Option Return Predictability*

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Abstract

The cross-section of *delta-hedged* equity option returns can be predicted by a variety of underlying stock characteristics and firm fundamentals including idiosyncratic volatility, past stock returns, profitability, cash holding, new share issuance, and dispersion of analyst forecasts, although they do not significantly predict stock returns in our sample. We document new option portfolio strategies that are profitable even after transaction costs. These profits are robust and cannot be explained by common risk factors. The systematic patterns in the relative valuation of options and the underlying stocks we uncover have important implications for option pricing models and option market efficiency.

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Abstract

The cross-section of *delta-hedged* equity option returns can be predicted by a variety of underlying stock characteristics and firm fundamentals including idiosyncratic volatility, past stock returns, profitability, cash holding, new share issuance, and dispersion of analyst forecasts, although they do not significantly predict stock returns in our sample. We document new option portfolio strategies that are profitable even after transaction costs. These profits are robust and cannot be explained by common risk factors. The systematic patterns in the relative valuation of options and the underlying stocks we uncover have important implications for option pricing models and option market efficiency.

Keywords: Equity option returns; delta-neutral call writing; stock return predictors.

JEL Classification: G02; G12; G13

1. Introduction

A voluminous literature has documented predictability in the cross-section of expected stock return. Harvey, Liu, and Zhu (2016) have categorized 316 explanatory factors documented in existing studies. Despite the tremendous growth in equity options in recent decades, however, little is known about the determinants of expected option returns.

In this paper, we examine whether a set of variables that are well known to predict stock returns can also predict *delta-hedged* equity option returns. Delta-hedging is frequently used by option traders and market makers to reduce the total risk of an option position. By construction, delta-hedged options are insensitive to the movements in underlying stock prices. Stock return predictability, regardless of the underlying causes, implies predictability in raw option return via the dependence of option prices upon the underlying stock prices. By focusing on delta-hedged options, however, we investigate option return predictability beyond those simply inherited from the predictability of the underlying stock returns.

Using Fama-MacBeth type cross-sectional regressions from 1996 to 2012, we find significant predictability in daily-rebalanced delta-hedged option gains for 8 out of 12 long-recognized stock market anomalies,[1] although such anomalies do not generate significant abnormal profits over the same sample period in the stock market. Delta-hedged option gains increase with size, momentum, reversal, and profitability and decrease with cash holding, analyst forecast dispersion, new issues, and idiosyncratic volatility, but none of these variables has significant predictive power for the cross-section of stock returns in our sample. The other four anomalies, book-to-market, accruals, asset growth, and earnings surprise, do not significantly affect the delta-hedged option gains. The results hold for both call and put options, with the same signs.[2] Thus, the predictability in delta-hedged option gains we document is not simply driven by the underlying stock return predictability; otherwise, the patterns for calls and puts would have the opposite signs.

These systematic relations between delta-hedged option gains and various characteristics of the underlying stocks challenge the traditional option pricing models. Stock return predictability does not imply predictability in delta-hedged option gains under the pure no-

[1] The 12 anomalies we examine largely overlap with those studied by Chordia, Subrahmanyam, and Tong (2014) as well as Stambaugh, Yu, and Yuan (2015).
[2] At the end of the month, we pick one call option and one put option for each optionable stock that are closest to being at-the-money and have a common time-to-maturity (about 50 calendar days).

arbitrage option pricing models. For example, under the Black-Scholes model, the expected delta-hedged option gains should be zero and unpredictable (e.g., Bertsimas, Kogan, and Lo (2001)). Even in models where options are not redundant, our results are surprising. For example, under a stochastic volatility model, Bakshi and Kapadia (2003) show that the expected delta-hedged option gains are determined only by the volatility risk premium. Our findings are robust to controlling for volatility risk premium and also proxies of stock jump risk.

The systematic patterns in the relative valuation between options and the underlying stocks we document suggest a set of tradable strategies. We focus on delta-neutral covered call writing, consisting of a short position in an approximately at-the-money equity call option and a long position in delta shares of the underlying stock, in which delta refers to the Black-Scholes call option delta. The delta-hedged positions are then held for a month to construct the buy-and-hold monthly return. At the end of each month from January 1996 to December 2012, we rank all stocks with qualified options traded into deciles by each of the 12 stock characteristics, and we form a portfolio of delta-neutral covered call writing on stocks in each decile. Consistent with the regression results on the cross-sectional determinants of the delta-hedged option gains, the decile portfolio returns to delta-neutral call writing monotonically increase (or decrease) with 8 out of the 12 underlying stock characteristics. The (10-1) long-short spreads are significant across different weighting schemes, including equal weight, and value weight by the stock market capitalization or the market value of option open interest at the beginning of the month. The monthly returns and Sharpe ratios of long-short portfolios, sorted according to the eight significant stock characteristics, range from 1.28% to 3.92% and from 0.63 to 2.00 respectively.[3] The results are qualitatively similar for the quintile portfolio sorts as well.

Our option strategies generate stable profits across different sample periods. During the last decade, the stock market anomalies have weakened or become insignificant as the financial market has become more efficient.[4] The liquidity and quality of trading have also improved in the option market.[5] In contrast, the profitability of our option strategies has not diminished in recent years, even during the 2008–2009 financial crisis. In fact, the performance has been strong

[3] For each stock characteristic sort, we form a long-short portfolio of delta-neutral call writing ensuring the average long-short monthly return spread is positive in each case.

[4] For example, Chordia et al. (2014) show that the returns of the 12 anomalies decline over time due to an increase in the presence of hedge funds and lower trading costs. McLean and Pontiff (2015) suggest that sophisticated investors learn about mispricing from academic publications.

[5] See e.g., Figures 1–3 of Goyenko, Ornthanalai, and Tang (2015).

in recent years with limited downside risk. Our findings are not sensitive to seasonality, market conditions (such as investor sentiment or stock market performance), and the macroeconomic environment (such as The National Bureau of Economic Research (NBER) recessions versus expansions). Moreover, the profits of our option strategies are virtually unchanged and remain significant both economically and statistically after controlling for common stock market risk factors or systematic volatility risk factors.[6] Our findings are also robust to controlling for recent changes in stock volatility, volatility-related mispricing, stock illiquidity, option bid-ask spread, and option demand pressure.

Our option strategies remain profitable after taking into consideration the option transaction costs, even when options are bought at the ask quotes and sold at the bid quotes.[7] Further, our option strategies are more profitable when the underlying stocks face high arbitrage costs (e.g., stocks with low liquidity, price, institutional ownership, and analyst coverage).

Our results could manifest some systematic mispricing between options and the underlying stocks. Alternatively, they could be driven by exposures to unknown priced risk factors unique to options market that are captured by various stock characteristics (these stock characteristics are not significantly related to the expected stock return in our sample).

Our paper contributes to the literature on option return predictability. Goyal and Saretto (2009) find that options with high implied-volatility relative to the historical volatility earn low returns. Cao and Han (2013) document that delta-hedged equity option return decreases monotonically with the idiosyncratic volatility of the underlying stock. Bali and Murray (2013) construct a skewness asset from a pair of option positions and a position in the underlying stock. They find a strong negative relation between risk-neutral skewness and the skewness asset returns. An, Ang, Bali, and Cakici (2014) find that stocks with high past returns tend to have call and put option contracts that exhibit increases in implied volatility over the next month. They interpret the result as being consistent with rational models of informed trading that gives rise to stock-level information predicting option returns.[8] Boyer and Vorkink (2014) report a negative

[6] Stock market risk factors include the Fama and French (2015) five factors, momentum factor (Carhart (1997)), stock market liquidity factor (Pastor and Stambaugh (2003)), and Kelly and Jiang (2014) tail risk factor. Systematic volatility factors including the zero-beta straddle return of S&P 500 Index option, the value-weighted zero-beta straddle returns of S&P 500 individual stock options, and the change in the Chicago Board Options Exchange Market Volatility Index (ΔVIX).

[7] Muravyev and Pearson (2015) argue that the transaction costs in options are actually smaller than commonly perceived. For an average trade, the effective spreads that take into account of trade timing are much smaller than the conventionally measured spreads.

[8] Unlike our study, these papers use a raw option return, or straddle return, or the change in option implied volatility as the main variable of interest.

cross-sectional relationship between returns on individual equity options and their ex-ante skewness, consistent with investors' preference for skewness or gambling in options. Unlike previous studies that focus the relation between option returns and various statistical properties of underlying stock returns, we examine whether some well-known stock characteristics and firm fundamentals can predict option returns after adjusting the exposures to the underlying stocks. These stock characteristics have not been explored systematically in depth by the nascent literature on option returns.

Our paper complements several recent studies that examine the implication of option market microstructure for expected option return. Christoffersen, Goyenko, Jacobs, and Karoui (2015) find a positive illiquidity premium in *daily* option returns.[9] Muravyev (2015) documents that option market order flow imbalance significantly predicts *daily* option returns and this predictability is largely driven by the inventory risk faced by the market makers. Our paper has a different focus. We study monthly delta-hedged option returns as opposed to daily option returns. We control for option liquidity and transaction costs.

The systematic patterns in the relative valuation between options and the underlying stocks we document support the previous finding that options are not redundant assets (e.g., Buraschi and Jackwerth (2001), Coval and Shumway (2001), Jones (2006)). Our paper is also related to the literature on option market efficiency. Some tests (e.g., put-call parity violations) are sensitive to market microstructure issues and some tests depend on specific option pricing models. Constantinides, Jackwerth, and Perrakis (2009) use the stochastic dominance argument to draw a model-free conclusion on mispricing of out-of-money S&P 500 call options. Their results do not provide evidence that the options market is becoming more rational over time. Our study does not rely on a particular option-pricing model. Our findings are consistent with Constantinides et al. (2009), but we extend the scope of investigation to individual stock options.

The rest of the paper proceeds as follows. Section 2 describes the data and measures. In Section 3, we present our main empirical results with a focus on the portfolio analysis of delta-neutral call writing. Robustness analysis is also presented in Section 3. Section 4 takes into account option transaction costs and stock limits to arbitrage. Section 5 concludes the paper.

[9] Christoffersen et al. (2015) define delta-hedged option returns as the raw option returns adjusted by the underlying stock return multiplied by option elasticity. Unlike the adjusted option return they study, we focus on the holding return of a portfolio consisting of an option that is delta hedged by the underlying stock.

2. Data, Delta-Hedged Option Return, and Equity Return Predictors

2.1. Data and sample coverage

We collect our sample data from both stock and equity option markets. The data process for the option market follows Cao and Han (2013). We obtain data on U.S. individual stock options from OptionMetrics from January 1996 to December 2012. The dataset includes the daily closing bid and ask quotes, trading volume, and open interest of each option. Implied volatility, option's delta, vega, and other Greeks are computed by OptionMetrics based on standard market conventions. We obtain stock returns, prices, and trading volume from the Center for Research on Security Prices (CRSP). The Fama-French common risk factors and the risk-free rate are taken from Kenneth French's website. The annual accounting data are obtained from Compustat. The quarterly institutional holding data are from Thomson Reuters (13F) database. The analyst coverage and forecast data are from I/B/E/S.

Our analysis focuses on the options of common stocks (CRSP share codes 10 and 11). To avoid extremely illiquid stocks, we exclude stocks with a closing price at the end of the previous month below five dollars. At the end of each month and for each optionable stock, we extract from the Ivy DB database of OptionMetrics a pair of options (one call and one put) that are closest to being at-the-money and have the shortest maturity among those with more than one month to expiration. Several filters are applied to the extracted option data. First, U.S. individual stock options are of the American type. We exclude an option if the underlying stock paid a dividend during the remaining life of the option.[10] The options we analyze are therefore effectively European-type options.[11] Second, in order to avoid biases related to the microstructure, we only retain options in which the trading volume and bid quote are positive, the bid price is strictly smaller than the ask price, and the mid-point of the bid and ask quote is at least $1/8. Third, we exclude all option observations that violate obvious no-arbitrage conditions.[12] Fourth, we exclude options with moneyness lower than 0.8 or higher than 1.2. Fifth, most of the options selected each month have the same maturity. We drop options whose

[10] Including options with the underlying stocks making dividend payments before maturity does not change our results.

[11] This controls for early exercise of American calls, although American puts could still contain an early exercise premium. Nevertheless, the early exercise premium is usually small for the short-maturity options studied in our sample.

[12] For example, one no-arbitrage conditions for a call option price C is $S \geq C \geq \max(0, S\text{-}Ke^{-rt})$, where S, K, T, and r are the underlying stock price, the option strike price, the option time to maturity, and the risk-free rate, respectively.

maturity is different from the majority of options.[13] Lastly, we only retain stocks with both call and put available after filtering.[14]

Our final sample contains 159,902 option-month observations for both call and put options on individual stocks. Table 1 shows that the average moneyness of the chosen options is 1, with a small standard deviation of 0.05. The time to maturity is between 47 and 52 calendar days, with an average of 50 days. These short-term options are most actively traded, have a relatively smaller bid-ask spread, and provide more reliable pricing information. We utilize this set of option data to study how expected option returns vary across the cross-section of underlying stocks.

Appendix Table A1 reports the sample coverage of 5,179 underlying stocks. Over the entire 204-months sample period, the average number of underlying stocks per month is 792. On average, stocks with option retained in our sample comprise 40% of the total market capitalization and 11% of the total number of stocks in the CRSP universe. Over 90% of the firms have market capitalization over 300 million dollars. Relative to the full CRSP sample, the average size percentile, book-to-market ratio percentile, and volatility percentile of stocks in our sample are 81%, 33%, and 50%, respectively. Moreover, the average institutional ownership is 69% and the average number of analyst coverage is 11.5. Based on the 12 industries defined by Fama and French, Panel C of Table A1 provides the industry distribution of underlying stocks, which is similar to that in the full CSRP sample.[15] Therefore, our results are unlikely to be driven by small, illiquid, highly volatile stocks or stocks with low attention or by a few industries.

2.2. Delta-hedged option returns

2.2.1. Daily rebalanced delta-hedged gains

If an option can be perfectly replicated by the underlying stock (e.g., under the Black-Scholes model), a delta-hedged option is riskless and should earn zero return on average. Cao and Han (2013) find that the average delta-hedged individual stock options return is negative, which

[13] Releasing any of these filters on options or the underlying stocks does not affect our main results.
[14] Previous studies such as Pan and Poteshman (2006) find that the put-call ratio contains information about future stock price. Hence, to ensure that our option data filters do not bias the distribution of the underlying stock return, we drop stocks with only call or only put available after filtering. However, out results hold for the delta-hedged return of both call and put even after removing such restrictions.
[15] There are relatively fewer stocks in the finance industry, and slightly more stocks in the energy, and business equipment industries.

implies that, on average, individual options are relatively overvalued compared to the underlying stocks according to the Black-Scholes model.[16]

We measure a delta-hedged call option return by following Cao and Han (2013). We first define the delta-hedged option gain, which is the change in value of a self-financing portfolio consisting of a long call position, hedged by a short position in the underlying stock so that the portfolio is not sensitive to stock price movements, with the net investment earning the risk-free rate. Following Bakshi and Kapadia (2003) and Cao and Han (2013), we define the delta-hedged gain for a call option portfolio over a period $[t, t+\tau]$ as

$$\widehat{\prod}(t, t+\tau) = C_{t+\tau} - C_t - \int_t^{t+\tau} \Delta_u \, dS_u - \int_t^{t+\tau} r_u \, (C_u - \Delta_u S_u) du, \quad (1)$$

where C_t is the call option price, $\Delta_t = \partial C_t / \partial S_t$ is the call option delta and r is the risk-free rate. The empirical analysis uses a discretized version of (1). Specifically, consider a portfolio of a call option that is hedged discretely N times over a period $[\,t, t+\tau\,]$, where the hedge is rebalanced at each of the dates t_n (where we define $t_0 = t, t_N = t+\tau$).

The discrete delta-hedged call option gain is

$$\prod(t, t+\tau) = C_{t+\tau} - C_t - \sum_{n=0}^{N-1} \Delta_{C,t_n} [S(t_{n+1}) - S(t_n)] - \sum_{n=0}^{N-1} \frac{\alpha_n r_{t_n}}{365} \left[C(t_n) - \Delta_{C,t_n} S(t_n)\right], \quad (2)$$

where Δ_{C,t_n} is the delta of the call option on date t_n, r_{t_n} is the annualized risk-free rate on date t_n, and α_n is the number of calendar days between t_n and t_{n+1}. The definition for the delta-hedged put option gain is the same as (2), except with put option price and delta replacing the call option price and delta.

With a zero net investment initial position, the delta-hedged option gain $\prod(\mathrm{t}, \mathrm{t}+\tau)$ in Eq. (2) is the excess dollar return of the delta-hedged call option. Since the option price is homogeneous of degree one in the stock price and the strike price (see e.g., Merton (1973)), $\prod(\mathrm{t}, \mathrm{t}+\tau)$ is proportional to the initial stock price. To make it comparable across stocks with

[16] Bakshi and Kapadia (2003) find a similar result of a negative delta-hedged gain and interpret it as evidence of a negative price of volatility risk under a stochastic volatility model.

different market prices, we scale the dollar return $\prod(\mathrm{t}, \mathrm{t}+\tau)$ by the absolute value of the securities involved (i.e., $(\Delta_t * S_t - C_t)$ for call options and $(P_t - \Delta_t * S_t)$ for put).[17]

Consistent with Bakshi and Kapadia (2003) and Cao and Han (2013), Table 1 Panel A and B show that the pooled delta-hedged option gains on average are negative for both call and put options. For instance, the average delta-hedged option gain of at-the-money call options is -1.03% over the next month and -1.26% if held until maturity which is on average 50 calendar days. The pattern for put options is similar.

2.2.2. Monthly return to delta-neutral call writing

The delta-hedged option gain measure (scaled appropriately to make them comparable across stocks) is theoretically motivated, but it is not convenient for a portfolio analysis and trading practice. Since we use a self-financing portfolio, the delta-hedged option gain is not the return of a portfolio in the traditional sense. To conduct a portfolio analysis with the buy-and-hold approach, we consider delta-neutral call writing.[18] At the end of each month, we sell one contract of call option hedged by a long position in delta shares of the underlying stock.[19] Building up such a position requires a positive amount of capital. To avoid the high option transaction costs,[20] we hold the position for one month without rebalancing the delta-hedges for most of our analysis.

Specifically, the return to selling a delta-neutral call over $[t, t+1]$ is

$$\frac{H_{t+1}}{H_t} - 1 = \frac{(\Delta_t \cdot S_{t+1} - C_{t+1})}{(\Delta_t \cdot S_t - C_t)} - 1, \tag{3}$$

where the initial investment cost is $H_t = (\Delta_t \cdot S_t - C_t) > 0$, with C and S denoting call option price and the underlying stock price and Δ_t being the Black-Scholes call option delta at initial time t. The payoff at the end of holding period is $H_{t+1} = (\Delta_t \cdot S_{t+1} - C_{t+1})$.

[17] We obtain similar results when we scale the delta-hedged option gains by the initial price of the underlying stocks or options.

[18] We focus on delta-hedged call options for portfolio analyses and trading strategies since at-the-money calls have a much higher trading volume and higher frequency of trading than at-the-money puts (see, e.g., Christoffersen et al. (2015) and Goyenko et al. (2015)). In robustness tests we document that our results hold for delta-hedged put options.

[19] The delta-neutral call writing is related to but different from traditional covered call writing (also known as a "buy-write" strategy) in which investors hold the underlying stock and sell a call option against it. The cover call writing involves the same number of shares of stock and option (there is no delta adjustment). Therefore, a covered call position using at-the-money options would have a positive exposure to the underlying stock.

[20] As shown in Table 1 Panel A and B, the mean (median) quoted bid-ask spread of these at-the-money options is about 20% (15%).

Table 1 Panel C shows that the average monthly buy-and-hold return to delta-neutral call writing is positive with an average monthly return of 3.67%. This is consistent with the negative average delta-hedged option gain, which is long the options and short the underlying stock, the opposite of delta-neutral call writing. Extending the holding period to the option maturity date (about 50 calendar days) increases the average return to 6.05%. As a robustness check, we also consider the daily rebalanced and compounded return to delta-neutral call writing, which has a mean of 1.55% per month. The average monthly return of delta-neutral call writing is statistically significant regardless of whether daily balancing of the option delta is performed.

[Insert Table 1 about here]

2.3. Stock return predictors

We explore whether a host of underlying firm characteristics can predict delta-hedged option gains and returns to delta-neutral call writing. The 12 well-known anomalies included in our analyses are described below:

1. Ln(ME): Measured as the natural logarithm of the market value of the firm's equity (e.g., Banz (1981) and Fama and French (1992)).

2. Ln(BM): The natural logarithm of book equity for the fiscal year-end in a calendar year divided by market equity at the end of December of that year, as in Fama and French (1992).

3. $RET_{(-1,0)}$: The lagged one month return (Jegadeesh (1990)).

4. $RET_{(-12,-2)}$: The cumulative return on the stock over the 11 months ending at the beginning of the previous month (Jegadeesh and Titman (1993)).

5. ACC: Accounting accruals, as measured in Sloan (1996), defined as the change in non-cash current assets, less the change in current liabilities (exclusive of short-term debt and taxes payable) and depreciation expenses, all divided by average total assets.

6. AG: Asset growth, as in Cooper, Gulen, and Schill (2008), computed as the year-on-year

percentage change in total assets.

7. CH: The cash-to-assets ratio, as in Palazzo (2012), is defined as the value of corporate cash holdings over the value of the firm's total assets.

8. DISP: Analyst earnings forecast dispersion, as in Diether, Malloy, and Scherbina (2002), computed as the standard deviation of annual earnings-per-share forecasts scaled by the absolute value of the average outstanding forecast.

9. ISSUE: New issues, as in Pontiff and Woodgate (2008), measured as the change in shares outstanding from 11 months ago.

10. IVOL: Idiosyncratic volatility, as in Ang, Hodrick, Xing, and Zhang (2006), computed as the standard deviation of the regression residual of individual stock returns on the Fama and French (1993) three factors using daily data in the previous month.

11. PROFIT: Profitability, as in Fama and French (2006), calculated as earnings divided by book equity, where earnings is defined as income before extraordinary items.

12. SUE: Standardized unexpected earnings, computed as the difference between the reported earnings-per-share and analysts' consensus forecast (median) scaled by the lagged stock price. This is used as a proxy for earnings surprises in order to analyze post-earnings-announcement-drift (PEAD) as in Bernard and Thomas (1989, 1990), Ball and Brown (1968), and Livnat and Mendenhall (2006).

To avoid the impact of outliers in regression analyses, we winsorize all the explanatory variables each month at the 0.5% and 99.5% levels. Panel D of Table 1 provides the summary statistics of the 12 stock return predictors above. Due to the disparate data availability across these variables, the number of observations varies from 109,637 to 159,892. Except for the multivariate regression analysis, we use the maximum number of observations for each stock return predictor to examine its impact on option returns.

Table 2 documents the time-series average of the cross-sectional correlations between these stock characteristics. We also include various control variables to be used in our regression analysis, namely the Amihud (2002)-based liquidity measure from the equity market (calculated as the average of the daily ratio of the absolute stock return to dollar volume over the previous month), option demand pressure (measured by option's open interest at the end of the previous month scaled by the total stock trading volume of last month),[21] the (quoted) option bid-ask spread (computed as the ratio of the difference between ask and bid quotes of the option over the mid-point of the bid and ask quotes at the end of the previous month), and the VOL_deviation (volatility mispricing measure as in Goyal and Saretto (2009), which is calculated as the log difference between the realized volatility and Black-Scholes implied volatility for at-the-money options at the end of last month). The correlations among these variables are generally low, suggesting that the stock return predictors we consider are largely independent and capture different aspects of the cross-sectional determinants of stock returns.

[Insert Table 2 about here]

3. Empirical Results

In this section, we conduct cross-sectional tests between delta-hedged equity option returns and some well-known stock return predictors. We first run cross-sectional regressions using the *daily rebalanced delta-hedged gain* as the dependent variable in order to compare our results to those reported in pervious literature. We then focus on *delta-neutral call writing* for portfolio analyses and implementable option trading strategies based on the underlying firm characteristics. Finally, we conduct various robustness checks including using alternative option return measures.

3.1. Delta-hedged option gains and equity return predictors: cross-sectional regressions

We first study how those equity characteristics affect the cross-sectional variations of delta-hedged option gains using monthly Fama-MacBeth regressions. The dependent variable in month t's regression is the delta-hedged option gain until maturity (scaled to make them comparable across stocks)—i.e., $\prod(\mathrm{t}, \mathrm{t}+\tau)/(\Delta_t * S_t - C_t)$ for call and $\prod(\mathrm{t}, \mathrm{t}+\tau)/(P_t - \Delta_t * S_t)$ for put—where the common time to maturity τ is about 50 calendar days. All independent variables are all predetermined at time t.

[21] The impact of demand-pressure on the option price is documented in Bollen and Whaley (2004) and Garleanu, Pedersen, and Poteshman (2009). Our results do not change materially if we use the option trading volume of the previous month rather than option open interest or if we scale by the stock's total shares outstanding.

[Insert Table 3 about here]

Table 3 shows the univariate regressions of delta-hedged option gains on each of these 12 stock return predictors, either with or without controls. The set of control variables include stock illiquidity (Amihud measure), option demand pressure, quoted option bid-ask spread, and VOL_deviation. There are significantly positive coefficients for Ln(ME), $RET_{(-1,0)}$, $RET_{(-12,-2)}$, and PROFIT. For example, Ln(ME) has a coefficient of 0.006 in the regression with delta-hedged call option gain as the dependent variable, with the corresponding t-statistic at 14.79. The coefficients for CH, DISP, ISSUE, and IVOL are also significantly negative. For example, in the regression with the delta-hedged call option gain as the dependent variable, the coefficient for CH is -0.023 with a t-statistic of -7.62. For the other four anomalies, including Ln(BM), ACC, AG, and SUE, we do not find robust and significant coefficients. Out of the 12 long-recognized stock return predictors, our Fama-MacBeth regressions show that 8 stock market predictors are also significant predictors for delta-hedged option gains. These patterns in the relative valuation of options and stocks challenge the existing option pricing models. They also suggest a set of profitable trading strategies in the equity option market that we explore next.

3.2. Returns to delta-neutral call writing: Portfolio sorts

In this section, we further study the relation between stock return predictors and delta-hedged option returns using the portfolio-sorting approach. Specifically, we focus on delta-neutral call writing on individual stocks, which consists of a short position in an at-the-money call option and a long position of delta shares of the underlying stocks. The positions are held for a month without modifying the delta hedge in order to construct a buy-and-hold return. At the end of each month and for each stock return predictor examined, we sort all optionable stocks into 10 deciles and then compare the portfolios of delta-neutral call writing on the stocks belonging to the top versus the bottom decile. [22] The portfolio-sorting approach allows us to confirm our findings in Fama-MacBeth regressions and to examine the profitability of delta-hedged option trading strategies based on stock anomalies while accounting for transaction costs.

To ensure the robustness of portfolio analyses, we use three weighting schemes in

[22] As a robustness check, we also rank all stocks with options traded into quintiles. We use the Black-Scholes call option delta in reported tables. We obtain similar results if we compute the option delta using the historical GARCH volatility estimate.

computing the average return of delta-neutral call writing for a portfolio: equal weight (EW), weight by the market capitalization of the underlying stock (VW), and weight by the market value of option open interests at the beginning of the period (Option-VW). Table 4 reports the average return for each decile portfolio, the difference in the average returns of the top decile (quintile), and the bottom decile (quintile) portfolios. The associated Newey-West (1987) t-statistics are in parentheses.

[Insert Table 4 about here]

We consider the (10-1) return spread first. For the EW scheme, the (10-1) spread portfolio formed by sorting on the logarithm of the underlying stock market capitalization Ln(ME) has a monthly return of -3.79% with a t-statistic of -23.65. For the VW (Option-VW) case, the spread return is -3.46% (-4.01%) per month with a t-statistic of -21.81 (-14.40). Ln(BM) does not provide a significant result for the EW spread (consistent with the previous Fama-MacBeth regression), but it has statistically significant predictive power for a value-weighted (either by stock or option values) portfolio of delta-hedged option returns. Past underlying stock returns are also predictors for the return of delta-neutral call writing. The spread portfolio of delta-neutral covered calls sorted by the past one-month stock return $RET_{(-1,0)}$ (resp. $RET_{(-12,-2)}$, past 12-month stock return excluding the most recent month) has a monthly return of -1.28% (-1.58%), -0.75% (-1.28%) and -1.02% (-2.02%) for EW, VW and Option-VW, respectively. All are significant at the 1% level. For accounting accruals (ACC), the spreads are significant at the 10% level for EW and Option-VW, but with opposite signs. We therefore do not consider accruals as a valid equity option return predictor. Asset growth (AG) provides significant monthly spread returns ranging from -0.39% to -0.71% under different weighting schemes. Cash holding (CH) shows strong predictive power under the EW and Option-VW schemes. Analyst earnings forecast dispersion (DISP), net share issuance (ISSUE) and idiosyncratic return volatility of the underlying stock (IVOL) all strongly and positively predict the next month returns of delta-neutral covered calls. For example, for IVOL, the spread is 3.92% per month using EW portfolios. For PROFIT, the spread is negative and significant. For SUE, only the spread in the EW case is significant. Similar to ACC, we do not consider it to be a valid option return predictor.[23]

For the (5-1) spread, the results are comparable with the (10-1) spread though the magnitude is generally smaller. In summary, using portfolio sorts, we find many of the 12 variables can predict the returns to delta-neutral call writing. The results are especially strong for Ln(ME), $RET_{(-1,0)}$, $RET_{(-12,-2)}$, CH, DISP, ISSUE, IVOL, and PROFIT.

3.3. Time-series of return spreads and sub-period evidence

Panel A of Table 5 reports the time-series distribution of the equal-weighted (10-1) monthly return spread. To ensure that all trading strategies have positive average returns, we sort on the negative values of the following variables: Ln(ME), Ln(BM), $RET_{(-1,0)}$, $RET_{(-12,-2)}$, ACC, AG, PROFIT, and SUE. The median return spreads are positive for all of the strategies we consider. Seven out of twelve spreads have positive skewness. The kurtosis results show that five out of twelve spreads exhibit a leptokurtic distribution. Sharpe ratios are generally very high for each option strategy. For example, for PROFIT, the monthly Sharpe ratio is 1.38, which corresponds to an annualized Sharpe ratio of 4.78.

Figure 1 plots the time-series of the equal-weighted (10-1) monthly return spreads sorted on the eight stock characteristics that have significant predictive power for option returns. According to Chordia et al. (2014) and McLean and Pontiff (2015), the stock market anomalies have weakened or become insignificant in recent years because the financial market has become more efficient. Meanwhile, according to Goyenko et al. (2015), liquidity, trading volume, and quality of trading have also gradually improved in the option market. In contrast, the profitability of our option strategies has been very stable after 2000 and does not diminish even during the 2008–2009 financial crisis.

[Insert Figure 1 about here]

We further conduct a variety of sub-period analyses to gain a better understanding about our option trading strategies. The empirical results are reported in Panel B, Table 5. We first

[23] The insignificance of accrual and SUE is consistent with a related paper by Hong, Schonberger, and Subramanyam (2015). Hong et al. (2015) examine four accounting anomalies (accrual, earnings surprise, change in net operating asset turnover, and net operating assets) in option return predictability. Consistent with our findings, they find that accrual and SUE cannot predict option returns after controlling for underlying stock price movement. However, they do not investigate these eight equity characteristics that strongly predict delta-hedged option returns in our study.

partition the sample into 1996–2004 and 2005–2012 periods to check whether the option market becomes more efficient in the recent period. Despite the common view that the financial market has become more efficient, our results do not weaken in the recent period (Column (1) and Column (2)) as demonstrated by the fact that most predictors have significant results for both sample periods. Furthermore, we split our sample into January and non-January groups or according to the level of market sentiment at the beginning of the month. As shown in Columns (3)–(6) of Table 5 Panel B, for the eight stock characteristics Ln(ME), $RET_{(-1,0)}$, $RET_{(-12,-2)}$, CH, DISP, ISSUE, IVOL, and PROFIT that significantly spread equity option returns in Table 5 Panel A, such predictabilities are robust in both January and non-January months, both when market sentiment is high and when it is low.[24] We then examine the impact of stock market performance and macroeconomic conditions.[25] In Columns (7)–(10) of Table 5 Panel B, we find no significant differences in the profitability of our option trading strategies between stock market up and down periods or across different macroeconomic conditions. Finally, we split the sample into high- and low-funding liquidity periods, according to the broker-dealer's leverage or a leverage factor of the corresponding quarter.[26] Columns (11) and (12) show our results are robust across periods of high- and low-funding liquidity without significant differences in the results.

[Insert Table 5 about here]

3.4. Controlling for common risk factors

The analysis in Table 5 indicates that the predictability based on firm characteristics for option returns is stable over time. It is possible, however, that our anomaly-based trading strategy involving delta-neutral call writing is exposed to some priced risk factors. We therefore examine whether the return of our option strategies can be explained by known common risk factors. Specifically, we regress the time series of equal-weighted monthly returns of our option

[24] Baker and Wurgler (2006) construct an index of market-wide investor sentiment. The index contains six underlying measures of investor sentiment: the average closed-end fund discount, the number of IPOs, the first-day returns of IPOs, NYSE turnover, the equity share of total new issues, and the dividend premium.

[25] The business cycle dates are from NBER: http://www.nber.org/cycles.html

[26] The broker-dealer quarterly leverage is defined as total financial asset / (total financial asset - total financial liability) by Adrian, Etula, and Muir (2014). The leverage factor is constructed as seasonally adjusted log changes in the level of broker-dealer leverage. The data are obtained from Table L.129 of the Federal Reserve. http://www.federalreserve.gov/releases/z1/current/data.htm

strategies on several common risk factors and examine whether the intercept terms are significantly different from zero.

The risk factors we control for include the five factors in Fama and French (2015), momentum factor (Carhart (1997)), stock market liquidity risk factor (Pastor and Stambaugh (2003)), and the Kelly and Jiang (2014) tail risk factor.[27] We also control for systematic volatility factors that include the zero-beta straddle return of the S&P 500 Index option in Coval and Shumway (2001) as a proxy of the market volatility risk, the change in the Chicago Board Options Exchange Market Volatility Index (ΔVIX, an alternative market volatility risk as used in Ang et al. (2006), and the value-weighted zero-beta straddle returns of S&P 500 individual stock options (common individual stock variance risk used in Driessen, Maenhout, and Vilkov (2009)). As shown in Panel A of Table 6, none of these systematic risk factors can explain the profits of our option strategies. After controlling for these risk factors, all of the alphas are still highly significant and remain similar in magnitudes as the raw returns. In Panel B of Table 6, it is apparent that only a few factor loadings are statistically significant. Thus, our option strategies generate abnormal profits that are largely independent of well-known common risk factors including the aggregate market volatility risk. In unreported tests, we find that our results remain robust after controlling for shocks to the common factor in idiosyncratic volatility (CIV) used in Herskovic, Kelly, and Lustig (2016) during the 1996–2010 period.

[Insert Table 6 about here]

3.5. Fama-MacBeth regressions

To complement previous results obtained from portfolio sorts and time-series analyses, we report results from Fama-MacBeth cross-sectional regressions in Table 7, with returns to delta-neutral call writing on individual stocks as the dependent variable. The key regressors are various firm characteristics that have been shown to predict the cross-section of stock returns. We verify our findings using Fama-MacBeth regressions. More importantly, we show the robustness of our findings to a variety of controls including stock and option illiquidity, individual stock volatility

[27] We thank the authors for making the tail risk factor available to us.

risk, and jump risk.[28]

In Table 7 Panel A, we regress returns to delta-neutral call writing on one stock return predictor at a time with and without additional controls. The control variables in Table 7 Panel A are (1) the Amihud measure of stock illiquidity; (2) option demand pressure (measured by the option's open interest at the end of the month scaled by the monthly stock trading volume) to control for the effect identified by Garleanu, Pedersen, and Poteshman (2009); and (3) option bid-ask spread (the ratio of the difference between ask and bid quotes of option to the midpoint of the bid and ask quotes at the end of each month) to control for the effect identified by Christoffersen et al. (2015); and (4) the VOL_deviation (the log difference between the realized stock volatility and Black-Scholes implied volatility for at-the-money options) to control for the effect identified by Goyal and Saretto (2009).

[Insert Table 7 about here]

Column (1) in Table 7 Panel A shows that the coefficient estimates of eight stock characteristics Ln(ME), $RET_{(-1,0)}$, $RET_{(-12,-2)}$, CH, DISP, ISSUE, IVOL, and PROFIT are all significant at the 1% level and also agree in signs with the results based on portfolio sorts reported in Tables 4, 5, and 6. Column (2) shows that the regression coefficients for seven out of the eight stock characteristics preserve their sign and statistical significance when we include the four control variables. The sole exception is size Ln(ME), which is significant only at the 10% level in the presence of the controls. The sign and significance of the control variables in our regressions are consistent with previous studies.[29]

In Table 7 Panel B, we control for individual stock volatility risk premium (VRP), jump risk measures, and recent changes in realized stock volatility as well as the contemporaneous change in option-implied volatility. The individual stock volatility risk premium is measured as the difference between expected stock return variance over the next month under the risk-neutral

[28] In addition, the sign and the statistical significance of the regression coefficients on the stock return predictors do not change when we also control for option Greeks including delta, vega, theta, and gamma. The results are available upon request.

[29] For example, Christoffersen et al. (2015) report the return to buying delta-hedged calls increases with option illiquidity. Consistent with their finding, we find a negative relation between return to delta-neutral call writing and option illiquidity. Goyal and Saretto (2009) find that delta-hedged options on stocks with high-implied volatility (relative to historical volatility) earn low returns. This is consistent with the negative regression coefficient of return to delta-neutral call writing on VOL_deviation.

measure and the same expectation under the empirical measure. Following Jiang and Tian (2005), Bollerslev, Tauchen, and Zhou (2009), the risk-neutral expected stock variance is extracted from a cross section of equity options on the last trading day of each month and the empirical counterpart is proxied by realized return variance computed from high-frequency return data over the given month (see Cao and Han (2013) Appendix A for details). Due to data limitation and to ensure the reliability of the variance risk premium estimates, we compute the volatility risk premium only for about one-third of our sample of optionable stocks.

Table 7 Panel B reports a positive coefficient for individual stock variance risk premium in all regressions, suggesting higher returns to selling delta-hedged calls on stocks with high VRP, which is consistent with Cao and Han (2013). After controlling for VRP, the coefficients for all of eight stock characteristics Ln(ME), $RET_{(-1,0)}$, $RET_{(-12,-2)}$, CH, DISP, ISSUE, IVOL, and PROFIT are still significant at the 1% level and have the same signs as the cases without VRP as a control. Therefore, individual stock variance risk premium cannot explain the significant relation between returns to delta-neutral call writing and various firm characteristics that are known to be related to the cross-section of stock return.

Following Bakshi and Kapadia (2003) as well as Cao and Han (2013), we control for the jump risk by including the option-implied risk-neutral skewness and kurtosis of the underlying stock return (see Cao and Han (2013) Appendix B for details of these measures).[30] In all regressions, the risk-neutral skewness and kurtosis are both positively and significantly related to returns to selling delta-hedged calls. This is consistent with Boyer and Vorkink (2014) as well as with Bali and Murray (2013). More importantly, comparing the third column of Table 7 Panel B to the first column of Table 7 Panel A reveals that controlling for risk-neutral skewness and kurtosis of the underlying stock return does not change the sign and statistical significance of the coefficient estimates for the eight stock characteristics Ln(ME), $RET_{(-1,0)}$, $RET_{(-12,-2)}$, CH, DISP, ISSUE, IVOL, and PROFIT. Hence, our findings are not driven by individual stock jump risk.

Table 7 Panel B also shows that the significant relations between returns to selling delta-hedged call options and various stock characteristics are robust to controlling for change in realized stock volatility over the most recent six months as well as contemporaneous change in option-implied volatility. This suggests that delta-hedged option returns are not simply driven by

[30] We construct a model-free and ex-ante measure of risk neutral skewness and kurtosis by following Bakshi, Kapadia, and Madan (2003).

changes in option-implied volatility, and our findings are not explained by stock volatility dynamics somehow captured by stock characteristics (such as the overreaction to volatility effect documented by Poteshman (2001)).

In Table 7 Panel C, we use multivariate analysis to determine the marginal explanatory power for delta-hedged option returns by each stock characteristic we study. Specifically, we regress returns to delta-neutral call writing on all the 12 stock return predictors simultaneously, both with and without the control variables, paralleling Table 7 Panel A. We find that the coefficients for seven characteristics ($RET_{(-1,0)}$, $RET_{(-12,-2)}$ CH, DISP, ISSUE, IVOL, and PROFIT) remain statistically significant and have the same signs as the corresponding univariate regression coefficients in Table 7 Panel A, with or without the controls. This suggests that delta-neutral call-writing strategy based on each of these seven characteristics has an independent source of profitability that could not be spanned by the other stock anomaly-based option strategies.

3.6. Other robustness checks

3.6.1. Equity returns and stock characteristics

So far we have studied how a set of stock characteristics commonly used to predict stock returns affects the cross-section of delta-hedged option returns. By construction, the delta-hedged option is not sensitive to underlying stock price movement. Therefore, the cross-section of delta-hedged option returns should not be mechanically related to stock return predictors. To the extent that delta hedges are not done perfectly—e.g., due to the measurement error of delta—our key results might be driven by the underlying stock predictability. To address such concern, we check the equity return predictability during our sample period, for both stocks covered in our sample and stocks in the full CRSP sample. The results are reported in Appendix Table A2. During the 1996–2012 sample period, these firm characteristics have rather weak power in predicting stock returns. The pattern is similar for both stocks covered in our study and the full CSRP sample. This result is consistent with Chordia et al. (2014) and McLean and Pontiff (2015) that many stock market anomalies have attenuated in recent years. Therefore, the systematic patterns in the delta-hedged option returns cannot simply manifest the underlying stock return predictability. Moreover, as shown in Column (1) and Column (2) of Table A2, there is no consistently positive or negative relation between the direction of stock anomalies and the direction of option return predictability across these 12 stock return predictors. For example, short-term reversal ($RET_{(-1,0)}$) and momentum ($RET_{(-12,-2)}$) predict the future stock return in the opposite direction, while both negatively predict the return to delta-neutral call writing.

3.6.2. Variations in delta-neutral call writing

Here we verify the robustness of our findings to two variations in delta-neutral call writing. First, so far in our portfolio analyses and trading strategies, we have only considered monthly buy-and-hold returns of delta-neutral call writing. Strictly speaking, the position is delta-neutral only at the beginning of the month because we do not rebalance the delta hedges as time goes by, although the option's delta will change as the stock price changes over time. As a robustness check, here we consider the daily rebalanced compounded return to delta-neutral call writing in which we readjust the option delta hedges each day and compound the daily returns of delta-neutral call writing over the month to arrive at the monthly return. We then repeat the portfolio sorts using the daily rebalanced and compounded return to delta-neutral call writing. Appendix Table A3 shows that the results based on *daily-rebalanced delta-neutral call writing* are consistent with those reported in Table 4 for all 12 equity characteristics. Therefore, our results are robust to the daily changes of option's delta within the one-month holding period, which suggests that our option return predictability results are not driven by the equity exposures of the option portfolios we consider and some patterns in the underlying stock returns.

Second, Appendix Table A4 report results based on returns of delta-neutral call writing held until maturity (about 50 calendar days). The patterns are identical to Table 4 in which the holding period is one month. Returns to delta-neutral call writing held until maturity increase with the underlying stock's idiosyncratic volatility, analyst forecast dispersion, and cash holding and shares issuance, but decreases with the underlying stock's market cap, past stock returns, and profitability. All of these predictive relations are statistically significant, as in Table 4. The only difference is that now with a longer holding period, the return spreads between the extreme decile or quintile portfolios sorted by the underlying equity characteristics are bigger in magnitudes than the corresponding results in Table 4. The reduced option transaction cost at option maturity is another advantage of option trading strategies holding until maturity.

3.6.4. Strategies involving delta-neutral protective puts

In Table 3, the results of delta-hedged option gains are consistent across both call and put sorted on various underlying stock characteristics. Now we examine whether these stock return predictors could be used to trade put options profitably. The basic unit of analysis here is a delta-neutral *protective put.* Specifically, for each stock, we buy one contract of put option against a short position of delta shares of the underlying stock, where delta is the Black-Scholes put option delta. Since the delta of the at-the-money put option is negative, we buy both the put option and the underlying stock. The position is held for a month to construct a buy-and-hold return. We then repeat the portfolios analysis of returns to delta-neutral protective puts sorted on various stock characteristics. As shown in Appendix Table A5, the average long-short (10-1) return spread sorted on each of these equity return predictors is always significant, with a sign that is opposite to the counterpart of the return to delta-neutral call writing in Table 4. There are no contradictions in these results because of the put-call parity and the fact that Table 4 uses a short (delta-hedged) position for a call option, while Table A5 uses a long (delta-hedged) position for a put option.[31]

3.6.5. Controlling for the impact of idiosyncratic volatility

Cao and Han (2013) document a significant relation between a delta-hedged option return and underlying stock idiosyncratic volatility. Intuitively, delta-hedged option positions are sensitive to volatility risk. This paper uncovers other equity characteristics that significantly predict the cross-section of delta-hedged options. Our findings are more surprising because the lack of clear links between a delta-hedged option and firm characteristics such as profitability, cash holding, share issuance, and analyst forecast dispersion. Here we test and rule out the possibility that our findings work entirely through the volatility channel—i.e., our results can be explained by Cao and Han (2013)—and some correlations between stock idiosyncratic volatility and the new set of equity characteristics we found to have predictive power for delta-hedged option returns.

Appendix Table A6 presents the average returns of double-sorted portfolios of delta-neutral covered calls. Each month, we first sort optionable stocks into five quintiles (G1–G5) by idiosyncratic volatility (IVOL). Within each quintile, we then further sort by one of the seven

[31] The results for call and put have the same sign in the regressions in Table 3, because we use a long position for both call and put when constructing the daily rebalanced delta-hedged option gains.

new equity characteristics we find to be significant predictors of delta-hedged option returns into five quintiles. Table A6 shows that after controlling for stock idiosyncratic volatility, each of the seven equity characteristics (size, past one-month return, past one-year return, cash holding, analyst forecast dispersion, share issuance, and profitability) continues to be a significant predictor of next month's return of delta-neutral covered call with the same sign as the results in Table 4 based on univariate sorts. These findings also collaborate the multivariate regression results in Table 7 Panel C in which we show that the coefficients for the seven new equity characteristics remain statistically significant after controlling for IVOL. Together, these results show that the significant cross-sectional determinants of delta-hedged option returns documented in this paper go beyond the IVOL effect in Cao and Han (2013).

4. Impact of Option Transaction Costs and Limits to Arbitrage

In this section we examine the profitability of various stock anomaly-based option trading strategies after accounting for option transaction costs. We also study how limits to arbitrage in the underlying stocks affect the profitability of the option trading strategies.

4.1. Accounting for option transaction costs

For all of the previous results, we ignore option transaction costs and assume that options can be bought or sold at the midpoint of the bid and ask price quotes. Table 8 examines the impact of option transaction costs on the profitability of our option strategies. Due to data limitation, we could not control for the real effective spread, which is defined as twice the difference between the actual execution price and the market quote at the time of order entry. To take into account the costs associated with buying or selling options, we therefore assume the effective option spread is equal to 10%, 25%, 50%, 75%, and 100% of the quoted spread.[32] Effective spread is defined as twice the difference between the actual execution price and the market quote at the time of order entry. The column "MidP" in Table 8 corresponds to zero effective spread—i.e., option returns are computed with price being equal to the midpoint of the bid and ask quotes—as in all previous tables.

[32] As shown in Table 1, the average quoted bid-ask is about 20%, with a median of 15.6%. Previous studies such as De Fontnouvelle, Fisher, and Harris (2003) and Mayhew (2002) show that for equity options the ratio of effective spread to the quoted spread is less than 0.5. Muravyev and Pearson (2015) also argue that for the average trade, effective spreads that take trade timing ability into account are much smaller than conventionally measured effective spreads.

Table 8 shows that for all of the portfolio strategies sorted on the eight equity return predictors, the equal-weighed (10-1) return spread to delta-neutral call writing decreases monotonically with the transaction costs. In the case of new issuance (ISSUE) for example, it is 1.46% per month when measured at the midpoint of the bid and ask quotes. When the effective option spread is 25% (50%) of the quoted spread, the average return of our option strategy is reduced to 1.24% (1.03%). When the effective option spread increases to 75% (100%) of the quoted spread, the average return of our option strategy further drops to 0.82% (0.62%). However, even if the effective option spread is as large as 100% of the quoted spread, seven out of eight of our option strategies still deliver positive average returns that are statistically significant (the lone exception is the strategy based on stock size). The anomaly-based option trading strategies therefore survive option transaction costs and can be implemented in real life.[33]

[Insert Table 8 about here]

4.2. The impact of stock limits to arbitrage

Delta-neutral writing involves both the positions in option and underlying stocks. We further examine how the profitability of our option strategy varies with proxies of limits to arbitrage for the underlying stocks. In an efficient market without frictions, sophisticated investors should fully arbitrage away predictable returns due to mispricing. However, mispricing may not disappear completely because of limits to arbitrage (Shleifer and Vishny (1997)). If the returns of our option strategies reflect some type of mispricing, then we should expect that these returns are more pronounced among stocks that are more difficult to arbitrage.

We use double portfolio sorts to examine how the profits from eight option strategies depend on proxies for limits to arbitrage. We use the previous month's illiquidity as defined by Amihud (2002). We also use the stock price level at the end of the previous month to proxy for transaction costs since stocks with lower price tend to have higher percentage bid-ask spreads. Following Nagel (2005), the percentage of institutional ownership at the end of the most recent quarter is used as a proxy for short-sale constraints. Information uncertainty is a risk that

[33] Using intra-day transaction data for options with various moneyness and maturity between 30 and 182 calendar days, Goyenko et al. (2015) find that in aggregate, the effective-to-quoted spread ratio has decreased from 1 to 0.8. The effective-to-quoted spread ratio would be far below 0.8 for these short-term maturity ATM options used in our study.

arbitrageurs are uncertain about the true fundamental value of their arbitrage positions. Following Zhang (2006), we use analyst coverage, measured as the number of analysts following the firm in the previous month, to proxy for information uncertainty.

Each month, we first sort our sample into five quintiles (G1–G5) by 1/Amihud (2002) measure for liquidity, stock price level for bid-ask spread, institutional ownership for short-sale constraints, or analyst coverage for information uncertainty. Within each quintile, we then further sort by eight equity characteristics into five quintiles. Table 9 shows that the average long-short return spread by various option strategies is significantly higher for Group 1, that is, illiquid and low priced stocks, stocks with low institutional holding, and stocks followed by fewer analysts. This finding is consistent with limits to arbitrage hypothesis—i.e., the existence of option return predictability is related to trading frictions.

Furthermore, the difference in the anomaly-based long-short option trading profits between the highest and lowest arbitrage cost groups is significant for all of these eight option strategies. In the case of cash holding (CH) for example, the difference in the long-short portfolio returns between the low- and high-liquidity portfolios is 147 basis points per month; between low and high priced stocks it is 133 basis points; across the institutional ownership portfolios it is 155 basis points, and across the analyst coverage portfolios it is 135 basis points. In all cases, the difference in the long-short portfolio returns between the high- and low-arbitrage cost portfolios is statistically and economically significant. This suggests that the profits of option strategies are difficult to arbitrage amongst stocks with lower liquidity, price level, institutional ownership, or analyst coverage. These results highlight again that stock limits to arbitrage play an important role in explaining the significant relation between delta-hedged option returns and the eight equity characteristics found in this paper.

[Insert Table 9 about here]

5. Conclusion

This paper documents a novel and surprising finding that many well-known stock characteristics could significantly predict *delta-hedged* option returns, even after their predictive power for the stock returns have diminished or become insignificant. Consistent with relative mispricing between options and the underlying stocks, we uncover a set of profitable trading strategies that involve delta-neutral call options based on the underlying stock characteristics and firm fundamentals. These strategies produce stable profits over time and across a wide range of market conditions. The profitability remains strong for daily-rebalanced delta-hedged options, and similar results hold for delta-neutral protective put strategies. More importantly, their return profitability cannot be explained by common stock market risk factors or volatility risk factors. Even after accounting for realistic option transaction costs, most of the option strategies based on stock characteristics and firm fundamentals still yield both statistically and economically significant profits.

Our paper examines the option return predictability from a new but important perspective—i.e., underlying firm fundamentals and stock characteristics—thereby complementing the existing literature that concentrates on the effects of statistical moments of the underlying stock return (such as volatility or skewness). We find that stock market anomalies can explain the cross-section of delta-hedged option returns. Besides the salient trading implications, our paper also adds to the literature on option market price efficiency.

It is surprising that the profitability of our option strategies does not decline over time given the fact that the stock market has become more efficient and the liquidity and quality of trading of the option market have also been improved. A plausible explanation is the insufficient arbitrage activities in the option market. Option traders tend to focus on volatility-related information and neglect other stock characteristics. In addition, they usually cover a limited number of stocks and their corresponding options, and do not conduct long-short portfolio trading that prevails in the stock market. Our results challenge existing option-pricing models. More research is needed to better understand the option return predictability documented in this paper.

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Appendix: Variable Definitions

Delta-Hedged Option Return Measures	
Delta-hedged gains	Delta-hedged gain, as in Bakshi and Kapadia (2003), defined as the change (over the next month or until option maturity) in the value of a portfolio consisting of one contract of long option position and a proper amount of the underlying stock re-hedged daily so that the portfolio is not sensitive to stock price movement. As in Cao and Han (2013), the call option delta-hedged gain is scaled by (Δ*S-C), where Δ is the Black-Scholes option delta, S is the underlying stock price, and C is the price of call option. The put option delta-hedged gain is scaled by (P-Δ*S), where P is the price of a put option.
Returns to delta-neutral call writing	For each stock at the end of the previous month, we sell one contract of call option against a long position of Δ shares of the underlying stock, where Δ is the Black-Scholes call option delta. The position is held for one month or until maturity to compute the buy-and-hold return.
Daily rebalanced and compounded monthly returns to delta-neutral call writing	As in Cao and Han (2013), for each stock at the end of the previous month, we sell one contract of call option against a long position of Δ shares of the underlying stock, where Δ is the Black-Scholes call option delta. We then adjust the delta-hedge on each trading day by buying or selling the proper amount of stock, keeping the option position to be one contract until the end of month when it is closed out. The daily buy-and-hold return is compounded over the month to arrive at the monthly return.
Stock Return Predictors	
Ln(ME)	The natural logarithm of the market value of the firm's equity. See Banz(1981) and Fama and French (1992).
Ln(BM)	The natural logarithm of book equity for the fiscal year-end in a calendar year divided by market equity at the end of December of that year, as in Fama and French (1992).
$RET_{(-1,0)}$	The lagged one month return (Jegadeesh (1990)).
$RET_{(-12,-2)}$	The cumulative return on the stock over the 11 months ending at the beginning of the previous month (Jegadeesh and Titman (1993)).
ACC	Accounting accruals, as measured in Sloan (1996), defined as the change in non-cash current assets, less the change in current liabilities (exclusive of short-term debt and taxes payable) and depreciation expenses, all divided by average total assets.
AG	Asset growth, as in Cooper, Gulen, and Schill (2008), computed as the year-on-year percentage change in total assets.
CH	Cash-to-assets ratio, as in Palazzo (2012), defined as the value of corporate cash holdings over the value of the firm's total assets.
DISP	Analyst earnings forecast dispersion, as in Diether, Malloy, and Scherbina (2002), computed as the standard deviation of annual earnings-per-share forecasts scaled by the absolute value of the average outstanding forecast.

ISSUE	New issues, as in Pontiff and Woodgate (2008), measured as the change in shares outstanding from 11 months ago.
IVOL	Annualized idiosyncratic volatility, as in Ang, Hodrick, Xing, and Zhang (2006), computed as the standard deviation of the regression residuals of the Fama and French (1993) three-factor model using daily data within the previous month.
PROFIT	Profitability, as in Fama and French (2006), calculated as earnings divided by book equity in which earnings are defined as income before extraordinary items.
SUE	Most recent standardized unexpected earnings within previous three months, computed as the difference between the reported earnings-per-share and analysts' consensus forecast (median), scaled by the lagged stock price. See Livnat and Mendenhall (2006).
Control Variables	
Ln(Amihud)	The natural logarithm of illiquidity, calculated as the average of the daily Amihud (2002) illiquidity measure over the previous month.
Option demand pressure	(Option open interest / stock volume) $\times 10^3$. Option open interest is the total number of option contracts that are open at the end of the previous month. Stock volume is the stock trading volume over the previous month.
Option bid-ask spread	The ratio of the difference between the bid and ask quotes of option to the midpoint of the bid and ask quotes at the end of previous month.
VOL_deviation	Volatility mispricing, as in Goyal and Saretto (2009), calculated as the log difference between the realized volatility and Black-Scholes implied volatility for at-the-money options at the end of last month. The realized volatility is the standard deviation of daily stock returns over the previous month.
VRP	Volatility risk premium, defined as the difference between the square root of realized variance estimated from intradaily stock returns over the previous month and the square root of a model free estimate of the risk-neutral expected variance implied from stock options at the end of the month.
Option-implied skewness and kurtosis	The risk-neutral skewness and kurtosis of stock returns, as in Bakshi, Kapadia, and Madan (2003), are inferred from a cross section of out of the money calls and puts at the beginning of the period.
ΔVOL	Change in realized volatility, defined as the difference between the realized daily return volatility of last month and the previous six months' average realized volatility.
Ln (IV_t / IV_{t-1})	The contemporaneous change in option-implied volatility.
Institutional ownership	The percentage of common stocks owned by institutions in the previous quarter.
Analyst coverage	The number of analysts following the firm in the previous month.

Table 1: Summary Statistics

This table reports the descriptive statistics of option returns and equity characteristics used to predict delta-hedged option returns. The option sample period is from January 1996 to December 2012. In Panel A (Panel B), call (put) option delta-hedged gain is the change over the next month or until option maturity in the value of a portfolio consisting of one contract of long call (put) position and a proper amount of the underlying stock, re-hedged daily so that the portfolio is not sensitive to stock price movement. The call option delta-hedged gain is scaled by (Δ*S-C), where Δ is the Black-Scholes option delta, S is the underlying stock price, and C is the price of call option. The put option delta-hedged gain is scaled by (P-Δ*S), where P is the price of put option. Moneyness is the ratio of stock price to option strike price. Days to maturity is the number of calendar days until the option expiration. Vega is the option vega according to the Black-Scholes model scaled by the stock price. Option bid-ask spread is the ratio of the difference between ask and bid quotes of option to the midpoint of the bid and ask quotes at the end of each month. In Panel C, delta-neutral call writing strategy is as follows: for each stock, we sell one contract of call option and delta hedge by a long position of Δ shares of the underlying stock, where Δ is the Black-Scholes call option delta. The position is held for one month or until maturity to compute the buy-and-hold return. For the daily rebalanced returns, the delta-hedges are rebalanced daily, and we then compound the daily returns of the rebalanced delta-neutral call writing over the month to arrive at the monthly return. Panel D reports the time-series average of cross-sectional statistics of equity return predictors. All of these variables are winsorized each month at the 0.5% level. Ln(ME) represents the logarithm of market capitalization in billions of U.S. dollars. Ln(BM) is the logarithm of the book-to-market ratio. $RET_{(-1,0)}$ is the lagged one month return. $RET_{(-12,-2)}$ is the cumulative returns over the second through twelfth months prior to the current month. ACC represents accruals as measured as in Sloan (1996). AG is the asset growth computed in Cooper, Gulen and Shill (2008). CH is the cash-to-assets ratio as in Palazzo (2012). DISP is the analyst earnings forecast dispersion, as in Diether, Malloy, and Scherbina (2002). ISSUE represents new issues as in Pontiff and Woodgate (2008). IVOL is the annualized idiosyncratic volatility computed as in Ang, Hodrick, Xing, and Zhang (2006). PROFIT is the profitability as in Fama and French (2006). SUE is the difference between the reported earnings-per-share and analysts' consensus forecast (median), scaled by the lagged stock price.

Variable		Mean	Standard deviation	10th percentile	Lower quartile	Median	Upper quartile	90th percentile
Panel A: Call Options (15,9902 observations)								
Delta-hedged gain until maturity / (Δ*S – C)	(%)	-1.26	7.70	-7.65	-4.11	-1.49	0.92	4.48
Delta-hedged gain until month-end / (Δ*S – C)	(%)	-1.03	4.67	-5.46	-2.97	-1.10	0.70	3.34
Moneyness = S/K	(%)	100.26	4.46	95.00	97.50	100.00	102.80	105.64
Days to maturity		50	2	47	50	50	51	52
Vega		0.14	0.01	0.13	0.14	0.14	0.15	0.15
Quoted option bid-ask spread	(%)	19.29	15.56	5.57	8.80	14.65	24.77	39.19

Variable		Mean	Standard deviation	10th percentile	Lower quartile	Median	Upper quartile	90th percentile
Panel B: Put Options (15,9902 observations)								
Delta-hedged gain until maturity / (P - Δ*S)	(%)	-1.25	5.77	-6.73	-3.75	-1.46	0.76	4.09
Delta-hedged gain until month-end / (P - Δ*S)	(%)	-0.87	3.88	-4.71	-2.67	-1.01	0.62	3.02
Moneyness = S/K	(%)	100.24	4.47	95.00	97.50	100.00	102.80	105.63
Days to maturity		50	2	47	50	50	51	52
Vega		0.14	0.01	0.13	0.14	0.14	0.15	0.15
Quoted option bid-ask spread	(%)	20.53	16.36	5.96	9.48	15.61	26.39	41.54

Panel C: Returns to Delta-Neutral Call Writing Strategy

Buy & hold until month-end	(%)	3.67	5.81	-1.48	1.40	3.52	6.13	9.45
Buy & hold until maturity	(%)	6.05	11.46	-4.27	1.55	6.08	11.36	17.64
Daily rebalanced & compounded until month-end	(%)	1.55	5.69	-3.19	-0.22	1.61	3.73	6.66

Panel D: Equity Characteristics Summary (Time-Series Average of Cross-Sectional Statistics)

Variable		Obs	Mean	Standard deviation	10th percentile	Lower quartile	Median	Upper quartile	90th percentile
Ln(ME)		143,667	7.60	1.50	5.82	6.51	7.41	8.55	9.68
Ln(BM)		143,434	-1.10	0.80	-2.12	-1.59	-1.04	-0.55	-0.14
$RET_{(-1,0)}$	(%)	159,772	1.76	13.62	-13.54	-6.22	1.02	8.73	17.67
$RET_{(-12,-2)}$	(%)	157,714	27.85	69.38	-32.45	-11.70	13.22	46.47	98.57
ACC		127,559	-0.04	0.08	-0.12	-0.07	-0.04	0.00	0.05
AG		152,959	0.67	3.53	-0.09	0.01	0.13	0.34	0.90
CH		140,238	0.23	0.23	0.01	0.04	0.14	0.36	0.59
DISP	(%)	154,084	27.94	234.09	0.86	1.62	3.46	8.98	23.51
ISSUE		155,567	0.05	0.13	-0.04	-0.01	0.01	0.05	0.17
IVOL		159,892	0.41	0.22	0.18	0.25	0.36	0.51	0.69
PROFIT		149,375	0.04	0.47	-0.20	0.03	0.12	0.19	0.28
SUE	(%)	109,637	0.06	0.59	-0.15	-0.01	0.05	0.16	0.38

Table 2: Time-Series Average of Cross-Sectional Correlations

The table presents cross-sectional Pearson correlations of all variables used in the cross-sectional regressions. The equity characteristics used to predict delta-hedged option returns are described in Table 1. Ln(Amihud) is the logarithm of Amihud (2002) illiquidity measure. Option demand is measured by the option's open interest at the end of the month scaled by the monthly stock trading volume. Option bid-ask is the ratio of the difference between the ask and bid quotes of the option to the midpoint of the bid and ask quotes at the end of each month. The VOL_deviation is the log difference between the realized volatility and Black-Scholes implied volatility for at-the-money options. We compute the correlations each month and report the time-series average of these correlations. The sample period is from January 1996 to December 2012.

	Ln (BM)	$RET_{(-1,0)}$	$RET_{(-12,-2)}$	ACC	AG	CH	DISP	ISSUE	IVOL	PROFIT	SUE	Ln (Amihud)	Option demand	Option bid-ask	VOL_ deviation
Ln(ME)	-0.089	-0.041	-0.084	-0.050	0.001	-0.275	-0.065	-0.149	-0.407	0.215	-0.014	-0.906	-0.044	-0.370	0.048
Ln(BM)		0.018	0.003	0.001	-0.026	-0.355	0.015	-0.027	-0.115	0.095	0.006	0.103	-0.003	0.154	0.000
$RET_{(-1,0)}$			-0.004	-0.008	-0.009	0.015	-0.001	-0.006	0.086	-0.026	0.060	0.011	0.041	-0.033	0.144
$RET_{(-12,-2)}$				-0.053	-0.012	0.095	-0.015	0.139	0.058	-0.102	0.091	-0.072	-0.027	-0.103	0.019
ACC					0.091	-0.011	-0.020	-0.007	0.010	0.150	-0.01	0.046	-0.003	0.013	0.002
AG						0.017	0.003	0.069	0.034	0.003	0.004	0.005	0.001	-0.014	-0.002
CH							0.039	0.118	0.293	-0.239	0.028	0.207	0.029	-0.029	-0.027
DISP								0.021	0.055	-0.054	-0.037	0.061	0.008	0.027	-0.003
ISSUE									0.170	-0.164	-0.007	0.088	-0.004	-0.002	0.023
IVOL										-0.185	-0.006	0.350	-0.046	0.033	0.538
PROFIT											-0.009	-0.194	-0.040	-0.056	0.029
SUE												-0.012	0.006	-0.029	0.015
Ln(Amihud)													0.069	0.462	-0.034
Option demand														0.007	-0.105
Option bid-ask															-0.010

Table 3: Delta-Hedged Option Gains and Equity Characteristics

This table reports the average coefficients from monthly Fama-MacBeth regressions of delta-hedged option gains until maturity for both call options and put options. The equity characteristics used to predict delta-hedged option returns are described in Table 1. In the "Without Controls" column, the regressions are the univariate regressions with each equity predictor as the independent variable. In the "With Controls" column, the independent variables are one of the equity predictors and control variables. The unreported control variables include Ln(Amihud) (the Amihud (2002) illiquidity measure's logarithm), option demand pressure (measured by option's open interest at the end of the month scaled by the monthly stock trading volume), option bid-ask spread (the ratio of the difference between the ask and bid quotes of the option to the midpoint of the bid and ask quotes at the end of each month) and the VOL_deviation (the log difference between the VOL and the Black-Scholes implied volatility for at-the-money options). All independent variables are winsorized each month at the 0.5% level. The sample period is from January 1996 to December 2012. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

	Call Options		Put Options	
Dependent Variable	Delta-hedged gain until maturity (Δ*S-C)		Delta-hedged gain until maturity (P - Δ*S)	
	Without Controls	With Controls	Without Controls	With Controls
Ln(ME)	0.006***	-0.002**	0.004***	-0.001
	(14.79)	(-2.34)	(13.76)	(-1.08)
Ln(BM)	0.00	0.002***	0.001	0.001***
	(0.84)	(3.95)	(1.27)	(3.09)
$RET_{(-1,0)}$	0.020***	0.014***	0.004	-0.001
	(5.57)	(4.38)	(1.62)	(-0.33)
$RET_{(-12,-2)}$	0.006***	0.005***	0.004***	0.003***
	(4.78)	(4.44)	(4.32)	(4.01)
ACC	0.002	0.009***	-0.003	0.001
	(0.47)	(2.61)	(-0.89)	(0.39)
AG	-0.000*	-0.000*	-0.000**	-0.000**
	(-1.94)	(-1.86)	(-2.31)	(-2.11)
CH	-0.023***	-0.014***	-0.017***	-0.010***
	(-7.62)	(-5.30)	(-8.01)	(-5.36)
DISP	-0.003***	-0.002***	-0.002***	-0.001***
	(-4.72)	(-4.25)	(-3.88)	(-3.24)
ISSUE	-0.018***	-0.013***	-0.014***	-0.010***
	(-5.99)	(-5.04)	(-5.53)	(-4.48)
IVOL	-0.038***	-0.074***	-0.027***	-0.057***
	(-14.86)	(-23.31)	(-11.32)	(-18.68)
PROFIT	0.014***	0.009***	0.010***	0.006***
	(13.00)	(11.33)	(10.64)	(7.96)
SUE	0.054	0.024	0.030	0.026
	(0.70)	(0.33)	(0.52)	(0.45)

Table 4: Returns to Delta-Neutral Call Writing Sorted on Equity Characteristics

This table reports the average monthly returns of delta-neutral call writing sorted on the underlying equity characteristics. The equity characteristics used to predict delta-hedged option returns are described in Table 1. At the end of each month, we rank all stocks with options traded into deciles by the equity characteristics. For each stock, we sell one contract of call option against a long position of Δ shares of the underlying stock, where Δ is the Black-Scholes call option delta. The position is held for one month without rebalancing the delta-hedges. We use three weighting schemes in computing the average return to delta-neutral call writing for a portfolio of stocks: equal weight (EW), weight by the market capitalization of the underlying stock (VW), and weight by the market value of option open interest at the beginning of the period (Option-VW). The table reports the return for each decile portfolio and the spread return that is long in the tenth decile and short in the first decile. We also rank all stocks with options traded into quintiles by the equity characteristics and the spread return that is long in the fifth quintile and short in the first quintile is reported. All returns in this table are expressed in percent. The sample period is from January 1996 to December 2012. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

	1	2	3	4	5	6	7	8	9	10	(10-1) Spread	(5-1) Spread
Ln (ME)												
EW	5.94	4.86	4.21	3.81	3.56	3.25	2.93	2.76	2.45	2.15	-3.79***	-3.10***
	(30.83)	(27.95)	(26.57)	(24.34)	(22.94)	(21.40)	(21.83)	(19.43)	(16.72)	(17.21)	(-23.65)	(-23.97)
VW	5.49	4.54	3.97	3.56	3.35	3.06	2.83	2.59	2.35	2.03	-3.46***	-2.79***
	(28.38)	(27.43)	(25.88)	(22.41)	(20.98)	(19.69)	(20.91)	(19.49)	(17.23)	(16.65)	(-21.81)	(-23.03)
Option-VW	6.16	5.68	4.76	3.98	3.85	3.67	3.04	2.87	2.67	2.15	-4.01***	-3.70***
	(21.72)	(16.70)	(22.71)	(15.23)	(16.68)	(20.14)	(15.01)	(12.88)	(13.88)	(13.78)	(-14.40)	(-13.67)
Ln (BM)												
EW	3.82	3.78	3.64	3.48	3.51	3.42	3.54	3.44	3.49	3.80	-0.02	-0.15
	(20.78)	(22.97)	(22.70)	(24.05)	(26.11)	(23.82)	(23.38)	(23.74)	(22.84)	(21.89)	(-0.10)	(-1.19)
VW	2.23	2.23	2.34	2.25	2.30	2.32	2.43	2.37	2.36	2.68	0.45***	0.29**
	(13.70)	(15.93)	(18.43)	(16.78)	(18.74)	(17.62)	(17.49)	(16.18)	(15.31)	(14.94)	(2.81)	(2.35)
Option-VW	2.91	2.86	3.07	2.71	2.85	2.78	2.82	3.00	2.93	3.75	0.84***	0.43**
	(12.41)	(14.75)	(20.36)	(14.71)	(18.21)	(14.39)	(15.21)	(14.62)	(14.29)	(13.59)	(2.96)	(2.00)
$RET_{(-1,0)}$												
EW	5.38	4.08	3.58	3.35	3.17	3.01	3.09	3.22	3.41	4.10	-1.28***	-0.97***
	(26.68)	(23.61)	(23.04)	(24.48)	(22.22)	(21.10)	(21.65)	(24.06)	(23.17)	(22.96)	(-8.08)	(-7.88)
VW	3.97	2.94	2.49	2.23	2.26	2.06	2.07	2.11	2.37	3.23	-0.75***	-0.60***
	(17.20)	(16.07)	(16.11)	(17.59)	(19.21)	(15.93)	(15.40)	(12.00)	(15.04)	(16.38)	(-3.69)	(-3.78)
Option-VW	5.03	3.70	3.06	2.67	2.55	2.41	2.44	2.50	2.89	4.00	-1.02***	-0.81***
	(19.15)	(16.43)	(15.91)	(16.04)	(13.59)	(13.79)	(16.20)	(11.31)	(14.08)	(13.87)	(-3.61)	(-3.87)

RET$_{(-12,-2)}$												
EW	5.44	4.11	3.65	3.36	3.14	3.09	3.10	3.14	3.38	3.86	-1.58***	-1.16***
	(24.07)	(20.62)	(24.20)	(20.50)	(23.15)	(24.12)	(25.62)	(22.54)	(21.73)	(20.04)	(-7.20)	(-6.48)
VW	4.11	3.04	2.51	2.34	2.25	2.17	2.19	2.21	2.30	2.83	-1.28***	-0.89***
	(17.04)	(15.18)	(17.04)	(16.95)	(18.72)	(16.36)	(19.40)	(15.96)	(13.29)	(13.37)	(-4.48)	(-4.16)
Option-VW	5.28	3.61	3.19	2.80	2.41	2.63	2.53	2.38	2.65	3.26	-2.02***	-1.45***
	(17.29)	(15.64)	(15.70)	(14.78)	(15.84)	(16.77)	(15.83)	(11.83)	(11.73)	(11.94)	(-5.22)	(-5.16)
ACC												
EW	4.26	3.70	3.58	3.39	3.34	3.27	3.38	3.69	3.90	4.10	-0.16*	0.02
	(26.43)	(23.86)	(24.53)	(26.24)	(25.99)	(22.60)	(22.25)	(23.92)	(24.01)	(26.13)	(-1.79)	(0.39)
VW	2.90	2.51	2.34	2.31	2.15	2.17	2.26	2.48	2.58	2.84	-0.06	0.06
	(18.19)	(15.80)	(13.17)	(18.75)	(16.04)	(16.71)	(18.24)	(18.72)	(15.73)	(17.67)	(-0.50)	(0.63)
Option –VW	3.44	3.03	2.74	2.88	2.81	2.71	2.84	3.23	3.13	3.81	0.37*	0.23
	(16.95)	(13.75)	(11.91)	(16.97)	(15.25)	(13.95)	(15.37)	(16.78)	(14.83)	(17.96)	(1.72)	(1.41)
AG												
EW	4.61	3.61	3.24	3.16	3.20	3.25	3.35	3.54	3.90	4.21	-0.39***	-0.05
	(24.96)	(24.02)	(25.18)	(24.84)	(22.91)	(22.93)	(21.56)	(22.26)	(23.34)	(23.59)	(-3.46)	(-0.48)
VW	2.88	2.53	2.28	2.23	2.16	2.13	2.35	2.49	2.47	2.56	-0.33**	-0.17
	(18.20)	(19.80)	(20.85)	(18.65)	(15.99)	(14.78)	(15.21)	(13.24)	(16.54)	(11.75)	(-1.98)	(-1.47)
Option-VW	4.07	3.24	2.79	2.72	2.59	2.39	2.70	2.88	3.08	3.36	-0.71***	-0.50**
	(15.92)	(18.95)	(21.20)	(18.63)	(16.44)	(15.15)	(9.91)	(13.35)	(15.26)	(11.35)	(-2.89)	(-2.45)
CH												
EW	3.21	3.10	3.17	3.32	3.48	3.74	3.87	4.01	4.21	5.19	1.99***	1.55***
	(20.39)	(25.15)	(21.32)	(22.13)	(23.11)	(24.90)	(23.45)	(22.89)	(22.72)	(27.05)	(13.47)	(11.63)
VW	2.46	2.16	2.19	2.29	2.24	2.42	2.58	2.66	2.70	2.67	0.21	0.24
	(16.87)	(19.29)	(16.54)	(19.13)	(16.82)	(16.48)	(15.69)	(11.13)	(13.28)	(9.53)	(0.80)	(1.29)
Option-VW	2.72	2.74	2.70	2.72	3.10	3.04	3.03	3.01	3.08	3.77	1.05***	0.55**
	(15.49)	(17.78)	(15.00)	(16.68)	(19.78)	(15.17)	(15.63)	(12.23)	(11.16)	(12.32)	(3.50)	(2.16)
DISP												
EW	2.81	2.76	2.94	3.09	3.34	3.49	3.80	4.11	4.45	4.84	2.03***	1.86***
	(22.29)	(23.15)	(23.47)	(22.31)	(23.65)	(23.35)	(23.39)	(23.60)	(25.64)	(25.03)	(17.09)	(19.25)
VW	2.02	2.15	2.08	2.19	2.40	2.41	2.52	2.66	3.01	3.52	1.51***	1.09***
	(16.31)	(18.85)	(17.87)	(16.32)	(17.67)	(15.94)	(14.68)	(14.36)	(16.31)	(17.14)	(9.13)	(8.06)
Option-VW	2.16	2.31	2.41	2.54	2.69	2.85	2.96	3.30	3.82	4.59	2.43***	1.93***
	(10.21)	(22.15)	(18.59)	(17.12)	(16.44)	(13.07)	(14.67)	(12.98)	(16.64)	(14.62)	(9.32)	(9.60)

ISSUE												
EW	2.95	2.87	3.15	3.51	3.68	3.78	3.86	3.90	4.06	4.41	1.46***	1.33***
	(23.45)	(23.61)	(24.40)	(23.86)	(23.87)	(24.10)	(22.02)	(22.74)	(24.64)	(25.71)	(13.18)	(14.86)
VW	2.33	2.06	2.18	2.25	2.42	2.45	2.46	2.66	2.51	2.79	0.46***	0.49***
	(19.17)	(21.06)	(17.95)	(17.27)	(17.84)	(14.50)	(14.63)	(16.39)	(13.57)	(15.04)	(3.59)	(4.49)
Option-VW	2.66	2.09	2.70	2.78	3.11	3.21	3.27	3.26	3.38	3.45	0.79***	1.05***
	(20.85)	(12.19)	(16.70)	(17.16)	(16.67)	(18.71)	(14.97)	(14.04)	(15.25)	(10.77)	(2.71)	(5.56)
IVOL												
EW	2.03	2.38	2.75	3.09	3.35	3.67	3.94	4.39	4.84	5.95	3.92***	3.19***
	(20.53)	(21.16)	(24.24)	(22.58)	(22.57)	(24.27)	(22.98)	(23.85)	(24.29)	(27.62)	(24.93)	(23.32)
VW	1.80	2.04	2.15	2.46	2.70	2.86	3.15	3.43	3.75	4.79	2.98***	2.28***
	(16.38)	(18.33)	(16.04)	(17.09)	(18.09)	(15.62)	(17.07)	(17.05)	(15.95)	(18.95)	(15.29)	(13.07)
Option-VW	1.83	1.91	2.12	2.52	2.99	3.12	3.51	4.04	4.56	5.54	3.71***	3.15***
	(17.39)	(11.79)	(11.86)	(17.42)	(17.79)	(15.60)	(14.78)	(16.89)	(15.87)	(16.58)	(12.68)	(12.62)
PROFIT												
EW	5.45	4.31	3.87	3.52	3.39	3.13	3.15	2.96	3.03	3.06	-2.39***	-1.83***
	(27.26)	(22.95)	(27.30)	(22.29)	(23.04)	(23.77)	(22.13)	(21.92)	(22.62)	(22.89)	(-18.62)	(-17.30)
VW	3.79	3.01	2.73	2.54	2.40	2.24	2.26	2.14	2.17	2.09	-1.71***	-1.18***
	(16.72)	(15.66)	(17.55)	(12.38)	(17.60)	(18.82)	(17.55)	(17.27)	(18.50)	(14.97)	(-9.23)	(-8.75)
Option-VW	4.96	3.73	3.36	3.19	2.77	2.76	2.71	2.50	2.51	2.37	-2.59***	-1.95***
	(14.53)	(14.80)	(16.48)	(11.36)	(18.40)	(15.57)	(15.69)	(15.21)	(18.17)	(14.17)	(-8.84)	(-8.89)
SUE												
EW	4.00	3.10	2.99	2.58	2.65	2.88	3.00	3.06	3.28	3.81	-0.19***	-0.05
	(22.77)	(23.22)	(21.38)	(18.56)	(21.11)	(21.39)	(23.02)	(23.36)	(22.83)	(23.81)	(-2.87)	(-0.82)
VW	2.78	2.31	2.23	2.06	2.12	2.17	2.21	2.26	2.32	2.59	-0.18	-0.03
	(17.35)	(16.84)	(17.84)	(15.91)	(18.52)	(14.86)	(14.25)	(15.20)	(14.15)	(14.02)	(-1.25)	(-0.27)
Option-VW	3.72	2.69	2.55	2.26	2.19	2.47	2.20	2.50	2.72	3.57	-0.14	-0.06
	(15.61)	(14.38)	(15.58)	(12.74)	(11.60)	(13.19)	(10.44)	(15.80)	(11.93)	(18.07)	(-0.75)	(-0.38)

Table 5: The Long-Short Return Spread of Delta-Neutral Call-Writing Portfolio Strategies

The equity characteristics used to predict delta-hedged option returns are described in Table 1. At the end of each month, we rank all stocks with options traded into deciles by each of the equity characteristics. For each stock, we construct a delta-neutral call writing position that sells one contract of call option against a long position of Δ shares of the underlying stock, where Δ is the Black-Scholes call option delta. We compute the holding period return of a spread portfolio that is long delta-neutral covered calls on stocks ranked in the tenth decile and short delta-neutral covered calls on stocks ranked in the first decile. Panel A of this table reports the time-series distribution of the equal-weighted (10-1) return spread. Panel B reports the equal-weighted (10-1) return spreads for different subsamples. The sentiment index is constructed by Baker and Wurgler (2006). The business cycle dates are from The National Bureau of Economic Research (NBER). The broker-dealer's quarterly leverage is defined by Adrian, Etula, and Muir (2014) and obtained from the Federal Reserve. The sample period is from January 1996 to December 2012.

Panel A: A Time-Series Distribution of Delta-Neutral Call-Writing Return Spread Sorted on Various Equity Characteristics

Sorted on	Equal-Weighted (10-1) Return Spread											
	Mean	Min	10-Pctl	Q1	Med	Q3	90-Pctl	Max	Std	Skewness	Excess Kurtosis	Sharpe Ratio
– Ln(ME)	3.79***	-2.73	1.81	2.52	3.61	4.78	6.10	11.15	1.89	0.51	1.57	2.00
– Ln(BM)	0.02	-10.92	-2.26	-0.97	0.13	1.25	2.20	13.12	2.35	-0.16	7.97	0.01
– $RET_{(-1,0)}$	1.28***	-3.76	-1.07	0.00	1.04	2.48	4.03	9.23	2.01	0.52	0.92	0.63
– $RET_{(-12,-2)}$	1.58***	-4.72	-0.99	0.15	1.27	2.63	4.32	11.89	2.44	1.17	2.80	0.65
– ACC	0.16*	-3.20	-1.30	-0.65	0.10	0.86	1.79	4.13	1.22	0.12	0.45	0.13
– AG	0.39***	-4.45	-0.98	-0.28	0.39	1.13	1.94	6.51	1.30	0.03	3.12	0.30
+ CH	1.99***	-5.00	-0.20	1.02	2.10	3.15	3.99	7.45	1.97	-0.51	1.85	1.01
+ DISP	2.03***	-4.09	0.26	1.19	2.07	2.84	3.84	6.39	1.54	-0.47	1.89	1.32
+ ISSUE	1.46***	-7.15	0.18	0.79	1.58	2.38	3.08	7.10	1.65	-1.68	7.50	0.88
+ IVOL	3.92***	-3.16	1.70	2.68	3.70	5.12	6.77	14.47	2.22	0.53	3.18	1.77
– PROFIT	2.39***	-5.38	0.67	1.59	2.39	3.23	4.48	8.16	1.73	-0.64	3.68	1.38
– SUE	0.19***	-3.69	-1.05	0.49	0.18	0.84	1.70	3.19	1.08	0.01	0.57	0.18

Panel B: Sub-Period Analysis

Sorted on	Equal-Weighted (10-1) Return Spread											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	1996–2004	2005–2012	January	Feb-Dec	Sentiment Low	Sentiment High	Negative Mkt Ret	Positive Mkt Ret	NBER Recession	NBER Expansion	Broker-dealer Leverage Low	Broker-dealer Leverage High
# of Months	102	102	17	187	102	102	78	126	26	135	102	102
– Ln(ME)	4.12***	3.41***	3.87***	3.78***	3.57***	3.48***	3.91***	3.98***	3.21***	3.91***	4.02***	3.56***
	(15.67)	(25.73)	(6.54)	(22.79)	(16.20)	(14.67)	(17.37)	(20.39)	(11.08)	(17.37)	(15.75)	(19.90)
– Ln(BM)	0.10	0.07	0.28	0.01	0.31	0.20	0.19	0.15	0.16	0.19	-0.48**	0.52**
	(0.36)	(0.40)	(0.31)	(0.03)	(1.30)	(0.63)	(0.87)	(0.59)	(0.28)	(0.87)	(-2.27)	(2.23)
– RET$_{(-1,0)}$	1.73***	0.77***	2.22*	1.19***	1.20***	1.12***	1.56***	1.38***	0.97**	1.56***	1.44***	1.12***
	(7.17)	(5.50)	(2.11)	(8.02)	(5.77)	(5.11)	(7.83)	(6.67)	(2.25)	(7.83)	(5.24)	(6.65)
– RET$_{(-12,-2)}$	2.10***	1.00***	2.78**	1.48***	1.08***	1.34***	1.66***	1.74***	2.93***	1.66***	1.14***	2.03***
	(6.31)	(4.32)	(2.60)	(6.56)	(3.16)	(4.19)	(6.01)	(5.44)	(5.23)	(6.01)	(3.25)	(8.17)
– ACC	0.22	0.09	0.31	0.15	0.30***	0.01	0.16	0.25**	0.09	0.16	0.26**	0.06
	(1.55)	(0.92)	(1.73)	(1.57)	(2.75)	(0.06)	(1.57)	(2.34)	(0.24)	(1.57)	(2.50)	(0.41)
– AG	0.32	0.48***	0.35	0.40***	0.73***	0.30	0.32**	0.45***	0.19	0.32**	0.67***	0.12
	(1.60)	(5.10)	(1.48)	(3.31)	(5.33)	(1.54)	(2.09)	(3.23)	(1.16)	(2.09)	(4.89)	(0.81)
+ CH	2.04***	1.93***	1.57**	2.02***	1.79***	1.92***	2.01***	2.03***	2.26***	2.01***	1.61***	2.36***
	(7.96)	(15.59)	(2.69)	(12.85)	(9.79)	(10.69)	(9.88)	(8.57)	(5.61)	(9.88)	(6.85)	(15.79)
+ DISP	1.92***	2.16***	2.36***	2.00***	2.06***	1.46***	1.82***	2.38***	2.43***	1.82***	2.13***	1.93***
	(10.30)	(15.57)	(6.05)	(16.72)	(12.40)	(8.29)	(12.44)	(20.29)	(6.76)	(12.44)	(13.13)	(11.38)
+ ISSUE	1.25***	1.71***	1.34**	1.47***	1.47***	1.01***	1.36***	1.74***	1.52***	1.36***	1.51***	1.41***
	(6.81)	(17.76)	(2.24)	(12.47)	(9.39)	(4.57)	(8.72)	(12.44)	(6.47)	(8.72)	(10.15)	(7.79)
+ IVOL	4.36***	3.42***	4.57***	3.86***	3.95***	3.23***	4.02***	4.35***	4.04***	4.02***	3.85***	3.99***
	(18.66)	(22.18)	(5.39)	(22.70)	(21.02)	(11.21)	(18.54)	(20.65)	(8.92)	(18.54)	(18.87)	(17.06)
– PROFIT	2.48***	2.29***	2.71***	2.36***	2.60***	1.92***	2.36***	2.68***	2.41***	2.36***	2.56***	2.22***
	(10.97)	(23.11)	(16.85)	(16.75)	(18.18)	(9.49)	(13.41)	(18.80)	(6.90)	(13.41)	(12.70)	(13.94)
– SUE	0.27**	0.11	0.35	0.24***	0.10	0.15	0.22***	0.22**	0.27	0.22***	0.13	0.25**
	(2.50)	(1.46)	(1.57)	(3.41)	(0.96)	(1.31)	(2.65)	(2.53)	(1.02)	(2.65)	(1.53)	(2.33)

Table 6: Alphas and Factor Loadings of Delta-Neutral Covered Calls Strategies

The equity characteristics used to predict delta-hedged option returns are described in Table 1. At the end of each month, we rank all stocks with options traded into deciles by the equity characteristics. For each stock, we sell one contract of call option against a long position of Δ shares of the underlying stock, where Δ is the Black-Scholes call option delta. We compute the spread return that is long in the tenth decile and short in the first decile. Panel A reports the return spread and alphas on several common risk factors. αCAPM is the alpha from CAPM. αCarhart-4 is calculated from the Carhart (1997) four-factor model. αFF-5 is calculated from the Fama and French (2015) five-factor model. α9-factor is calculated from a nine-factor model with Fama and French (2015) five-factors, the Pastor and Stambaugh (2003) liquidity factor, the Coval and Shumway (2001) zero-beta straddle return of the S&P 500 Index option (ZB-STRAD-Index), the value-weighted zero-beta straddle returns of S&P 500 individual stock options (ZB-STRAD-Stock), and change in the Chicago Board Options Exchange Market Volatility Index (ΔVIX). α10-factor is calculated from a ten-factor model that includes all the factors in α9-factor plus the Kelly and Jiang (2014) tail risk factor. Panel B reports the factor loadings for the ten-factor model. The sample period is from January 1996 to December 2012. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

Panel A: Raw Returns and Risk-Adjusted Returns of Equal-Weighted (10-1) Return Spread

Sorted on	Raw Return	αCAPM	αCarhart-4	αFF-5	α9-factor	α10-factor
– Ln(ME)	3.79***	3.76***	3.71***	3.69***	3.86***	3.89***
	(23.65)	(24.25)	(23.38)	(21.47)	(20.40)	(20.06)
– Ln(BM)	0.02	0.00	0.07	0.15	0.14	0.09
	(0.10)	(0.01)	(0.39)	(0.77)	(0.64)	(0.42)
– $RET_{(-1,0)}$	1.28***	1.26***	1.25***	1.29***	1.23***	1.28***
	(8.08)	(8.04)	(7.89)	(7.80)	(5.59)	(6.00)
– $RET_{(-12,-2)}$	1.58***	1.56***	1.60***	1.59***	1.77***	1.84***
	(7.20)	(6.92)	(7.08)	(6.52)	(6.83)	(7.63)
– ACC	0.16*	0.14	0.16*	0.16*	0.20	0.21
	(1.79)	(1.55)	(1.86)	(1.78)	(1.58)	(1.59)
– AG	0.39***	0.39***	0.38***	0.33***	0.26*	0.26*
	(3.46)	(3.33)	(3.47)	(3.03)	(1.96)	(1.96)
+ CH	1.99***	1.99***	1.99***	1.96***	1.94***	1.90***
	(13.47)	(13.95)	(14.13)	(13.01)	(10.42)	(10.28)
+ DISP	2.03***	1.98***	2.02***	1.94***	1.99***	1.97***
	(17.09)	(15.55)	(16.47)	(15.21)	(13.84)	(13.36)
+ ISSUE	1.46***	1.42***	1.45***	1.40***	1.29***	1.27***
	(13.18)	(11.77)	(11.85)	(9.77)	(7.46)	(7.13)
+ IVOL	3.92***	3.86***	3.91***	3.86***	3.98***	4.00***
	(24.93)	(22.76)	(22.75)	(21.54)	(18.12)	(17.48)
– PROFIT	2.39***	2.34***	2.36***	2.35***	2.34***	2.32***
	(18.62)	(18.79)	(19.72)	(18.04)	(15.21)	(14.24)
– SUE	0.19***	0.19***	0.18**	0.15**	0.12	0.12
	(2.87)	(2.68)	(2.55)	(2.03)	(1.24)	(1.22)

Panel B: Exposures of Equal-Weighted (10-1) Return Spread to Common Risk Factors

	Equal-Weighted (10-1) Return Spread Sorted on											
	–	–	–	–	–	–	+	+	+	+	–	–
	Ln(ME)	Ln(BM)	$RET_{(-1,0)}$	$RET_{(-12,-2)}$	ACC	AG	CH	DISP	ISSUE	IVOL	PROFIT	SUE
$Alpha_{10\text{-factor}}$	3.890	0.086	1.282	1.839	0.210	0.264	1.901	1.968	1.266	3.996	2.325	0.123
	(20.06)	(0.42)	(6.00)	(7.63)	(1.59)	(1.96)	(10.28)	(13.36)	(7.13)	(17.48)	(14.24)	(1.22)
MKT-RF	0.110	-0.098	0.033	0.137	0.005	0.080	-0.065	0.028	-0.013	-0.029	0.018	0.032
	(1.78)	(-1.77)	(0.55)	(2.41)	(0.14)	(2.51)	(-1.23)	(0.77)	(-0.31)	(-0.55)	(0.35)	(1.00)
SMB	0.114	-0.043	-0.040	0.086	0.028	-0.017	0.101	0.090	0.113	0.099	0.090	0.029
	(2.27)	(-0.65)	(-0.84)	(1.34)	(0.89)	(-0.41)	(1.97)	(2.74)	(3.16)	(1.79)	(1.63)	(0.94)
HML	-0.049	0.022	-0.083	-0.088	-0.009	0.011	0.020	-0.118	-0.095	-0.062	-0.028	0.010
	(-0.76)	(0.36)	(-1.19)	(-1.33)	(-0.23)	(0.28)	(0.39)	(-2.86)	(-1.95)	(-1.13)	(-0.64)	(0.27)
RMW	0.093	-0.068	-0.063	0.091	0.003	0.088	0.117	0.070	0.057	0.074	0.070	0.061
	(1.31)	(-0.68)	(-0.98)	(1.03)	(0.07)	(1.28)	(1.62)	(1.31)	(0.74)	(1.00)	(1.09)	(1.35)
CMA	-0.007	-0.263	0.107	-0.123	-0.120	0.033	-0.116	-0.024	-0.015	-0.203	-0.125	-0.034
	(-0.08)	(-1.69)	(1.16)	(-1.10)	(-2.01)	(0.56)	(-1.33)	(-0.37)	(-0.16)	(-1.88)	(-1.97)	(-0.61)
LIQ	-0.009	0.044	0.007	-0.040	-0.001	-0.006	0.052	-0.004	0.019	-0.015	0.039	-0.018
	(-0.45)	(1.77)	(0.26)	(-1.32)	(-0.07)	(-0.40)	(2.08)	(-0.27)	(1.03)	(-0.65)	(1.72)	(-1.10)
ZB-STRAD-INDEX	0.015	-0.003	-0.010	0.010	0.010	-0.002	-0.002	0.014	-0.002	0.009	-0.001	0.003
	(2.85)	(-0.32)	(-1.66)	(1.58)	(2.72)	(-0.41)	(-0.25)	(3.38)	(-0.42)	(1.16)	(-0.18)	(1.04)
ZB-STRAD-STOCK	-0.017	0.006	0.008	0.000	-0.028	-0.006	0.006	-0.038	-0.019	-0.029	-0.002	-0.014
	(-1.41)	(0.36)	(0.61)	(0.02)	(-3.66)	(-0.58)	(0.39)	(-3.72)	(-1.50)	(-1.79)	(-0.14)	(-1.80)
ΔVIX	0.046	-0.090	-0.009	0.099	0.001	0.046	-0.039	-0.052	-0.047	-0.152	-0.047	0.022
	(0.70)	(-1.54)	(-0.14)	(1.93)	(0.01)	(1.75)	(-0.70)	(-1.61)	(-1.14)	(-3.05)	(-0.90)	(0.72)
TAILRISK	-0.355	0.643	-0.724	-0.923	-0.083	-0.109	0.555	0.284	0.311	-0.245	0.236	0.013
	(-1.15)	(2.40)	(-2.93)	(-2.90)	(-0.64)	(-0.74)	(1.70)	(1.27)	(1.63)	(-0.79)	(0.80)	(0.13)
Adj. R^2	0.081	0.077	0.059	0.139	0.088	0.015	0.063	0.284	0.201	0.212	0.129	0.005

Table 7: Fama-MacBeth Regressions for Returns to Delta-Neutral Call Writing

This table reports the average coefficients from monthly Fama-MacBeth regressions of the returns to delta-neutral call writing. For each stock, we sell one contract of call option hedged by a long position of Δ shares of the underlying stock, where Δ is the Black-Scholes call option delta. The position is held for one month without rebalancing delta hedges during the holding period. Equity characteristics used to predict delta-hedged option returns are described in Table 1. Panel A and B present the results for one equity characteristics at a time. Panel C presents the results using all 12 variables. The control variables include Ln(Amihud) (the logarithm of Amihud illiquidity measure), option demand pressure (measured by the option's open interest at the end of the month scaled by the monthly stock trading volume), option bid-ask spread (the ratio of the difference between ask and bid quotes of option to the midpoint of the bid and ask quotes at the end of each month), VOL_deviation (the log difference between the realized volatility and Black-Scholes implied volatility for at-the-money options), VRP (the volatility risk premium is defined as the difference between the square root of realized variance estimated from intradaily stock returns over the previous month and the square root of a model free estimate of the risk-neutral expected variance implied from stock options at the end of the month), option-implied skewness and kurtosis (the risk-neutral skewness and kurtosis of stock returns inferred from a cross section of out of the money calls and puts at the beginning of the period), ΔVOL (the change in volatility is defined as the difference between previous month's realized daily return volatility and the previous six months' average realized volatility), and Ln (IV_t /IV_{t-1}) (the contemporaneous change in the option-implied volatility of the same option over the same month). The sample period is from January 1996 to December 2012. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

Panel A: Using the Individual Stock Return Predictor as a Regressor

	Without Controls	With Control Variables				
	Stock return predictor	**Stock return predictor**	Ln(Amihud)	Option demand pressure	Option bid-ask spread	VOL_deviation
Ln(ME)	-0.007***	-0.002*	0.006***	-0.003	-0.017***	-0.013***
	(-25.38)	(-1.90)	(7.38)	(-0.72)	(-2.77)	(-10.16)
Ln(BM)	-0.001	-0.002***	0.007***	-0.004	-0.015***	-0.013***
	(-1.46)	(-4.36)	(20.83)	(-0.84)	(-2.68)	(-10.81)
$RET_{(-1,0)}$	-0.022***	-0.020***	0.007***	0.001	-0.021***	-0.013***
	(-7.67)	(-7.51)	(20.86)	(0.25)	(-3.35)	(-10.84)
$RET_{(-12,-2)}$	-0.005***	-0.003***	0.007***	-0.003	-0.021***	-0.014***
	(-4.52)	(-3.26)	(21.35)	(-0.72)	(-3.36)	(-10.90)
ACC	-0.002	-0.009***	0.007***	0.001	-0.017***	-0.014***
	(-0.68)	(-3.42)	(23.04)	(0.14)	(-3.05)	(-10.66)
AG	0.000	0.000	0.007***	-0.003	-0.018***	-0.014***
	(1.08)	(0.88)	(22.46)	(-0.70)	(-3.22)	(-10.42)
CH	0.027***	0.017***	0.006***	-0.003	-0.015**	-0.014***
	(14.87)	(9.97)	(17.22)	(-0.70)	(-2.28)	(-10.64)
DISP	0.002***	0.002***	0.007***	-0.005	-0.020***	-0.013***
	(5.16)	(4.24)	(21.05)	(-1.25)	(-3.15)	(-10.47)
ISSUE	0.028***	0.020***	0.007***	-0.003	-0.018***	-0.014***
	(10.67)	(8.62)	(21.37)	(-0.78)	(-3.16)	(-10.66)
IVOL	0.052***	0.080***	0.002***	0.005	0.001	-0.047***
	(26.99)	(27.93)	(6.00)	(1.44)	(0.20)	(-27.11)
PROFIT	-0.013***	-0.008***	0.007***	-0.005	-0.017***	-0.013***
	(-15.47)	(-10.66)	(19.66)	(-1.19)	(-2.94)	(-10.10)
SUE	-0.013	-0.022	0.005***	-0.012***	-0.012**	-0.008***
	(-0.25)	(-0.44)	(17.18)	(-2.80)	(-2.39)	(-7.05)

Panel B: Controlling for Volatility Risk Premium, Jump Risk, and Changes in Volatility

	Control for Volatility Risk Premium		Control for Jump Risk			Control for Changes in Volatility		
	Stock return predictor	VRP	**Stock return predictor**	Option-implied Skewness	Option-implied Kurtosis	**Stock return predictor**	ΔVOL	Ln (IV_t /IV_{t-1})
Ln(ME)	-0.004***	0.093***	-0.005***	0.003***	0.103***	-0.007***	0.005***	-0.163***
	(-11.69)	(15.51)	(-17.87)	(8.49)	(8.48)	(-28.93)	(2.66)	(-23.49)
Ln(BM)	0.001	0.100***	0.000	0.004***	0.130***	-0.000	0.003	-0.162***
	(0.80)	(13.39)	(0.87)	(9.83)	(9.53)	(-1.01)	(1.46)	(-23.49)
$RET_{(-1,0)}$	-0.013***	0.098***	-0.012***	0.004***	0.124***	-0.009***	0.002	-0.165***
	(-3.39)	(13.97)	(-4.10)	(9.46)	(9.71)	(-3.46)	(1.06)	(-22.83)
$RET_{(-12,-2)}$	-0.003***	0.101***	-0.003***	0.004***	0.131***	-0.004***	0.003*	-0.164***
	(-3.33)	(13.83)	(-3.39)	(9.76)	(9.04)	(-4.27)	(1.81)	(-23.02)
ACC	0.004	0.103***	-0.001	0.004***	0.129***	0.001	0.003	-0.166***
	(0.81)	(13.61)	(-0.26)	(9.08)	(9.06)	(0.29)	(1.27)	(-23.60)
AG	-0.000	0.100***	0.000	0.004***	0.130***	0.000	0.003*	-0.164***
	(-1.32)	(13.69)	(0.40)	(9.52)	(9.19)	(1.13)	(1.66)	(-23.41)
CH	0.010***	0.100***	0.015***	0.004***	0.120***	0.024***	0.004**	-0.170***
	(3.91)	(14.66)	(7.02)	(8.73)	(8.92)	(15.46)	(2.12)	(-22.29)
DISP	0.005***	0.099***	0.002**	0.004***	0.119***	0.003***	0.003	-0.163***
	(3.34)	(13.80)	(2.32)	(9.45)	(9.46)	(6.14)	(1.31)	(-22.83)
ISSUE	0.012***	0.100***	0.012***	0.004***	0.128***	0.022***	0.004**	-0.164***
	(3.64)	(14.08)	(4.91)	(9.48)	(9.38)	(10.59)	(2.03)	(-23.13)
IVOL	0.033***	0.093***	0.036***	0.003***	0.093***	0.067***	-0.042***	-0.161***
	(12.85)	(15.96)	(18.01)	(8.22)	(8.63)	(27.85)	(-17.63)	(-22.17)
PROFIT	-0.006***	0.099***	-0.008***	0.004***	0.121***	-0.013***	0.004**	-0.162***
	(-4.14)	(13.95)	(-8.82)	(9.35)	(8.76)	(-16.97)	(2.36)	(-23.34)
SUE	-0.082	0.092***	0.021	0.003***	0.111***	0.020	0.003	-0.146***
	(-0.67)	(13.18)	(0.27)	(8.48)	(7.86)	(0.31)	(1.40)	(-22.99)

Panel C: Using Multiple Equity Characteristics Simultaneously as Regressors

	(1)	(2)
	Without Controls	With Controls
Intercept	0.047***	0.004
	(17.67)	(1.12)
Ln(ME)	-0.003***	0.005***
	(-12.46)	(7.65)
Ln(BM)	0.001	0.001***
	(1.48)	(2.89)
$RET_{(-1,0)}$	-0.025***	-0.013***
	(-10.13)	(-5.71)
$RET_{(-12,-2)}$	-0.005***	-0.002***
	(-5.91)	(-2.88)
ACC	-0.004	-0.002
	(-1.18)	(-0.75)
AG	-0.000	-0.001*
	(-0.57)	(-1.71)
CH	0.006***	0.003**
	(3.96)	(2.29)
DISP	0.004***	0.002***
	(4.65)	(3.43)
ISSUE	0.004**	0.003*
	(2.10)	(1.76)
IVOL	0.030***	0.074***
	(14.11)	(25.47)
PROFIT	-0.003***	-0.001*
	(-3.53)	(-1.68)
SUE	0.060	0.125**
	(0.89)	(1.98)
Ln(Amihud)		0.006***
		(8.61)
Option demand pressure		0.000
		(0.03)
Option bid-ask spread		0.002
		(0.38)
VOL_deviation		-0.039***
		(-19.38)
Average adj. R^2	0.113	0.166

Table 8: Impact of Option Transaction Costs on the Return of Option Portfolio Strategy

This table reports the impact of stock options' transaction costs on the profitability of our option-trading strategy based on the equity characteristics. Equity characteristics used to predict delta-hedged option returns are described in Table 1. Each month and for each optionable stock, we sell one contract of short-maturity at-the-money option, delta-hedged with the underlying stock, and rebalance the delta-hedges each month. The position is held for one month to compute the buy-and-hold return. For the column "MidP," we assume the options are transacted at the midpoint of the bid and ask quotes (i.e., effective spread is zero). The other columns correspond to different assumptions on the ratio of effective bid-ask spread (ESPR) to the quoted bid-ask spread (QSPR). All of the numbers in this table are expressed in percent. The sample period is from January 1996 to December 2012. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

Sorted on	Equal-Weighted (10-1) Return Spread						Equal-Weighted (5-1) Return Spread					
		Effective Bid-Ask Spread / Quoted Bid-Ask Spread						Effective Bid-Ask Spread / Quoted Bid-Ask Spread				
	MidP	10%	25%	50%	75%	100%	MidP	10%	25%	50%	75%	100%
– Ln(ME)	3.79***	3.37***	2.76***	1.75***	0.75***	-0.22	3.10***	2.76***	2.26***	1.43***	0.62***	-0.18
	(23.65)	(20.71)	(16.28)	(9.42)	(3.67)	(-0.95)	(23.97)	(20.84)	(16.25)	(9.33)	(3.63)	(-0.92)
– $RET_{(-1,0)}$	1.28***	1.22***	1.14***	1.00***	0.86***	0.73***	0.97***	0.93***	0.87***	0.73***	0.59***	0.49***
	(8.08)	(7.88)	(7.54)	(6.86)	(6.04)	(5.13)	(7.88)	(7.64)	(7.18)	(6.61)	(5.57)	(4.62)
– $RET_{(-12,-2)}$	1.58***	1.45***	1.25***	0.98***	0.73***	0.42***	1.16***	1.06***	0.91***	0.69***	0.48***	0.24**
	(7.20)	(6.91)	(6.33)	(5.63)	(4.44)	(2.89)	(6.48)	(6.22)	(5.71)	(4.94)	(3.82)	(2.17)
+ CH	1.99***	1.89***	1.74***	1.51***	1.27***	1.04***	1.55***	1.47***	1.36***	1.17***	0.99***	0.81***
	(13.47)	(13.14)	(12.57)	(11.44)	(10.07)	(8.48)	(11.63)	(11.28)	(10.71)	(9.65)	(8.44)	(7.11)
+ DISP	2.03***	1.87***	1.64***	1.26***	0.88***	0.51***	1.86***	1.72***	1.51***	1.17***	0.83***	0.50***
	(17.09)	(16.03)	(14.34)	(11.27)	(8.00)	(4.65)	(19.25)	(18.05)	(16.16)	(12.77)	(9.18)	(5.54)
+ ISSUE	1.46***	1.37***	1.24***	1.03***	0.82***	0.62***	1.33***	1.24***	1.12***	0.92***	0.72***	0.53***
	(13.18)	(12.80)	(12.08)	(10.47)	(8.43)	(6.17)	(14.86)	(14.20)	(13.11)	(11.04)	(8.72)	(6.31)
+ IVOL	3.92***	3.68***	3.32***	2.74***	2.17***	1.61***	3.19***	2.99***	2.69***	2.19***	1.71***	1.24***
	(24.93)	(23.82)	(22.00)	(18.59)	(14.85)	(10.97)	(23.32)	(22.17)	(20.32)	(16.95)	(13.33)	(9.61)
– PROFIT	2.39***	2.20***	1.92***	1.46***	1.00***	0.56***	1.83***	1.67***	1.43***	1.05***	0.66***	0.29***
	(18.62)	(17.30)	(15.22)	(11.60)	(7.92)	(4.33)	(17.30)	(16.03)	(14.02)	(10.43)	(6.68)	(2.90)

Table 9: Impact of Limits to Arbitrage on the Returns of the Option Portfolio Strategies

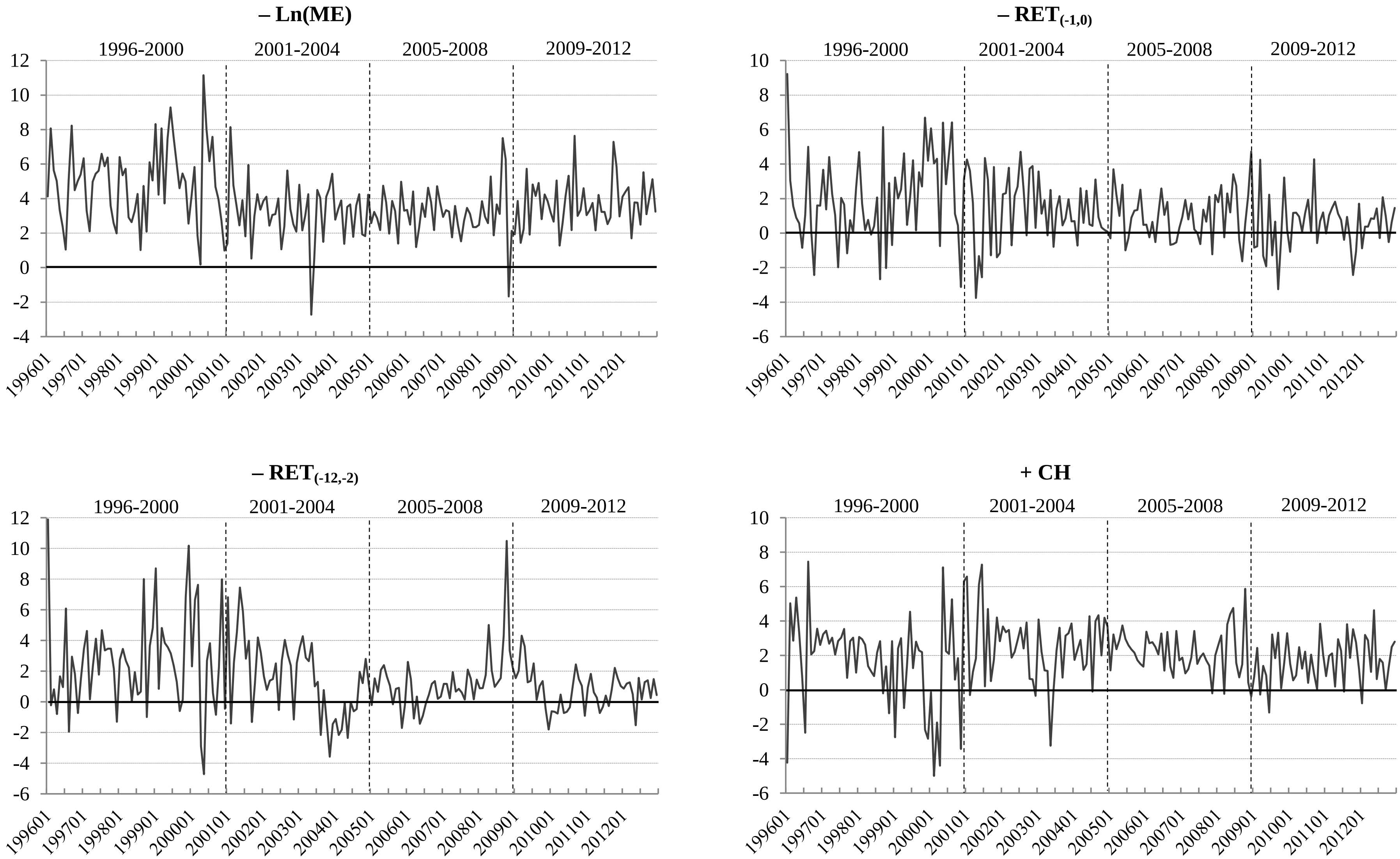
This table reports the equal-weighted average return spread in various subsamples. Each month, we first sort our sample into five quintiles (G1–G5) by stock liquidity defined as the 1/Amihud (2002) measure, stock price level, institutional ownership, or analyst coverage. Within each quintile, we then further sort by the equity characteristics into five quintiles. All of the numbers in this table are expressed in percent. The sample period is from January 1996 to December 2012. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

Equal-Weighted (5-1) Return Spread across Arbitrage Cost Measure Quintiles

Sorted on		Stock Liquidity	Stock Price	Institutional Ownership	Analyst Coverage			Stock Liquidity	Stock Price	Institutional Ownership	Analyst Coverage
– Ln(ME)	G1-Low	2.09***	1.54***	4.14***	2.75***	+ DISP	G1-Low	1.42***	0.70***	2.41***	1.60***
		(12.22)	(7.80)	(23.87)	(15.83)			(8.95)	(5.52)	(13.44)	(12.38)
	3	0.80***	0.92***	2.58***	2.12***		3	1.35***	0.31***	1.44***	1.73***
		(4.42)	(7.45)	(19.02)	(14.46)			(10.86)	(2.69)	(10.61)	(13.59)
	G5-High	0.45***	0.66***	1.56***	1.50***		G5-High	0.62***	0.16	1.17***	1.26***
		(2.82)	(5.87)	(13.80)	(13.62)			(4.26)	(1.33)	(8.77)	(8.54)
	(G5-G1)	-1.64***	-0.88***	-2.58***	-1.25***		(G5-G1)	-0.80***	-0.55***	-1.23***	-0.34*
		(-7.14)	(-3.87)	(-13.40)	(-6.25)			(-4.20)	(-3.51)	(-7.25)	(-1.91)
– $RET_{(-1,0)}$	G1-Low	1.03***	0.83***	1.13***	1.27***	+ ISSUE	G1-Low	1.43***	1.56***	1.98***	1.56***
		(6.04)	(4.99)	(5.64)	(6.00)			(9.67)	(9.30)	(11.55)	(10.96)
	3	1.05***	0.47***	0.77***	0.97***		3	0.91***	0.55***	1.07***	0.86***
		(6.65)	(3.35)	(5.79)	(6.43)			(8.37)	(4.17)	(10.66)	(6.03)
	G5-High	0.58***	0.20	0.84***	0.59***		G5-High	0.21	0.15	0.51***	0.62***
		(3.97)	(1.46)	(6.30)	(4.15)			(1.34)	(1.12)	(4.05)	(4.86)
	(G5-G1)	-0.46**	-0.63***	-0.29	-0.68***		(G5-G1)	-1.22***	-1.41***	-1.47***	-0.94***
		(-2.54)	(-3.38)	(-1.44)	(-3.25)			(-6.09)	(-7.38)	(-10.00)	(-5.19)
– $RET_{(-12,-2)}$	G1-Low	0.89***	0.36*	1.32***	0.91***	+ IVOL	G1-Low	2.74***	2.98***	4.11***	3.53***
		(4.54)	(1.77)	(4.97)	(4.09)			(18.06)	(20.02)	(23.56)	(18.30)
	3	0.65***	-0.39***	0.97***	1.44***		3	2.37***	1.44***	2.65***	2.52***
		(3.61)	(-2.78)	(5.38)	(7.68)			(14.52)	(8.73)	(15.60)	(14.93)
	G5-High	0.52***	-0.07	0.86***	1.14***		G5-High	1.33***	0.90***	2.11***	1.94***
		(2.90)	(-0.41)	(4.65)	(5.88)			(7.12)	(6.11)	(14.37)	(10.32)
	(G5-G1)	-0.37	-0.43*	-0.45*	0.23		(G5-G1)	-1.40***	-2.08***	-2.00***	-1.59***
		(-1.60)	(-1.70)	(-1.85)	(1.17)			(-8.30)	(-11.64)	(-11.28)	(-8.30)
+ CH	G1-Low	1.87***	1.74***	2.14***	1.85***	– PROFIT	G1-Low	1.76***	1.12***	2.58***	1.95***
		(10.38)	(10.96)	(10.95)	(10.83)			(12.24)	(8.19)	(17.24)	(12.08)
	3	1.03***	0.86***	1.20***	1.17***		3	0.94***	0.31**	1.54***	1.17***
		(5.81)	(6.24)	(6.95)	(6.76)			(7.62)	(2.45)	(12.12)	(6.77)
	G5-High	-0.52***	0.41***	0.59***	0.50**		G5-High	0.38***	0.11	0.89***	0.94***
		(-2.90)	(2.73)	(3.41)	(2.56)			(2.65)	(0.70)	(6.87)	(8.67)
	(G5-G1)	-1.47***	-1.33***	-1.55***	-1.35***		(G5-G1)	-1.38***	-1.01***	-1.69***	-1.01***
		(6.60)	(-6.69)	(-7.66)	(-7.40)			(-8.45)	(-5.61)	(-9.34)	(-5.86)

Figure 1. Time-series return spread to delta-neutral call writing.

This figure plots the time-series of an equal-weighted (10-1) return spread to delta-neutral call writing sorted on the equity characteristics. The equity characteristics used to predict delta-hedged option returns are described in Table 1. At the end of each month, we rank all stocks with options traded into deciles by the equity characteristics. All return spreads in this figure are expressed in percent. The sample period is from January 1996 to December 2012.



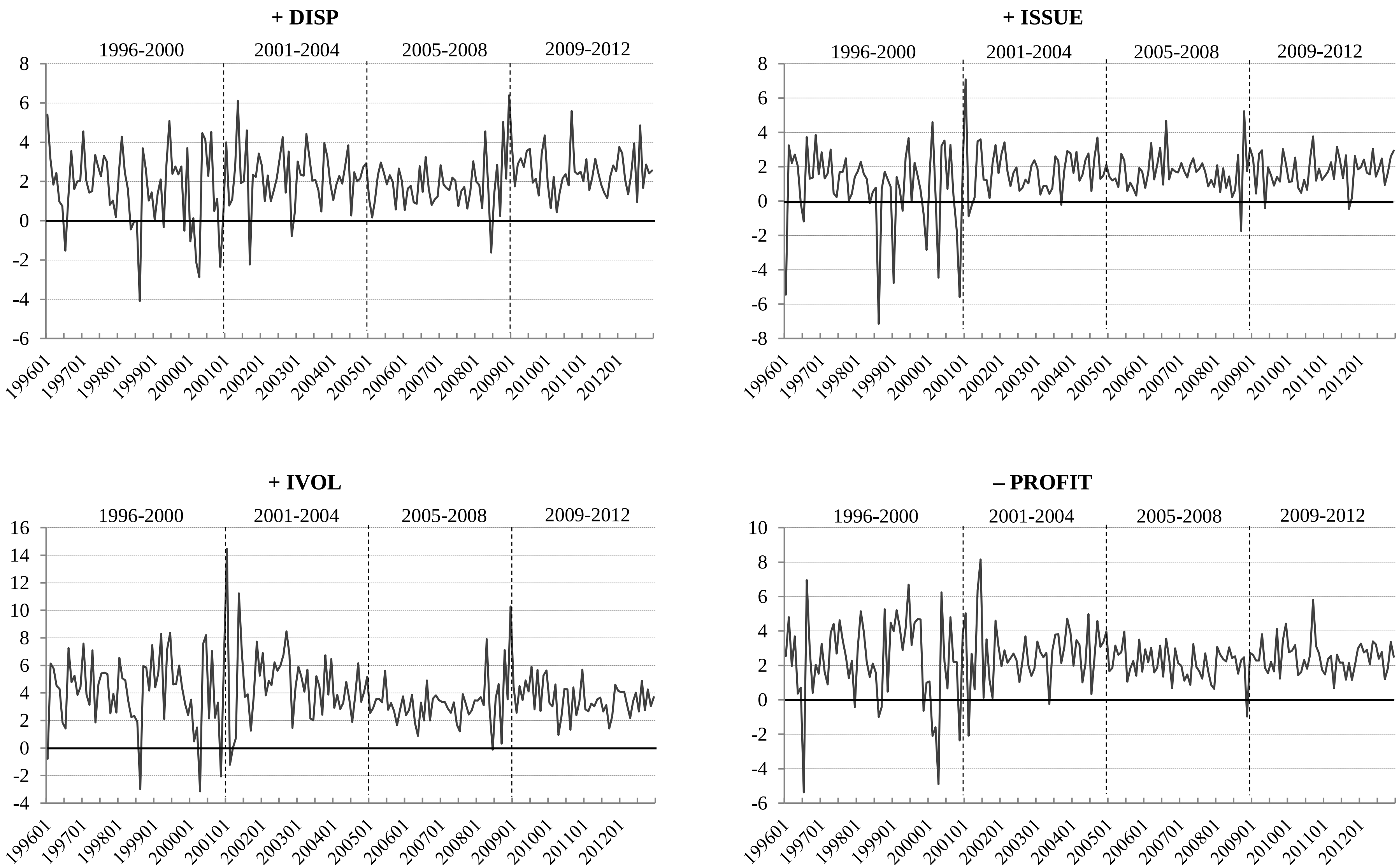

+ DISP
+ ISSUE
+ IVOL
– PROFIT
1996-2000
2001-2004
2005-2008
2009-2012

Table A1: Sample Coverage of Underlying Stocks

This table provides details about the stock-month sample for the underlying stocks with qualified option observations of both call and put. At the end of each month, we extract from the Ivy DB database of OptionMetrics one call and one put on each optionable common stock whose price is above $5. The selected options are approximately at-the-money with a common maturity of about one-and-a-half month. We exclude the following option observations: moneyness is lower than 0.8 or higher than 1.2; the option price violates obvious no-arbitrage option bounds; the reported option trading volume is zero; the option bid quote is zero or the midpoint of the bid and ask quotes is less than $1/8; and the underlying stock paid a dividend during the remaining life of the option. Panel A reports the time-series summary statistics and Panel B reports the time-series average of cross-sectional distributions. Panel C reports the time-series average of a Fama-French 12-industry distribution for the sample of stocks with qualified option observations and full CRSP sample. Percent coverage of stock universe (EW) is the number of sample stocks, divided by the total number of CRSP stocks. The percent coverage of the stock universe (VW) is the total market capitalization of sample stocks divided by the total market value of all CRSP stocks. Firm size is the firm's market capitalization. Book-to-market is the fiscal year-end book value of common equity divided by the calendar year-end market value of equity. Volatility is the standard deviation of daily stock returns over one month. The size, book-to-market, and volatility percentiles are defined using the full CRSP sample. Institutional ownership is the percentage of common stocks owned by institutions in the previous quarter. Analyst coverage is the number of analysts following the firm in the previous month. The sample period is from January 1996 to December 2012.

Panel A: Time-Series Distribution (204 Monthly Obs)

Jan 1996–Dec 2012	Mean	Std	10-Pctl	Q1	Med	Q3	90-Pctl
Number of stocks in the sample each month	792	162	575	705	806	901	1,000
Stock % coverage of stock universe (EW)	10.87	2.58	7.47	9.54	10.90	12.55	14.33
Stock % coverage of stock universe (VW)	40.26	8.35	29.10	34.37	39.67	45.76	50.92
Stock % traded at NYSE/AMEX	50.77	7.71	40.57	46.00	51.50	56.29	50.77
Stock % included in S&P500 index	28.39	3.62	24.09	25.61	28.19	31.13	33.33
Stock % already included in previous month	50.77	7.71	40.57	46.00	51.50	56.29	60.30

Panel B: Time-Series Average of Cross-Sectional Distributions (159,902 Stock-Month Obs)

Jan 1996–Dec 2012	Mean	Std	10-Pctl	Q1	Med	Q3	90-Pctl
Firm size in million	7,788	24,134	333	682	1,726	5,252	16,030
Firm size CSRP percentile (%)	81	15	60	72	84	93	97
Firm book-to-market CSRP percentile (%)	33	24	6	13	27	49	70
Firm volatility CSRP percentile (%)	50	22	20	33	51	68	81
Institutional ownership (%)	69	21	40	57	72	84	93
Analyst coverage	11.52	7.34	3.37	5.85	9.96	15.90	21.96

Panel C: Time-Series Average of Industry Distribution

FF-12 Industry	Stocks with options	CRSP sample	FF-12 Industry	Stocks with options	CRSP sample
Consumer nondurables	4.19%	5.10%	Telecom	3.85%	3.01%
Consumer durables	2.19%	2.32%	Utilities	2.04%	2.48%
Manufacturing	9.20%	9.21%	Wholesale	11.61%	10.36%
Energy	5.04%	3.50%	Healthcare	12.94%	10.39%
Chemicals	2.18%	1.91%	Finance	9.77%	19.68%
Business Equipment	23.48%	18.17%	Others	13.52%	13.87%

Table A2: Equity Returns Sorted on Equity Characteristics

The equity characteristics used to predict delta-hedged option returns are described in Table 1. At the end of each month, we rank all stocks into deciles by equity characteristics and calculate both equal-weighted and value-weighted stock returns. We calculate these returns for the sample of all CRSP stocks (common stocks with price above $5 at the end of last month) and for a sample of stocks matched to the option sample. The table reports the spread stock return that is long in the tenth decile and short in the first decile. All returns in this table are expressed in percent. The sample period is from January 1996 to December 2012. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

			All Stocks: (10-1) Return Spread		Matched Sample: (10-1) Return Spread	
	Sign for return to delta-neutral call writing	Sign for stock return in literature	EW	VW	EW	VW
Ln(ME)	–	–	-0.20	-0.48	0.51*	0.34
			(-0.71)	(-1.44)	(1.79)	(1.09)
Ln(BM)	–	+	0.82*	0.22	0.41	0.07
			(1.79)	(0.68)	(1.04)	(0.18)
$RET_{(-1,0)}$	–	–	-0.56	-0.44	-0.04	0.04
			(-1.42)	(-1.21)	(-0.12)	(0.13)
$RET_{(-12,-2)}$	–	+	1.30**	0.76	0.92**	1.20**
			(2.39)	(1.56)	(2.16)	(2.05)
ACC	–	–	-0.24	-0.10	0.15	0.06
			(-1.64)	(-0.53)	(1.06)	(0.20)
AG	–	–	-0.41*	-0.29	0.05	-0.15
			(-1.92)	(-1.32)	(0.28)	(-0.42)
CH	+	+	-0.01	0.51	-0.35	0.85**
			(-0.02)	(1.05)	(-1.03)	(2.10)
DISP	+	–	-0.90**	-0.40	-0.75***	-0.49
			(-2.57)	(-0.93)	(-3.12)	(-1.41)
ISSUE	+	–	-1.03***	-0.57*	-0.75**	-0.38
			(-2.95)	(-1.79)	(-2.55)	(-1.16)
IVOL	+	–	-1.03*	-0.63	-0.72**	-0.35
			(-1.73)	(-1.07)	(-1.98)	(-0.73)
PROFIT	–	+	0.64	0.40	0.90***	0.73
			(1.44)	(1.25)	(3.28)	(1.64)
SUE	–	+	0.69***	0.11	0.31**	0.10
			(3.93)	(0.78)	(2.34)	(0.35)

Table A3: Return Spread to Daily Rebalanced and Compounded Delta-Neutral Call Writing Sorted on Equity Characteristics

Equity characteristics used to predict delta-hedged option returns are described in Table 1. At the end of each month, we rank all stocks with options traded into deciles (quintiles) by these equity characteristics. For each stock, we sell one contract of call option against a long position of Δ shares of the underlying stock, where Δ is the Black-Scholes call option delta. The delta-hedges are rebalanced daily. For each stock and in each month, we compound the daily returns of the rebalanced delta-hedged call-option positions over the month to arrive at the monthly return. We use three weighting schemes in computing the average return to delta-neutral call writing for a portfolio of stocks: equal weight, weight by the market capitalization of the underlying stock, and weight by the market value of option open interest at the beginning of the period. The table reports the spread return that is long in the tenth decile (the fifth quintile) and short in the first decile (the first quintile). All returns in this table are expressed in percent. The sample period is from January 1996 to December 2012. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

	(10-1) Return Spread			(5-1) Return Spread		
	EW	VW	Option-VW	EW	VW	Option-VW
Ln(ME)	-2.47***	-1.95***	-3.07***	-1.94***	-1.43***	-2.84***
	(-16.26)	(-14.11)	(-12.71)	(-14.73)	(-11.27)	(-11.21)
Ln(BM)	-0.07	0.02	0.29	-0.11	-0.08	-0.03
	(-0.34)	(0.14)	(1.21)	(-0.80)	(-0.70)	(-0.16)
$RET_{(-1,0)}$	-0.50***	-0.02	-0.31	-0.32***	0.02	-0.11
	(-3.53)	(-0.13)	(-1.43)	(-3.02)	(0.15)	(-0.65)
$RET_{(-12,-2)}$	-1.37***	-0.74***	-1.15***	-1.07***	-0.46***	-0.83***
	(-6.69)	(-3.02)	(-3.94)	(-6.42)	(-2.91)	(-3.95)
ACC	-0.08	-0.09	0.16	0.03	0.03	0.12
	(-1.08)	(-0.78)	(0.78)	(0.50)	(0.34)	(0.75)
AG	-0.33***	0.01	-0.47**	-0.11	0.12	-0.20
	(-3.97)	(0.08)	(-2.38)	(-1.53)	(1.14)	(-1.33)
CH	1.35***	0.52***	1.08***	0.94***	0.24	0.52**
	(8.48)	(2.87)	(4.17)	(6.35)	(1.33)	(2.37)
DISP	1.25***	0.57***	1.32***	1.11***	0.40***	1.08***
	(10.70)	(3.55)	(5.71)	(11.91)	(3.06)	(5.95)
ISSUE	0.75***	0.03	0.54**	0.65***	0.15	0.54***
	(5.53)	(0.30)	(2.21)	(5.21)	(1.65)	(3.05)
IVOL	2.20***	1.30***	2.21***	1.69***	0.93***	1.85***
	(12.66)	(6.03)	(7.74)	(10.33)	(4.41)	(7.02)
PROFIT	-1.68***	-0.81***	-2.01***	-1.16***	-0.42***	-1.22***
	(-15.41)	(-5.19)	(-9.24)	(-12.57)	(-3.09)	(-7.05)
SUE	-0.17*	0.20	0.13	-0.10	0.14	0.22
	(-1.93)	(1.09)	(0.60)	(-1.49)	(1.35)	(1.42)

Table A4: Return to Delta-Neutral Call Option Strategies Held until Maturity

Sorted on Equity Characteristics

Equity characteristics used to predict delta-hedged option returns are described in Table 1. At the end of each month, we rank all stocks with options traded into deciles by the equity characteristics. For each stock, we sell one contract of call option against a long position of Δ shares of the underlying stock, where Δ is the Black-Scholes call option delta. We use three weighting schemes in computing the average return of buying delta-hedged puts for a portfolio of stocks: equal weight (EW), weight by the market capitalization of the underlying stock (VW), and weight by the market value of option open interest at the beginning of the period (Option-VW). The table reports the spread return that is long in the tenth decile (the fifth quintile) and short in the first decile (the first quintile). All returns in this table are expressed in percent. The sample period is from January 1996 to December 2012. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

	(10-1) Return Spread			(5-1) Return Spread		
	EW	VW	Option-VW	EW	VW	Option-VW
Ln(ME)	-7.39***	-6.90***	-8.66***	-6.06***	-5.60***	-7.60***
	(-22.88)	(-20.11)	(-14.91)	(-23.67)	(-21.87)	(-15.45)
Ln(BM)	-0.21	0.95***	1.22**	-0.43	0.78***	0.71*
	(-0.60)	(2.87)	(2.11)	(-1.65)	(3.39)	(1.81)
$RET_{(-1,0)}$	-2.02***	-1.58***	-1.76***	-1.62***	-1.12***	-1.73***
	(-4.83)	(-3.48)	(-2.93)	(-4.90)	(-3.61)	(-4.18)
$RET_{(-12,-2)}$	-3.18***	-3.41***	-4.71***	-2.37***	-2.41***	-3.55***
	(-6.70)	(-5.82)	(-6.08)	(-6.14)	(-5.03)	(-5.68)
ACC	-0.04	-0.11	0.46	0.26*	-0.14	0.56
	(-0.20)	(-0.41)	(0.98)	(1.85)	(-0.56)	(1.47)
AG	-0.76***	-0.88**	-1.12**	-0.09	-0.26	-0.55
	(-3.45)	(-2.57)	(-2.21)	(-0.48)	(-1.14)	(-1.40)
CH	3.67***	0.38	2.64***	2.96***	0.68**	1.65***
	(9.91)	(0.76)	(4.60)	(9.44)	(2.08)	(3.67)
DISP	4.01***	3.37***	5.06***	3.59***	2.34***	4.02***
	(19.18)	(11.01)	(12.16)	(20.60)	(10.47)	(13.12)
ISSUE	2.95***	1.12***	2.27***	2.61***	1.16***	2.33***
	(12.00)	(3.82)	(4.06)	(12.44)	(4.90)	(5.56)
IVOL	7.28***	5.94***	7.40***	6.04***	4.57***	6.19***
	(22.57)	(15.64)	(13.61)	(20.20)	(14.05)	(13.59)
PROFIT	-4.81***	-3.72***	-5.68***	-3.74***	-2.65***	-4.26***
	(-16.72)	(-9.80)	(-10.31)	(-14.83)	(-11.01)	(-10.55)
SUE	-0.19	-0.40	-0.25	-0.03	-0.07	0.04
	(-1.18)	(-1.21)	(-0.63)	(-0.20)	(-0.33)	(0.12)

Table A5: Return of Delta-Neutral Put Option Strategies

Sorted on Equity Characteristics

Equity characteristics used to predict delta-hedged option returns are described in Table 1. At the end of each month, we rank all stocks with options traded into deciles (quintiles) by equity characteristics. For each stock, we buy one contract of put option hedged by a short position of Δ shares of the underlying stock, where Δ is the Black-Scholes put option delta. The option position is held for one month without rebalancing delta-hedges. We use three weighting schemes in computing the average return of buying delta-hedged puts for a portfolio of stocks: equal weight (EW), weight by the market capitalization of the underlying stock (VW), and weight by the market value of option open interest at the beginning of the period (Option-VW). The table reports the spread return that is long in the tenth decile (the fifth quintile) and short in the first decile (the first quintile). All returns in this table are expressed in percent. The sample period is from January 1996 to December 2012. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

	(10-1) Return Spread			(5-1) Return Spread		
	EW	VW	Option-VW	EW	VW	Option-VW
Ln(ME)	3.10***	2.90***	3.61***	2.52***	2.36***	3.13***
	(30.00)	(23.66)	(15.47)	(29.72)	(24.76)	(12.79)
Ln(BM)	0.02	-0.41***	-0.79***	0.14	-0.27**	-0.34*
	(0.15)	(-3.05)	(-3.38)	(1.35)	(-2.31)	(-1.83)
$RET_{(-1,0)}$	0.59***	0.40***	-0.54***	0.48***	0.37***	-0.24
	(5.51)	(2.60)	(-2.63)	(6.08)	(3.02)	(-1.29)
$RET_{(-12,-2)}$	1.10***	0.83***	1.18***	0.80***	0.59***	0.85***
	(6.64)	(3.78)	(4.03)	(5.87)	(3.49)	(4.04)
ACC	0.11	0.11	-0.13	-0.04	-0.05	-0.17
	(1.41)	(0.90)	(-0.64)	(-0.68)	(-0.50)	(-1.24)
AG	0.28***	0.29*	0.51**	0.02	0.19*	0.35**
	(2.82)	(1.77)	(2.42)	(0.26)	(1.73)	(2.17)
CH	-1.52***	-0.11	-0.89***	-1.22***	-0.15	-0.48***
	(-13.17)	(-0.46)	(-4.16)	(-11.33)	(-0.85)	(-2.79)
DISP	-1.59***	-1.25***	-1.80***	-1.46***	-0.92***	-1.59***
	(-16.18)	(-8.35)	(-9.18)	(-20.16)	(-7.92)	(-9.26)
ISSUE	-1.21***	-0.52***	-0.60**	-1.10***	-0.45***	-0.65***
	(-11.39)	(-4.26)	(-2.37)	(-13.59)	(-4.23)	(-3.37)
IVOL	-3.17***	-2.48***	-3.35***	-2.54***	-1.89***	-2.62***
	(-27.70)	(-15.49)	(-14.10)	(-24.44)	(-12.67)	(-13.38)
PROFIT	1.83***	1.49***	1.89***	1.42***	1.08***	1.52***
	(17.12)	(9.32)	(7.91)	(16.46)	(9.17)	(8.77)
SUE	0.16***	0.13	-0.11	0.03	-0.01	-0.04
	(3.00)	(0.94)	(-0.47)	(0.58)	(-0.17)	(-0.22)

Table A6: Controlling for the Impact of Idiosyncratic Volatility

This table reports the equal-weighted average returns of delta-neutral covered calls within each idiosyncratic volatility (IVOL) quintile. Each month, we first sort optionable stocks into five quintiles (G1–G5) by IVOL. Within each IVOL quintile, we then further sort by the other seven equity characteristics into five quintiles (Q1–Q5). All of the numbers in this table are monthly portfolio returns expressed in percent. The sample period is from January 1996 to December 2012. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

Equal-Weighted (5-1) Return Spread within IVOL Quintiles

IVOL Quintiles	Q1 Low	2	3	4	Q5 High	(5-1)	t-stat
			Ln(ME) Quintiles				
G1- Low	2.91	2.25	2.02	1.94	1.85	-1.06***	(-9.64)
2	3.80	3.17	2.69	2.50	2.23	-1.57***	(-10.65)
3	4.63	3.70	3.34	3.05	2.64	-1.99***	(-12.09)
4	5.50	4.29	3.94	3.63	3.13	-2.37***	(-12.23)
G5- Low	6.82	5.72	5.17	4.66	4.17	-2.65***	(-12.92)
			$RET_{(-1,0)}$ Quintiles				
G1- Low	2.54	2.25	2.12	2.05	2.05	-0.50***	(-6.79)
2	3.43	2.97	2.81	2.71	2.68	-0.76***	(-6.28)
3	4.06	3.63	3.39	3.20	3.29	-0.77***	(-6.47)
4	4.74	4.26	4.16	3.94	3.72	-1.02***	(-5.60)
G5- Low	6.42	5.52	5.13	4.87	5.01	-1.40***	(-6.85)
			$RET_{(-12,-2)}$ Quintiles				
G1- Low	2.43	2.25	2.08	2.12	2.13	-0.30***	(-3.49)
2	3.46	2.91	2.71	2.79	2.65	-0.81***	(-5.81)
3	4.18	3.66	3.37	3.15	3.15	-1.03***	(-6.42)
4	4.81	4.38	4.00	3.81	3.80	-1.02***	(-4.78)
G5- Low	6.43	5.42	4.93	5.01	4.99	-1.44***	(-6.64)
			CH Quintiles				
G1- Low	2.33	2.17	2.22	2.28	2.63	0.29***	(3.65)
2	2.91	2.89	2.94	3.12	3.45	0.54***	(4.34)
3	3.44	3.47	3.53	3.62	4.08	0.64***	(3.64)
4	3.83	4.06	3.97	4.28	4.90	1.07***	(6.94)
G5- Low	5.20	5.24	5.19	5.30	6.17	0.96***	(4.81)
			DISP Quintiles				
G1- Low	2.03	2.06	2.10	2.28	2.46	0.43***	(6.56)
2	2.60	2.66	2.79	3.06	3.27	0.67***	(7.13)
3	3.06	3.18	3.39	3.60	4.02	0.96***	(8.51)
4	3.53	3.65	3.93	4.42	4.82	1.29***	(10.48)
G5- Low	4.52	4.95	5.13	5.59	6.01	1.49***	(8.95)
			ISSUE Quintiles				
G1- Low	2.17	2.11	2.16	2.25	2.29	0.12*	(1.76)
2	2.77	2.76	2.96	3.01	2.99	0.23***	(3.06)
3	3.25	3.47	3.53	3.51	3.69	0.44***	(4.46)
4	3.95	4.13	4.06	4.16	4.39	0.44***	(2.92)
G5- Low	5.00	5.36	5.30	5.38	5.80	0.79***	(3.85)
			PROFIT Quintiles				
G1- Low	2.45	2.26	2.15	2.00	2.10	-0.34***	(-5.49)
2	3.39	2.91	2.82	2.68	2.61	-0.77***	(-9.82)
3	4.16	3.60	3.30	3.20	3.05	-1.11***	(-11.57)
4	5.00	4.29	3.86	3.69	3.62	-1.38***	(-8.84)
G5- Low	6.47	5.39	4.96	4.88	4.81	-1.66***	(-10.43)