Why do Short Interests Predict Returns? Over-valuation and Information

Kalok Chan Hung Wan Kot Sophie X. Ni*

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Abstract

We decompose short interest into the component related to short sale constraints and the component related to informed trading. We find that the predictability of short sale constraints is stronger for stocks with low institutional ownership, while the predictability of informed trading is not related to institutional ownership. After large increases in institutional ownership and hedge fund assets in the second half of the sample period, the relationship between short sale constraints and future stock returns becomes weak, while that between informed trading and future stock returns remains the same. Our results provide evidence that stocks will be overpriced in the presence of short sale constraints modeled in Miller (1977) after controlling for informed trading.

*Chan : Department of Finance, Hong Kong University of Science & Technology (kachan@ust.hk). Kot: Department of Finance and Decision Sciences, Hong Kong Baptist University (hwkot@hkbu.edu.hk). Ni: Department of Finance, Hong Kong University of Science& Technology (sophieni@ust.hk). We benefits from comments by Harrison Hong , and thank Harry Leung for his capable research assistance.

1 Introduction

It is well documented in the literature that there is a negative cross-sectional relationship between the level of short interest ratios (SIR) and future abnormal stock returns. Stocks with high short interest relative to shares outstanding show low returns over the subsequent months. Some researchers argue that short sellers are informed traders that possess information about company performance. This information hypothesis suggests that the negative relationship between SIR and future returns is a reflection of the information possessed by short sellers. Indeed, Akbas, Boehmer, Erturk, and Sorescu (2013) document that short interest predicts future bad news, negative earnings surprises and downward revisions in analyst earnings forecasts.

Another explanation for the negative predictability of short interest ratios is the over-valuation hypothesis suggested by Miller (1977). Miller argues that when there are short sale constraints, a stock price will only reflect the valuations of optimists, but not the valuations of pessimists, as pessimists simply sit out of the market. These combined effects of short sale constraints and differences in opinion about stock prices could result in the over-valuation of stocks with high SIR. Asquith, Pathak, and Ritter (2005) argue that high SIR stocks are likely to be more short sale constrained, and pessimistic investors are unable to establish short positions. A high SIR may also suggest a high degree of divergence in the valuations of optimists and pessimists Figlewski (1993).

The information hypothesis implies that short sellers are well informed, and that the predictability of short interest is because short sellers are actively involved in shorting stocks. In contrast, the over-valuation hypothesis suggests that the predictability is because investors are unable to short stocks. To distinguish between the information and over-valuation hypotheses, we decompose short interest into the component that is likely to be related to informed trading, and the component that is likely to be related to short sale constraints independent of information. We use three methods to decompose. First, we take advantage of the informed trading in the options market. Easley, OHara, and Srinivas (1998) develop a multimarket sequential trade model, and show that informed trading occurs in both stock and options markets in a pooling equilibrium. Pan and Poteshman

(2006) construct put-call ratios (PCR) from the option volume initiated by buyers to open new positions, and present strong evidence that the option trading volume contains information about future stock prices. We construct a monthly measure of PCR similar to that used by Pan and Poteshman (2006), and find that the predictability of PCR is mainly from its unexpected component. We then use the unexpected PCR (UPCR^{I}) as a proxy for informed trading.

When investors use the options market to buy put or sell calls in expecting a decrease in the stock price, the options market makers sell or short the stock to hedge their sold put and purchased call positions. We use the short interest ratios from options market makers as (SIRM^{I}) another measure of informed trading from the options market. We then use the short interest from other investors who are not options market makers (SIRO^{S}) as a proxy for short sale constraints. Here we use the superscript 'I' to indicate the variable is a measure of informed trading in SIR, and the superscript 'S' to indicate the variable is measures of short sale constraints.

In the second method, we decompose the short interest ratios into the expected SIR (ESIR^{S}), computed as the previous 12-month SIR moving average, and the unexpected SIR (USIR^{I}), measured as the difference between SIR and ESIR^{S}. USIR^{I} is more likely to be related to informed trading, as informed trading is unpredictable and short lived. Boehmer, Jones, and Zhang (2008) document that the average short position lasts only about 37 trading days. ESIR^{S} is more likely to be associated with short sale constraints, because they are more persistent and driven by the characteristics of the stocks rather than the trading of short sellers.

In the third method, we use predicted short interest (PSIR^{S}) as a measure of short sale constraints. For each stock, we regress past SIR on lagged volatility, and use the estimated coefficients and lagged volatility to predict SIR. We use volatility to estimate PSIR^{S} because under the over-valuation hypothesis, stocks with greater disagreement will be more overvalued than stocks with lesser disagreement. We then use the residuals in the predictive regression as a proxy for informed trading.

Our decomposition is based on the facts that there is informed trading in the options market, and that informed trading in SIR is driven by the trading activity of short sellers, thus it is short lived and difficult to predict. In contrast, short sale constraints arise from the fact that some investors are unable to short the stocks. Short sale constraints are persistent and driven by the characteristics of the stocks, such as the degree of divergence of opinion. Indeed, we find that stock borrowing costs are positively related the measures of short sale constraints, but not related to the measures of informed trading during the 2007 to 2011 period.

After decomposing SIR into the component related to short sale constraints and the component related to informed trading, we examine their power in predicting stock returns. Our results show that cross-sectionally, both the short sale constraints and informed trading contribute to the predictive power of short interest ratios. Measures of informed trading and short sale constraints are negatively related to future stock returns up to 12 months.

Another way to test the over-valuation hypothesis is to examine how institutional ownership (IO) influences the predictive power of short sale constraints and informed trading. Stocks with high institutional ownership have higher short supply, and are easier to be shorted than stocks with low institutional ownership (Nagel (2005)). Under the over-valuation hypothesis, ceteris paribus, the predictive power of short sale constraints will be stronger for stocks with low institutional ownership. The information hypothesis, however, has no theoretical implications for the relationship between the predictive power of informed trading and IO. Regardless of the level of the IO, informed trading will occur in similar ways as long as there is information. It is likely that stocks with low IO are subject to informed trading because they are less information efficient. However after we decompose the SIR of the *same* stock into the component related to informed trading and the component related to short sale constraints, the differences in their interactions with IO are no longer subject to cross-sectional differences in informed trading.

Consistent with the over-valuation hypothesis, our cross-sectional results suggest that IO only influences the predictive power of short sale constraints, but not that of informed trading. From 1991 to 2011, the predictive power of all of the measures of short sale constraints is stronger for stocks with lower IO. In contrast, the predictive power of the measures of informed trading is not related to IO. Although the literature documents that short interest has stronger predictive power for stocks with low IO, which is consistent with the over-valuation hypothesis, we cannot exclude the possibility that the interaction between short interest and IO arises from the characteristics of stocks other than short sale constraints. Our finding that the positive interaction with IO only occurs on measures of short sale constraints, but not on measures of informed trading, suggests that it is indeed, the short sale constraint, not the informed trading, that drives the interaction between SIR and IO in predicting stock returns.

A large increase in institutional ownership (IO) occurred from 2000 to 2002. For stocks with options, the average institutional ownership increased from 50% to 71%; for stocks without options, it increased from 30% to above 40%. Even more striking is the growth of hedge funds in our sample period. Their total assets relative to total common stock market value increased by 38 times to 1.83%. Goldman-Sachs (2009) asserts that hedge funds account for 85% of all short interest in the market. Increased institutional ownership will relax, to some extent, short sale constraints, and increased shorting activity from hedge funds suggests a higher proportion of trading from shorting. Under the over-valuation hypothesis, relaxed short sale constraints and increased shorting activity will drive down over-valued stock prices. So the predictive power of short sale constraints will become weaker. Under information hypothesis, there is no implication concerning how increased IR and shorting activity will alter the predictive power of informed trading.

We separate our sample period into the first half period (1991-2002) and the second half period (2003-2011), and find that the predictive power of the measures of short sale constraints becomes weaker in the second period. Consistent with our hypothesis, the predictive power of the measures for informed trading remains the same in the second period.

The remainder of this paper is organized as follows. Section 2 presents the literature review. Section 3 develops the main hypotheses. Section 4 presents the data and preliminary statistics. Section 5 discusses the empirical results. Section 6 concludes the paper.

2 Literature Review

2.1 Predictive ability of short interest

There is extensive evidence of the ability of short interest to predict returns. Using monthly short-interest data, Asquith and Meulbroek (1996) and Desai, Ramesh, Thiagarajan, and Balachandran (2002) document a strong and negative relationship between short interest and subsequent abnormal stock returns. The predictive ability of short interest extends to daily intervals, even at the intraday level. For example, Aitken, Frino, McCorry, and Swan (1998) find that stock prices decrease by -0.2% following short sales within fifteen minutes or twenty trades. Senchack and Starks (1993) find that changes in short sales are followed by negative abnormal returns. More recently, Boehmer, Jones, and Zhang (2008) use daily short sales data, and show that heavily shorted stocks under-perform lightly shorted stocks by a risk adjusted average of 1.16% over the following 20 trading days.

There is also theoretical evidence that stocks with high short interest levels followed by negative abnormal returns are consistent with the short-sale constraint hypothesis (Miller (1977)), which states that stock prices tend to be upward-biased due to short sale constraints because pessimistic investors are not able to participate in the equity market due to short sale constraints and the sole participation of optimistic investors bids prices above a level at which all investors are able to participate. Chen, Hong, and Stein (2002) obtain similar results by developing a model that allows for risk aversion and show that stocks under short constraints reflect optimistic beliefs, and thus have lower future returns. Diamond and Verrecchia (1987) examine the effects of short sale constraints in a rational expectation framework. They show that the price of a short sale constrained stock adjusts more slowly to unfavorable private information than it does to favorable private information. However, they argue that rational investors recognize the existence of short-sale constraints and adjust their beliefs, such that no overpricing of securities exists, on average.

Short sale constraints are difficult to observe. A few studies attempt to infer the short sale cost through the rebate rate, which is the interest rate that institutional short sellers receive on the proceeds of their sales. If the number of shares available for borrowing exceeds the demand for short selling, short sellers earn a rebate that is approximately equal to the Federal Funds rate. If the demand for shorting a stock exceeds the amount available to borrow at the Federal Funds rate, the rebate rate falls below the Fed funds rate. Therefore, a lower rebate rate is an indication of a higher short sale cost. Some studies use proprietary databases of rebate data (Jones and Lamont (2002), Geczy, Musto, and Reed (2002), DAvolio (2002)). In particular, DAvolio (2002) finds that stocks with lower rebate rates have higher short interest relative to shares and lower subsequent returns.

Nagel (2005) identify short sale constraints based on IO, which can serve as a proxy for short supply. Asquith, Pathak, and Ritter (2005) document that stocks with high short interest generally under-perform in the market. Furthermore, when the high short-interest portfolios are further ranked by IO, they find a positive and monotonic relationship between returns and IO. In other words, the lower the amount of institutional ownership, the more negative the portfolios abnormal returns. Nagel (2005) finds that the under-performance of stocks with a high market-to-book ratio, analyst forecast dispersion, turnover, or volatility is most pronounced among stocks with low institutional ownership.

2.2 Stock return predictability from the options market

Previous studies document evidence of informed trading in the options market. There are a number of reasons for informed traders preferring to trade stock options instead of the underlying stocks. First, greater financial leverage may induce informed traders to trade in the options market instead of the stock market (Black (1975) and Mayhew, Sarin, and Shastri (1995)). Second, investors with private information about the volatility of the underlying stock prices can only make their bets on volatility in the options market (Back (1993)). For these reasons, the options market may not be redundant, but it can play an important role in discovering information. Easley, OHara, and Srinivas (1998) develop a multimarket sequential trade that incorporates both options and stocks, and show that informed trading occurs in both the stock and the options market.

Although numerous empirical studies investigate the informational linkage between the stock and options markets, there is no conclusive evidence as to which market plays a greater role in discovering information. According to intraday transaction data, Stephan and Whaley (1990) find that stock price movements lead to option price movements. However, Chan, Chung, and Johnson (1993) caution that the stock lead documented in Stephan and Whaley (1990) might be due to price discreteness in the options market. They show that the stock lead disappears when the bid and ask quotes are used instead of the transaction prices. Vijh (1990) finds that the price effects of large option trades are generally small, which suggests that option trades are not information-related. However, Chan, Chung, and Fong (2002) find that stock and option quote revisions predict each other, which suggests that valuable information is also contained in the options market. In a more recent study, Pan and Poteshman (2006) examine a unique dataset and provide strong evidence that the option trading volume contains information on future stock prices. They construct put call ratios from the option volumes initiated by buyers to enter new positions and find that stocks with low put-call ratios outperform stocks with high put-call ratios by 0.4% on the next day and more than 1% over a week. Their evidence confirms that informed traders do trade in the options market.

2.3 Short sales versus put options

While informed investors with positive information about a stock can trade in both the equity and the options market, informed investors with negative information find it especially attractive to trade in the options market. Short sellers face borrowing costs that can fluctuate depending on the supply and demand for equity loans. Consequently, when investors possess negative information about future stock prices and equity borrowing costs are high, they may be better off trading in the options market and buying put options instead of short selling in the equity market.

Some studies investigate the relationship between short sale constraints and options. Senchack and Starks (1993) examine stock price reactions to unexpected increases in short interest. They find evidence of small, negative abnormal returns for a short period around the announcement date, mostly for stocks with listed options and rather than for stocks without. Danielsen and Sorescu (2001) analyze stock price performance following options listings. As the introduction of options effectively provides a lower cost means of establishing a short position, the listing of options mitigates the short-sale constraints. Consistent with the overvaluation effect, Danielsen and Sorescu (2001) find that the option introductions are followed by negative abnormal returns in the underlying stocks. Finally, Ofek, Richardson, and Whitelaw (2004) show that violations of put-call parity are asymmetric in the direction of short-sale constraints and their magnitudes are strongly related to the cost and difficulty of short selling.

3 Hypotheses

The literature offers two explanations for the predictability of short interest ratios. One is the over-valuation hypothesis and the other is the information hypothesis. The over-valuation hypothesis is an implication of Miller (1977)‘s model. It holds that stocks with high levels of short interest are over-valued because pessimistic investors are unable to establish short positions, leaving only the optimists to participate in the pricing process. In this model, market forces are unable to prevent overpricing in the amount of shorting costs when these costs are high and investors disagree about the stock price. The greater the shorting costs or the disagreement, the greater the possible overpricing and, therefore, the lower the subsequent stock returns. The information hypothesis builds on a broadening base of empirical research demonstrating that short sellers are well informed traders. Short sellers tend to be investors with superior analytical skills and typically initiate short positions when they can infer a low fundamental valuation from public sources (Akbas, Boehmer, Erturk, and Sorescu (2013) and Engelberg, Reed, and Ringgenberg (2012)).

Differentiating between the over-valuation hypothesis and the information hypothesis is important, because their theoretical implications differ. In Miller‘s model, uninformed but irrationally optimistic investors take long positions. When short positions are more difficult to establish than long positions, stocks will be over-valued as a result of the optimists‘s long trades. The over-valuation eventually dissipates when the fundamental value is revealed.

Under the information hypothesis, short sellers are regarded as informed traders whose absence from the market makes prices noisier. They play an active role in making prices more efficient by trading on negative information. Because this process is not instantaneous, their positions (which are publicly observable at a monthly frequency) provide investors with a signal that the stock is overvalued. In contrast to the over-valuation hypothesis, this implies that the level of short interest is related to fundamental information about the stock and gives short sellers a role in making prices more efficient.

3.1 Hypothesis on Options Trading

Easley, OHara, and Srinivas (1998) develop a multimarket sequential trade model, and show that informed trading occurs in both stock and option markets in a pooling equilibrium. Pan and Poteshman (2006) construct put-call ratios (PCR) from option volumes initiated by buyers to open new positions, and present strong evidence that the option trading volumes contain information about future stock prices.

To construct measures of informed trading, we start with the monthly open bought put call ratios (PCR), calculated as the monthly open bought put volumes divided by the monthly open bought put and call volumes, to construct measures of informed trading in the options market. Our PCR is similar to the put-call ratio used in Pan and Poteshman (2006). New information is short lived and difficult to forecast. If the return predictability of options market activity is primarily due to the discovery of information, we hypothesize that it is the unexpected component of PCR ($UPCR^I$), not the expected PCR (EPCR), that contributes to the predictability of put call ratios for stock returns. Here we use superscript 'I' to indicate that the variable is a measure of informed trading

Bearish option strategies and short sales are often regarded as substitutes. A measure of options trading may also be a reflection of the short sale constraints of the underlying stocks. Figlewski and Webb (1993) argue that short sale constrained investors buy put options and write call options as substitutes for selling a stock short directly. We argue the short sale constraints unrelated to information are persistent and should only be captured by the expected component of the put call ratios (EPCR). Other factors, such as hedging demand, also drive the variations in ECPR. So EPCR is not necessarily a measure for short sale constraints in the stock markets. Indeed Figure 2 show that EPCR is not related to the stock borrowing costs. The predictability of PCR may be higher for stocks with low institutional ownership. This interaction with the institutional ownership will not be observed if we use UPCR^{I} instead, as UPCR^{I} is a measure of informed trading but not short sale constraints, and there is no theoretical link between the institutional ownership and informed trading in predicting returns.[1]

When investors who hold negative views about the underlying stock build a synthetic short position by buying puts and/or writing calls, options market makers who trade against investors will hedge their own synthetic long stock positions, which they can accomplish by shorting the stock. If the options trading is related to information, the short interest ratios from options market makers (SIRM^{I}) can also serve as a proxy for informed trading. After subtracting SIRM^{I}, the short interest from the other investors (SIRO^{S}) who are not options market makers will be more related to the short sale constraints than SIRM^{I}. (Here we use the superscript 'S' to indicate that the variable is a measure of short sale constraints.) Under the over-valuation hypothesis, after we control for informed trading in the options market measured by SIRM^{I} or UPCR^{I}, SIRO^{S} will still predict stock returns, and its predictive power will be stronger for stocks with lower institutional ownership.

3.2 Hypothesis on expected and unexpected short interest

Although it is difficult to completely separate short sale constraints from information, we argue that the expected component of short interest (ESIR^{S}) is more likely to be related to short sale constraints, while the unexpected component of short interest (USIR^{I}) is more likely to be associated with informed trading. The argument is based on the fact that if the predictability of SIR is from information, it must be driven by the shorting activity of short sellers. New information is short lived and hard to predict. Boehmer, Jones, and Zhang

[1] In the unreported results, we find that the predictive power of PCR is stronger for stocks with high raw measure of institutional ownership, but this pattern of interaction disappears if we use size adjusted institutional ownership.

(2008) document that the average short position lasts only 37 trading days. Therefore the informed trading must come from short term variations in SIR. In contrast, under the over-valuation hypothesis, it is the inability to short that makes stocks overvalued. Some short sale constraints simply come from institutional regulations, such that some mutual funds are prohibited from shorting. The short sale constraints unrelated to information, therefore, should be persistent and related to the characteristics of the stocks. It is natural to consider the variation in USIR^{I} is driven by the trading activity of short sellers, and the variation in ESIR^{S} represents short sale constraints that are persistent and not related to informed trading. Under the over-valuation hypothesis, we will see, after controlling for informed trading measured by USIR^{I}, ESIR^{S} still predicts stock returns.

3.3 Hypothesis on predicted and residual short interest based on volatility

As suggested by Figlewski (1993), in an over-valuation setup, we can consider short open interest as the shares shorted by pessimists, and shares outstanding as the shares bought by optimists. Their ratio, SIR, can then measure the degree of divergence between pessimists and optimists. For any given degree of short sale constraints, the more heterogeneous the expectations, the greater will be the over-valuation of stock prices. Volatility is another simple measure of divergence of opinion on stock prices. Nagel (2005) documents that the under-performance of stocks with high volatility is most pronounced among stocks with high short sale constraints. We use volatility to predict short interest ratios. We then use the predicted SIR (PSIR^{S}) as another measure of short sale constraints, and use the residual (RSIR^{I}) in the predictive regression as a measure of informed trading. Under the over-valuation hypothesis, after controlling for informed trading measured with RSIR^{I}, PSIR^{S} will still have predictive power for stock returns. .

3.4 Hypothesis on the role of institutional ownership

Another way to test the over-valuation hypothesis is to examine the interactions of institutional ownership (IO) with the measures of short sale constraints and the measures of informed trading in predicting stock returns. Asquith, Pathak, and Ritter (2005) argue that short sale constraints are most likely to bind among stocks with low institutional ownership. Because of institutional constraints, most institutional investors, such as mutual funds, never sell short and hence cannot trade against the overpricing of stocks they do not own. Furthermore, the stock loan supply tends to sparse and short selling is more expensive when institutional ownership is low. A higher IO implies a lower level of short sale constraints and induces more short selling activity (Nagel (2005)). Under the over-valuation hypothesis, the predictability of short sale constraints will be stronger for stocks with low institutional ownership. In contrast, the information hypothesis gives no obvious reason to establish a link between the predictability of informed trading and the institutional ownership. Cross-sectionally, stocks with low IO may be subject to more informed trading. Our analysis decomposes the SIR of the *same* stock into the component related to short sale constrains and the component related to informed trading. The differences in their interactions with IO are no longer subject to cross-sectional differences in informed trading.

As shown in Figure 1, there is a large increase in institutional ownership from 2000 to 2002. For stocks with options, the average IO increases from 50% to 71%; for stocks without options, the average IO increases from 30% to above 40%. More striking from Figure 1 is the growth of hedge funds, which actively engage in shorting activity. Kot (2013) documents that hedge fund assets and IO are significantly related to short selling activity, and the relationships are stronger after 2001 than before 2001. Goldman-Sachs (2009) assumes that hedge funds account for 85% of all short interest in the market. Indeed, Figure 1 also shows the large increase in the SIR during our sample period, especially for stocks with options. The average SIR for stocks with options increases by 5 times from 0.02 in January 1991 to 1.21 in September 2008. Under the over-valuation hypothesis, the dramatically increased IO and hedge fund shorting activity in our second sample period will push down the over-valued stock prices from short sale constraints. We hypothesize that the negative return predictability of measures of short sale constraints will become weaker during the second sample period, 2003 to 2011, than during the first sample period, 1991 to 2002. In contrast, the information hypothesis has no implications for how the increased IO and hedge fund activity in the second sample period are related to the predictive power of measures of informed trading.

4 Data and Statistics

4.1 Data

We obtain monthly short-interest data from the exchanges, with the exception of the Amex data from 2005 to 2008, which are from Compustat. We calculate the SIR by dividing the number of shares shorted by the number of shares outstanding. The data on institutional ownership (IO) are from 13-F filings, available from Thomson Financial. We also normalize IO by shares outstanding. Data on stock returns, prices, volumes and shares outstanding are from the Center for Research on Security Prices (CRSP) at the University of Chicago. The data on stock borrowing costs are from Markit.

We obtain options public investors (non-market makers) daily volumes from Chicago Board of Options Exchange and International Stock Exchange for the 1991 to 2011 period. For each option, the volumes from public investors are divided into open buy volume, open sell volume, close buy volume and close sell volume. The open buy or sell volume is the volume to establish a new long or short position. The close buy or sell volume is the volume to close an existing short or long position. Because the monthly short interest data reflect the short position as of the settlement on the fifteenth of each month, we retrieve the stock and option data mid-month to match the short interest data.

4.2 Variables

We start with monthly put-call ratios to estimate informed trading in the options market.

$$\text{PCR}_{i,t} = \frac{\text{Put}_{i,t}}{\text{Put}_{i,t} + \text{Call}_{i,t}}, \tag{1}$$

where $\text{Put}_{i,t}$ is the public investors' total open buy put volume across all strikes and moneynesses from the sixteenth of month $t-1$ to the fifteenth of month t, and $\text{Call}_{i,t}$ is the same variable for calls. We construct PCR in the same way as Pan and Poteshman (2006), except that they use daily data. We do not use delta weighted volumes because Pan and Poteshman (2006) show that the volumes of out-of-the-money options contain more information than the volumes of the options of the other moneyness.

We then construct the unexpected PCR (UPCR^{I}) as a measure of informed trading in the options market by subtracting PCR by expected PCR (EPCR).

$$\text{EPCR}_{i,t} = \frac{\sum_{t-3}^{t-1} \text{PCR}_{i,t}}{3}, \tag{2}$$

$$\text{UPCR}^{\text{I}}_{i,t} = \text{PCR}_{i,t} - \text{EPCR}_{i,t}. \tag{3}$$

We use superscript 'I' to indicate that the variable measures informed trading. We use the previous 3-month moving average to compute $\text{EPCR}_{i,t}$. Options expiring within 3 months are the options most actively traded. In general, option expiration days are constructed in 3-month cycles. The 3-month moving average captures the seasonality of options volumes. During our sample period, 3,563 stocks introduced options. We omit fewer observations by using the previous 3-month moving average than using the longer-term moving average.[2]

When public investors buy puts or sell calls to establish synthetic short positions in the options market, the options market makers who take the opposite position to that of public investors will short or sell stocks to hedge their synthetic long positions. The short interest from options market makers can also serve as a proxy for informed trading in the

[2] Similar results are obtained if we use the previous 12-month moving average.

options market. We use delta weighted net open interest on options from public investors to estimate the short interest ratios from options market makers (SIRM^{I}) as follows:

$$\text{SIRM}^{\text{I}}_{i,t} = \frac{\max(0, \text{shortOpenInterest}_{i,t} - \text{longOpenInterst}_{i,t})}{\text{Shares Outstanding}_{i,t}}, \tag{4}$$

where $\text{shortOpenInterest}_{i,t}$ is the delta weighted short open interest for all available options on stock i on the fifteenth of month t, and $\text{longOpenInterst}_{i,t}$ is the delta weighted long open interest of public investors. From 1991 to 2001, we use the open interest data provided by CBOE. From 2002 to 2011, we accumulate the short options open interest with the open sell and close buy daily volumes, and the long open interest with the open buy and close sell daily volumes.

After estimating the short interest ratios from options market makers (SIRM^{I}), we use the short interest ratios from the other investors as a measure of short sale constraints (SIRO^{S}). We use superscript 'S' to indicate that the variable measures short sale constraints.

$$\text{SIRO}^{\text{S}}_{i,t} = \text{SIR}_{i,t} - SIRM^{I}{}_{i,t} \tag{5}$$

The second method for decomposing short interest ratios is to use the expected short interest ratios ($\text{ESIR}^{S}_{i,t}$) as a measure of short sale constraints, and the unexpected short interest ratios $\text{USIR}^{\text{I}}_{i,t}$ as a measure of informed trading, as follows:

$$\text{ESIR}^{\text{S}}_{i,t} = \frac{\sum_{t-12}^{t-1} \text{SIR}_{i,t}}{12}, \tag{6}$$

$$\text{USIR}^{\text{I}}_{i,t} = \text{SIR}_{i,t} - \text{ESIR}^{\text{S}}_{i,t}. \tag{7}$$

In the third method, we use the past short interest ratios and lagged volatility to estimate the predicted SIR ($\text{PSIR}^{\text{S}}_{i,t}$) as a measure of short sale constraints, and the residual SIR ($\text{RSIR}^{I}_{i,t}$) as a measure of informed trading. We first run the following regression to estimate the relationship between short interest ratios and lagged volatility:

$$\text{SIR}_{i,0} = a_{i,t} + b_{i,t} \cdot \text{Vol}_{i,-1} + e_{i,0} \tag{8}$$

where $\text{Vol}_{i,-1}$ is the lagged monthly volatility estimated by the standard deviation of daily stock returns. In every month t, we generate estimate coefficients $\hat{a}_{i,t}$ and $\hat{b}_{i,t}$ using the SIR from month $t-12$ to $t-1$ and the lagged Vol from month $t-13$ to $t-2$. We then predict the short interest ratio for month t as follows:

$$\text{PSIR}^{\text{S}}_{i,t} = \hat{a}_{i,t} + \hat{b}_{i,t} \cdot \text{Vol}_{i,t-1}. \tag{9}$$

Finally, we estimate residual short interest ratios RSIR^{I} as another measure of informed trading as follows:

$$\text{RSIR}^{\text{I}}_{i,t} = \text{SIR}_{i,t} - \text{PSIR}^{\text{S}}_{i,t}. \tag{10}$$

Table 1 summarizes the short sale constraints measures and the informed trading measures and their relationship with short interest ratios.

Nagel (2005) argues that the strong positive correlation between firm size and institutional ownership suggests that sorting stocks on raw institutional ownership would not provide a conclusive test of the short sale constraints hypotheses. We purge size effects from the raw measure of institutional ownership using the same methodology as in Nagel (2005) as follows:

$$\log(\frac{\text{IORaw}_{i,t}}{\text{1-IORaw}_{i,t}}) = a + b \cdot \text{Size}_{i,t} - c \cdot (\text{Size}_{i,t})^2 + e_{i,t}, \tag{11}$$

where $\text{IORaw}_{i,t}$ is the number of shares owned by institutions relative to the number of shares outstanding, and $\text{Size}_{i,t}$ is the size in logrithm. We run the above cross-sectional regression each quarter, then use the residual $e_{i,t}$ as the size adjusted institutional ownership IO.

Table 2 contains the descriptive statistics for the monthly variables for the stocks with and without options during 1991-2011. The average short interest ratio of stocks without options (0.014) is much lower than that of stocks with options (0.059). A similar pattern can be observed for variables $\mathrm{USIR^I}$ and $\mathrm{ESIR^S}$. The first autocorrelation of $\mathrm{ESIR^S}$ is higher than that of $\mathrm{USIR^I}$ for both stocks with and without options. This pattern is consistent with our argument that short sale constraints should be more persistent than informed trading. Similar patterns can be observed between $\mathrm{SIRM^I}$ and $\mathrm{SIRO^S}$, and between $\mathrm{RSIR^I}$ and $\mathrm{PSIR^S}$.

Table 3 reports the correlation coefficients among the measures of short sale constraints and measures of informed trading. Every month, we compute the correlation coefficient across stocks and report the monthly average. In general, the measures of short sale constraints are positively related to each other. For stocks with options, the correlation coefficients among $\mathrm{SIRO^S}$, $\mathrm{ESIR^S}$ and $\mathrm{PSIR^S}$ are all above 0.80. For stocks with options, the correlation between $\mathrm{ESIR^S}$ and $\mathrm{PSIR^S}$ is 0.96. The measures of informed trading are also positively related to each other. The correlations of $\mathrm{UPCR^I}$ with $\mathrm{SIRM^I}$, $\mathrm{USIR^I}$ and $\mathrm{RSIR^I}$ are 0.14, 0.03 and 0.03, respectively. The correlations between $\mathrm{USIR^I}$ and $\mathrm{RSIR^I}$ are 0.89 for stocks both with and without options. In contrast, the measures of short sale constraints and measures of informed trading are either slightly negatively or not related to each other. For example, $\mathrm{ESIR^S}$ and $\mathrm{PSIR^S}$ are negatively related to $\mathrm{USIR^I}$ and $\mathrm{RSIR^I}$, with correlation coefficients in the order of -0.10. Furthermore, Table 3 shows that institutional ownership (IO) is positively related to measures of short sale constraints, with correlations of 0.12 for stocks with options and 0.07 for stocks without options. In contrast, IO is not related to proxies of informed trading. These results suggest that different factors influence variations in short sale constraints and variations in informed trading.

Table 3 shows positive correlations between IO and the measures of short sale constraints calculated from short interest ratios. Chen, Hong, and Stein (2002) and DAvolio (2002) point out that variations in short interest ratios across stocks may instead be a reflection of institutional ownership, and thus stocks with high short interest have more of their shares available for lending. If so, a stock with a high short interest ratio may be the easiest one to short. Because our measures of short sale constraints are mainly constructed from short interest ratios, it is important to show that stocks with high short sale constraints are indeed difficult or costly to short, while stocks with high informed trading are not necessarily so. To investigate whether this is the case, we sort stocks monthly into deciles based on measures of short sale constraints or informed trading for the 2007 to 2011 period, and compute each decile‘s daily average stock borrowing costs. The borrowing costs are the difference between Federal Fund rates and the average rebate rates received by the hedge funds that borrow the stocks. Figure 2 depicts the time series average borrowing costs for each decile sorted on various measures of short sale constraints or informed trading. It is clear from the figure that stocks with high short sale constraints are more difficult to short. The stock borrowing costs are almost monotonically increasing when we sort stocks by measures of short sale constraints. In contrast, there is no obvious relationship between stock borrowing costs and measures of informed trading.

Figure 1 depicts the time series of the monthly averages of the main variables. For each variable we retrieve the monthly figure for each firm and take the average. It is evident that SIR increases from 1991 to 2008, and reaches to a peak in September 2008. PCR tends to increase when the market is on a downward trend. It sinks to the lowest level at the height of the dot-com boom, then jumps to the top in July 2002 after the burst of the boom, and in September 2008 during the financial crisis. Figure 1 also shows that the raw measure of institutional ownership increases substantially in the sample period especially from 2000 to 2002. For stocks with options, the average IO increases from 0.5 to above 0.7, and for stocks without options, their average IO increases by around 0.1.

Hedge funds have grown dramatically in the past two decades. Most of the hedge funds actively engage in shorting stocks. Based on Miller (1977)‘s model, increased shorting activities will mitigate the over-valuation from short sale constraints. It is important to examine whether the growth of hedge funds changes the predictive power of short sale constraints. Thus in Figure 1 we plot the time series of the total number of hedge funds and their total assets relative to the total market value of common stocks. The number of hedge funds increases from 79 in early 1991 to 1655 in 2011. Their total assets relative to total stock market value grows by 37 times from 0.05% to 1.8%.

5 Results

5.1 Informed Trading from Options Trading

Table 4 reports the predictive power of the variables associated with put-call ratios (PCR). Monthly PCR has strong predictability for future 1-month returns. The coefficient is -0.70 with a t-statistic of -3.05 when the dependent variable is the future 1-month four-factor excess return, suggesting that informed investors buy more puts when they expect stock prices to decrease. The predictive power of PCR is no longer statistically significant for the later months, but remains negative. Consistent with our hypothesis on informed trading, the predictability of PCR is not related to institutional ownership adjusted for size.[3]

New information is unpredictable. If PCR is a measure of informed trading in options markets, we expect that its predictive power comes only from its unexpected component. Consistent with our hypothesis, Table 4 shows that the unexpected put-call ratios, ($UPCR^I$), have predictive power for stock returns, while the expected put-call ratios (EPCR) are not related to subsequent stock returns. The coefficient estimates for $UPCR^I$ are statistically significant and negative for the first month, and remain marginally significant for the future fourth to twelfth month returns. Consistent with our argument that there is no obvious relationship between informed trading and institutional ownership, Table 4 shows that the predictability of $UPCR^I$ is not related to IO. These results support our hypothesis that the predictability of put-call ratios come from information, but not from the short sale constraints.

Table 4 also shows that the coefficient estimates for EPCR are not statistically different from zero. EPCR is more related to the characteristics of the stocks than th informed trading. For example, the hedging demand for put options is high for large stocks. Bearish

[3] In unreported results, when we use the raw measure of the institutional ownership, the coefficient estimates of its interaction with PCR are positive and statistically significant, while the coefficient estimates of its interaction with $UPCR^I$ are not statistically different from zero.

option strategies and short sales are often seen as substitutes. EPCR may also be a reflection of the short sale constraints of the underlying stocks. However we do not expect EPCR to have predictive power, as introducing options relaxes short sale constraints to a certain degree.

5.2 Stock and Options markets

Table 5 reports the predictability of short interest ratios from investors who are not options market makers ($\mathrm{SIRO}^{\mathrm{S}}$), after we control for informed trading from the options market. Informed trading is measured by short interest from options market makers ($\mathrm{SIRM}^{\mathrm{I}}$) or unexpected open bought put-call ratios ($\mathrm{UPCR}^{\mathrm{I}}$). Both $\mathrm{SIRO}^{\mathrm{S}}$ and $\mathrm{SIRM}^{\mathrm{I}}$ (or $\mathrm{UPCR}^{\mathrm{I}}$) predict subsequent stock returns. The predictive power of $\mathrm{SIRO}^{\mathrm{S}}$ remains statistically significant up to the future twelfth month, while the predictive power of $\mathrm{SIRM}^{\mathrm{I}}$ is only significant in the first month and the seventh to ninth month returns. Similar results are obtained if we use unexpected put call ratios as the measure of informed trading. These results suggest that after controlling for the informed trading, the short sale constraints measured by $\mathrm{SIRO}^{\mathrm{S}}$ still predict stock returns.

Furthermore, the coefficient estimates for the interactions between $\mathrm{SIRO}^{\mathrm{S}}$ and size adjusted institutional ownership (IO) are positive and mostly statistically significant, while the interactions between the measures of informed trading and IO are negative and mostly insignificant. These different interaction patterns imply, consistent with the over-valuation hypothesis, that this measure of short sale constraints has stronger predictive power for stocks that are more difficult to short.

5.3 Stock Market

Table 6 presents the results after we decompose short interest ratios (SIR) into expected SIR ($\mathrm{ESIR}^{\mathrm{S}}$) and unexpected SIR ($\mathrm{USIR}^{\mathrm{I}}$). We use $\mathrm{ESIR}^{\mathrm{S}}$ as a measure of short sale constraints, because it is persistent and influenced by stock characteristics related to short sale constraints. We use $\mathrm{USIR}^{\mathrm{I}}$ as a measure of informed trading, because it is unpredictable and driven by the trading of short sellers. After controlling for USIR^{I}, short sale constraints measured by ESIR^{S} still predict stock returns at least over the next 12 months. ESIR^{S} has predictive power for both stocks with options and stocks without options, but is stronger for stocks without options. When the dependent variables are the subsequent first to third month four-factor adjusted returns, the mean coefficient estimate on ESIR^{S} is -8.57 (mean t-statistics: -5.16) for stocks without options, and -3.88 (mean t-statistics: -2.23) for stocks with options.

Our hypothesis also states that the predictive power of short sale constraints will be stronger for stocks with low institutional ownership (IO), while the predictive power of informed trading will not be related to institutional ownership. Consistent with our hypothesis, Table 6 shows that the coefficient estimates for the interactions between ESIR^{S} and IO are positive for both stocks with and without options, while those for the interactions between USIR^{I} and IO are close to zero. Furthermore, Table 6 shows that the interactions between ESIR^{S} and IO are stronger for stocks without options than for stocks with options. These different patterns of predictability of ESIR^{S} are consistent with the argument that stocks with options are less short sale constrained than stocks without options, as investors can choose to buy puts or sell calls to overcome short sale constraints in the stock market.

Table 7 presents the results after we decompose short interest ratios (SIR) into predicted SIR (PSIR^{S}) and residual SIR (RSIR^{I}). We use PSIR^{S} as a measure of short sale constraints because it is estimated from stock volatility. Given the same amount of short sale constraints, the higher the divergence of opinion, the greater the over-valuation of the stock price. RSIR^{I} is the difference between SIR and PSIR^{S}. As it is unpredictable, it can serve as a proxy for informed trading. After controlling for RSIR^{I}, short sale constraints measured by PSIR^{S} also predict stock returns at least up to the following 12 months. PSIR^{S} has predictive power for stocks with and without options, and is again stronger for stocks without options. When the dependent variables are the first subsequent month four-factor adjusted excess returns, the coefficient estimate for ESIR^{S} is -8.57 (mean t-statistics: -5.51) for stocks without options, and -4.05 (mean t-statistics: -2.32) for stocks with options.

Consistent with our hypothesis on the role of institutional ownership, Table 7 shows that the coefficient estimates for the interactions between PSIR^{S} and IO are positive for stocks both with and without options, while those on the interactions between RSIR^{I} and IO are close to zero. As for ESIR^{S}, Table 7 shows that the interactions between PSIR^{S} and IO are stronger for stocks without options than with options.

5.4 The first half and the second half periods

Hedge funds have grown dramatically in the past two decades. As shown in Figure 1, the total number of hedge funds increases from 79 in early 1991 to 1655 in 2011. Their total assets relative to total stock market value increases by 36 times from 0.05% to 1.8% during the same period. Furthermore, a large increase in institutional ownership occurs during the early 2000 to 2002. For stocks with options, the average institutional ownership increases from 50% to 71%, and for stocks without options, it increases to 40%. Hedge funds are actively engaging in shorting stocks. Goldman-Sachs (2009) asserts that hedge funds account for 85% of all of the short interest in the market. Under the over-valuation hypothesis, the increased IO and hedge fund shorting activity in our second sample period will push down the prices of over-valued stocks. The negative return predictability of our proxies of short sale constraints will become weaker during the second sample period.

Figure 3 reports the point estimates and t-statistics of the coefficients for the measures of short sale constraints and informed trading when we use raw returns as the dependent variables, and Figure 4 plots the results when we use four-factor adjusted excess returns. We reports the results for the analysis in which the dependent variables are the raw returns because Nagel (2005) documents that short sale constraints can explain the underperformance of stocks with high market-to-book. If increased IO and the shorting activity of hedge funds in the second sample period drive down the over valuation from short sale constraints, the difference in the predictive power between the first and the second period will be larger for raw returns than for four-factor excess returns.

In Figure 3, it is clear that the predictability of short sale constraints becomes weaker during the second half of the sample period. Both the point estimates and the t-statistics are less negative in the later period, especially when we use raw returns as the dependent variables. For stock with options, when we use raw returns, the average coefficients for the ESIR are in the order of -6 during the first half period, and only around -1 during the second half period. The t-statistics for ESIR^{S} are all significantly negative for the first period, and are insignificant for the second period. When we use four-factor adjusted excess returns, for stock with options, the differences in the coefficients and t-statistics for ESIR^{S} are not as large as when we use raw returns, although we can see that the coefficient estimators are less negative and less statistically significant. The same pattern is observed when we use PSIR^{S} and SIRO^{S} for stock with options. Both the point estimates and the t-statistics are less negative in the second period, and the difference between the two periods is larger when raw returns are used in the predictive regression.

Similar results are obtained for stocks without options. When we use ESIR^{S} as a measure of short sale constraints, its average coefficient estimates are below -10 for the first period, and only marginally below zero for the second period. The average t-statistic is -4.10 (-3.23) when raw (excess) returns are used for the first period, and is mostly insignificant for the second period. The difference in the predictive power of PSIR^{S} between two periods is smaller, but still it is clear from the figures that its predictability is higher for the first half period than the second half period.

These results suggest that the increased hedge funds shorting activity and IO relax short sale constraints to a certain degree in the later period, and stocks are less overvalued due to short sale constraints than stocks in the early period. In contrast, we do not observe any obvious difference in the predictive power of informed trading between the first and the second sample periods.

6 Conclusion

We decompose short interest ratios into the component related to informed trading and the component related to short sale constraints. Our decomposition is based on the facts that there is informed trading in the options market, and that informed trading in short interest ratios is driven by the trading activity of short sellers; thus it is short lived and difficult to predict. In contrast, short sale constraints arise because some investors are unable to short the stocks; short sale constraints are persistent and driven by the characteristics of the stocks such as the degree of divergence of opinion. The decomposition is supported by the finding that stock borrowing costs are positively related measures of short sale constraints, but not to the measures of informed trading.

Our results show that both informed trading and short sale constraints have predictive power for subsequent stock returns. Cross-sectionally, stocks with a higher level of short sale constraints or informed shorting have lower subsequent returns for at least 12 months. In predicting returns, the two components show different interactions with institutional ownership. The predictability of informed trading is unrelated to institutional ownership, while the predictability of short sale constraints is stronger for stocks with lower institutional ownership. Furthermore, after large increases in institutional ownership and in the shorting activity of hedge funds, we find that the predictive power of the measures short sale constraints becomes weaker, while the predictive power of the measures of informed trading does not change.

It is well documented in the literature that short interest ratios have higher predictive power for stocks with lower institutional ownership. This finding is consistent with the over-valuation of stocks with higher short sale constraints, but we cannot exclude an alternative explanation that the high predictive power of SIR for stocks with low IO comes from the characteristics of stocks other than short sale constraints. For example, stocks with lower IO may be subject to more informed trading because they are less information efficient or have higher shorting costs. Our results are generated from the decomposition of the SIR of the *same* stock into the component related to short sale constraints and the component related to informed trading. The difference in their interactions with IO clearly shows that it is the short sale constraints and not the information that contribute to the link between SIR and IO in predicting stock returns.

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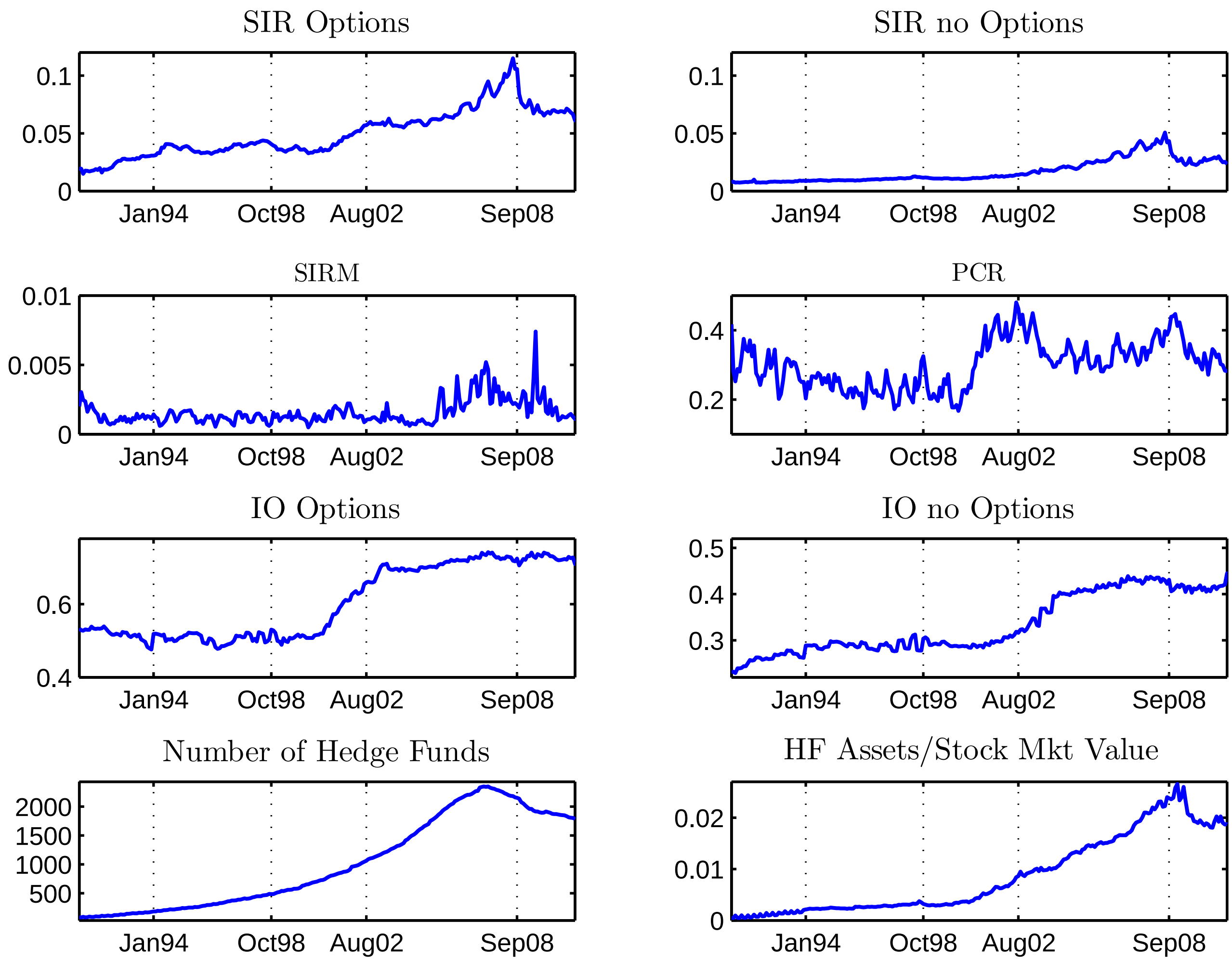

Figure 1: **Time Series Plots of Main Variables.** SIR is the ratio of short interest to shares outstanding. PCR is the open bought put volumes divided by the open bought call and put volumes. IO is the raw measure of institutional ownership relative to shares. Variables are monthly averages across stocks from 1991 to 2011.

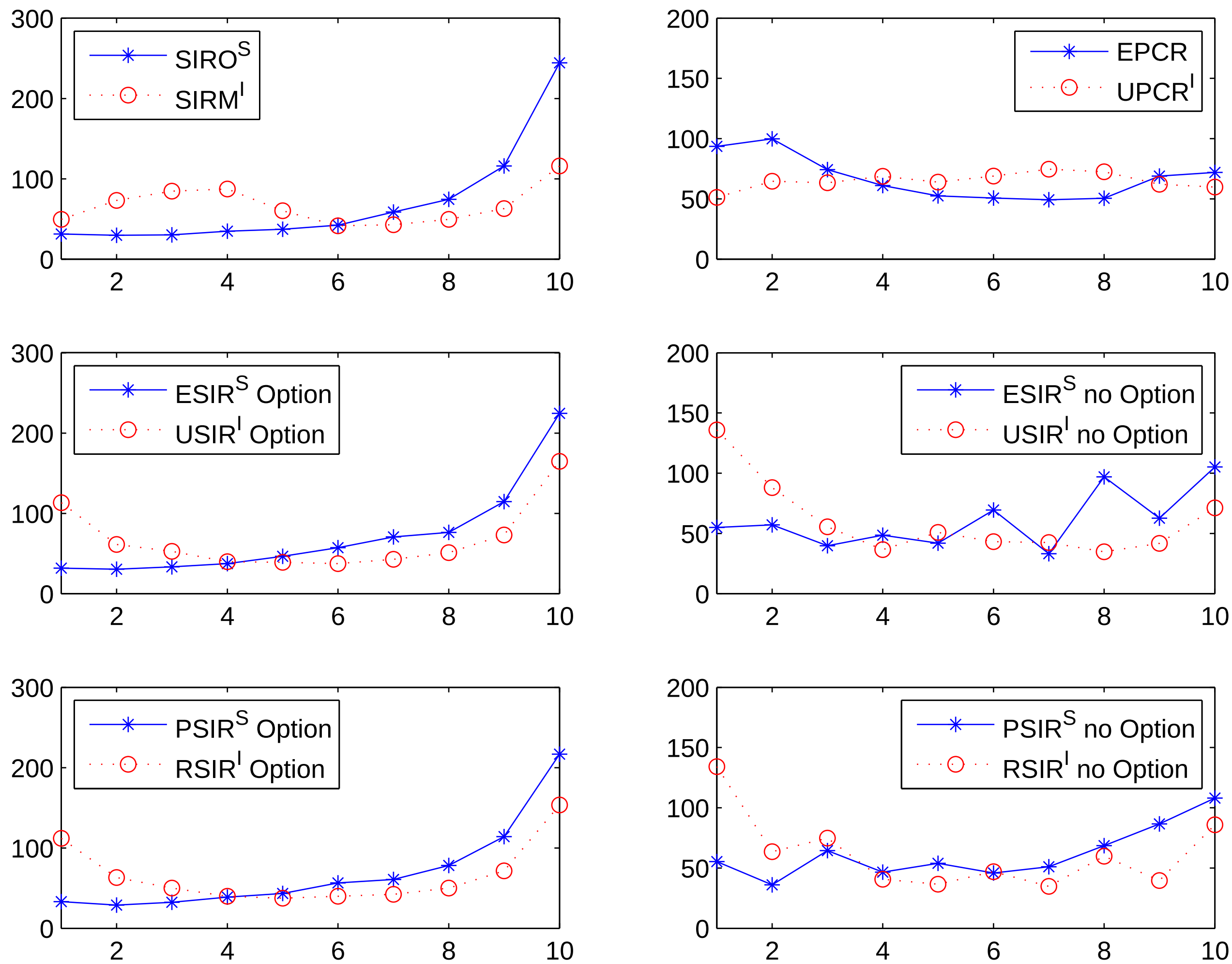

Figure 2: **Borrowing Costs of Short Sale Constraint Deciles and Informed Trading Deciles.** Reported are the stock borrowing costs for deciles of stocks sorted by various measures of short sale constraints or informed trading. Stock borrowing costs is the difference between Federal Fund rates and the average rebate rates received by hedge funds that borrow the stocks. $SIRM^I$ is the short interest ratios of options market makers, $SIRO^S$ is the short interest ratio of the other investors who are not options market makers. EPCR is the expected put call ratio. $UPCR^I$ is the unexpected put call ratios. $ESIR^S$ is the expected short interest ratio, computed as the moving average of the previous 12-month SIR. $USIR^I$ is the unexpected short interest ratio, the difference between SIR and $ESIR^S$. $PSIR^S$ is the predicted SIR based on previous SIR and stock volatility. $RSIR^I$ is the residual SIR, the difference between SIR and $PSIR^S$. Variables with superscript 'I' are measures of informed trading; variables with superscript 'S' are measures of short sale constraints. Variables are monthly from 2007 to 2011.

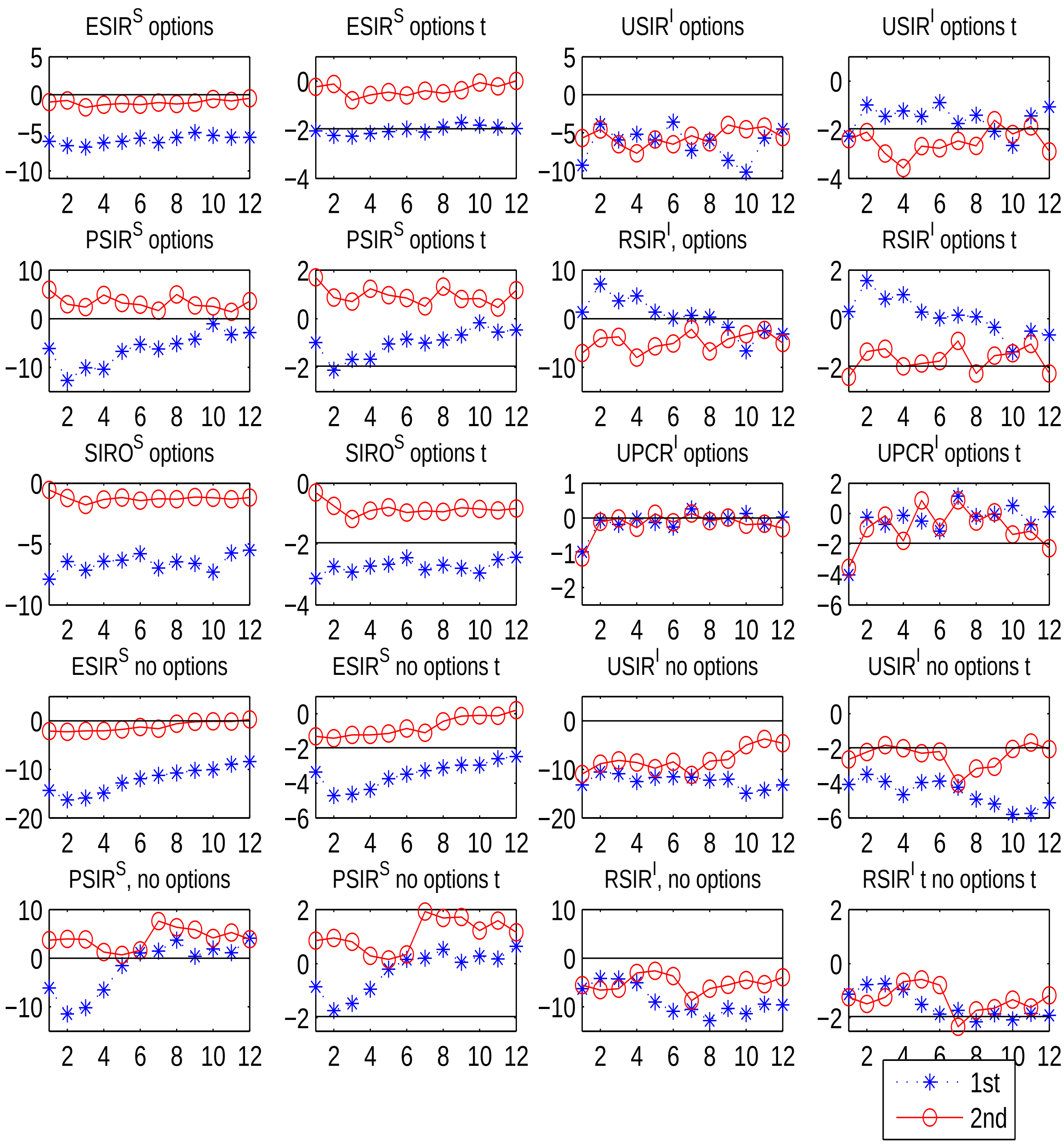

Figure 3: **Estimated Coefficients and t-statistics for the First and Second Half Sample Period, Raw Returns.** The dependent variable is the 1st, the 2nd, up to the 12th subsequent month raw returns. ESIR^{S} is the expected SIR. USIR^{I} is the unexpected SIR. PSIR^{S} is the predicted SIR based on lagged stock volatility. RSIR^{I} is the residual SIR. SIRO^{S} is the non-options market maker short interest relative to shares. UPCR^{I} is the unexpected put call ratio. Variables with superscript 'I' are measures of informed trading; variables with superscript 'S' are measures of short sale constraints. The first half period is 1991 to 2002, indicated by a circled solid line. The second half period is from 2003 to 2011, indicated by a starred dotted line. T-statistics are estimated by Fama-Macbeth monthly cross-sectional regression.

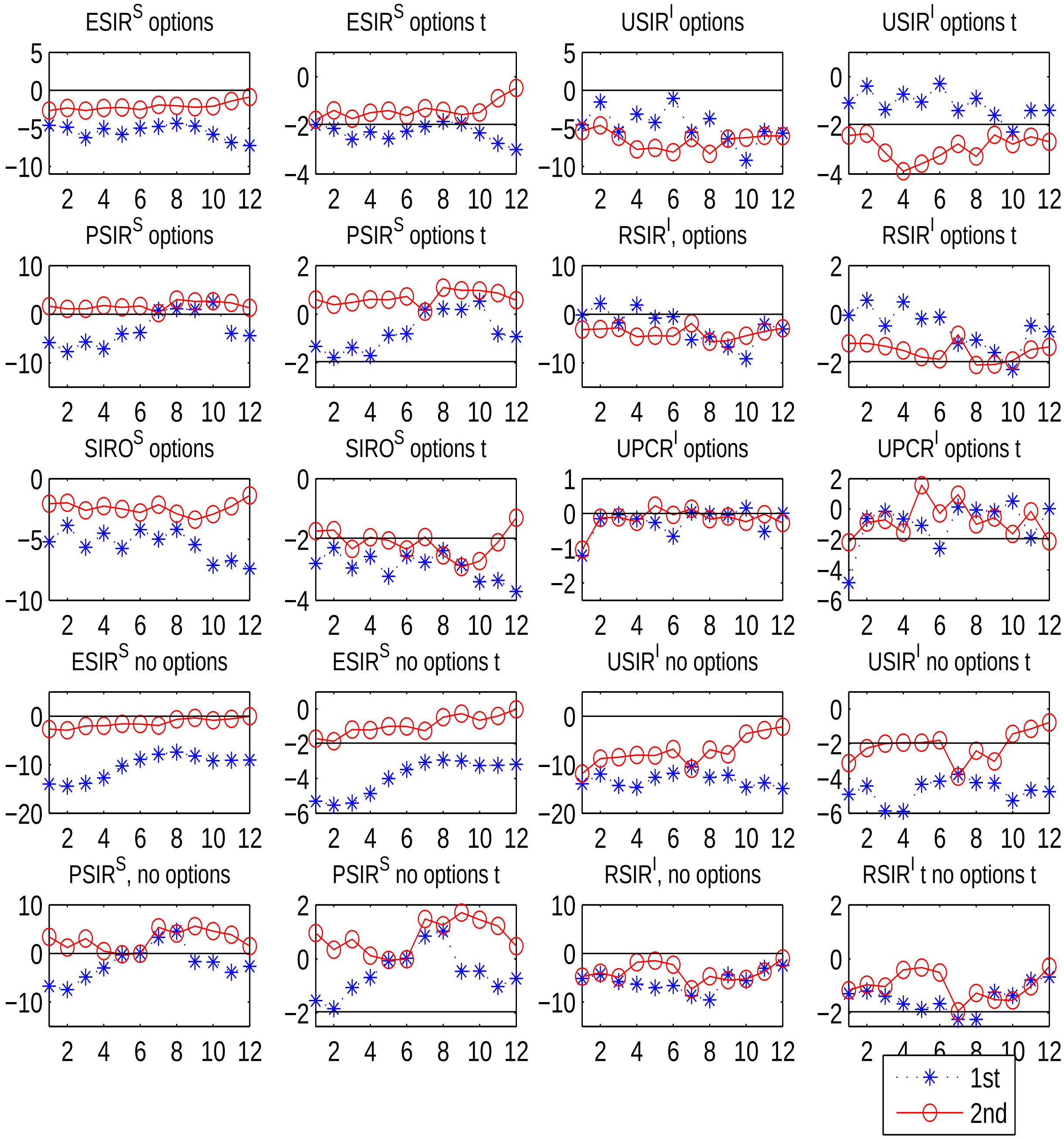

Figure 4: **Estimated Coefficients and t-statistics for the First and Second Half Sample Period, four-factor Excess Returns.** The dependent is the 1st, the 2nd, up to the 12th subsequent month four-factor adjusted excess returns. ESIR^{S} is the expected SIR. USIR^{I} is the unexpected SIR. PSIR^{S} is the predicted SIR from lagged stock volatility. RSIR^{I} is the residual SIR. SIRO^{S} is the non-options market maker short interest relative to shares. UPCR^{I} is the unexpected put call ratio. Variables with superscript 'I' are measures of informed trading; variables with superscript 'S' are measures of short sale constraints. The first half period is 1991 to 2002, indicated by a circled solid line. The second half period is from 2003 to 2011, indicated by a starred dotted line. T-statistics are estimated by Fama-Macbeth monthly cross-sectional regression.

Table 1: **Measures of Short Sale Constraints and Informed Trading**

Short Sale Constraints		**Informed Trading**		**Relation**
$SIRO^S$	SIR non-option-market-maker	$SIRM^I$	SIR option-market-maker	$SIR = SIRO^S + SIRM^I$
		$UPCR^I$	Unexpected put call ratios	
$ESIR^S$	Expected SIR	$USIR^I$	Unexpected SIR	$SIR = ESIR^S + USIR^I$
$PSIR^S$	Predicted SIR	$RSIR^I$	Residual SIR	$SIR = PSIR^S + RSIR^I$

SIR is the short interest ratio relative to shares outstanding. $UPCR^I$ is the unexpected monthly open buy put volume relative to the sum of the open buy call and put volume. Variables are monthly from 1991 to 2011.

Table 2: **Summary Statistics**

(%)						
	Mean	**Std**	**P25**	**Median**	**P75**	**Auto**
			Stocks with Options			
SIR	5.68	2.68	3.71	5.26	7.29	64.58
$SIRO^S$	5.65	2.76	3.71	5.26	7.29	63.98
$SIRM^I$	0.15	0.30	0.01	0.04	0.15	36.41
PCR	28.00	23.73	9.57	22.75	42.51	13.61
$UPCR^I$	-0.18	26.31	-16.40	-1.71	14.46	-3.22
EPCR	28.11	16.66	15.62	26.00	38.71	56.33
$ESIR^S$	5.39	2.18	3.71	5.13	6.92	78.26
$USIR^I$	0.32	2.33	-1.13	0.21	1.64	60.45
$PSIR^S$	5.42	2.38	3.73	5.14	6.92	59.32
$RSIR^I$	0.39	2.49	-1.03	0.27	1.71	47.70
IORaw	58.64	8.67	52.84	59.29	64.96	70.54
IO	53.83	8.73	47.87	53.79	59.78	65.98
	Mean	**Std**	**P25**	**Median**	**P75**	**Auto**
			Stocks without Options			
SIR	1.46	1.31	0.56	1.08	2.02	58.18
$ESIR^S$	1.54	1.02	0.79	1.26	2.09	81.26
$USIR^I$	0.06	1.00	-0.41	-0.01	0.42	53.63
$PSIR^S$	1.56	1.12	0.78	1.27	2.12	60.81
$RSIR^I$	0.06	1.04	-0.39	0.00	0.44	43.61
IORaw	29.05	8.16	23.11	28.77	34.76	78.01
IO	51.17	12.02	42.79	51.40	59.75	74.49

SIR is the short interest relative to shares outstanding. $SIRM^I$ is the SIR from options market makers, $SIRO^S$ is the SIR from other investors who are not options market makers. PCR is the monthly open buy put volume relative to the sum of the open buy call and put volume. EPCR is the expected PCR computed as the previous 3-month moving average of PCR. $UPCR^I$ is the unexpected PCR, the difference between PCR and EPCR. $ESIR^S$ is the expected SIR, computed as the moving average of the previous 12-month SIR. $USIR^I$ is the unexpected SIR, the difference between SIR and $ESIR^S$. $PSIR^S$ is the predicted SIR from previous SIR and stock volatility. $RSIR^I$ is the residual SIR, the difference between SIR and $PSIR^S$. IORaw is the raw measure of institutional ownership, and IO is the institutional ownership adjusted for size. Variables with superscript 'I' are measures of informed trading; variables with superscript 'S' are measures of short sale constraints. Variables are monthly from 1991 to 2011.

Table 3: **Correlation Coefficients**

Stocks with Options									
	$SIRO^S$	$ESIR^S$	$PSIR^S$	EPCR	$UPCR^I$	$SIRM^I$	$USIR^I$	$RSIR^I$	IO
$SIRO^S$	1								
$ESIR^S$	0.82	1							
$PSIR^S$	0.80	0.96	1						
EPCR	0.06	0.06	0.06	1					
$UPCR^I$	-0.01	-0.01	-0.01	-0.36	1				
$SIRM^I$	-0.03	0.05	0.05	0.17	0.14	1			
$USIR^I$	0.40	-0.12	-0.08	0.05	0.03	0.10	1		
$RSIR^I$	0.38	-0.09	-0.16	0.04	0.03	0.09	0.89	1	
IO	0.13	0.13	0.12	0.12	0.00	0.06	0.03	0.05	1

Stocks without Options					
	$ESIR^S$	$PSIR^S$	$USIR^I$	$RSIR^I$	IO
$ESIR^S$	1				
$PSIR^S$	0.96	1			
$USIR^I$	-0.12	-0.08	1		
$RSIR^I$	-0.09	-0.16	0.89	1	
IO	0.08	0.07	-0.01	0.00	1

$SIRM^I$ is the short interest ratio (SIR) from options market makers, $SIRO^S$ is the SIR from other investors who are not options market makers. EPCR is the expected put call ratio. $UPCR^I$ is the unexpected put call ratio. $ESIR^S$ is the expected SIR. $USIR^I$ is the unexpected SIR. $PSIR^S$ is the predicted SIR from previous SIR and stock volatility. $RSIR^I$ is the residual SIR. IO is the institutional ownership adjusted for size. Variables with superscript 'I' are measures of informed trading, and variables with superscript 'S' are measures of short sale constraints. Variables are monthly from 1991 to 2011.

Table 4: **Predictability of Options Market Trading**

	1st month returns				2nd month returns			
Const	-0.02	0.00	-0.08	-0.19*	-0.07	-0.06	-0.07	-0.16
	(-0.12)	(0.03)	(-0.42)	(-1.99)	(-0.49)	(-0.39)	(-0.37)	(-1.58)
PCR	-0.70**	-0.90*			-0.24	-0.49		
	(-3.05)	(-2.13)			(-1.07)	(-1.13)		
PCR*IO		0.31				0.41		
		(0.46)				(0.57)		
$UPCR^I$			-0.91**	-1.15*			-0.25	-0.89
			(-4.39)	(-2.21)			(-1.24)	(-1.83)
$UPCR^I$*IO				0.51				1.26
				(0.59)				(1.55)
EPCR			-0.44				-0.25	
			(-1.18)				(-0.66)	
	3rd month returns				**4th-6th month returns**			
Const	-0.12	-0.11	-0.08	-0.15	-0.23	-0.22	-0.25	-0.33
	(-0.73)	(-0.70)	(-0.40)	(-1.42)	(-0.75)	(-0.72)	(-0.65)	(-1.51)
PCR	-0.11	-0.25			-0.53	-2.01**		
	(-0.42)	(-0.57)			(-1.22)	(-2.61)		
PCR*IO		0.30				2.63*		
		(0.41)				(2.23)		
$UPCR^I$			-0.14	0.45			-0.76*	0.02
			(-0.62)	(0.82)			(-2.11)	(0.02)
$UPCR^I$*IO				-0.96				-1.26
				(-1.05)				(-0.87)
EPCR			-0.23				-0.32	
			(-0.60)				(-0.45)	
	7th-9th month returns				**10th-12th month returns**			
Const	-0.11	-0.11	0.07	-0.22	0.15	0.14	0.24	-0.04
	(-0.33)	(-0.34)	(0.17)	(-0.87)	(0.42)	(0.41)	(0.55)	(-0.15)
PCR	-0.44	-0.99			-0.91	-2.02**		
	(-1.01)	(-1.34)			(-1.83)	(-2.59)		
PCR*IO		1.03				1.86		
		(0.86)				(1.63)		
$UPCR^I$			-0.29	0.57			-0.79	-1.07
			(-0.80)	(0.59)			(-1.86)	(-1.02)
$UPCR^I$*IO				-1.02				1.00
				(-0.61)				(0.57)
EPCR			-1.11				-1.13	
			(-1.48)				(-1.37)	

This table shows the predictive power of put call ratios from its unexpected component. The dependent is the subsequent monthly four-factor adjusted excess returns. PCR is the monthly open bought put volumes divided by the open bought put and call volumes. EPCR is the expected PCR, the average of the previous 3-month PCR. $UPCR^I$ is the unexpected PCR, calculated as the difference between PCR and EPCR. IO is the institutional ownership adjusted for size. Fama Macbeth cross sectional t-statistics adjusted for serial correlations are reported in parentheses. The time period is from January 1991 to December 2011. **: significant at 1%. *: significant at 5%.

Table 5: **Predictability of Short Interest vs Options Market Trading**

	1st month returns				2nd month returns			
Cons	-0.02	0.00	-0.03	-0.01	-0.02	0.03	-0.04	-0.01
	(-0.24)	(0.05)	(-0.32)	(-0.11)	(-0.22)	(0.28)	(-0.44)	(-0.09)
SIRO^{S}	-4.18**	-9.81*	-4.15**	-8.05	-3.75**	-11.28**	-2.82	-8.89*
	(-2.53)	(-2.18)	(-2.49)	(-1.77)	(-2.45)	(-2.54)	(-1.71)	(-1.98)
SIRO^{S}*IO		10.07*		9.45		11.14*		8.90
		(1.98)		(1.86)		(1.98)		(1.81)
SIRM^{I}	-32.07*	44.46			-8.01	37.98		
	(-2.14)	(1.21)			(-0.52)	(1.07)		
SIRM^{I}*IO		-147.32**				-86.88		
		(-2.44)				(-1.49)		
UPCR^{I}			-0.81**	-1.22**			-0.16	-0.87
			(-4.86)	(-2.47)			(-1.04)	(-1.79)
UPCR^{I}*IO				0.68				1.24
				(0.82)				(1.52)
	3rd month returns				**4th-6th month returns**			
Const	0.00	0.05	0.01	0.03	0.10	0.21	0.11	0.19
	(0.04)	(0.47)	(0.06)	(0.30)	(0.49)	(1.00)	(0.52)	(0.93)
SIRO^{S}	-4.52**	-13.53**	-4.12**	-10.77**	-10.41**	-30.27**	-9.47**	-26.13**
	(-2.53)	(-3.22)	(-2.48)	(-2.54)	(-3.49)	(-3.81)	(-3.37)	(-3.70)
SIRO^{S}*IO		13.96**		10.23*		29.30**		24.54**
		(2.42)		(2.00)		(2.69)		(2.55)
SIRM^{I}	-25.98	31.46			-49.45	97.20		
	(-1.63)	(0.86)			(-1.60)	(1.35)		
SIRM^{I}*IO		-115.89				-250.50*		
		(-1.78)				(-2.05)		
UPCR^{I}			-0.08	0.40			-0.64*	0.36
			(-0.47)	(0.75)			(-2.19)	(0.43)
UPCR^{I}*IO				-0.80				-1.65
				(-0.90)				(-1.14)
	7th-9th month returns				**10th-12th month returns**			
Const	0.24	0.36	0.27	0.38	0.50	0.58	0.57	0.62
	(1.07)	(1.61)	(1.21)	(1.70)	(2.12)	(2.48)	(2.35)	(2.57)
SIRO^{S}	-10.01**	-23.63**	-10.40**	16.91*	-14.56**	-21.46**	-14.06**	-21.60**
	(-3.28)	(-2.82)	(-3.49)	(-2.22)	(-5.11)	(-2.74)	(-4.92)	(-3.01)
SIRO^{S}*IO		22.21*		7.20		10.01		10.96
		(1.98)		(0.71)		(0.95)		(1.12)
SIRM^{I}	-66.05*	-34.83			-9.92	13.98		
	(-2.29)	(-0.42)			(-0.35)	(0.18)		
SIRM^{I}*IO		-110.03				-21.26		
		(-0.85)				(-0.16)		
UPCR^{I}			0.02	0.67			-0.45	-1.25
			(0.08)	(0.71)			(-1.38)	(-1.20)
UPCR^{I}*IO				-1.18				1.20
				(-0.72)				(0.70)

This table compares the predictability of short sale constraints and informed trading in the options market, and their interactions with institutional ownership. SIRO^{S} is the short interest ratio from non-options market makers. SIRM^{I} is the short interest ratio from options market makers. UPCR^{I} is the unexpected open bought put-call ratios. IO is the institutional ownership adjusted for size. Fama Macbeth cross sectional t-statistics adjusted for serial correlations are reported in parentheses. The time period is from 1991 to 2011. $^{*}*$: significant at 1%. *: significant at 5%.

Table 6: **Predictive Power of** ESIR^S **and** USIR^I **for Monthly Returns**

	Panel A 1st month returns, Stock with Options				1st month returns, Stock without Options			
Const	-0.06	-0.04	-0.19*	-0.04	0.24*	0.25*	0.16	0.26*
	(-0.67)	(-0.49)	(-2.00)	(-0.43)	(2.01)	(2.05)	(1.37)	(2.12)
ESIR^S	-3.92**	-8.65		-3.86*	-7.36**	-17.35**		-8.69**
	(-2.34)	(-1.80)		(-2.21)	(-4.70)	(-4.80)		(-5.21)
ESIR^S*IO		7.99				16.20**		
		(1.18)				(3.05)		
USIR^I			-8.40	-6.22*			-12.55*	-13.24**
			(-1.08)	(-2.29)			(-2.16)	(-5.55)
USIR^I*IO			4.21				2.87	
			(0.34)				(0.32)	
	Panel B 2nd month returns, Stock with Options				**2nd month returns, Stock without Options**			
Const	-0.04	-0.02	-0.15	-0.02	0.27*	0.28*	0.17	0.28**
	(-0.44)	(-0.18)	(-1.50)	(-0.26)	(2.24)	(2.32)	(1.56)	(2.30)
ESIR^S	-3.13*	-9.05*		-3.38*	-7.57**	-25.16**		-8.90**
	(-1.92)	(-2.03)		(-1.98)	(-4.92)	(-7.56)		(-5.37)
ESIR^S*IO		9.59				28.88**		
		(1.56)				(6.45)		
USIR^I			-4.28	-3.01			-7.19	-10.85**
			(-0.55)	(-1.19)			(-1.23)	(-4.64)
USIR^I*IO			0.36				-1.79	
			(0.03)				(-0.20)	
	Panel C 3rd month returns, Stock with Options				**3rd month returns, Stock without Options**			
Const	-0.02	0.00	-0.16	0.01	0.20	0.21	0.12	0.20
	(-0.25)	(-0.04)	(-1.50)	(0.05)	(1.69)	(1.77)	(1.05)	(1.69)
ESIR^S	-3.84**	-11.01**		-4.40**	-6.90**	-24.30**		-8.12**
	(-2.32)	(-2.65)		(-2.51)	(-4.48)	(-6.78)		(-4.89)
ESIR^S*IO		11.64*				28.58**		
		(2.00)				(5.74)		
USIR^I			-6.01	-5.78*			-11.56*	-11.57**
			(-0.76)	(-2.29)			(-1.98)	(-4.95)
USIR^I*IO			-0.66				2.66	
			(-0.05)				(0.30)	
	Panel D 4-6th month returns, Stock with Options				**4-6th month returns, Stock without Options**			
Const	-0.02	0.06	-0.36	0.09	0.59*	0.61*	0.41	0.60*
	(-0.08)	(0.24)	(-1.39)	(0.36)	(2.15)	(2.24)	(1.61)	(2.17)
ESIR^S	-8.24**	-26.46**		-10.16**	-15.69**	-59.41**		-18.67**
	(-2.38)	(-3.18)		(-2.81)	(-4.21)	(-6.56)		(-4.81)
ESIR^S*IO		28.82**				71.61**		
		(2.51)				(6.59)		
USIR^I			-20.79	-13.65**			-43.03**	-32.00**
			(-1.29)	(-2.43)			(-2.89)	(-5.59)
USIR^I*IO			14.68				23.37	
			(0.56)				(1.11)	

to be continued

Table 6 continued

Panel E 7-9th month returns, Stock with Options					9-7th month returns, Stock without Options			
Const	0.11	0.20	-0.17	0.23	0.55*	0.57*	0.46	0.61*
	(0.47)	(0.84)	(-0.57)	(0.90)	(2.06)	(2.14)	(1.85)	(2.25)
$ESIR^S$	-7.62*	-21.85**		-9.12**	-10.96**	-50.36**		-13.55**
	(-1.99)	(-2.36)		(-2.30)	(-2.99)	(-5.10)		(-3.57)
$ESIR^S$*IO		21.33				64.24**		
		(1.76)				(5.34)		
$USIR^I$			-11.13	-17.93**			-36.00**	-32.92**
			(-0.63)	(-3.07)			(-2.83)	(-7.02)
$USIR^I$*IO			-12.14				15.13	
			(-0.45)				(0.82)	
Panel F 10-12th month returns, Stock with Options					**10-12th month returns, Stock without Options**			
Const	0.37	0.41	-0.03	0.46	0.58*	0.60*	0.47	0.63*
	(1.33)	(1.49)	(-0.09)	(1.64)	(2.15)	(2.23)	(1.84)	(2.28)
$ESIR^S$	-12.07**	-24.02**		-12.35**	-12.25**	-49.52**		-14.61**
	(-3.30)	(-2.69)		(-3.22)	(-3.36)	(-4.84)		(-3.86)
$ESIR^S$*IO		19.28				60.47**		
		(1.63)				(4.63)		
$USIR^I$			6.36	-19.17**			-33.81*	-27.61**
			(0.35)	(-3.30)			(-2.12)	(-5.52)
$USIR^I$*IO			-39.32				15.51	
			(-1.48)				(0.69)	

This table compares the predictive power of expected and unexpected short interest ratios and their interactions with institutional ownership. The dependent variables are the subsequent monthly four-factor adjusted excess returns. $ESIR^S$ is the expected short interest ratio computed as the moving average of previous 12-month SIR. $USIR^I$ is the unexpected SIR, calculated as the difference between SIR and $ESIR^S$. Variables with superscript 'I' are measures of informed trading; variables with superscript 'S' are measures of short sale constraints. IO is the institutional ownership adjusted for size. Fama Macbeth cross-sectional t-statistics adjusted for serial correlations are reported in parentheses. The time period is from 1991 to 2011. **: significant at 1%. *: significant at 5%.

Table 7: **Predictive Power of** $\mathrm{PSIR}^{\mathrm{S}}$ **and** $\mathrm{RSIR}^{\mathrm{I}}$ **for Monthly Returns**

	Panel A 1st month returns, Stock with Options				1st month returns, Stock without Options			
Const	-0.08	-0.06	−0.19*	-0.04	0.24*	0.25*	0.16	0.26*
	(-0.86)	(-0.63)	(-1.99)	(-0.43)	(2.02)	(2.05)	(1.43)	(2.15)
$\mathrm{PSIR}^{\mathrm{S}}$	-3.73**	-7.84		-4.05**	-7.21**	-14.96**		-8.57**
	(-2.24)	(-1.65)		(-2.32)	(-4.82)	(-4.46)		(-5.51)
$\mathrm{PSIR}^{\mathrm{S}}$*IO		6.96				12.64**		
		(1.77)				(2.61)		
$\mathrm{RSIR}^{\mathrm{I}}$			-7.95	-6.68**			-13.48**	-13.17**
			(-1.02)	(-2.55)			(-2.43)	(-5.86)
$\mathrm{RSIR}^{\mathrm{I}}$*IO			3.32				5.25	
			(0.27)				(0.61)	
	Panel B 2nd month returns, Stock with Options				**2nd month returns, Stock without Options**			
Const	-0.02	0.00	-0.15	0.00	0.27*	0.28*	0.18	0.29**
	(-0.18)	(0.00)	(-1.49)	(-0.01)	(2.23)	(2.29)	(1.62)	(2.35)
$\mathrm{PSIR}^{\mathrm{S}}$	-3.71**	-8.87*		-4.01**	-7.15**	-22.61**		-8.80**
	(-2.31)	(-2.00)		(-2.40)	(-4.89)	(-7.02)		(-5.58)
$\mathrm{PSIR}^{\mathrm{S}}$*IO		8.56				25.45**		
		(1.89)				(5.86)		
$\mathrm{RSIR}^{\mathrm{I}}$			-4.18	-2.14			-6.68	-9.58**
			(-0.54)	(-0.89)			(-1.18)	(-4.48)
$\mathrm{RSIR}^{\mathrm{I}}$*IO			1.81				0.19	
			(0.15)				(0.02)	
	Panel C 3rd month returns, Stock with Options				**3rd month returns, Stock without Options**			
Const	-0.01	0.00	-0.16	0.03	0.19	0.20	0.13	0.21
	(-0.08)	(-0.01)	(-1.50)	(0.27)	(1.62)	(1.69)	(1.17)	(1.77)
$\mathrm{PSIR}^{\mathrm{S}}$	-4.42**	-10.57**		-5.13**	-5.92**	-22.52**		-7.74**
	(-2.75)	(-2.60)		(-3.01)	(-4.06)	(-6.34)		(-5.03)
$\mathrm{PSIR}^{\mathrm{S}}$*IO		10.31*				27.51**		
		(1.99)				(5.19)		
$\mathrm{RSIR}^{\mathrm{I}}$			-6.78	-4.05			-12.28*	-12.98**
			(-0.85)	(-1.64)			(-2.12)	(-5.40)
$\mathrm{RSIR}^{\mathrm{I}}$*IO			3.70				1.81	
			(0.29)				(0.20)	
	Panel D 4-6th month returns, Stock with Options				**4-6th month returns, Stock without Options**			
Const	0.05	0.10	-0.34	0.14	0.60*	0.61*	0.43	0.64*
	(0.18)	(0.41)	(-1.29)	(0.56)	(2.18)	(2.24)	(1.70)	(2.29)
$\mathrm{PSIR}^{\mathrm{S}}$	-9.29**	-26.02**		-10.57**	-14.50**	-52.99**		-18.70**
	(-2.75)	(-3.16)		(-2.92)	(-4.01)	(-6.09)		(-4.98)
$\mathrm{PSIR}^{\mathrm{S}}$*IO		27.12**				63.78**		
		(2.35)				(6.13)		
$\mathrm{RSIR}^{\mathrm{I}}$			-24.84	-12.36**			-47.52**	-30.28**
			(-1.61)	(-2.40)			(-3.51)	(-5.67)
$\mathrm{RSIR}^{\mathrm{I}}$*IO			24.82				34.41	
			(0.99)				(1.78)	

to be continued

Table 7 continued

Panel E 7-9th month returns, Stock with Options					9-7th month returns, Stock without Options			
Const	0.12	0.18	-0.16	0.23	0.56*	0.57*	0.48*	0.63**
	(0.48)	(0.74)	(-0.53)	(0.89)	(2.08)	(2.13)	(1.96)	(2.31)
$PSIR^S$	-7.42*	-22.11**		-9.04**	-10.79**	-46.07**		-13.47**
	(-1.92)	(-2.36)		(-2.27)	(-3.08)	(-5.04)		(-3.63)
$PSIR^S$*IO		23.22*				57.80**		
		(1.93)				(5.22)		
$RSIR^I$			-4.44	-17.49**			-43.14**	-30.71**
			(-0.25)	(-3.15)			(-3.35)	(-7.00)
$RSIR^I$*IO			-21.32				30.85	
			(-0.81)				(1.60)	
Panel F 10-12th month returns, Stock with Options					**10-12th month returns, Stock without Options**			
Const	0.37	0.40	-0.03	0.48	0.59*	0.60*	0.49	0.65**
	(1.33)	(1.44)	(-0.10)	(1.71)	(2.17)	(2.23)	(1.93)	(2.34)
$PSIR^S$	-11.90**	-25.50**		-12.76**	-12.42**	-48.75**		-15.32**
	(-3.30)	(-2.90)		(-3.32)	(-3.54)	(-5.27)		(-4.16)
$PSIR^S$*IO		22.67*				58.94**		
		(1.95)				(4.97)		
$RSIR^I$			8.86	-18.56**			-32.26**	-25.73**
			(0.50)	(-3.46)			(-2.27)	(-5.57)
$RSIR^I$*IO			-40.50				15.08	
			(-1.52)				(0.74)	

This table compares the predictive power of predicted and residual short interest ratios and their interactions with institutional ownership. The dependent is the subsequent monthly four-factor adjusted excess returns. $PSIR^S$ is the predicted short interest ratio based on the previous stock volatility. $RSIR^I$ is the residual short interest ratio computed as the difference between SIR and $PSIR^S$. Variables with superscript 'I' are measures of informed trading; variables with superscript 'S' are measures of short sale constraints. IO is the size adjusted institutional ownership. Fama Macbeth cross-sectional t-statistics adjusted for serial correlations are reported in parentheses. The variables are monthly and the time period is 1991 to 2011. **: significant at 1%. *: significant at 5%.