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by
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Abstract

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During the lock-up period, company insiders are prohibited from selling their shares for a set period immediately after initial public offerings (IPOs), usually 180 days. This strict prohibition limits the borrowing of securities by short sellers within this period. Therefore, upon reaching the lock-up expiry date, the short-sale constraint may be loosened and new investors may rush into the stock market, which affects asset price and stock return.

This thesis focuses on the IPOs' performance during the lock-up period and the reasons for the unusual performance. The first section commences by questioning the role of the short seller and its relation to the stock return during the lock-up period. Since Regulation SHO required that short sale transaction data be made available during year 2005 to 2007, we are able to use the daily short selling transaction data to examine the trading behaviour of short sellers during the period around

the lock-up expiry date. We find that transactions around the lock-up expiration are associated with a significant drop in the abnormal return. Furthermore, on the lock-up expiry day, the short selling percentage reaches the highest point, while stock return drops to the lowest level compared to the lock-up period. Hence, there is a connection between short sale and stock return on the lock-up expiry day. We then examine whether trading behaviour of short sellers around the lock-up expiration contains any information of future stock returns. The results all indicate a highly significant predictability of short seller trading activities on future stock returns. The findings lead us to develop the second section.

Since there is a dramatic drop of IPOs' abnormal return during the lock-up expiry day in the Regulation SHO period, in the second section, we investigate whether this is a universal phenomenon by using a comprehensive sample period from year 1990 to 2014. By implementing an event study with a wider event window, we discover that the abnormal returns indeed decrease significantly during most of the sample period. However, we reveal that the return decline trend ceases right after the lock-up expiration and even reverses to the highest level of return before the lock-up expiry day for several years. Therefore, we may assume that the lock-up expiration event does not have a permanent impact on stock returns.

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Chapter 1

Introduction

1.1 Motivation

Bartlett (1995) demonstrates that in the lock-up agreement, without underwriters' prior written consent, the selling security holders will not directly or indirectly sell or make any short sale of any securities for a period of 180 days after the commencement of the public offering of the stock by the underwriters.

The information of insiders are forbidden to sell stocks under the lock-up agreement will be revealed through SEC filings and news, even the lock-up expiry date is known to the public. Therefore, upon the expiration of the lock-up agreement, if the market perfectly anticipated the expiration as predicted by efficient market hypothesis, we should expect a zero abnormal return on average.

Moreover, this strict prohibition of insiders selling stocks leads limited borrowing of securities by short sellers within this lock-up period. Short sellers, as the liquidity providers, are able to affect the market value of stocks by moderating the trend of higher prices due to those optimistic investors who are willing to buy IPOs,

knowing that insiders are less able to take advantage of them. Therefore, on the lock-up expiry date, the short sale constraint may be loosened and new pessimistic investors such as short sellers may rush into the stock market, which suppresses the increased tendency of asset price and stock return.

Therefore, in the first study, we intend to examine the impact of short sellers' trading activities on IPOs performance during the lock-up period and the possible reasons for it. In order to do so, we plan to investigate the following hypotheses:

First, as the details of the lock-up agreement are public knowledge, there should not be an abnormal price reaction at the time of the lock-up expiration under the efficient market hypothesis and then the resultant average abnormal return (AAR) should be zero.

Second, on the lock-up expiry date, the release of the locked shares will provide more investment opportunities for short sellers, which will attract relatively larger numbers of short sales at the lock-up expiration and may lead to decreased future return;

Third, once the lock-up agreement expires, a number of new traders (ordinarily the insiders and other market participants who infer private information from insiders) will rush into the stock market to reveal the true value of IPOs by utilizing private information.

After proving the declining trend of stock returns on the lock-up expiry date, we further develop our research by implementing the second study. Since the large flow of sell orders may temporarily suppress the price due to price pressure in order to attract liquidity providers, the observed negative abnormal returns may be transient. Thus, we are able to test the following hypotheses:

First, whether the sharp decline tendency of IPOs at the lock-up expiry day only

exists within Regulation SHO sample period or if it is a widespread phenomenon across time;

Second, whether the decreasing pattern of abnormal return at the lock-up expiry day is a temporary effect, which is predicted to subsequently rise again;

Third, whether the characteristics of IPOs have any correlation with the return reversal trend after the lock-up expiry date.

1.2 Road Map

The rest of this thesis is organized as following:

Chapter 2 illustrates the decline phenomenon of abnormal return upon the lock-up expiry day and investigates the impact of short sellers' trading behaviour on IPOs during the lock-up period.

Chapter 3 verifies the reversal trend of abnormal return after lock-up expiration and examines the factors that impact the extent of return reverse.

Finally, Chapter 4 concludes the thesis with a short summary on existing results and potential research directions.

Chapter 2

Short Sellers' Impact on Stock Return during Lock-up Period

2.1 Introduction

Company insiders are prohibited from selling their shares for a set of period immediately after initial public offerings (IPOs), usually 180 days. This so-called lock-up agreement limits the number of pessimistic investors entering market since insiders of low-quality firms or insiders who have negative expectations of firms' future returns will be unable to sell their stocks during this period.

However, information on lock-up expiration, such as the lock-up expiry date and the number of shares being locked are publicly available through SEC filling, news, and analyst reports. Hence, the lock-up agreement also attracts optimistic investors who believe that the insiders cannot take advantage of them to be more willing to buy IPOs during the lock-up period.

Therefore, on the lock-up expiry date, which represents the first opportunity

for insiders to sell, new investors, especially pessimistic insiders, short sellers, and other market participants who infer private information from insiders may rush into the stock market, which may affect asset price and stock return.

There already exist many corporate finance literatures examining the impact of trading by other market participants on stock returns, such as insiders, venture capitalists, and even underwriters. Therefore, in this Chapter, we shed light on the role of short sellers by investigating the short sale transactions subsequent to the IPO.

We use daily short sale transactions datasets from SEC for 359 IPOs listed on NASDAQ during Regulation SHO period from year 2005 to 2007 to illustrate the dramatic decline tendency of cumulative abnormal return (CAR) during the lock-up expiry day. Furthermore, we examine the trading behaviour of short sellers surrounding lock-up expiration for raising the importance of short sellers' role in explaining the abnormal return drop around the lock-up expiry day.

2.2 Literature Review and Contributions

Initial public offerings (IPOs) usually feature so-called 'lock-up' agreements, which prohibit insiders from selling their shares before a certain date, normally 180 days after IPOs. This lock-up agreement also may limit the number of shares that can be sold over a designated period. Once the lock-up period has expired, the lock-up shares are released and insiders are free to sell. The sudden release of trading volume increases the information asymmetry between traders and increases the supply in the stock market, which decreases share value. If the insiders intend to sell at the lock-up expiry day, which is the first opportunity for them to sell

after stock going public, other traders may infer private information from insider trading activity and reveal the real value of those stocks.

Several previous articles increase the academic attention on IPOs lock-up agreement by investigating the price changes during lock-up expiration. [Field and Hanka 2001], [Brav et al. 2000], [Ofek 2000] and [Bradley et al. 2001] indicate that stock prices for IPOs regularly decline at the time of lock-up expiration. Our findings are consistent with these literatures as there is a statistically significant lowest average abnormal return and cumulative abnormal return on lock-up expiration.

Therefore, many papers attempt to explain this price or return decline phenomenon at the lock-up expiry day. [Field and Hanka 2001] and [Bradley et al. 2001] seek to explain this phenomenon by discovering the connection of venture capital backing with price decline at lock-up expiration.

Several articles also focus on the impact of trading by informed insiders on stock prices after the IPO. [Bettis et al. 2000], [Brealey et al. 1977], [Courteau 1995] and [Brav and Gompers 2003] explain the reasons behind the return decline phenomenon from the aspect of insider trading activity, while in our paper, we add to the current literature by shedding additional light on a different aspect: the role of short sellers during the lock-up period.

The role of short sellers in predicting stock return has been extensively investigated in the literature. [Wu and Zhang 2011], [Blau et al. 2012] and [Engelberg et al. 2012] suggest that short sellers analyse public available information more thoroughly and more quickly than other traders do. [Senchack and Starks 1993], [Asquith et al. 2005], [Boehmer et al. 2010] and [Boehmer et al. 2013] suggest that short sellers have an information advantage in predicting future returns. [Engelberg et al. 2012] finds that the leading effect of short selling on lower future returns

is concentrated around news events and the predictability for future returns more than doubles on news days. [Christophe et al. 2004] and [Christophe et al. 2010] focus on short selling around earnings announcements and analyst downgrades, and discover that short sellers can profit by accessing non-public information prior to the earnings announcement events.

In addition, several literatures explain this leading effect of short selling on stock returns based on the hypothesis first raised by [Miller 1977], in which the author proposes that short sales would increase the supply of stock on the market by the amount of the outstanding short position and hence moderate the market value of that stock. [Miller 1977] also hypothesizes that dispersion of investor opinion in the presence of short-sale constraints leads to stock price over-valuation.

Due to the immediately implementation of the lock-up agreement after IPO, the lock-up of insider shares restricts the supply of short selling and leads to perceived high cost of borrowing shares, which creates a restricted environment for short sellers. The short sell constraint topic is also raised by [Lamont 2004], in which the author illustrates that when short sellers have difficulty to short the stocks that they are willing to short, overpricing can be substantial.

Therefore, optimistic investors in the stock market keep pushing the price up when pessimistic investors are unable to trade or have difficulty trading. Once approaching lock-up expiration, the short selling volume that represents the position of pessimists will increase and the insiders who hold a pessimistic attitude will start to sell their stocks. The market value will begin to reflect the mean valuation over the cross-section of investors or even undervaluation since there is an influx of new pessimists into the market (the insiders of low-quality firms or the insiders who have negative expectations for stock returns afterwards).

[Hanley et al. 1996], [Ofek and Richardson 2003], [Derrien 2005] and [Ljungqvist et al. 2006] suggest that constraints on short selling immediately following an IPO may contribute to short-term pricing inefficiencies. In our paper, we not only confirm the significant impact of short sellers on stock return, but also prove the predictability of short selling on future market return during the lock-up period.

[Field and Hanka 2001] proposes that since short selling is profitable only when the decline in price is sufficient to cover the dividends short sellers need to pay to the lender of the stock, their findings imply an impossibility of short selling on the lock-up expiry day. However, in our research, by using the daily short selling dataset from Regulation SHO, we conclusively prove the existence of short sales at lock-up expiration and even during the lock-up period.

Therefore, our article provides three contributions on initial public offering and lock-up expiration:

First, we confirm the reducing tendency of IPOs abnormal return and the existence of short sales during lock-up expiration and certify that the trading volume and short selling volume are at the highest level when approaching the lock-up expiry date.

Second, within the extensive body of literature about insider impact on the lock-up expiry day, and by comparing the trading of short sellers with the transactions of insiders, we raise the role of short sellers in explaining the return decline during lock-up expiration. Especially, we identify the superior predictability of short selling on future return at lock-up expiration, which is two to three times stronger than usual.

Third, we further investigate short seller impact on stock returns by considering other factors simultaneously, such as analyst dispersion and research and devel-

opment (R&D) intensity to asertain whether divergence of opinion or high-tech feature will impact the predictability of short selling on stock returns during the lock-up period.

2.3 Data and Methodology

2.3.1 Dataset

Our primary database for this research is the SEC Regulation SHO database for NASDAQ daily short sale transactions. Since Regulation SHO requires that all Self-Regulatory Organizations make trade-level short selling data available to the public starting in January 2005, the dataset period available for us is from January 2005. We also hand-collect the lock-up expiry date from NASDAQ website for each IPOs listed on NASDAQ during Regulation SHO period, which is from January 03, 2005 to August 31, 2007.

The sample consists of 359 IPOs that have complete CRSP, COMPUSTAT and short-sale transaction data for calculating the abnormal return and abnormal short sale volume. And the IPOs are limited to common stocks with SHRCD equals to 10 or 11. We also exclude the stocks which have the lock-up expiry date exceed the end of Regulation SHO period, since we only have daily short-sale transaction data available till August 31, 2007.

Since SEC rule 16 (a) requires all trades by officers, directors, and ten percent block-holders must be disclosed on Form 4 no later than the tenth day of the month after the transaction. Thus, we can apply the data in Form 4 from Thomson Reuters for testing the hypothesis of insider influence on stock price and comparing with

the short seller impact on stock returns approaching lock-up expiration.

For evaluating the impact of investor opinion divergence and stock technical level on IPOs during the lock-up period, we compute the analyst dispersion ratio and research and development intensity ratio by using dataset from monthly I/B/E/S summary history file and annual COMPUSTAT fundamental file.

2.3.2 Methodology

In this section, we examine the abnormal return and the abnormal short-sale position around the lock-up expiry day, and how, short seller transactions affect stock return during the lock-up period.

The parameters of the lock-up agreement are clearly specified in the company's form S-1 under the heading shares eligible for future sale. Therefore, according to the efficient market hypothesis, we should expect that the average price reaction at the lock-up expiry day should be insignificantly different from zero, as market participants know that a large number of shares are free to trade after lock-up expiration. Furthermore, an efficient market should have already estimated correctly the number of shares sold at the lock-up expiry day.

In order to research on the assumption of zero abnormal return and the influence of short seller and insider trading activity on stock return without affecting by the characteristics of the stock itself, we modify the [Daniel et al. 1997] approach to generate the daily DGTW abnormal return and the DGTW abnormal short selling percentage as the measurements for the abnormal return and the abnormal short-sale position.

Since our dataset is in daily frequency, we need to modify the calculation of

momentum accordingly by using preceding seven-day return instead of preceding twelve-month return in computing the daily momentum. Then by ranking on size, book-to-market ratio and momentum, we generate a total of 125 portfolios. Each has its own combination of size, book-to-market ratio and momentum ranking score. And the ranking procedure is repeated and updated each day to reconstruct the daily portfolio and to generate the daily DGTW abnormal return.

Then we implement an event study to illustrate the Average Abnormal Return and Cumulative Average Abnormal Return during ten trading days around lock-up expiration. The event window is [-10,10] relative to the lock-up expiry day at day 0.

Firstly, we follow [Michaely et al. 1994] by using the return on market index as a benchmark return and take the difference between the stock return and the value-weighted market portfolio return at each point in time during the event window for each stock, as shown in equation 2.1;

$$AR_{i,t} = RET_{i,t} - VWRET_{i,t} \tag{2.1}$$

Secondly, we calculate the Average Abnormal Return (AAR) for each day within the event window, which eliminates the idiosyncrasies in measurement due to particular stocks;

$$AAR_t = \frac{1}{N} \sum_{i=1}^{N} AR_{i,t} \tag{2.2}$$

Finally, we sum up the AAR calculated in equation 2.2 over T days in the event window to form the Cumulative Average Abnormal Return (CAAR), which

provides us the information of aggregate effect of the abnormal returns.

$$CAAR_T = \sum_{t=1}^{T} AAR_t \tag{2.3}$$

For the further research on the impact of short seller and insider trading on stock returns, we implement three methods:

First, we use a panel regression model to investigate whether short seller transactions contain any additional information about future market return compared with insider trading.

$$\begin{aligned} Ret_{i,t} &= \alpha + \beta_1 Short_{i,t-1} + \beta_2 Short_{i,t-2} + \beta_3 Short_{i,t-3} + \\ &\beta_4 Insider_{i,t-1} + \beta_5 Insider_{i,t-2} + \beta_6 Insider_{i,t-3} + \beta_7 Dummy_{unlock} + \\ &\beta_{8,n} \sum_{n=1}^{3} Short_{i,t-n} * Dummy_{unlock} + \beta_{9,n} \sum_{n=1}^{3} Insider_{i,t-n} * Dummy_{unlock} \end{aligned} \tag{2.4}$$

$Ret_{i,t}$ is the three days rolling average DGTW abnormal return, $Short_{i,t-1}$ is the lagged DGTW abnormal short sale percentage, $Insider_{i,t-1}$ is the lagged insider net purchase percentage, $Dummy_{unlock}$ is a dummy variable that equals to 1 for [-1,1] trading days around lock-up expiration, $Short_{i,t-n} * Dummy_{unlock}$ indicate the DGTW abnormal short-sale percentage at [-1-n,1-n] trading days around lock-up expiry day and $Insider_{i,t-n} * Dummy_{unlock}$ indicate the insider net purchase percentage at [-1-n,1-n] trading days around the lock-up expiry date. We implement this regression with the firm-year fixed effect and control variables, results are indicated in Table 2.5 and 2.6.

Second, we use the Granger causality test to check whether short seller trading is helpful in forecasting stock returns. As detailed, we use auto-regression with lag

length of two as indicated in following equation 2.5:

$$\begin{aligned} &unrestrictedmodel : Ret_t = alpha + \beta_1 Ret_{t-1} + \beta_2 Ret_{t-2} + \beta_3 Short_{t-1} + \\ &\beta_4 Short_{t-2} + \epsilon_{1,t} \\ &restrictedmodel : Ret_t = alpha + \beta_1 Ret_{t-1} + \beta_2 Ret_{t-2} + \epsilon_{0,t} \end{aligned} \tag{2.5}$$

Ret_t represents the DGTW abnormal return and $Short_t$ represents the DGTW abnormal short sale percentage. We also use the causality test of DGTW abnormal short sale percentage on price within the lock-up period. The results are illustrated in Table 2.9

Third, to investigate whether short seller predictability and influence on stock return during the lock-up period differs across firms with certain features, we partition our sample according to attributes such as analyst dispersion and research and development intensity and repeat the panel regression analysis.

For the calculation of analyst dispersion as the measurement of investor opinion divergence, we apply the coefficient of variation for analyst annual forecasts generated from I/B/E/S monthly summary history file. And we generate the research and development intensity by computing the ratio of the firm's expenditure on research and development to the firm's sales from annual COMPUSTAT fundamental dataset. The measurements are defined as following:

$$Analyst\ Dispersion = \frac{STD\ (\ Earnings\ Forecasts\ )}{\mid AVG\ (\ Earnings\ Forecasts\ ) \mid}$$

$$R\&D\ Intensity = \frac{Expenditure\ on\ R\&D}{Total\ Sales}$$

2.3.3 Summary Statistic

The Table 2.1 displays the mean of each variable during 100 trading days around lock-up expiration.

Table 2.1: Summary Statistic during 100 Trading Days around Lock-up Expiration

	Before	After	Unlock	Total
Short size	18926	26156	35341	22472
Short percentage	0.071%	0.089%	0.111%	0.080%
DGTW XShort	-0.006%	-0.002%	0.006%	-0.004%
DGTW XReturn	-0.006%	0.005%	-0.129%	-0.002%

The second column represents the average value of each variables within lock-up period. The third column indicates the average value of each variables after lock-up expire day. The fourth column displays the average value of each variables on lock-up expiration. And the last column presents the mean of each variable across whole sample period. Short size represents the average short sale position during lock-up period. Short percentage is the percentage of short sale position within trading volume. DGTW XShort is the abnormal short position calculated by using DGTW short position as the benchmark. DGTW XReturn is the abnormal return computed by subtracting the DGTW benchmark return from stock return.

The results can be interpreted as follows:

- The short selling position is relatively small during the lock-up period and this may be due to the limitation of available shares for borrowing under the lock-up agreement;
- The short selling positions reach the highest and the abnormal returns become the lowest at the lock-up expiration compared with other periods, which indicates short seller trading may have a connection with the stock returns on the lock-up expiry day.

Then we check the IPOs' daily performance around lock-up expiration to observe the correlation of short sale position and abnormal return in daily basis.

Table 2.2: Summary Statistic during 5 Trading Days around Lock-up Expiration

Trading Day	Short Size	Short percentage	DGTW XShort	DGTW XReturn	Price
-5	25310	0.072%	-0.007%	-0.081%	16.34
-4	24197	0.079%	-0.001%	-0.017%	16.31
-3	23646	0.083%	-0.007%	-0.200%	16.13
-2	20708	0.074%	-0.005%	-0.133%	16.22
-1	22466	0.074%	-0.008%	-0.205%	16.07
0	35341	0.111%	0.006%	-0.129%	15.81
1	29182	0.105%	-0.013%	-0.284%	16.28
2	28441	0.102%	0.003%	0.041%	16.01
3	21458	0.070%	-0.007%	0.192%	15.83
4	24679	0.086%	-0.005%	-0.116%	16.29
5	25110	0.085%	0.002%	-0.125%	16.11

Trading day represents the length of trading days being apart from the lock-up expire day. Short size represents the average short sale position during lock-up period. Short percentage is the percentage of short sale position within trading volume. DGTW XShort is the abnormal short position calculated by using DGTW short position as the benchmark. DGTW XReturn is the abnormal return computed by subtracting the DGTW benchmark return from stock return.

The Table 2.2 reports the mean of each variable during 5 trading days around lock-up expiration. The lock-up expiry date (Trading day=0) still has the highest short sale position and the lowest price, while the next trading day after lock-up expiration performs the lowest abnormal return across these 11 trading days, which indicates a negative correlation between short selling volume and IPOs performance around the lock-up expiry day and the time-lag reaction of stock return one day after lock-up expiration may establish a possibility of using short selling to predict future stock return.

Table 2.3: Summary Statistic during 100 Trading Days Before Lock-up Expiration

Trading Day	Short Size	Short percentage	DGTW XShort	DGTW XReturn	Price
$[-10, -1]$	25254	0.080%	-0.003%	-0.029%	16.21
$[-20, -11]$	19447	0.068%	-0.006%	-0.052%	15.99
$[-30, -21]$	16628	0.062%	-0.010%	0.029%	15.79
$[-40, -31]$	16209	0.061%	-0.007%	0.002%	15.72
$[-50, -41]$	18301	0.070%	-0.006%	-0.031%	15.44
$[-60, -51]$	19108	0.076%	-0.008%	-0.005%	15.47
$[-70, -61]$	17211	0.064%	-0.006%	0.001%	15.41
$[-80, -71]$	16516	0.068%	-0.007%	0.002%	15.64
$[-90, -81]$	18731	0.075%	-0.007%	0.002%	15.66
$[-100, -91]$	21860	0.085%	-0.004%	0.003%	15.87

Trading day represents the length of trading days being apart from the lock-up expire day. Short size represents the average short sale position during lock-up period. Short percentage is the percentage of short sale position within trading volume. DGTW XShort is the abnormal short position calculated by using DGTW short position as the benchmark. DGTW XReturn is the abnormal return computed by subtracting the DGTW benchmark return from stock return.

In Table 2.3, we illustrate the mean of each variable during 100 trading days before lock-up expiration. During this lock-up period, short sellers trade relatively more during [-10,-1] trading days before lock-up expiration. And consistent with the results in Table 2.1 and 2.2, DGTW abnormal returns become quite low when approaching the lock-up expiry day. The investors continue pushing up the price of stocks during the lock-up period, as indicated in the last column of Table 2.3, the average price reaches the highest level at [-10,-1] trading days before the lock-up expiry date.

This phenomenon is persistent with the statement we raised before. During the lock-up period, insiders are prohibited from selling their stocks. And other market participants would be more willing to buy stocks knowing the insiders would be less possible to take advantage of them during the lock-up period. Therefore, we

would observe a huge increase in price during the lock-up period. And once the lock-up expiry day arrived, short sellers and other pessimists who severed as the liquidity providers will participate into the market to push down the overestimated price as indicated in the last column of Table 2.2.

The outcome presented in the Tables above lead us to the following possible explanations:

First, short sellers become interested and more available in shorting IPOs when approaching the lock-up expiry date;

Second, short seller trading activity on these IPOs affect the abnormal return of the stocks, which leads to the low and negative stock return around lock-up expiration;

Overall, the lock-up expiry day has a positive effect on short sale positions while having a negative impact on IPOs abnormal returns.

2.3.4 Figure

To clearly illustrate the variation of stock performance during the lock-up period, we present the following Figures:

The Figure 2.1, which illustrates the cumulative average abnormal return during 10 trading days around the lock-up expiry day, indicates that the cumulative abnormal return of IPOs drops dramatically around lock-up expiration. And this is consistent with the summary statistic in Table 2.1, 2.2 and 2.3 that the lock-up expiry day has the lowest stock return comparing with other periods. Figures 2.2 and 2.3 display the cumulative average abnormal return of IPOs that have higher or lower than the median of average percentage of short sale position in 60 trading days

before, which we defined as heavily shorted or lightly shorted stocks accordingly.

These two Figures 2.2 and 2.3 convey the following conclusion:

- The heavily shorted IPOs have a generally positive and increasing CAAR trend before the lock-up expiry day, which indicates that during lock-up period, short sellers focus on those stocks with increasing cumulative average return since short sellers served as the liquidity providers for moderating the over-valued stock price during the lock-up period.

- The heavily shorted stocks show a decrease trend of 0.024 around the lock-up expiry day, while the lightly shorted stocks show a reduction of 0.019, therefore the heavily shorted stocks suffer larger declines in value during the lock-up expiry day;

We also provide the Figures of short sale position and insider net purchase during 100 trading days around the lock-up expiry day. In the Figure 2.4, the short sale position is relatively large when approaching the lock-up expiry day, and become even larger after the lock-up agreement expired. This is reasonable as the shares available for borrowing is limited during the lock-up period.

And in Figure 2.5, insider selling is near to zero during the lock-up period and increases when approaching lock-up expiration. As described in the lock-up agreement, insiders should not directly or indirectly sell, offer, or make any short sale of common stock or any other convertible format securities for a period of 180 days immediately after the initial public offering.

Therefore, why can we still observe insider selling prior to the lock-up expiry date? There is another important aspect of the lock-up agreement. Since SEC or other authorities do not mandate the lock-up agreement, it is just an agreement

between the investment bank and the selling security holders. The underwriter can release any proportion of the lock-up shares at any time without notice and hence insiders can sell shares ahead of lock-up expiration.

However, insider sales are still subject to Rule 144 and Rule 701. We may not be able to observe huge volume of insider sales at the lock-up expiry date, as it may take several months or even years for an insider to be legally allowed to sell their securities. Furthermore, as suggested by [Gompers and Lerner 1998], in the event that venture capitalists distribute equity to their investors, they do not need to report this proportion of shares to the SEC. Thus, we do not observe many insider sales at the lock-up expiry day.

2.3.5 Event Study

To formally prove the sharp decline phenomenon of abnormal returns and to test the zero return assumption under efficient market hypothesis, we implement the event study by using daily stock return and value-weighted market portfolio return to calculate the Average Abnormal Return and Cumulative Average Abnormal Return with an event window of 10 trading days around lock-up expiration.

The following Table 2.4 illustrates the Average Abnormal Return and Cumulative Average Abnormal Return for 10 trading days around the lock-up expiry day. The AAR becomes the lowest and highly significant on the lock-up expiry day with a value of -0.41% and t-statistic equals to -2.0. And the AAR of one trading day before and after are all significantly negative and low. The CAAR on lock-up expiration is also quite low compared with the CAAR during lock-up period.

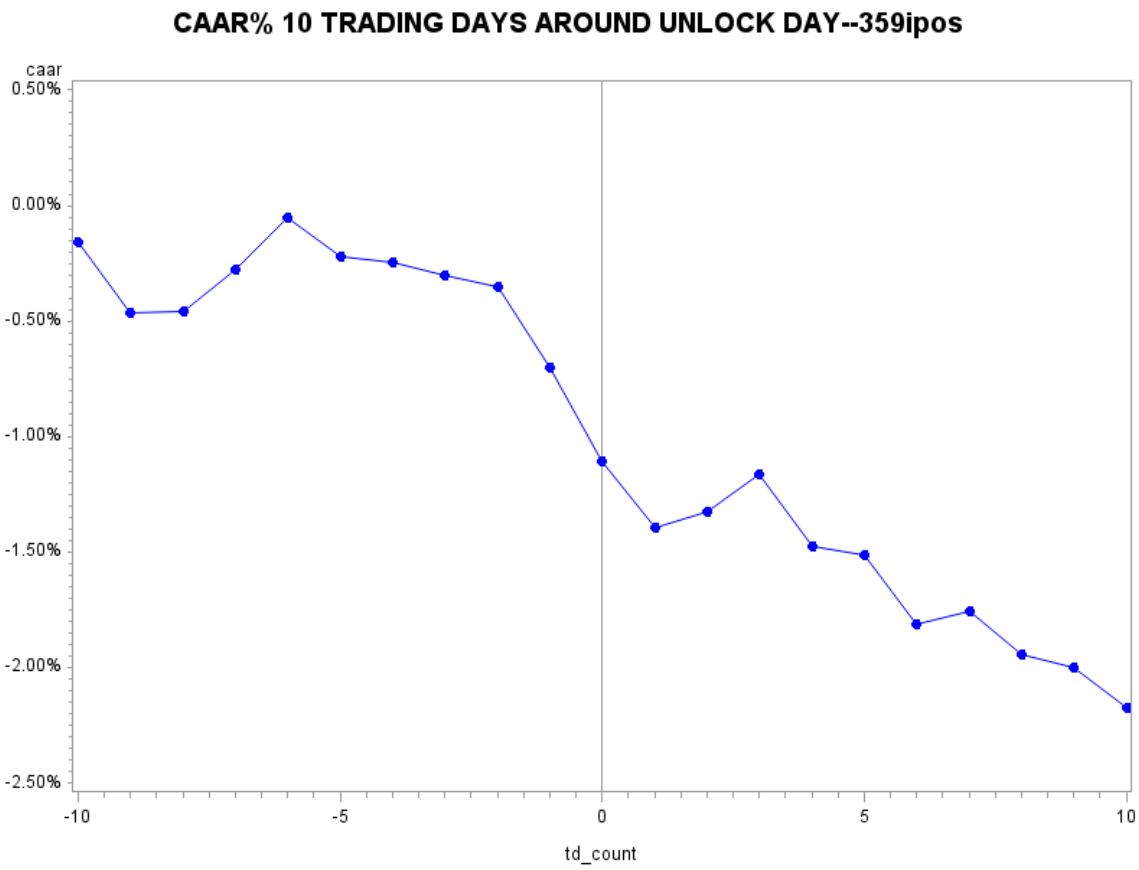

Figure 2.1: Cumulative Average Abnormal Return during 10 Trading Days around Lock-up Expiration

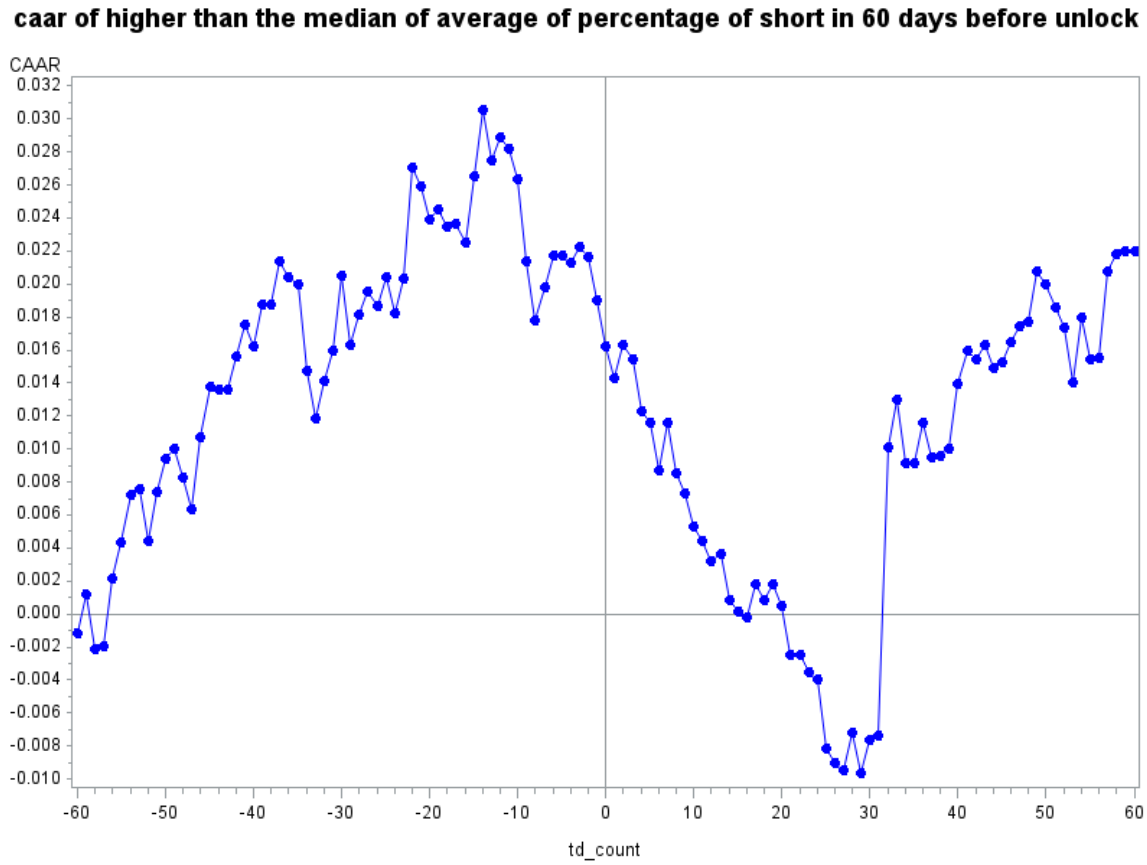

Figure 2.2: Cumulative Average Abnormal Return of Heavy-shorted IPOs

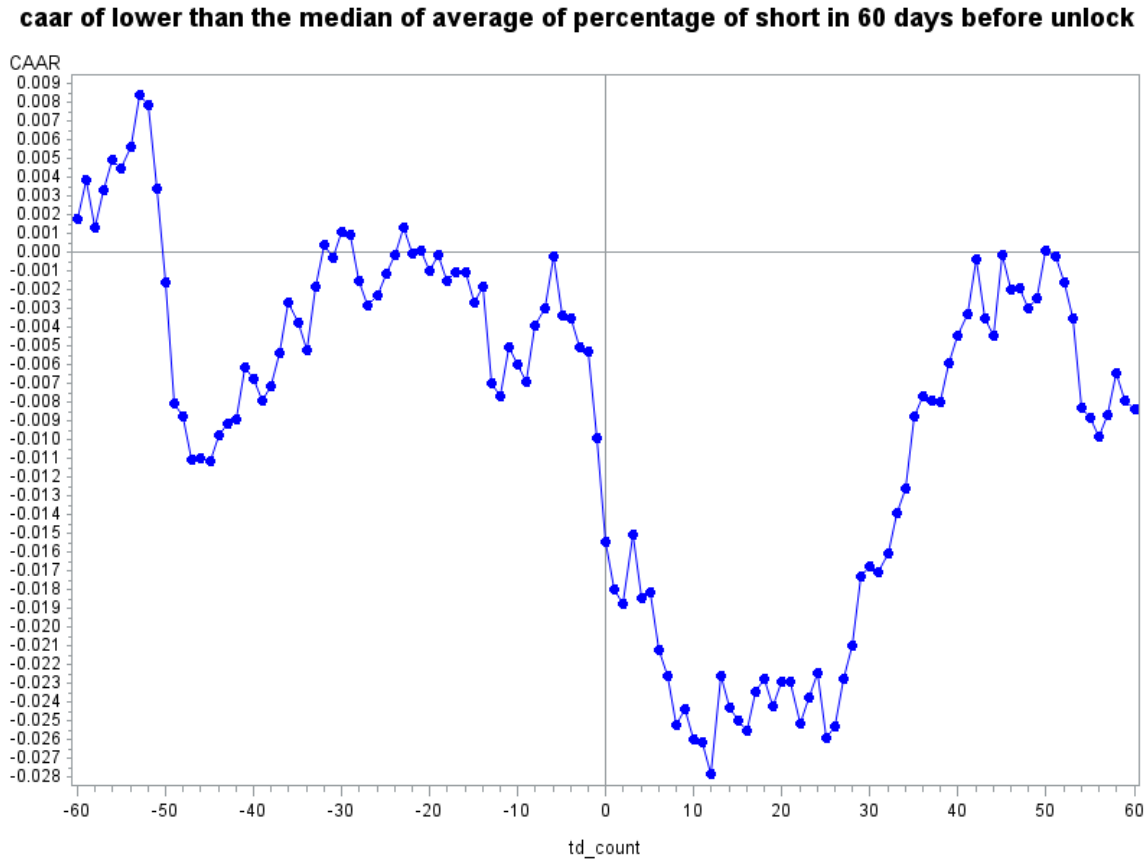

Figure 2.3: Cumulative Average Abnormal Return of Light-shorted IPOs

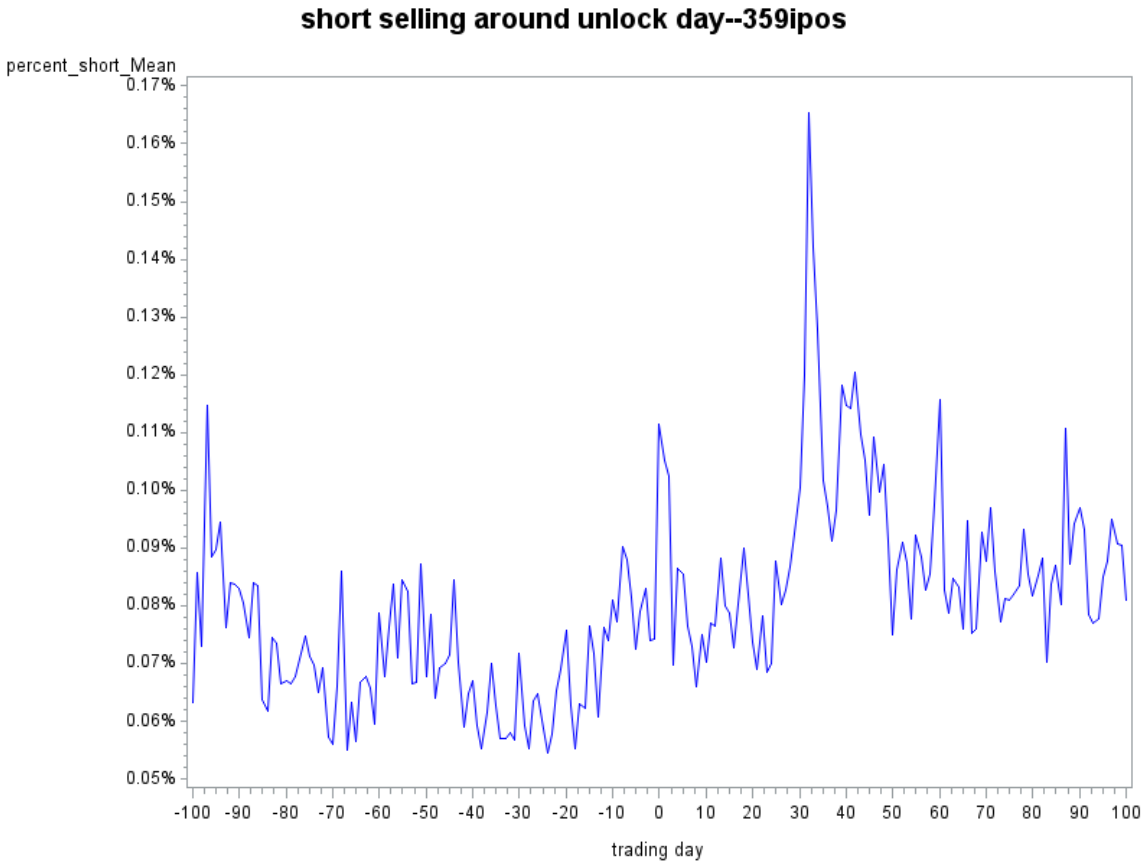

Figure 2.4: Percentage of Short Selling Volume around Lock-up Expiration

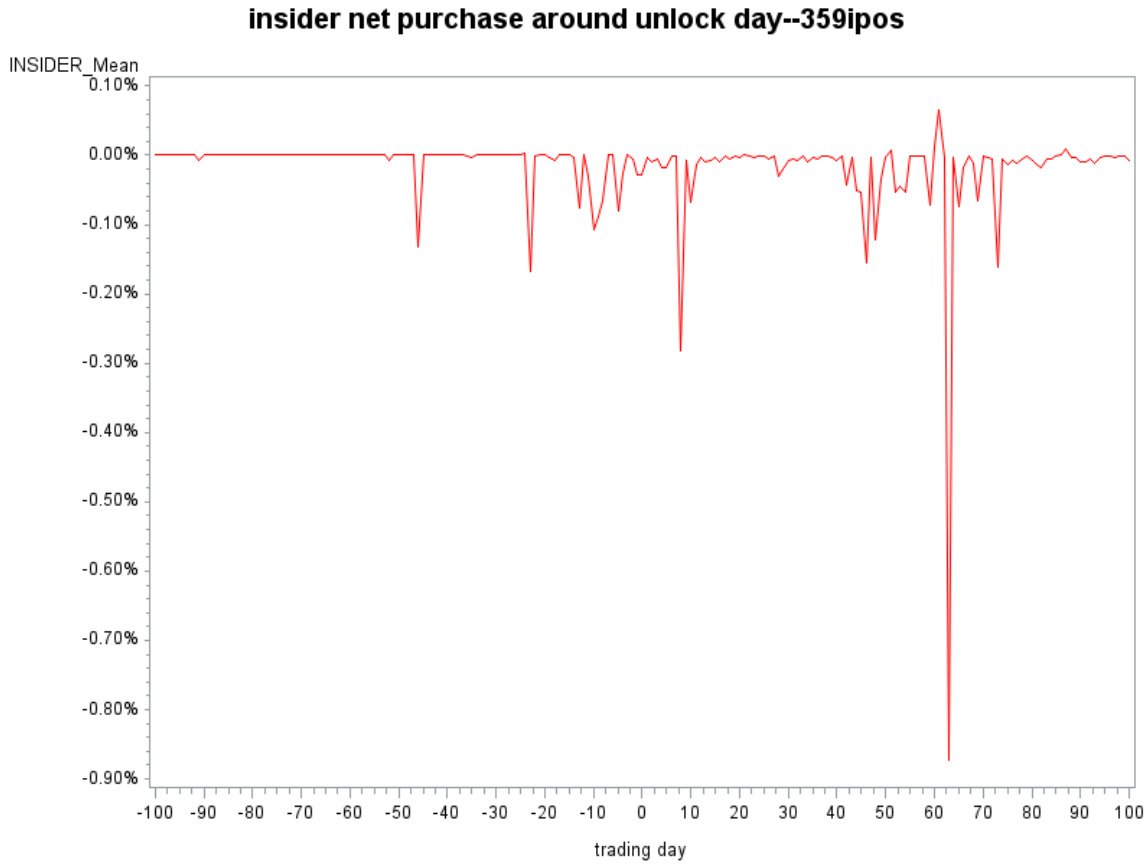

Figure 2.5: Percentage of Insider Net Purchase Volume around Lock-up Expiration

Table 2.4: Average Abnormal Return and Cumulative Average Abnormal Return during 10 Trading Days around Lock-up Expiration

Trading Day	AAR	T-stat	CAAR	T-stat
-10	-0.16%	-0.77	-0.16%	-0.77
-9	-0.31%	-1.88	-0.47%	-2.86
-8	0.01%	0.05	-0.46%	-2.15
-7	0.18%	1.17	-0.28%	-1.85
-6	0.23%	1.48	-0.06%	-0.36
-5	-0.17%	-1.20	-0.22%	-1.60
-4	-0.03%	-0.14	-0.25%	-1.29
-3	-0.06%	-0.37	-0.30%	-2.00
-2	-0.05%	-0.31	-0.35%	-2.38
-1	-0.35%	-2.66	-0.70%	-5.33
0	-0.41%	-2.00	-1.11%	-5.43
1	-0.29%	-1.61	-1.39%	-7.86
2	0.06%	0.39	-1.33%	-8.00
3	0.17%	1.11	-1.16%	-7.73
4	-0.31%	-2.21	-1.48%	-10.39
5	-0.04%	-0.29	-1.52%	-10.84
6	-0.30%	-2.18	-1.81%	-13.33
7	0.06%	0.40	-1.75%	-12.28
8	-0.19%	-1.14	-1.95%	-11.67
9	-0.06%	-0.40	-2.00%	-14.39
10	-0.18%	-1.22	-2.18%	-14.98

Trading day represents the length of trading days being apart from the lock-up expire day. AAR is the average abnormal return followed by the T-statistics in the third column. CAAR is the cumulative average abnormal return followed by the T-statistics in the fifth column.

As a result, we are able to reject the hypothesis that the abnormal return is insignificantly different from zero, as the efficient market has already predicted the average price reaction at the time of lock-up expiration. This return decline finding challenges the efficient market hypothesis on this aspect.

2.4 The Predictability of Short Selling on Stock Return

2.4.1 Significance Test

The phenomenon of negative abnormal return and positive short sale position around lock-up expiration has been demonstrated in the previous section. In this section, we now turn to multiple regression analysis to investigate the impact of short sales and insider sells on IPOs' abnormal return during the lock-up period.

We use the panel regression in equation 2.4 to check the influence of short sellers and insiders on stock returns, as indicated in the Table 2.5.

In this Table, the results indicate that the short selling of the previous three days can predict and affect the three-days rolling average DGTW abnormal return by using different regression models, while insiders do not appear to have significant influence on stock returns. Furthermore, the lock-up expiration event, represented by the Unlock dummy variable that equals to 1 for one trading day around the lock-up expiry date, has a highly significant negative effect on stock return, which is consistent with the significant decrease of abnormal return around the lock-up expiry day in the Tables and Figures reported in the previous section.

In addition, there is a significant negative effect of the short sales transacted at one trading day before the lock-up expiry date, indicating stocks with a large percentage of short sales on the previous day will experience a greater decline in value at the lock-up expiry day. By regressing a three-day rolling average DGTW abnormal short selling percentage and a three-day rolling average insider selling percentage on stock returns, results are indicated in Table 2.6.

The highly significant positive effect of short selling on stock returns still exists for $Short_{i,t-1}$, and the highly significant negative effect of short selling on stock

return in $Short_{i,t-2}$, $Short_{i,t-3}$, $Dummy_{unlock}$ and $Short_{i,t-1} * Dummy_{Unlock}$.

Overall, short seller trading activities do have predictability for future IPOs return and the influence is even more pronounced around the lock-up expiry day.

2.4.2 Robustness Test

To investigate whether the influence of a short sale position on stock returns is mostly dependent on the transactions before or after the lock-up expiry day, in this section we only use the dataset within the lock-up period for a robustness check, as shown in Table 2.7.

Since the previous panel regression results include the transaction data after the lock-up expiry date, the results may be affected by trading after lock-up expiration. In Table 2.7, we apply a robustness check to implement a panel regression by only using data within the lock-up period (trading day≤0). As indicated in the above Table, $Short_{i,t-1}$ and $Short_{i,t-3}$ are still highly significant, while $Short_{i,t-2}$ become significant at 10% level. By using a panel regression model with three-day rolling average independent variables, as indicated in column (3) and (4), $Short_{i,t-2}$ is no longer significant, while $Short_{i,t-1}$, $Short_{i,t-3}$, $Dummy_{unlock}$, $Short_{i,t-3} * Dummy_{unlock}$ are still highly significant.

We also implement another robustness test by using three-month momentum and sixty-day momentum to rank and to compose the 125 portfolios for computing the DGTW abnormal return and abnormal short sale position instead of using seven-day momentum in previous sections. We calculate the three-month momentum by using the monthly return during previous three months for each stock and compute the sixty-day momentum by applying the daily return over sixty trading

days before for each stock.

The results are presented in Table 2.8. The coefficient of short seller trading activity is still significant during both the entire sample period and within the lock-up period.

Therefore, we shall conclude that short seller trading activities during the lock-up period, especially on the lock-up expiry day, have a significant influence on stock returns and even contain helpful information for predicting the future stock returns.

Table 2.5: Panel Regression Result

	(1)	(2)	(3)	(4)
$Short_{i,t-1}$	0.322	0.322	0.291	0.287
	(18.02)***	(17.49)***	(16.42)***	(15.89)***
$Short_{i,t-2}$	-0.124	-0.125	-0.145	-0.149
	(-6.75)***	(-6.64)***	(-7.95)***	(-8.04)***
$Short_{i,t-3}$	-0.085	-0.086	-0.099	-0.104
	(-4.77)***	(-4.65)***	(-5.59)***	(-5.73)***
$Insider_{i,t-1}$	0.003	0.003	0.004	0.004
	(0.87)	(0.88)	(1.10)	(1.10)
$Insider_{i,t-2}$	0.000	0.000	0.001	0.001
	(0.03)	(0.03)	(0.21)	(0.21)
$Insider_{i,t-3}$	-0.003	-0.003	-0.002	-0.002
	(-0.72)	(-0.73)	(-0.56)	(-0.56)
$Dummy_{unlock}$	-0.002	-0.002	-0.002	-0.002
	(-4.26)***	(-4.10)***	(-4.10)***	(-4.03)***
$Short_{i,t-1} * Unlock$	-0.724	-0.726	-0.750	-0.752
	(-2.42)**	(-2.44)**	(-2.53)**	(-2.54)**
$Short_{i,t-2} * Unlock$	0.301	0.267	0.340	0.303
	(0.97)	(0.87)	(1.11)	(0.99)
$Short_{i,t-3} * Unlock$	0.509	0.453	0.510	0.446
	(1.64)	(1.46)	(1.65)*	(1.45)
$Insider_{i,t-1} * Unlock$	-0.003	-0.007	-0.020	-0.019
	(-0.03)	(-0.06)	(-0.18)	(-0.17)
$Insider_{i,t-2} * Unlock$	-0.140	-0.151	-0.171	-0.168
	(-1.10)	(-1.19)	(-1.36)	(-1.33)
$Insider_{i,t-3} * Unlock$	-0.058	-0.033	-0.073	-0.070
	(-0.43)	(-0.24)	(-0.55)	(-0.52)
Control Variable	No	No	Yes	Yes
Fixed Effect	No	Yes	No	Yes

This Table reports the results of panel regression with t-value in parentheses. The dependent variable is the three days rolling average DGTW abnormal return. $Short_{i,t-1}$ is the lagged DGTW abnormal short sale percentage, $Insider_{i,t-1}$ is the lagged insider net purchase percentage, $Dummy_{unlock}$ is a dummy variable that equals to 1 for [-1,1] trading days around lock-up expiration, $Short_{i,t-n} * Dummyunlock$ indicate the DGTW abnormal short sale percentage at day [-1-n,1-n] trading days around lock-up expire day and $Insider_{i,t-n} * Dummyunlock$ indicate the Insider net purchase percentage at day [-1-n,1-n] trading days around lock-up expire date. Significant level: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 2.6: Panel Regression Result with Rolling Independent Variable

	(1)	(2)	(3)	(4)
$Short_{i,t-1}$	0.909	0.936	0.871	0.876
	(21.34)***	(21.44)***	(20.61)***	(20.41)***
$Short_{i,t-2}$	-0.383	-0.392	-0.405	-0.406
	(-6.31)***	(-6.47)***	(-6.73)***	(-6.75)***
$Short_{i,t-3}$	-0.326	-0.301	-0.339	-0.335
	(-7.63)***	(-6.88)***	(-8.00)***	(-7.79)***
$Insider_{i,t-1}$	0.004	0.005	0.007	0.007
	-(0.54)	-(0.56)	-(0.85)	-(0.85)
$Insider_{i,t-2}$	0.003	0.003	0.003	0.003
	-(0.32)	-(0.32)	-(0.26)	-(0.26)
$Insider_{i,t-3}$	-0.009	-0.009	-0.007	-0.007
	(-1.09)	(-1.09)	(-0.91)	(-0.91)
$Dummy_{unlock}$	-0.002	-0.002	-0.002	-0.002
	(-4.27)***	(-4.13)***	(-4.13)***	(-4.09)***
$Short_{i,t-1} * Unlock$	-1.915	-1.900	-2.018	-1.997
	(-2.80)***	(-2.79)***	(-2.98)***	(-2.95)***
$Short_{i,t-2} * Unlock$	0.795	0.784	0.907	0.917
	-(0.79)	-(0.78)	-(0.91)	-(0.92)
$Short_{i,t-3} * Unlock$	1.182	1.048	1.160	0.995
	-(1.54)	-(1.37)	-(1.53)	-(1.31)
$Insider_{i,t-1} * Unlock$	0.089	0.047	0.025	0.016
	-(0.33)	-(0.17)	-(0.09)	-(0.06)
$Insider_{i,t-2} * Unlock$	-0.175	-0.147	-0.184	-0.177
	(-0.59)	(-0.50)	(-0.63)	(-0.61)
$Insider_{i,t-3} * Unlock$	-0.070	-0.064	-0.077	-0.077
	(-0.56)	(-0.51)	(-0.61)	(-0.61)
Control Variable	No	No	Yes	Yes
Fixed Effect	No	Yes	No	Yes

This Table reports the results of panel regression with both rolling average of dependent variable and independent variables. The t-statistics are illustrated in parentheses. The dependent variable is the three days rolling average DGTW abnormal return. $Short_{i,t-1}$ is the lagged DGTW abnormal short sale percentage, $Insider_{i,t-1}$ is the lagged insider net purchase percentage, $Dummy_{unlock}$ is a dummy variable that equals to 1 for [-1,1] trading days around lock-up expiration, $Short_{i,t-n} * Dummyunlock$ indicate the DGTW abnormal short sale percentage at day [-1-n,1-n] trading days around lock-up expire day and $Insider_{i,t-n} * Dummyunlock$ indicate the Insider net purchase percentage at day [-1-n,1-n] trading days around lock-up expire date. Significant level: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 2.7: Panel Regression Result within Lock-up Period

	(1)	(2)	(3)	(4)
$Short_{i,t-1}$	0.280	0.276	0.697	0.688
	(8.04)***	(7.94)***	(8.47)***	(8.37)***
$Short_{i,t-2}$	-0.063	-0.067	-0.028	-0.030
	(-1.79)*	(-1.91)*	(-0.26)	(-0.28)
$Short_{i,t-3}$	-0.108	-0.109	-0.499	-0.501
	(-3.08)***	(-3.12)***	(-6.05)***	(-6.09)***
$Insider_{i,t-1}$	0.008	0.008	0.026	0.026
	(0.91)	(0.87)	(1.20)	(1.23)
$Insider_{i,t-2}$	0.006	0.005	0.003	0.002
	(0.65)	(0.57)	(0.10)	(0.07)
$Insider_{i,t-3}$	0.000	-0.001	-0.009	-0.011
	(-0.02)	(-0.11)	(-0.42)	(-0.52)
$Dummy_{unlock}$	-0.002	-0.002	-0.002	-0.002
	(-4.47)***	(-4.60)***	(-4.47)***	(-4.57)***
$Short_{i,t-1} * Unlock$	-0.547	-0.587	-1.701	-1.812
	(-1.85)*	(-1.99)**	(-2.57)**	(-2.74)***
$Short_{i,t-2} * Unlock$	0.366	0.400	1.038	1.146
	(1.10)	(1.20)	(1.01)	(1.11)
$Short_{i,t-3} * Unlock$	0.398	0.392	0.761	0.763
	(1.31)	(1.29)	(0.93)	(0.93)
$Insider_{i,t-1} * Unlock$	-0.120	-0.080	-0.090	0.024
	(-1.16)	(-0.77)	(-0.37)	(0.10)
$Insider_{i,t-2} * Unlock$	-0.097	-0.119	-0.160	-0.170
	(-0.19)	(-0.24)	(-0.62)	(-0.66)
$Insider_{i,t-3} * Unlock$	-0.041	-0.056	-0.021	-0.026
	(-0.36)	(-0.49)	(-0.19)	(-0.25)
Control Variable	No	Yes	No	Yes
Fixed Effect	Yes	Yes	Yes	Yes
Rolling Predictor	No	No	Yes	Yes

This Table reports the results of robustness test by only using dataset within lock-up period. The T-statistics are illustrated in parentheses. The dependent variable is the three days rolling average DGTW abnormal return. $Short_{i,t-1}$ is the lagged DGTW abnormal short sale percentage, $Insider_{i,t-1}$ is the lagged insider net purchase percentage, $Dummy_{unlock}$ is a dummy variable that equals to 1 for [-1,1] trading days around lock-up expiration, $Short_{i,t-n} * Dummyunlock$ indicate the DGTW abnormal short sale percentage at day [-1-n,1-n] trading days around lock-up expire day and $Insider_{i,t-n} * Dummyunlock$ indicate the Insider net purchase percentage at day [-1-n,1-n] trading days around lock-up expire date. Significant level: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 2.8: Panel Regression Result with three-month momentum and sixty-day momentum

	(1)	(2)	(3)	(4)
Momentum Frequency	Three-month		Sixty-day	
$Short_{i,t-1}$	0.448	0.178	0.081	0.179
	(21.87)***	(2.76)***	(3.89)***	(2.79)***
$Short_{i,t-2}$	-0.220	-0.068	-0.109	-0.250
	(-10.38)***	(-1.03)	(-5.07)***	(-3.92)***
$Short_{i,t-3}$	-0.076	0.010	-0.001	0.035
	(-3.70)***	(0.15)	(-0.02)	(0.55)
$Insider_{i,t-1}$	0.001	0.002	0.002	0.002
	(0.35)	(0.29)	(0.58)	(0.21)
$Insider_{i,t-2}$	0.000	0.001	0.003	0.003
	(0.02)	(0.07)	(0.81)	(0.32)
$Insider_{i,t-3}$	-0.003	-0.006	0.000	-0.002
	(-0.78)	(-0.59)	(0.12)	(-0.24)
$Dummy_{unlock}$	-0.001	-0.001	-0.001	-0.001
	(-1.76)*	(-1.83)*	(-3.28)***	(-3.72)***
$Short_{i,t-1} * Unlock$	-1.345	-1.110	-0.219	-0.344
	(-4.04)***	(-4.09)***	(-0.69)	(-1.28)
$Short_{i,t-2} * Unlock$	0.858	0.710	0.621	0.742
	(2.09)**	(2.15)**	(1.69)*	(2.40)**
$Short_{i,t-3} * Unlock$	-0.205	-0.291	0.076	0.047
	(-0.51)	(-0.90)	(0.19)	(0.14)
$Insider_{i,t-1} * Unlock$	0.029	0.018	0.066	0.054
	(0.27)	(0.22)	(0.64)	(0.63)
$Insider_{i,t-2} * Unlock$	-0.048	-0.068	-0.043	-0.055
	(-0.39)	(-0.69)	(-0.36)	(-0.55)
$Insider_{i,t-3} * Unlock$	-0.038	-0.046	0.061	0.060
	(-0.31)	(-0.46)	(0.46)	(0.54)
Sample Period	Whole	Lockup	Whole	Lockup
Control Variable	Yes	Yes	Yes	Yes
Fixed Effect	Yes	Yes	Yes	Yes

This Table reports the results of robustness test by replacing the seven-day Momentum with three-month Momentum and sixty-day Momentum. The T-statistics are illustrated in parentheses. The dependent variable is the three days rolling average DGTW abnormal return. $Short_{i,t-1}$ is the lagged DGTW abnormal short sale percentage, $Insider_{i,t-1}$ is the lagged insider net purchase percentage, $Dummy_{unlock}$ is a dummy variable that equals to 1 for [-1,1] trading days around lock-up expiration, $Short_{i,t-n} * Dummyunlock$ indicate the DGTW abnormal short sale percentage at day [-1-n,1-n] trading days around lock-up expire day and $Insider_{i,t-n} * Dummyunlock$ indicate the Insider net purchase percentage at day [-1-n,1-n] trading days around lock-up expire date. Significant level: * significant at 10%; ** significant at 5%; *** significant at 1%

2.4.3 Causality Test

In this section, we use the Granger test to investigate whether there is a causality relationship between short seller trading activity and stock returns during the lock-up period.

The following Table 2.9 indicates the results of the Granger-causality test by using an equation 2.5 under two different conditions: 1. The causality test of DGTW abnormal short sale percentage on DGTW abnormal return within the lock-up period. 2. The causality test of DGTW abnormal short sale percentage on price within the lock-up period.

Table 2.9: Granger Causality Test Result

Test method	(1)	(2)
F-test	2.261**	4.436**
Asymptotically Equivalent Test	4.523**	8.873**

The Table reports the causality test results of short percentage on return within lock-up period in the second column and the causality test results of short percentage on price within lock-up period in the last column.

Therefore, the information contained in short seller trading activity is useful for forecasting stock price and return during the lock-up period. Furthermore, the price decline and negative abnormal return during lock-up expiration are further verified to be correlated with short seller trading activity.

2.4.4 The Influence of Short Sale on Abnormal Returns across Different Features of IPOs

In this section, we design a subgroup comparison regression model to further test the impact and predictability of short seller trading activity on stock returns during the lock-up period. We investigate whether an abnormal short sale position will have a different influence over IPOs abnormal returns across different characteristics such as investor opinion divergence and technical potential.

As suggested in [Miller 1977], short sale constrained securities become overpriced when investors disagree about their value. Therefore, we expect that the abnormal return of IPOs with high analyst dispersion should be more negative since, during the lock-up period, short sales are constrained and overpriced stocks feature negative abnormal return. Also, we anticipate that short sellers predict less accurately on stocks with high analyst dispersion during the lock-up period since those stocks will be overvalued and hence more difficult to predict than those with low analyst dispersion.

Under the costly arbitrage hypothesis raised by [Pontiff 1996], the short sellers may not want to bet against the volatile stocks as they may receive a loss when positive news comes to market before lock-up expiration. Therefore, stocks with less divergent investor opinions, which are less volatile, would be more attractive to short sellers and thus short sellers will exert a better predictability over those low dispersion IPOs.

For the dataset, we are using the I/B/E/S monthly summary history file. We evaluate the divergence of investor opinion by calculating the analyst dispersion. The dispersion among financial analysts is estimated by dividing the standard

deviations of earnings forecasts over the absolute value of the mean of earnings forecasts among analysts for the current fiscal year-end. This measurement of analyst dispersion is widely used in many literatures and it is the principal proxy used by [Diether et al. 2002]. However, there is a limitation of computing analyst dispersion as there should be at least two analysts for calculating the dispersion value for each stock. Therefore we eliminated those stocks with only one analyst.

After computing the monthly analyst dispersion ratio for each stock, we sort all the stocks into five quantiles based on their monthly analyst dispersion ratio. Then we compare the average DGTW abnormal return of the lower quantile (the lowest twenty percent) and the top quantile (the highest twenty percent) analyst dispersion stocks within the lock-up period. The results are shown in Table 2.10.

Table 2.10: Abnormal Return across Different Analyst Dispersion Stocks during lock-up period

Analyst Dispersion	Low	High
Abnormal Return	0.003%	-0.016%

This Table reports the average DGTW abnormal return within lock-up period across the lowest quantile (bottom twenty percent) and the highest quantile (top twenty percent) of stocks based on their analyst dispersion ratio during lock-up expire month.

As we expected, the results in Table 2.10 indicate that the abnormal return of stocks with high analyst dispersion is significantly more negative than the stocks with low analyst dispersion.

Then we compare the forecasting performance of the lowest analyst dispersion quantile stocks (the bottom twenty percent stocks) and the highest analyst dispersion quantile (the top twenty percent stocks). This is carried out by using

panel regression of a three-day rolling DGTW abnormal return on DGTW abnormal short sale percentage and the lock-up expiry day dummy variable for entire sample period and the lock-up period.

Table 2.11: The Predictability of Short Sale on IPOs Return across Different Analyst Dispersion Stocks

	Whole Period		Lockup Period	
Analyst Dispersion	High	Low	High	Low
$Short_{i,t-1}$	-0.021	-0.105	-0.053	0.442
	(-0.40)	(-1.99)**	(-0.51)	(2.68)***
$Short_{i,t-2}$	-0.044	-0.109	-0.045	0.188
	(-0.87)	(-1.98)**	(-0.43)	(1.11)
$Short_{i,t-3}$	-0.051	-0.128	-0.146	0.053
	(-1.06)	(-2.40)**	(-1.42)	(0.32)
$Dummy_{unlock}$	-0.0004	-0.0005	-0.0004	-0.0006
	(-0.46)	(-0.47)	(-0.53)	(-0.72)
$Short_{i,t-1} * Unlock$	1.144	-1.316	1.176	-1.863
	(1.88)*	(-2.00)**	(2.08)**	(-3.08)***
$Short_{i,t-2} * Unlock$	0.098	2.867	0.099	2.571
	(0.16)	(2.62)***	(0.17)	(2.61)***
$Short_{i,t-3} * Unlock$	-0.122	0.278	-0.027	0.097
	(-0.20)	(0.30)	(-0.05)	(0.12)
Control Variable	Yes	Yes	Yes	Yes
Fixed Effect	Yes	Yes	Yes	Yes

This Table reports the results of panel regression across the stocks within the highest quantile and the lowest quantile of analyst dispersion. The T-statistics are illustrated in parentheses. The dependent variable is the three days rolling average DGTW abnormal return. $Short_{i,t-1}$ is the lagged DGTW abnormal short sale percentage, $Insider_{i,t-1}$ is the lagged insider net purchase percentage, $Dummy_{unlock}$ is a dummy variable that equals to 1 for [-1,1] trading days around lock-up expiration, $Short_{i,t-n} * Dummyunlock$ indicate the DGTW abnormal short sale percentage at day [-1-n,1-n] trading days around lock-up expire day. Significant level: * significant at 10%; ** significant at 5%; *** significant at 1%

As displayed in Table 2.11, the predictability of short seller trading activity is stronger for those stocks with low analyst dispersion. Since the stocks with less analyst dispersion indicate that the stocks have less uncertainty and are less risky,

we observe the results that short sellers performed a better predictability for low dispersion stocks within entire sample period.

The phenomenon is still strong during the lock-up period, which is consistent with our hypothesis that within the lock-up period, stocks are mostly short sell constrained. Therefore stocks with high dispersion of investor opinion will be overpriced and will be more difficult to predict. That is why we observe less predictability of short sale abnormal positions on abnormal returns of high analyst dispersion stocks within the lock-up period. Overall, the short seller trading behaviour will have more influence and predictability over stocks with lower divergence of investor opinion.

For investigating the impact of short sale on stock returns across stocks with different technology level, we use research and development intensity ratio as the proxy for the high-tech firms. We compute the ratio by dividing the expenditure of a firm on research and development over the firm's sales collected from COMPUSTAT annual fundamental file.

High-tech sectors, such as aircraft and spacecraft, electrical equipment, and pharmaceuticals are normally recognized by their greater R&D intensity, while low-tech sectors, such as food products, iron and steel, and textiles usually have low R&D intensity. Thus, We expect a more volatile and more dramatic decrease on stock return for high research and development intensity stocks during the lock-up expiry day.

Therefore, we compare the average DGTW abnormal return of the bottom quantile (the lowest twenty percent) and the top quantile (the highest twenty percent) R&D intensity stocks. The results are shown in Table 2.12

Table 2.12: The Abnormal Return across Low and High R&D intensity Stocks

R&D Intensity	High		Low	
Period	Before	Unlock	Before	Unlock
Abnormal Return	0.006%	-0.56%	-0.04%	0.11%

This Table reports the average DGTW abnormal return within lock-up period across the lowest quantile (bottom twenty percent) and the highest quantile (top twenty percent) of stocks based on their research and development intensity ratio during lock-up expire year.

The results reported in Table 2.12 support our assumption. The stocks with high R&D intensity, which are the high-tech sectors stocks, experience a substantial decrease on the lock-up expiry day. The average DGTW abnormal return of high R&D intensity stocks at the lock-up expiry day is even more negative than the average DGTW abnormal return of whole sample displayed in Table 2.1, which is -0.129% at lock-up expiration.

Then we compare short seller predictability on stock returns across IPOs with low and high levels of R&D intensity. We apply the same methodology as the analyst dispersion analysis above. We sort the stocks into five quantiles based on the annual R&D intensity ratio. Then we compare the forecasting performance of the IPOs with the lowest quantile of R&D intensity to the highest quantile of R&D intensity by using panel regression of a three-day rolling DGTW abnormal return on DGTW abnormal short sale percentage and the lock-up expiry day dummy variable for both whole sample period and the lock-up period. The results are reported in Table 2.13.

Table 2.13: The Predictability of Short Sale on IPOs Return across Different R&D Intensity Stocks

	Whole Period		Lockup Period	
R&D Intensity	High	Low	High	Low
$Short_{i,t-1}$	0.441	-0.204	-0.707	-0.800
	(8.32)***	(-3.13)***	(-6.80)***	(-5.77)***
$Short_{i,t-2}$	-0.173	0.057	-0.015	0.012
	(-3.16)***	(0.86)	(-0.14)	(0.08)
$Short_{i,t-3}$	-0.105	-0.009	-0.111	-0.403
	(-1.98)**	(-0.13)	(-1.06)	(-2.90)***
$Dummy_{unlock}$	-0.005	0.0001	-0.004	0.0005
	(-2.58)***	(0.06)	(-3.57)***	(0.38)
$Short_{i,t-1} * Unlock$	-1.909	-0.239	-0.761	0.358
	(-0.99)*	(-0.16)	(-0.58)	(0.27)
$Short_{i,t-2} * Unlock$	1.462	1.182	1.304	1.227
	(0.97)	(0.61)	(1.27)	(0.69)
$Short_{i,t-3} * Unlock$	1.266	2.541	1.272	2.935
	(0.92)	(1.37)	(1.34)	(1.72)*
Control Variable	Yes	Yes	Yes	Yes
Fixed Effect	Yes	Yes	Yes	Yes

This Table reports the results of panel regression across the stocks within the highest quantile and the lowest quantile of research and development intensity. The T-statistics are illustrated in parentheses. The dependent variable is the three days rolling average DGTW abnormal return. $Short_{i,t-1}$ is the lagged DGTW abnormal short sale percentage, $Insider_{i,t-1}$ is the lagged insider net purchase percentage, $Dummy_{unlock}$ is a dummy variable that equals to 1 for [-1,1] trading days around lock-up expiration, $Short_{i,t-n} * Dummyunlock$ indicate the DGTW abnormal short sale percentage at day [-1-n,1-n] trading days around lock-up expire day. Significant level: * significant at 10%; ** significant at 5%; *** significant at 1%

During lock-up period, the impact of short seller trading activity on stock returns does not vary across different R&D intensity stocks, while during whole sample period, which includes the time after lock-up expiration, the short selling across high-tech firms has a more significant influence on stock returns.

2.5 Conclusion and Future Directions

In this Chapter, we verify the sharp decline trend of IPOs abnormal returns and examine the impact of short seller trading activity on IPOs' performance around the lock-up expiry day by using a sample of 359 IPOs listed in NASDAQ during Regulation SHO from year 2005 to 2007.

First, by implementing an event study, we determine that around the lock-up expiry day, the short sale position is relatively large and IPOs abnormal return declines dramatically. Second, we apply a panel regression of short sale position and insider selling on a three-day rolling average abnormal return in order to examine the influence and predictability of short seller trading activity on stock return around the lock-up expiry day. The results reveal that short sales do have influence and predictability on future IPOs returns, especially around lock-up expiration. It implies that the trading activities of short sellers during lock-up expiration contain information of IPOs' future performance.

Since information about the lock-up expiry date and short sale transactions is available to the public, the price should have already reflected the information instead of being predicted by using this published information under the extreme version of efficient market hypothesis. Therefore, this paper may support the adaptive market hypothesis proposed by [Lo 2004], that price reflects as much information as dictated by the combination of environmental conditions and the number and nature of species in the economy. Since the lock-up period has relatively fewer traders in the stock market and explicitly fewer pessimists participate in the market, the resource is relatively redundant and numbers of species are relatively small. Therefore, the price cannot fully reflect the publicly available in-

formation, which provides predictable profit for short sellers on the lock-up expiry day.

The sample period we used for this topic is only from year 2005 to 2007, which has daily short sale transactions data available. Therefore, in the next topic, we plan to extend the sample period and the event window to further investigate whether this return decline trend during lock-up expiration is a general phenomenon and whether this phenomenon is temporary or permanent.

Chapter 3

The Reversal Phenomenon of Stock Return after Lock-up Expiration

3.1 Introduction

In the previous Chapter, which examines whether the abnormal return at lock-up expiry day is insignificantly different from zero, we ascertain that the abnormal return is negative and reaches a sharp decline when approaching lock-up expiration. Therefore, in this Chapter, we plan to verify whether this dramatic decline in abnormal return on the lock-up expiry day is a universal and permanent phenomenon.

As proposed by [Bradley et al. 2001] and [Field and Hanka 2001], the authors believe that it is theoretically feasible that the negative abnormal returns during lock-up expiration are temporary due to the price pressure for attracting liquidity providers. However, they do not observe any rebound tendency of stock returns after lock-up expiry day based on the sample period and the length of event window

they used. Hence, they draw the conclusion that the decline of abnormal returns during lock-up expiration is permanent.

According to the Figures 2.1, 2.2 and 2.3 in Chapter 2, which illustrate the reversal pattern of cumulative abnormal return at lock-up expiration and few months after, we determine the possibility of return reverse by expanding both the sample period and the event window. In this study, we plan to test the following hypotheses:

First, the dramatic decrease of IPOs abnormal return at lock-up expiry day is a general but transient phenomenon due to price pressure for liquidity provision;

Second, the decline trend of IPOs abnormal return at lock-up expiration will cease and even rebound shortly after stocks are released from the lock-up agreement;

Third, the extent of reverse tendency will be different across various features of IPOs such as illiquidity, high-tech, and the length of the lock-up period.

3.2 Literature Review and Contributions

There are many published academic studies focusing on the pricing inefficiency following an IPO and the abnormal return reducing trend approaching lock-up expiry day. [Field and Hanka 2001], [Bradley et al. 2001], [Ofek 2000], [Derrien 2005] and [Ljungqvist et al. 2006] all indicate that they have found a dramatic decline tendency of IPOs abnormal return around the lock-up expiration and they claim that this phenomenon seems to represent a permanent loss with no rebound trend in subsequent days or weeks.

However, according to the price pressure theory, the price on lock-up expiry

day is depressed by the large flow of sell orders from pessimistic investors and declines for attracting liquidity providers. Therefore, this price decline and return decrease phenomenon on the lock-up expiration should be transitory. Literatures, such as [Barclay and Litzenberger 1988], [Mikkelson and Partch 1988] and [Kadlec et al. 1997] provide us the possibility of research on return reverse after the lock-up expiration, by investigating the return changes during seasoned equity offers. They find that the large price decline around the execution days of seasoned equity offers is partially reversed within a few days.

Therefore, in this Chapter, we design the analysis model based on an event study across the lock-up expiry day to observe the abnormal return changes after the lock-up expiration. We then discuss the impact factors or characteristics that would affect the abnormal return variation after the lock-up expiry day.

[Brav et al. 2000] and [Brav and Gompers 2003] claim that firms with significant information asymmetry usually have a longer lock-up period, while stocks issued with higher-quality underwriters and associated with less information asymmetry normally implement a shorter lock-up period. Furthermore, the price decline at the lock-up expiry day should be less for informational transparent firms; Therefore, we expect a less dramatic return reverse pattern for stocks with less information asymmetry. If we use the length of lock-up period as a proxy for the level of information asymmetry for each IPO, we should observe more rebound tendency for stocks with longer lock-up period and hence greater information asymmetry.

In our paper, we point out that the decline and negative performance of IPOs abnormal return during the lock-up expiry day is generally common but not permanent. By extending the sample period to 25 years, which is from year 1990 to 2014, and expanding the event window to 20 trading days around the lock-up

expiration during event study analysis, we conclusively prove the existence of the abnormal return reverse after IPOs are released from the lock-up agreement. We further discover that the abnormal return decrease effect is discontinued and even rebounded quite dramatically immediately after the lock-up expiry day within some periods, such as recession, and for some special characteristic stocks, like high liquidity stocks and stocks with a longer lock-up period.

3.3 Data and Methodology

In order to illustrate and verify that the IPOs abnormal return reverse tendency on the lock-up expiration is a common and transient phenomenon, in the following subsections, we present the dataset and methodology we applied for measuring the trend of abnormal returns before and after the lock-up expiry day.

3.3.1 Dataset

We collect the lock-up expiry date data of 4314 common IPOs from SDC that are issuing from year 1990 to 2014. More specifically, those IPOs are listed within the period from January 25th, 1990 to May 07th, 2014. Since we need to investigate the performance of IPOs around the lock-up expiry day and the lock-up period for IPOs is usually 180 days, the lock-up expiry date in our sample is from June 4th, 1990 to November 3rd, 2014 and the sample period of our dataset is from May 4th, 1990 to December 2nd, 2014.

The dataset we used for calculating the market adjusted return is the daily dataset from CRSP and Fama-French Daily Research Factors and the lock-up expiry day information is collected from SDC for each stock. In order to calculate the

Cumulative Abnormal Return around the lock-up expiration used for the event study, we mainly use the market adjusted return as our abnormal return for computing the Cumulative Abnormal Return around lock-up expiry day. We also use market model, Fama French three factor model and Carhart four factor model to calculate the Cumulative Abnormal Return for robustness test. There is no significant difference in results among these methods.

For the event study, the estimation period is 100 trading days with a minimum of 30 trading days non-missing value, the event window is 20 trading days around lock-up expiry day with 5 trading days' gap between estimation period and the beginning of the event window. The length of estimation period and event window is limited by the relatively short lock-up period.

We separate our sample into individual years based on the year in which the lock-up agreement expires. In the Table 3.1, which illustrates the summary statistics of IPOs during sample period, the second column that represents the number of IPOs issued each year reaches the highest level during 1996 and decreases dramatically after Dot-com Bubble in 2000 and after Housing Bubble in 2007. The last two columns illustrate whether the Cumulative Average Abnormal Return at the lock-up expiry day decreased compared with the CAAR within the lock-up period and the CAAR after the lock-up expiration for stocks being unlocked each year.

Table 3.1: Summary Statistic of Initial Public Offerings by Year, 1990-2014

YEAR	NIPO	NLOCK	CAAR	$CAAR_{Before}$	$CAAR_{After}$	UP_{Before}	UP_{After}
1990	79	52	-6.19%	-2.46%	-5.87%	-1	1
1991	222	101	2.01%	1.34%	3.34%	1	1
1992	282	290	0%	0.61%	0.58%	-1	1
1993	366	276	0.42%	0.54%	0.24%	-1	-1
1994	300	370	-1.52%	-0.41%	-1.29%	-1	1
1995	319	244	-0.04%	0.55%	0.63%	-1	1
1996	503	476	0.24%	1.28%	0.09%	-1	-1
1997	330	391	-3.28%	-0.8%	-3%	-1	1
1998	166	299	-2.82%	-0.1%	-2.23%	-1	1
1999	243	164	1.49%	0.84%	2.09%	1	1
2000	153	223	-13.06%	-4.03%	-15.61%	-1	-1
2001	44	95	-2.73%	1.44%	-1.4%	-1	1
2002	61	65	-1%	0.3%	3.34%	-1	1
2003	62	28	-0.07%	1.63%	1.98%	-1	1
2004	165	125	-2.22%	-0.95%	-2.31%	-1	-1
2005	150	159	-0.71%	-0.46%	-0.42%	-1	1
2006	146	159	0.89%	0.64%	-0.73%	1	-1
2007	170	156	-3.42%	-1.82%	-5.18%	-1	-1
2008	22	107	-3.1%	-0.62%	-2.02%	-1	1
2009	40	11	-0.22%	-1.02%	0.93%	1	1
2010	89	74	0.31%	0.42%	0.19%	-1	-1
2011	75	93	-4.2%	-1.27%	-5.63%	-1	-1
2012	103	93	-3.46%	-1.04%	-5.28%	-1	-1
2013	158	109	-1.69%	0.29%	-1.11%	-1	1
2014	66	154	-0.61%	-0.17%	-3.07%	-1	-1

The column NIPO represents the number of stocks being initially listed at each year. The column NLOCK represents the number of stocks being released from lock-up agreement at each year. The column CAAR represents the average cumulative abnormal return of IPOs being released at that year. The column $CAAR_{Before}$ illustrates the average cumulative abnormal return within lock-up period at each year. The column $CAAR_{After}$ demonstrates the average cumulative abnormal return after lock-up expiration for each year. UP_{Before} equals to -1 when the CAAR of the lock-up expire day is lower than the CAAR within lock-up period. UP_{After} equals to 1 when the CAAR after lock-up expiration is larger than the CAAR of the lock-up expire day. Therefore a negative UP_{Before} indicates the drop phenomenon of abnormal return at the lock-up expire date and a positive UP_{After} suggests a reversal trend of abnormal return after lock-up expiration.

As shown in the seventh column, during the 25-year sample period, the CAAR

at the lock-up expiry day is smaller than the CAAR within the lock-up period across 21 years, which indicats that overall the stock return will drop at the lock-up expiry day. However, in the last column, which compares the CAAR after the lock-up expiration with the CAAR at lock-up expiry day, the results show that the CAAR after lock-up expiration is larger than the CAAR of the lock-up expiration across 12 years. Therefore, the decline pattern of abnormal return during lock-up expiry day is not permanent overall.

3.3.2 Methodology

In order to evaluate the short-term performance and long-run performance of IPOs, we try to implement these two measurements based on the methodology used in [Ritter 1991], instead of using monthly data, and we use daily data to calculate the following measurements:

- The daily adjusted cumulative abnormal returns by using different types of benchmark returns;
- The daily Buy and hold abnormal returns by using market portfolio return as the benchmark return.

To demonstrate the reversal pattern of abnormal returns immediately after the lock-up expiry day, we construct an event study by using the daily market adjusted abnormal return to calculate the Cumulative Abnormal Return of 20 trading days before and after the lock-up expiry day.

Firstly, we follow [Michaely et al. 1994] to compute the abnormal return by using the return on market index as the benchmark return and take the difference

between stock return and value-weighted market portfolio return at each point in time during the event window, as shown in equation 3.1.

$$AR_{i,t} = RET_{i,t} - VWRET_{i,t} \tag{3.1}$$

We also implement market model, Fama French three-factor model, and Carhart four-factor model for computing the abnormal return as a robustness test.

$$\begin{aligned}
&Market\ Model : AR_{i,t} = RET_{i,t} - (\alpha_{i,t} + \beta_{i,t} * MKT_{i,t}) \\
&Fama\ French\ Model : AR_{i,t} = RET_{i,t} - (\alpha_{i,t} + \beta_{1,i,t} * MKT_{i,t} + \beta_{2,i,t} * SMB_{i,t} + \beta_{3,i,t} * HML_{i,t}) \\
&Carhart\ Model : AR_{i,t} = RET_{i,t} - (\alpha_{i,t} + \beta_{1,i,t} * MKT_{i,t} + \beta_{2,i,t} * SMB_{i,t} + \beta_{3,i,t} * HML_{i,t} + \beta_{4,i,t} * UMD_{i,t})
\end{aligned} \tag{3.2}$$

Secondly, we calculate the cumulative abnormal returns by summing up all the abnormal returns across time:

$$CAR_{i,t} = \sum_{t=T1}^{T2} AR_{i,t} \tag{3.3}$$

Finally, we compute the cross-sectional average of cumulative abnormal returns to generate the Cumulative Average Abnormal Return (CAAR):

$$CAAR_t = \frac{1}{N} \sum_{i=1}^{N} CAR_{i,t} \tag{3.4}$$

For robustness purposes, we compute the Buy and Hold Abnormal Return (BHAR) and calculate the abnormal return for each IPO beginning on day t-20 through t+20 as the difference between the firms buy-and-hold return and the benchmark buy-and-hold return. To be consistent with Cumulative Abnormal

Return, we also use the return on market index as the benchmark return.

$$BHAR_{i,t} = \prod_{t=T1}^{T2}(1 + RET_{i,t}) - \prod_{t=T1}^{T2}(1 + VWRET_{i,t}); \tag{3.5}$$

Whereas, the mean buy-and-hold abnormal return is:

$$\overline{BHAR_t} = \frac{1}{N}\sum_{i=1}^{N} BHAR_{i,t} \tag{3.6}$$

For further research on the reversal tendency of abnormal return after the lock-up expiry day, we implement two analyses:

First, we calculate the coefficient and correlation of cumulative average abnormal return before and after lock-up expiration to capture the reversal trend. After calculating the firm average cumulative abnormal return for each event day, we run the regression of the cumulative average abnormal return before lock-up expiration on the cumulative average abnormal return after lock-up expiration to generate the coefficient that will roughly illustrate whether the 'before lock-up expiration' CAAR and the 'after lock-up expiration' CAAR is negatively correlated or positively correlated.

$$CAAR_{t1} = \alpha + \beta CAAR_{t2}(t1 < 0, t2 > 0) \tag{3.7}$$

After calculating the firm average cumulative abnormal return for each event day, we also compute the correlation of the cumulative average abnormal return before lock-up expiration and the cumulative average abnormal return after lock-up expiration as a robustness check.

Second, by applying cross-sectional regression, we investigate the characteristics and factors that affect the extent of return reversal after the lock-up expiry day. In order to do so, we need to generate the correlation (or coefficient) of the CAAR before and after lock-up expiration for each stock as the dependent variable. The regression model is designed as below:

$$Correlation_i = \alpha + \beta_1 ZEROS + \beta_2 TECH + control\ variables \tag{3.8}$$

For the impact factors, we expect that those stocks with less liquidity will have limited reverse degree since price recovery is mostly served as the compensation for liquidity provision as demonstrated in [Da et al. 2013]. Since illiquid stocks are more likely to have trading days with zero return, we follow [Lesmond et al. 1999] to adopt ZEROS, which illustrates the proportion of days during lock-up expire month with zero return as an indicator of illiquidity of that stock during lock-up expire month. The ZEROS is defined as following:

$$ZEROS_i = \frac{Number\ of\ Days\ with\ Zero\ Return}{D_i} \tag{3.9}$$

Where D_i is the number of trading days for stock i in the lock-up expire month.

TECH is a dummy variable that equals to one when stocks are from technology related industry, which includes computer equipment industry, electric equipment industry and computer industry.

In order to further investigate the features of IPOs that affect the reverse degree of abnormal return after lock-up expiration, we also use the length of lock-up period as a proxy for the level of information asymmetry for each IPO following

the assumption raised by [Brav et al. 2000] and [Brav and Gompers 2003]. We separate our sample into three subsamples according to the length of lock-up period to verify whether the information asymmetry or information transparency feature will make any influence on the extent of return rebound after the lock-up expiry date.

3.3.3 Figure

To intuitively display the reversal pattern of Cumulative Average Abnormal Return right after the lock-up expiry day, we generate the following Figures of CAAR across different sample periods.

The following Figure 3.1 display the Cumulative Average Abnormal Return and Average Buy-and-Hold Abnormal Return of IPOs over the 41 event days during 1990 to 2014 by using CRSP value weighted return as the benchmark return.

During 1990 to 2014, which is the entire dataset sample period in our paper, there is a mild reverse trend immediately after the lock-up expiry day.

The following Figures display the Cumulative Average Abnormal Return of IPOs during different periods. We use NBER monthly recession indicators to partition our sample into two subgroups and then calculate the CAAR and BHAR of IPOs released from the lock-up agreement during Recession periods and Non-Recession periods. Figures are displayed in 3.2 and 3.3. Furthermore, we provide additional Figures 3.4 and 3.5 about return changes during two great crisis events within our sample period. The first one is the Dot-Com Bubble Crisis that covers the period from 1997 to 2000 with a climax on March 10, 2000. The second crisis is the Housing Bubble and Credit Crisis occurred from 2007 to 2009.

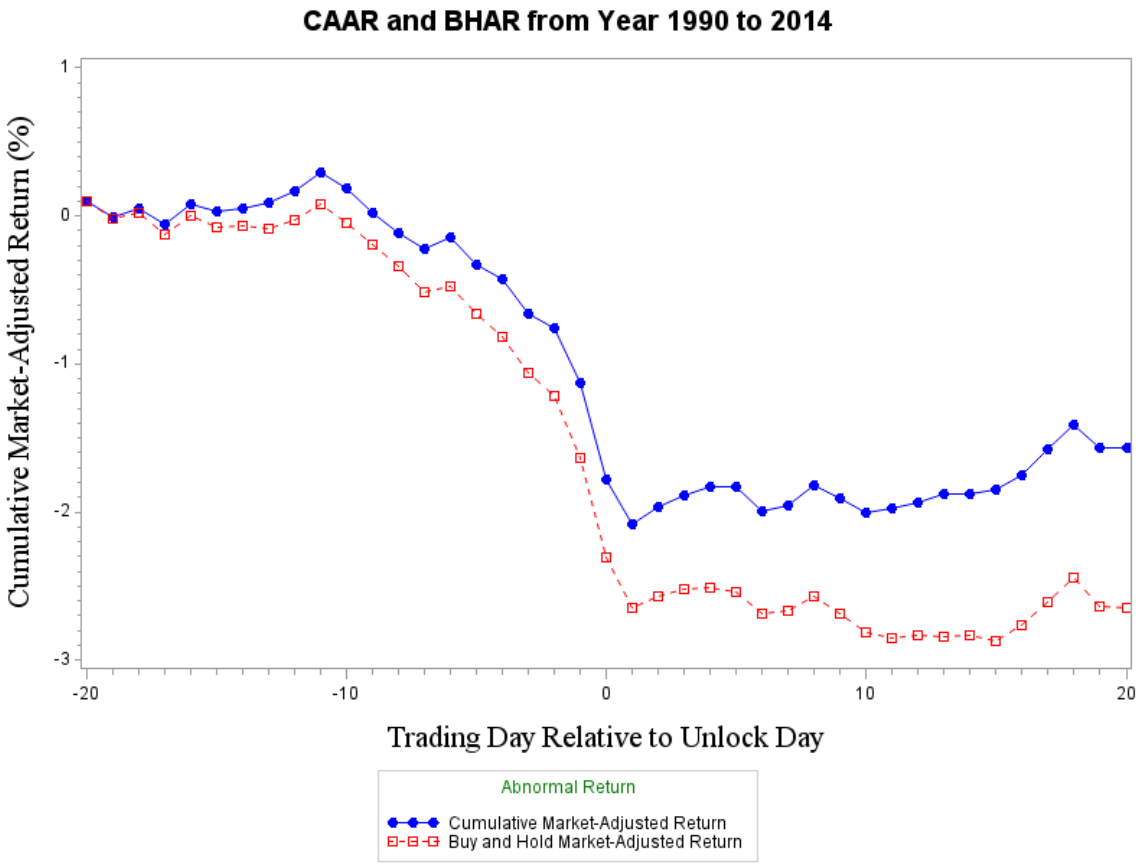

Figure 3.1: Cumulative Average Abnormal Return and Buy-and-Hold Average Abnormal Return from Year 1990 to 2014

From these Figures, we can determine that the stock returns at the lock-up expiry day drop sharply during all periods. The return decline trend does not continue after the lock-up expiry day. For some periods, such as recession measured by NBER indicator, the cumulative average abnormal returns reverse so dramatically that they even reach the highest level before lock-up expiration.

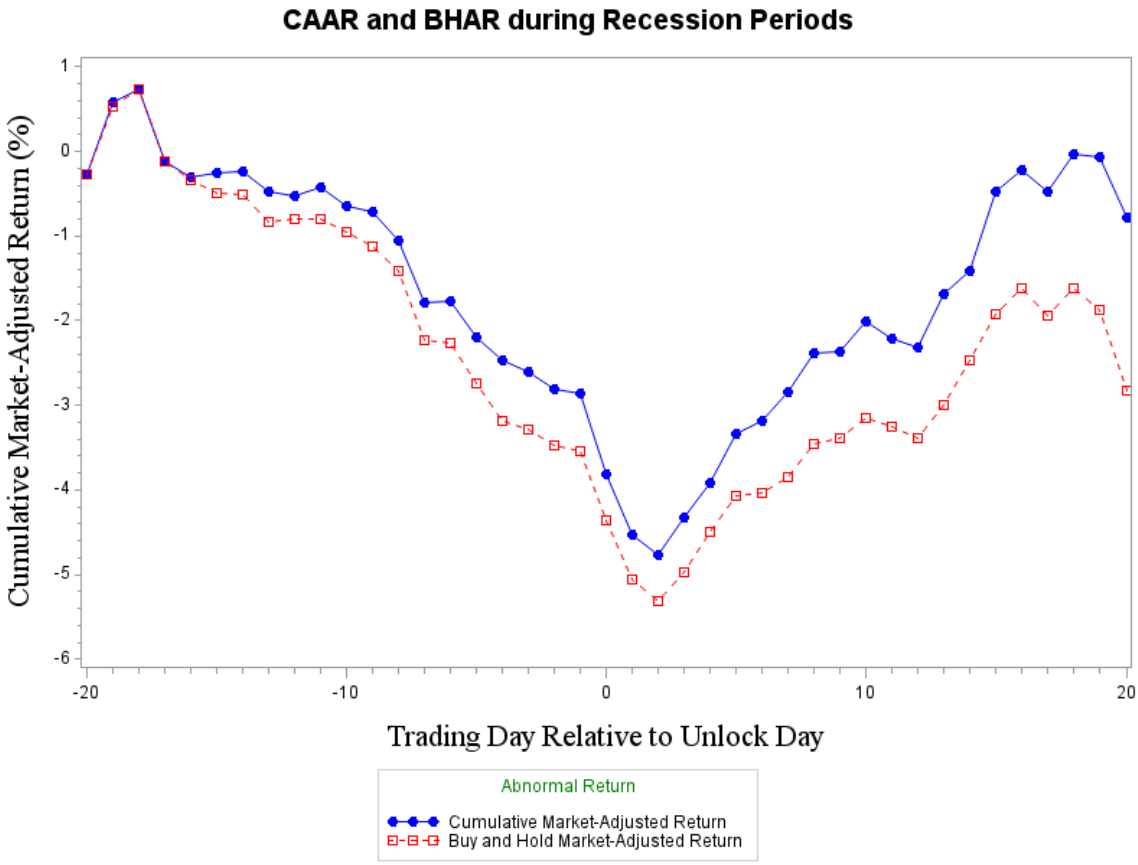

Figure 3.2: Cumulative Average Abnormal Return and Buy-and-Hold Average Abnormal Return during Recession

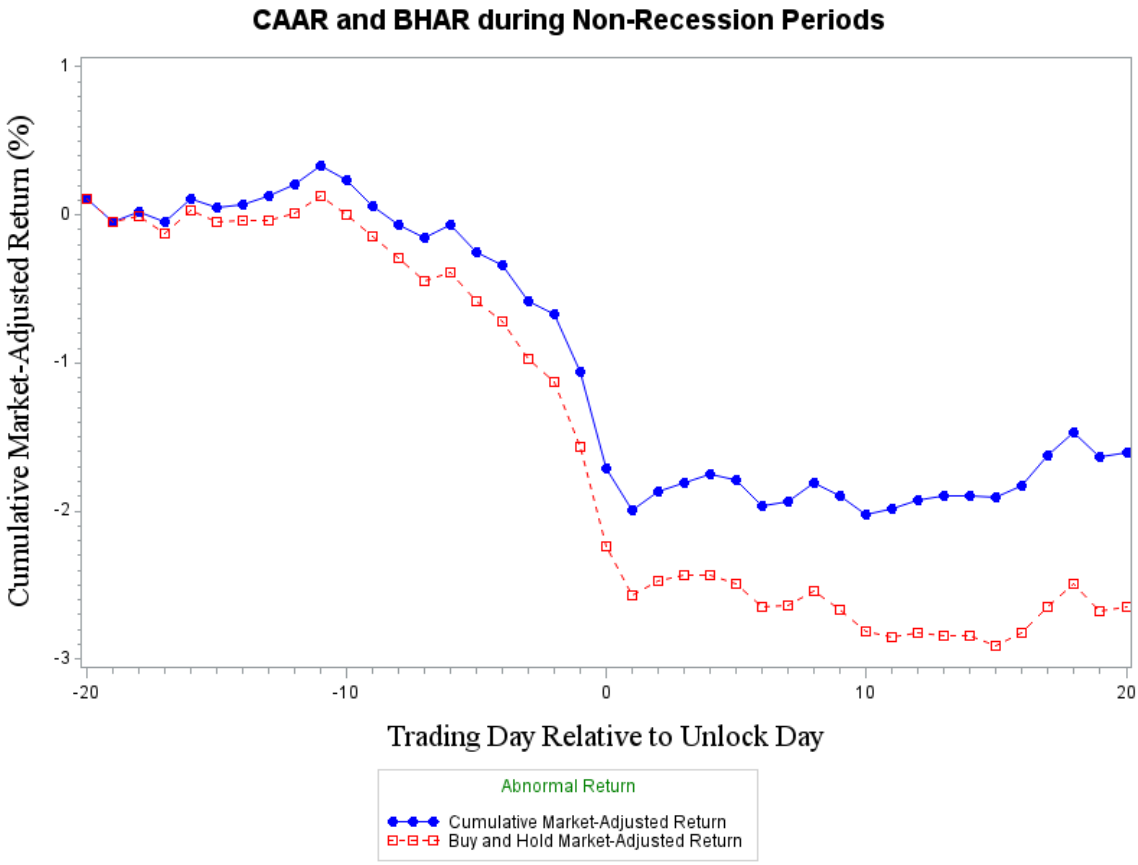

Figure 3.3: Cumulative Average Abnormal Return and Buy-and-Hold Average Abnormal Return during Non-Recession

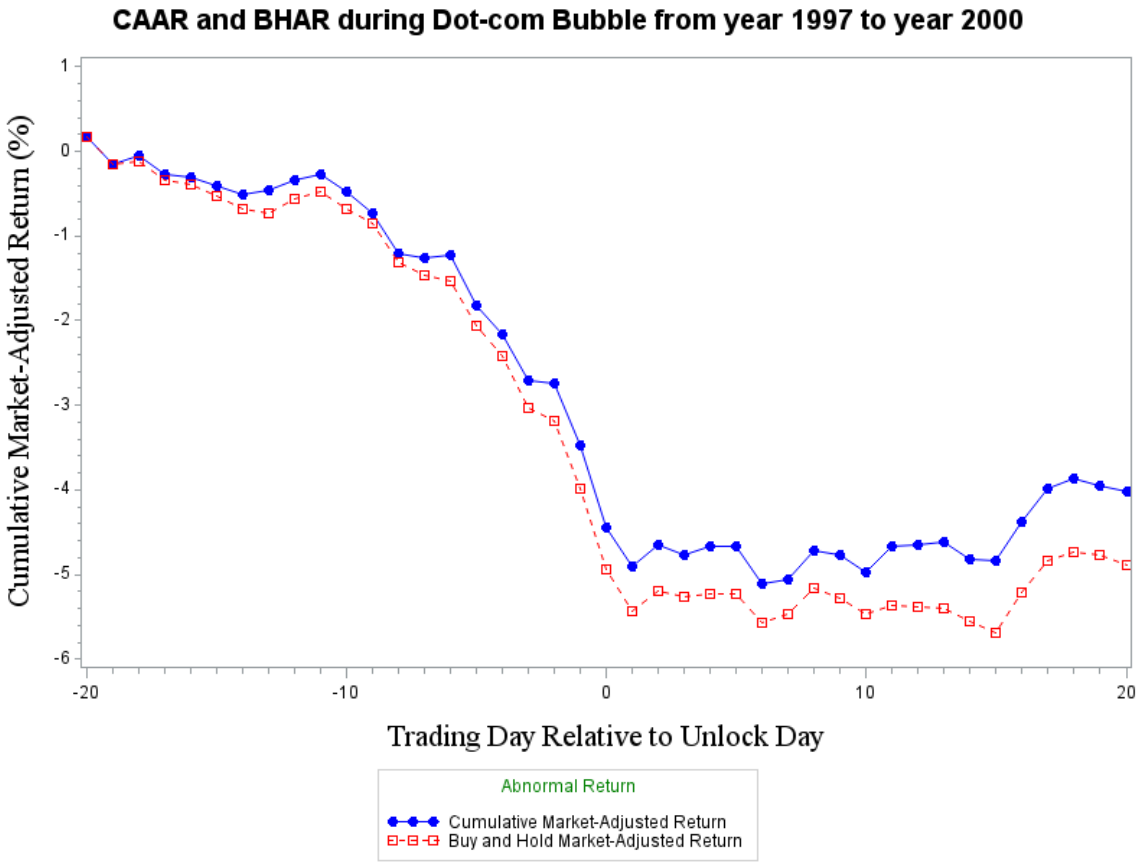

Figure 3.4: Cumulative Average Abnormal Return and Buy-and-Hold Average Abnormal Return during Dot-Com Bubble Period

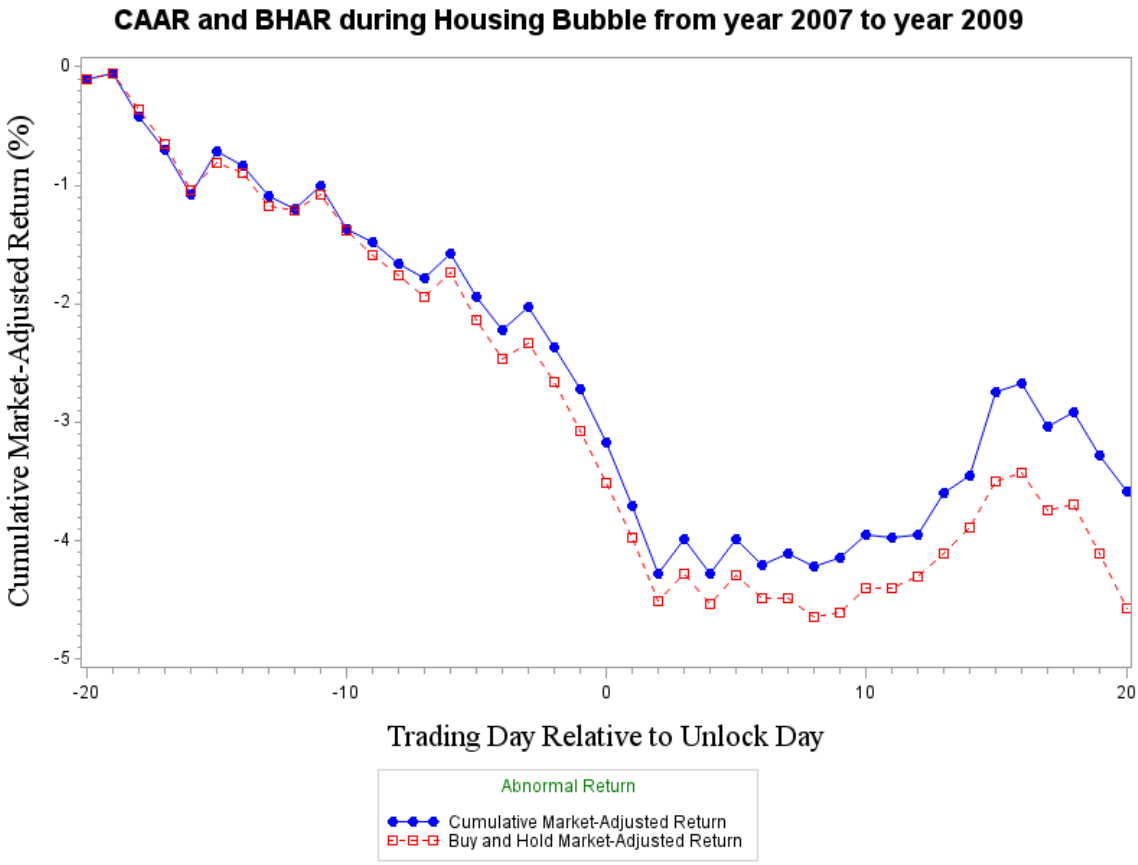

Figure 3.5: Cumulative Average Abnormal Return and Buy-and-Hold Average Abnormal Return during Housing Bubble Period

3.4 The Reversal Pattern of Cumulative Market-Adjusted Return after Lockup Expiry Day

To investigate the reverse phenomenon of the Cumulative Abnormal Return shortly after the IPOs lock-up expiry day, we implement two measurements to demonstrate the reversal pattern in a numerical expression. Furthermore, we apply the cross-sectional regression to examine the impact factors behind this reverse tendency of abnormal returns after lock-up expiration.

3.4.1 The Measurement of Reversal Pattern after Lockup Expiry Day

In this section, we explore the reaction of market price right after the lock-up expiry date. Based on previous literature, such as [Bradley et al. 2001] and [Field and Hanka 2001], the cumulative abnormal return will continue decreasing even after the lock-up expiry day and create a permanent impact on stock price. Therefore, we plan to provide information to prove that the impact of lock-up expiration is temporary and the cumulative abnormal return will start to reverse immediately after the lock-up expiry day.

To do so, we implement two measurements to illustrate the reversal pattern in numerical format, And then followed by a robustness test, using the first derivative test.

After calculating cumulative abnormal return for each IPO over 41 event days, we compute the average cumulative abnormal return for each event day across IPOs. We regress the Cumulative Average Abnormal Return of 20 event days before

lock-up expiration on the Cumulative Average Abnormal Return of 20 event days after lock-up expiration to generate the coefficient for illustrating whether the return of before and after lock-up expiration are negatively correlated as we expected.

We also compute the correlation of Cumulative Average Abnormal Return over 20 event days before and 20 event days after the lock-up expiry day to demonstrate whether the return of before and after lock-up expiration have a negative correlation, which can be interpreted as the rebound tendency after the lock-up expiry date.

Table 3.2: The Relationship of Cumulative Average Abnormal Return Before and After Lockup Expiration

	Coefficient	Correlation
CAAR	-1.76***	-0.86***

This Table represents the coefficient and correlation of cumulative average abnormal returns before and after lock-up expire date to illustrate the reverse tendency of abnormal returns after lock-up expiration. Significant level: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.2 provides the results of coefficient and correlation of Cumulative Average Abnormal Return over 20 event days before and after lock-up expiry date.

The Table reveals that the Cumulative Average Abnormal Return of the periods before and after lock-up expiration are significantly and negatively correlated, which proves that the cumulative abnormal return will reverse immediately after the lock-up expiry date.

To conclusively prove that the reversal trend happened shortly after the lock-up expiry day, we implement a first derivative test that computes the first derivative of before and after lock-up expiration cumulative abnormal return curve, represented

by the coefficient of regressing cumulative average abnormal return on the event days before and after lock-up expiration.

Table 3.3: The First Derivative of Cumulative Average Abnormal Return Curve across Different Periods

	All		Recession		Non-Recession	
	Before	After	Before	After	Before	After
First derivative	-0.05%	0.02%	-0.18%	0.25%	-0.04	0.01%
	(-4.9)***	(4.72)***	(-12.18)***	(16.53)***	(-4.20)***	(2.68)***

This Table represents the first derivative results of cumulative average abnormal returns before and after lock-up expire date to illustrate the reverse tendency of abnormal returns after lock-up expiration. The T-statistics are illustrated in parentheses. Significant level: * significant at 10%; ** significant at 5%; *** significant at 1%

In Table 3.3, the results indicate that the sign of the slope of after lock-up expiration cumulative average abnormal return curve is opposite to before lock-up expiration curve. Furthermore, the slope of after lock-up expiration curve is more positive during recession periods, which reveals the impressive reverse tendency of cumulative abnormal return during recession illustrated in Figure 3.2.

3.4.2 The Impact Factors behind the Curtain

After exhibiting the reversal trend of Cumulative Abnormal Return after the lock-up expiry day, in this section we explore the factors that affect the extent of the Cumulative Abnormal Return rebound after lock-up expiration.

Larger reverse tendencies of abnormal returns may exist for certain subgroups. Hence, our goal in this section is to examine whether the reversal phenomenon of abnormal returns is concentrated in stocks with certain characteristics. We then partition our sample into several subgroups based on a variety of features and

repeat the event study analysis.

However, instead of using cumulative average abnormal return, we apply regression on the cumulative abnormal return for each stock of 20 event days before and after lock-up expiration to generate 4314 coefficient and correlation for each stock as our dependent variable for impact factors analysis.

First, we regress the Cumulative Abnormal Return of 20 event days before lock-up expiration on the Cumulative Abnormal Return of 20 event days after lock-up expiration for each stock and generate the coefficient (or correlation) to indicate the degree of how much the abnormal return before and after lock-up expiration are related. Then we use the coefficient (or correlation) as the dependent variable of our cross-sectional regression to investigate the factors that impact the degree of return reversal after lock-up expiration.

Table 3.4: Cross-sectional Regression Results of impact factors

	Coefficient		Correlation	
	All	Negative	All	Negative
ZEROS	0.12	0.33	0.10	0.17
	(1.4)	(3.84)***	(1.87)*	(4.16)***
TECH	0.06	0.04	0.03	0.01
	(2.26) **	(1.34)	(1.97) **	(0.56)
Control Variable	Yes	Yes	Yes	Yes

This Table presents the results of cross-sectional regression with T-stat in parentheses. The second and the fourth columns illustrate the regression results of using coefficient and correlation as dependent variable, while the third and fifth columns display the regression results by only using negative coefficient and negative correlation as dependent variable to further investigate the impact of illiquidity and high-tech on reverse trend only.

Table 3.4 presents the results of cross-sectional regression by using coefficient (or correlation) as dependent variable, ZEROS and TECH as independent variable, and Carhart four factors as control variables. The independent variable ZEROS, as

calculated in equation 3.9, represents the level of illiquidity of each IPO during its lock-up expire month. The stocks with less liquidity will perform a larger value of ZEROS. The independent variable TECH is a dummy variable for firms in high-tech industry. TECH equals to one when the stock is from technology related industry, which includes computer equipment industry, electric equipment industry and computer industry.

The results in Table 3.4 indicate that ZEROS is positively related with coefficient and correlation, which means that stock illiquidity is positively correlated with the coefficient and correlation of Cumulative Abnormal Return before and after lock-up expiration. This is consistent with what we expected that the Cumulative Abnormal Return would perform less reversal when stocks have less liquidity. For the high-tech stocks, their chance of return reversal after lock-up expiration will be relatively smaller than normal stocks.

According to the analysis in the previous section, the reversal pattern of Cumulative Abnormal Return is sharper during recession periods. Therefore, we further test the effect of the impact factors during recession and non-recession periods, determined by the NBER recession indicator.

Table 3.5: Cross-sectional Regression Results of impact factors during Recession and Non-Recession Periods

	Coefficient		Correlation	
	Recession	Non-Recession	Recession	Non-Recession
ZEROS	0.09	0.12	0.25	0.09
	(0.26)	(1.42)	(0.99)	(1.71)*
TECH	0.10	0.06	0.08	0.03
	(0.91)	(2.22)**	(1.05)	(1.90)**
Control Variable	Yes	Yes	Yes	Yes

This Table presents the results of cross-sectional regression with T-stat in parentheses. The second and the fourth columns illustrate the regression results of dataset within recession periods determined by NBER recession indicator, while the third and fifth columns display the regression results by using dataset within non-recession periods to further investigate the impact of illiquidity and high-tech on reverse trend under different market environment.

The results presented in Table 3.5 indicate that the limited return reversal phenomenon that occurred during non-recession periods may mostly be caused by the low-liquidity and high-tech characteristics of those stocks, while the reversal pattern during recession periods would not be significantly affected by those characteristics.

We also compare the difference of coefficient and correlation across different characteristics, such as high-tech vs. normal firms by using TECH dummy variable and liquid vs. illiquid firms by using ZEROS (when the value of ZEROS is above the mean of ZEROS, we define that stock as an illiquid stock). The results are displayed in Table 3.6.

Table 3.6: Coefficient and Correlation of CAAR Before and After Lockup Expiration across Different Characteristics

	ZEROS		TECH	
	Liquid	Illiquid	High-Tech	Normal
Coefficient	-0.022	-0.008	0.027	-0.028
Correlation	-0.016	0.006	0.018	-0.013

This Table illustrates the difference of coefficient and correlation of CAAR before and after lock-up expiration across stocks in different level of liquidity and technology potential. Liquid represents the stocks that have ZEROS smaller than the average, while illiquid represents the stocks with ZEROS larger than the average. High-Tech represent the firms within technology-related industry.

The stocks with more liquidity will have more ability to reverse after the lock-up expiry day, while the high-tech firms will reveal less reversal after lock-up expiration.

Since [Brav et al. 2000] who attempts to model the determinants of the length of the lock-up period, has found that the firms with greater information asymmetries accept longer lock-up, we expand our research on return reversal by discussing whether the length of lock-up period will have any impact on return turnover after the lock-up expiry date.

As suggested by [Brav et al. 2000] concludes that the firms with great information asymmetry will use longer lock-up period lengths. Therefore, we shall observe a more negative coefficient or correlation among firms with longer lock-up period, which means more dramatic return reverse tendency will occur after lock-up expiration for firms with greater information asymmetry.

We investigate the extent of the return reverse after lock-up expiration across different lock-up period. Hence, we expect stocks with longer lock-up period to experience larger reverse as stocks with great information asymmetries will be

more sensitive to lock-up expiration. Then they will perform a more than expected drop on lock-up expiry day and hence a sharp reverse to reveal the true value of stocks after lock-up expiration.

We first divide our sample into a subsample of stocks with lock-up lengths longer than 180 days, a subsample of stocks with lock-up lengths equal to 180 days, and a subsample of stocks with lock-up lengths shorter than 180 days for detecting differences in return reverse degree due to differences in lock-up length.

Table 3.7: Coefficient and Correlation of CAAR Before and After Lockup Expiration across Different Lockup Period Length

Lockup Period	< 180	= 180	> 180
Coefficient	-0.006	-0.011	-0.025
Correlation	0.005	-0.001	-0.014

This Table illustrates the difference of coefficient and correlation in abnormal returns across stocks with shorter or longer lock-up period. The stocks with lock-up length more than 180 days defined as stocks with longer lock-up length. In contrary, the stocks with lock-up length less than 180 days defined as stocks with shorter lock-up length.

Table 3.7 demonstrates the coefficient and correlation of cumulative abnormal returns before and after lock-up expiration across stocks with different lock-up lengths.

The coefficient and correlation both become more negative for stocks with longer lock-up period lengths, which indicates that stocks with longer lock-up periods will be more likely to experience return reverse trend after the lock-up expiry date.

Therefore, in this section, we have discovered that the IPOs with more liquidity or longer lock-up periods will be more likely to reverse and those illiquid stocks, high-tech related stocks, or stocks with shorter lock-up length will be less likely to rebound.

3.4.3 Robustness Test

In order to investigate whether the abnormal return reverse results after lock-up expiration is due to the benchmark selection and event window length for calculating the cumulative abnormal return, in this subsection, we repeat the analysis by using different benchmark returns and different event windows.

As mentioned in equation 3.2, we calculate the abnormal return by subtracting totally four different benchmark returns which are market portfolio return, market model return, fama french model return and carhart model return. The following Figures illustrate the cumulative average abnormal return across different periods by implementing different benchmark returns.

The following Figure 3.6 display the Cumulative Average Abnormal Return of IPOs over the 41 event days during 1990 to 2014 by using different benchmark returns.

The following Figures display the Cumulative Average Abnormal Return of IPOs by subtracting different benchmark returns during recession and non-recession periods. We use NBER monthly recession indicator to partition our sample into two subgroups and then calculate the CAAR of IPOs released from the lock-up agreement during Recession periods and Non-Recession periods. Figures are displayed in 3.7 and 3.8.

All the figures indicate that these four measurements of cumulative abnormal return have no significant difference. We still observe the huge decline of abnormal return before lock-up expiration, the mild reverse right after lock-up expiration and the dramatic rebound immediately after the lock-up expiry day during recession period. Therefore our results of return rebound tendency is robust under the aspect

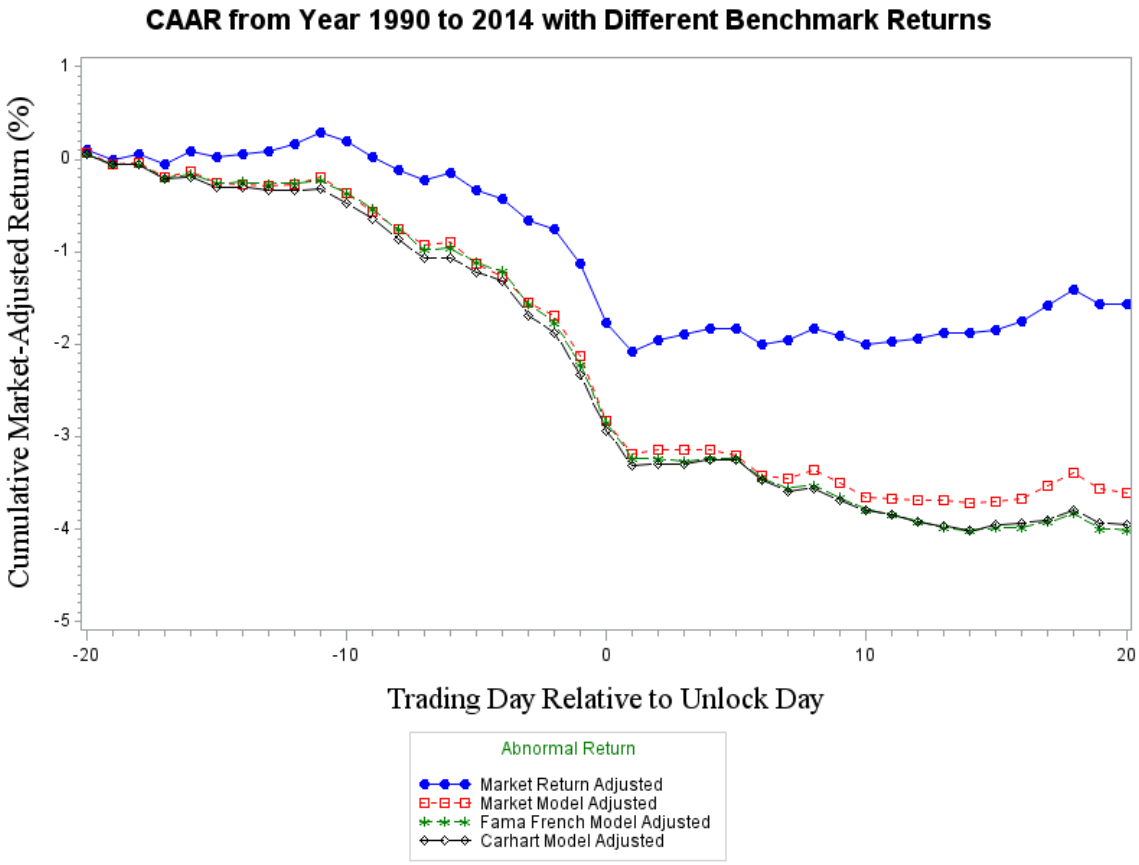

Figure 3.6: Cumulative Average Abnormal Return from Year 1990 to 2014 across Different Benchmark Returns

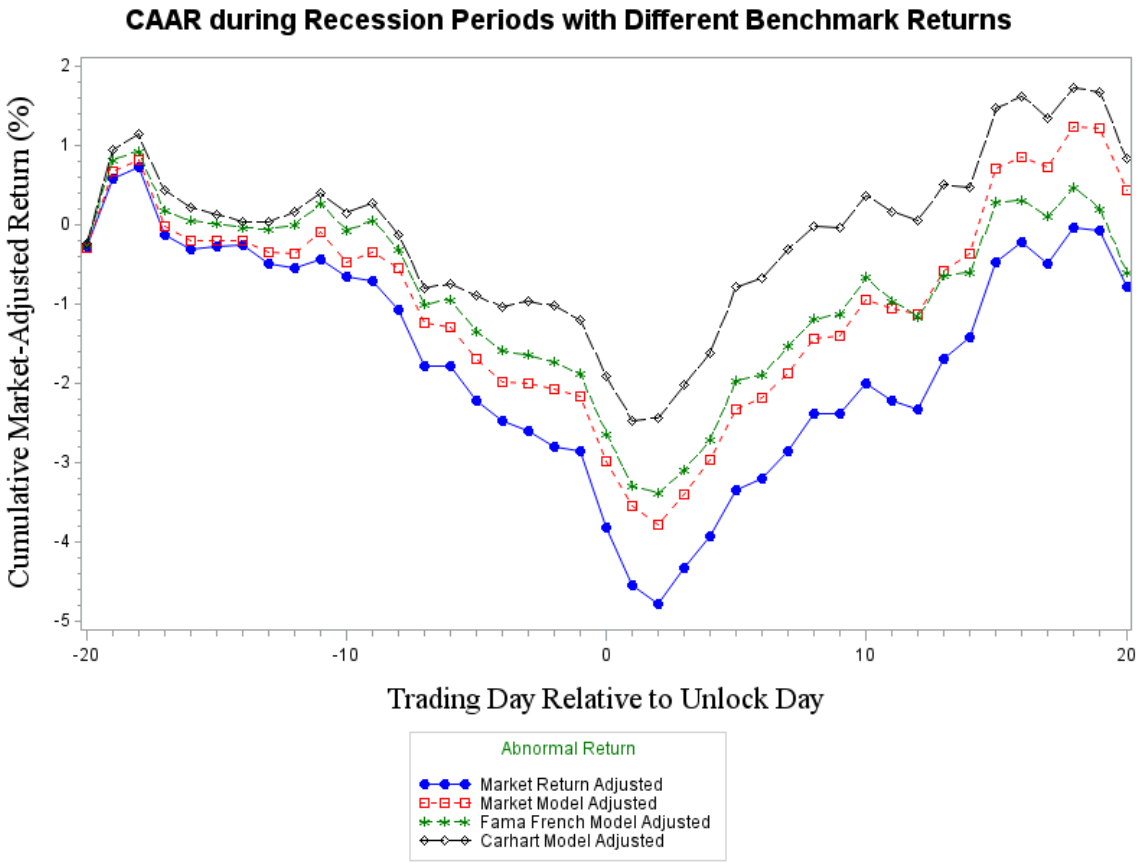

Figure 3.7: Cumulative Average Abnormal Return across Different Benchmark Returns during Recession

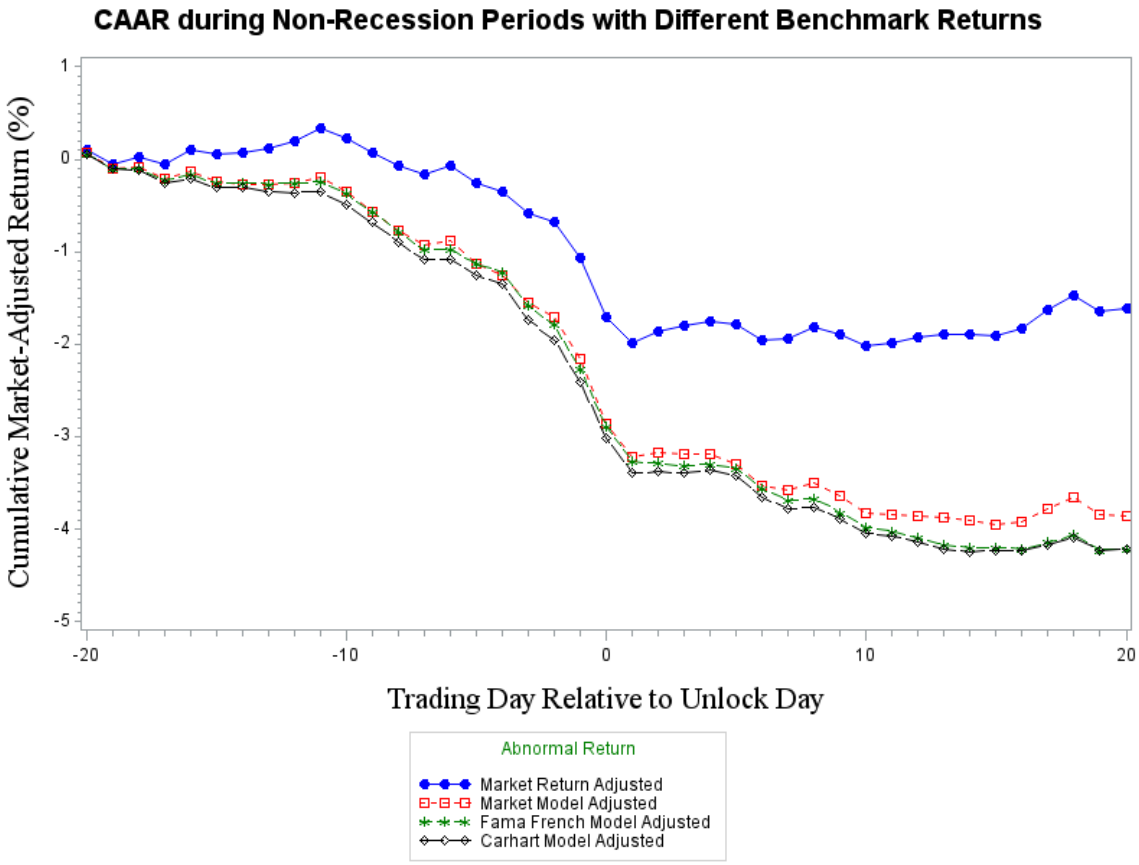

Figure 3.8: Cumulative Average Abnormal Return across Different Benchmark Returns during Non-Recession

of different measurements of abnormal return.

By applying a different event window length, we repeat the event study analysis and generate the coefficient and correlation of cumulative abnormal return before and after lock-up expiration. The results are displayed in Table 3.8

Table 3.8: The Relationship of Cumulative Average Abnormal Return Before and After Lockup Expiration

Event Window	Coefficient	Correlation
41 days	-1.76***	-0.86***
21 days	-2.28**	-0.62**
15 days	-0.39	-0.10

This Table represents the coefficient and correlation of cumulative average abnormal returns before and after lock-up expire date to illustrate the reverse tendency of abnormal returns after lock-up expiration by using different length of event window. Significant level: * significant at 10%; ** significant at 5%; *** significant at 1%

With 10 trading days around the lock-up expiry day and 7 trading days around the lock-up expiry day event study, the coefficient and correlation of cumulative abnormal return before and after lock-up expiration are still negative. And the decline of significance level may due to the smaller sample size by decreasing the length of event window. Therefore, overall we can declare that our results on the reversal tendency of IPOs abnormal returns after the lock-up expiry day are strong and robust.

3.5 Conclusion and Future Directions

In this Chapter, we confirm the phenomenon of IPOs abnormal return decline on the lock-up expiry day by using a more comprehensive dataset with a 25-year sample period. Across the 25 years, the abnormal returns for 80% of the sample period display a decreasing trend during lock-up expiration. Therefore, the abnormal return reducing trend on lock-up expiration is a general and universal phenomenon.

Then we expand the research on return changes during lock-up period to the next level by examining whether the decline tendency will be continued after lock-up expiration or reversed within few days after. The conclusion is that IPOs abnormal return will stop decreasing shortly after the lock-up expiry day. In addition, it will even rebound entirely to the level before lock-up expiration during special periods such as recession. These findings support the price pressure hypothesis during lock-up expiration since the lock-up expiry day event did not perform a permanent impact on the market value of firms.

Furthermore, we explore the characteristics that influence the extent of return reverse after the lock-up expiry day. The results indicate that return reverse trends do vary across different features of IPOs. Specifically, IPOs are more likely to experience return reverse tendency if they are liquidity stocks or have great information asymmetry.

Future work will mostly focus on providing more profound explanations of the reasons for the return reverse tendency and the extent to which the reverse varies across time.

Chapter 4

Conclusion and Future Research

This chapter concludes the thesis by providing a short summary of the work described in previous chapters, including the influence of short seller trading activity on the IPOs abnormal return during lock-up period and the return reverse tendency shortly after lock-up expiration. This is followed by a description of potential future research directions.

4.1 Conclusion

Our goal in this thesis is to investigate the trading behaviour of short sellers and the performance of IPOs during lock-up period.

Chapter 1 introduced this thesis by briefly describing the research problem, followed by the possible hypotheses. Since the information contained in the lock-up agreement is publicly available through SEC filling, news and analyst reports, the lock-up agreement will attract optimistic investors who trust that insiders are less able to take advantage of them within lock-up period.

Once the lock-up agreement expires, pessimistic investors enter the market and push down the over-valued stock price. A significant decline of stock abnormal return is a universal and permanent trend and is investigated in this thesis.

Chapter 2 studied the role of short seller and its relationship with stock return during the lock-up period. We use daily data from SEC for 359 IPOs during Regulation SHO period to examine the trading behaviour of short sellers surrounding lock-up expiration.

We find that transactions around lock-up expiration are associated with a substantial drop of abnormal returns. Furthermore, on the lock-up expiry day, the short selling positions reach the highest level, while the stock returns drop to the lowest.

By applying a panel regression method, we find that there is a highly significant predictability of short selling on future stock returns. It implies that short seller transactions during lock-up period contain information about IPOs future returns.

Furthermore, by separating our sample into subgroups based on several features of IPOs, we reveal that short seller trading activity has more influence and predictability over stocks with lower divergence of investor opinion.

Chapter 3 demonstrated the universality of IPOs abnormal return decline on the lock-up expiry day and the reversal tendency of IPOs abnormal return shortly after lock-up expiry day by using a dataset with a 25-year sample period.

By using the NBER monthly indicators, we revealed that during recession periods, the abnormal return rebounded dramatically immediately after the lock-up expiry day, while during non-recession periods, the abnormal return just stopped decreasing and experienced less of a reverse trend after lock-up expiration. Even though the abnormal return after the lock-up expiry day performed differently

across different periods and different characteristics of IPOs, eighty percentage of the sample period encountered a decline in the abnormal return on lock-up expiration.

Therefore, we concluded in Chapter 3 that the abnormal return decline is a universal phenomenon, but the trend does not be continued after lock-up expiration. The abnormal return of stocks with longer lock-up period, stocks with more liquidity and stocks being unlocked during recession periods are more likely to be reversed after lock-up expiration.

4.2 Future Research

For the future research, we will focus on:

- Explain why the efficient market hypothesis is not applicable to the lock-up expiry day event and why the market consistently fails to anticipate this event;
- Determine the role of analysts around lock-up expirations;
- Examine the resource of short sale position to further prove the role of short sellers in return decline phenomenon on lock-up expiry date;
- Investigate whether SEC should regulate this lock-up agreement in case of the early release of insider shares by underwriters.

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