The Effects of Investor Sentiment on Speculative Trading and Prices of Stock and Index Options

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ABSTRACT

We find that speculative demand for equity options is positively related to investor sentiment, while hedging demand is invariant to sentiment. Consistent with a demand based view of option pricing, we find that sentiment is related to time-series variation in the slope of the implied volatility smile of stock options, but has little impact on the prices of index options. The pricing impact is more pronounced in options with higher concentration of speculative trading, higher transactions costs, higher stock return volatility, and smaller stock size. Our results suggest that the correlated biases of noise traders affect the trading and prices of securities that are subject to speculation, but do not affect prices of securities in which demand is driven by hedging motives unrelated to sentiment.

JEL Classification Code: G1

Key Words: Options, Volatility Smile, Sentiment, Speculation, Hedging

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Derivative securities permit individuals and firms to achieve payoffs that other securities cannot provide thus making them indispensable tools for risk management. In addition, because of their high leverage, they are also perfect vehicles for speculation. Although a large literature exists that examines the application and pricing of derivative securities,[1] there is relatively little evidence regarding the extent to which investors use derivatives for speculation, and whether speculative trading affects derivative prices, despite the fact that speculation in derivatives markets is often singled out as one of the factors contributing to price bubbles and crashes.[2]

This study takes a step toward filling this void by linking speculative trading behavior in equity options to measures of investor sentiment and examining the extent to which sentiment related trading affects option prices. Our focus on the link between investor sentiment and trading in the options markets is motivated by the fact that sentiment can be interpreted as capturing the correlated beliefs of investors that are unrelated to fundamentals (e.g., DeLong, Shleifer, Summers and Waldman (1990)), which is also a definition of speculation (e.g., Baker and Wurgler (2006)).

Different types of options serve different purposes and are likely to attract different types of traders. For example, Bollen and Whaley (2004) show that most trading in S&P500 (SPX) index options involves puts, while most trading in stock options involves calls. They attribute this fact to the hedging demands of institutional investors, who purchase index put options as portfolio insurance against market declines. In contrast, Lakonishok, Lee, Pearson and Poteshman (2007) document that hedging motivated trades account for only a small fraction of trading in stock options. Apart from the stock call writing, a majority of non-market maker stock

[1] For example, Bates (1991, 2000), Bakshi, Kapadia and Madan (2003), Bollen and Whaley(2004), Coval and Shumway (2001) , Liu, Pan and Wang (2005), Jackwerth and Rubinstain (1996), Pan(2002) , and among others.
[2] For example, most recently, speculative trading in oil futures has been blamed for high oil prices and the US congress is currently considering a number of bills to limit speculative activity in energy derivatives.

option trading involves naked positions; i.e., speculative trades that appear to be motivated by views about future stock price movements.

We begin our analysis by examining how hedging and speculative demand for options responds to investor sentiment. To compute these demands for options, we take advantage of a data set from the Chicago Board Options Exchange (CBOE) that records the purchases and the sales of put and call options over the 1990 to 2001 period. For every month we construct the positive exposure demand (PD) for stock and index options that measures non-market maker net option demand with positive exposure to the underlying stock or index for that period. Based on the discussion in the previous paragraph, we use the PD for S&P500 (SPX) puts as a proxy for hedging motivated option demand, and use the PDs for index calls, and calls and puts on stock options as proxies for demand motivated by speculation.

In our analysis, we rely on two measures of investor sentiment used in prior research investigating the effects of sentiment on stock prices; namely the index of consumer sentiment (CS) based on a survey conducted by University of Michigan and used in Lemmon and Portnaiguina (2006), and the sentiment measure (BW) of Baker and Wurgler (2006). We focus on whether speculation and hedging demands respond differently to investor sentiment.

Consistent with the view that our measures of sentiment reflect the systematic optimism/pessimism of speculative traders, we find that speculative demand is increasing in investor sentiment, while hedging demand is invariant to sentiment. Both the level and change in the value of investor sentiment are positively related to the positive exposure demand (PD) for index SPX calls and stock options, but are unrelated to the PD for SPX puts. Further supporting this view, we find that sentiment has the strongest effect on the PD for stock puts--which Lakonishok et al find to be a common speculative position in their data.

Given the evidence that speculative demand is related to investor sentiment we then examine whether sentiment also impacts the prices of stock and index options. Under the Black-Scholes assumption of frictionless markets, market-makers in options can perfectly and costlessly hedge their positions resulting in supply curves that are flat. According to this efficient market hypothesis, price movements are driven by changes in assets' fundamental values, with demand shocks and irrational sentiment playing no role because the arbitrageurs readily offset price deviations. In contrast, if arbitrage is limited (Shleifer and Vishny (1997)) or hedging is costly, then supply curves for options become upward sloping. In this case, as shown by Garleanu, Pedersen, and Poteshman (2007) demand imbalances generated by the trades of end users of options can affect option prices.

To the extent that speculative demand driven by sentiment is concentrated in equity options, and because high transaction costs, holding costs, margin requirements, and difficulties in short selling are more likely to impede arbitrage activities in stock option markets (Figlewski (1989), Pontiff (1996)), then we expect the prices of stock options to respond more strongly to sentiment than prices of index options. Alternatively, if our measures of investor sentiment instead proxy for changes in fundamentals (e.g., Lemmon and Portniaguina (2006) and Baker and Wurgler (2006)), then we expect both the prices of stock and index options respond to sentiment in similar ways, because payoffs of stock options in aggregate and index options are driven by the same underlying fundamentals.

The dependent variable in our pricing analysis is the slope of the implied volatility function (IVF), which is computed as the difference in implied volatility between OTM calls (or ITM puts) and OTM puts (or ITM calls). Bollen and Whaley (2004) find that the slope of the option implied volatility smile changes significantly from month to month. Our tests examine the extent to which changes in sentiment can explain the time-series variation in the slope of the implied volatility function.

Consistent with the demand based view of option pricing, investor sentiment has a significant effect on stock option prices, but has no effect on index option prices. In multivariate regressions that control for the lagged dependent variable, realized volatility, the excess market returns and a measure of institutional investor sentiment, we find that both the level and the change in the value of investor sentiment are positively related to the slope of the implied volatility function for options on individual stocks. In contrast, we find no evidence that our measures of investor sentiment are related to the slope of the implied volatility function for index SPX options. Similar to Han (2008), we find that the slope of the IVF for index options is related to a measure of institutional investor sentiment, but that institutional investor sentiment has no effect on the slope of the IVF for options on individual stocks. We also examine whether our results may be driven by the fact that our sentiment measures are proxy for time variation in physical jump information in the underlying stock returns or any time-series variation in aggregate risk aversion not captured by index options.[3] We do not find that this is the case.

Finally, we examine whether the effects of sentiment on speculative trading and option prices vary cross-sectionally. As predicted by models of limited arbitrage, we find options with a higher proportion of trading from less sophisticated investors and higher underlying volatility exhibit demands and prices that are more sensitive to sentiment. We also find that sentiment has stronger effects on the prices of options with high transaction costs and options written on small size stocks. However, in contrast to the findings in the stock market, where individual investor sentiment mainly affects the pricing of stocks with small size and high transaction costs, we also

[3] The theoretical models of Bates (1991, 2000) and Pan (2002) the risk neutral jump size is the single factor that drives time-series variation in the slope of the option implied volatility smile.

find evidence that options written on large size stocks and options with relatively low trading costs also exhibit demands and pricing that are sensitive to sentiment. These results suggest that speculators are also attracted to options on large firms (perhaps because options on large stocks also offer high leverage) and that liquidity supply in these securities is not perfectly elastic.

Our paper is related to the existing literature investigating the relation between investor sentiment and security prices in the stock market. For example, Lee, Shleifer and Thaler (1991) propose that fluctuations in the discounts of closed-end funds are driven by changes in individual investor sentiment. Baker and Wurgler (2006) present evidence that investor sentiment has significant effects on the cross-section of stock prices. Lemmon and Portniaguina (2006) show that sentiment measured by consumer confidence predicts future returns for small stocks and for stocks with high levels of individual ownership. Kumar and Lee (2006) document that individual investor trades are systematically correlated and can explain the return co-movements for stocks with high retail investor concentration. Most of these studies suggest that sentiment of noise trader only affects the prices of small stocks. Our study, on the other hand, implies that the high potential returns and limited liability offered by options and the frictions associated with hedging by liquidity suppliers in the options market allows investor sentiment to influence trading and prices of options on all stocks both large and small.

Our findings are also related to a number of studies that document behavioral biases in options markets. Stein (1989) finds that longer term implied volatilities of S&P 100 index options overreact to changes in short-term volatility. Poteshman (2001) documents both under-reaction and over-reaction to volatility fluctuations in the market for S&P500 index options. Constantinides, Jackwerth and Perrakis (2006) find no evidence that prices in the option market have become more rational over time. Han (2008) finds a positive relationship between the risk-neutral skewness in S&P500 index option prices and measures of institutional investor sentiment. In contrast to these papers, we focus on the how measures of sentiment relate to the speculation and hedging trading activity and price differences of stock and index options.

Our finding that net positive exposure demand exhibits significant time-series variation related to investor sentiment is also consistent with the results in Lakonishok, Lee, Pearson and Poteshman (2007), who document that during the bubble period in the late 1990's, the least sophisticated investors increased their purchases of growth stock calls. However they do not systematically examine how investor sentiment is related to the speculation and hedging trading activities, nor do they investigate whether investor sentiment affects option prices.

The remainder of the paper is structured as follows. Section I presents data on the trading activity of individual and institutional investors in stock and index options. Section II describes the data and presents summary statistics. Section III presents the results and Section IV concludes with a brief summary.

I. Index and Stock Option Trading

As a precursor to our main analysis we first document the trading behavior of different types of investors in stock and index options. In order for sentiment to affect asset prices, the security must be traded by investors whose beliefs are likely to be affected by information that is unrelated to the fundamental value of the asset (i.e., noise traders). Other studies associate noise traders with small individual investors, while institutional investors are generally assumed to act as rational arbitrageurs (Lee, Shleifer, and Thaler (1991), Kumar and Lee (2006), Lemmon and Portniaguina (2006)). To our knowledge, there is no existing evidence regarding the extent to which individual and institutional investors trade stock and index options differently, except for the general perception that institutional investors actively trade index options for hedging purposes.

To examine the trading behavior of different classes of investors in the options markets, we take advantage of a data set obtained from the CBOE, which contains option volume for CBOE traded equity options for four classes of investors; firm proprietary traders, discount brokerage customers, full service brokerage customers, and other public customers. Firm proprietary traders trade for investment banks, clients of brokerage firms such as E-Trade are an example of discount brokerage customers, and clients of Merrill Lynch are an example of Full-service brokerage customers. Among these groups of option investors, we associate firm proprietary traders with institutional investors, and discount brokerage customers with individual investors. The full service brokerage customers account for the bulk of option trading and include both hedge funds and individual investors, and thus it is not clear how to classify these investors. Poteshman and Sebin (2003) and Pan and Poteshman (2005) provide evidence suggesting that the firm proprietary traders have the highest level of trading sophistication in the options markets, and discount brokerage customers have the lowest level of sophistication.

To measure trading activity of the different investors we compute the percentage of total volume attributable to each class of investors. The percentage volume is the sum of long and short option volume for a particular type of investors divided by the sum of long and short volume of all non-market maker investors. Figure 1 depicts the monthly option trading activity of firm proprietary traders and discount brokerage customers in individual stock options and SPX index options.[4] For stock options, discount customers account for a slightly larger share of the total trading activity compared to firm proprietary traders; the former group accounts for

[4]Since the rest of non-market maker percentage trading activity is mainly from full service customers, we do not include their trading in Figure 1.

10.15% of total non-market-maker volume on average over the whole sample time period, while the latter group accounts for 9.16% of all non-market-maker volume. These numbers illustrate that individual investors are important participants in stock option market. Further breaking down options into calls and puts indicates that compared with firm traders, discount customers are more active in call trading than put trading.

In contrast, individual investors are not active in the market for SPX options. From 1990 through 2001, 27.4% of total non-market-maker volume of index option is generated on average from firm proprietary traders, while only 2.4% is from discount brokerage customers. Additionally, consistent with the conventional wisdom that trading of index puts is driven by the hedging demand of institutional investors, firm proprietary traders dominate trading activity in index put options.

Insert Figure 1 around here

II. Data Sources and Sample Selection

In this Section we describe the option and sentiment data and present the summary statistics of main variables used in our analysis.

A. Option trading and price data

The data used to compute option trading activity is obtained from the CBOE. The data set contains daily non-market maker volume for all CBOE-listed options and non-market maker open interest for all exchange listed equity options over the period January 1990 through December 2001. For each option, the daily trading volume is subdivided into four types of trades: "open-buys', in which non-market markers buy options to open new long positions, "close-buys", in which non-market makers buy options to close out existing written option positions, "open-sells", in which non-market makers sell options to open new short positions, and "close-sells," in which non-market makers sell options to close out existing long options positions. For each option, non-market maker volume is also subdivided into four classes of investors: firm proprietary traders, discount brokerage customers, full service brokerage customers, and other public customers. We use this CBOE volume data to compute positive exposure demand (PD) for options each month during the sample period. Positive exposure demand ($\mathrm{PD_t}$) measures the newly established demand in month t that increases traders' net positive exposure to the underlying stock or index and is computed as the sum of call ($\mathrm{PD_t^C}$) and put ($\mathrm{PD_t^P}$) as follows:

$$\mathrm{PD_t} = \mathrm{PD_t^C} + \mathrm{PD_t^P}, \tag{1}$$

$$\text{where} \quad \mathrm{PD_t^C} = 100 \times [\log(\mathrm{BuyCall_t}) - \log(\mathrm{SellCall_t})],$$

$$\mathrm{PD_t^P} = 100 \times [-\log(\mathrm{BuyPut_t}) + \log(\mathrm{SellPut_t})],$$

where $\mathrm{BuyCall_t}$ is the number of call contracts open purchased by non-market makers in month t across all stock options or SPX options, $\mathrm{SellCall_t}$, $\mathrm{BuyPut_t}$ and $\mathrm{SellPut_t}$ are the number of contracts of open sold calls, open purchased puts, and open sold puts across all stock options or SPX options.[5] In the empirical analysis, we compute positive exposure demand for both stock and index options and for different classes of investors. We use superscript 'S'('I') to indicate stock (SPX) options, 'Disc' to index discount brokerage customers, 'Full' to refer to full service brokerage customers, and 'Firm' to indicate firm proprietary traders. For example, $\mathrm{PD_t^{I\_Firm\_C}}$ refers to firm proprietary trader positive exposure demand for SPX index calls during month t.

[5] We use open volume but not close volume to compute PD because investors close an existing option positions not solely based on their perceptions about future. Other conditions, such as past performance of the position, margin requirement, time to expiration, also cause investor to close a position. For example, when the option expiration day is approaching, many investors close their stock option position to avoid physical delivery of underlying, also investor will have to close a short position under margin requirement, even though they are unwilling to do so.

The data on option prices are compiled from the Berkeley Option Database and Ivy OptionMetrics. The time period covered in this study is from January 1988 to May 2007. Over the period from January 1988 to December 1995 we obtain option price data from the Berkeley Option Database, and from January 1996 through May 2007 the option price data is obtained from OptionMetrics. For the first part of the data period, we follow Bakshi, Cao and Chen (1997) and Bollen and Whaley (2004) and compute daily option implied volatilities from the midpoint of the last bid-ask price quote before 3:00 PM Central Standard Time. For American-style stock options we use the dividend-adjusted binomial method with the actual dividends paid over the life of an option as a proxy for the expected dividends. For SPX index options, which are European, we compute implied volatilities by inverting the Black-Scholes (1973) formula. Linearly interpolated LIBOR is used as the risk free rate. Starting in January 1996 we use the implied volatilities supplied by OptionMetrics which are computed in a similar manner.[6]

We use the implied volatility on the last trading day of the month for options that meet the following four conditions: (1) the option has positive trading volume on that day, (2) the option bid price is larger than zero and within standard no-arbitrage bounds[7], (3) the time to expiration of the option is within (including) 10 to 60 trading days, and (4) the options written on same stock satisfying condition (1)-(3) have more than 2 strike prices for at least one maturity. For options on same underlying that meet the criteria above we first choose the maturity with the highest number of strikes; if options of different maturities have the same number of strike prices, we then choose the maturity with the highest trading volume to ensure that we include the

[6] When calculating implied volatilities OptionMetrics projects dividends rather than using actual realized dividends and uses the settlement prices of CME Eurodollar futures instead of spot prices when futures are available.
[7] For a call, the ask price is not less than $S\text{-}K\text{-}PV(D)$, and the bid price is not larger than S; for a put, the ask price is not less than $K\text{-}S\text{+}PV(D)$, and the bid price is not larger than K. For the European SPX options, we adjust the arbitrage bound by replacing K with Ke^{-rT}.

most actively traded options. The final sample for stock options consists of 106,987 stock end-of- month days from 4,586 different firms, and the average number of stocks in each month increases from 30 in 1988 to 1,071 in 2007, reflecting the dramatic growth in option markets during the sample period.

The primary measure we use to examine the relation between sentiment and option prices is the slope of the implied volatility function (IVF), i.e., the implied volatility difference between OTM calls (or ITM puts) and OTM puts (or ITM calls). To compute the slope of the IVF, we first classify options into moneyness categories based on the delta of the option. Table I lists the range of option deltas for each moneyness category. This method is used in Bollen and Whaley (2004), and takes into account the volatility and maturity of the options.[8] Following Bollen and Whaley (2004), we classify the options into five categories: Category 2 includes OTM puts (or ITM calls), category 3 includes all ATM options, category 4 includes OTM calls (or ITM puts), and categories 1 and 5 contain deep OTM (or deep ITM) options. Holding the underlying stock and the maturity (T) of the option constant, the strike prices increase monotonically from category 1 to category 5.

Insert Table I here

The slope of the implied volatility function (IVF) is computed as the difference in implied volatilities (IV) between options in moneyness category 4 and those in category 2. For individual stock options, the slope measure is the average slope across all stocks in the sample in the month of interest. For index options, the slope measure is the slope of the IVF for SPX options.

[8] When computing the option delta, we estimate volatility using the previous 60 trading days stock or index returns. We obtain similar results by using the implied volatilities of the options to compute delta or by using K/S to classify moneyness.

Specifically, the Slope measures for stock options (Slope_t^S) and SPX options (Slope_t^I) in month t are given by:

$$\mathrm{Slope}_t^S = \frac{1}{N_{t,2,4}} \sum_i^{N_{2,4}} \left(IV_{i,t,T,4} - IV_{i,t,T,2}\right) \tag{2.1}$$

$$\mathrm{Slope}_t^I = IV_{SPX,t,T,4} - IV_{SPX,t,T,2}, \tag{2.2}$$

where $N_{t,2,4}$ is the number of stocks in both moneyness category 2 and category 4 on the last trading day of month t, $IV_{i,t,T,4}$ and $IV_{i,t,T,2}$ are the average IVs of options in moneyness categories 4 and 2, respectively, with maturity T and underlying stock i. We do not use option in categories 1 and 5 because these deep moneyness options are very illiquid and more than half of optionable stocks do not have deep OTM options on most of the trading days. The above slope measures are also used in Bollen and Whaley (2004) and Han (2008), and are essentially equivalent to the risk neutral skewness embedded in option prices (Bakshi, Kapadia and Madan (2003)).[9]

B. Sentiment Measures

We employ two main measures of investor sentiment. The first is the monthly index of Consumer Sentiment (CS) collected by University of Michigan. We view CS as a measure of the sentiment of individual investors because it is based on a survey of households' perceptions about current and future financial conditions. Lemmon and Portniaguina (2006) find that the level of consumer sentiment predicts future returns on small stocks and those with low institutional ownership.

[9] We use slope of IVF instead of model free risk neutral skewness developed in Bakshi, Kapadia and Madan (2003) because most stocks do not have enough number of strike prices to generate integral to compute the risk neutral skewness; the median number of strike prices for optionable stocks in our sample is only 3.

The second measure is the Baker and Wurgler (2006) sentiment index (BW). This sentiment index is based on the first principal component of six sentiment proxies orthogonalized to a set of macroeconomic conditions. The six sentiment proxies include NYSE turnover, the dividend premium, the closed-end fund discount, the number and first-day returns on IPOs, and the equity share in new issues. In contrast to the consumer confidence index, which is based on survey data, the Baker and Wurgler measure is generated from market data.

We also use sentiment estimated by the bull-bear spread (BB) based on the Investor's Intelligence survey on investment newsletter writers. Han (2008) considers the bull-bear spread a proxy for institutional investor sentiment because many of the writers are market professionals. Han (2008) finds that among three measures of institutional investor sentiment, BB has the most power to explain the prices of index options. In this study, we use BB as a control variable to help isolate the sentiment of unsophisticated traders from that of more sophisticated market participants.

C. Summary Statistics

Table II presents summary statistics for the main variables. The positive exposure demand for stock options (PD^{S}) is close to zero on average, while the positive exposure demand for stock calls ($PD^{S\text{-}C}$) is positive, and is negative for stock puts ($PD^{S\text{-}P}$), implying that the average stock option open buy volume exceeds the open sell volume, which is consistent with results in Lakonishok, Lee, Pearson and Poteshman (2008). The PDs for SPX index options are all negative, especially for puts ($PD^{I\text{-}P}$), suggesting put purchases comprise the bulk of SPX option trading (Bollen and Whaley 2004). The slope of the IVF for stock options ($Slope^{S}$) is -196.91 basis points (-1.97%). The slope of the IVF for index options ($Slope^{I}$) is -393.16 basis points, much more negative than $Slope^S$, which is similar to the findings in Bollen and Whaley (2004) and Bakshi, Kapadia and Madan (2003)).

Insert Table II around here

The Michigan consumer sentiment index (CS) has a mean value 91.69 and strong auto correlation (0.92), while its monthly change dCS has a zero mean and zero autocorrelation. The other two sentiment measures, stock market sentiment from Baker and Wurgler (2006) (BW), and institutional investor sentiment Bull-Bear Spread (BB), also have high auto-correlation. Table II also reports summary statistics for several other variables. These variables include the realized volatility for stocks or S&P500 over the remaining life of the option contracts (σ^S or σ^I), the monthly excess return on the value-weighted CRSP index (R_m), the cross sectional average realized future monthly skewness of stock ($Skew^S$), the default spread (AB) measured as the yield spread between Aaa and Baa rated bonds, and its monthly changes (dAB). These variables serve as control variables in our analysis.

Table III reports the correlation coefficients for the main variables used in the tests. The positive exposure demands of stock puts and calls, PD^{S_C} and PD^{S_P}, are positively correlated with each other, while the positive exposure demand of index calls, PD^{I_C}, is positively correlated with PD^{S_P}, but not with PD^{S_C}. In contrast, the positive exposure demand for index puts, PD^{I_P} is largely uncorrelated with PD^{S_C}, PD^{S_P} and PD^{I_C}. These correlations suggest that hedging demand as proxied by the positive exposure demand for index put options, PD^{I_P}, is driven by different forces from those that drive speculative demand, proxied by PD^{S_C}, PD^{S_P} and PD^{I_C}. The proxies for speculative demand are positively correlated with the slope of the IVF for stock options, Slope^{S}, and with the measures of individual investor sentiment, CS, dCS, BW and dBW. In contrast, hedging demand has either negative or near zero correlations with these sentiment variables. The slope of the IVF for stock options, Slope^{S}, is positively correlated with both the levels and changes of the consumer sentiment and Baker Wurgler sentiment variables. In contrast, the slope of the IVF for index options, Slope^{I}, is negatively associated with CS, BW and dBW, and exhibits a small positive correlation with dCS. These correlation coefficients provide preliminary evidence consistent with the view that our sentiment measures are positively associated with speculation demands and with the slope of the IVF for stock options, but that sentiment exhibits a different relation to hedging demand and the slope of the IVF for SPX index options. Moreover, the correlations between the Bull-Bear spread, BB, and the other sentiment measures are quite small, which is consistent with the idea that BB largely reflects the sentiment of institutional investors as suggested by Han (2008), while the other two sentiment variables reflect the sentiment of individual investors.

Insert Table III here

III. Results

In this section we present our main results. We first examine how the measures of investor sentiment are related to speculation and hedging demands. We then investigate the relations between investor sentiment and the pricing of stock and index options. We also present several robustness tests and conclude with an examination of the cross-sectional effects of sentiment on stock option positive exposure demands and prices.

A. Speculation and Hedge Demands and Sentiment

The first part of our empirical analysis investigates the relations between sentiment and speculation and hedging demand for options. Based on our prior analysis, we use the positive exposure demand (PD) for SPX index puts as a proxy for hedging demand and consider the PDs for index calls and stock put and call options as proxies for speculation demand. If sentiment is related to the aggregate speculation of noise traders, optimistic investors will purchase more calls and less puts (high PD) when sentiment is high, and pessimistic investors will purchase more puts and less calls (low PD) when sentiment is low. To the extent that demand for index puts is primarily driven by hedging motives, we do not expect a positive relation between sentiment and hedging demand proxied by PD^{I_P}.

To investigate this hypothesis, we estimate the following time-series regression specifications:

$$PD_t^S = a^S + b^S Sent_t + c^S BB_t + d^S R_{m,t} + f^S PD_{t-1}^S + \varepsilon_t^S \quad (3.1)$$

$$PD_t^I = a^I + b^I Sent_t + c^I BB_t + d^I R_{m,t} + f^I PD_{t-1}^I + \varepsilon_t^I, \quad (3.2)$$

where PD_t^S and PD_t^I are positive exposure demand for stock and SPX options, respectively, computed from Eq.(1). In the analysis, we also break down PD_t^S and PD_t^I into call and put options. $Sent_t$ is sentiment measured either by Michgan index of Consumer Sentiment (CS) or the Baker and Wurgler (2006) sentiment index (BW). Because CS and BW have high autocorrelations, we also use their monthly changes as independent variables in some model specifications. The Bull-Bear spread, BB, controls for institutional investor sentiment based on Han (2008), and R_m is the value weighted market excess return. The regressions also include the lagged dependent variable.

The results are presented in Table IV. When the dependent variable is the demand for stock options (PD^S), the coefficient estimates on the raw measure of consumer sentiment (CS) and its monthly change (dCS) are both positive and statistically significant. In economic terms, a one standard deviation change of dCS is associated with 5 unit variation of PD^S, amounting to 16% of the unconditional standard deviation of PD^S. The coefficient estimates on sentiment measures BW and dBWare also positive, but only the coefficient for dBW is significant at the 10% confidence level.

Breaking down PD^S into the positive exposure demand for stock puts (PD^{S_P}) and the positive exposure demand for stock calls (PD^{S_C}) shows that sentiment is more strongly related to PD^{S_P} than to PD^{S_C}. For example, the former has a coefficient of 0.29 on CS with a t-statistics of 3.00, while the latter has a coefficient of 0.14 on CS with a t-statistics of 1.55. This result is consistent with the findings in Lakonishok, Lee, Pearson and Poteshman (2007), who document that hedging motives appear to account for only a small fraction of stock option trading except writing of covered calls[10], and that trading of stock puts, in particular, tend to be naked positions motivated by directional bets on stock prices.

The positive exposure demand for index options (PD^I) is positively related to sentiment measured by CS and BW, but is unrelated to changes in sentiment. The positive relation arises from SPX call trading, but is not evident for SPX put trading. A one standard deviation change of CS is associated with 23% of the unconditional standard deviation of PD^{I_C}. When the positive exposure demand for SPX puts (PD^{I_P}) is the dependent variable, the coefficients on the sentiment measures are all not significantly different from zero, which is consistent with the idea

[10] Writing covered call refers to writing call and purchasing the underlying stock. According to Ameritrade Handbook for Margins, the only option transactions permitted in an Individual Retirement Account are the writing of covered calls and, if qualified, purchasing of a call or put.

that hedging demand is driven by factors that are unrelated to the speculative sentiment of noise traders.

Insert Table IV here

In Table V, we further decompose the positive exposure demands according to the investor class initiating the trading: customers of discount brokers, customers of full-service brokers, and firm proprietary traders. Among these groups of option investors, we associate firm proprietary traders with institutional investors, and discount brokerage customers with individual investors. The full service brokerage customers include both hedge funds and individual investors. Poteshman and Sebin (2003) and Pan and Poteshman (2005) document that the firm proprietary traders have the highest level of trading sophistication, and discount brokerage customers have the lowest level of sophistication.

Although the statistical significance varies considerably, a general observation is that the positive exposure demands of discount customers and full service customers for stock options and SPX calls are mostly positively related to the various sentiment measures, while the demands for stock options and index calls by firm proprietary traders are generally negatively related to sentiment. When the dependent variable is the demand for index puts ($PD^{I\text{-}P}$), the sentiment measures have positive coefficients for discount customers, and negative or zero coefficients for full service customers and firm proprietary traders. These findings suggest that discount customers may also write index puts when sentiment is high, selling these puts to those with hedging demands.

Insert Table V around here

A potential issue with interpreting the results in Table IV and V is that it does not address the issue of causality. In order to assess whether PD for stock options causes sentiment, or vice-versa, we perform a Granger causality test based on a VAR regression with one lag and five variables, PD^s, dCS, dBW, BB and R_m as follows:

$$PD_t^S = a_1 + b_{11}PD_{t-1} + b_{12}dCS_{t-1} + b_{13}dBW_{t-1} + b_{14}BB_{t-1} + b_{15}R_{m,t-1} + \varepsilon_{1,t} \tag{4.1}$$

$$dCS_t = a_2 + b_{21}PD_{t-1} + b_{22}dCS_{t-1} + b_{23}dBW_{t-1} + b_{24}BB_{t-1} + b_{25}R_{m,t-1} + \varepsilon_{2,t} \tag{4.2}$$

$$dBW_t = a_3 + b_{31}PD_{t-1} + b_{32}dCS_{t-1} + b_{33}dBW_{t-1} + b_{34}BB_{t-1} + b_{35}R_{m,t-1} + \varepsilon_{3,t} \tag{4.3}$$

$$BB_t = a_4 + b_{41}PD_{t-1} + b_{42}dCS_{t-1} + b_{43}dBW_{t-1} + b_{44}BB_{t-1} + b_{45}R_{m,t-1} + \varepsilon_{4,t} \tag{4.4}$$

$$R_{m,t} = a_5 + b_{51}PD_{t-1} + b_{52}dCS_{t-1} + b_{53}dBW_{t-1} + b_{54}BB_{t-1} + b_{55}R_{m,t-1} + \varepsilon_{5,t}, \tag{4.5}$$

Table VI reports the results showing that the past change in consumer sentiment Granger causes PD^S. There is no evidence of reverse causality. In the presence of dCS_{t-1}, the coefficient estimates on dBW and BB in the first row of the table are not significant.[11] Among the other variables, market excess return (R_m) Granger causes both consumer sentiment and the Bull-Bear spread, consistent with findings in Lemmon and Portniaguina (2006) and Brown and Cliff (2005).

Insert Table VI Here

B. Sentiment and Option Prices

The previous section documents that the measures of sentiment are positively related to the demand of speculators for stock options and index calls, but is unrelated to the demand for index puts. To the extent that market-makers in options cannot perfectly and costlessly hedge their positions, supply curves for options become upward sloping. In this case, systematic

[11] In unreported results we find no evidence of causality between PD^I and sentiment.

demand imbalances generated by the trades of end users of options can affect option prices (Garleneau, Pedersen, and Poteshman (2007)). If our sentiment measures reflect aggregate speculation by investors, then we expect sentiment to affect the prices of stock options, which are subject to fluctuations in speculative demand. We further conjecture that speculative demand will be concentrated in out of the money options in order to take advantage of their higher leverage. Based on this argument, we expect the slope of the IVF of stock options, measured as the implied volatility difference between OTM calls (or ITM puts) and OTM puts (or ITM calls), to be positively associated with sentiment. In contrast, we expect sentiment to be unrelated to the prices of index options (particularly index puts), which, as we have shown, are largely immune from demand imbalances associated with changes in aggregate sentiment.

One alternative hypothesis is that the sentiment measures are simply proxies for changes in risk preferences of investors or economic fundamentals. For example, Lemmon and Portniaguina (2006) find that consumer confidence is related to a number of macroeconomic variables. In good economic states it is plausible that investors become less fearful about the likelihood of a potential crash, and therefore alters the jump risk premium embedded in option prices. Bates (2000) and Pan (2002) show that the risk neutral jump component is the most important factor affecting the slope of implied volatility function.[12] Based on their models, Appendix A1 shows that the slope of the IVF is a monotonic increasing function of the risk

[12] Other models have also been developed to incorporate stochastic volatility, jumps and the price of volatility and jump risks to account for the slope of IVF. For example, Merton (1976) constructs a model of pure jumps, Hull and White (1987), Melino and Turnbull (1990), Scott (1987), Stein and Stein (1991) and Heston(1993) model stochastic volatility. Using Bakshi Cao and Chen (1997) document the importance of incorporating stochastic volatility and jumps.

neutral jump size [13]. If sentiment affects option prices through changes in the risk neutral jump size, then sentiment will be positively related to the slope of the IVF for both index and stock options (see Appendix A2). Further, the effect will be more pronounced on the slope of the IVF for index options, because the idiosyncratic jump component in stock option prices will mitigate the effect of market jump risks (Bakshi, Kapadia and Madan (2003)).

The empirical specification used to investigate the impact of sentiment on option prices is as follows:

$$\mathrm{Slope}_t^S = \alpha^S + g^S \mathrm{Sent}_t + h^S \mathrm{BB}_t + i^S \sigma_t^S + j^S R_{m,t} + k^S \mathrm{Slope}_{t-1}^S + \varepsilon_t^S \quad (5.1)$$

$$\mathrm{Slope}_t^I = \alpha^I + g^I \mathrm{Sent}_t + h^I \mathrm{BB}_t + i^I \sigma_t^I + j^I R_{m,t} + k^I \mathrm{Slope}_{t-1}^I + \varepsilon_t^I, \quad (5.2)$$

where Slope_t^S and Slope_t^I are calculated based on Eqs. (2.1) and (2.2), respectively, Sent_t is sentiment measured either by Michgan index of Consumer Sentiment (CS) or the Baker and Wurgler (2006) sentiment index (BW). In some specifications, we instead use the monthly changes in the sentiment measures to estimate the coefficients g^S and g^I. If sentiment affects option prices through changes in speculative demand, then the coefficient g^S will be positive and significant, and the coefficient g^I will be less than g^S since the demand for index options is largely driven by hedging motives. Alternatively, if sentiment instead influences option prices because it proxies for changes in risk preferences or fundamentals, we expect that both of the coefficients g^I and g^S will be positive, as innovations in risk or fundamentals will affect prices of both index and stock options in similar ways.

The regressions also control for a number of other factors related to the slope of the IVF. Han (2008) finds that institutional investor sentiment proxied by the bull-bear spread (BB) is

[13] Since individual stocks have positive jumps, we focus only on jump size, not jump probability. If jump sizes are all negative, more negative risk neutral jump size has the same effect on option prices as higher risk neutral jump probability given same maturity of the options.

related to the risk neutral skewness and the slope of the IVF for SPX index options. Li and Pearson (2006) find that volatility is negatively related to the slope of the IVF for index options, and Denis and Mayhew (2002), and Han (2008) find that volatility is related to the risk neutral sknewness of stock and index options, respectively. We control for volatility using the average realized volatility of underlying stock or index returns measured over the remaining life of the option contracts (σ^S or σ^I). We also control for R_m, the excess market return because Amin, Coval and Seyhun (2004) document that S&P 100 index call (put) prices are overvalued after large upside (downside) market movements. Finally, we include the past month's slope measure to control for the serial dependence in the slope.

Table VII reports the results. For stock options (Panel A), the coefficients estimates on CS and dCS are positive and significant. Adding the control variables hardly changes the magnitudes of these coefficient estimates or the associated t-statistics. In economic terms, a one standard deviation increase of CS is associated with an 86 basis point increase in the slope of the implied volatility function for stock options ($Slope^S$), a magnitude equivalent to 31% of the unconditional standard deviation of $Slope^S$. The coefficient estimates for BW are also positive, but exhibit smaller t-statistics. This finding is consistent with Lemmon and Portniaguina (2006), who also find that the Michigan index is a better predictor of stock returns than the Baker Wurgler measure after 1977. The results for index options (Panel B) exhibit a different pattern. Most of the coefficient estimates on the various sentiment measures are negative and none are statistically significant. These findings show that sentiment affects stock options and index option prices in a manner consistent with the idea that fluctuations in speculative demand driven by changes in aggregate sentiment affect option prices.

As seen in the table, the coefficient estimates on BB (a measure of institutional investor sentiment) are not significantly related to the slope of the implied volatility function for stock options. For index options, the coefficient estimate on the level of BB is positive and statistically significant, consistent with the empirical findings of Han (2008). The coefficient estimates on realized volatility (σ^S/σ^I) are negative in most specifications. The negative relation between volatility and slope is consistent with the theoretical prediction of Bakshi, Kapadia and Madan (2003), and the empirical findings of Li and Pearson (2006). There is no consistent relation between market excess returns (R_m) and the slope of the IVF for either stock or index options.

Insert Table VII around Here

Panel C of the table reports the results for two subperiods, 1988 through 1997, and 1998 through May 2007. The latter period contains the large market runup and decline associated with the internet bubble, and as shown in Figure 1, this period also exhibits a change in the trading behavior of discount brokerage customers. The point estimates on dCS and BW during the first period are similar to those during the second period. The coefficients on dBW are positive and statistically significant only during the second period, and negative and insignificant during the first period. Overall, there is little evidence that the effects of sentiment on option prices differ significantly across the two time periods[14].

C. Robustness Tests

One alternative explanation for our results is that our measures of sentiment are actually correlated with investors' assessment of future physical jumps. It is also possible for positive

[14] We also estimate the regressions for each subperiod for index options. The coefficients on CS, BW, and their monthly changes are all insignificant.

exposure demand to contain information about future stock return jumps; investors will buy more calls and less put today if they correctly foresee that positive jumps will occur, and will buy more puts or less calls if they know that negative jumps will happen. If sentiment is associated with future jumps in stock returns, we will observe a spurious relation between stock option positive exposure demand and sentiment.

To investigate whether physical jump information related to sentiment explains our empirical results, we reestimate the regressions for positive exposure demand and the slope of the IVF controlling for future realized return skewness (Skew) as a proxy for physical jump information. Future skewness is a reasonable proxy for physical jumps, because a stock with high return jumps must also exhibit high return skewness. We estimate future realized skewness using daily returns from one trading day after when we record the option price, to the last trading day of the following month.

The results are reported in Table VIII. Panel A explores whether future skewness can explain the relation between sentiment and positive exposure demand for stock options, and Panel B examines whether skewness can explain the relation between sentiment and option prices. To save space we only report results for the models where sentiment is measured using the Michigan index of consumer sentiment (CS) and its monthly change (dCS). In both panels, the coefficient estimates on skewness are not statistically significant and including skewness in the regressions has little effect on the coefficient estimates of the measures of individual investor sentiment. The results suggest that our sentiment measures are not merely proxying for information on future physical jumps.

Insert Table VIII Here

Another alternative explanation is that sentiment proxies for time variation in risk premiums. To address this possibility, we reestimate the regressions and include the default spread (AB) or its change (dAB) as an additional control variable. Stock and Watson (2003) show that the default spread is the best predictor of business cycles, and Lemmon and Portniaguina (2006) document that among various macro economic variables, default spread is the one most correlated with the Michigan Consumer Sentiment index. The results are reported in Table IX. The coefficient estimates on AB are all positive and statistically significant. However, when we replace AB with dAB, the coefficient estimates become either negative or insignificant. More importantly for our purposes, controlling for the information contained in the default spread does not change our inferences regarding the effects of sentiment on option prices. The coefficient estimates on dCS and dBW remain unchanged after adding the proxies for default risk.

Insert Table IX Here

D. Cross-Sectional Analysis

This section investigates the relation between sentiment and positive exposure demand (PD^S) and the slope of the IVF ($Slope^S$) for stocks with different characteristics. If the positive relation of sentiment with PD^S and $Slope^S$ arise from demand imbalances driven by speculation, then we should find that the association between sentiment and the slope of the IVF is stronger for stocks in which trading by speculative investors is more concentrated and in stocks with high arbitrage and hedging costs. As proxies for the costs of arbitrage we use volatility, transaction costs and firm size.

We estimate individual investor trading activity on options on a particular stock by the option open interest of discount investors divided by the option open interest of all non-market maker investors during entire month. We use open interest instead of volume because our open interest data cover options listed on all exchanges, while the volume data only include options listed on the CBOE. We estimate volatility using daily returns during the current month. Option transaction costs are estimated by the average percentage bid ask spreads of OTM options traded in the previous month, where the percentage bid ask spread is the difference between the ask and the bid prices divided by the mean of the ask and bid prices. We use prior month cost estimates to avoid any endogeneity arising from the co-movement of prices and bid ask spreads.

To investigate whether sentiment influences the positive exposure demand (PD^S) and slope of implied volatility smile ($Slope^S$) for stocks with different characteristics differently, we first sort stocks into quintiles based on the characteristic of interest[15] and then compute PD^S and average of $Slope^S$ across stocks in each quintile for every month. We then sort months into quintiles based on the level of the Michigan Consumer Sentiment and compare PD^S or $Slope^S$ during periods of high and low sentiment across stock characteristic quintiles.

The results are reported in Table X. As seen in Panel A, the difference in PD^S during periods of high and low sentiment is 34.46 units for stocks with the lowest concentration of trading by individual investors and 82.49 units for stocks in the highest quintile of individual investor trading. Panel A also shows a similar effect on $Slope^S$; the difference in $Slope^S$ between high and low sentiment periods is 366.70 basis points for stocks in the lowest quintile of individual investor trading, and 528.05 basis points for stocks in the highest quintile. Similar patterns are documented for stocks sorted on the basis of volatility, transaction costs and firm size. In all

[15] For the size quintiles, we obtain same results using NYSE breakpoints.

cases there is a positive association between the proxies for arbitrage costs and the effect of sentiment on the slope of the IVF. For example, as shown in Panel B, the difference in the effect of sentiment on option prices across stocks with high and low volatilities is 285.59 basis points, while the effect across transaction cost quintiles is 205.33 basis points.

In the contrast, there is no consistent pattern for positive exposure demand (PD^S), except for the case of stock volatility. The effect of sentiment is stronger on PD^S of options with low trading costs, and is stronger for big stocks.

Insert Table X Here

IV. Conclusion

This paper examines the impact of individual investor sentiment on the trading and pricing of equity options used for speculation and hedging. We construct the positive exposure demand (PD) for stock and index options that measures non-market maker net option demand with positive exposure to the underlying stock or index. We then use PDs for index calls, stock calls and puts as proxies for demand of speculators, and PD for index puts as a proxy for option demand driven by hedging motives. We find that speculation demand is positively related to investor sentiment, while hedging demand is invariant to sentiment. The cross-sectional analysis suggests that sentiment has stronger effects on the PD for options with higher concentration of trading by discount brokerage customers and in options with higher underlying stock volatility.

If market makers cannot perfectly or costlessly hedge their positions, then supply curves will be upward sloping and demand imbalances driven by investor sentiment can affect option prices. Consistent with this view, we find that sentiment affects the prices of stock options but is unrelated to the prices of index options, in which trades are largely motivated by hedging demands unrelated to investor sentiment. These results are not driven by the possibility that sentiment proxies for changes in fundamentals or risk, but instead support the view that limits to arbitrage allow the correlated biases of “noise” traders to be reflected in the prices of securities predominantly traded by these investors.

Our study helps to understand the trading behavior of speculators in option markets and provides evidence that speculative trading affects option prices. Our results have important implications for pricing and hedging using options in the presence of time varying demand by speculators when arbitrage is imperfect.

Appendix A1: Slope of the IVF for Index Options and Market Risk Neutral Jump Size

This appendix demonstrates that the slope of IVF is a monotonic increasing function of the market risk neutral jump size for index options. Adopting the models in Bates (2000) and Pan (2002), we assume the following data-generating process for index price S under physical probability measure P (to simplify exposition, we assume no dividend):

$$dS_t = [r + \eta^s V_t + \lambda(\mu - \mu_t^*)]S_t dt + \sqrt{V_t} S_t dW_t^1 + dZ_t - \mu S_t \lambda dt \quad \text{(A1)}$$

$$dV_t = \kappa(\bar{v} - V_t)dt + \sigma_v \sqrt{V_t}\left(\rho dW_t^1 + \sqrt{1-\rho} dW_t^2\right), \quad \text{(A2)}$$

where r is interest rate, $W = [W^1, W^2]'$ is a standard Brownian motion in $\mathbb{R}^2$, Z is a pure-jump process with jump probability λ , jump volatility σ^J and average relative jump size μ conditional on jump occurs, and η^s is the premium for conventional return risks. Eq.(A2) models stochastic volatility with constant long-run mean $\bar{v}$, mean-reversion rate κ, instantaneous variance V_t, volatility coefficient σ_v, and correlation coefficient of the return and the volatility ρ .

The corresponding dynamic of index price S under risk neutral probability measure is as follows:

$$dS_t = rS_t dt + \sqrt{V_t} S_t dW_t^1(Q) + dZ_t(Q) - \mu_t^* S_t \lambda dt \quad \text{(A3)}$$

$$dV_t = [\kappa(\bar{v} - V_t)dt + \eta^v V_t]dt + \sigma_v \sqrt{V_t}\left[\rho dW_t^1(Q) + \sqrt{1-\rho^2} dW_t^2(Q)\right], \quad \text{(A4)}$$

where $W(Q) = [W^1(Q), W^2(Q)]$ is a Brownian motion under Q, and $\eta^v$is the premium for volatility. The jump process $Z(Q)$ has a distribution under Q that is identical to the distribution of Z under P defined in Eq. (A1), except that under Q, the average jump size is μ_t^*.

We use simulation method to confirm the slope of IVF is a monotonic function of μ_t^*, Figure 2 plots Black-Scholes IVF and the slope of IVF for various values of μ_t^*. The Black-Scholes (1973) implied volatilities (IV) are inverted from the average call and put prices generated by simulation based on Eq.(A3) and Eq.(A4), where *S*=100, $V = 0.04$, $\kappa = 6.4$, $\bar{v} = 0.04$, $\sigma_v = 0.30$, $\rho = -0.48$, $\eta^v = 3.1$, $\lambda = 2$, $\sigma_J = 0$. [16] '*Slope*' is measured as IV difference between options with strike prices *K*=110 and *K*=90, '*Slope left*' is the *IV* difference between *K*=100, and 90, and '*Slope right*' is the *IV* difference between K=110 and 100.

Insert Figure 2 here.

When $\mu_t^* = -0.2$ or (-20%), the risk neutral jump size used in Pan (2002) and Betas (1991), we see the familiar IV 'smirk' exhibited by the solid line on upper panel of Figure 2. Also the IVs of ATM options are higher than the volatility generated from physical stock returns. Compared with the IVF of high μ_t^*, the IVF of low μ_t^* has more negative (less) slope when *K* is less than spot, and also less slope when *K* is higher than spot. The lower panel of Figure 2 shows that '*Slope*' and '*Slope right*' are monotonous increasing in μ_t^*. '*Slope left*' has similar pattern, except when μ_t^* is large. Figure 2 also indicates that there's no systematic relation between level of IV of ATM options and different values of μ_t^* as we assume jump volatility is constant.

Appendix A2: Slope of IVF for Stock Options and Market Risk Neutral Jump Size

Suppose an individual stock has no dividend payment, and its beta on market excess return is one. Since our focus is the time varying of slope, we can simplify the

[16] The parameters are similar to those used in Bates (1991) and Pan(2002). Changing parameters does not qualitatively affect the results

exposition by omitting the stochastic volatility. Assume this stock price S' has the following data generating process under physical probability measures:

$$dS'_t = [r + \eta^s V_t + \lambda(\mu - \mu^*)]S'_t dt + \sqrt{V'_t} S'_t \left(dW_t^1 + \sqrt{1-\rho_{13}^2} dW_t^3 \right) + [dZ_t - \mu S'_t \lambda dt] + dZ'_t \tag{A5}$$

where V'_t is stock's variance, W^3 is the Brownian motion of the stock returns, ρ_{13} is the correlation coefficient between the index and the stock Brownian motions, Z' is the stock idiosyncratic jump with yearly jump probability λ', and average relative jump size 0 conditional on the jump occurs. We assume zero correlation between Z'_t and Z_t, and when market jump occurs, the S' appreciates or depreciates by same return as the index price S does.

The corresponding dynamic of individual stock price S' under risk neutral probability measures is as follows:

$$dS'_t = rS'_t dt + \sqrt{V'_t} S'_t \left(dW_t^1(Q) + \sqrt{1-\rho_{13}^2} dW_t^3(Q) \right) + dZ_t(Q) - \mu^* S'_t \lambda dt + dZ'_t(Q), \tag{A6}$$

where $Z'(Q)$ is the idiosyncratic jump process and has a distribution identical to the distribution of Z' under P defined in Eq. (A5).

Eq.(A6) shows that the slope of individual stock options is determined by market jump (Z), as well as idiosyncratic jump (Z'). The term $dZ_t(Q)$ in Eq. (A6) implies that the risk neutral jump size of index returns (μ_t^*) will also affect the slope of stock options.

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Table I
Moneyness Groups

This table lists the range of the delta for each moneyness group. Delta is the Black Scholes (1973) delta in which the volatility is the annualized stock volatility computed from the previous 60 days of daily returns.

Category	1 Deep ITM Call Deep OTM Put	2 ITM Call OTM Put	3 ATM Call ATM Put	4 OTM Call ITM Put	5 Deep OTM Call Deep ITM Put
Call Delta	[0.875, 1]	[0.625, 0.875)	[0.375, 0.625)	[0.125, 0.375)	[0, 0.125)
Put Delta	[-0.125, 0]	[-0.375, -0.125)	[-0.635,-0.375)	[-0.875, -0.625)	[-1, -0.875)

Table II
Summary Statistics

PD^S or PD^I is the monthly non-market maker stock or SPX index option net demand with positive exposure to the underlying (positive exposure demand), computed based on Eq.(1) from January 1990 to December 2001. PD^{S_C} and PD^{S_P} are the positive exposure demand for stock calls and puts, respectively. PD^{I_C} and PD^{I_P} are similar variables for index SPX calls and puts, respectively. $Slope^S$ or $Slope^I$ is the average slope of the implied volatility function (IVF) for stock or SPX index options computed from Eq.(2.1) -(2.2). CS is the Michigan Consumer Sentiment index. BW is Baker and Wurgler (2006) sentiment from January 1988 to December 2005. dCS and dBW are monthly changes of their associated variables. BB is institutional investor sentiment of bull-bear spread used in Han(2008). σ^S or σ^I is the cross sectional average realized volatility of stocks or index S&P500 during remain life of selected option contracts. R_m is the value-weighted monthly market excess returns. $Skew^S$ is cross sectional average realized stock skewness in following month. AB is the default spread measured as rate difference between Moody's Aaa and Baa bond, and dAB is its monthly change. Unless otherwise specified, all variables are from January 1988 to May 2007.

	Mean	Std	Min	Max	Auto
PD^S	-0.73	31.84	-101.18	70.81	0.76
PD^{S_C}	12.76	16.43	-26.45	53.07	0.68
PD^{S_P}	-13.49	21.25	-93.02	31.16	0.75
PD^I	-45.36	22.96	-134.14	1.32	0.54
PD^{I_C}	-11.56	18.24	-74.46	21.17	0.63
PD^{I_P}	-33.80	12.54	-68.56	-1.22	0.38
$Slope^S$	-196.91	323.11	-1122.39	1216.79	0.44
$Slope^I$	-393.16	246.73	-1611.04	364.57	0.65
CS	91.96	10.14	63.90	112.00	0.92
dCS	-0.02	3.95	-12.20	17.30	-0.01
BW	-0.01	0.66	-1.34	2.99	0.85
dBW	0.00	0.36	-1.69	1.31	-0.21
BB	12.27	15.40	-32.00	41.05	0.71
σ^S	4345.33	1387.93	2129.95	9859.31	0.85
σ^I	1521.65	917.21	515.73	10336.90	0.47
R_m	0.20	0.13	-0.67	0.51	0.17
$Skew^S$	0.02	0.56	-2.08	1.16	0.03
AB	-0.85	0.21	-1.41	-0.55	0.95
dAB	0.00	0.07	-0.44	0.18	0.22

Table III
Correlation Coefficients

This table reports the correlation coefficients of variables used in the main studies of the paper. Variables are explained in Table II.

	PD^{S}	PD^{S_C}	PD^{S_P}	PD^{I}	PD^{I_C}	PD^{I_P}	$Slope^{S}$	$Slope^{I}$	CS	dCS	BW	dBW	BB	σ^{S}	σ^{I}
PD^{S_C}	0.80														
PD^{S_P}	0.88	0.42													
PD^{I}	0.18	-0.14	0.38												
PD^{I_C}	0.30	-0.06	0.50	0.84											
PD^{I_P}	-0.11	-0.16	-0.03	0.61	0.08										
$Slope^{S}$	0.34	0.29	0.28	0.14	0.25	-0.10									
$Slope^{I}$	0.08	0.15	0.01	-0.21	-0.11	-0.21	0.04								
CS	0.52	0.25	0.59	0.44	0.52	0.06	0.38	-0.24							
dCS	0.23	0.16	0.23	0.03	0.04	-0.01	0.11	0.10	0.19						
BW	0.23	-0.10	0.41	0.38	0.52	-0.06	0.14	-0.15	0.43	-0.06					
dBW	0.15	0.17	0.09	0.05	0.01	0.07	0.05	-0.01	0.02	-0.05	0.27				
BB	0.17	0.01	0.15	0.11	0.16	-0.03	0.09	0.14	0.20	-0.03	0.14	0.01			
σ^{S}	0.19	-0.07	0.33	0.36	0.42	0.04	-0.05	-0.46	0.39	-0.10	0.66	0.03	0.21		
σ^{I}	0.05	0.00	0.08	0.23	0.19	0.14	-0.01	-0.53	0.25	-0.09	0.24	-0.03	0.12	0.52	
R_m	0.14	0.09	0.14	0.02	0.08	-0.07	0.09	-0.03	0.14	0.06	0.14	-0.09	-0.05	0.10	-0.12

Table IV

Sentiments and Positive Exposure Demand for Options

This table reports the estimates from monthly time series regression specified in Eq.(3.1) -(3.2) over 1990 through 2001. The dependent variable is positive exposure demand for various types of options. Sentiment (Sent) is measured by consumer sentiment (CS), Baker and Wurgler sentiment (BW), or their monthly change (dCS or dBW). Lag is the lagged dependent variable. Detailed explanation of each variable is in Table II. The parentheses contain t-statistics computed from Newey-West (1997) standard errors that correct for serial correlation with 3 lags and heteroscedasticity.

Sent	Const	Sent	BB	R_m	Lag	Obs/R^2	Const	Sent	BB	R_m	Lag	Obs/R^2
	Dependent: PD^S (Stock Options)						Dependent: PD^I (SPX)					
CS	-32.10	0.35	-0.08	1.07	0.74	143	-72.04	0.51	-0.05	0.09	0.43	143
	(-2.12)	(2.16)	(-0.75)	(2.87)	(8.26)	0.64	(-4.54)	(3.10)	(-0.37)	(0.19)	(6.09)	0.33
dCS	-0.33	1.27	-0.03	1.00	0.76	143	-21.16	0.18	0.05	0.10	0.54	143
	(-0.18)	(2.68)	(-0.31)	(2.64)	(9.06)	0.65	(-4.66)	(0.24)	(0.42)	(0.20)	(5.69)	0.27
BW	-0.42	1.59	-0.06	1.17	0.76	143	-24.92	6.79	-0.04	0.35	0.47	143
	(-0.21)	(0.63)	(-0.56)	(2.69)	(9.15)	0.63	(-4.79)	(2.46)	(-0.26)	(0.67)	(4.28)	0.31
dBW	-0.51	6.97	-0.03	1.19	0.75	143	-21.24	2.29	0.05	0.14	0.54	143
	(-0.25)	(1.81)	(-0.30)	(2.89)	(8.62)	0.64	(-4.72)	(0.47)	(0.43)	(0.27)	(5.72)	0.27
	Dependent: PD^{S_C} (Stock Calls)						Dependent: PD^{I_C} (SPX Calls)					
CS	-7.50	0.14	-0.13	0.16	0.68	143	-43.50	0.41	0.00	0.27	0.49	143
	(-0.92	(1.55)	(-1.90)	(0.64)	(7.56)	0.46	(-4.62)	(4.30)	(0.00)	(0.81)	(6.11)	0.44
dCS	4.70	0.45	-0.10	0.13	0.69	143	-5.08	0.15	0.08	0.31	0.62	143
	(3.32)	(1.81)	(-1.43)	(0.51)	(7.72)	0.47	(-2.87)	(0.28)	(0.87)	(0.89)	(9.02)	0.39
BW	4.60	-0.72	-0.08	0.15	0.70	143	-7.12	6.94	0.00	0.53	0.49	143
	(2.99)	(-0.38)	(-1.28)	(0.52)	(7.36)	0.46	(-3.77)	(3.46)	(-0.04)	(1.44)	(5.40)	0.44
dBW	4.57	5.36	-0.09	0.23	0.69	143	-5.07	-0.62	0.08	0.31	0.62	143
	(3.16)	(2.20)	(-1.28)	(0.86)	(7.87)	0.47	(-2.87)	(-0.16)	(0.86)	(0.85)	(8.82)	0.39
	Dependent: PD^{S_P} (Stock Puts)						Dependent: PD^{I_P} (Index Puts)					
CS	-32.59	0.29	0.07	0.88	0.68	143	-25.32	0.06	-0.05	-0.15	0.38	143

	(-3.39)	(3.00)	(0.89)	(3.67)	(7.10)	0.66	(-1.92)	(0.43)	(-0.53)	(-0.65)	(2.99)	0.11
dCS	-4.52	0.87	0.10	0.84	0.76	143	-20.23	0.01	-0.04	-0.14	0.39	143
	(-3.12)	(2.53)	(1.26)	(3.80)	(11.50)	0.67	(-4.89)	(0.03)	(-0.46)	(-0.62)	(3.03)	0.11
BW	-5.04	2.68	0.07	1.00	0.74	143	-20.29	-0.57	-0.03	-0.16	0.39	143
	(-3.15)	(1.93)	(0.80)	(3.97)	(10.57)	0.65	(-4.88)	(-0.38)	(-0.32)	(-0.69)	(3.01)	0.11
dBW	-4.40	2.06	0.09	0.95	0.77	143	-20.21	2.70	-0.04	-0.11	0.39	143
	(-2.79)	(0.87)	(1.12)	(3.74)	(8.95)	0.64	(-4.88)	(0.99)	(-0.45)	(-0.49)	(3.03)	0.12

Table V

Sentiments and Positive Exposure Demand for Options from Different Classes of Investors

This table reports the estimates of coefficients on sentiment measures from monthly time series regression specified in Eq.(3.1) -(3.2) over 1990 through 2001. The dependent is the positive exposure demand (PD) of different investor classes for various types of options. Superscript 'S' or 'I' indicates stock or index; 'C'or 'P' indexes call or put; 'Disc' refers to customers of discount brokers, 'Full' refers to customers of full service brokers, and 'Firm' is the firm proprietary traders. The sentiment measures are the Michigan Consumer Sentimen (CS), Baker and Wurgler sentiment (BW), and their monthly changes dCS and dBW. Table II contains more detailed variable explanations. The parentheses contain t-statistics computed from Newey-West (1997) standard errors that correct for heteroscedasticity and serial correlation with 3 lags.

	CS	dCS	BW	dBW		CS	dCS	BW	dBW
Dependent		Stock Options			Dependent		Index Options		
				Panel A: PD of Discount Brokerage Customers					
PD^{S_Disc}	0.91	1.58	3.65	19.79	PD^{I_Disc}	2.73	1.37	28.53	3.55
	(3.48)	(2.03)	(0.64)	(3.46)		(5.69)	(0.77)	(2.90)	(0.20)
$PD^{S\_Disc\_C}$	-0.04	0.48	-5.72	9.95	$PD^{I\_Disc\_C}$	0.36	-0.14	7.00	-0.20
	(-0.28)	(1.23)	(-1.82)	(2.64)		(1.29)	(-0.15)	(1.46)	(-0.02)
$PD^{S\_Disc\_P}$	0.67	1.01	6.93	8.96	$PD^{I\_Disc\_P}$	1.74	2.07	12.42	4.89
	(3.76)	(1.98)	(2.23)	(2.47)		(4.61)	(1.75)	(2.22)	(0.38)
				Panel B: PD of Full Service Brokerage Customers					
PD^{S_Full}	0.26	1.73	0.51	5.28	PD^{I_Full}	0.67	0.05	10.06	2.15
	(1.39)	(3.20)	(0.18)	(1.20)		(2.13)	(0.05)	(2.42)	(0.28)
$PD^{S\_Full\_C}$	0.06	0.55	-2.00	4.86	$PD^{I\_Full\_C}$	0.85	0.12	13.47	0.40
	(0.59)	(1.92)	(-0.91)	(1.66)		(4.47)	(0.17)	(4.22)	(0.06)
$PD^{S\_Full\_P}$	0.31	1.24	3.23	0.89	$PD^{I\_Full\_P}$	-0.09	-0.05	-2.45	1.68
	(2.40)	(2.88)	(2.08)	(0.33)		(-0.48)	(-0.12)	(-0.98)	(0.43)
				Panel C: PD of Firm Proprietary Traders					
PD^{S_Firm}	0.05	-1.89	-1.07	-1.27	PD^{I_Firm}	-0.58	0.02	-14.09	-4.36
	(0.23)	(-3.88)	(-0.40)	(-0.26)		(-2.59)	(0.03)	(-4.23)	(-0.59)
$PD^{S\_Firm\_C}$	-0.09	-0.46	-0.82	2.86	$PD^{I\_Firm\_C}$	-0.61	-0.14	-10.30	-4.21
	(-0.70)	(-1.40)	(-0.38)	(0.91)		(-3.55)	(-0.25)	(-5.31)	(-0.74)
$PD^{S\_Firm\_P}$	0.14	-1.44	1.79	-3.88	$PD^{I\_Firm\_P}$	0.00	0.16	-3.00	-0.30
	(0.81)	(-2.90)	(1.07)	(-0.84)		(0.01)	(0.47)	(-1.53)	(-0.07)

Table VI

Granger Causality Test for Sentiments and Stock Option Positive Exposure Demand

This table reports the estimates of VAR model with five variables and 1 lag investigating the causality between various sentiments and positive exposure demand for stock options over 1990 through2001. PD^S is the stock option positive exposure demand defined in Eq. (1). The sentiment variable dCS is the monthly change of the Michigan Consumer Sentiment The sentiment variable dBW is the monthly change of Baker and Wurgler (2002) sentiment index. The BB variable is the monthly bull-bare spread. The parentheses contain OLS t-statistics. The P-values of restricted F-statistics are reported below t-statistics.

	Const	PD^S_{t-1}	dCS_{t-1}	dBW_{t-1}	BB_{t-1}	$R_{m,t-1}$
PD^S_t	0.00	0.75	0.01	0.00	0.00	0.03
t-stats	(-0.18)	(8.20)	(2.79)	(0.06)	(-1.10)	(2.96)
P-value of F stats			0.04	0.70	0.49	0.04
dCS_t	-0.07	0.80	-0.05	0.67	-0.01	0.26
t-stats	(-0.20)	(0.92)	(-0.59)	(0.89)	(-0.54)	(3.52)
P-value of F stats		0.76		0.39	0.46	0.00
dBW_t	0.00	0.18	-0.01	-0.21	0.00	0.02
t-stats	(-0.09)	(1.80)	(-0.74)	(-2.01)	(-0.39)	(2.35)
P-value of F stats		0.09	0.55		0.46	0.02
BB_t	3.26	-0.64	0.06	-0.86	-0.38	0.87
t-stats	(2.77)	(-0.23)	(0.24)	(-0.40)	(-5.49)	(3.62)
P-value of F stats		0.68	0.71	0.82		0.00
$R_{m,t}$	1.13	-0.92	0.13	-0.55	-0.04	0.00
t-stats	(2.85)	(-0.85)	(1.34)	(-0.63)	(-1.53)	(0.01)
P-value of F stats		0.34	0.20	0.85	0.28	

Table VII
Sentiment and Slope of Stock and Index Options

This table reports the results for the regression models that investigate the relation between the slopes of implied volatility function (IVF) and various sentiment variables. The dependent variable is the slope of IVF for stock or SPX index options. Panel A is for stock options, Panel B is for index SPX options, Panel C is for two periods of stock options. Table II contains the detailed explanation for the independent variables. The parentheses contain t-statistics computed from Newey-West (1997) standard errors that correct for serial correlation with 3 lags and heteroscedasticity.

Const	CS	dCS	BW	dBW	BB	σ^S/σ^I	R_m	Lag	Obs/ R^2
Panel A: Dependent variable is the average slope of stock options IVF									
-895.36	8.34							0.34	232
(-5.99)	(5.58)							(3.37)	0.23
-108.56		11.83						0.44	232
(-3.94)		(3.04)						(5.00)	0.19
-111.98			41.51					0.42	215
(-4.68)			(1.95)					(4.35)	0.18
-110.15				66.40				0.43	215
(-4.02)				(1.27)				(5.05)	0.18
-920.92	10.88				0.78	-0.05	-2.18	0.30	232
(-5.93)	(6.26)				(0.61)	(-3.97)	(-0.38)	(3.17)	0.27
-32.02		10.42			1.40	-0.02	-2.53	0.43	232
(-0.39)		(2.63)			(1.07)	(-1.48)	(-0.43)	(4.95)	0.19
124.75			118.78		1.55	-0.06	0.91	0.39	215
(1.43)			(3.14)		(1.38)	(-3.02)	(0.15)	(4.24)	0.21
-24.52				56.76	1.65	-0.02	-0.92	0.43	215
(-0.30)				(1.06)	(1.25)	(-1.75)	(-0.16)	(5.06)	0.18
Panel B: Dependent variable is the slope of SPX index options									
-74.24	-0.89							0.68	232
(-0.43)	(-0.51							(8.14)	0.42
-156.06		5.78						0.68	232
(-3.28)		(1.22)						(6.37)	0.43
-155.38			-23.09					0.68	215
(-4.25)			(-1.36)					(8.02)	0.42
-156.00				-16.89				0.68	215
(-3.23)				(-0.40)				(6.21)	0.41
-130.74	-1.82				6.44	-0.05	4.11	0.50	232
(-0.80)	(-1.18				(2.93)	(-1.76)	(0.94)	(8.33)	0.47
-282.32		4.19			5.71	-0.04	4.83	0.53	232
(-3.72)		(1.20)			(2.45)	(-1.63)	(1.00)	(7.35)	0.47
-293.18			14.22		6.24	-0.05	4.96	0.51	215
(-4.25)			(0.84)		(2.84)	(-1.82)	(1.13)	(8.53)	0.47

-289.42				-36.65	6.28	-0.05	3.84	0.50	215
(-4.16)				(-0.93)	(2.93)	(-1.95)	(0.75)	(7.64)	0.47
Panel C: Dependent variable is the average slope of stock options IVF, two periods									
198801-199712									
-985.83	12.60				4.87	-0.08	10.20	0.08	119
(-3.63)	(5.22)				(2.30)	(-1.71)	(1.71)	(0.79)	0.18
113.36		10.61			3.48	-0.07	10.64	0.22	119
(0.61)		(1.72)			(1.61)	(-1.38)	(1.86)	(2.11)	0.08
263.50			119.73		3.43	-0.11	12.35	0.19	119
(1.35)			(2.20)		(1.55)	(-2.09)	(2.27)	(1.75)	0.09
129.45				-55.87	3.59	-0.07	12.51	0.21	119
(0.72)				(-0.57)	(1.65)	(-1.54)	(2.23)	(2.09)	0.07
199801 – 200705									
-908.02	11.55				2.07	-0.03	-10.07	0.53	113
(-4.56)	(5.39)				(1.15)	(-3.07)	(-1.28)	(5.76)	0.64
-122.69		12.42			3.66	0.00	-9.98	0.62	113
(-0.94)		(3.40)			(1.64)	(-0.32)	(-1.22)	(6.29)	0.59
65.13			83.16		2.20	-0.04	-7.07	0.59	96
(0.51)			(2.15)		(1.03)	(-2.18)	(-0.79)	(5.41)	0.59
-69.31				128.08	2.59	-0.01	-8.30	0.63	96
(-0.55)				(2.27)	(1.23)	(-0.72)	(-1.04)	(6.74)	0.60

Table VIII
Information Interpretation for the Role of Sentiment

This table reports estimates from monthly time series regressions investigating whether jump information affects positive exposure demand and slope of IVF for stock options. In Panel A, the dependent variable is the positive exposure demand for stock options (PD^S). In Panel B, the dependent variable is the average slope of IVF of stock options ($Slope^S$). Table II contains the detailed explanation for the independent variables. The parentheses contain t-statistics computed from Newey-West (1997) standard errors that correct for serial correlation with 3 lags and heteroscedasticity.

Dependent	Const	CS	dCS	$Skew^S$	BB	σ^S	R_m	Lag
Panel A: Jump Information in PD^S								
PD^S	-32.44	0.33		7.36	-0.08		1.12	0.74
	(-2.01)	(1.96)		(0.50)	(-0.75)		(2.96)	(7.92)
PD^S	-2.03		1.23	6.10	-0.03		1.11	0.76
	(-0.59)		(2.84)	(0.40)	(-0.32)		(2.87)	(8.76)
Panel B: Pricing Effect of Jump Information								
$Slope^S$	-936.24	10.89		117.73	0.71	-0.05	-2.18	0.29
	(-6.02)	(6.00)		(0.74)	(0.53)	(-3.81)	(-0.37)	(3.06)
$Slope^S$	-49.35		10.88	124.28	1.51	-0.02	-2.13	0.42
	(-0.72)		(2.56)	(0.80)	(1.26)	(-1.53)	(-0.34)	(4.42)

Table IX

Sentiment and Slope of Stock Option: Controlling for Time Varying Risk Aversion

This table presents the results of test examining whether the relation between individual investor sentiment and slope of stock option implied volatility function (IVF) can be explained by the time varying risk aversion not captured by slope of index options. The dependent variable is the average slope of IVF across stocks ($Slope^S$). AB is the risk aversion proxy measured by the yield difference between Moody's Aaa corporate bond and Baa bond. dAB is the monthly change of AB. Table II contains detailed variable explanation. The parentheses contain t-statistics computed from Newey-West (1997) standard errors that correct for serial correlation with 3 lags and heteroscedasticity

Const	CS	dCS	AB	dAB	BB	σ^S	R_m	Lag
-638.13	9.54		194.73		0.83	-0.05	-1.98	0.27
(-2.99)	(4.97)		(1.65)		(0.57)	(-3.64)	(-0.35)	(2.91)
-929.25	10.99			-33.18	0.64	-0.05	-1.70	0.30
(-5.79)	(6.10)			(-0.14)	(0.48)	(-3.86)	(-0.29)	(3.04)
252.35		11.11	324.50		1.58	-0.03	-2.41	0.36
(2.16)		(2.80)	(3.10)		(1.13)	(-1.77)	(-0.42)	(4.02)
-38.15		11.07		143.22	1.38	-0.02	-1.78	0.43
(-0.54)		(2.53)		(0.49)	(1.14)	(-1.38)	(-0.29)	(4.39)

Table X

Sentiment and Stock Option Positive Exposure Demand and Slope of IV Smile, Cross Sectional Stock Portfolio Analysis

This table reports the positive exposure demand (PD^S) and the slopes of implied volatility smile ($Slope^S$) for each sentiment quintile for stocks of different characteristics. The sentiment is measured by the level of the Michigan Consumer Sentiment (CS). The left part of the table reports the average positive exposure demand (PD^S), and the right part reports the average slopes of implied volatility smile ($Slope^S$) in basis points for each stock characteristic and sentiment quintile. The PD^S or $Slope^S$ differences between high and low sentiment periods are reported on rows started with 'H – L'; their cross sectional difference between stocks with large and small quintile categories are reported in column headed with 'L –S'. Panel A to Panel D form stock portfolios based on individual investor option trading activity, stock volatilities, pre-month option transaction cost and stock sizes. The parentheses contain t-statistics computed from Newey-West (1997) standard errors that correct for serial correlation with 3 lags and heteroscedasticity.

	PD^S						$Slope^S$					
Panel A: Discount Investor Stock Option Trading Activity Measured by Open Interest												
	Small	2	3	4	Large	L-S	Small	2	3	4	Large	L-S
Low CS	-47.24	-47.21	-24.12	-11.39	-11.94	35.31	-455.37	-510.51	-413.69	-452.70	-427.17	28.20
2	-28.54	-36.94	-18.97	4.04	18.70	47.23	-271.31	-286.49	-316.18	-152.51	-188.66	82.65
3	-21.58	-17.88	-11.77	4.61	18.37	39.96	-396.00	-327.96	-365.81	-344.88	-95.10	300.90
4	-19.22	-10.87	6.97	16.23	36.74	55.96	-237.30	-244.40	-158.62	-86.57	-161.95	75.35
High CS	-12.79	13.24	23.81	45.85	70.56	83.34	-88.67	-166.82	-83.35	-40.53	100.88	189.55
H - L	34.46	60.45	47.93	57.24	82.49	48.04	366.70	343.69	330.34	412.17	528.05	161.36
t-stats	(3.21)	(4.96)	(4.97)	(5.08)	(5.78)	(3.80)	(6.45)	(5.99)	(5.29)	(5.98)	(7.20)	(2.46)
Panel B: Stock Volatility												
	Small	2	3	4	Large	L-S	Small	2	3	4	Large	L-S
Low CS	-23.85	-29.83	-20.01	-27.47	-8.69	15.16	-282.36	-382.13	-444.67	-426.19	-504.19	-221.83
2	-34.80	-13.07	-4.72	-4.78	7.73	42.53	-143.42	-253.34	-300.55	-364.40	-310.96	-167.54
3	-29.89	-4.32	-4.86	-4.49	8.39	38.28	-140.49	-244.83	-306.07	-338.32	-252.57	-112.08
4	-18.48	4.18	11.27	17.00	12.11	30.59	-101.96	-157.82	-267.53	-249.47	-282.69	-180.72

High CS	0.80	13.78	30.80	35.54	37.11	36.31	-18.04	-61.62	-30.60	-92.08	45.73	63.77
H - L	24.66	43.61	50.81	63.01	45.80	21.15	264.33	320.51	414.07	334.12	549.92	285.59
t-stats	(2.42)	(4.28)	(4.70)	(5.38)	(4.85)	(2.15)	(5.71)	(8.87)	(12.24)	(7.50)	(8.95)	(5.25)
Panel C: Option Trading Cost												
	Small	2	3	4	Large	L-S	Small	2	3	4	Large	L-S
Low CS	-34.65	-17.45	-20.70	-22.87	-11.27	23.38	-449.93	-378.40	-404.07	-432.86	-387.26	62.67
2	-7.80	-12.37	-15.90	-6.50	-2.26	5.54	-320.02	-309.28	-255.65	-279.32	-226.27	93.75
3	-6.48	-8.90	-7.11	-12.89	2.76	9.24	-340.60	-266.44	-269.22	-195.63	-206.62	133.98
4	28.76	13.48	8.82	-0.42	4.67	-24.09	-240.97	-245.12	-191.84	-187.27	-172.18	68.80
High CS	30.32	28.37	26.68	16.02	29.27	-1.05	-197.88	-56.31	43.97	12.80	70.11	268.00
H - L	64.97	45.82	47.38	38.88	40.53	-24.44	252.04	322.10	448.04	445.67	457.37	205.33
t-stats	(3.84)	(3.44)	(4.11)	(3.87)	(4.49)	(-1.80)	(7.19)	(8.22)	(9.94)	(9.25)	(8.28)	(4.44)
Panel D: Stock Size												
	Small	2	3	4	Large	L-S	Small	2	3	4	Large	L-S
Low CS	19.89	11.88	-6.55	-26.42	-22.84	-42.73	-235.58	-452.85	-467.66	-423.12	-388.60	-153.02
2	43.57	20.75	-1.64	-1.59	-14.90	-78.47	-80.26	-278.01	-326.58	-295.85	-274.15	-193.89
3	39.86	8.46	2.79	-8.53	-7.33	-47.19	-256.50	-187.33	-243.81	-264.49	-283.58	-27.08
4	52.02	30.80	17.13	9.01	0.08	-51.94	-159.22	-214.01	-288.73	-211.49	-186.76	-27.54
High CS	36.80	46.24	49.48	31.06	31.28	-5.52	192.62	45.64	23.90	-55.09	-123.21	-315.83
H - L	16.91	34.36	56.03	57.48	44.12	27.22	428.20	498.49	491.55	368.03	265.39	-162.80
t-stats	(1.80)	(2.57)	(5.05)	(5.00)	(4.85)	(1.96)	(3.56)	(7.59)	(10.75)	(9.77)	(9.76)	(-1.87)

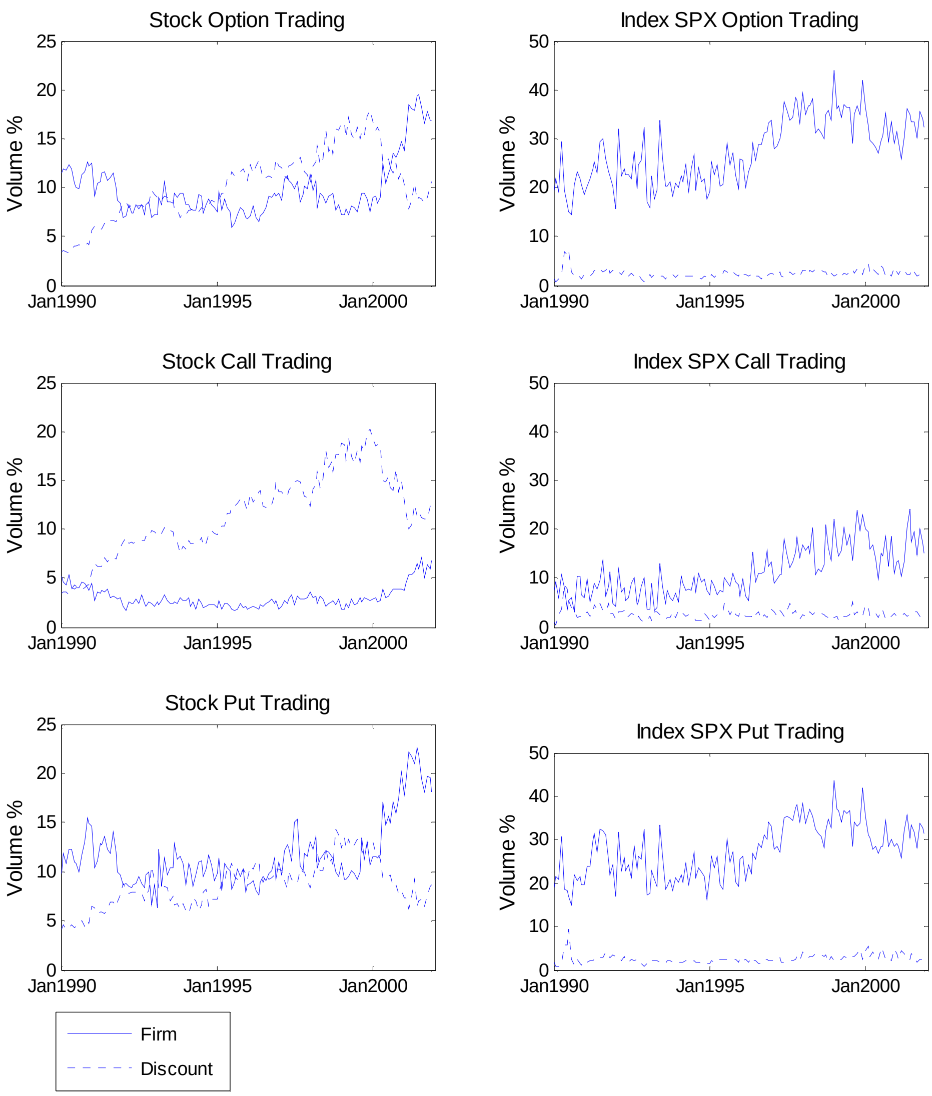

Figure 1. Firm and Discount Investors Trading Activity on Stock and Index Options
This figure depicts the trading activity of firm proprietary traders and customers from discount brokers on stock and SPX index options from January 1990 to December 2001. Trading activity is measured by total volume originated from specific group of investors (Firm or Discount) divided by total non-market maker volume.

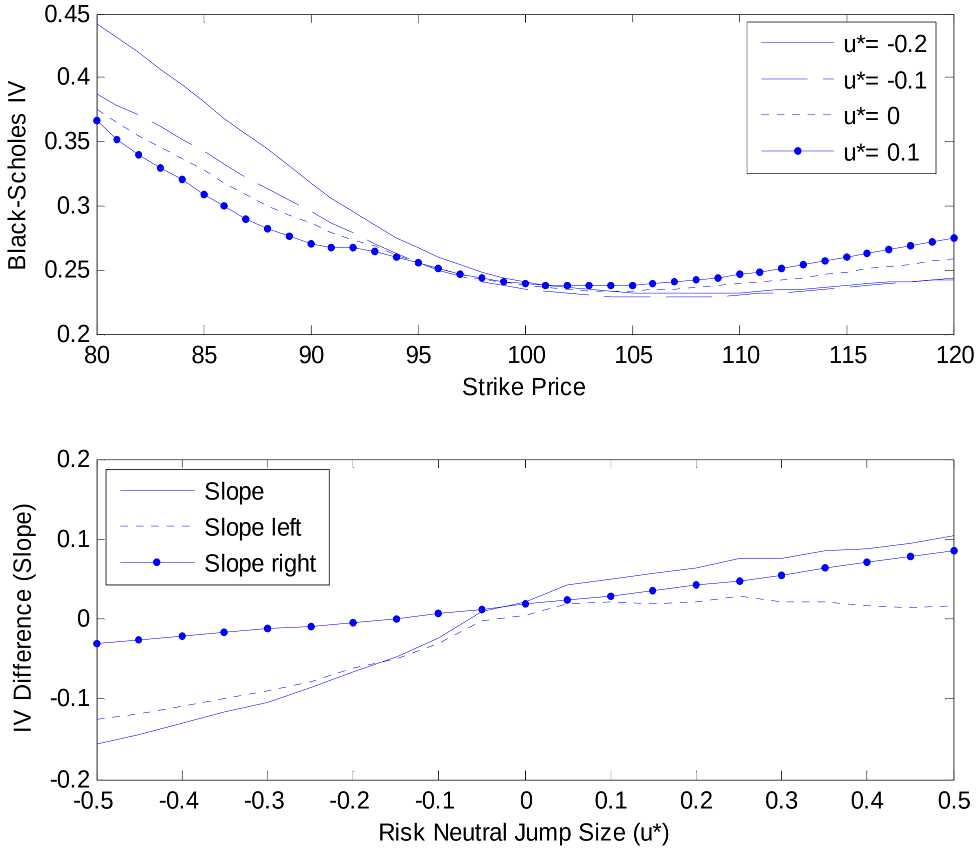

Figure 2. Slope of IVF and Risk Neutral Jump Size. This figure reports the results of simulations based on Eq.(A3)-(A4) for IVF and slopes of IVF under various values of risk neutral jump size (u^*) . Slope is the IV difference between options of strike 110 and options of strike 90. The Slope left is the IV difference between strike 100 and 90, and Slope right is the IV difference between strike 110 and 100. The spot price is 100.