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 trading day returns followed by subsequent underperformance, especially around the expiration of IPO share lockups. Miller (1977) provides a theory that offers a unified explanation for these phenomena based on divergence of investor opinions about fundamental value combined with short-sales constraints. Our paper provides a direct test of Miller's explanation by analyzing a relatively new and comprehensive database from the securities lending market. Consistent with Miller's explanation, we find evidence that the combination of heterogeneous investor beliefs with short-sales constraints is key to explaining aftermarket IPO pricing.

Keywords: divergence of opinions; 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).

Miller's (1977) theory offers a unified explanation for these phenomena that hinges on the combination of divergence of investor opinions about fundamental value with short-sales constraints. Under Miller's explanation, investors with relatively optimistic opinions buy the stock in the immediate aftermarket, while investors with relatively pessimistic opinions are unable to register their negative opinions due to short-sales constraints. Assuming that the offering price reflects the consensus valuation of the stock, Miller's explanation predicts that the aftermarket price will exceed the offering price and the magnitude of this overpricing will be increasing in the combined effects of divergence of investor opinions and short-sales constraints.

Miller's explanation also predicts that newly listed firms will subsequently underperform seasoned firms. This is because (i) the resolution of investor uncertainty about fundamental value, and (ii) the relaxation of short-sales constraints due to increases in the supply of 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 typically result in an abrupt increase in the supply of lendable shares, thereby significantly relaxing short-sales constraints. This prediction separates Miller's explanation from other theories of IPO pricing (e.g., Rock's 1986 theory), which are silent with respect to the effect of short-sales constraints and divergence of investor opinions on the long-run underperformance of new issuers, especially around IPO lockup expirations.

While Miller's theory provides an intuitive explanation for aftermarket IPO pricing, the existing evidence is inconclusive with respect to the importance of short-sales constraints in the IPO setting. Geczy, Musto, and Reed (2002) find that most IPO stocks are available to short in the immediate aftermarket and that short selling costs do not appear to be sufficient to explain the IPO pricing puzzles. Similarly, Edwards and Hanley (2010) find evidence of active short selling in IPOs 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 direct test of Miller's explanation for aftermarket IPO pricing by analyzing a relatively new and comprehensive database from the securities lending market.

To identify new issuers that are ex ante expected to have greater divergence of investor opinions and more binding short-sales constraints, we develop a composite "*Miller Score*" using a parsimonious set of pre-IPO characteristics available from the new issuers' prospectuses, including sales growth, the sign of 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 a 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. On the flip side, new issuers with a big 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 more likely to have higher divergence of investor opinions and more binding short-sales constraints. 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 opinions 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.

Consistent with Miller's overvaluation story, we find that new issuers with a top *Miller Score* are associated with more positive first-day returns and more negative returns around IPO lockup expirations. The economic magnitudes of our results are quite striking. The average first-day return increases with our composite score, ranging from 9% for new issuers with a low *Miller Score* to 32% for new issuers with a top *Miller Score*. In addition, the average market-adjusted return around IPO lockup expirations decrease from effectively 0% for new issuers with a low *Miller Score* to -9% for new issuers with a top *Miller Score*.

We next analyze detailed data from the securities lending market available from Markit, including stock loan fees, rebate rates, and active supply utilization. The evidence confirms that new issuers with a high *Miller Score* have more binding short-sales constraints. On average, new issuers with a top *Miller Score* have lending fees of 7%, corresponding to rebate rates below -6%,

and an active supply utilization of 66%, while new issuers with a low *Miller Score* have lending fees of 1%, corresponding to a rebate rate of 0%, and an active supply utilization of 27%.[1]

A hypothetical trading strategy that short sells IPOs prior to lockup agreement expirations is superficially 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 new issuers, the risk that stock loans are recalled, and the risk that stock loans become more expensive. Indeed, our analysis suggests that short selling around lockup expirations is particularly costly and risky for IPOs with a high *Miller Score*, which are precisely the stocks with the greatest back-test returns.

Prior research in finance explores the theoretical link between short-sales constraints and asset prices (e.g., Miller 1977; Harrison and Kreps 1978; Jarrow 1980; Figlewski 1981; Diamond and Verrecchia 1987; Duffie et al. 2002). Our direct examination of the securities lending market for IPO stocks provides an ideal setting for empirical tests of the interplay of heterogeneous investor beliefs and short-sales constraints. Overall, our paper adds to ongoing research on the importance of short-sales constraints for asset pricing (e.g., Chen et al. 2001; Hong and Stein 2003; Scheinkman and Xiong 2003; Hong et al. 2006; Chang et al. 2007; Cen et al. 2013; Kaplan et al. 2013; Drechsler and Drechsler 2014; Beneish et al. 2015; Engelberg et al. 2015).

[1] As an illustrative example, we consider Twitter Inc. (NYSE: TWTR)—a high *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 investing 38 cents in R&D and advertising per dollar of sales. TWTR offered at its IPO only 13% of its shares outstanding. The 87% of the shares outstanding that were not offered in the IPO were primarily held by the founders and other pre-IPO investors, including venture capital and private equity firms, and were subject to a 180-day lockup agreement with the underwriters. Trading opened on November 7, 2013, at $44.90, up 73% from the $26 offering price. First-day trading volume was 170% of the number of shares offered in the IPO. TWTR's IPO 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, the short sellers were actively targeting TWTR with the active supply utilization peaking at 99% and stock loan fees (per annum) hovering at 9%.

Our paper is organized as follows. Section I reviews prior research and provides our testable predictions. Section II describes our sample and research design. Section III presents our empirical results. Section IV concludes.

I. Prior Literature and Testable Predictions

The pricing of IPOs provides two of the most enduring and persistent capital market puzzles. First, the shares of new issuers are generally offered at a price that is substantially below the closing price on the first trading day. For example, Ritter (2016) reports that the average first-day return for over 8,000 IPOs between 1980 and 2015 is 18%. Second, the subsequent stock returns of IPOs are typically lower than the returns of seasoned securities. For example, Ritter (2016) reports that the cumulative average three-year market-adjusted return for over 8,000 IPOs from 1980 to 2014 is -18%. Prior research indicates that underperformance is particularly pronounced around lockup agreement expirations. Lockup agreements prohibit insiders and other pre-IPO shareholders from selling 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 almost 3,000 IPOs from 1988 to 1996 and find an average cumulative market-adjusted stock return of -2% over the 21 days surrounding the expiration of IPO share lockups.[2]

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 heterogeneity in investors beliefs about the security's value with short-sales constraints. Investor heterogeneity is

[2] Brav and Gompers (2003) find lockup agreements in 99% of new issuers. Field and Hanka (2001) find that the fraction of new issuers with a 180-day lockup period increased from 43% in 1988 to 91% in 1996. Espenlaub et al. (2001) find that firms going public on the London Stock Exchange in the U.K. usually have lockup agreements that do not specify a clear-cut expiration but rather tie it to other corporate events such as the publication of annual or interim reports.

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 (e.g., Kim and Ritter 1999). With divergent investor opinions and a limited supply of shares available for lending, the market price will reflect the valuations of the most optimistic investors who participate in the immediate aftermarket, which will be above the consensus valuation. If the offering price is set to reflect the consensus valuation, then the stock will initially trade above the offering price. As the stock becomes more seasoned, the reduction in divergence of investor opinions along with the increase in the supply of shares should cause its price to fall toward the consensus valuation.

A key requirement of Miller's explanation is that restrictions on short selling are sufficient to prevent pessimistic investors from registering their views via short sales. Such short sales would effectively increase the supply of the security, causing price to fall toward the consensus valuation. While evidence related to short-sales constraints for IPOs is sparse, the evidence is currently interpreted as being inconsistent with Miller's explanation. Geczy et al. (2002) examine short selling activity for a sample of 311 IPOs using a proprietary database provided by a large securities lender between October 28, 1998 and October 26, 1999. 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. Edwards and Hanley (2010) 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. They conclude that short selling is an integral part of the IPO aftermarket and that other factors may therefore be responsible for evidence of positive first-day returns.

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

PREDICTION I: *IPOs with a combination of high divergence of investor opinions and more limited supply of shares experience more positive first-day returns.*

Miller's explanation also predicts that IPOs with high divergence of investor opinions 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 shares should cause price to fall toward the consensus valuation. This process should be accelerated around IPO lockup agreement expirations as insiders and other pre-IPO shareholders are allowed to sell their shares, thereby increasing the supply of shares and loosening short-sales constraints. This discussion leads to our second prediction:

PREDICTION II: *IPOs with a combination of high divergence of investor opinions and more limited supply of shares experience more negative returns around lockup expirations.*

It is important to note that Prediction II distinguishes Miller's theory of aftermarket IPO pricing from a variety of other theories, which primarily focus on explaining evidence of positive first-day returns (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 new issue, and the uninformed investors, who have homogeneous expectations about the distribution of the value of the new issue. 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 predicts that premarket discounting is more pronounced for new issuers with higher information asymmetry. Rock's (1986) model, however, is silent with respect to the effect of short-sales constraints and divergence of investor opinions on the long-run underperformance of new issuers, especially around IPO lockup expirations.

We next examine variation in short-sales constraints across new issuers. Specifically, we predict that divergence of investor opinions 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 opinions and a small float, i.e., a small number of circulating shares, as in the case of new issuers offering a small fraction of their number of shares outstanding. Our third prediction is summarized as follows:

PREDICTION III: *IPOs with a combination of high divergence of investor opinions and more limited supply of shares are more difficult and costly to short sell.*

II. Sample and Research Design

A. 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 867 IPOs listed on NYSE, NASDAQ, and AMEX over the period from 2007 to 2014 obtained from the Securities Data Company (SDC) database.[3] Following prior research on IPO pricing (e.g., Ritter and Welch 2002), we exclude from our initial sample new issuers 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. We also exclude from our initial sample new issuers with missing first trading day data from CRSP and missing pre-IPO accounting data.[4] To obtain our final sample, we exclude 32 IPOs with no or multiple lockup agreements, 30 IPOs with lockup agreements expiring sooner or later than 180 days after the IPO day, and 176 new issuers with no Markit coverage around lockup expirations.[5]

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 we can track new issuers for at least 180 days after the IPO day. Table I, Panel A, summarizes our sample selection. Table I, Panel B, reports the distribution of our sample over the sample period. The

[3] 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/.

[4] We reviewed all cases with missing pre-IPO accounting data from Compustat and complemented our sample with hand-collected data directly from the offering prospectuses available from the SEC's EDGAR database.

[5] Even though the vast majority of new issuers have lockup agreements expiring 180 days after the IPO day, our results are not sensitive when we include the few cases of IPOs with lockup agreements expiring sooner or later than 180 days after the IPO day. Our analysis is simplified, however, by focusing on new issuers with 180-day long lockup agreements (see, e.g., Figure 2).

number of new issuers ranges over time from a minimum of 16 for 2008 to a maximum of 155 for 2014, which was the most active year for IPOs since 2000.[6]

B. Ex Ante Determinants of Investor Heterogeneity and Short-Sales Constraints

Miller (1977) hypothesizes that high divergence of investor opinions about a newly listed firm's value coupled with short-sales constraints can lead to overpricing in the immediate aftermarket and long-run underperformance. To test Miller's hypothesis, we search for ex ante characteristics that would make an IPO firm to be more likely to have high divergence of investor opinions and more limited supply of shares in the securities lending market.

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*." With respect to the valuation of a new issuer, investors' opinions are more likely to diverge when there is a great deal of uncertainty about the firm's future operating performance.

To identify ex ante determinants of divergence of investor opinions, we rely on a parsimonious set of fundamental firm characteristics measured using financial accounting data from the IPO 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 intangible intensity. The idea underlying this parsimonious set of variables is simple. Uncertainty about future operating performance, and therefore divergence of investor opinions, should be higher for high growth new issuers experiencing operating losses, while making larger investments in intangibles.[7] We also consider other pre-IPO characteristics including firm size, firm age, the existence of

[6] We note that SEC's 2008 short-sale ban on financials did not directly affect our sample of new issuers. There are no financial IPOs in our sample that had their debut or lockup expiration within the duration of the ban (i.e., from September 19, 2008 to October 2, 2008).

[7] 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).

venture-capital investment, and tech-industry membership. We find, however, that variation in aftermarket pricing with these additional characteristics is subsumed by variation with pre-IPO sales growth, operating losses, and intangible intensity.

We hasten to note that prior research has used the dispersion in sell-side analysts' earnings forecasts as a measure of divergence of investor opinions in the general population of stocks (e.g., Diether et al. 2002; Boehme et al. 2006). Analyst coverage of new issuers, however, typically starts only the day after the end of the quiet period, i.e., 40 calendar days after the IPO day. As a result, analyst forecast dispersion is determined endogenously and simultaneously with short sales constraints and IPO pricing. By focusing on ex ante determinants of divergence of investor opinions measured using information from the IPO prospectuses, we alleviate issues of simultaneity and endogeneity in our empirical tests. In additional analysis, we use analyst coverage data from IBES and find that the dispersion in analysts' earnings forecasts around IPO lockup expirations increases with pre-IPO sales growth and intangible intensity and is higher among new issuers with pre-IPO operating losses.

With respect to the securities lending market, a key determinant of the supply of shares available for lending in the aftermarket and hence 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 (e.g., Field and Hanka 2001). The combination of a small offering size with lockup agreements on the remaining shares outstanding restricts the supply of lendable shares and makes short-sales constraints more binding (e.g., Ofek and Richardson 2003). On the flip side, new issuers with a

big offering size are less likely to face binding restrictions on the supply of shares in the securities lending market.

C. Introducing the Miller Score

Miller (1977) hypothesizes that divergence of investor opinions and short-sales constraints combine to distort IPO pricing in the aftermarket. To simultaneously examine variation in the determinants of divergence of investor opinions and short-sales constraints, we introduce a four-point scoring method. Specifically, a new issuer scores one point for each of the following four criteria: (i) it has above median pre-IPO sales growth, (ii) it reports a pre-IPO operating loss, (iii) it has above median intangible intensity, and (iv) it has below median offering size.

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 firm has above median sales growth and intangible intensity, reported a pre-IPO operating loss, and has below median offering size. Conversely, a low *Miller Score* of zero indicates that the firm has below median sales growth and intangible intensity, reported a pre-IPO operating profit, and has above median offering size.

Top-score IPOs are ex ante more likely to have higher divergence of investor opinions and more binding short-sales constraints. 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 opinions and short-sales constraints. Thus, aftermarket pricing distortions are possible even for IPOs with a *Miller Score* of zero. Importantly, however, such pricing distortions 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.[8]

D. Timeline of Research Design

Appendix A illustrates the timeline of our research design. We measure the ex ante determinants of divergence of investor opinions, including sales growth, the operating loss indicator, and intangible intensity using financial accounting data from the prospectus as of the most recent fiscal year prior to the IPO.[9] We measure the offering size as the number of shares offered in the IPO divided by the number of shares outstanding in the company immediately after the IPO, again using information provided in the prospectus. At the end of the first trading day in the aftermarket, 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 IPO lockup expirations, we measure market-adjusted returns, stock loan fees, rebate rates and active supply utilization in the securities lending market.

E. Descriptive Statistics

Before presenting our empirical results, we discuss the descriptive statistics. Appendix B provides all variable definitions. Table I, Panel C, summarizes the empirical distributions of key

[8] Our scoring method assigns the same weight of 1/4 to each of the four pre-IPO characteristics considered. 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 opinions (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 only the composition of the intermediary *Miller Score* portfolios, while the composition of the bottom and top *Miller Score* portfolios remains unchanged. Our analyses focus on the extreme *Miller Score* portfolios and, therefore, our inferences remain unchanged using this alternative scoring method.

[9] 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 IPO 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.

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 effect of skewness due to extreme observations in our measures of sales growth and intangible intensity, the portfolio partitions used in our subsequent empirical tests are based on the median values of pre-IPO characteristics.[10] Pre-IPO operating losses are reported by 34% of the new issuers in our sample. The average offering size accounts for nearly 30% of the number of shares outstanding, which indicates that the fraction of locked-up shares is 70% for the average new issuer. The average offering price is $15.60 per share, while 72% of new issuers 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).[11]

Consistent with prior research dating back to Logue (1973), we find evidence of significantly positive first-day returns. The average first-day return is 16.4%. In line with prior research (e.g., Field and Hanka 2001; Brav and Gompers 2003), we also find evidence of significantly negative returns around IPO lockup expirations. The average market-adjusted return cumulated over the ten trading days before through the twenty trading days after IPO lockup expirations is -3.54%.

Turning to the securities lending market, we use daily data from Markit to measure IPO short selling costs. Markit sources its data from a consortium of institutional lenders who are

[10] Koh and Reeb (2015) provide evidence of a disclosure bias among firms reporting missing and blank R&D values due to proprietary costs. In additional analysis, we obtain similar results using an indicator variable for IPOs in the technology sector in lieu of partitions based on intangible intensity. Following Ritter (2016), we define technology stocks as internet-related stocks plus other technology stocks, not including biotech.

[11] 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. In additional analysis, we use information from the SDC database and find that high *Miller Score* IPOs are associated with a wider offering price range relative to the final offering price.

believed to collectively account for the majority of loanable equity inventory in the U.S. In a recent study, Drechsler and Drechsler (2014) note that the securities lending activity covered by Markit includes over 95% of the U.S. equities in the CRSP database, and 85% of borrowing activity in the U.S. securities lending market. Other recent studies using securities lending market data from Markit include Beneish et al. (2015) and Engelberg et al. (2015).

Markit provides information about stock supply and demand along with stock loan fees, rebate rates, and develops a daily cost of borrow 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. The DCBS is more widely available on Markit than actual stock loan fees and rebate rates. Specifically, actual stock loan fees and rebate rates are available at daily frequencies around lockup expirations for 51% of new issuers in our sample. To deal with the incomplete coverage of actual stock loan fees and rebate rates, we use the mean values of loan fees and rebate rates of securities with the same DCBS on the same trading day.

For each new issuer, we obtain DCBS data over the window from ten trading days before to twenty trading days after the IPO lockup expiration. Over the same window, 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. Following Beneish et al. (2015), we classify IPOs as hard-to-borrow or "special" if the average cost of borrow score around lockup expirations is higher than two and as easy-to-borrow or "general collateral" otherwise.

Turning to the empirical distributions in Table I, Panel C, we find that for the average new issuer in our sample the annualized stock loan fee around IPO lockup expirations is 3.13%, resulting in a negative rebate rate of -2.38% to short sellers. Around lockup expirations, hard-to-

borrow new issuers account for 26.4% of our sample, while the average active supply utilization is hovering at 40.5%.

With respect to the pairwise correlations in Table I, Panel D, we first confirm that the *Miller Score* is positively correlated with sales growth, the pre-IPO loss indicator, and intangible intensity, while it is negatively correlated with the offering size. We also find significant preliminary evidence supporting our predictions based on Miller's story. The *Miller Score* is positively correlated with first-day returns and negatively correlated with lockup expiration 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 stock loan rebate rates and are more likely to be "on special" in the securities lending market. Finally, the negative correlation between the first-day return and the lockup return suggests that some of the initial IPO pricing reflects overpricing in the immediate aftermarket that is corrected six months later, around lockup expirations.

III. Empirical Results

A. Evidence from the First Trading Day

Table II examines variation in first-day returns with pre-IPO characteristics. The portfolio results in Table II, Panel A, provide evidence that first-day returns are higher for new issuers that are ex ante more likely to have higher divergence of investor opinions and more binding short-sales constraints. Specifically, the average first trading day return is significantly higher for new issuers with above median sales growth, pre-IPO operating losses, above median intangible intensity, and below median offering size.

Table II, Panel B, shows that arranging new issuers in portfolios based on the *Miller Score* yields a significant spread in first-day returns. The average first-day return increases with our

composite score and it ranges from 9.23% for new issuers with a low *Miller Score* to 32.01% for new issuers with a high *Miler Score*. The difference in first-day returns across the top-score and the zero-score portfolios of 22.78% is significantly different from zero at the 1% level (t-statistic = 5.47). The OLS regression results in Table II, Panel C, confirm that the *Miller Score* has significant explanatory power for first-day returns after controlling for variation in the macro environment captured by year fixed effects.[12]

Table III 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 investor heterogeneity and trading volume (e.g., Harris and Raviv 1993), we find evidence that on the first trading day offer turnover is higher for IPOs that are ex ante more likely to have high divergence of investor opinions, i.e., IPOs with high sales growth, high intangible intensity, and negative pre-IPO earnings.[13] In addition, offer turnover is significantly higher for new issuers 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.

Taken together, the evidence supports our first prediction that new issuers with high divergence of investor opinions and more limited supply of shares available for lending experience more positive returns on the first trading day. Our evidence extends prior studies on the relationship

[12] 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.

[13] Harris and Raviv (1993) provide a model where trading is generated by differences of opinion among traders 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.

between uncertainty over fundamental value and first-day returns (e.g., Beatty and Ritter 1986; Houge et al. 2001; Gao et al. 2006).

B. Evidence from IPO Lockup Expirations

IPO lockup agreements are intended to keep company insiders from immediately selling stock when a company raises public capital, creating unique supply constraints in the securities lending market (e.g., Field and Hanka 2001; Brav and Gompers, 2003). A key prediction based on Miller's (1977) hypothesis is that new issuers with high valuation uncertainty and a restricted stock supply in the securities lending market are more likely to become overpriced in the immediate aftermarket and to experience a price correction around subsequent lockup expirations when an increased supply of shares comes to the market. As we explain in Section II, this prediction separates Miller's (1977) theory from other theories of IPO pricing that make no predictions concerning returns around lockup expirations (e.g., Rock's 1986 theory).

Table IV examines variation in stock returns around lockup expirations. We measure market-adjusted lockup 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 lockup expirations. We extend Brav and Gompers' (2003) return measurement window forward by ten additional trading days to capture more of the post-lockup selling.

While new issuers, on average, experience negative abnormal returns around lockup expirations, we find evidence of significant variation in return predictability with ex ante determinants of divergence of investor opinions and short-sales constraints. Table IV, Panel A,

shows that IPO lockup returns are significantly more negative for new issuers with high sales growth, negative pre-IPO earnings, high intangible intensity, and a small offering size.

Arranging our sample based on our composite *Miller Score* yields a strong negative relationship with lockup returns. Specifically, the portfolio results in Table IV, Panel B, show that market-adjusted returns around lockup expirations decrease from close to 0% for zero-score IPOs to -9.15% for top-score IPOs. Evidence of 0% lockup returns for new issuers with a low *Miller Score* suggests that investors have correctly anticipated the number of shares sold at lockup expiration for this subset of new issuers in our sample. On the flip side, evidence of significantly negative lockup returns of -9.15% for new issuers with a high *Miller Score* is consistent with overpricing in the immediate aftermarket and a significant price correction around IPO lockup expirations. The OLS regression results in Table IV, Panel C, provide consistent evidence of predictability in lockup returns based on the *Miller Score* and confirm that such evidence is robust to controlling for year fixed effects.[14]

Overall, the evidence supports our second prediction that new issuers with high divergence of investor opinions and more limited stock supply available for lending experience more negative returns around subsequent lockup expirations. Although consistent with Miller's story about aftermarket IPO pricing, our evidence is at odds with prior evidence that shorting frictions do not explain lockup expiration returns (e.g., Geczy et al. 2002).

C. Short-Run and Long-Run IPO Performance

Figure 1 provides additional evidence with respect to variation in the short-run and long-run stock return performance of IPOs. Panel A plots average market-adjusted stock returns

[14] In additional analysis, we find evidence that trading volume around lockup expirations is higher for IPOs that are ex ante more likely to have higher divergence of investor opinions and more binding short-sales constraints, and that the trading volume around lockup expirations increases across *Miller Score* portfolios.

cumulated forward starting from the IPO day to 270 calendar days after the trading debut of (i) all IPOs (solid black line), (ii) IPOs with a top *Miller Score* of one (dotted red line), and (iii) IPOs with a low *Miller Score* of zero (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 correction six months later around lockup expirations, which is consistent with prior evidence of negative abnormal lockup returns. Arranging new issuers based on the *Miller Score*, the figure clearly shows that this pattern is more pronounced for top-score IPOs. The group of IPOs with a top *Miller Score* experiences both more positive first-day returns and a more dramatic price correction around lockup expirations. In contrast, the group of IPOs with a zero *Miller Score* experiences lower first-day returns and no price correction around lockup expirations.

Figure 1, Panel B, plots average market-adjusted stock returns cumulated from ten trading days before to twenty trading days after lockup expirations. By centering on the lockup expiration, the figure visually confirms our evidence that the underperformance of new issuers around lockup expirations is primarily due to the negative abnormal returns of IPOs with a high *Miller Score*, while IPOs with a zero *Miller Score* do not experience abnormal returns. 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 (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 the gradual incorporation of the views of more pessimistic investors and a gradual reversion toward the consensus valuation.

To summarize, we find evidence consistent with Miller's story of aftermarket IPO pricing. IPOs with high divergence of investor opinions and more limited supply of shares in the securities lending market initially trade at a premium that starts to dissipate around subsequent lockup expirations.

D. Evidence from the Securities Lending Market

Next, we use data on the securities lending market available from Markit to search for direct evidence of a link between the pre-IPO characteristics underlying our composite *Miller Score* and short-sales constraints.[15]

D.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. Prior research has focused on the level of short interest, measured as the ratio of shares shorted to shares outstanding (e.g., Edwards and Hanley 2010). The problem with this measure is that a low value can reflect either low demand or limited supply of shares in the 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 opening a short position.

Table V provides evidence on the relation between pre-IPO firm characteristics and stock loan fees around lockup expirations. The univariate portfolio results in Table V, 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 more likely to have high

[15] 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).

divergence of investor opinions. Stock loan fees are also higher for new issuers with small offerings, i.e., IPOs for which the stock supply in the securities lending market is ex ante more likely to be constrained. Arranging our sample in portfolios based on the *Miller Score* in Table V, Panel B, shows that stock loan fees increase from a low of 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 V, Panel C, provide consistent evidence of a significantly positive association between the *Miller Score* and stock loan fees after controlling for macro effects.

Table VI explores variation in stock loan rebate rates and provides additional insights into the costs of short selling IPO stocks. 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 the difficulty of shorting, i.e., the degree to which short-sales constraints are binding (see, e.g., Ofek et al. 2004). Around the expiration of IPO share lockups, we find that 83% of our sample experiences negative rebates, with an average stock loan rebate rate of -2.38% per annum. In contrast, only a small fraction of the general population experiences negative rebate rates at any given point in time (e.g., D'Avolio 2002; Evans et al. 2008; Reed 2013).

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

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

Following Beneish et al. (2015), we next classify IPOs as hard-to-borrow or "special" when Markit's average daily cost of borrow score around the lockup expiration is higher than two, which corresponds to average stock loan fees and rebate rates of 1.66% and -1.00%, respectively. We classify all other IPOs as easy-to-borrow or "general collateral" securities. Using this scheme, we find that nearly 26.4% of new issuers in our sample are on special. In contrast, only a small fraction of stocks in the general population is on special at any given point in time (e.g., D'Avolio 2002; Asquith et al. 2005; Reed 2013).

Table VII provides evidence of variation in specialness with pre-IPO characteristics. Table VII, Panel A, shows that the frequency of on-special status is higher for new issuers with high pre-IPO sales growth, negative operating earnings, high intangible intensity, and a small offering size. In addition, arranging new issuers in Table VII, Panel B, based on the *Miller Score* reveals that the frequency of on-special status increases by nearly six times, from a low of 8.9% for zero-score IPOs to a high of 52.6% for top-score IPOs. The probit regression results in Table VII, Panel C, confirm that as we move from a *Miller Score* of zero to a *Miller Score* of one, the odds of an IPO being on special increase by nearly six times.

D.2. Variation in Active Supply Utilization

To supplement our findings, 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 borrow in the securities lending market.

Table VIII examines variation in active supply utilization around lockup expirations 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 new issuers that are ex ante more likely to have high divergence of investor opinions and a smaller supply of shares available for lending, 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 new issuers based on our composite *Miller Score*, we find that active supply utilization increases from a low value of 27.4% for zero-score IPOs to over 66% for top-score IPOs, consistent with a decrease in the supply slack across portfolios.[16] The OLS regression results in Table VIII, Panel C, provide consistent evidence of a significantly positive association between the *Miller Score* and active supply utilization, with our score explaining on a stand-alone basis 15% of the variation in utilization rates.

D.3. Short-Sales Constraint Dynamics

Figure 2 provides evidence with respect to the dynamics of short-sales constraints starting shortly after the IPO day. The figure plots average values of stock loan fees (Panel A), stock loan rebate rates (Panel B), as well as the active supply utilization (Panel C) for (i) all IPOs (solid black line), (ii) IPOs with *Miller Score* of one (dotted red line), and (iii) IPOs with *Miller Score* of zero (dashed green line). The measurement window stretches 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

[16] 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%.

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 six months after the IPO.

Figure 2 illustrates that new issuers that are ex ante more likely to have high investor heterogeneity and limited supply of shares in the securities lending market are associated with a higher cost of borrowing. Starting with Figure 2, Panel A, the top-score IPOs have stock loan fees of around 4% over the first three months of trading, then rise over the subsequent three months to reach a peak at 10% immediately prior to the lockup expiration, and finally fall back to 4% in the three months after the lockup expiration. In contrast, the zero-score IPOs have stock loan fees that hover between 1% and 2% throughout the 270 day post-IPO period. The evidence is consistent with increased short-selling activity over the days leading to the lockup expiration especially for high *Miller Score* IPOs. The evidence for rebate rates in Figure 2, Panel B, mirrors the evidence for stock loan fees. Even though the rebate rates are consistently more negative for new issuers with a top *Miller Score*, there is significant variability in the aftermarket. Focusing on the top-score IPOs, rebate rates fluctuate from -3% to -2% over the first three months of trading, drop over the subsequent three months leading to the lockup expiration reaching a nadir at -9%, and revert back closer to -3% over the three months following the lockup expiration. In contrast, focusing on the zero-score IPOs, the stock loan rebate rates are less volatile, hovering around 0% over the six months leading up to the lockup expiration.

In line with the evidence for stock loan fees and rebate rates, Figure 2, Panel C, shows that active supply utilization is higher for IPOs that are ex ante more likely to be overpriced in the immediate aftermarket. Focusing on the top-score IPOs, active supply utilization peaks at 71% around 180 days after the offering day, which is consistent with more binding short-sales

constraints immediately before lockup expirations, and drops to 58% over the subsequent three months, which is consistent with a relaxation of supply constraints.

Overall, the evidence supports our third prediction that new issuers with high divergence of investor opinions and more limited stock supply in the securities lending market are more difficult and expensive to short, as indicated by more positive stock lending fees, more negative rebate rates, and higher active supply utilization.

D.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 lockups, i.e., IPOs that are within the 31-day window centered on each lockup expiration.[17] This strategy yields a payoff approximating the stock loan rebate rate minus the market-adjusted lockup return minus the risk-free rate. We use information on stock loan rebate rates from Markit to estimate the payoffs from short selling IPO lockups.

Table IX, 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 the 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

[17] 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.

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.

Arranging new issuers in portfolios based on the *Miller Score*, we find that the average daily payoffs to short sellers increase across 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. [18]

The premium from targeting IPO lockups, however, may not be attainable in practice. 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 the existence of a transaction on Markit does not imply a liquid market at the quoted rates. In addition, the combination of a small active supply with a high utilization rate, especially for top *Miller Scor*e

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

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. 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*."

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 IX, 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 more likely to have high divergence of investor opinions and a smaller supply of shares available for lending in the aftermarket. Arranging stocks 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.

Table IX, 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 new issuers, 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).

To summarize, even though lockup returns are predictably more negative for new issuers with a high *Miller Score*, evidence of a significant premium for short selling IPO lockups is likely to reflect compensation for the costs and risks faced by arbitrageurs. Our analysis suggests that short selling IPO lockups is especially costly and risky when targeting new issuers with a high

Miller Score, i.e., when targeting new issuers that are ex ante more likely to become overpriced in the immediate aftermarket and subsequently underperform.

IV. Conclusion

Focusing on a parsimonious set of pre-IPO characteristics, we find that new issuers that are ex ante more likely to have higher divergence of investor opinions and more binding short-sales constraints are associated with more positive first-day returns and more negative returns around subsequent lockup expirations. We also provide direct evidence that such IPOs are more difficult and expensive to short sell by analyzing a relatively new and comprehensive database from the securities lending market. Overall, our evidence suggests that the combination of investor heterogeneity with short-sales constraints is key to explaining aftermarket IPO pricing.

Recent research suggests that restrictions on short selling also 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 heterogeneous beliefs and a limited supply of 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.[19]

[19] 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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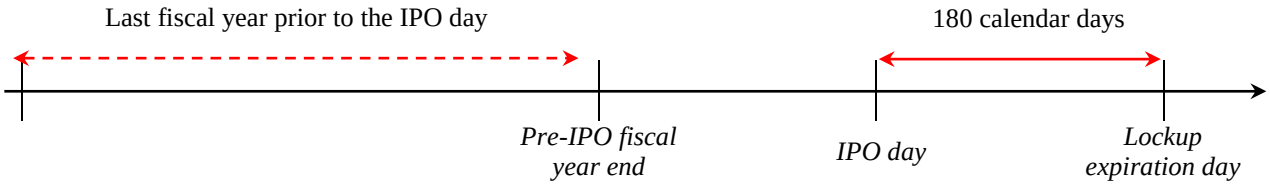
Appendix A
Timeline of Research Design



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 B
Variable Definitions

Variable	Definition
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 lockup expiration. We use the CRSP value-weighted index including distributions to proxy for the market portfolio.
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 borrow 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 I
Sample Selection and Descriptive Statistics

Panel A: Sample Selection.

Sample selection	# of IPOs
NYSE/NASDAQ/AMEX IPOs from 2007 to 2014 with offering price ≥ $5, excluding (i) ADRs, unit offerings, REITs, SPACs, closed-end funds and (ii) IPOs with missing first trading day data and pre-IPO accounting data	867
Exclude IPOs with no or multiple lockup agreements	(32)
Exclude IPOs with lockup agreements expiring sooner or later than 180 days after the IPO day	(30)
Exclude IPOs with no coverage by Markit around lockup expirations	(176)
Our sample	629

Panel B: 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 C: Empirical Distributions of Key Variables.

Variable	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
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 D: Pairwise Pearson (Spearman) Correlations Above (Below) Main Diagonal.

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

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

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

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 (big) 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* and year 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.

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	0.0594
t-statistic	*8.33*	*3.12*	*5.96*
Miller Score	.	0.2178	0.2081
t-statistic	.	*12.13*	*9.63*
Year fixed effects	No	No	Yes
Adj. R^2	0.00%	7.61%	9.44%

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

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 (big) 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* and year 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.

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	0.4884
t-statistic	*20.56*	*14.18*	*14.66*
Miller Score	.	0.3509	0.3287
t-statistic	.	*5.48*	*4.56*
Year fixed effects	No	No	Yes
Adj. R^2	0.00%	4.43%	5.81%

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

This table reports evidence of variation in lockup expiration 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 (big) 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* and year 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.

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	-0.0075
t-statistic	*-3.85*	*1.01*	*-0.62*
Miller Score	.	-0.0947	-0.0888
t-statistic	.	*-3.92*	*-3.43*
Year fixed effects	No	No	Yes
Adj. R^2	0.00%	2.58%	2.74%

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

This table reports evidence of variation in stock loan fees with pre-IPO characteristics. We measure stock loan fees as the daily average 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 (big) 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* and year 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.

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	-0.0135
t-statistic	*4.38*	*0.65*	*-1.68*
Miller Score	.	0.0624	0.0554
t-statistic	.	*3.21*	*3.19*
Year fixed effects	No	No	Yes
Adj. R^2	0.00%	5.58%	9.36%

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

This table reports evidence of variation in stock loan rebate rates with pre-IPO characteristics. We measure stock loan rebate rates as the daily average 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 (big) 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* and year 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.

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	0.0505
t-statistic	*-2.10*	*0.78*	*6.23*
Miller Score	.	-0.0623	-0.0549
t-statistic	.	*-3.12*	*-3.13*
Year fixed effects	No	No	Yes
Adj. R^2	0.00%	5.21%	14.38%

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

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 (big) 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* and year 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.

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	-1.2495
t-statistic	*-7.82*	*-10.92*	*-26.29*
Miller Score	.	1.4055	1.3255
t-statistic	.	*10.97*	*14.26*
Year fixed effects	No	No	Yes
Pseudo R^2	0.00%	8.92%	10.72%

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

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 daily average 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 (big) 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* and year 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.

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	0.2727
t-statistic	*16.27*	*7.19*	*17.64*
Miller Score	.	0.4003	0.3819
t-statistic	.	*10.73*	*11.41*
Year fixed effects	No	No	Yes
Adj. R^2	0.00%	15.04%	16.90%

Table IX
Short Selling IPO Lockups: A Risky Business

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.

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%

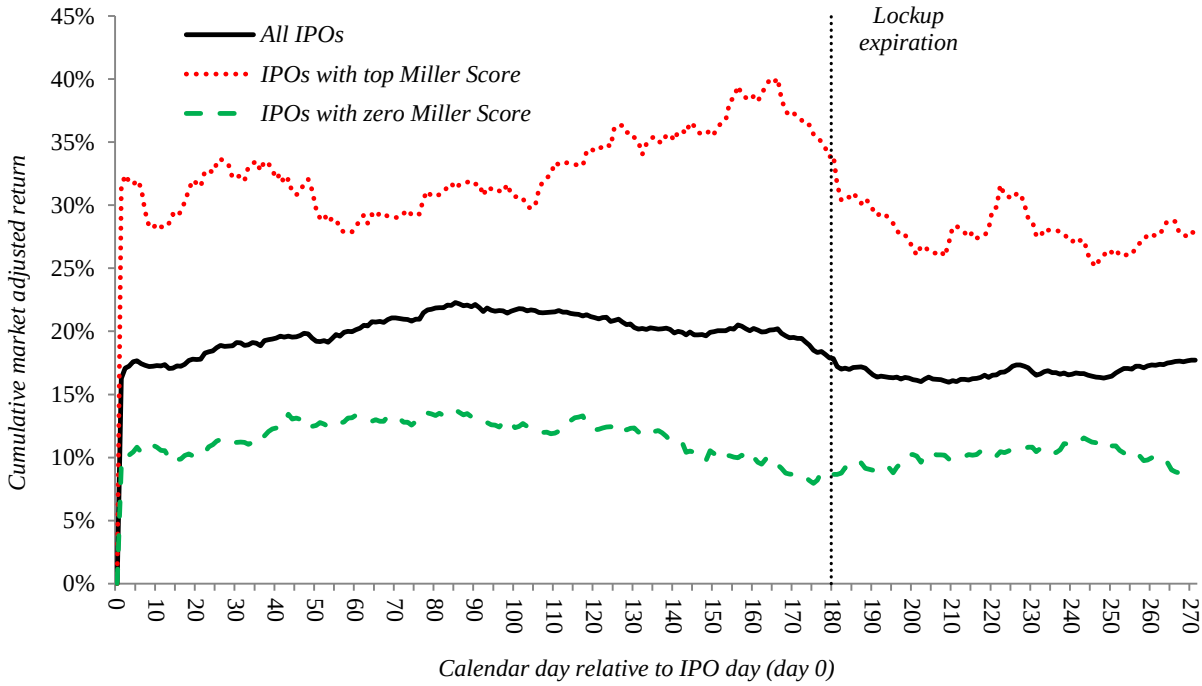
Panel C: Diversification Restrictions.

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%

Figure 1
IPO Stock Return Performance

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.

Panel A: Cumulative Aftermarket Returns.



Panel B: Cumulative IPO Lockup Returns.

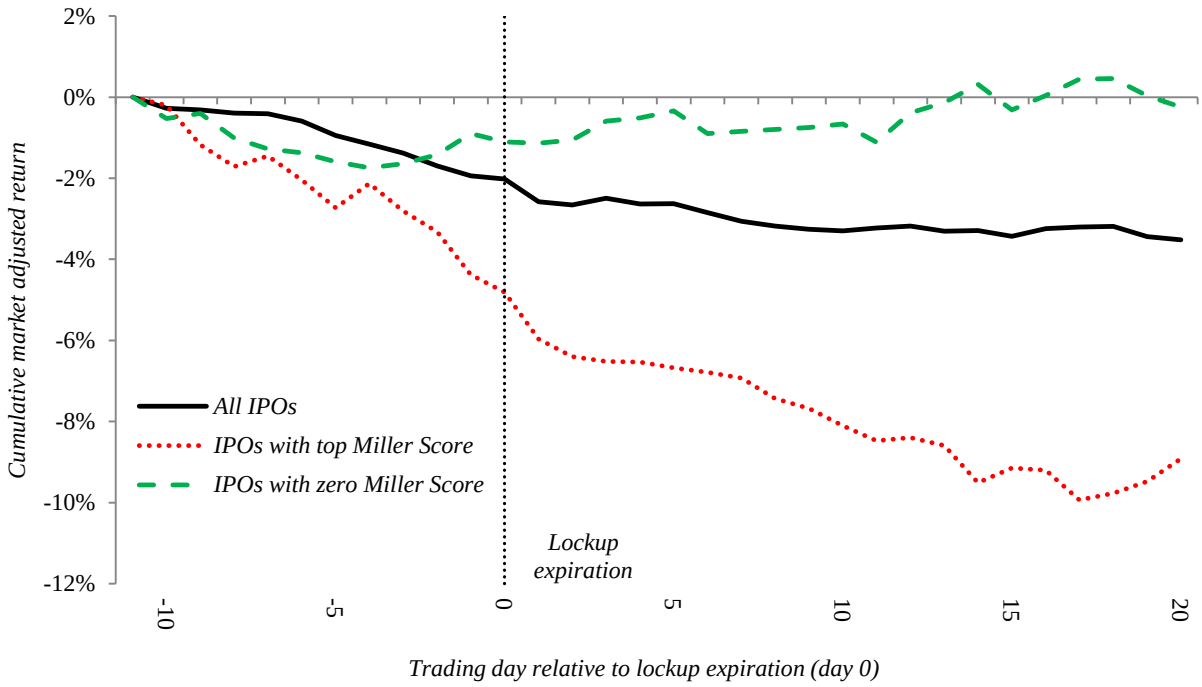
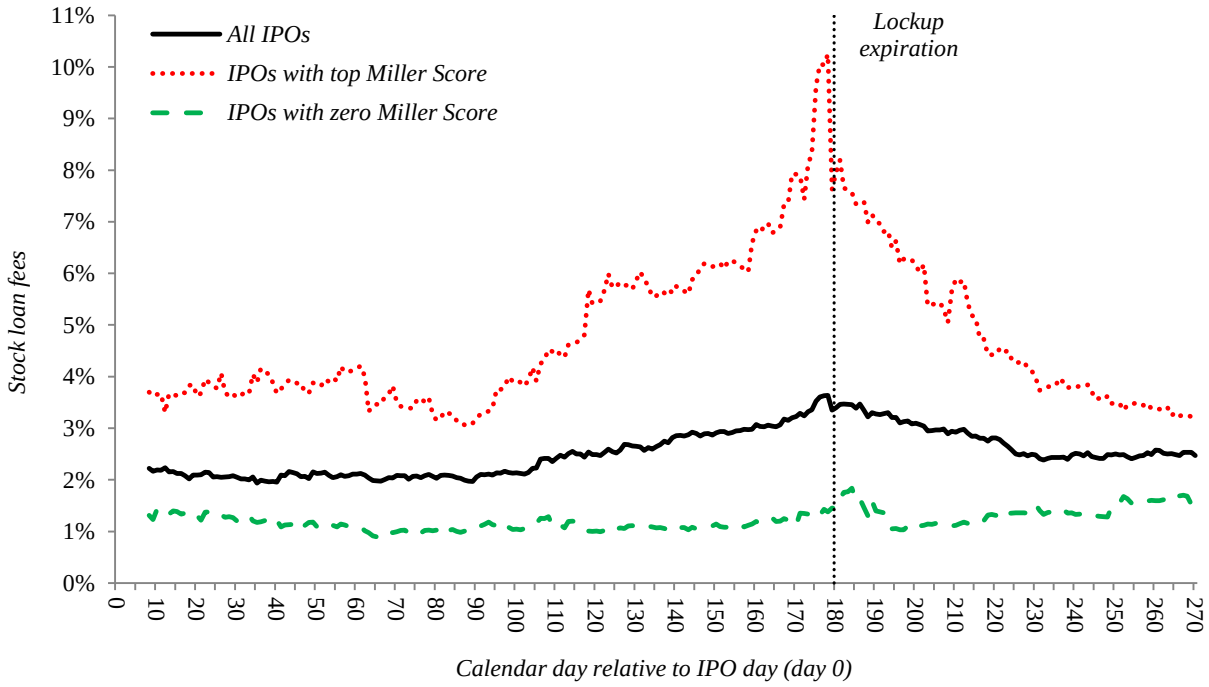


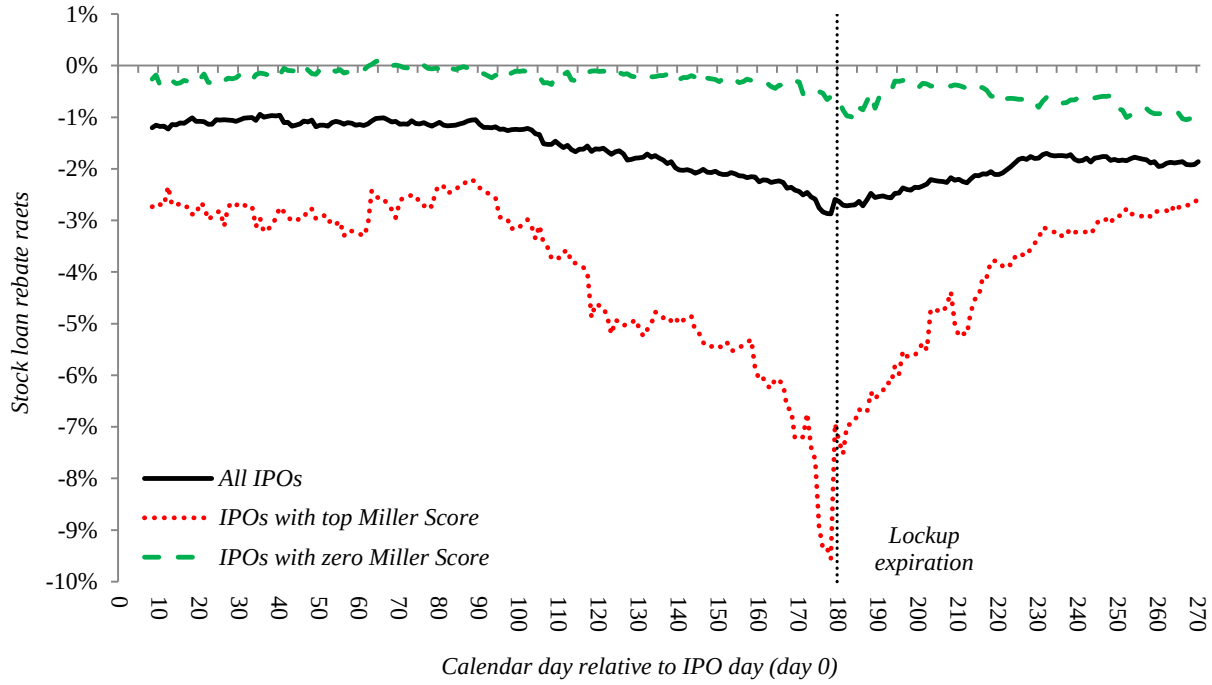
Figure 2
IPO Short-Sales Constraint Dynamics

This figure reports mean values of stock loan fees (Panel A), stock loan rebate rates (Panel B), and active supply utilization (Panel C) 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 stock loan fees and rebate rates of securities with the same daily cost of borrow 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. 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. 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.

Panel A: Stock Loan Fees.



Panel B: Stock Loan Rebate Rates.



Panel C: Active Supply Utilization.