# Short-Sale Constraints and the Idiosyncratic Volatility Puzzle: An Event Study Approach

Doran, James and Jiang, Danling and Peterson, David

Florida State University

7 August 2007

# Short-Sale Constraints and the Idiosyncratic Volatility Puzzle: An Event Study Approach*

James S. Doran†

Danling Jiang‡

David R. Peterson§

February 2, 2009

*We appreciate helpful comments and suggestions from Don Autore, Simon Gervais, David Hirshleifer, Irena Hutton, Sonya Lim, Jay Ritter, Sheridan Titman, and seminar participants at the University of Florida. We thank Kenneth French for making the Fama-French three-factor returns available online. All errors remain ours.

†Bank of America professor, The College of Business, Florida State University. (850)644-7868, jsdoran@cob.fsu.edu, http://www.jamesdoran.org/.

‡Contact author. Assistant professor, The College of Business, Florida State University. (850)645-1519, djiang@cob.fsu.edu, http://mailer.fsu.edu/∼djiang/.

§Wachovia Professor of Finance, The College of Business, Florida State University. (850)644-8200, dpeterson@cob.fsu.edu http://www.cob.fsu.edu/fin/vita/dpeterson.pdf.

# Short-Sale Constraints and the Idiosyncratic Volatility Puzzle: An Event Study Approach

**Abstract**

Using event studies, we show that short-sale constraints play an important role in the negative relation between idiosyncratic volatility and stock returns. We explore three exogenous events that change short-sale constraints: the IPO lockup period expiration, option introduction, and the recent short-selling ban on financial stocks. Following mitigation of short-sale constraints from the first two events, high idiosyncratic volatility stocks underperform low volatility stocks in the short and long run, and are associated with higher abnormal trading volume. Additionally, highly volatile financial firms experience greater price increases upon the short-sale ban enforcement and greater price drops upon the ban expiration.

[Keywords] Idiosyncratic Volatility, Short-Sale Constraints, IPO Lockup, Option Introduction, Short-Sale Ban

[JEL Classification] G12, G14, G18

# 1 Introduction

Traditional asset pricing theories predict that idiosyncratic risk should be either unpriced if it can be diversified away or positively priced if it is undiversifiable (Sharpe 1964, Merton 1987).[1] Recently, however, Ang, Hodrick, Xing, and Zhang (2006) document a strong negative relation between idiosyncratic volatility and stock returns, posing an interesting puzzle to traditional pricing theories.

One possible explanation is that high idiosyncratic volatility reflects strongly divergent beliefs of investors and noise trading, leading to stock overpricing when short sale constraints are binding (Miller 1977, Chen, Hong, and Stein 2002, Scheinkman and Xiong 2003). Consistent with this explanation, there is evidence that this negative volatility-return relation appears only among firms with large proportions of retail trading (noise) (Han and Kumar 2008) and only among those subject to binding short sale constraints (Boehme, Danielsen, Kumar, and Sorescu 2006, Duan, Hu, and McLean 2007). In particular, since short-sale constraints more likely bind for highly volatile (usually low-price and small) stocks, this negative relation is further strengthened. Therefore, it is crucial to understand to what extent short-sale constraints contribute to the idiosyncratic volatility puzzle.

Short sale constraints, in a broad sense, involve various limitations, costs, and risks of selling short (Lamont 2004). Theoretical work commonly models short-sale constraints as the limited ability of investors to sell short due to legal or institutional restrictions (Miller 1977, Harrison and Kreps 1978, Diamond and Verrecchia 1987, Chen, Hong, and Stein 2002, Bai, Chang, and Wang 2006, Xu 2007).[2] Empirical studies about idiosyncratic volatility, instead, mainly look for patterns of the volatility-return relation, conditioning on proxies for costs or degrees of difficulty to sell short. These proxies include, for example, firm size, institutional ownership, short interest ratios, and costs of borrowing stocks (loan

[1] Other models predicting a positive relation between returns and idiosyncratic risk include those derived by Barberis and Huang (2001), Jones and Rhodes-Kropf (2003), and Malkiel and Xu (2006).

[2] These model all assume that investors are banned from or have limitations on selling short.

fees).[3] However, these short-sale-constraint measures are also proxies for liquidity, investor sophistication, and shorting demand (stock overpricing).[4] As a result, findings based on these measures are often subject to multiple interpretations,[5] and accordingly, the extent to which short-sale constraints contribute to overpricing of high idiosyncratic volatility stocks remains inconclusive.

This paper attacks this issue using an event study approach. We analyze how exogenous shocks that mitigate or strengthen short-sale constraints affect the relation between idiosyncratic volatility and stock returns. Specifically, we study three events: the expiration of the IPO lockup period, the introduction of tradable options, and the imposition and expiration of explicit bans on short sales in September and October of 2008. Since these events mainly involve changes in regulations or institutional setups for restrictions in direct or indirect (short) selling, the short-term price reactions at the time of these events provide clean measures of the pricing effect of short-sale constraints as described in asset pricing models. Therefore, we can directly test the role of short-sale constraints in pricing idiosyncratic volatility.

During the IPO lock-up period, insiders and other pre-IPO stockholders typically cannot sell their shares for six months (Bradley, Jordan, Yi, and Roten 2001). The inability to sell owned shares is deemed the most stringent short-sale constraint (Ofek and Richardson 2003). Upon the IPO lockup expiration, investors are allowed to sell the locked-up shares and impound their negative information into the price. On the other hand, locked-up shares become lendable, making short-selling more feasible and less costly. Thus, the IPO lock-up period expiration introduces shocks to mitigate the constraints on selling short (Ofek and

[3]See Boehme, Danielsen, Kumar, and Sorescu (2006) and Duan, Hu, and McLean (2007).

[4]For instance, both the short interest ratio and the loan fee also capture investor demand to sell short the stocks (Asquith, Pathak, and Ritter 2005, Cohen, Diether, and Malloy 2007). Institutional ownership is not only a proxy for lendable shares (Nagel 2005), but is also a proxy for investor sophistication (Jiang, Xu, and Yao 2007) or informed institutional trading (Duan, Hu, and McLean 2007). Firm size is related to shorting costs as well as liquidity and information asymmetry.

[5]For instance, several papers find that the negative volatility-return relation is stronger among firms with low institutional ownership. However, Jiang, Xu, and Yao (2007) use institutional ownership to proxy for investor sophistication. Duan, Hu, and McLean (2007) use it to indicate informed/uninformed trading. Boehme, Danielsen, Kumar, and Sorescu (2006) use it for firm visibility and investor recognition.

Richardson 2003, Hong, Scheinkman, and Xiong 2006).

Option introductions provide another way to loosen short-sale constraints. Upon the introduction of tradable options, investors who face difficulty selling short underlying stocks can now alternatively sell short synthetically through the option markets (Figlewski and Webb 1993, Danielsen and Sorescu 2001). Such positions involve selling calls and buying puts, prompting market makers (who are commonly the counterparty) to hedge their positions through selling short the underlying security. Since market makers face fewer short selling constraints than regular retail/institutional investors (Evans, Geczy, Musto, and Reed 2008), the availability of tradable options effectively mitigates short sale constraints in the equity market. If high idiosyncratic volatility stocks are more overpriced, we expect them to experience more negative price reactions than less volatile stocks upon these two events as a result of mitigation of short-sale constraints.

Our results provide strong support for these hypotheses. Over the period 1988–2007, during a 21-day window surrounding the expiration of the lockup period, the value-weighted highest idiosyncratic volatility quintile of IPOs underperforms the lowest quintile by 13.09%. Over the period 1996–2006, for 61 days following the introduction of tradable options the value-weighted relative underperformance is 11.73%. The return patterns hold for alternative short-term event windows, alternative benchmark returns, and persist for 12 through 36 months after the events.[6] The effects are weaker for equal-weighted returns, which reflects the pattern documented by Ang, Hodrick, Xing, and Zhang (2006) that value-weighted volatile stocks underperform the most. In addition, for 21 days surrounding the event day, value-weighted highly volatile IPOs experience over two times the abnormal trading volume of less volatile stocks. For 61 days following option introduction, newly-introduced options for highly volatile stocks have relative volume almost eight times more than less volatile stocks.[7] Evidence from both returns and trading volume is consistent with the notion that

[6]We do not attribute the long-term price correction to the loosening of short-sale constraints. As suggested by Loughran and Ritter (1997), among others, the long-term abnormal returns are likely caused by the revelation of fundamentals that force optimistic investors to correct their beliefs.

[7]The relative volume is the volume of newly-introduced options on event stocks relative to the volume of

highly volatile, particularly big-cap, stocks are more overpriced at the time of the event, and this overpricing is partly caused by short-sale constraints impeding rational arbitrage.

The third event we study is the recent ban on short selling financial stocks amid the credit crisis in September and October, 2008. The pressure on financial stocks due to the excess leverage in credit positions during the subprime/housing market collapse led to significant price declines in these stocks. Before the implementation of the short-sale restriction around mid September, the financial sector had declined by over 35% for the year.[8] Over this period there were significant short positions taken in these stocks. Thus, the temporary short-sale ban on these financial stocks provides a natural experiment to test whether short sellers targeted and had a stronger price impact on more volatile (and thus more overpriced) financial firms. When the short-sale ban is enforced, short-sellers are forced to cover their short positions, which can drive up the prices of the "no-short" stocks in the face of a downward-sloping demand curve. If highly volatile stocks are more overpriced and thus more heavily shorted, then we expect their price appreciation to be greater due to the removal of more short sales from the market. In contrast, when the ban expires, we expect those short sellers to re-establish their short positions, pushing prices down, particularly among more overpriced high volatility stocks.

Consistent with our hypothesis, surrounding the enforcement of the ban, the value-weighted two-day returns of these "no-short" stocks (excluding low-price, thinly-traded stocks) is positive, 17.16%. Upon the expiration of the ban, the value-weighted daily return of the "no-short" stocks is negative, −5.12%. Furthermore, compared to the lowest idiosyncratic volatility quintile, the highest quintile responds 8.81%–14.08% more positively to the ban enforcement, and 0.22%–4.65% more negatively to the ban expiration. In addition, we show that short positions, as measured by short interest ratios, are indeed significantly greater among highly volatile financial stocks than less volatile ones before and after the ban period. Consistent with our earlier results, the results are all stronger among value-weighted

existing options on matched stocks with similar idiosyncratic volatility.

[8]Based on the year-to-date return of the XLF financial sector ETF.

returns. Taken together, our evidence provides strong support for short sellers having a substantial impact on the pricing of highly volatile stocks.

Previous literature (Field and Hanka 2001, Bradley, Jordan, Yi, and Roten 2001, Brav and Gompers 2003) documents negative abnormal returns and positive abnormal volume associated with IPOs upon the lockup expiration. We add to this research by showing that these negative price reactions are much stronger among firms with high idiosyncratic volatility, where the value-weighted negative price responses are one to three times larger. Our option introduction results also contribute to the debate about whether these events depress stock prices (Danielsen and Sorescu 2001, Mayhew and Mihov 2005, Blau 2008). We show that the negative price reaction, although insignificant for stocks in general, is fairly robust among those with high idiosyncratic volatility where they are three to fourteen times greater. Therefore, the reduction of short-sale constraints upon option introductions is substantial among highly overpriced securities. Moreover, after conditioning on idiosyncratic volatility, we show that the alphas of the trading strategies are improved by two to nine times based on the long-term performance following IPOs and option introductions. Therefore, our findings carry important practical implications.

This study is developed in the following sections. Section 2 presents the motivational literature and develops hypotheses. Data are described in Section 3. We provide the results from our empirical tests in Section 4. Section 5 contains a summary and conclusion.

# 2 Motivation and Hypotheses

## 2.1 The idiosyncratic volatility puzzle

Ang, Hodrick, Xing, and Zhang (2006) show that, with value weighting, a portfolio of low idiosyncratic stocks outperforms a portfolio of high idiosyncratic stocks by around 1% per month over the period 1963–2000, and that this finding cannot be explained by numerous firm-specific and macro-economic factors. They measure idiosyncratic volatility as the standard deviation of the residual returns from the regression of daily security returns within a

month on the Fama and French (1993) three-factor model and examine the cross-sectional return patterns in the subsequent months. Ang, Hodrick, Xing, and Zhang (2009) show that the underperformance of highly volatile stocks is a common phenomenon worldwide. The negative relation between idiosyncratic volatility and stock returns is at odds with traditional asset pricing theory. As Ang et al. state, "our results on idiosyncratic volatility represent a substantive puzzle."

Several studies respond to the idiosyncratic volatility puzzle. Using alternative measures of firm-specific volatility, Malkiel and Xu (2006), Spiegel and Wang (2006), Chua, Goh, and Zhang (2007), and Diavatopoulos, Doran, and Peterson (2008), and Fu (2009) find a positive relation between stock returns and alternative measures of idiosyncratic volatility.[9] These authors suggest that the measure of idiosyncratic volatility employed by Ang et al. (2006) may not adequately capture the expected idiosyncratic risk and, hence, Ang et al.'s results do not cause rejection of rational asset pricing models.

Some evidence suggests that the findings of Ang et al. (2006) do not hold for equal-weighted portfolio returns (Bali and Cakici 2007) and may be driven by the short-term reversal effect (Huang, Liu, Rhee, and Zhang 2006). Doran, Jiang, and Peterson (2008), however, show that once January is excluded, the negative volatility-return relation is fairly robust. This is because high idiosyncratic volatility stocks, particularly the small ones, earn abnormally high returns in January.

Nevertheless, the empirical findings of Ang et al. (2006, 2009) represent a trading strategy with abnormal returns, leading subsequent studies to focus on explaining why high volatility stocks earn abysmal returns. Jiang, Xu, and Yao (2007) suggest that the underperformance of highly volatile stocks is caused by the adverse selection of firms with poor future earnings. These firms tend to disclose less information, creating greater idiosyncratic volatility in

[9]Malkiel and Xu (2006) use size and beta sorted portfolios to estimate idiosyncratic volatility. Spiegel and Wang (2006) estimate it using E-GARCH models. Fu (2009) estimates the expected idiosyncratic volatility from exponential GARCH models. Chua, Goh, and Zhang (2007) find the expected component of idiosyncratic volatility, and Diavatopoulos, Doran, and Peterson (2008) estimate idiosyncratic volatility from the implied volatility of options.

returns. Kapadia (2006) and Boyer, Mitton, and Vorkink (2008) find that the negative relation between idiosyncratic volatility and returns is largely driven by a negative relation between skewness and returns.

Han and Kumar (2008) find that the negative volatility-return relation is only present among stocks actively traded by retail investors. Since retail investors are more likely to be uninformed and subject to behavioral biases, their evidence suggests that noise trading, defined as trading by uninformed investors acting as if they were given genuine information, plays an important role in this puzzle. Studies that involve short-sale constraints show that high idiosyncratic volatility predicts low returns only among highly shorted stocks (Duan, Hu, and McLean 2007), or highly shorted, but less visible, firms (Boehme, Danielsen, Kumar, and Sorescu 2006).

## 2.2 Heterogeneous beliefs and short-sale constraints

Several models suggest that idiosyncratic volatility is a proxy for investor disagreement and noise (overconfidence) trading. Miller (1977, 2001) suggests that volatility, or uncertainty about firm fundamentals, is positively correlated with investor differences of opinions. De-Long, Shleifer, Summers, and Waldmann (1990) show that noise trading produces excess volatility in stock markets. Behavioral models based on investor overconfidence by Odean (1998), Daniel, Hirshleifer, and Subrahmanyam (1998), and Scheinkman and Xiong (2003) also predict excess price volatility due to investor overconfidence, which is defined as investors overestimating the precision of cash flow signals. In these models, return volatility represents both cash flow volatility and the amount of noise (overconfidence) trading. The greater the volatility, the larger the asset mispricing (both underpricing and overpricing). Barberis and Xiong (2008) posit that investors experience positive utility when realizing trading gains, and thus are attracted to high volatility securities, causing overpricing and subsequent low returns on these securties.

When excess volatility, driven by divergence of opinion or noise trading, is further com-

bined with short-sale constraints, securities will on average be overvalued. For instance, in the model by Miller (1977), when short-sale constraints are binding, stock prices only reflect the beliefs of the optimistic investors and, hence, deviate above their fundamental values. Scheinkman and Xiong (2003) illustrate that, with short-sale constraints, heterogeneous beliefs due to overconfidence create an opportunity to sell at a higher price to others in the future. Therefore, investors are willing to pay more for shares, generating a price bubble. Hong, Scheinkman, and Xiong (2006) further show that when short-sale constraints are mitigated, such as when there is an increase in floating assets, a market bubble can burst. In these models short-sale constraints contribute to the upward bias in price that leads to low subsequent returns; mitigation of short-sale constraints can trigger the downward price adjustments to fundamentals.

## 2.3 Events that change short-sale constraints

The expiration of the IPO lockup period is a loosening of short-sale constraints. A share lockup represents the "most stringent form of short sale constraint" (Ofek and Richardson 2003), where insiders are not allowed to sell. Ofek and Richardson posit that the bursting of the Internet bubbles in late 1990's and 2000 are largely triggered by the expiration of large blocks of locked-up shares after the spring of 2000.[10] The model by Hong, Scheinkman, and Xiong (2006) further shows that an increase in floating assets, such as at the end of an IPO lockup, can cause price depreciation when pessimistic investors are able to sell. IPO evidence (Field and Hanka 2001, Bradley, Jordan, Yi, and Roten 2001, Brav and Gompers 2003) documents an average $-1\%$ to $-2\%$ cumulative abnormal return and 40% abnormal volume during short windows upon the IPO unlock-up.

In our setting, if highly volatile stocks are more overpriced and the demand curve for shares is downward sloping, the selling of insider shares should drive down the price more for highly volatile stocks.[11] Moreover, if insider selling occurs in a large amount upon the

[10] Battalio and Schultz (2006), however, suggest that short-sale constraints are not binding for the internet stocks in early 2000.

[11] Our tests only identify whether short-sale constraints make overpricing worse, but not whether short-sale

expiration date, we expect that trading volume to be even greater among high volatility IPOs than low volatility ones.

Empirical studies find that the introduction of options helps mitigate short-sale constraints.[12] For instance, option introductions tends to depress stock prices after 1981 (Sorescu 2000), are associated with increased short selling of underlying stocks (Figlewski and Webb 1993), and are linked to the extent to which stock price drops are related to contemporaneous increases in short interest (Danielsen and Sorescu 2001). With tradable options, short-sellers can establish synthetic short positions by selling calls and/or buying puts, forcing option market makers to hedge their positions through short sales of underlying securities. Options market makers are effectively allowed to sell short without borrowing the stock, and are thus important short sellers of hard-to-borrow stocks, driving down stock prices (Evans, Geczy, Musto, and Reed 2008). Thus, other things equal, optionable stocks should suffer less from short-sale constraints than non-optionable stocks. In our setting, we expect highly volatile stocks to experience greater price reductions from the mitigation of short-sale constraints upon option introduction. Moreover, since synthetic short selling involves trading both calls and puts, we expect the option volume following option introduction to be greater among highly volatile stocks.

We do not, however, expect all overpricing to be corrected immediately after the mitigation (not elimination) of short-sale constraints for at least two reasons. First, there are other forms of impediments to arbitrage, such as agency problems, holding costs of short positions, and noise trader risk (Shleifer and Vishny 1997). When arbitrage in general is limited, the full correction of mispricing demands irrational investors adjusting their beliefs in the face of substantive information about firm fundamentals, which takes time to reveal. Second, even when arbitrage has no limitations, average investors can have biased beliefs. When rational investors are risk averse as well, asset price reflects this average belief (Daniel, Hirshleifer,

constraints cause overpricing. Thus, the premise does not contradict to the argument of Battalio and Schultz (2006).

[12]Mayhew and Mihov (2005) and Blau (2008), however, find no consistent evidence that short-sale constraints are alleviated through option trading upon option introduction.

and Subrahmanyam 2001). As a result, highly volatile stocks can still be overpriced, and this overpricing will only correct itself in the long run with the revelation of fundamentals. Thus, we hypothesize that the price correction process occurs both in the short and long run.

The most explicit form of short-sale constraints is a short-sale ban. The recent short-sale ban amid the financial turmoil in September and October of 2008 provides an interesting setting to study the overpricing of high idiosyncratic volatility. On the September 17$^{\text{th}}$, the SEC issued an order (Release No. 34-58572) limiting the activity of naked short sales, and it became effective on Thursday, September 18$^{\text{th}}$ at 12:01 am.[13] The SEC stated, "*we are concerned about the possible unnecessary or artificial price movements based on unfounded rumors regarding the stability of financial institutions and other issuers exacerbated by 'naked' short selling.*" On September 18$^{\text{th}}$, the Financial Services Authority of the UK then imposed a ban on short-selling all United Kingdom financial stocks (Reference number FSA/PN/102/2008).[14] On that same day, US regulators followed suit and issued, after the closing bell, an emergency order (RELEASE NO. 34-58592) that prohibited short sales for 799 securities (mostly financial stocks).[15] Consequently, all individual investors were prohibited from short selling the stock of any financial firm and certain institutional investment managers were required to report short positions. The ban was in effect through October 8$^{\text{th}}$ and lifted at the opening bell on October 9$^{\text{th}}$. After the ban is enforced, we expect short sellers to be forced to cover their short positions, elevating prices, especially on highly volatile stocks. After the ban expires, we expect the opposite to happen; short sellers take new positions and drive down prices, again most strongly among highly volatile stocks. As evidence of short sellers targeting highly volatile stocks, we expect that highly volatile stocks should have a greater short interest ratio (the number of shares shorted as a percentage of shares outstanding) than less volatile stocks prior to and after the ban.

[13] See http://www.sec.gov/rules/other/2008/34-58572.pdf

[14] See http://www.fsa.gov.uk/pages/Library/Communication/PR/2008/102.shtml.

[15] See http://www.sec.gov/rules/other/2008/34-58592.pdf.

### 2.4 Hypotheses

To summarize, based on prior theoretical and empirical work, we develop the following three hypotheses:

H1: High idiosyncratic volatility stocks underperform their counterparts upon and following IPO lockup expiration and option introduction.

H2: High idiosyncratic volatility stocks are traded more around IPO lockup expirations, and the newly-introduced options on highly volatile stocks are traded more than those on less volatile stocks.

H3: High idiosyncratic volatility stocks outperform their counterparts upon enforcing the short-sale ban but underperform when the ban expires. High idiosyncratic volatility stocks are more heavily shorted (have higher short interest ratios) than low idiosyncratic volatility stocks prior to the ban enforcement and after the ban expiration.

## 3 Data

Our main sample includes all common stocks (share codes 10 and 11) listed on the NYSE, AMEX, and Nasdaq from July 1963 through December 2007. Stock returns and other stock trading data are obtained from the Center of Research in Securities Prices (CRSP). The book value of equity is from COMPUSTAT. The Fama-French factor returns are from Kenneth French's website.

Following Ang et al. (2006), we define the idiosyncratic volatility of a firm (IVOL) as the standard deviation of its daily residual returns from the Fama and French (1993) three-factor model, and we require at least 17 valid daily returns in a month to include the firm in the analysis for that month. Following Fama and French (1992), we define book-to-market equity (BM), used from July of year $t$ to June of year $t+1$, as the ratio of book equity as of December year $t-1$ over market equity (ME) at the end of December of year $t-1$. ME is the product of the stock price and shares outstanding. Share turnover (TURN) is the total

trading volume over a month divided by shares outstanding at the end of the month.[16]

Following Ofek and Richardson (2003), the event time of the expiration of the IPO lockup period is defined as the number of lockup days after the offer day of the IPO. We obtain 5389 IPOs with lockup expiration dates from the Securities Data Corporation (SDC) Global New Issues dataset over the period 1988—2007.[17] Among these IPOs, we identify 4128 event firms that have available monthly returns during the expiration month of the IPO lockup period in our sample. The lockup expiration date is defined as the IPO offer date plus the number of lockup days. Field and Hanka (2001) report that the error rate of the lockup days from SDC is modest at 3%. Thus, the lockup expiration date is considerably reliable.

Option data from 1996 through 2007 are obtained from OptionMetrics. The event day of option introductions is defined as the day when options of an underlying stock first appear in the OptionMetrics database. We require the event stock to have returns in our main sample at the month of the option introduction. The final sample contains 3034 option introductions.

Stock trading data from August through October, 2008, are collected from finance.yahoo.com and money.msn.com. Short interest and shares outstanding are obtained from ShortSqueeze.com, which is a private company that provides short interest data for all publicly traded stocks in the US. The stock tickers in the "no-short" list are from SEC release NO. 34-58592. There are 799 financial firms on the list. We exclude firms with stock prices less than $2.50, and firms with less than 1000 shares traded in each of the three event days (September 18, 19, and October 9) to avoid excess impacts from market microstructure issues, such as the bid-ask spread.[18] In addition, we exclude firms that are (1) on the list of REG 25 (Release No. 58190), which was issued on July 18$^{th}$, 2008, and enforced stringent rules on the short sales on 20 prominent financial stocks,[19] (2) involved in government bailouts or mergers and

[16]To account for the double counting problem with NASDAQ firms (e.g., Atkins and Dyl (1997)), their trading volume reported in CRSP is divided by two.

[17]The lockup period data are available on SDC beginning in 1988.

[18]Changing the criteria on stock prices and trading volume can sometimes strengthen the results for equal-weighted returns upon the ban expiration, but has relatively small impacts on value-weighted returns.

[19]See http://www.sec.gov/rules/other/2008/34-58190.pdf.

acquisitions, including Wachovia (WB), Washington Mutual (WM), and AIG, and (3) explicitly petitioned to be removed from the ban list.[20]. The purpose is to identify a sample of firms that are not impacted by firm-specific regulatory events other than the short-sale ban issued on September 18. But keeping those firms in the sample does not qualitatively change our results. Our final sample includes 542 stocks.

[INSERT TABLE 1]

We report the summary statistics of firm characteristics in Panel A of Table 1. For the full sample of firms, idiosyncratic volatility (IVOL) is on average 3.52% per day, or 55.88% per annum. It is higher in more recent years and for the IPO and option samples. The full sample is also smaller and has a lower book-to-market ratio than the more recent samples, including IPOs and new-optionable firms. Panel B reports the distribution of the number of IPO lockup days for the IPO sample. The lockup periods range from 90 to 1095 days, with an average of 210 days and a median of 180 days. These numbers are consistent with prior research (e.g., Bradley, Jordan, Yi, and Roten (2001)).

# 4 Results

In this section we first replicate prior results showing that the stocks with the highest idiosyncratic volatility underperform low volatility stocks only when portfolios are value-weighted. We then test the three hypotheses developed in Section 2 and demonstrate how short-sale constraints affect the negative volatility return-relation.

## 4.1 Portfolio returns and idiosyncratic volatility

[INSERT TABLE 2 HERE]

Each month we sort stocks based on idiosyncratic volatility (IVOL), estimated in month $t-1$, into quintiles and compute the average value- and equal-weighted returns of each

[20]REG34 allows firms to remove themselves from the no-short list. These firms included AMB, JMP, NITE, ACAP, GLRE, DHIL as of September 30. The AMEX compiled the list of firms that requested being taken off the "no-short" list.

quintile for the subsequent month. We form hedging portfolios (H−L) that are long the highest and short the lowest IVOL quintiles and compute mean returns and alphas from the Fama and French (1993) three-factor model. Results are presented in Table 2 for the full sample period, 1963—2007, the period that we study IPO lockup expirations 1988—2007, and the period that we study option introductions, 1996–2007.

For the full sample period the value-weighted return of the highest IVOL quintile underperforms the lowest IVOL quintile by 0.95% per month ($t = -2.94$), which is similar in magnitude to the 1.06% per month reported by Ang et al. (2006) for the period 1963—2001 and the 0.93% per month reported by Bali and Cakici (2007) for the period 1963—2004. In contrast, the underperformance is absent for equal-weighted returns; the highest IVOL quintile outperforms the lowest IVOL quintile by 0.05% per month ($t = 0.15$), which is similar in magnitude to the 0.02% per month documented by Bali and Cakici. Consistent with prior studies, the negative return differential of H−L is robust to controls for the Fama and French (1993) three-factor model. Results for the two subperiods are similar to the full period except that the value-weighted mean H−L return is insignificant for the period 1996–2007.

## 4.2 IPO lockup expiration and option introduction

We now turn to Hypothesis 1, which predicts that mitigation in the degree of short-sale constraints from the IPO lockup expiration or the option introduction should strengthen the negative volatility-return relation, at least in the short term. We examine the short-run and long-run abnormal return performance of stocks with different idiosyncratic volatility around and after the two events.

### 4.2.1 Return performance around and after events

Following Ofek and Richardson (2003) and others, we compute cumulative abnormal returns (CARs) for trading day intervals (−1, 1), (−3, 3) and (−10, 10) for the IPO sample, where day 0 is the date of lockup expiration, and a daily abnormal return is defined as a stock's

return minus the CRSP value-weighted market index return.[21] To examine the long-term performance, we compute buy-and-hold abnormal returns (BHARs) for 12 calendar months subsequent to the end of the IPO lockup period, where a BHAR is defined as the difference between the buy-and-hold return of the event stock and the buy-and-hold return on a matched portfolio selected from 25 value-weighted size-BM portfolios.[22] These benchmark portfolios are formed each month.[23] CARs and BHARs are both value- and equal-weighted. We also form calendar time portfolios to examine the long-term performance of event firms.

We sort all event firms into quintiles according to an adjusted idiosyncratic volatility, AIVOL, at the end of the month prior to the event, where AIVOL is defined as the difference between IVOL and the equal-weighted IVOL across all available firms in a given month. This adjustment is made to account for the upward time trend in idiosyncratic volatility, as shown by Campbell, Lettau, Malkiel, and Xu (2001).[24] We then report the average CARs or BHARs, for each of the five AIVOL quintiles, across the different event windows.

Relative to the lowest IVOL quintile, we expect the highest IVOL quintile to have worse performance around and subsequent to the events, representing the correction of part of the overpricing when short-sale constraints are relaxed. We report H−L portfolio returns and the two-tailed bootstrapped $t$-values. The results are provided in Panel A of Table 3 for lockup expiration and in Panel B for option introduction. We plot in Figure 1, for the lowest and highest AIVOL quintiles, both value- and equal-weighted BHARs through the 12 months subsequent to lockup expiration (Panel A) and option introduction (Panel B).

[INSERT TABLE 3 and FIGURE 1 HERE]

For the full IPO sample, the value-weighted CAR ranges from −1.57% to −2.78% for the three event windows. Equal-weighted CARs are less negative. This is consistent with

[21] Similar results are obtained when we define CARs as the cumulative differences between stock returns and the expected returns from a market model, or relative to the equal-weighted market index returns.

[22] The results are stronger using size-adjusted returns.

[23] The IPOs are matched with the benchmark portfolios according to the market cap for the month before the lockup expiration. The stocks with option introduction are matched according to the market cap for the most recent June.

[24] Subtracting the equal-weighted IVOL from firms' IVOL eliminates the time trend in the aggregate IVOL. However, subtracting the value-weighted IVOL does not.

prior literature (Field and Hanka 2001, Bradley, Jordan, Yi, and Roten 2001, Brav and Gompers 2003) that documents negative price reactions around −1% to −2% surrounding the IPO lockup expiration. More importantly, we show that this value-weighted negative price reaction is concentrated among the highest AIVOL quintile of IPOs.

Consistent with Hypothesis 1, around and after the lockup period expiration the CAR differentials between the highest and the lowest AIVOL quintiles of IPOs are all negative. For example, for value-weighted CARs the range is from −1.89% to −13.09% for all three intervals, and all are statistically significant at the 1% level. Equal-weighted CARs are weaker, with values between −0.31% to −2.65%. This is consistent with observations that equal-weighted high IVOL stocks do not significantly underperform on a regular basis.[25] Thus, relaxation of short-sale constraints should have a much smaller effect on the volatility-return relation among small stocks. Overall, we find that the value-weighted negative price reaction is 1.71 to 4.47 times higher for the highest idiosyncratic volatility IPOs than for all IPOs. This is a novel finding for IPO lockup expirations.

After the expiration the value-weighted and equal-weighted H−L BHARs are highly negative and statistically significant.[26] Over the 12-month period following the lockup expiration, the BHAR is −21.34% ($t = -4.78$) for the value-weighted H−L portfolio and −12.68% ($t = -2.84$) for the equal-weighted one. This evidence is again consistent with the notion that highly volatile IPOs are more overpriced and the lockup expiration triggers the long-term correction of overpricing.

For option introductions, we examine the CARs for intervals of (0, 20), (0, 40), and (0, 60), where day 0 is the day the options first trade. We investigate event windows after introduction because synthetic short-selling would not occur until options become available.[27]

[25]Consistent with Doran, Jiang, and Peterson (2008), we find that excluding January returns significantly strengthens the underperformance of equal-weighted CARs on high AIVOL IPOs. For brevity, these results are not reported here and available upon request.

[26]In unreported analyses we do not find substantial changes in IPO idiosyncratic volatility after the lockup expiration. While we observe some regression-to-the-mean effect for idiosyncratic volatility, the rank based on IVOL across firms remains relatively stable for at least 12 months after the lockup expiration.

[27]In contrast, some insider selling can occur a few days prior to lockup expiration because the lead underwriters are allowed to release locked-up shares early (Brav and Gompers 2003).

Results are similar to those for IPO lockup expirations. The stocks with option introductions experience a value-weighted CAR between −0.10% and −2.18%. Again, the equal-weighted CARs are less negative. The results are consistent with Danielsen and Sorescu (2001), who find that after 1981, stocks with option introductions tend to underperform.[28] More importantly, we show that the negative price reactions are concentrated among the highest AIVOL quintile of stocks; these stocks experience a value-weighted average CAR between −1.48% and −9.93%, and all are statistically significant at the 5% level.

Consistent with Hypothesis 1, value-weighted H−L CARs between the highest and lowest AIVOL quintiles are negative and significant in all three event windows, with values between −2.45% and −11.73%. Equal-weighted H−L CARs are closer to zero than value-weighted CARs. H−L BHARs are negative and highly significant for both value and equal-weighted returns. In sum, the negative price reaction among the highest AIVOL quintile is substantially greater than the lowest AIVOL quintile and all stocks with option introductions.

Overall, our results are consistent with Hypothesis 1. For both the ending of the IPO lockup period and option introduction, we find that high idiosyncratic volatility firms substantially underperform low volatility firms around and following these events. This suggests that mitigation of short-sale constraints causes greater price corrections on more highly volatile stocks. The long-term abnormal returns further confirm that high idiosyncratic volatility stocks are more overpriced at the time of the event.

### 4.2.2 Stock and option trading volume

As Ofek and Richardson (2003) note, an IPO lockup represents an extreme form of short-sale constraint because investors cannot sell their shares even when they hold a pessimistic view of the stock. After the lockup period ends, we expect pessimistic shareholders to sell their shares, causing a downward price correction and high abnormal trading volume, particularly

[28]It is worth noticing that the negative price reactions of all option introduction event stocks are mixed in statistical significance. The results are stronger for value-weighted CARs and for longer event windows. Therefore, whether option introductions reduce short-sale constraints of event stocks as a whole may be subject to further debate (e.g. Mayhew and Mihov (2005) and Blau (2008)). But, the focus of the current paper is the cross-sectional difference in price reactions across idiosyncratic volatility.

on highly volatile stocks. Additionally, Ofek, Richardson, and Whitelaw (2004) show that a portfolio that is short stocks with high short-sale constraints, proxied by the magnitude of the violation of put-call parity, has a significantly positive alpha. While shorting these stocks may not be possible, the introduction of options allows the creation of a synthetic short position to form the position. Thus, our Hypothesis 2 suggests that we expect to observe greater option trading volume on highly volatile stocks.

For each IPO, following Ofek and Richardson (2003), we measure excess trading volume as the percentage change of the average daily turnover around the lockup expiration over the trading day windows (−1, 1), (−3, 3), and (−10,10) from the average daily turnover over a base period prior to the event (−60, −20). We expect the excess trading volume to be positive and highly among high volatility stocks.

The abnormal trading volume measure is constructed differently for option volume for two reasons. First, because no prior option volume exists, we cannot compute the change in option volume relative to its historical level. Instead, we have to use a contemporaneous benchmark. Second, prior research (e.g., Mayhew and Mihov (2004)) shows that option volume is positively related to the volatility of underlying stocks. Thus, it is important to control for the effect of volatility on option volume. We address the two issues by matching the event stocks with a group of benchmark stocks with similar volatility and existing options. Specifically, for each stock with an option introduction, we define the relative option volume ratio as the ratio of the average daily option volume for that stock during the trading-day windows (0, 20), (0, 40), and (0, 60) over the average daily option volume for a group of benchmark stocks over the same window, where the benchmark group refers to all optionable stocks with the same idiosyncratic volatility quintile rank that have options introduced at least 36 months ago.[29] We employ the same AIVOL quintiles as with returns and report the value- and equal-weighted abnormal turnover across the AIVOL quintiles. We also report H−L differences and their bootstrapped t-values. IPO lockup expirations and option

[29]The ranks are determined by the breakpoints using all stocks in a given month.

introductions are in Panels A and B of Table 4, respectively.

[INSERT TABLE 4 HERE]

Similar to Field and Hanka (2001), we find positive excess trading volume, from 35% to 66%, around the IPO lockup expiration. The excess trading volume is smaller when the event window becomes wider, indicating that the excess trading is concentrated around the event day. More importantly, in all cases the excess stock trading volume is greatest among the highest AIVOL quintile of IPOs. All H−L abnormal volumes in Panel A are positive. All are highly significant except for the IPOs for the two earlier periods with equal weighting. In particular, for the event window (−10, 10), the value-weighted excess volume of the highest AIVOL quintile is 66%, which is 40% higher than that of the lowest quintile, 26%. This abnormal turnover evidence, along with the prior return evidence, supports the hypothesis that trading of highly volatile stocks responds more than that of low volatility stocks surrounding the IPO lockup expiration.

The results for the option volume are similar to the findings following the ending of the IPO lockup. The relative option volume ratio is highest for the highest AIVOL quintile, especially when value-weighting. The H−L abnormal volumes in Panel B are all positive, with significant value-weighted differences for all three periods. The only equally-weighted differences that are significant are for the longest event window. The volume for all new option introductions is less than the benchmark group, but does increase with time. As Mayhew and Mihov (2004) posit, since exchanges choose options based on the anticipated trading demand, the options that are listed earlier should have higher trading volume than newly-listed ones. Our findings confirm this. More importantly, we find that the relative option volume ratio is highest and the increase in trading volume is the largest among options of highly volatile underlying stocks. For instance, with value-weighting, the highest AIVOL quintile of stocks has a relative option volume ratio of 0.31, 0.78, and 0.93 over the three event windows, while the three numbers are 0.09, 0.11, and 0.12 for the lowest quintile, with the differences highly significant ($t$-statistics greater than 9).

In other words, controlling for the effect of volatility on option volume, the options on the most volatile stocks are almost eight times higher than on the least volatile stocks. Overall, consistent with Hypothesis 2, our evidence suggests that if option introductions depress stock returns and increase option trading volume through allowing synthetic short selling, then these effects are most prominent among highly volatile stocks.

### 4.2.3 Calendar-time portfolios

Schultz (2003) shows that the results from BHARs can be misleading if there is a pseudo market timing issue. Fama (1998) argues that the calendar-time portfolio methodology provides better test statistics for long-run abnormal return estimates than the BHAR methodology.[30] To assess the robustness of our long-run performance results, we form calendar-time portfolios that include firms that have the IPO lockup period end or options introduced in the prior 36 months.[31] In each month we sort stocks that have events occurring in the most recent 36 months into terciles based on their IVOL measured at the end of the prior month, and then compute both value-weighted and equal-weighted portfolio returns. We examine whether highly volatile IPOs underperform more subsequent to the lockup expiration and whether highly volatile option introduction firms underperform more subsequent to option introduction. To fully explore profitable trading strategies, we exclude January returns because the volatility-return relation is reversed, driving returns in the opposite direction of our strategy.[32] In Table 5 we report the results of regressing the excess monthly returns for each tercile and the H−L portfolios on the Fama and French (1993) three factors. IPO firms are in Panel A and option introduction firms are in Panel B. We expect the intercepts of the highest IVOL portfolios and those of the H−L portfolios will be negative.

[INSERT TABLE 5]

[30]Loughran and Ritter (2000), however, suggest that when misvaluation is time-varying, the calendar-time portfolio approach may reduce the power to detect misvaluation.

[31]We choose to report the results based on 36-month long-run performance because the long horizon ensures that each IVOL portfolio is well-diversified. The results based on 24-month or 60-month long-run performances are qualitatively similar.

[32]The negative H−L alphas remain after including January months, but not they are not statistically significant except for the value-weighted IPOs.

There is strong evidence for the underperformance of highly volatile stocks subsequent to the expiration of the IPO lockup period and the introduction of options. The intercepts of the highest IVOL tercile are negative and highly significant, as are the intercepts of the H−L portfolios. Monthly Fama and French (1993) alphas are approximately 1% following option introduction and range from 1% to almost 2% for IPO lockup expiration. Thus, the abnormal returns are both economically and statistically significant. Compared to all IPOs or stocks with option introductions, the alphas on the highest IVOL group are substantially (one and one-half to eight times) larger. For example, value-weighted all IPOs produce an alpha of −0.20%, while the highest IVOL group has an alpha of −1.57%. Similarly, with value weighting the highest IVOL stocks with option introductions yield an alpha that is over three times higher than for all stocks with option introductions. These results are consistent with the findings for BHARs in Table 3 and imply profitable trading strategies.

## 4.3 Short-sale ban on financial firms

Finally, we test the price reactions to the short-sale ban enforcement and subsequent expiration in 2008. For each stock in our sample, average daily returns are calculated for the two-day announcement window, September 18$^{\text{th}}$ and 19$^{\text{th}}$, the subsequent thirteen days the ban was enforced, and the day after the ban expiration, October 9$^{\text{th}}$. A two-day window for the ban enforcement is used because of the initial issuance by the SEC to limit naked short sales on September 18$^{\text{th}}$ at 12:01 am, the FSA ban of British financials on the same day, and the actual ban on the 799 financial firms was enacted at the close on September 18$^{\text{th}}$.

Similar to the end of the IPO lockup period and the option introduction, IVOL is calculated using a Fama-French three-factor model with at least 17 daily returns over the window $(-41, -11)$, where day 0 is September 18$^{\text{th}}$. We then sort all event firms into quintiles according to IVOL. Based on Hypothesis 3, we expect that the highest IVOL firms will significantly outperform the lowest IVOL firms on the two days of the ban enforcement, and significantly underperform on the day of the expiration of the ban. We calculate returns for

each quintile and for the H−L difference. Bootstrapped t-values are presented for the H−L returns. The results are reported in Table 6, Panel A, and plotted in Figure 2.

[INSERT TABLE 6 AND FIGURE 2]

Consistent with the idea of a downward-sloping demand curve, the enforcement of the short-sale ban causes an instant upward price move. The value-weighted two-day return is 17.16% and the equal-weighted return is 17.34% (the return is similar for each of the two days), suggesting substantial price impacts by removing short sellers from our sample firms. In contrast, the lifting of the ban causes a negative price impact, −5.12% for value-weighted and −10.69% for equal-weighted returns. During the window when the ban is effective, the cumulative return on our sample firms is more negative (over −20%), which reflects the deteriorating fundamentals and worsening uncertainty of the macro-economic environment of that period.[33]

Supporting our Hypothesis 3, on the two days of the ban, the value and equal-weighted H−L returns are 14.08% and 8.81%, respectively, and both are statistically significant. The value and equal-weighted H−L returns on the day after the expiration of the ban are −4.65% and −0.22%, respectively, and the former is statistically significant. The H−L returns are insignificant in the middle period, implying that the differing effect of the ban across volatility groups is only temporary.

Next, we test whether short sellers targeted highly volatile (thus, more overpriced) stocks before and after the short-sale ban. The purpose is to provide evidence that the short-sale ban causes greater price impacts by removing more short positions off the market. Based on Hypothesis 3, we expect the highest IVOL quintile to have a greater short interest ratio than the lowest quintile prior to the ban enforcement and after the ban expiration.

[33]The results are similar to the overall performance of financial stocks during these windows. For instance, the financial sector ETF, XLF, experienced returns of 20.65%, −30.38%, and −12.13% in the three windows, respectively. The results are also consistent with the media consensus that the short-sale ban failed to stop price declines on financial stocks. Even SEC Chairman Christopher Cox publicly acknowledged that the biggest mistake of his tenure was agreeing in September to an extraordinary three-week ban on short selling of financial company stocks and that this ban was not productive. See "SEC Chief Defends His Restraint," by Amit R Paley and David S. Hilzenrath, *Washington Post*, December 24, 2008.

Short interest data are released twice a month on scheduled dates at 4:30 pm Eastern Time for NASDAQ stocks and by midnight for NYSE and AMEX stocks. The required report dates, settlement dates, and trade dates are usually a few days earlier than the release dates, with the trade dates earliest among the three. Since we are interested in the actual short positions taken prior to September $18^{\text{th}}$ and after October $9^{\text{th}}$, we choose to report the data on the latest trade date prior to the ban enforcement, September $10^{\text{th}}$ (which is released on the $24^{\text{th}}$), and the earliest trade date following the ban expiration, October $9^{\text{th}}$ (which is released on November $11)^{\text{th}}$. Since the later trade date coincides with the date of the ban expiration, we also report the short interest ratios on October $28^{\text{th}}$ (with the release date November $11^{\text{th}}$) to account for the possibility that short positions taken on October $9^{\text{th}}$ are reported in the later date. We report the percentage short interest ratios for all event stocks and across the IVOL quintiles in Panel B of Table 6, together with the test of the H−L differences.

The evidence in Panel B strongly supports Hypothesis 3 that short positions are heavily taken on volatile, particularly large-cap, stocks. All H−L short interest ratios are positive and they are highly significant for value-weighted results; the short interest ratio of the highest IVOL quintile is on average five times of that of the lowest quintile. For instance, as of September $10^{\text{th}}$ prior to the ban, the value-weighted short interest ratio is 15% in the highest IVOL quintile but only 3.09% in the lowest quintile. These two numbers are 11.77% and 2.17%, respectively, on October $9^{\text{th}}$, right after the ban was lifted. This pattern persists on October $28^{\text{th}}$. Equal-weighted results are weak, which is consistent with our return findings: the differential price impacts across IVOL groups are concentrated among large firms. Overall, these results on the enforcement and expiration of ban are consistent with our hypothesis and demonstrate that the effect of short-sale constraints contributes to the negative volatility-return relation.

# 5 Summary and Conclusion

Through the use of event studies, we provide novel evidence showing that relaxing or strengthening of short-sale constraints affects the negative volatility-return relation. When short-selling constraints are mitigated at the end of the IPO lockup period, highly volatile stocks experience a substantially worse short-run and long-run abnormal performance than low volatility stocks. Similar results are found for stocks with option introductions. The abnormal returns associated with high idiosyncratic volatility stocks are much more negative than those previously documented for all event stocks. Evidence from stock trading volume surrounding the IPO unlock-up and option trading volume following option introductions reveal significant more trading activities associated with high idiosyncratic volatility stocks.

We further show that during the short-sale ban of 2008, the importance of short-sale constraints on the temporary pricing of financial firms from September $18^{\text{th}}$ through October $9^{\text{th}}$. When the short sale ban was enforced, higher volatility stocks experienced stronger temporary price appreciation than lower volatility stocks; when the ban expired, the reverse held. Highly volatile stocks are heavily shorted prior to the ban and after the ban expiration.

Overall, our evidence suggests that short-sale constraints play an important role in the idiosyncratic volatility puzzle. It is worth remarking that our evidence does not identify whether binding short-sale constraints are the only source of overpricing of high idiosyncratic volatility. As suggested by prior theoretic work, both divergent investor beliefs and limits of arbitrage jointly determine asset mispricing. Short-sale constraints are only one form of such barriers to arbitrage. Our results only show that the extent to which short-sale constraints worsen the overpricing of highly volatile firms relative that of the less volatile firms is economically and statistically significant. As a result, reducing the barriers to short selling should enhance the efficiency of pricing high volatility stocks in the market.

# References


Ang, Andrew, Robert J. Hodrick, Yuhang Xing, and Xiaoyan Zhang, 2006, The Cross-Section of Volatility and Expected Returns, *Journal of Finance* 61, 259–299.

Ang, Andrew, Robert J. Hodrick, Yuhang Xing, and Xiaoyan Zhang, 2009, High Idiosyncratic Volatility and Low Returns: International and Further U.S. Evidence, *Journal of Financial Economics* 91, 1–23.

Asquith, Paul, Parag A. Pathak, and Jay R. Ritter, 2005, Short Interest, Institutional Ownership, and Stock Returns, *Journal of Financial Economics* 78, 243–276 Forthcoming.

Atkins, Allen B., and Edward A. Dyl, 1997, Market Structure and Reported Trading Volume: NASDAQ versus the NYSE, *Journal of Financial Research* 20, 291–304.

Bai, Yang, Eric C. Chang, and Jiang Wang, 2006, Asset Prices Under Short-Sale Constraints, Working paper, MIT.

Bali, Turan G., and Nusret Cakici, 2007, Idiosyncratic Volatility and the Cross-Section of Expected Returns, *Journal of Financial and Quantitative Analysis* forthcoming.

Barberis, Nicholas, and Ming Huang, 2001, Mental Accounting, Loss Aversion, and Individual Stock Returns, *Journal of Finance* 56, 1247–1292.

Barberis, Nicholas, and Wei Xiong, 2008, Realization Utility, Working paper, Princeton University.

Battalio, Robert, and Paul Schultz, 2006, Options and the Bubble, *Journal of Finance* 61, 2071–2102.

Blau, Benjamin M., 2008, Short-Sale Constraints, Listing Decisions, and Return Predictability around Option Introductions, Working paper, Brigham Young University.

Boehme, Rodney D., Bartley R. Danielsen, Praveen Kumar, and Sorin M. Sorescu, 2006, Idiosyncratic Risk and the Cross-Section of Stock Returns: Merton (1987) Meets Miller (1977), Working paper.

Boyer, Brian, Todd Mitton, and Keith Vorkink, 2008, Expected Idiosyncratic Skewness, Working paper, Brigham Young University.

Bradley, Daniel J., Bradford D. Jordan, Ha-Chin Yi, and Ivan C. Roten, 2001, Venture Capital and IPO Lockup Expiration: An Empirical Analysis, *Journal of financial research* 24, 465–492.

Brav, Alon, and Paul A. Gompers, 2003, The Role of Lockups in Initial Public Offerings, *Review of Financial Studies* 16, 1–29.

Campbell, John Y., Martin Lettau, Burton G. Malkiel, and Yexiao Xu, 2001, Have Individual Stocks Become More Volatile? An Empirical Exploration of Idiosyncratic Risk, *The Journal of Finance* 56, 1–43.

Chen, Joseph, Harrison Hong, and Jeremy C. Stein, 2002, Breadth of Ownership and Stock Returns, *Journal of Financial Economics* 66, 171–205.

Chua, Choong Tze, Jeremy Goh, and Zhe Zhang, 2007, Expected Volatility, Unexpected Volatility, and the Cross-section of Stock Returns, *Journal of Financial Research* forthcoming.

Cohen, Lauren, Kaul B. Diether, and Christopher J. Malloy, 2007, Supply and Demand Shifts in the Shorting Market, *Journal of Finance* 62, 2061–2096.

Daniel, Kent, David Hirshleifer, and Avanidhar Subrahmanyam, 1998, Investor Psychology and Security Market Under- and Overreactions, *Journal of Finance* 53, 1839–1886.

Daniel, Kent, David Hirshleifer, and Avanidhar Subrahmanyam, 2001, Overconfidence, Arbitrage, and Equilibrium Asset Pricing, *Journal of Finance* 56, 921–965.

Danielsen, Bartley R., and Sorin M. Sorescu, 2001, Why Do Option Introductions Depress Stock Prices? An Empirical Study of Diminishing Short-Sale Constraints, *Journal of Financial and Quantitative Analysis* 36, 451–484.

DeLong, J. Bradford, Andrei Shleifer, Lawrence Summers, and Robert J. Waldmann, 1990, Noise Trader Risk in Financial Markets, *Journal of Political Economy* 98, 703–738.

Diamond, Douglas W., and Robert E. Verrecchia, 1987, Constraints on Short Selling and Asset Price Adjustment to Private Information, *Journal of Financial Economics* 18, 277–311.

Diavatopoulos, Dean, James S. Doran, and David R. Peterson, 2008, The Information Content in Implied Idiosyncratic Volatility and the Cross-Section of Stock Returns: Evidence from the Option Markets, *Journal of Futures Markets* 28, 1013–1116.

Doran, James S., Danling Jiang, and Dave R. Peterson, 2008, Gambling in the New Year? The January Idiosyncratic Volatility Puzzle, Working paper, Florida State University.

Duan, Ying, Gang Hu, and R. David McLean, 2007, Costly Arbitrage and Idiosyncratic Risk: Evidence from Short Sellers, Working paper, Boston College and Unversity of Alberta.

Evans, Rich, Chris Geczy, David K. Musto, and Adam V. Reed, 2008, Failure is an Option: Impediments to Short Selling and Option Prices, *Review of Financial Studies* forthcoming.

Fama, Eugene F., 1998, Market Efficiency, Long-Term Returns, and Behavioral Finance, *Journal of Financial Economics* 49, 283–306.

Fama, Eugene F., and Kenneth R. French, 1992, The Cross-Section of Expected Stock Returns, *Journal of Finance* 47, 427–465.

Fama, Eugene F., and Kenneth R. French, 1993, Common Risk Factors in the Returns on Stocks and Bonds, *Journal of Financial Economics* 33, 3–56.

Field, Laura C., and Gordon Hanka, 2001, The Expiration of IPO Share Lockups, *Journal of finance* 56, 471–500.

Figlewski, Stephen, and Gwendolyn P. Webb, 1993, Options, Short Sales, and Market Completeness, *Journal of Finance* 48, 761–777.

Fu, Fangjian, 2009, Idiosyncratic Risk and the Cross-Section of Expected Stock Returns, *Journal of Financial Economics* 91, 24–37.

Han, Bing, and Alok Kumar, 2008, Retail Clienteles and the Idiosyncratic Volatility Puzzle, Working paper, University of Texas at Ausin.

Harrison, J. M., and D. M. Kreps, 1978, Speculative Investor Behavior in a Stock Market with Heterogeneous Expectations, *Quarterly Journal of Economics* 93, 323–336.

Hong, Harrison, José Scheinkman, and Wei Xiong, 2006, Asset Float and Speculative Bubbles, *Journal of Finance* 61, 1073–1117.

Huang, Wei, Qianqiu Liu, S. Ghon Rhee, and Liang Zhang, 2006, Return Reversals, Idiosyncratic Risk and Expected Returns, Working paper.

Jiang, George, Danielle Xu, and Tong Yao, 2007, The Information Content of Idiosyncratic Volatility, *Journal of Financial and Quantitative Analysis* forthcoming.

Jones, C., and M. Rhodes-Kropf, 2003, The Price of Diversifiable Risk in Venture Capital and Private Equity, Working paper, Columbia University.

Kapadia, Nishad, 2006, The Next Microsoft? Skewness, Idiosyncratic Volatility, and Expected Returns, Working paper.

Lamont, Owen, 2004, Short Sale Constraints and Overpricing, in Frank J. Fabozzi, eds.: *The Theory and Practice of Short Selling: Risks, Rewards, Strategies* (John Wiley & Sons, ).

Loughran, Tim, and Jay Ritter, 1997, The Operating Performance of Firms Conducting Seasoned Equity Offerings, *Journal of Finance* 52, 1823–1850.

Loughran, Tim, and Jay Ritter, 2000, Uniformly Least Powerful Tests of Market Efficiency, *Journal of Financial Economics* 55, 361–389.

Malkiel, Burton G., and Yexiao Xu, 2006, Idiosyncratic Risk and Security Returns, Working paper.

Mayhew, Stewart, and Vassil Mihov, 2004, How Do Exchanges Select Stocks for Option Listing, *Journal of Finance* 59, 447–471.

Mayhew, Stewart, and Vassil Mihov, 2005, Short Sale Constraints, Overvaluation, and the Introduction of Options, Working paper, Texas Christian University.

Merton, Robert C., 1987, A Simple Model of Capital Market Equilibrium with Incomplete Information, *Journal of Finance* 42, 483–510.

Miller, Edward, 1977, Risk, Uncertainly and Divergence of Opinion, *Journal of Finance* 32, 1151–1168.

Miller, Edward M., 2001, Why the Low Returns to Beta and Other Forms of Risk, *Journal of Portfolio Management* pp. 40–55.

Nagel, Stefan, 2005, Short Sales, Institutional Investors, and The Cross-Section of Stock Returns, *Journal of Financial Economics* forthcoming.

Odean, Terrance, 1998, Volume, Volatility, Price and Profit When All Traders are Above Average, *Journal of Finance* 53, 1887–1934.

Ofek, Eli, and Matthew Richardson, 2003, DotCom Mania: The Rise and Fall of Internet Stock Prices, *Journal of Finance* 58, 1113–1137.

Ofek, Eli, Mathew Richardson, and Robert F. Whitelaw, 2004, Limited Arbitrage and Short Sale Restrictions: Evidence from The Options Market, *Journal of Financial Economics* 74, 305–342.

Scheinkman, Jose A., and Wei Xiong, 2003, Overconfidence and Speculative Bubbles, *Journal of Political Economy* 111, 1183–1219.

Schultz, Paul, 2003, Pseudo Market Timing and the Long-Run Underperformance of IPOs, *Journal of Finance* 58, 483–517.

Sharpe, William F., 1964, Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk, *Journal of Finance* 19, 425–442.

Shleifer, Andrei, and Robert Vishny, 1997, The Limits of Arbitrage, *Journal of Finance* 52, 35–55.

Sorescu, Sorin M., 2000, The Effect of Options on Stock Prices: 1973-1995, *Journal of Finance* 55, 487–514.

Spiegel, Matthew, and Xiaotong Wang, 2006, Cross-Sectional Variation in Stock Returns: Liquidity and Idiosyncratic Risk, Working paper, Yale University.

Xu, Jianguo, 2007, Price Convexity and Skewness, *Journal of Finance* 62, 2521–2552.

**Table 1. Summary statistics**

This table reports, in Panel A, the summary statistics of firm idiosyncratic volatility of returns (IVOL), logarithmic firm size (LOGME), and book-to-market equity (BM) for firms over the period 1963—2007, and two sub-periods. IVOL is the standard deviation of daily residual returns from regressing 17 or more daily returns during the prior month on the Fama-French three factors. IVOLs equal to zero are excluded. LOGME is the logarithmic market equity at the end of the prior month. BM is the book equity over market equity, where book equity is measured at the fiscal year-end through December of year *s*-1 and market equity is measured at the end of December of year *s*-1 for BM from July of year *s* through June of year *s*+1. Firms with IPO lockup expirations refer to event IPOs with lockup expiration dates in the sample 1988—2007. Firms with option introduction refer to event firms with option introduced over the period 1996—2007. The short-sale ban sample includes the stocks on the ban list that have trading volume of at least 1000 shares for each of the three event days (September 18th, 19th, and October 9th) and a price of at least $2.50 on September 18th. Panel B provides descriptive statistics for the number of IPO lockup days.

| Panel A: Full sample | | | | |
|---|---|---|---|---|
| | Number of Firms | IVOL | LOGME | BM |
| Full Sample | 22104 | 3.52 | 3.79 | 0.74 |
| 1988—2007 | 15937 | 3.94 | 4.30 | 0.63 |
| 1996—2007 | 11924 | 3.83 | 4.90 | 0.62 |
| IPO Lockup Expiration (1988—2007) | 4128 | 3.94 | 4.75 | 0.35 |
| Option Introduction (1996—2007) | 3034 | 3.57 | 6.26 | 0.47 |
| Short-Sale Ban (September — October, 2008) | 542 | 2.18 | 5.84 | N/A |
| Panel B: IPO lockup days | | | | |
| | Mean | Median | Min | Max |
| IPO Lockup Expiration | 210 | 180 | 45 | 1095 |

**Table 2. Portfolios sorted by idiosyncratic volatility across different periods**

This table reports the average monthly percentage returns of the quintiles sorted on idiosyncratic volatility (IVOL) over the periods 1963—2007, 1980—2007, and 1996—2007. At the end of each month, stocks are sorted into quintiles based on IVOL measured in the current month. Value- and equal-weighted (VW and EW, respectively) portfolio returns for the following month are calculated. IVOL is defined in Table 1. α is the intercept of the regression of the monthly excess returns on the market (MKT), size (SMB), and book-to-market (HML) factors. Robust Newey-West (1987) *t*-statistics are reported in italics below the average returns and alphas of the long minus short portfolios (H-L).

| | Sample period | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1963-2007 | | | 1988-2007 | | | 1996-2007 | | |
| IVOL Rank | IVOL | $RET_{VW}$ | $RET_{EW}$ | $IVOL_{t-1}$ | $RET_{VW}$ | $RET_{EW}$ | $IVOL_{t-1}$ | $RET_{VW}$ | $RET_{EW}$ |
| L (low) | 0.91 | 0.97 | 1.18 | 1.03 | 1.15 | 1.25 | 1.04 | 1.05 | 1.24 |
| 2 | 1.56 | 1.04 | 1.41 | 1.78 | 1.02 | 1.38 | 1.75 | 0.84 | 1.33 |
| 3 | 2.21 | 1.10 | 1.42 | 2.59 | 1.06 | 1.36 | 2.53 | 0.82 | 1.28 |
| 4 | 3.15 | 0.75 | 1.27 | 3.76 | 0.59 | 1.19 | 3.65 | 0.49 | 1.20 |
| H (high) | 6.07 | 0.02 | 1.13 | 7.59 | 0.01 | 1.36 | 7.10 | 0.18 | 1.35 |
| H–L | | -0.95 | -0.05 | | -1.14 | 0.11 | | -0.87 | 0.11 |
| | | *-2.94* | *-0.15* | | *-2.00* | *0.20* | | *-0.98* | *0.12* |
| α(H–L) | | -1.26 | -0.39 | | -1.40 | -0.05 | | -1.01 | 0.17 |
| | | *-6.37* | *-1.84* | | *-4.27* | *-0.13* | | *-2.41* | *0.33* |

**Table 3. Cumulative and buy-and-hold abnormal returns around mitigation of short-sale constraints**

This table reports the percentage cumulative abnormal returns (CARs) and buy-and-hold abnormal returns (BHARs) of idiosyncratic volatility quintiles following the expiration of the IPO lockup period from 1988—2007 (Panel A) and option introduction from 1996—2007 (Panel B). Day 0 refers to the date of the lockup expiration or the day when options of a stock first appear in OptionMetrics. If an expiration day falls on a weekend or holiday, the immediately following trading day is defined as the expiration day. CAR is defined as the cumulative daily return difference between the event firm and the value-weighted CRSP market portfolio. A BHAR is the difference between the buy-and-hold returns of the event firms and a matched benchmark portfolio. Using NYSE breakpoints, 25 value-weighted benchmark portfolios are formed each month from independently sorting stocks into five firm size (measured at the end of the most recent June) and book-to-market equity (BM) portfolios. BM is defined in Table 1. In Panel A, size is matched at the end of the month prior to the event. In Panel B, size is matched at the end of December of the year prior to the event. The adjusted idiosyncratic volatility (AIVOL) is the difference between idiosyncratic volatility and the equal-weighted idiosyncratic volatility of all available firms, formed to account for the time trend in idiosyncratic volatility. Bootstrapped *t*-statistics are reported in italics.

| Panel A: IPO lockup expiration | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | CAR (-1,+1) | | CAR (-3,+3) | | CAR (-10,+10) | | 12-month BHAR | |
| AIVOL | VW | EW | VW | EW | VW | EW | VW | EW |
| All | -1.57 | -1.35 | -1.87 | -1.62 | -2.78 | -2.06 | -1.32 | -1.05 |
| L (low) | -0.79 | -0.82 | 0.01 | -0.77 | 0.66 | -0.52 | 1.12 | 3.46 |
| 2 | -0.78 | -1.09 | -0.03 | -1.51 | -0.60 | -1.21 | 8.20 | 5.25 |
| 3 | -1.68 | -1.55 | -2.41 | -1.91 | -1.92 | -1.98 | 0.78 | -0.87 |
| 4 | -2.35 | -2.17 | -2.96 | -2.76 | -2.74 | -3.42 | -2.63 | -3.87 |
| H (high) | -2.69 | -1.13 | -5.22 | -1.16 | -12.43 | -3.16 | -20.22 | -9.22 |
| H-L | -1.89 | -0.31 | -5.22 | -0.40 | -13.09 | -2.65 | -21.34 | -12.68 |
| | *-3.76* | *-0.62* | *-7.70* | *-0.58* | *-11.89* | *-2.39* | *-4.78* | *-2.84* |
| Obs | 4106 | | 4122 | | 4127 | | 4001 | |
| Panel B: Option introduction | | | | | | | | |
| | CAR (0,+20) | | CAR (0,+40) | | CAR (0,+60) | | 12-month BHAR | |
| AIVOL | VW | EW | VW | EW | VW | EW | VW | EW |
| All | -0.10 | -0.03 | -0.73 | -0.31 | -2.18 | -0.51 | -3.48 | -1.76 |
| L (low) | 0.97 | 0.25 | 1.46 | 0.00 | 1.80 | -0.27 | 5.29 | 2.39 |
| 2 | 1.33 | 0.07 | 2.21 | -0.53 | 0.44 | -0.92 | 5.61 | 0.76 |
| 3 | -1.92 | -0.62 | -1.69 | -1.52 | -2.73 | -1.10 | -6.77 | -1.01 |
| 4 | -0.13 | 0.40 | 0.37 | 0.44 | -2.40 | 1.02 | -1.51 | -0.75 |
| H (high) | -1.48 | -0.25 | -6.96 | 0.08 | -9.93 | -1.26 | -23.85 | -10.19 |
| H-L | -2.45 | -0.50 | -8.42 | 0.08 | -11.73 | -0.99 | -29.14 | -12.58 |
| | *-2.04* | *-0.41* | *-5.07* | *0.04* | *-6.34* | *-0.53* | *-5.82* | *-2.57* |
| Obs | 2747 | | 2719 | | 2719 | | 2614 | |

**Table 4. Abnormal trading volume around mitigation of short-sale constraints**

This table reports the average daily excess trading volume of idiosyncratic volatility quintiles of stocks following the expiration of the IPO lockup period (Panel A) and daily relative option volume ratio following option introduction (Panel B). The abnormal volumes are both value-weighted (VW) and equal-weighted (EW). In Panel A, excess trading volume is defined as the change of daily turnover for a given stock over the event window from that over the pre-event window. The pre-event window is defined as trading days from -60 through -20 prior to the event. The event windows include trading days from -1 (or -3, -10) through trading day 1 (or 3, 10). In Panel B, the relative option volume ratio is defined as the ratio of the average daily total option volume for a given event stock over the three event windows over the average option volume for a group of benchmark stocks on the same day, where the benchmark group refers to all optionable stocks with the same idiosyncratic volatility quintile rank that have options introduced at least 36 months ago. Average bootstrapped *t*-statistics are reported in italics below the mean difference in excess volume between the highest and lowest AIVOL quintiles (H-L).

Panel A: Excess trading volume around IPO lockup expiration

| | (-1,1) | | (-3,3) | | (-10,10) | |
|---|---|---|---|---|---|---|
| AIVOL | VW | EW | VW | EW | VW | EW |
| All | 0.66 | 0.54 | 0.51 | 0.46 | 0.39 | 0.35 |
| L (low) | 0.55 | 0.41 | 0.42 | 0.36 | 0.26 | 0.27 |
| 2 | 0.45 | 0.48 | 0.37 | 0.40 | 0.24 | 0.28 |
| 3 | 0.68 | 0.62 | 0.51 | 0.50 | 0.45 | 0.37 |
| 4 | 0.79 | 0.57 | 0.56 | 0.47 | 0.43 | 0.38 |
| H (high) | 0.96 | 0.62 | 0.79 | 0.55 | 0.66 | 0.46 |
| H-L | 0.41 | 0.21 | 0.37 | 0.19 | 0.40 | 0.19 |
| | *3.18* | *1.60* | *3.38* | *1.76* | *5.63* | *2.66* |
| Obs | 4127 | | 4127 | | 4127 | |

Panel B: Relative option volume ratio following option introduction

| | (0,20) | | (0,40) | | (0,60) | |
|---|---|---|---|---|---|---|
| AIVOL | VW | EW | VW | EW | VW | EW |
| All | 0.17 | 0.14 | 0.34 | 0.21 | 0.40 | 0.24 |
| L (low) | 0.09 | 0.13 | 0.11 | 0.17 | 0.12 | 0.18 |
| 2 | 0.12 | 0.11 | 0.16 | 0.14 | 0.19 | 0.16 |
| 3 | 0.08 | 0.13 | 0.11 | 0.17 | 0.13 | 0.19 |
| 4 | 0.08 | 0.12 | 0.12 | 0.15 | 0.14 | 0.17 |
| H (high) | 0.31 | 0.21 | 0.78 | 0.41 | 0.93 | 0.48 |
| H-L | 0.22 | 0.09 | 0.67 | 0.24 | 0.81 | 0.30 |
| | *9.58* | *1.18* | *12.14* | *1.88* | *12.33* | *2.14* |
| Obs | 2747 | | 2719 | | 2719 | |

**Table 5: Calendar time portfolios based on the IPO lockup period expiration and option introduction**

This table reports the time-series regression results of the calendar time portfolio returns on the Fama-French three-factors (MKT, SMB, and HML), with January returns excluded. The portfolios include stocks following the expiration of the IPO lockup period (Panel A) or option introduction (Panel B). Porfolio "All" includes all event stocks. In each month, stocks with either of the two events occurring during the past 36 months are sorted according to idiosyncratic volatility (IVOL) into terciles, labeled as "L", "M", and "H." H-L refers to high minus low terciles. The event month returns are excluded. Both value-weighted and equal-weighted portfolio returns are computed. Robust Newey-West (1987) *t*-statistics are reported below the coefficients in italics. R-squares are adjusted for degrees of freedom.

| | Value-weighted | | | | | Equal-weighted | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Panel A: IPO lockup expiration | | | | | | | | | | |
| IVOL | Intercept | MKT | SMB | HML | $R^2$ | Intercept | MKT | SMB | HML | $R^2$ |
| All | -0.20 | 1.32 | 0.80 | -0.66 | 90% | -0.69 | 1.33 | 0.97 | -0.06 | 84% |
| | *-1.07* | *20.27* | *11.32* | *-7.12* | | *-3.32* | *14.93* | *7.11* | *-0.47* | |
| L (low) | 0.36 | 1.14 | 0.45 | -0.39 | 80% | -0.11 | 1.11 | 0.69 | 0.24 | 80% |
| | *1.65* | *18.94* | *6.70* | *-4.73* | | *-0.59* | *21.74* | *12.09* | *3.45* | |
| M | -0.28 | 1.52 | 0.94 | -0.76 | 86% | -0.45 | 1.34 | 0.97 | -0.21 | 85% |
| | *-1.01* | *20.14* | *11.19* | *-7.27* | | *-1.94* | *21.17* | *13.78* | *-2.38* | |
| H (high) | -1.57 | 1.66 | 1.10 | -0.76 | 82% | -1.11 | 1.47 | 1.16 | -0.24 | 74% |
| | *-4.58* | *17.65* | *10.50* | *-5.82* | | *-3.05* | *14.73* | *10.44* | *-1.72* | |
| H-L | -1.94 | 0.52 | 0.65 | -0.36 | 38% | -1.00 | 0.36 | 0.47 | -0.48 | 34% |
| | *-4.93* | *4.82* | *5.43* | *-2.44* | | *-2.81* | *3.68* | *4.35* | *-3.58* | |
| Panel B: Option introduction | | | | | | | | | | |
| IVOL | Intercept | MKT | SMB | HML | $R^2$ | Intercept | MKT | SMB | HML | $R^2$ |
| All | -0.28 | 1.29 | 0.69 | -0.62 | 92% | -0.65 | 1.51 | 0.88 | -0.11 | 91% |
| | *-1.43* | *15.17* | *7.79* | *-5.85* | | *-2.52* | *17.64* | *7.69* | *-0.93* | |
| L (low) | 0.18 | 0.99 | 0.24 | 0.27 | 78% | -0.09 | 1.06 | 0.40 | 0.60 | 85% |
| | *0.90* | *19.09* | *4.39* | *3.90* | | *-0.51* | *24.36* | *8.92* | *10.21* | |
| M | -0.48 | 1.34 | 0.67 | -0.58 | 88% | -0.55 | 1.39 | 0.80 | -0.09 | 91% |
| | *-1.61* | *17.85* | *8.58* | *-5.78* | | *-2.33* | *23.28* | *12.88* | *-1.17* | |
| H (high) | -0.88 | 1.85 | 0.90 | -0.88 | 87% | -1.16 | 1.81 | 1.09 | -0.50 | 86% |
| | *-1.96* | *16.34* | *7.70* | *-5.76* | | *-2.68* | *16.59* | *9.64* | *-3.39* | |
| H-L | -1.06 | 0.86 | 0.67 | -1.15 | 73% | -1.07 | 0.75 | 0.69 | -1.10 | 73% |
| | *-2.15* | *6.89* | *5.16* | *-6.87* | | *-2.33* | *6.45* | *5.72* | *-7.04* | |

**Table 6: Returns and short interest ratios of portfolio sorted on idiosyncratic volatility upon the short-sale ban and its expiration**

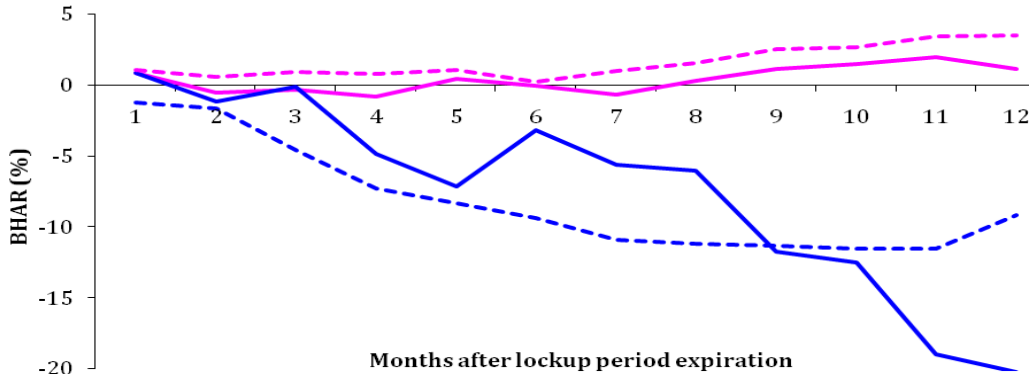
Panel A reports the average cumulative returns over three event windows of all sample firms and the quintiles sorted on idiosyncratic volatility (IVOL) for the financial firms that are in the initial SEC list to ban short selling. On September 18th, stocks are sorted into quintiles based on IVOL that is computed as described in Table 1 using no less than 17 daily returns from day -41 through -11, where day 0 refers to 9/18/2008. We first compute the cumulative returns over each window for each stock and then take the average across quintiles. Both value- and equal-weighted (VW and EW, respectively) portfolio returns are reported in percent. Panel B reports the average short interest ratio across all and quintiles of stocks. The short interest ratio is defined as the number of shares shorted over the shares outstanding and reported in percent. The release dates of the short interests are listed under each window. Bootstrapped *t*-statistics are reported in italics based on bootstrapped standard errors.

| Panel A: Cumulative Returns | | | | | | |
|---|---|---|---|---|---|---|
| | Enforcement September 18th and 19th | | Ban Effective September 20th –October 8th | | Expiration October 9th | |
| $IVOL_{t-1}$ Rank | VW | EW | VW | EW | VW | EW |
| All | 17.16 | 17.34 | -20.34 | -22.40 | -5.12 | -10.69 |
| L (low) | 12.33 | 11.94 | -21.37 | -21.63 | -8.97 | -9.96 |
| 2 | 17.11 | 15.35 | -19.91 | -20.95 | -4.36 | -10.40 |
| 3 | 23.44 | 19.16 | -30.18 | -24.54 | -11.96 | -11.90 |
| 4 | 23.60 | 19.50 | -21.00 | -22.43 | -9.39 | -11.01 |
| H (high) | 26.41 | 20.75 | -23.51 | -22.47 | -13.62 | -10.19 |
| H–L | 14.08 | 8.81 | -2.14 | -0.84 | -4.65 | -0.22 |
| | *5.99* | *3.75* | *-1.06* | *-0.423* | *- 3.34* | *-0 .17* |
| Panel B: Short Interest Ratio | | | | | | |
| | Enforcement September 10th | | Expiration October 9th | | Post-Expiration October 28th | |
| $IVOL_{t-1}$ Rank | VW | EW | VW | EW | VW | EW |
| All | 7.56 | 6.77 | 5.54 | 4.76 | 5.07 | 4.49 |
| L (low) | 3.09 | 5.16 | 2.17 | 3.37 | 2.29 | 3.54 |
| 2 | 8.50 | 6.40 | 6.09 | 4.69 | 5.47 | 4.33 |
| 3 | 6.73 | 7.17 | 5.38 | 5.00 | 4.85 | 4.56 |
| 4 | 5.50 | 7.60 | 4.00 | 5.47 | 3.86 | 5.09 |
| H (high) | 15.00 | 7.48 | 11.77 | 5.22 | 10.64 | 4.89 |
| H–L | 11.92 | 2.31 | 9.61 | 1.85 | 8.35 | 1.35 |
| | *7.84* | *1.51* | *8.98* | *1.82* | *9.23* | *1.49* |

**Figure 1: Long-run performance of idiosyncratic volatility portfolios after mitigation of short-sale constraints**

This figure plots the buy-and-hold abnormal returns (BHARs) of the highest (H) and the lowest (L) quintiles, sorted on adjusted idiosyncratic volatility (AIVOL), from one through twelve months subsequent to the end of the IPO lockup (Panel A) and option introduction (Panel B). The value-weighted BHARs (VW) are represented by solid lines and the equal-weighted BHARs (EW) by dotted lines. The definitions of AIVOL, BHARs, and the events are in Table 3.

**Panel A: BHARs Following IPO Lockup Expiration**




**Panel B: BHARs Following Option Introduction**

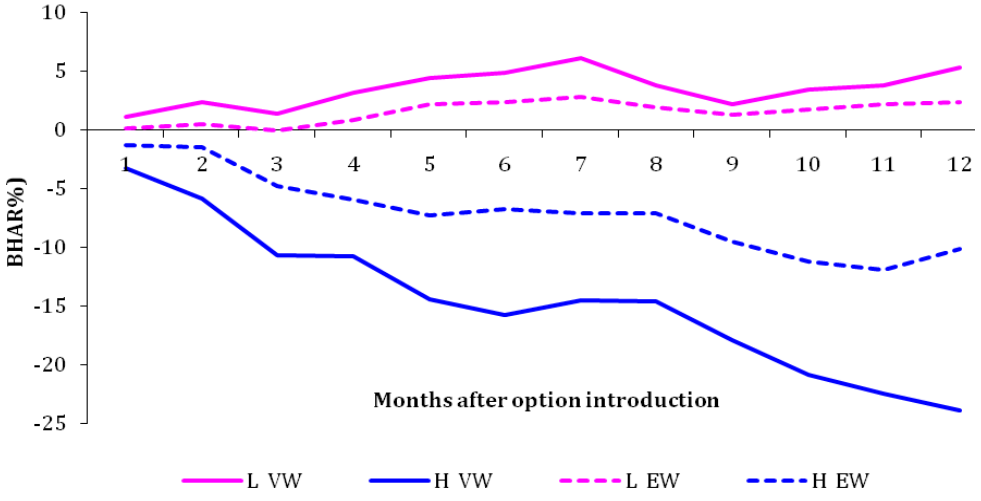


**Figure 2: Cumulative returns of portfolios based on idiosyncratic volatility following the short-sale ban**

The figures plot returns of the highest (H) and lowest (L) idiosyncratic volatility quintiles over the window of the short-sale ban. The figure plots the value-weighted cumulative percentage returns for the two day window 9/18/2008—9/19/2008 (short-sale ban enforcement), the 13-day window 9/22/2008—10/08/2008 (no restriction) and the one-day window 10/9/2008 (short-sale ban expiration). Idiosyncratic volatility (IVOL) is the standard deviation of daily residual returns from regressing 17 or more daily returns from day *t*-41 through *t*-11, where *t* refers to 9/18/2008.