Short selling around the expiration of IPO share lockups

Michael Gibbs\textsuperscript{a}, (Grace) Qing Hao\textsuperscript{b,}\textsuperscript{*}

\textsuperscript{a}Department of Finance, California State University, Long Beach, CA 90840, USA
\textsuperscript{b}Department of Finance and Real Estate, University of Texas at Arlington, Arlington, TX 76019, USA

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**A B S T R A C T**

We are the first to examine daily short selling activity around the expiration of IPO share lockups. We find that short selling increases before the lockup expiration date and declines afterward, and the level of short selling is higher in stocks of venture capital (VC)- and private equity (PE)-backed IPOs than other IPOs. Unlike VC-backed IPO stocks, PE-backed IPO stocks do not experience a negative return or a trading volume jump on the lockup expiration date. PE investors do not reduce percentage ownership in the IPO firm as much as VC investors do after lockup expirations. Short selling in PE- and VC-backed IPO stocks prior to the lockup expiration date can predict PE and VC ownership reduction but not the stock returns after the lockup expires. In contrast, short selling in stocks of the IPO firms without a PE or VC investor can predict stock returns after the lockup expires.

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1. Introduction

A typical initial public offering (IPO) sells about one-third of the outstanding shares to the public, leaving the rest of the shares to be locked up for a few months after the IPO. The expiration dates of IPO share lockup represent the first time when the shares that are locked up can be sold on the market. Consequently, the public float may be increased significantly. While the expiration date of share lockup is pre-scheduled, it is not known beforehand how many shares will be sold by insiders and, more importantly, how the stock price will react to the lockup expiration.

While the literature confirms the negative stock price impact of the lockup expiration, we do not have answers to the following questions. Does short selling increase in the days leading up to the lockup expiration date? Is short selling before the lockup expiration date informative about the post-lockup stock returns? Is short selling before the lockup expiration date related to insider selling, especially venture capital (VC) and private equity (PE) ownership reduction in the IPO firm, after lockup expires? By examining daily short selling activity around the expiration of IPO share lockups, we try to answer these questions.

We not only find that short selling increases significantly prior to the lockup expiration date, but we also determine that short selling increases more in VC- and PE-backed IPO stocks than in other IPO stocks. Our findings provide evidence as to whether short sales are constrained prior to lockup expirations. In addition, we find that short selling over several days prior to the lockup expiration date can predict the post-lockup stock returns for firms without a VC or PE investor, but not for VC- or PE-backed firms. Using hand collected data on insider ownership change around the lockup expiration date, we discover that short selling prior to the lockup expiration date can predict VC and PE investors’ ownership reduction but not the directors and executive officers’ ownership reduction after lockups expire. We discuss possible reasons for the findings.

Furthermore, unlike VC-backed IPO stocks, PE-backed IPO stocks do not have a negative return or a jump in trading volume on the lockup expiration date. Post-lockup abnormal stock returns are significantly higher for PE-backed firms than VC-backed firms. The results are robust to alternative measures of abnormal returns. While we confirm that PE funds do not reduce their proportional ownership in the IPO firm as much as VC funds do after lockup expirations, we argue that this is not the only reason for the different price impact of lockup expirations between VC- and PE-backed firms. A more important reason is that VC- and PE-backed firms are associated with different levels of information asymmetry. Specifically, VC-backed firms are smaller and not yet profitable.
firms that are more likely to be in technology industries. In contrast, PE-backed firms, which are primarily reverse leveraged buyouts (LBOs), are larger and profitable. Firms with little information asymmetry such as reverse LBOs are less likely to have a price impact upon lockup expiration because the signaling effect is likely to be small (Brav and Gompers, 2003). Moreover, compared to VC-backed firms, PE-backed firms offer more shares in the IPO and release fewer shares relative to the public float on the lockup expiration date, which also contributes to the different price impact of lockup expirations.

In addition to our main findings, we also find that the SDC New Issues Database reports a lockup expiration date that is one day earlier than the actual lockup expiration date for 78% of the IPOs in our sample. We conjecture that this one-day error contributes to the finding in the literature that trading volume jumps one day after the lockup expiration date rather than on the lockup expiration date itself (e.g., Field and Hanka, 2001; Fig. 3; Bradley et al., 2001; Fig. 5; Brav and Gompers, 2003, Fig. 2; Cao et al., 2004, Fig. 1).

Our study makes two contributions. First, we fill a gap in the IPO lockup expiration literature by providing empirical evidence as to how short sellers trade around the lockup expiration date on a daily basis. IPO share lockup is among the most widely watched features of IPOs. However, due to data availability, no prior study has examined daily short selling around the expiration of IPO share lockups. Two studies are related to short selling around lockup expirations. Geczy et al. (2002) study equity loans, while Johnston et al. (2005) examine monthly short interests around lockup expirations. However, neither of them provides direct evidence of short selling on a daily basis. Our study is made possible because the Securities and Exchange Commission (SEC)'s Regulation SHO mandates each trading venue to publicly disclose intra-day short sale transaction data. Our findings contribute to the debate over whether short selling is constrained for IPO stocks.

Second, our study adds to the literature regarding private equity and reverse LBOs. For example, Kaplan and Strömbäck (2009), Cao and Lerner (2008), Levis (2011), Lerner et al. (2011), Acharya et al. (2013), Huang, Ritter, and Zhang (2016),? Visnjic (2013), Fang et al. (2013), and Cumming and Zambelli (2013), among others. In contrast to the view that private equity investors are short-term oriented and are likely to flip their investments quickly (e.g., Kosman, 2009), our evidence suggests that private equity backers do not reduce their investments as much as VC funds do at the earliest opportunity after bringing their portfolio firm public. PE investors, in our sample, maintain a significant amount of ownership after the lockups expire.

Our paper proceeds as follows. Section 2 discusses the related literature. Section 3 outlines the data used in this study. Section 4 presents our empirical analyses and findings, while Section 5 provides our conclusions.

### 2. Related literature and hypothesis development

An extensive body of research has examined short selling (e.g., Brent et al., 1990; DeChow et al., 2001; Desai et al., 2002; Chen and Singal, 2003; Arnold et al., 2005; Asquith et al., 2005; Boehmer et al., 2008; Diether et al., 2009; Henry and Koski, 2010). However, research on short selling in IPO stocks is scant. A notable exception is Edwards and Hanley (2010), who focus on short selling in the immediate aftermarket and find active short selling on the first trading day for IPO stocks. Their finding is consistent with Geczy et al. (2002), who determine that stock loans are made as early as the first trading day for IPO stocks. Both studies suggest that short selling in IPO stocks is not as constrained as suggested by the prior literature.

As a significant event in an IPO stock’s early public life, share lockup expiration represents a unique setting to study short selling. IPO stocks are new to the public and are less likely to be associated with traded options. Thus, short selling becomes almost the only way for pessimistic investors to express their view in the stock market.

The literature documents negative stock returns around the share lockup expiration date and the effect is larger in venture-backed firms compared to non-venture-backed firms (e.g., Field and Hanka, 2001; Bradley et al., 2001). Given that the lockup expiration date is publicly declared beforehand, one reason for negative stock returns around the lockup expiration is considered to be short sale constraints. The rationale is that if short sales are not constrained prior to the lockup expiration, then any predictable price drop around the lockup expiration would be arbitrated away by short sellers. However, it is debatable whether the stock returns around lockup expirations are completely predictable. For example, shares of PokerTek Inc., a maker of electronic poker tables that went public in October 2005, surged 14% on its lockup expiration date. VC-backed Yelp Inc. stock soared nearly 23% on its lockup expiration date leading to the comment quoted in Russelillo and Benoit (2012) that “The lesson for all those people that got short in anticipation of the lockup [ending] is there is no such thing as a sure thing.”

Additionally, there is an important debate in the literature as to the role of lockups, particularly as it relates to the technology stock bubble and burst from 1999–2000. Ofek and Richardson (2003) consider lockups as a short selling constraint. However, Schultz (2008) debunks the Ofek and Richardson argument and finds that internet stocks declined sharply in March and April 2000 regardless as to whether their lockup periods had expired. Geczy et al. (2002) find that stock price drops around lockup expiration even for IPO stocks with little shorting frictions suggesting that short selling constraints are not a reason for the price behavior around lockup expirations. Johnston et al. (2005) examine monthly short interests for IPO stocks from January 1998–June 2001. They find that short interests are larger for stocks that ex-
perience more negative returns upon lockup expiration. By directly examining daily short selling activities around lockup expiration, we seek to provide additional evidence for the debate as to the roles of lockups.

At the heart of the debate as to whether short sales are constrained prior to lockup expiration is the exact definition of constrained short sales. Conceptually, short sale constraint is more of a continuous variable than a dummy variable. As shown in Fig. 1, at one end of the spectrum, the extreme form of constrained short sales is that no short sale can occur. Geczy et al. (2002) and Edwards and Hanley (2010) find strong evidence against the extreme form of constrained short sales for IPO stocks. At the other end of the spectrum, the extreme form of unconstrained short sales is that all the demand for short selling can be satisfied. However, we do not see how to test for the existence of unconstrained short sales empirically, because even if short selling increases when the demand for short selling is higher, it does not necessarily imply that short selling increases as much as investors would want to increase. As Ofek and Richardson (2003) argue, “The fact that short interest increases, however, still does not mean that short sales constraints are no longer binding. For example, there may still remain significant numbers of investors who would like to short Internet stocks but find it difficult to do so.”

With this caveat in mind, if we find that short selling increases when the demand for short selling increases prior to the lockup expiration date, then at least we can infer that short sales are not completely constrained. In other words, short sale constraint exists somewhere between the two extremes of the spectrum in Fig. 1. While the demand for short selling can increase before the lockup expiration date because more investors may bet on a price decline following the lockup expiration, if share supply and short sales are severely constrained by share lockups, then short selling may not be able to increase significantly prior to the lockup expiration date. In other words, increased short selling before the lockup expiration date would reject the hypothesis of completely constrained short sales. Although it does not necessarily suggest completely unconstrained short sales either, it can be interpreted as evidence between the two ends of the spectrum in Fig. 1. We state our first hypothesis in the alternative form.

**Hypothesis 1. Abnormal short selling increases before the lockup expiration date.**

Are short sellers informed about the post-lockup stock returns? While many studies find evidence of informed short sellers, it is not necessarily so in the context of IPO share lockup expirations. For example, given that the literature documents a negative stock return around lockup expiration dates, it is possible that a greater number of traders without any private information share short before the lockup expiration date, hoping to make a profit from their expected price decline. These uninformed short sellers have no private information as to the future value of the stock, and they simply extrapolate the past pattern into the future. As a result, they would introduce more noise and reduce the level of informativeness of short selling prior to the lockup expiration date.

While there can be various reasons why short selling may not be informative about future stock returns for IPO stocks, it is an empirical question whether any of the reasons is strong enough to make short selling uninformative. If short selling is, on average, informative, then we expect to find the following:

**Hypothesis 2. Abnormal short selling prior to the lockup expiration date increases more for IPO stocks with more negative stock returns following the lockup expiration.**

While the date on which a share lockup expires is publicly known in advance, a main driver of abnormal stock returns following the lockup expiration is probably the amount of shares that are sold or intended to be sold by insiders. “Such sales can move the stock’s price,” as Wall Street Journal’s weekly column “Lockup Expirations” warns investors. Field and Hanke (2001) examine several hypotheses that may explain why abnormal returns around lockup expirations are negative. They find that the abnormal return may be partly, but not completely, caused by consistently larger than expected insider sales. In order to better understand the information content of short selling prior to the lockup expiration date, we examine the relation between short selling and insider ownership reduction. We are particularly interested in answering the following question: Is short selling prior to the lockup expiration date informative about upcoming insider ownership reduction after the lockup expires? If the answer is yes, then we expect to find the following:

**Hypothesis 3. Abnormal short selling prior to the lockup expiration date increases more for IPO stocks with greater expected insider ownership reduction after the lockup period expires.**

3. Sample and summary statistics

3.1. IPO sample

We obtain a sample of IPOs conducted by U.S. domestic firms from January 2005–December 2006 and their offering characteristics from the Securities Data Company (SDC) new issues database. We choose this sample period as the short sale data mandated by the Regulation SHO are available from January 2005–mid-2007 and IPO lockup periods typically last for six months. We exclude closed-end funds, real estate investment trusts (REITs), and units. We also require that the IPO stock’s first price on the Center for Research in Security Prices (CRSP) is within a week of the issue date in the SDC database. The SDC New Issues database reports incorrect CUSIPs for some IPO stocks. We hand checked every IPO to ensure accurate matching with the CRSP database. This initial sample includes 315 IPOs, of which 99.05% have a share lockup agreement. We further exclude IPOs without a lockup agreement, IPOs whose lockup expiration date is later than May 31, 2007 (i.e., the last day when our Regulation SHO data are available), and IPOs with missing information in the SDC database on the number of shares restricted from selling during the lockup period. We exclude a few IPOs that have zero trading volume on the lockup expiration date according to the CRSP daily stock files. Our final sample has 213 IPOs.

We use data from multiple sources. The SDC database provides flag variables regarding whether an IPO is VC-backed or PE-backed.

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1 Studies finding informative short selling include Christophe et al. (2004), Boehmer et al. (2008), Diether et al. (2009), Christophe et al. (2010), Massoud et al. (2011), Brockman and Hao (2011a, 2011b), Engelberg et al. (2012), and Kecskés et al. (2013), among others.

2 According to the explanation provided by a client support executive at the SDC, the number of shares locked up is covered in the SDC database only if it is explicitly given in the data sources. For example, the total number of shares being locked up is not provided in the lock-up agreement section of the SEC filing by FTD Group, Inc. (SDC deal no. 1619744002); http://www.sec.gov/Archives/edgar/data/1283157/000104746905002902/a21514052424b4.htm. While the difference between the number of shares outstanding upon completion of the IPO and the number of shares sold in the IPO can be used as a proxy for the number of shares locked up, the number of shares outstanding does not include warrants or options to purchase shares, as pointed out by the SDC client support executive.

3 While we did not intentionally exclude American depositary receipt (ADR) or American depositary share (ADS) from the sample, no ADR or ADS is found in the final sample.
We follow the SDC’s definitions to identify VC- and PE-backed IPOs. The SDC database used to provide no information regarding whether an IPO is a reverse LBO (Cao and Lerner, 2009). However, we are able to use the SDC database to identify reverse LBOs for our sample period.4 We obtain stock price, return, trading volume, and the number of shares outstanding from CRSP, accounting information from Compustat, institutional ownership from Thomson’s 13F filings database, investor ownership from IPO prospectuses and proxy statements at the EDGAR website, insider trading data from Thomson’s insider filing files, earnings announcements from I/B/E/S, information on seasoned equity offerings (SEO)s from the SDC New Issues database, and information as to whether an IPO stock has traded options from the OptionMetrics database. We also use SEC filings to correct the IPO issue date provided by the SDC’s new issues database. We obtain underwriters’ reputation ranks from Jay Ritter’s website. Our short sale data are from the TAQ database, as well as eight stock exchanges, which we detail later in Section 3.4.

In the U.S., the lockup restriction is a contract between the underwriters and pre-issue shareholders, and the underwriters can ex post waive the selling restrictions, for instance, when there is a follow-on equity offering prior to the expiration of the lockup. The lockup expiration date may also be revised due to earnings releases. We use company filings with the SEC and the Factiva news database to confirm the actual lockup expiration date.

3.2. Lockup expiration date

We initially obtain IPO share lockup expiration dates from the SDC New Issues database. An IPO may have multiple lockup expiration dates. We focus on the lockup expiration date with the most shares unlocked as this is arguably the lockup expiration date with the largest price movement. In addition, keeping only one lockup expiration date for each IPO addresses potential concerns that the regression residuals are not independent. For convenience, we refer to the lockup period with the most shares locked up as the largest share lockup.

Next, we rely on IPO prospectuses to manually correct the lockup expiration dates obtained from the SDC database. We find that the SDC database reports lockup expiration dates one day earlier than the actual lockup expiration dates for 78% of the IPOs in our sample. Our finding has important implications for the literature on IPO lockup expiration. We conjecture that this one-day error contributes to the finding in the earlier literature that trading volume jumps one day after the lockup expiration date rather than on the lockup expiration date itself. Examples include Field and Hanka (2001, Fig. 3), Bradley et al. (2001, Fig. 5), Brav and Gompers (2003, Fig. 2), Cao et al. (2004, Fig. 1), among others. These studies largely rely on the lockup expiration dates provided by the SDC database, as their samples include a large number of firms ranging from 1497 to 2871 IPOs, which makes it difficult to hand check the accuracy of the dates.5 We are not aware of any other study pointing this issue out with the exception of Altinkilic and Hansen (2003), who find a pattern for offering dates for SEOs in the SDC database that is similar to what we find for lockup expirations.

3.3. Summary statistics

Among the 213 IPOs in our final sample, about 40% are VC-backed and 40% are PE-backed. Among the PE-backed IPOs, 71 IPOs or 33% of our sample are reverse LBOs. The fraction of PE-backed IPOs in our sample is in line with those in Huang, Ritter, and Zhang (2013). As explained earlier, we focus on the lockup expiration date with the most shares being unlocked, as this is arguably the lockup expiration date with the largest price movement. About 15% of the IPOs have another lockup expiration date prior to the date on which the most shares are unlocked. The mean (median) number of shares unlocked on the biggest lockup expiration date relative to the total number of shares outstanding is 62% (65%). In contrast, for stocks whose first lockup period expires prior to the biggest lockup, the mean (median) number of shares unlocked on the first lockup expiration date is only 5% (0.5%) of the total number of shares outstanding.6

Table 1 presents the summary statistics for VC-backed IPOs, PE-backed IPOs, and other IPOs. Since the PE-backed IPOs in our sample are primarily reverse LBOs, their summary statistics are very similar. We do not tabulate results for reverse LBOs here for the sake of brevity.

We test for the statistical significance of the differences between VC-backed IPOs and PE-backed IPOs. The results are reported in the last two columns of Table 1. There are several noticeable differences between VC- and PE-backed IPOs. The average market capitalization for PE-backed firms is more than twice as large as that of VC-backed firms. PE-backed firms have more debt than VC-backed firms, which is consistent with the findings in Levis (2011). Furthermore, more VC-backed firms are in technology industries and their IPOs are more underpriced than PE-backed firms. Compared to PE-backed firms, VC-backed firms offer a smaller fraction of the outstanding shares in the IPO and have a greater fraction of the outstanding shares locked up. In other words, VC-backed firms release more shares relative to the public float on the lockup expiration date. We also notice that compared to PE-backed firms, more VC-backed IPOs have another lockup expiration date prior to the largest lockup’s expiration date.7 Finally, VC-backed firms are unprofitable, which is in sharp contrast to the profitable PE-backed firms.

3.4. Measure of short selling

Our daily short sale data are from the American Stock Exchange (AMEX), the Archipelago, the Boston Stock Exchange, the Chicago Stock Exchange, the National Association of Securities Dealers, the National Association of Securities Dealers Automated Quotations (NASDAQ), the National Stock Exchange (formerly known as the Cincinnati Stock Exchange), the Philadelphia Stock Exchange, and the New York Stock Exchange (NYSE).8 All of the above self-regulatory organizations (SROs) made tick data on short sales publicly available starting on January 2, 2005 as a result of the SEC’s Regulation SHO adopted in 2004. While the short sale data for NYSE is available through the TAQ database, all other SROs make

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4 As the SDC often backfills data for historical IPOs, we re-obtained information as to whether an IPO is backed by VC/PE investors and whether an IPO is a reverse LBO from the SDC database in December 2015 to assure the best accuracy.
5 Some studies, such as Field and Hanka (2001), check data accuracy for a small fraction of their sample IPOs. However, they did not check the accuracy of the issue date.
6 In untabulated results, we find that short selling is less informative about stock returns prior to the first lockup than the largest lockup.
7 After manually checking the IPO prospectuses, we find that all the small share lockups that expire prior to the largest share lockups are related to selling restricted shares under Rules 144 and 701.
8 Table 2 in Brockman and Hao (2011a) reports the short sale distribution by these nine market venues. They find that “The NYSE accounts for roughly 83% of shares sold short in NYSE-listed ADRs, while NASDAQ accounts for 8% and ARCA accounts for 9%.”
short sale data available only on their own websites. The ending date for the available Regulation SHO data varies from May to August of 2007 across the various SROs. As such, we select a sample period during which short sale data are available for all the SROs (i.e., January 2005-May 2007). The SHO dataset also includes an indicator variable indicating whether a transaction is exempt from the price test rules. Since exempt transactions apply to special cases, such as trades related to “bona fide” market making, we exclude these transactions from our main empirical analysis.9

We aggregate the intra-day transaction data on short sales on a daily basis. We obtain stock returns, trading volume, and the number of shares outstanding from the CRSP. We scale short volume by trading volume. The ratio of short volume to trading volume is used in many studies that examine whether daily short sales are informative about future stock returns (e.g., Christophe et al., 2004; Boehmer et al., 2008; Diether et al., 2009; Henry and Koski, 2010; Engelberg et al., 2012). As Henry and Koski (2010) explain, “short selling is high on days when total trading volume is also high.” Edwards and Hanley (2010) confirm that this pattern is also true for IPO stocks, starting from the first trading date. Thus, the ratio of short volume to trading volume can reflect whether short selling increases disproportionately with total trading volume. Controlling for trading volume is important since several studies (e.g., Field and Hanka, 2001) find that trading volume increases permanently after the lockup expiration date. Given the jump in trading volume after lockups expire, the ratio of short volume to trading volume allows for a better comparison prior to and after the lockup expiration date.

Following Christophe et al. (2004) and Henry and Koski (2010), we measure the abnormal short selling (ABSS) on date $t$ as follows:

$$
ABSS_t = \frac{\text{short volume} - \text{average short volume}}{\text{trading volume}} - 1. \quad (1)
$$

Our benchmark period is from days $-70$ through $-21$. Alternatively, we use the period from the first trading date until the day before the lockup expiration date as the benchmark period. The main results are similar. Recall that 15% of the IPOs have another lockup expiration date prior to the expiration date of the largest share lockup. To address this concern that our benchmark period

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9 Engelberg et al. (2012) find that exempt trades are uninformative as they represent market making activities. During the period from January 2005-May 2007, these exempt transactions represent roughly 20% of the total transactions.
may include the first lockup expiration date for these firms, we also use the period prior to the first lockup expiration date as our benchmark period. Again, our results are robust to the alternative definition of the benchmark period.

Similarly, we compute daily abnormal trading volume on date $t$ as follows:

$$\text{abnormal trading volume}_t = \frac{\text{trading volume}_t \times \text{Benchmark index return}}{\text{average trading volume over benchmark period}} - 1. \tag{2}$$

The benchmark period is the same as for abnormal short sales. We measure the market-adjusted return as the difference between the stock return and the Nasdaq Composite Index return. The main results are robust to the CRSP equally-weighted index-adjusted returns and the Fama-French (1993) three-factor alphas. The estimation period for the Fama-French (1993) three-factor model is from trading days $-70$ through $-21$, which is the same as the benchmark period used to estimate abnormal short selling. We require at least 40 days of returns available during the estimation period.

### 3.5. Short selling, trading volume, and stock returns

Fig. 2 plots the mean daily abnormal short sales, abnormal trading volume, market-adjusted returns, and the buy-and-hold abnormal returns from event day $-20$ through event day $+20$. While the mean trading volume jumps on the lockup expiration date and remains high afterward, the mean short sale peaks one day prior to the lockup expiration date. In untabulated results, we find that daily abnormal short selling is consistently positive at the 5% or 1% significance level from Day $\leq -10$ until Day $-1$, and remains positive at the 10% significance level from Day 0 until Day 3. In addition, we find that the average abnormal short sale is significantly higher over several days before the lockup expiration date than several days after the lockup expiration.\(^{10}\) In contrast, the average daily abnormal trading volume is not significantly positive until the lockup expiration date. As explained in Section 2, we cannot argue for completely unconstrained short sales based on our evidence. However, the following two results at least suggest that short sales are not completely constrained either. First, trading volume does not increase, but short selling increases significantly prior to the lockup expiration date. Second, short sales drop significantly after the lockup period expires.

Table 2 provides the summary statistics for short selling, trading volume, and stock returns for VC-backed, PE-backed, and other IPO firms, respectively. Consistent with Hypothesis 1, the average abnormal short sale over five days prior to the lockup expiration date, $\text{ABSS}[5, -1]$, is significantly positive across the three groups of IPOs. In particular, $\text{ABSS}[5, -1]$ is 0.30 for VC-backed IPOs and 0.24 for PE-backed IPOs, suggesting that the average short selling during five days prior to the lockup expiration date is 30% and 24% higher than the average short sale over the benchmark period for VC-backed IPOs and PE-backed IPOs, respectively. Untabulated results reveal that the abnormal short selling in VC-backed IPO stocks and PE-backed IPO stocks is significantly higher than other IPO stocks.\(^{11}\) In addition, the abnormal trading volume jumps significantly on the lockup expiration date only for VC-backed IPO stocks, but not for PE-backed or other IPO stocks. In contrast to the negative abnormal return on the lockup expiration date for VC-backed IPOs, the abnormal return on the lockup expiration date is not negative for either PE-backed or other IPO firms. The results are robust to both market-adjusted returns and the Fama-French (1993) three-factor alphas.

Note that there is a caveat for using regression-based asset pricing models, such as the Fama-French (1993) model around the lockup expiration date. As Table 2 indicates, the stock returns from the first trading day of the IPO until 11 days prior to the lockup expiration date are significantly positive for all the three groups of absolute number of short sales increases after lockup expiration, but not as much as trading volume does.

\(^{10}\) As abnormal short selling (ABSS) is measured as the shorting volume scaled by the trading volume and the trading volume increases after lockup expiration, we also examine whether the absolute number of short sales increases, decreases, or does not change after lockup expiration. In untabulated results, we find that the...
IPOs. This may be due to the information momentum effect argued by Aggarwal et al. (2002) or to other reasons. Regardless of the reason, the positive price trend before the lockup expiration date suggests that an IPO stock’s factor loadings prior to the lockup expiration date may be different than those after the lockup expiration date. Specifically, using positive stock returns before the lockup expiration date to estimate factor loadings may create a downward bias in the post-lockup abnormal returns.12 Consistent with this view, most of the three-factor alphas in Table 2 are lower than the corresponding market-adjusted returns.

In the last two columns of Table 2, we report the statistical significance of the differences in means and medians between VC-backed firms and PE-backed firms. We find that the pre-lockup expiration stock returns are not significantly different between VC- and PE-backed firms. However, the post-lockup stock returns are significantly lower for VC-backed firms than for PE-backed firms. The results are robust to both market-adjusted returns and the Fama-French (1993) three-factor alphas.13 We also find statistical significance at the 1% level for the mean and median differences in the abnormal trading volume between VC-backed and PE-backed firms. However, we do not find any statistically significant difference between VC-backed firms and PE-backed firms in terms of the abnormal short selling prior to the lockup expiration date.14

12 A similar argument is made in Hao (2014) for seasoned equity issuers’ abnormal returns.
13 Cao and Lerner (2009) examine the post-IPO long run stock performance for reverse LBOs from 1981-2003. They find evidence that reverse LBOs perform better than other IPOs and the stock market as a whole. Their Table 6 indicates that reverse LBOs’ superior stock performance even exists in the first year following the IPO. Consistent with Cao and Lerner (2009), we find that PE-backed IPO stocks have the best stock performance after lockup expirations among the three groups of IPOs in Table 2.
14 In untabulated results, we also break down the sample based on whether the IPO stock has traded options before the largest share lockup expiration. We do not find any significant difference in the abnormal short selling averaged over five days prior to the lockup expiration date between the two groups.

### 3.6. Insider ownership reduction after the lockup expiration date

To collect insider ownership before and after the lockup expiration date, we manually search through the IPO prospectus and the first proxy statement after the lockup expiration date. We collect two measures of insider ownership and report the summary statistics in Tables 3 and 4. Table 3 reports summary statistics of the ownership by directors and executive officers as a group for PE-backed, VC-backed, and other IPOs. The average ownership reduction by directors and executive officers is 9.47% for PE-backed firms, 9.62% for VC-backed firms, and 4.77% for other IPO firms. Both PE- and VC-backed firms have greater ownership reduction by directors and executive officers than other IPO firms, as the PE and VC investors are often on the boards of directors of the IPO firms. In untabulated results, we do not find any statistically significant difference in the directors’ and executive officers’ ownership change between PE- and VC-backed firms.

Table 4 presents summary statistics of the VC and PE ownership for the PE- and VC-backed firms only. On average, there are two PE investors for PE-backed firms and five VC investors for the VC-backed firms at the time of the IPO. PE investors’ ownership is larger than VC investors’ ownership both before and after lockup expirations. VC investors reduce percentage ownership more than PE investors after the lockup expiration date. Specifically, for PE-backed firms, PE investors’ total ownership is reduced from 51% at the time of the IPO to 35% as reported in the first proxy statement after the lockup expiration date. This 16% ownership reduction represents 35% of the PE ownership at the time of the IPO. For VC-backed firms, VC investors’ total ownership changes from 43% at the time of the IPO to 24% as reported in the first proxy statement after the lockup expiration date. This 19% ownership decline accounts for 48% of the VC ownership at the time of the IPO. The evidence suggests that PE funds do not reduce their percentage ownership after lockups expire as much as VC funds do. The results seem to be consistent with the “patient capital” view for private equity funds (e.g., Finkl and Greising, 2010). While VC funds reduce percentage ownership more than PE funds after lockup expirations, the difference in their ownership...
reduction alone may not explain the different price impact of lockup expirations between VC- and PE-backed firms. Recall our finding that there is no negative return or jump in trading volume on the lockup expiration date for PE-backed firms. It is important to discuss how the price impact of lockup expiration varies by the type of firm. Lakonishok and Lee (2001) find that insider trading is able to predict future stock returns mainly in small firms. Brav and Gompers (2003) suggest that information asymmetry can affect the stock price reaction at lockup expiration. As our Table 1 indicates, among the IPO firms, VC-backed firms are not only smaller, but also less profitable. In addition, more VC-backed firms are in technology industries. In contrast, PE-backed firms are more informationally transparent as they are larger and more profitable.\(^{15} \) Given that VC-backed firms are associated with greater information asymmetry than PE-backed firms, we would expect insider selling in VC-backed firms to have a more negative impact on the stock price than PE-backed firms. That PE funds' percentage ownership reduction is smaller than VC funds may be a reason for the difference in the stock return around the lockup expiration between VC-backed and PE-backed firms. The fact that PE-backed firms are less associated with information asymmetry than VC-backed firms may be a more significant reason as to why the stock returns after lockups expire are negative for VC-backed firms, but not for PE-backed firms.

### 4. Regression results

To determine whether abnormal short selling prior to the lockup expiration date is informative about post-lockup stock returns or insider ownership reduction following the lockup expiration, we use the following regression model:

\[
Y = a + b_1 \text{ABSS}[-5, -1] + b_2 \text{Control} + \epsilon. \tag{3}
\]

The dependent variable, \(Y\), is the abnormal stock return or the insider ownership change after the lockup expiration. The main independent variable is \(\text{ABSS}[-5, -1]\), the average abnormal short

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\(^{15}\) Our finding is consistent with the comment in Katz (2009) that “profit levels are crucial and technology considerations largely irrelevant for PE-backed firms, where the converse is true for VC-backed firms.”
sales over five days prior to the lockup expiration date. The control variables include indicator variables that are equal to one if the IPO firm is VC-backed, PE-backed, has a top-tier underwriter, is a technology firm, has another lockup expiring earlier, has conducted an SEO earlier, and has options traded prior to the lockup expiration date, respectively (and zero otherwise). The inclusion of the control variables indicating whether a firm is VC-backed, has a top-tier underwriter, or is a technology firm is motivated by the findings in Field and Hanka (2001) and Bradley et al. (2001). The variables indicating whether a firm has conducted an SEO or has another lockup expiring earlier control for a reduced desire by insiders to sell after lockups expire (Braw and Gompers, 2003). The indicator variable for having traded options controls for the possible effect of options on the stock return, as options may substitute for short sales as a venue to express negative views. We control for institutional ownership as it proxies for the supply of short sales (e.g., Asquith et al., 2005). Share overhang and insider shares that are locked up can proxy for an increase in share supply after lockups expire. The control variables also include firm size, IPO underpricing, and buy-and-hold market-adjusted returns from the first trading day after the IPO until event day −1, and over event days [−10, −6] and [−5, −1], respectively. All of the variables are defined in the appendix. The t-statistics reported for all of the regression analysis throughout the paper are based on heteroskedasticity-corrected standard errors.

4.1. Regression of stock return on short selling

We estimate the regression of post-lockup stock returns as in Eq. (3). The dependent variables are the market-adjusted stock returns during event days [0, +10] and [0, +20], respectively. If short selling is informative about post-lockup stock returns, then we expect the coefficient on abnormal short selling, ABSS[−5, −1], to be significantly negative. In untabulated results, we find that the coefficients on abnormal short selling are negative in both regressions. However, none of the coefficients are statistically significant. Overall, our results suggest that abnormal short selling averaged across all types of IPOs in our sample prior to the lockup expiration date is not informative about post-lockup stock returns.\(^6\)

It is not immediately clear why short selling prior to the lockup expiration date may be uninformative about post-lockup stock returns. To gain a better understanding, we interact abnormal short selling, ABSS[−5, −1], with the VC and PE indicator variables, respectively. Table 5 shows that the coefficient of ABSS[−5, −1] is significantly negative in the two regressions. The results suggest that short selling is informative about stock returns over event days [0, +10] and [0, +20] for firms without a PE or VC investor. The inverse relation between abnormal short selling and stock returns is also economically significant. A one standard deviation increase in abnormal short selling (0.82) is associated with a 3.94% decrease in the abnormal return over days [0, +10] and a 4.12% decrease in the abnormal return over days [0, +20].

The coefficient of the interaction term between short selling and the VCdummy is not statistically significant in any of the two regressions suggesting that the predictive ability of short selling in VC-backed IPO stocks for post-lockup stock returns is not significantly different from that of the firms without a PE or VC investor. However, in untabulated tests, when we regress post-lockup stock returns on the pre-lockup short selling for VC-backed firms only, we find that the negative coefficient on short selling is not statistically significant. Therefore, we conclude that short selling cannot predict post-lockup stock returns for VC-backed firms.

The coefficient of the interaction term between short selling and the PE dummy is positive and statistically significant in both regressions implying that short selling in PE-backed IPO stocks is less informative about post-lockup stock returns than that of the firms without a PE or VC investor. In addition, the positive coefficient of the interaction term between short selling and the PE dummy seems to be large enough to cancel out the negative coefficient of abnormal short selling, suggesting that short selling in PE-backed IPO stocks may be uninformative regarding stock returns. We have confirmed this in untabulated results.

We confirm that the main results in Table 5 are robust to an alternative measure of abnormal returns. Specifically, we estimate the same two regressions in Table 5 using the Fama-French (1993) three-factor alphas as the dependent variables. We also replace the market-adjusted returns during days [−10, −6] and [−5, −1] with the three-factor alphas in the control variables. Table 6 presents the results, which are qualitatively similar to those in Table 5.

Although we find that short sales do not predict subsequent returns for the entire sample, we find that short sales can predict subsequent returns for IPOs without a VC or PE investor. In other words, VC- and PE-backed firms drive the finding that short sales do not predict subsequent returns for the entire sample. While it is difficult to determine the exact reason, we believe that the contrasting result for VC- and PE-backed firms versus other IPO firms is informative itself. For example, we can rule out short sale constraints as a reason for why short sales cannot predict subsequent returns for VC- and PE-backed firms for the following reason. As Table 1 shows, both VC- and PE-backed firms are associated with a larger institutional ownership compared to other IPO firms. To the extent that institutional ownership can proxy for share supply and thus is inversely related to short sale constraint (e.g., Asquith et al., 2005), VC- and PE-backed firms should not have greater short sale constraints than other IPO firms. Taken together, we think it is more likely that there are more uninformed short sellers in VC- and PE-backed firms than other IPO firms.

While we cannot pinpoint the exact reason for why there are more uninformed short sellers in VC- and PE-backed firms than other IPO firms, we conjecture that hedging-motivated short selling in VC- and PE-backed firms may reduce the predictive ability of short selling for post-lockup stock returns. Specifically, limited partners of VC and PE funds may short shares directly or indirectly to hedge for expected stock distributions by the VC and PE funds against a potential price decline following lockup expirations. Note that as pre-IPO shareholders, VC and PE funds are restricted from shorting shares prior to the lockup expiration date. However, the limited partners of the VC and PE funds are not restricted from shorting shares prior to the lockup expiration date, as long as the limited partners are not pre-IPO shareholders themselves. Given that VC and PE funds typically distribute shares following lockup expirations, the limited partners may short shares as a hedging strategy prior to the lockup expiration date. The limited partners can short shares themselves or arrange prepaid forward sales with financial institutions. In the latter case, the financial institutions may short shares prior to the lockup expiration date as part of their hedging strategies. As mentioned in Tresnowski and Nowak (2004), these hedging strategies are sponsored by most large investment banks.

If a significant portion of the short selling is done, directly or indirectly, by the limited partners of VC and PE funds for hedging purposes, then short selling will be less informative about future stock returns. We would like to clarify why the limited partners of VC and PE funds who hedge prior to the lockup expiration date are considered as uninformed short sellers. Following the

\(^6\) However, if we measure the abnormal short selling over event days [−5, −2] instead of [−5, −1], the abnormal short selling across all types of IPOs in our sample is able to predict post-lockup stock returns, suggesting that the abnormal short selling on day −1 is uninformative about future stock returns. The results are not tabulated for brevity.
Table 5
Regression of the market-adjusted return (%) on short sale.
The sample includes 213 U.S. IPOs from January 2005 through December 2006, after applying the sample filters explained in Section 3.1. If an IPO has multiple lockup expiration dates, we keep only the lockup expiration date with the most shares unlocked. The dependent variables are the post-lockup abnormal returns (%), which are measured as the Nasdaq index-adjusted returns. All of the variables are defined in the appendix. All the t-statistics are based on heteroscedasticity-corrected standard errors. ***, **, and * indicate statistical significance at the 1, 5, and 10% levels, respectively.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Return [0, +10] (%)</th>
<th>Return [0, +20] (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td>Coefficient</td>
<td>t-stat</td>
</tr>
<tr>
<td>Intercept</td>
<td>−14.86***</td>
<td>−3.16</td>
</tr>
<tr>
<td>ABSS [−5, −1]</td>
<td>−4.80**</td>
<td>−2.02</td>
</tr>
<tr>
<td>ABSS [−5, −1] × VC</td>
<td>3.58</td>
<td>1.27</td>
</tr>
<tr>
<td>ABSS [−5, −1] × PE</td>
<td>5.45*</td>
<td>1.97</td>
</tr>
<tr>
<td>VC</td>
<td>−3.27</td>
<td>−1.48</td>
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<tr>
<td>PE</td>
<td>−0.31</td>
<td>−0.17</td>
</tr>
<tr>
<td>Return [−5, −1] (%)</td>
<td>−92.10*</td>
<td>−1.76</td>
</tr>
<tr>
<td>Return [−10, −6] (%)</td>
<td>−5.07</td>
<td>−0.60</td>
</tr>
<tr>
<td>Ln(Mktcap)</td>
<td>3.33***</td>
<td>3.34</td>
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<tr>
<td>Shares locked/shares outstanding</td>
<td>2.08</td>
<td>0.60</td>
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<tr>
<td>13F holdings</td>
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<tr>
<td>Tech</td>
<td>0.62</td>
<td>0.40</td>
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<tr>
<td>Top IB</td>
<td>−3.43**</td>
<td>−2.15</td>
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<tr>
<td>Return [IPO, day −11] (%)</td>
<td>0.01</td>
<td>0.30</td>
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<tr>
<td>Underpricing</td>
<td>1.87</td>
<td>0.63</td>
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<tr>
<td>Overhang</td>
<td>−0.36</td>
<td>−0.98</td>
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<tr>
<td>Prior lockup</td>
<td>2.64</td>
<td>1.13</td>
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<tr>
<td>Prior SEO</td>
<td>−0.35</td>
<td>−0.15</td>
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<tr>
<td>Options</td>
<td>−3.97*</td>
<td>−1.82</td>
</tr>
<tr>
<td>Year 2005</td>
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<td>−0.56</td>
</tr>
<tr>
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<td>213</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.09</td>
<td>0.04</td>
</tr>
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</table>

Table 6
Regression of the Fama-French three-factor alpha (%) on short sale.
The sample includes 213 U.S. IPOs from January 2005 through December 2006, after applying the sample filters explained in Section 3.1. If an IPO has multiple lockup expiration dates, we keep only the lockup expiration date with the most shares unlocked. The dependent variables are the post-lockup abnormal returns (%), which are measured as the Fama-French (1993) three-factor alphas. All of the variables are defined in the appendix. All the t-statistics are based on heteroscedasticity-corrected standard errors. ***, **, and * indicate statistical significance at the 1, 5, and 10% levels, respectively.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>FF alpha [0, +10] (%)</th>
<th>FF alpha [0, +20] (%)</th>
</tr>
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<tbody>
<tr>
<td>Parameter</td>
<td>Coefficient</td>
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<tr>
<td>Intercept</td>
<td>−10.68**</td>
<td>−2.06</td>
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<tr>
<td>ABSS [−5, −1]</td>
<td>−3.67*</td>
<td>−1.70</td>
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<tr>
<td>ABSS [−5, −1] × VC</td>
<td>2.35</td>
<td>0.82</td>
</tr>
<tr>
<td>ABSS [−5, −1] × PE</td>
<td>3.78*</td>
<td>1.68</td>
</tr>
<tr>
<td>VC</td>
<td>−2.13</td>
<td>−1.01</td>
</tr>
<tr>
<td>PE</td>
<td>1.12</td>
<td>0.62</td>
</tr>
<tr>
<td>FF alpha [−5, −1] (%)</td>
<td>0.03</td>
<td>0.28</td>
</tr>
<tr>
<td>FF alpha [−10, −6] (%)</td>
<td>0.00</td>
<td>−0.03</td>
</tr>
<tr>
<td>Ln(Mktcap)</td>
<td>2.19***</td>
<td>2.14</td>
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<tr>
<td>Shares locked/shares outstanding</td>
<td>0.23</td>
<td>0.05</td>
</tr>
<tr>
<td>13F holdings</td>
<td>−4.02</td>
<td>−1.15</td>
</tr>
<tr>
<td>Tech</td>
<td>0.61</td>
<td>0.36</td>
</tr>
<tr>
<td>Top IB</td>
<td>−2.87*</td>
<td>−1.71</td>
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<tr>
<td>Return [IPO, day −11] (%)</td>
<td>−0.03</td>
<td>−1.15</td>
</tr>
<tr>
<td>Underpricing</td>
<td>3.57</td>
<td>1.08</td>
</tr>
<tr>
<td>Overhang</td>
<td>−0.24</td>
<td>−0.58</td>
</tr>
<tr>
<td>Prior lockup</td>
<td>4.06*</td>
<td>1.78</td>
</tr>
<tr>
<td>Prior SEO</td>
<td>−4.08*</td>
<td>−1.71</td>
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<tr>
<td>Options</td>
<td>−2.38</td>
<td>−1.11</td>
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<tr>
<td>Year 2005</td>
<td>0.94</td>
<td>0.64</td>
</tr>
<tr>
<td>Number of observations</td>
<td>213</td>
<td>213</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.03</td>
<td>0.06</td>
</tr>
</tbody>
</table>

In the literature, we define uninformed short sellers as those who have no private information as to the future value of the stock. While each of the VC and PE funds’ limited partners is informed about its own share selling or short covering upon lockup expiration, they do not know what other partners, especially the partners of other VC and PE funds, will do with their shares. Therefore, they are still largely uninformed about the stock price reaction to lockup expiration. 

** Our conversation with money managers reveals that even if the limited partners engage in hedging prior to lockup expiration date, they would like to keep it confidential instead of publicizing their hedging activity, which supports our assumption that the VC and PE funds’ limited partners who hedge for their share distribution do not know anything more than their own upcoming short covering.
expiration. To provide further evidence, we examine insider ownership change after lockup expirations in the next section.

4.2. Regression of post-lockup insider ownership change on short selling

To test Hypothesis 3, we examine whether pre-lockup expiration short selling is informative about insider ownership reduction after the lockup expiration. Specifically, we use two measures of insider ownership: directors and executive officers’ ownership, as reported in Table 3, and PE and VC ownership, as reported in Table 4. Interestingly, we find that pre-lockup expiration short selling can predict the ownership reduction by PE and VC funds but not the ownership reduction by directors and executive officers. Next, we will present the regression results and discuss the implications in detail.

First, we regress the ownership change by directors and executive officers on the pre-lockup expiration abnormal short selling, ABSI[−5,−1]. In untabulated results, we find that the abnormal short selling prior to the lockup expiration date cannot predict the directors and executive officers’ ownership change after the lockup expiration date. We also interact short selling with the VC and PE dummy variables. Again, we find that short selling cannot predict the directors and executive officers’ ownership change for VC-backed, PE-backed, or other IPOs. The results suggest that short selling is not informative about directors and executive officers’ ownership reduction.

It is worth mentioning that the single most significant predictor of the directors and executive officers’ ownership change after the lockup expiration date, regardless of whether scaled by the ownership before the lockup expiration date, is the IPO stock’s market adjusted return from the first trading day until 11 days prior to the lockup expiration date (p-value < 1%). In particular, a one standard deviation increase in the IPO stock’s market adjusted return from the first trading day until 11 days prior to the lockup expiration date (36%) is associated with a 3.24% reduction in the directors and executive officers’ ownership after the lockup expiration date. Given that the average reduction in the directors and executive officers’ ownership after the lockup expiration date is 8.64%, the reduction in the directors and executive officers’ ownership represents about 38% of the average ownership reduction, which is economically significant.

Next, we regress PE and VC investors’ ownership change around the lockup expiration on the abnormal short selling prior to lockup expiration. Table 7 reports the regression results. Note that PE and VC investors’ ownership change, as shown in Table 4, is negative, suggesting ownership reduction by PE and VC investors after lockup expirations. Therefore, a negative coefficient on abnormal short selling in the regression would confirm Hypothesis 3. In the first regression in Table 7, the dependent variable is the ownership change around lockup expiration. In the second regression in Table 7, the dependent variable is the ownership change around lockup expiration scaled by the ownership prior to the lockup expiration. The coefficient on the VC dummy is negative and significant in both regressions, which confirms the finding in Table 4 that VC investors reduce ownership more than PE investors. The coefficient of short selling is also negative and significant in both regressions. In particular, a one standard deviation increase in short selling (0.82) is associated with a 2.06% decrease in the unscaled ownership change and 3.65% decrease in the scaled ownership change after lockup expiration. Our findings suggest that short selling is informative about PE and VC investor ownership reduction. In other words, we confirm Hypothesis 3 for PE and VC investors. In untabulated results, we interact short selling with the VC dummy. We find the coefficient of the interaction term is not statistically significant suggesting no difference in the predictive ability of short selling between PE- and VC-backed firms.

To summarize the results in this section, we find that pre-lockup expiration short selling can predict the ownership reduction by PE and VC funds but not the ownership reduction by directors and executive officers. The contrasting results are consistent with the limited partners’ hedging explanation, as directors and executive officers are prohibited from shorting shares prior to the lockup expiration date, while the limited partners of PE and VC funds are not. Conceptually, information about the prospect of the firm can be another channel through which short selling is correlated with insider ownership change. However, we do not find any evidence for this, as short selling is not correlated with directors and executive officers’ ownership change for any of the three types of firms: PE-backed, VC-backed, or other IPO firms. After all, insiders may sell shares due to cash or diversification needs instead of negative information about the firm’s prospects (Lakonishok and Lee, 2001).

Note that the dependent variables in the regressions in Table 7 are the ownership reductions by PE and VC funds as reported in Table 4, which do not tell us whether the limited partners of the PE and VC funds are engaged in hedging-motivated short selling prior to the lockup expiration date. However, if some of the limited partners of the PE and VC funds have hedged by short selling the stock directly or indirectly prior to the lockup expiration date, we would expect three consequences. First, short selling prior to the lockup expiration date would be heavier in VC- and PE-backed firms than in other IPO firms. Second, greater ownership reduction by PE and VC funds after the lockup expiration date would be associated with greater short selling prior to the lockup expiration date. Third, short selling prior to the lockup expiration date would be less correlated with the post-lockup expiration stock returns. As we discuss the results in Table 2 earlier, the first expectation above is confirmed. As Tables 5–7 show, the last two expectations above are confirmed for VC- and PE-backed firms.

Overall, the evidence is largely consistent with the hedging explanation, except that the increase in trading volume on the lockup expiration date for VC-backed firms does not seem consistent with the hedging explanation. If the limited partners of VC funds cover their short positions by the shares distributed by VC funds, then they would not sell shares on the market, and the trading volume would not jump on the lockup expiration date. However, the hedging explanation does not require all or most of the shares owned by VC funds to be hedged. As long as some of the shares are not hedged, they can still be sold on the open market and drive up the trading volume on the lockup expiration date. It is an empirical question to what extent hedging-motivated short selling drives our results. Given the mixed evidence, the possibility of hedging by limited partners remains a conjecture.

4.3. Evidence from insider filings

We also explore a direct measure of insider selling by obtaining insider trading data from the Thomson Reuters Insider Filing Data Files. Corporate insiders are broadly defined to include those that have “access to non-public, material, insider information,” and these insiders are required to file SEC Forms 3, 4, and 5 when they trade in their companies’ stock (Thomson Reuters Insider Filing Data Manual). However, in untabulated results, we find that only nine of the 213 IPO firms in our sample have reported in-

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18 We do not include insider ownership change as an independent variable in the regressions of post-lockup stock returns for the following reason. Recall that we measure insider ownership change based on the ownership information in the IPO final prospectus and the first proxy statement after the lockup expiration date. Therefore, the ending date for the insider ownership change may be either before or after the ending date when we measure post-lockup stock returns.
sider sales on the lockup expiration date, among which five are VC-backed and four are PE-backed firms. Among the five VC-backed firms, only two have reported sales by a VC fund, with the average total sale per fund being only 0.26% of the shares outstanding. None of the four PE-backed firms has any reported sales by any PE fund on the lockup expiration date.

The fact that VC-backed firms have inactive insider sales reported on the lockup expiration date seems inconsistent with the significant jump in trading volume for VC-backed firms on the lockup expiration date. However, insiders’ ownership reduction in VC- and PE-backed firms may not be completely captured by reported insider sales. VC and PE funds are typically organized as limited partnerships. They can distribute either cash or portfolio firms’ stocks to their limited partners, who are investors in the VC or PE funds. Gompers and Lerner (1998) discuss several reasons why VC funds prefer share distribution over cash distribution. Their Footnote 3 provides a detailed explanation about VC distributions. However, share distribution makes it difficult for a researcher to identify the exit of VC or PE funds from their investment as VC and PE fund limited partners’ sale of stock are not required to be filed with the SEC unless the limited partner owns at least 10% of the outstanding shares of the IPO firm or is affiliated with the IPO firm.

4.4. Short selling by market makers

Our study focuses on short sale transactions made by non-market makers. However, it is an empirical question as to whether market makers make more informed short sales prior to the lockup expiration date than non-market makers. We use short sale transactions made by market makers to replicate the regression analysis in Tables 5 and 6. In untabulated results, we find that market makers are not informed about post-lockup stock returns, consistent with the finding in Engelberg et al. (2012) that short sales made by market makers are not informative about future returns.

We also use market makers’ short sales to replicate the regression analysis in Table 7. In untabulated results, we find that none of the coefficients on short selling is significantly negative. In contrast to the results in Table 6, market makers’ short selling is not informative about PE and VC ownership reduction after lockup expirations.

5. Conclusion

By examining the daily short selling activity around the expiration of IPO share lockups, we have several findings. First, we find that short selling increases significantly prior to the lockup expiration date, and the increase in short selling is greater for VC- and PE-backed IPO stocks than for other IPO stocks. In addition, we find that short selling prior to the lockup expiration date can predict post-lockup stock returns for IPO firms without a VC or PE investor but not for VC- and PE-backed firms. We also examine insider ownership reduction after the lockup expiration date. We find that short selling prior to the lockup expiration date can predict post-lockup ownership reduction by VC and PE funds but not ownership reduction by directors and executive officers. The evidence leads to the conjecture that the limited partners of VC and PE funds may short shares prior to the lockup expiration date as a hedging strategy. However, the conjecture seems inconsistent with the finding that the trading volume jumps significantly on the lockup expiration date for VC-backed firms. Therefore, hedging by the limited partners of VC and PE funds remains a conjecture. Other possible reasons for our findings are worth exploring in future research.

Acknowledgments

We are grateful to two anonymous reviewers and Jay Ritter for helpful comments and suggestions. We also have benefited from comments from Thomas Boulton, C.Y. Choi, Wendy Hu, Rongbing Huang, Serkan Karadas, Santra Mortal, David Rakowski, Yuchen Wang, Michael Ward, Sterling Yan, and seminar participants at the University of Texas at Arlington, the 2014 Southwestern Finance
Appendix. Definitions of variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>E13 holdings</td>
<td>The E13 holdings prior to the lockup expiration date.</td>
</tr>
<tr>
<td>Abnormal volume</td>
<td>The abnormal trading volume on the lockup expiration date measured as the average trading volume over the benchmark period (i.e., event days [−70, −21]), then minus one, as defined in Eq. [2].</td>
</tr>
<tr>
<td>ROA</td>
<td>Income before extraordinary items scaled by total assets (IBQ/TAQ). Accounting variables are obtained from unreported quarterly CompuStat files as of the quarter immediately prior to the lockup expiration date.</td>
</tr>
<tr>
<td>Ln(Mktcap)</td>
<td>The natural logarithm of Mktcap.</td>
</tr>
<tr>
<td>Short/Volume [x, y]</td>
<td>Short/Volume [−70, −21] as defined in Eq. [1].</td>
</tr>
<tr>
<td>Ln(Mktcap)</td>
<td>The market capitalization in Smlion measured using the market closing price on the first trading day.</td>
</tr>
<tr>
<td>Mktcap</td>
<td>The lockup period length measured in days.</td>
</tr>
<tr>
<td>Nasdaq</td>
<td>An indicator variable that is equal to one if the IPO stock is listed on Nasdaq and zero otherwise.</td>
</tr>
<tr>
<td>Options</td>
<td>An indicator variable that is equal to one if the IPO stock has traded options before the lockup expiration date, and zero otherwise.</td>
</tr>
<tr>
<td>Overhang</td>
<td>Share overhang, which is calculated as shares retained/shares sold in IPO.</td>
</tr>
<tr>
<td>PE</td>
<td>An indicator variable that is equal to one if the IPO firm is backed by private equity (buyout funds, not VC) and zero otherwise.</td>
</tr>
<tr>
<td>Prior lockup</td>
<td>An indicator variable that is equal to zero if there is a lockup expiration date prior to the lockup expiration date with the most shares unlocked, and zero otherwise.</td>
</tr>
<tr>
<td>Prior SEO</td>
<td>An indicator variable that is equal to one if the firm made seasoned offerings before the lockup expiration date, and zero otherwise.</td>
</tr>
<tr>
<td>Return [0]</td>
<td>The market-adjusted return on the lockup expiration date, where the market return is measured as the Nasdaq Composite index return.</td>
</tr>
<tr>
<td>Return [x, y]</td>
<td>The market-adjusted return during event days [x, y], where the market return is measured as the Nasdaq Composite index return.</td>
</tr>
<tr>
<td>Return IPO, day-11</td>
<td>The buy-and-hold Nasdaq Composite adjusted return from the issue date to day −11 relative to the lockup expiration date.</td>
</tr>
<tr>
<td>Secondary shares</td>
<td>The ratio of shareholders’ shares to the total shares offered in the IPO.</td>
</tr>
</tbody>
</table>

References

Vasicek, N. 2013. The Real Exit Selling Strategies Subsequent to Private Equity Backed IPOs. Goethe University, Frankfurt Working paper.