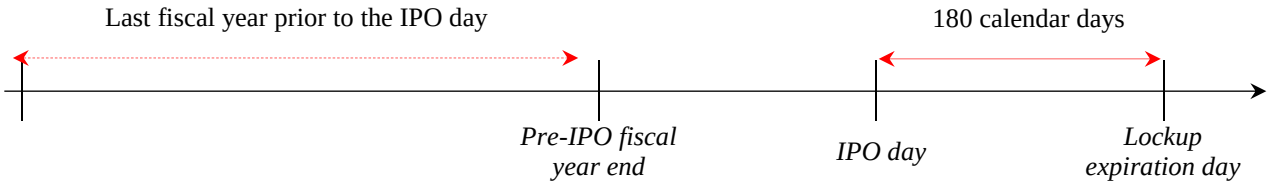
Appendix 1
Timeline of Research Design



Note: This figure describes our research design timeline. The mean (median) distance in calendar days between the pre-IPO fiscal year end and the IPO day is 191 (197) days.

Appendix 2
Variable Definitions

Variable	Definition
Analyst dispersion	Analyst forecast dispersion measured as the standard deviation of one-year-out EPS forecasts scaled by total assets per share. To measure dispersion, we require coverage by at least three analysts on IBES as of ten trading days prior to the lockup expiration.
First-day return	First trading day return measured from the IPO offering price per share to the closing price per share on the first trading day.
Intangible intensity	R&D plus advertising expenses divided by sales as of the last fiscal year prior to the IPO. We set missing values to zero.
Lockup return	Buy-and-hold market adjusted stock return from ten trading days before to twenty trading days after the IPO lockup expiration.
Loss indicator	Indicator variable =1 if the firm reported negative earnings before interest and tax expenses as of the last fiscal year prior to IPO; =0 o/w.
Miller Score	Our composite score of pre-IPO characteristics. An IPO scores one point for each of the four criteria: (i) it has above median pre-IPO sales growth, (ii) it reports a pre-IPO loss, (iii) it has above median intangible intensity, and (iv) it has below median offering size. To obtain the *Miller Score*, we sum up the points and divide by four to standardize the score to range between zero and one.
Offering price	Offering price per share.
Offering size	Number of shares offered in the IPO divided by the number of shares outstanding in the aftermarket.
Offer turnover	Number of shares traded on the first trading day divided by the number of shares offered in the IPO.
Sales growth	Percentage growth in sales as of the last fiscal year prior to the IPO.
Sales level	Sales as of the last fiscal year prior to the IPO.
Special	Indicator variable =1 if the average daily cost of borrowing score (DCBS) assigned by Markit over the ten trading days before to twenty trading days after the lockup expiration is greater than 2; =0 o/w. The DCBS is a number from 1 to 10 indicating the cost of borrowing in the securities lending market, where 1 is cheapest and 10 is most expensive.
Stock loan fee	Stock loan fees over the ten trading days before to twenty trading days after the lockup expiration. To deal with the sparse coverage of actual stock loan fees, we use the mean values of loan fees of securities with the same DCBS on the same trading day.
Stock loan rebate	Stock loan rebate rates over the ten trading days before to twenty trading days after the lockup expiration. To deal with the sparse coverage of actual rebate rates, we use the mean values of rebate rates of securities with the same DCBS on the same trading day.
Utilization	Active supply utilization over the ten trading days before to twenty trading days after the lockup expiration. We measure utilization as the quantity of current inventory on loan from beneficial owners divided by the quantity of current inventory available from beneficial owners.

Table 1
Descriptive Statistics

Panel A: Sample Distribution by Year.

Offer year	2007	2008	2009	2010	2011	2012	2013	2014	Total
# of IPOs	105	16	34	69	56	70	124	155	629
Proceeds (BN)	$21.7	$22.2	$10.3	$11.5	$15.9	$13.1	$34.5	$38.1	$167.2

Panel B: Empirical Distributions of Key Variables.

	Mean	Std. Dev.	Percentiles		
			25th	50th	75th
Offering price	$15.58	$6.70	$12.00	$15.00	$18.00
Sales level (MN)	$759.60	$2,477.64	$52.06	$119.59	$427.10
Total assets (MN)	$1,702.10	$8,713.67	$56.28	$151.65	$836.40
Sales growth	101.65%	288.50%	10.28%	32.04%	70.42%
Loss indicator	34.34%	47.52%	0.00%	0.00%	100.00%
Intangible intensity	91.83%	446.64%	0.00%	5.21%	23.31%
Offering size	29.67%	19.67%	18.33%	24.89%	33.36%
Miller Score	0.46	0.32	0.25	0.50	0.75
Analyst dispersion	18.82%	68.58%	0.52%	1.85%	6.96%
First-day return	16.38%	25.13%	0.00%	9.50%	26.50%
Offer turnover	74.69%	52.69%	44.70%	64.28%	92.33%
Lockup return	-3.54%	18.40%	-14.44%	-3.02%	5.88%
Stock loan fee	3.13%	8.38%	0.36%	0.40%	1.83%
Stock loan rebate	-2.38%	8.65%	-1.58%	-0.29%	-0.17%
Special	26.39%	44.11%	0.00%	0.00%	100.00%
Utilization	40.52%	33.04%	11.84%	30.13%	68.82%

Panel C: Securities Lending Market Characteristics: IPOs versus General Population.

	(1) IPO sample averages (629 firms)	(2) Population averages (3,549 firms)	(2) – (1)	*t-test*
Stock loan fee	3.13%	0.81%	-2.32%	*-6.93*
Stock loan rebate	-2.38%	0.24%	2.62%	*7.58*
Special	26.39%	6.42%	-19.97%	*-11.32*
Utilization	40.52%	15.88%	-24.64%	*-18.62*

Panel D: Pairwise Pearson (Spearman) Correlations above (below) Main Diagonal.

	Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1)	*Sales growth*		0.24	0.09	-0.03§	0.27	0.11	0.03§	0.01§	-0.03§	0.11	-0.10	0.16	0.17
(2)	*Loss indicator*	0.30		0.26	-0.15	0.70	0.32	0.14	0.08	-0.09	0.17	-0.17	0.21	0.25
(3)	*Intangible intensity*	0.23	0.59		0.00§	0.14	0.32	0.00§	-0.07	-0.09	0.09	-0.09	0.14	0.13
(4)	*Offering size*	-0.19	-0.10	-0.18		-0.43	-0.00§	-0.21	-0.20	0.07	-0.13	0.13	-0.17	-0.19
(5)	*Miller Score*	0.61	0.69	0.69	-0.52		0.17	0.28	0.21	-0.17	0.24	-0.23	0.32	0.39
(6)	*Analyst dispersion*	0.34	0.59	0.60	-0.05§	0.55		0.00§	-0.02§	-0.11	0.03§	-0.04§	0.06§	0.07
(7)	*First-day return*	0.23	0.13	0.21	-0.26	0.28	0.10		0.49	-0.11	0.21	-0.20	0.26	0.30
(8)	*Offer turnover*	0.18	0.12	0.14	-0.31	0.26	0.04§	0.44		-0.10	0.25	-0.26	0.31	0.33
(9)	*Lockup return*	-0.10	-0.12	-0.19	0.07	-0.18	-0.18	-0.10	-0.11		-0.08	0.07	-0.12	-0.16
(10)	*Stock loan fee*	0.27	0.25	0.29	-0.24	0.34	0.28	0.19	0.23	-0.13		-0.99	0.52	0.49
(11)	*Stock loan rebate*	-0.13	-0.22	-0.23	0.22	-0.26	-0.17	-0.17	-0.28	0.09	-0.73		-0.50	-0.47
(12)	*Special*	0.28	0.21	0.23	-0.23	0.31	0.24	0.19	0.25	-0.13	0.75	-0.59		0.78
(13)	*Utilization*	0.32	0.27	0.33	-0.24	0.40	0.32	0.24	0.30	-0.18	0.68	-0.48	0.68	

Note: The variables are defined in Appendix 2. Firm and time subscripts are omitted for brevity. All pairwise correlations are significantly different from zero at the 10% level or better, except for those indicated by §.

Table 2
IPO First-Day Returns: Testing Miller's (1977) Hypothesis

Panel A: Variation with Pre-IPO Characteristics.

	No	Yes	*Difference*
High sales growth	10.92%	21.83%	10.92%
t-statistic	*9.90*	*13.51*	*5.58*
Loss indicator	13.76%	21.40%	7.65%
t-statistic	*12.42*	*10.88*	*3.39*
High intangible intensity	11.90%	20.85%	8.95%
t-statistic	*9.41*	*13.76*	*4.53*
Small offering	11.78%	20.97%	9.19%
t-statistic	*9.77*	*13.45*	*4.66*

Panel B: Variation with *Miller Score*.

Miller Score	# of IPOs	*First-day return*	*t-statistic*
0.00	113	9.23%	*4.95*
0.25	158	10.88%	*6.78*
0.50	149	14.55%	*8.06*
0.75	131	21.96%	*9.10*
1.00	78	32.01%	*8.59*
High - Low		22.78%	*5.47*

Panel C: OLS Regression Results.

	Dependent variable = *First-day return*		
	(1)	(2)	(3)
Intercept	0.1638	0.0633	-0.0631
t-statistic	*8.33*	*3.12*	*-1.55*
Miller Score	.	0.2178	0.2050
t-statistic	.	*12.13*	*8.85*
Year fixed effects	No	No	Yes
Underwriter fixed effects	No	No	Yes
Adj. R^2	0.00%	7.61%	10.39%

This table reports evidence of variation in first-day returns with pre-IPO characteristics. We measure the first-day return as the return from the IPO offering price per share to the closing price per share on the first trading day. Panel A reports portfolio mean values of first-day returns across partitions of (i) above median (high) and below median (low) sales growth, (ii) profit and loss firms, (iii) above median (high) and below median (low) intangible intensity, and (iv) below median (small) and above median (large) offering size. Panel B reports portfolio mean values across partitions formed based on our *Miller Score*, which ranges from zero to one. A *Miller Score* of one indicates that the firm has above median sales growth and intangible intensity, reported a pre-IPO loss, and has below median offering size. A *Miller Score* of zero indicates that the firm has below median sales growth and intangible intensity, reported a pre-IPO profit, and has above median offering size. Panel C reports results from OLS regressions of first-day returns on the *Miller Score*, along with year and underwriter fixed effects. The t-statistics are based on standard errors clustered by year. Our sample includes 629 IPOs over the period from 2007 to 2014.

Table 3
IPO Share Turnover: Testing Miller's (1977) Hypothesis

Panel A: Variation with Pre-IPO Characteristics.

	No	Yes	*Difference*
High sales growth	68.06%	81.30%	13.24%
t-statistic	*24.36*	*26.25*	*3.17*
Loss indicator	71.60%	80.61%	9.01%
t-statistic	*27.45*	*22.91*	*2.06*
High intangible intensity	68.75%	80.61%	11.86%
t-statistic	*24.72*	*25.86*	*2.84*
Small offering	62.33%	87.01%	24.68%
t-statistic	*27.44*	*25.62*	*6.04*

Panel B: Variation with *Miller Score*.

Miller Score	# of IPOs	*Offer turnover*	*t-statistic*
0.00	113	62.41%	*20.72*
0.25	158	68.89%	*14.26*
0.50	149	67.38%	*22.65*
0.75	131	85.19%	*14.74*
1.00	78	100.58%	*17.91*
High - Low		38.17%	*5.99*

Panel C: OLS Regression Results.

	Dependent variable = *Offer turnover*		
	(1)	(2)	(3)
Intercept	0.7469	0.5850	0.1316
t-statistic	*20.56*	*14.18*	*3.33*
Miller Score	.	0.3509	0.3184
t-statistic	.	*5.48*	*4.37*
Year fixed effects	No	No	Yes
Underwriter fixed effects	No	No	Yes
Adj. R^2	0.00%	4.43%	7.55%

This table reports evidence of variation in offer turnover with pre-IPO characteristics. We measure offer turnover as the number of shares traded on the first trading day divided by the number of shares offered in the IPO. Panel A reports portfolio mean values of offer turnover across partitions of (i) above median (high) and below median (low) sales growth, (ii) profit and loss firms, (iii) above median (high) and below median (low) intangible intensity, and (iv) below median (small) and above median (large) offering size. Panel B reports portfolio mean values across partitions formed based on our *Miller Score*, which ranges from zero to one. A *Miller Score* of one indicates that the firm has above median sales growth and intangible intensity, reported a pre-IPO loss, and has below median offering size. A *Miller Score* of zero indicates that the firm has below median sales growth and intangible intensity, reported a pre-IPO profit, and has above median offering size. Panel C reports results from OLS regressions of offer turnover on the *Miller Score*, along with year and underwriter fixed effects. The t-statistics are based on standard errors clustered by year. Our sample includes 629 IPOs over the period from 2007 to 2014.

Table 4
IPO Lockup Returns: Testing Miller's (1977) Hypothesis

Panel A: Variation with Pre-IPO Characteristics.

	No	Yes	*Difference*
High sales growth	-1.49%	-5.59%	-4.10%
t-statistic	*-1.50*	*-5.23*	*-2.81*
Loss indicator	-2.38%	-5.78%	-3.40%
t-statistic	*-2.95*	*-3.92*	*-2.03*
High intangible intensity	-0.69%	-6.39%	-5.69%
t-statistic	*-0.88*	*-5.25*	*-3.93*
Small offering	-2.16%	-4.93%	-2.77%
t-statistic	*-2.05*	*-4.85*	*-1.89*

Panel B: Variation with *Miller Score*.

Miller Score	# of IPOs	*Lockup return*	*t-statistic*
0.00	113	-0.87%	*-0.70*
0.25	158	0.20%	*0.18*
0.50	149	-4.00%	*-2.24*
0.75	131	-6.50%	*-3.45*
1.00	78	-9.15%	*-4.51*
High - Low		-8.28%	*-3.49*

Panel C: OLS Regression Results.

	Dependent variable = *Lockup return*		
	(1)	(2)	(3)
Intercept	-0.0354	0.0083	-0.0856
t-statistic	*-3.85*	*1.01*	*-1.84*
Miller Score	.	-0.0947	-0.0946
t-statistic	.	*-3.92*	*-4.05*
Year fixed effects	No	No	Yes
Underwriter fixed effects	No	No	Yes
Adj. R^2	0.00%	2.58%	3.96%

This table reports evidence of variation in lockup returns with pre-IPO characteristics. We measure the lockup return as the buy-and-hold market adjusted return over the window from ten trading days before to twenty trading days after the lockup expiration. We use the CRSP value-weighted index including distributions to proxy for the market portfolio. Panel A reports portfolio mean values of lockup returns across partitions of (i) above median (high) and below median (low) sales growth, (ii) profit and loss firms, (iii) above median (high) and below median (low) intangible intensity, and (iv) below median (small) and above median (large) offering size. Panel B reports portfolio mean values across partitions formed based on our *Miller Score*, which ranges from zero to one. A *Miller Score* of one indicates that the firm has above median sales growth and intangible intensity, reported a pre-IPO loss, and has below median offering size. A *Miller Score* of zero indicates that the firm has below median sales growth and intangible intensity, reported a pre-IPO profit, and has above median offering size. Panel C reports results from OLS regressions of lockup returns on the *Miller Score*, along with year and underwriter fixed effects. The t-statistics are based on standard errors clustered by year. Our sample includes 629 IPOs over the period from 2007 to 2014.

Table 5
IPO Short-Sales Constraints: Variation in Stock Loan Fees

Panel A: Variation with Pre-IPO Characteristics.

	No	Yes	*Difference*
High sales growth	1.67%	4.58%	2.91%
t-statistic	*6.15*	*7.64*	*4.42*
Loss indicator	2.07%	5.15%	3.08%
t-statistic	*7.55*	*6.41*	*3.63*
High intangible intensity	1.73%	4.51%	2.78%
t-statistic	*6.39*	*7.52*	*4.22*
Small offering	2.21%	4.04%	1.84%
t-statistic	*5.96*	*7.33*	*2.76*

Panel B: Variation with *Miller Score*.

Miller Score	# of IPOs	*Stock loan fee*	*t-statistic*
0.00	113	1.26%	*4.07*
0.25	158	1.34%	*5.17*
0.50	149	2.33%	*4.71*
0.75	131	5.46%	*5.31*
1.00	78	7.03%	*4.47*
High - Low		5.77%	*3.60*

Panel C: OLS Regression Results.

	Dependent variable = *Stock loan fee*		
	(1)	(2)	(3)
Intercept	0.0313	0.0025	-0.0019
t-statistic	*4.38*	*0.65*	*-0.12*
Miller Score	.	0.0624	0.0567
t-statistic	.	*3.21*	*3.17*
Year fixed effects	No	No	Yes
Underwriter fixed effects	No	No	Yes
Adj. R^2	0.00%	5.58%	9.75%

This table reports evidence of variation in stock loan fees with pre-IPO characteristics. We measure stock loan fees as the average daily stock loan fees over the window from ten trading days before to twenty trading days after the lockup expiration. Panel A reports portfolio mean values of stock loan fees across partitions of (i) above median (high) and below median (low) sales growth, (ii) profit and loss firms, (iii) above median (high) and below median (low) intangible intensity, and (iv) below median (small) and above median (large) offering size. Panel B reports portfolio mean values across partitions formed based on our *Miller Score*, which ranges from zero to one. A *Miller Score* of one indicates that the firm has above median sales growth and intangible intensity, reported a pre-IPO loss, and has below median offering size. A *Miller Score* of zero indicates that the firm has below median sales growth and intangible intensity, reported a pre-IPO profit, and has above median offering size. Panel C reports results from OLS regressions of stock loan fees on the *Miller Score*, along with year and underwriter fixed effects. The t-statistics are based on standard errors clustered by year. Our sample includes 629 IPOs over the period from 2007 to 2014.

Table 6
IPO Short-Sales Constraints: Variation in Stock Loan Rebate Rates

Panel A: Variation with Pre-IPO Characteristics.

	No	Yes	*Difference*
High sales growth	-1.02%	-3.73%	-2.71%
t-statistic	*-3.56*	*-6.04*	*-3.97*
Loss indicator	-1.29%	-4.46%	-3.17%
t-statistic	*-4.47*	*-5.42*	*-3.63*
High intangible intensity	-1.00%	-3.76%	-2.76%
t-statistic	*-3.48*	*-6.08*	*-4.05*
Small offering	-1.39%	-3.36%	-1.97%
t-statistic	*-3.59*	*-5.94*	*-2.87*

Panel B: Variation with *Miller Score*.

Miller Score	# of IPOs	*Stock loan rebate*	*t-statistic*
0.00	113	-0.49%	*-1.40*
0.25	158	-0.66%	*-2.32*
0.50	149	-1.56%	*-3.00*
0.75	131	-4.64%	*-4.37*
1.00	78	-6.36%	*-3.97*
High - Low		-5.87%	*-3.58*

Panel C: OLS Regression Results.

	Dependent variable = *Stock loan rebate*		
	(1)	(2)	(3)
Intercept	-0.0238	0.0050	0.0380
t-statistic	*-2.10*	*0.78*	*2.31*
Miller Score	.	-0.0623	-0.0563
t-statistic	.	*-3.12*	*-3.13*
Year fixed effects	No	No	Yes
Underwriter fixed effects	No	No	Yes
Adj. R^2	0.00%	5.21%	14.82%

This table reports evidence of variation in stock loan rebate rates with pre-IPO characteristics. We measure stock loan rebate rates as the average daily stock loan rebate rates over the window from ten trading days before to twenty trading days after the lockup expiration. Panel A reports portfolio mean values of stock loan rebate rates across partitions of (i) above median (high) and below median (low) sales growth, (ii) profit and loss firms, (iii) above median (high) and below median (low) intangible intensity, and (iv) below median (small) and above median (large) offering size. Panel B reports portfolio mean values across partitions formed based on our *Miller Score*, which ranges from zero to one. A *Miller Score* of one indicates that the firm has above median sales growth and intangible intensity, reported a pre-IPO loss, and has below median offering size. A *Miller Score* of zero indicates that the firm has below median sales growth and intangible intensity, reported a pre-IPO profit, and has above median offering size. Panel C reports results from OLS regressions of stock loan rebate rates on the *Miller Score*, along with year and underwriter fixed effects. The t-statistics are based on standard errors clustered by year. Our sample includes 629 IPOs over the period from 2007 to 2014.

Table 7
IPO Short-Sales Constraints: Variation in Frequency of Stocks on Special

Panel A: Variation with Pre-IPO Characteristics.

	No	Yes	*Difference*
High sales growth	15.61%	37.14%	21.54%
t-statistic	*7.61*	*13.62*	*6.31*
Loss indicator	19.61%	39.35%	19.74%
t-statistic	*10.03*	*11.81*	*5.11*
High intangible intensity	16.56%	36.19%	19.63%
t-statistic	*7.88*	*13.35*	*5.72*
Small offering	20.06%	32.70%	12.63%
t-statistic	*8.86*	*12.35*	*3.63*

Panel B: Variation with *Miller Score*.

Miller Score	# of IPOs	*Special*	*t-statistic*
0.00	113	8.85%	*3.30*
0.25	158	17.09%	*5.69*
0.50	149	24.16%	*6.87*
0.75	131	39.69%	*9.25*
1.00	78	52.56%	*9.24*
High - Low		43.71%	*6.95*

Panel C: Probit Regression Results.

	Dependent variable = *Special*		
	(1)	(2)	(3)
Intercept	-0.6313	-1.3426	-0.8267
t-statistic	*-7.82*	*-10.92*	*-2.55*
Miller Score	.	1.4055	1.3638
t-statistic	.	*10.97*	*13.69*
Year fixed effects	No	No	Yes
Underwriter fixed effects	No	No	Yes
Pseudo R^2	0.00%	8.92%	11.30%

This table reports evidence of variation in the frequency of stocks on special with pre-IPO characteristics. A stock is on special if the average borrowing cost score assigned by Markit over the window from ten trading days before to twenty trading days after the lockup expiration is greater than two. Panel A reports portfolio mean values of the indicator variable for special across partitions of (i) above median (high) and below median (low) sales growth, (ii) profit and loss firms, (iii) above median (high) and below median (low) intangible intensity, and (iv) below median (small) and above median (large) offering size. Panel B reports portfolio mean values across partitions formed based on our *Miller Score*, which ranges from zero to one. A *Miller Score* of one indicates that the firm has above median sales growth and intangible intensity, reported a pre-IPO loss, and has below median offering size. A *Miller Score* of zero indicates that the firm has below median sales growth and intangible intensity, reported a pre-IPO profit, and has above median offering size. Panel C reports results from probit regressions of the indicator variable for special on the *Miller Score*, along with year and underwriter fixed effects. The t-statistics are based on standard errors clustered by year. Our sample includes 629 IPOs over the period from 2007 to 2014.

Table 8
IPO Short-Sales Constraints: Variation in Active Supply Utilization

Panel A: Variation with Pre-IPO Characteristics.

	No	Yes	*Difference*
High sales growth	31.15%	49.85%	18.70%
t-statistic	*18.63*	*26.29*	*7.40*
Loss indicator	34.45%	52.11%	17.66%
t-statistic	*22.23*	*23.29*	*6.49*
High intangible intensity	30.88%	50.13%	19.25%
t-statistic	*18.03*	*27.08*	*7.63*
Small offering	34.41%	46.61%	12.19%
t-statistic	*19.39*	*24.69*	*4.71*

Panel B: Variation with *Miller Score*.

Miller Score	# of IPOs	*Utilization*	*t-statistic*
0.00	113	27.39%	*10.21*
0.25	158	27.79%	*12.38*
0.50	149	41.04%	*15.61*
0.75	131	51.37%	*17.25*
1.00	78	66.09%	*21.95*
High - Low		38.70%	*9.60*

Panel C: OLS Regression Results.

	Dependent variable = *Utilization*		
	(1)	(2)	(3)
Intercept	0.4052	0.2204	0.4070
t-statistic	*16.27*	*7.19*	*6.89*
Miller Score	.	0.4003	0.3904
t-statistic	.	*10.73*	*11.31*
Year fixed effects	No	No	Yes
Underwriter fixed effects	No	No	Yes
Adj. R^2	0.00%	15.04%	17.52%

This table reports evidence of variation in active supply utilization with pre-IPO characteristics. We measure utilization as the current inventory on loan from beneficial owners divided by the current inventory available from beneficial owners. We take the average daily utilization over the window from ten trading days before to twenty trading days after the lockup expiration. Panel A reports portfolio mean values of active supply utilization across partitions of (i) above median (high) and below median (low) sales growth, (ii) profit and loss firms, (iii) above median (high) and below median (low) intangible intensity, and (iv) below median (small) and above median (large) offering size. Panel B reports portfolio mean values across partitions formed based on our *Miller Score*, which ranges from zero to one. A *Miller Score* of one indicates that the firm has above median sales growth and intangible intensity, reported a pre-IPO loss, and has below median offering size. A *Miller Score* of zero indicates that the firm has below median sales growth and intangible intensity, reported a pre-IPO profit, and has above median offering size. Panel C reports results from OLS regressions of active supply utilization on the *Miller Score*, along with year and underwriter fixed effects. The t-statistics are based on standard errors clustered by year. Our sample includes 629 IPOs over the period from 2007 to 2014.

Table 9
Short Selling IPO Lockups: A Risky Business

Panel A: Sharpe Ratios from Short Selling IPO Lockups.

Miller Score	*Payoff*			
	# of trading days	Mean	Std. dev.	Sharpe ratio
0.00	2,028	-0.03%	2.51%	-0.22
0.25	2,028	0.03%	2.11%	0.23
0.50	2,028	0.08%	2.95%	0.44
0.75	2,028	0.18%	2.84%	1.02
1.00	2,028	0.23%	3.14%	1.18
All IPOs	2,028	0.05%	1.67%	0.48
Stock market	2,028	0.03%	1.40%	0.36

Panel B: Variation in Short-Selling Risk.

Miller Score	*Standard deviation around lockup expiration windows*			
	# of IPOs	*Rebate rate*	*Stock loan fee*	*Stock return*
0.00	113	0.49%	0.47%	2.76%
0.25	158	0.62%	0.58%	2.79%
0.50	149	0.60%	0.59%	3.57%
0.75	131	1.14%	1.12%	3.83%
1.00	78	2.40%	2.39%	3.82%
All IPOs	629	0.92%	0.90%	3.32%

Panel C: Diversification Restrictions.

Miller Score	# of IPOs on any given trading day							
	0	1	2	3	4	5	>5	>25
0.00	32%	24%	18%	11%	7%	5%	4%	0%
0.25	24%	17%	18%	14%	10%	9%	9%	0%
0.50	25%	19%	20%	12%	7%	7%	10%	0%
0.75	24%	25%	16%	14%	11%	4%	5%	0%
1.00	46%	23%	13%	9%	3%	3%	2%	0%
All IPOs	5%	6%	11%	6%	4%	4%	64%	3%

This table examines the payoffs to short sellers from targeting IPO lockups over the window from ten trading days before to twenty trading days after the lockup expiration. Panel A reports the mean, standard deviation, and the annualized Sharpe ratios from a trading strategy financed by borrowing at the risk free rate that takes a long position in the stock market index and a short position in IPO lockups. We measure the payoff to this trading strategy at daily frequency as the stock loan rebate rate minus the market adjusted stock return minus the risk free rate. On trading days with multiple overlapping lockup expiration windows, we measure the equal-weighted payoff across the overlapping IPO lockups. On trading days that are not overlapping with any IPO lockup windows, we set the payoff equal to zero. We proxy for the stock market portfolio using the CRSP value-weighted index including distributions. We proxy for the daily risk free rate using the one-month T-bill rate. We implement the strategy across portfolios based on our composite *Miller Score*. A *Miller Score* of one indicates that the firm has above median sales growth and intangible intensity, reported a pre-IPO loss, and has below median offering size. A *Miller Score* of zero indicates that the firm has below median sales growth and intangible intensity, reported a pre-IPO profit, and has above median offering size. For comparison purposes, we report the mean and standard deviation of the daily stock market index return in excess of the risk free rate along with the corresponding annualized Sharpe ratio. We measure annualized Sharpe ratio as the ratio of the mean value of payoffs to the standard deviation of payoffs multiplied by the square root of 252, which corresponds to the number of trading days per year. Panel B reports the standard deviation of stock loan fees per annum, rebate rates per annum, and daily stock returns measured around lockup expiration windows across *Miller Score* portfolios. Panel C reports the average frequency distribution of the number of IPOs with overlapping lockup windows on any given trading day. Our sample includes 629 IPOs and 2,028 trading days over the period from 2007 to 2014.

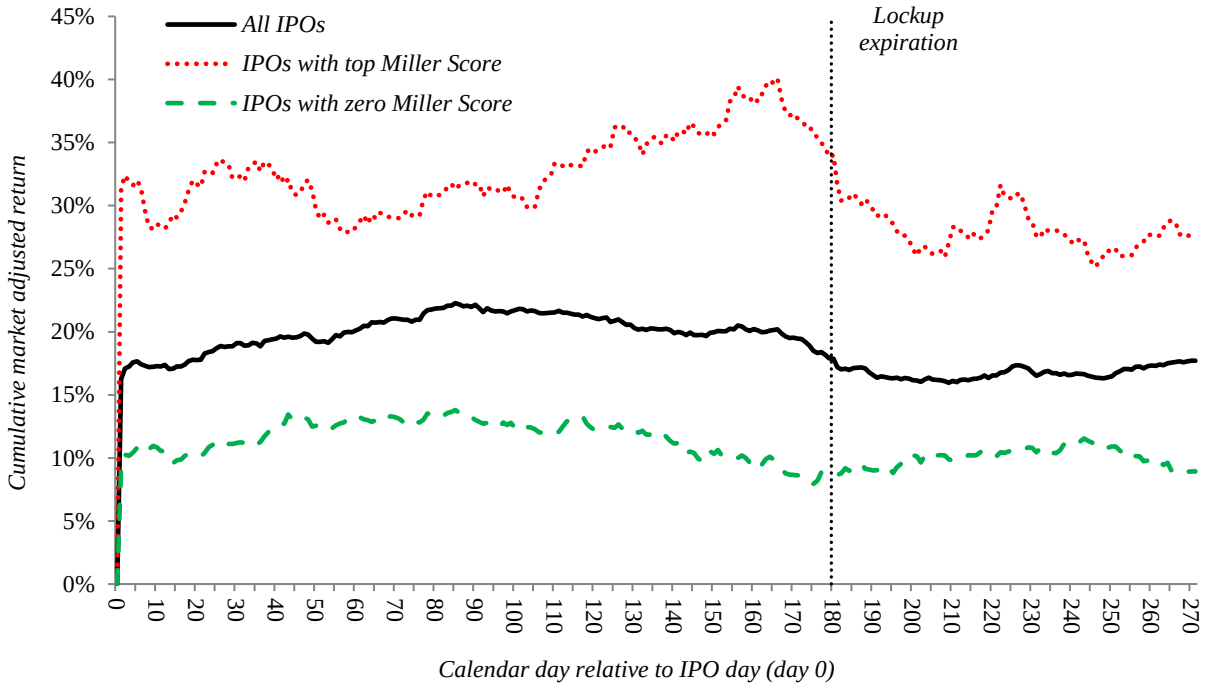
Table 10
Additional Analysis Using Analyst Forecast Dispersion Data

	(1) Low Analyst Forecast Dispersion & Large Offering Size	(2) High Analyst Forecast Dispersion & Small Offering Size	(2) – (1)	*t-test*
Analyst dispersion	0.62%	20.26%	19.64%	*4.39*
Offering size	44.28%	17.55%	-26.73%	*-13.48*
Sales growth	48.49%	156.38%	107.89%	*3.74*
Loss indicator	7.69%	59.24%	51.54%	*11.51*
Intangible intensity	3.28%	98.22%	94.94%	*2.53*
Stock loan fee	1.75%	5.11%	3.36%	*3.36*
Stock loan rebate	-0.98%	-4.18%	-3.20%	*-3.09*
Special	13.46%	42.68%	29.21%	*6.07*
Utilization	27.18%	57.51%	30.32%	*8.90*
Lockup return	-0.67%	-8.75%	-8.08%	*-4.35*

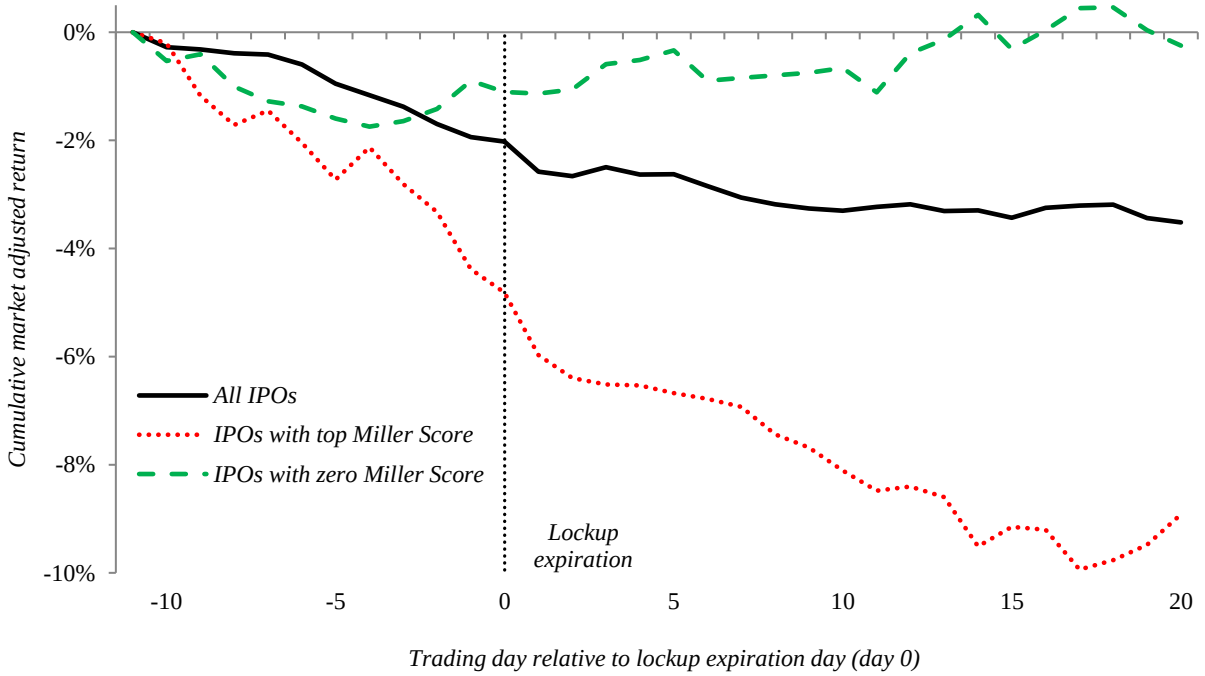
This table reports evidence of variation in pre-IPO sales growth, the operating loss indicator, intangible intensity, and the offering size, i.e., the ex ante determinants of divergence of opinion and short-sales constraints underlying our composite *Miller Score*, as well as stock loan fees, rebate rates, the frequency of stocks on special, active supply utilization, and lockup returns across two groups of IPOs stratified as of ten trading days prior to the lockup expiration. We measure stock loan fees, rebate rates, and utilization as the average daily values over the window from ten trading days before to twenty trading days after the lockup expiration. We measure the lockup return as the buy-and-hold market adjusted return over the window from ten trading days before to twenty trading days after the lockup expiration. The first group consists of 156 IPOs with below median (low) analyst forecast dispersion and above median (large) offering size. The second group consists of 157 IPOs with above median (high) analyst forecast dispersion and below median (small) offering size. We measure analyst forecast dispersion as the standard deviation of one-year-out EPS forecasts scaled by total assets per share. To measure dispersion, we require coverage by at least three analysts on IBES as of ten trading days prior to the lockup expiration. Our restricted sample excludes 40 IPOs from our full sample of 629 IPOs for which we do not have sufficient analyst coverage data.

Figure 1
IPO Stock Return Performance

Panel A: Cumulative Aftermarket Returns.



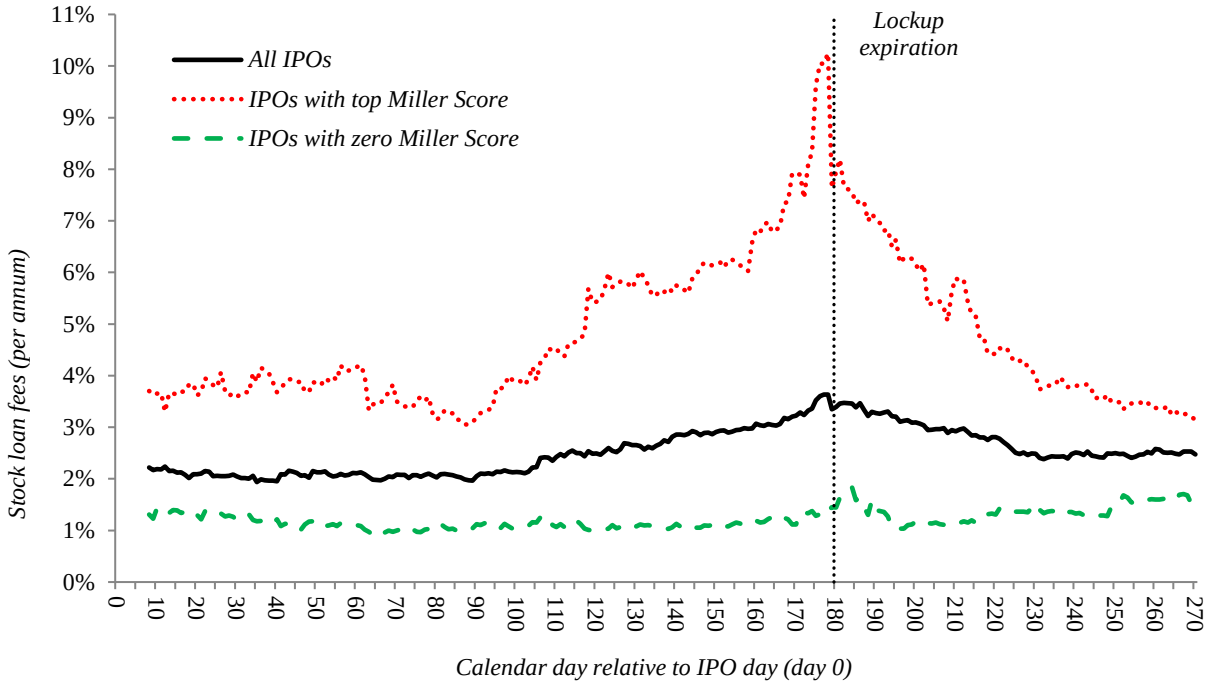
Panel B: Cumulative IPO Lockup Returns.



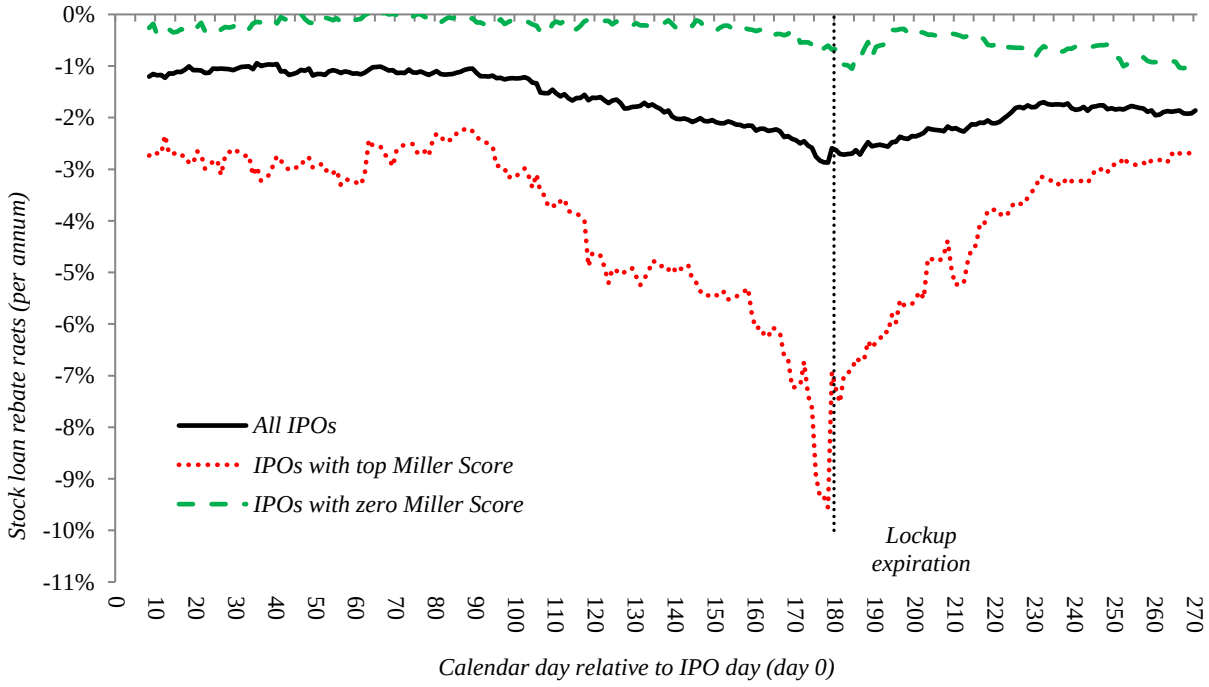
This figure reports mean cumulative market-adjusted stock returns for (i) all IPOs, (ii) IPOs with *Miller Score* of one (highest score), and (iii) IPOs with *Miller Score* of zero (lowest score). A *Miller Score* of one indicates that the firm has above median sales growth and intangible intensity, reported a pre-IPO loss, and has below median offering size. A *Miller Score* of zero indicates that the firm has below median sales growth and intangible intensity, reported a pre-IPO profit, and has above median offering size. We use the CRSP value-weighted index including distributions to proxy for the market portfolio. Panel A reports market-adjusted stock returns cumulated from the IPO day (day zero) to 270 calendar days after, where the day zero return is the market-adjusted return from the IPO offering price per share to the closing price per share on the first trading day. The vertical line indicates the lockup expiration on the 180th calendar day after the IPO day. Panel B focuses on the window from ten trading days before to twenty trading days after the IPO lockup expiration (day zero). Our sample includes 629 IPOs over the period from 2007 to 2014.

Figure 2
IPO Short-Sales Constraint Dynamics

Panel A: Stock Loan Fees.



Panel B: Stock Loan Rebate Rates.



This figure reports mean values of stock loan fees (Panel A) and rebate rates (Panel B) for (i) all IPOs, (ii) IPOs with *Miller Score* of one (highest score), and (iii) IPOs with *Miller Score* of zero (lowest score). A *Miller Score* of one indicates that the firm has above median sales growth and intangible intensity, reported a pre-IPO loss, and has below median offering size. A *Miller Score* of zero indicates that the firm has below median sales growth and intangible intensity, reported a pre-IPO profit, and has above median offering size. Stock loan fees and rebate rates are measured as the mean values of securities with the same daily cost of borrowing score (DCBS) from Markit on the same trading day. The DCBS is a number from 1 to 10 indicating the cost of borrowing in the securities lending market, where 1 is cheapest and 10 is most expensive. The measurement window stretches from one week after the IPO day (day zero) to 270 calendar days after. The vertical line indicates the IPO lockup expiration on the 180th calendar day after the IPO day. Our sample includes 629 IPOs over the period from 2007 to 2014.