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Option Return Predictability

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Option Return Predictability*

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Abstract

We uncover new and robust return predictability in the cross-section of *delta-hedged* equity options by the underlying stock characteristics and firm fundamentals. Expected returns of writing delta-hedged calls are negatively correlated with current stock price, firm profit margin and profitability, but positively correlated with firm cash holding, cash flow variance, new shares issuance, total external financing, distress risk, and dispersion of analyst forecasts. We develop ten option portfolio strategies that have annual Sharpe ratios above three and remain profitable after accounting for transaction costs and margin requirements. Their profits can be explained by two new option factors although stock market risk factors have little explanatory power. We examine the economic channels underlying option return predictability, including variance risk premium, jump risk, option demand pressure and investor gambling preference.

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Abstract

We uncover new and robust return predictability in the cross-section of *delta-hedged* equity options by the underlying stock characteristics and firm fundamentals. Expected returns of writing delta-hedged calls are negatively correlated with current stock price, firm profit margin and profitability, but positively correlated with firm cash holding, cash flow variance, new shares issuance, total external financing, distress risk, and dispersion of analyst forecasts. We develop ten option portfolio strategies that have annual Sharpe ratios above three and remain profitable after accounting for transaction costs and margin requirements. Their profits can be explained by two new option factors although stock market risk factors have little explanatory power. We examine the economic channels underlying option return predictability, including variance risk premium, jump risk, option demand pressure and investor gambling preference.

Keywords: cross-section of equity options; delta-neutral call writing; return predictability; stock characteristics; option factor model

JEL Classification: G02; G12; G13

1. Introduction

A voluminous literature has documented return predictability in the cross-section of stocks. Harvey, Liu, and Zhu (2016) have categorized 316 explanatory factors from the existing studies. Despite the tremendous growth in equity options in recent decades,[1] however, little is known about the determinants of the cross-section of expected returns of stock options.

In this paper, we examine whether a set of firm characteristics that are well known to predict stock returns can also predict the cross-section of *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. By focusing on delta-hedged options, we investigate option return predictabilities beyond those simply inherited from return predictabilities of the underlying stocks. Unlike raw option returns which have skewed and fat tailed distributions, delta-hedged option returns are better described by normal distributions and thus are more amenable to statistical analysis.[2] Further, delta-hedged options are more informative than raw option returns regarding potential option mispricing (Broadie, Chernov, and Johannes (2009)).

We adopt standard empirical methods in equity research. The basic unit of analysis in our study is delta-neutral covered call writing which sells one contract of equity call hedged by a long position of delta shares of the underlying stock.[3] All our results obtain when we analyze put options. At the end of each month, we rank all optionable stocks into deciles by a given stock characteristics and form portfolios of delta-neutral covered call writing on stocks in each decile. We close out the delta-hedged option positions after one month, and compute the holding returns of decile portfolios using equal weight, or value weight either by the stock market capitalization, or by the market value of option open interests at the beginning of the month. In all cases, we find monotonic patterns in the average returns of option portfolios, and the return differences between the top and the bottom decile portfolios are statistically significant. We thus uncover a set of option portfolio strategies that deliver both economically and statistically significant profits.

[1] Data from the Options Clearing Corporation (https://www.theocc.com/webapps/historical-volume-query) indicates that equity (not including index) options have about 362 billion shares traded during 2016 across all U.S. option exchanges, which is 25% of trading volume of all CRSP stocks (including non-optionable stocks). The dollar volume of equity options on Chicago Board Options Exchange in 2016 is US$666 billon (http://www.cboe.com/data/historical-options-data/annual-market-statistics).

[2] Under the Black-Scholes model, delta-hedged option returns have a symmetric distribution with zero mean (Bertsimas, Kogan, and Lo (2001)).

[3] We use the Black-Scholes option delta and pick short term (with time-to-maturity about 50 calendar days) options that are closest to being at-the-money. Our results are robust with regards to option maturity and moneyness.

Specifically, our option portfolio strategies prescribe writing covered calls on stocks with high cashflow variance, high cash holding, high new shares issuance, large total external financing, high distress risk, large dispersion of analyst forecasts, as well as on stocks with low price, low firm profit margin, and low profitability. For stocks with the opposite characteristics, our option portfolio strategies would enter into long positions in calls hedged by shorting delta shares of the underlying stocks. The monthly average returns of option portfolio strategies range from 1.63% to 5.01% with t-statistic all above 10. The monthly Sharpe ratios are 0.97 to 2.53, and the corresponding annualized Sharpe ratios are all well above three. This is in stark contrast to the finding that the profits of the long-short stock portfolios based on the same set of stock characteristics have weakened or become insignificant over our 1996-2016 sample period (e.g., Chordia, Subrahmanyam, and Tong (2014) and McLean and Pontiff (2016)). Our option portfolio strategies generate stable profits across different subperiods, different market conditions (e.g., both high and low sentiment periods, both up and down market) or macroeconomic environments (e.g., both recession and expansion periods). They remain profitable after taking into consideration option trading costs and margin requirements.

The option return predictabilities documented in this paper are distinct from known patterns in the nascent literature on the cross-section of option returns. Using Fama-MacBeth regressions, we still find significant relationships between returns to writing delta-neutral covered calls and the various stock characteristics after controlling for the difference between option implied-volatility and historical stock volatility (Goyal and Saretto (2009)), idiosyncratic volatility of the underlying stock (Cao and Han (2013)), risk-neutral stock skewness (Bali and Murray (2013)), recent stock returns (An, Ang, Bali, and Cakici (2014)), etc.

Our results about delta-hedged option return predictability suggest that options are non-redundant.[4] Under the Black-Scholes model, the delta-hedged option returns should be unpredictable. The systematic relationships between the expected delta-hedged option returns and various underlying stock characteristics are not captured by existing option pricing models even when options are not redundant. For example, under a stochastic volatility model, Bakshi and Kapadia (2003) show that the expected delta-hedged option returns are determined only by the variance risk premium. However, delta-hedged option returns are still significantly related to the stock characteristics after controlling for stock variance risk premium in Fama-MacBeth regressions. Moreover, the option portfolio strategies continue to have positive alpha in time-series regressions in the presence of several volatility-related risk factors

[4] See, e.g., Figlewski (1989), Figlewski and Green (1999), Buraschi and Jackwerth (2001), Coval and Shumway (2001), Jones (2006), for empirical support that options are not redundant.

such as changes in VIX (Ang et al. (2006)), the zero-beta straddle return of S&P 500 Index option (Coval and Shumway (2001)), and the value-weighted average of zero-beta straddle returns on individual stocks belonging to the S&P 500 Index (Cao and Han (2013)). Thus, the profits of our option portfolio strategies are not compensations for exposures to systematic volatility risk.

We examine several potential economic channels underlying our option return predictability results. We find that higher returns accrue to selling delta-hedged calls on stocks with large jump risk, high uncertainty in stock volatility, high information asymmetry, and when option demand pressure is large. Among these potential explanations, jump risk proxies have the largest explanatory power for our results, reducing the return predictability by the ten stock characteristics by 35% on average. Option demand pressure also plays a role but the effects of volatility uncertainty and information asymmetry are largely independent of our results.

We also conduct several tests for the option mispricing interpretation of our findings. [5] We find that investor gambling preference plays an important role to partly explain our results. Selling delta-hedged calls on stocks with lottery characteristics delivers a higher return on average. After controlling for stocks lottery characteristics, the ten stock characteristics are still significantly related to delta-hedged option returns, but the effects are reduced on average by about 30%.

However, we find no evidence that biased investor expectations cause the option return predictability we document. Our option trading strategies are always more profitable (higher by 0.88% per month on average) when implemented on stocks without earnings announcement than on stocks with earnings announcement during the holding period. In the latter case, the majority of the option strategy profits are earned outside the three-day earning-announcement window. Most of our option portfolio strategies do not have significantly positive returns around earnings announcements. These results are opposite to the patterns in stock return anomalies in Engelberg, McLean, and Pontiff (2018) that lead to conclude that stock market anomaly returns are due to stock mispricing that are at least partially corrected upon the arrival of news such as the earning announcements.

Turning to risk explanations, we find that existing common risk factors from the voluminous equity research could not explain our findings. The average returns of our option portfolio strategies are virtually unchanged and remain significant both economically and statistically after controlling for a comprehensive set of common stock risk factors, including the Fama and French (2015) five factors, the momentum factor (Carhart (1997)), the stock liquidity factor (Pastor and Stambaugh (2003)), the tail

[5] For example, Constantinides, Jackwerth, and Perrakis (2009) use the stochastic dominance argument to draw conclusions on mispricing of out-of-money S&P 500 call options. Both Boyer and Vorkink (2014) and Byun and Kim (2016) provide evidence of overpricing of equity call options due to investors' preference for skewness or gambling in options.

risk factor (e.g., Kelly and Jiang (2014)), the common factor in idiosyncratic volatility (Herskovic, Kelly, Lustig, and Van Nieuwerburgh (2016)), and the intermediary risk factors (e.g., Adrian, Etula and Muir (2014), He, Kelly, and Manela (2017)). Therefore, for risk-based explanations of our results, one needs to search for new priced risk factors beyond the set of common stock market risk factors in the existing literature. Such risk factors should improve our understanding of the risk-return trade-off in the financial market, including the stock market.

We also study the ability of several new factors constructed from options data to explain the set of option return predictability results. We find that two new option factors can well explain the profits of our option portfolio strategies. One factor is an option IVOL factor and the other is an option illiquidity factor. The factor realizations in each month are obtained as the returns of equal-weighted option portfolios of delta-neutral covered calls sorted on the idiosyncratic volatility or the Amihud illiquidity measure of the underlying stock, just like the construction of our option portfolios strategies (except they sort on other stock characteristics). These two factors are motivated by the findings of Cao and Han (2013) and Christoffersen, Goyenko, Jacobs, and Karoui (2018) respectively. When we regress the returns of our option portfolio strategies on these two factors only, the alphas are no longer significant statistically or economically.

Our paper contributes to the recent literature on option return predictability. This literature is growing rapidly but still small compared to the vast literature on stock return predictability. Goyal and Saretto (2009) find that straddles or delta-hedged calls on stocks with high implied-volatility relative to the historical volatility earn low returns. Cao and Han (2013) document that delta-hedged equity option returns decrease monotonically with the idiosyncratic volatility of the underlying stock. Bali and Murray (2013) find a strong negative relation between risk-neutral stock skewness and the returns of skewness assets constructed from a pair of options and a position in the underlying stock. 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. Boyer and Vorkink (2014) report a negative cross-sectional relationship between returns on individual equity options and their ex-ante skewness. Muravyev (2016) documents that option market order-flow imbalance significantly predicts *daily* option returns. Christoffersen et al. (2018) find a positive illiquidity premium in *daily* option returns. Most of the previous studies do not focus on delta-hedged option returns. We document multiple new predictabilities in option returns and conduct comprehensive tests of potential economic channels underlying the return predictabilities. We develop multiple robust option portfolio strategies that have high Sharpe ratios and build a new option factor model that can explain their profits.

The rest of the paper proceeds as follows. Section 2 describes the data and measures. Section 3 presents new profitable portfolio strategies of equity options based on a variety of underlying stock and firm characteristics. Section 4 tests several potential explanations for the significant cross-sectional relationships between delta-hedged option returns and underlying stock characteristics. Section 5 examines a two-factor option market model to explain the profits of our option portfolio strategies. Section 6 concludes the paper.

2. Data and Variables

This section introduces the data and key variables used in the empirical analyses.

2.1. Data and sample coverage

We collect data from both stock and equity option markets. The data process for the option market follows that of Cao and Han (2013). We obtain data on U.S. individual stock options from OptionMetrics from January 1996 to April 2016. The data set 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. The intra-day stock quotes and trades data are from Trade and Quote (TAQ) database.

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.[6] The options we analyze are therefore effectively European-type options.[7] 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

[6] Our results remain robust when we include options on stocks that make dividend payments before option maturity in our analyses.
[7] This controls for the 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.

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.[8] 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 maturity is different from the majority of options. Lastly, we only retain stocks with both call and put options available after filtering.[9]

Our final sample contains 186,220 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 0.04. 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 5,748 underlying stocks. Over the entire 244-months sample period, the average number of optionable stocks in our sample per month is 763. On average, these stocks comprise 36% of the total market capitalization and 11% of the total number of stocks in the CRSP universe. Relative to the full CRSP sample, the average size percentile, book-to-market ratio percentile, and volatility percentile of the optionable stocks in our sample are 80%, 33%, and 51%, respectively. Moreover, the average institutional ownership is 69% and the average number of analyst coverage is 11.5. The industry distribution of underlying stocks is similar to that in the full CSRP sample (see Panel C of Table A1). Therefore, our results are not limited to small, illiquid, highly volatile stocks or stocks with low attention or a few industries.

2.2. Delta-hedged option return

If an option can be perfectly replicated by the underlying stock and risk-free bond (e.g., under the Black-Scholes model), a delta-hedged option is riskless and should earn zero return on average. Bakshi and Kapadia (2003) find that delta-hedged gains for holding stock index options are significantly negative and interpret it as evidence of a negative price of volatility risk. Cao and Han (2013) find that the average return of holding delta-hedged individual-stock options is also negative.

The delta-hedged option gain measure is theoretically motivated, but it is not convenient for portfolio analysis and trading. The delta-hedged option gain is not the return of a portfolio in the

[8] For example, one no-arbitrage conditions for a call option price C is $S \geq C \geq \max(0, S-Ke^{-rt})$, 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.
[9] Removing any of these filters on options or the underlying stocks does not materially affect our results.

traditional sense since it involves a zero-cost portfolio. Thus, we consider delta-neutral call writing[10] that is not a self-financing option position. We are motivated by the popular covered call writing (also known as a "buy-write" strategy) in which investors hold the underlying stock and sell a call option against it (see, e.g., Lakonishok, Lee, Pearson, and Poteshman (2007)). The covered call writing involves the same number of shares of stock and option. Therefore, writing a covered call would have a positive exposure to the underlying stock. To isolate the effect of the underlying stock price movement, we sell one contract of call option hedged by a long position in delta shares of the underlying stock. Building up such a position requires a positive amount of capital. To reduce option transaction costs, we hold the position for one month without rebalancing the delta-hedges for most of our analysis. Our results are robust when we daily rebalance the delta hedges (see Section 3.3.1).

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

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

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

Table 1 Panel A shows that the average monthly buy-and-hold return to delta-neutral call writing is 3.5%.[11] By extending the holding period until option maturity (about 50 calendar days), the average return to delta-neutral call writing increases to 5.87%. As a robustness check, we rebalance the delta-hedge daily and compound the daily return to delta-neutral call writing into a monthly number. The average monthly return of delta-neutral call writing is positive and significant regardless of whether daily rebalancing of delta-hedge is performed.

Figure 1 shows that the distribution of raw monthly option returns is poorly behaved with a heavy left tail near -100% (i.e., when options are close to expire out-of-money). In contrast, the monthly return to delta-neutral call writing is well approximated by a normal distribution. This renders it feasible to apply standard statistical inferences such as t-statistics in our analyses.

[Insert Figure 1 and Table 1 about here]

[10] We focus on delta-hedged call options since at-the-money calls have much higher trading volume and higher frequency of trading than at-the-money puts (Christoffersen et al. (2018)). We have verified that all of our results hold for delta-hedged put options.

[11] This is consistent with the negative average delta-hedged option gain, which is long the option and short the underlying stock, opposite to delta-neutral call writing.

2.3. Stock characteristics

We identify a host of underlying stock characteristics that can predict the returns to delta-neutral call writing. These variables are motivated by 10 well-known stock return anomalies.

1. CFV: Cash flow variance, as in Haugen and Baker (1996), computed as the variance of the monthly ratio of cash flow to market value of equity over the last 60 months. Cash flow is net income plus depreciation and amortization, all scaled by market value of equity.

2. 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.

3. 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 forecasts.

4. ISSUE_1Y: 1-year new issues, as in Pontiff and Woodgate (2008), measured as the change in shares outstanding from 11 months ago.

5. ISSUE_5Y: 5-year new issues, as in Daniel and Titman (2006), measured as five-year real change in number of shares outstanding.

6. PM: Profit margin, as in Soliman (2008), calculated as earnings before interest and tax scaled by revenues.

7. Ln(PRICE): The log of stock price at the end of last month, as in Blume and Husic (1972).

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

9. TEF: Total external financing, as in Bradshaw, Richardson, and Sloan (2006), calculated as net share issuance plus net debt issuance minus cash dividends, scaled by total assets.

10. ZS: Z-Score, as in Dichev (1998). (1.2×(Working Capital / Assets) + 1.4×(Retained Earnings / Assets) + 3.3×(EBIT / Assets) + 0.6×(Market Value of Equity / Book Value of Total Liabilities) + (Revenues / Assets)). Higher values of ZS indicate lower probability of bankruptcy.

To avoid the impact of outliers on regression analyses, we winsorize all the explanatory variables

each month at the 0.5% and 99.5% levels. Panel B of Table 1 provides the summary statistics of the 10 stock characteristics above. Due to the disparate data availability across these variables, the number of observations varies from 145,381 to 186,220. We use the maximum number of cross-sectional observations for each stock characteristic when examining its relation with the expected delta-hedged option returns.

We also use other variables in our analyses, including VOL_deviation (volatility mispricing measure 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 the last month), idiosyncratic volatility (IVOL, as in Ang et al. (2006) and Cao and Han (2013), 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), the Amihud (2002) stock liquidity measure (calculated as the average of the daily ratio of the absolute stock return to dollar volume over the previous month), and other firm characteristics such as Ln(ME) and Ln(BM) in Fama and French (1992), momentum ($RET_{(-12,-2)}$), and short-term reversal ($RET_{(-1,0)}$). Table 2 reports the time-series average of the cross-sectional correlations between these stock characteristics. The correlations among these variables are generally low.

[Insert Table 2 about here]

3. Empirical Results

In this section, we conduct a battery of tests for the cross-sectional relation between future delta-hedged option return and a set of underlying stock characteristics. We implement various portfolio option-trading strategies, based on *delta-neutral* call writing (i.e., sell a call and long delta shares of the underlying stock). Moreover, we examine the profitability of option trading strategies after taking into considerations option transaction costs and margin requirement.

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

We first study the relation between return to delta-neutral call writing and the underlying stock characteristics using the portfolio-sorting approach. At the end of each month and for each stock characteristic, 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 decile versus the bottom decile. [12] To ensure the

[12] 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.

robustness of portfolio analyses, we use three weighting schemes in computing the average return of a portfolio of delta-neutral call writing: equal weight (EW), weight by market capitalization of the underlying stock (VW), and weight by the market value of option open interest at the beginning of the holding period (Option-VW).

For each stock characteristic sort, we have an associated option portfolio trading strategy, which consists of writing delta-neutral calls on stocks that belong the top decile and buying delta-neutral calls on stocks that belong the bottom decile. Motivated by practical considerations (e.g., for simplicity of the trading strategy and to minimize trading cost), we do not rebalance the delta hedges in Table 3 and most of the subsequent analyses. In other words, we buy-and-hold the long option short stock position for one month and then close it out. We verify the robustness of our results later (Section 3.3.1) to daily rebalancing of the delta hedges.

Table 3 reports the average return to delta-neutral call writing for the 10 decile portfolios sorted by each stock characteristic, the difference in the average returns between the top and the bottom decile portfolios (i.e., the profits of our option portfolio strategy). The associated Newey-West (1987) t-statistics are in parentheses.

[Insert Table 3 about here]

Table 3 reveals economically and statistically significant relations between each of the ten sorting stock characteristics and return to delta-neutral call writing over the next month. For the EW scheme, the (10-1) spread portfolio of delta-neutral call writing formed by sorting on the variance of cash flow (CFV) has a monthly return of 1.63% with a t-statistics of 11.74. For the VW (Option VW) case the spread return is 0.87% (1.51%), with t-statistics around 6. Cash holding (CH), analyst earnings forecast dispersion (DISP), net share issuance (ISSUE_1Y, ISSUE_5Y), and total external financing (TEF) all strongly and positively predict the next month returns of delta-neutral call writing. For example, when our option portfolio strategy has a monthly return of 2.03% (t-stat=19.81) when equal-weighted, 1.51% (t-sat=10.94) and 2.38% (t-stat=10.25) when value-weighted by stock and option respectively. The profits of the option portfolio strategy in the case of cash holding, net share issuance and total external financing have similar magnitudes,

The other four characteristics (PM, Ln(PRICE), PROFIT, and ZS) are significantly negatively related to next month returns of delta-neutral call writing. To ensure that the option portfolio strategies have positive average returns, we sort on the negative values of these variables in Table 3. The

corresponding option portfolio strategy are even more profitable. For example, the EW (10-1) spread portfolio formed by sorting on –PROFIT has a monthly return of 2.48% with t-statistics of 21.67. For the VW (Option VW) case the spread return is 1.73% (2.63%).

For robustness, we redo the portfolio analyses using quintile sorts. For brevity, we only report in the last column of Table 3 the (5-1) return spreads. The results are qualitatively the same as the (10-1) return spreads although the magnitude is generally smaller. In summary, using portfolio sorts, we show that 10 stock characteristics can predict the returns to delta-neutral call writing which has not been examined in previous studies.

We also perform portfolio sorts according to several stock characteristics that are known to be related to the cross-section of delta-hedged option returns, such as VOL_deviation (Goyal and Saretto (2009)), IVOL (Cao and Han (2013)), and Ln(Amihud) (Christoffersen et al. (2018)). We verify that writing delta-hedged call options delivers significantly higher returns on stocks with higher idiosyncratic volatility, larger spread between historical stock volatility and option implied volatility, as well as on more illiquid stocks. These results are consistent with the literature. In Section 4 we employ Fama-MacBeth regressions to show that our results are distinct from the effects of these and other stock characteristics (such as skewness).

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

Panel A of Table 4 reports the properties of time-series distributions of the equal-weighted monthly returns of our option portfolio strategies. They all have positive mean, median, and skewness. Their Sharpe ratios are much higher than the stock market anomalies. For example, for the option strategy associated with firm profitability, the monthly Sharpe ratio is 1.47, which corresponds to an annualized Sharpe ratio of 5.09. The lowest monthly Sharpe ratio is 0.97 (3.36 when annualized).

In Table 4 Panel B, we further conduct a variety of sub-period analyses to gain a better understanding regarding the profitability of our option-trading strategies. We first partition the full sample into two periods (1996–2005 versus 2006–2016). Our results remain significant and just as strong in the more recent subsample. 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), all 10 stock characteristics significantly predict delta-hedged option returns in both January and non-January months, both when market sentiment is high and when it is low, with little differences in the

magnitudes of profitability of our option strategies across these subperiods.[13] Columns (7)–(8) indicate that our option portfolio strategies are generally somewhat more profitable when stock market performance is good, but their returns remain significantly positive when stock market returns are negative. Columns (9)–(10) show similar positive performance for the option strategies across NBER expansion versus recession periods.[14] Finally, we split the sample into high- and low-funding liquidity periods, according to broker-dealer's leverage during the corresponding quarter.[15] Columns (11) and (12) show our results are significant in periods of high- as well as low-funding liquidity without material differences in the strength.

[Insert Table 4 about here]

Figure 2 plots the time-series of the equal-weighted (10-1) monthly return spreads of delta-neutral call writing sorted on each of the ten stock characteristics of the underlying stock in Table 3. One striking pattern is that for all option strategies, the positive return cases vastly outnumber the negative return cases, justifying their high average returns and high Sharpe ratio. Moreover, the profitability is stable over time and does not diminish either during or after the 2008–2009 financial crisis. This is in stark contrast to the stock market experience. According to Chordia et al. (2014) and McLean and Pontiff (2016), the stock market anomalies have weakened or become insignificant in recent years, with many equity strategies doing poorly or even crashed during the 2008–2009 financial crisis.

[Insert Figure 2 about here]

The consistent profitability of our option strategies could hint that they are compensations for exposures to some priced risk factors. However, these factors are unlikely to be the standard stock market factors because of the stable performance of option portfolio strategies during the crisis/recession periods. Section 5 examines this possibility in details. Alternatively, the profitability of our option portfolio strategies could manifest option mispricing that are previously under the radar and hence there are insufficient related arbitrage activities. Option traders traditionally focus on the relative valuation of an

[13] Baker and Wurgler (2006) construct an index of market-wide investor sentiment. The latest index is updated till September 2015 and contains five underlying measures of investor sentiment: the average closed-end fund discount, the number of IPOs, the first-day returns of IPOs, the equity share of total new issues, and the dividend premium. NYSE turnover is no longer included as indicator since their March 2016 update (see http://people.stern.nyu.edu/jwurgler/).

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

[15] 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 seasonally adjusted log changes in the level of broker-dealer leverage. The data are obtained from Level Table "Security Brokers and Dealers" of the Federal Reserve (Item FL664090005.Q for asset and Item FL664190005.Q for liability). https://www.federalreserve.gov/RELEASES/z1/

option and the underlying stock, or across options on the same underlying stock with different moneyness or maturity. Our results are based on the relative valuation of options (of same moneyness and maturity) on different underlying stocks. Our focus on various characteristics of the underlying stocks is new. Therefore, we suspect few market participants have traded on the option predictability patterns uncovered in this paper, even if they represent attractive risk-return trade-offs.

3.3. Robustness checks

We conduct additional tests to ensure that our results are robust to variations in the construction delta-neutral option positions and the type of options used in the analyses (e.g. put options instead of call options, other option moneyness and maturity). Since the results from these robustness checks are similar as Table 3, we only report them in the Appendix.

3.3.1. Variations in delta-neutral call writing

We first verify the robustness of our findings to two variations in delta-neutral call writing. Thus far 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 if we do not rebalance the delta hedges as time goes by, because option's delta will change as the stock price changes over time. As a first robustness check, we adjust the option delta hedges each day and compound the daily returns of delta-neutral call writing over all trading days of a given month to obtain a monthly return. Table A2 in the Appendix shows that the results based on daily-rebalanced delta-neutral call writing are consistent with those reported in Table 3 for all ten option strategies. This suggests that our option-return predictability results are not driven by predictability in the underlying stock returns. In unreported test, we further confirm that the significant relationships between return to delta-neutral call writing and various underlying stock characteristics are robust after controlling for contemporaneous stock return, which further remove the concern that our results are caused by delta-hedging error and stock return predictability.

Second, Table A3 in the Appendix reports results based on returns of delta-neutral call writing held until maturity (about 50 calendar days). The patterns are identical to Table 3 in which the holding period is one month. Returns of delta-neutral call writing held until maturity increase with cash flow variance, cash holding, analyst forecast dispersion, 1-year and 5-year shares issuance, as well as total external financing, but decrease with the underlying stock's price, profit margin, profitability, and Z-score. All of these predictive relations are statistically significant, just as in Table 3. The only difference

is that 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 3. Holding options until maturity also lowers transaction costs as there is no need to sell options to close the option position.

3.3.2. Strategies involving delta-neutral protective puts

In this subsection, we examine the profitability of put options portfolio strategies sorted by various stock characteristics. 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, in which delta is the Black-Scholes put option delta. Since delta of the put option is negative, the delta-neutral protective put is long 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 Table 3 for portfolios of delta-neutral protective puts sorted on the same set of ten stock characteristics. Since Table 3 uses short positions in delta-hedged calls, while Table A4 uses long positions in delta-hedged puts, put-call parity leads us to expect the opposite findings: if the average return to writing delta-neutral calls on stocks from the top decile sorted by a given characteristic is significantly higher than the average return to writing delta-neutral calls on stocks from the bottom decile, then we expect a significantly negative return spread of delta-neutral protective puts sorted on the same stock characteristic. This is indeed the case, as shown in Appendix Table A4. We obtain similar results for 10-minus-1 and 5-minus-1 return spreads, as well as across different weighting scheme for the option portfolios.

3.3.2. Across different moneyness and maturity group

Our results so far are based on at-the-money short-term maturity call options, because these options are most actively traded. In this subsection, we explore whether our documented return predictabilities also hold for options with different moneyness and maturities. For each stock at the end of each month, we assign its call options into 3x3 moneyness and maturity groups. Three moneyness groups are based on the option delta (Δ): out-of-money ($0.2<\Delta<0.4$), at-the-money ($0.4 \leqslant \Delta \leqslant 0.6$), and in-the-money ($0.6<\Delta<0.8$). Three maturity groups are based on days to maturity: short-term (30 to 60 days), medium-term (90 to 180 days), and long-term (180 to 360 days), respectively. For each moneyness-maturity option group, we calculate the average return to delta-neutral call writing for all call options on a given stock within that group. Then, we compute the equal-weighted average return to delta-neutral call writing across all stocks that belong to top (bottom) decile when sorted by one of the stock characteristics. As

shown in Appendix Table A5, the average 10-minus-1 return spread of delta-neutral call writing are generally significant with consistent signs across different moneyness-maturity groups, though the magnitude tends to be stronger for short-term or at-the-money options.

3.4. Accounting for option trading 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 5 examines the profitability of our option portfolio strategies after accounting for option transaction costs or margin requirement.

Due to the data limitation, we do not observe the effective spread, which is twice the difference between the actual execution price and the market quote at the time of order entry. For robustness, we recompute option returns corresponding to an effective option spread that is equal to 10%, 25%, 50%, 75%, and 100% of the quoted spread.[16] The column "MidP" in Table 5 corresponds to zero effective spread—i.e., option returns are computed with the price being equal to the midpoint of the bid and ask quotes—as in all previous tables.

Table 5 shows that for all of the portfolios of delta-neutral call writing sorted on one of the ten stock characteristics, the equal-weighed (10-1) return spread decreases monotonically with the transaction costs. In the case of 1-year new issuance (ISSUE_1Y) for example, it is 1.60% 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 based on new issuance is reduced to 1.29% (0.98%). When the effective option spread increases to 75% (100%) of the quoted spread, the average return of our option strategy further drops to 0.68% (0.39%). However, even if the effective option spread is 100% of the quoted spread (i.e., one always buys options at the ask and sells options at the bid), nine out of our ten option strategies still deliver positive average returns that are statistically significant (the only exception is the strategy based on stock price). The profitability of our option portfolio strategies therefore survive option transaction costs.

[Insert Table 5 about here]

[16] 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. Goyenko, Ornthanalai, and Tang (2015) report that in aggregate, the effective-to-quoted spread ratio is 0.8 for options with various moneyness and maturity between 30 and 182 calendar days. Muravyev and Pearson (2019) show that for an average option trade, the effective spreads that take trade timing into account are much smaller than the conventionally measured spreads.

Another cost of trading option is the margin requirement, especially for writing options. According to CBOE, the initial margin requirement for a naked short option position is "100% of option proceeds plus 20% of underlying security value less out-of-the-money amount, if any, to a minimum for calls of option proceeds plus 10% of the underlying security value, and a minimum for puts of option proceeds plus 10% of the puts exercise price."[17] To be conservative, we assume the delta-hedged long position in stock cannot be used to fulfill the margin requirement of selling a call option and initial margin requirement must be settled in cash.

Specifically, the return over $[t, t+1]$ to writing a delta-neutral call after taking into consideration the margin requirement is defined as

$$HPR = \frac{(\Delta_t \cdot S_{t+1} - C_{t+1}) + (\bar{M} + C_t)}{(\Delta_t \cdot S_t - C_t) + (\bar{M} + C_t)} - 1, \qquad (2)$$

where the total margin requirement is $\bar{M} + C_t$, with $\bar{M} = \text{Max}\,(0.2 \cdot S_t - (K - S_t)^+, 0.1 \cdot S_t)$.

Table 5 shows that adjusting for option margin requirement reduces the equal-weighed (10-1) return spread by about 40% on average. However, the profits of all ten option strategies are still significant both economically and statistically. Overall, our findings on the predictability in delta-hedged option returns cannot be explained by option transactions costs or margin requirement. As further support for this conclusion, our results still remain strong in recent years (see Figure 2 and the first two columns of Table 4 Panel B), although the liquidity and quality of trading have improved in the option market over time (see Figures 1–3 of Goyenko, Ornthanalai, and Tang (2015)).

4. Additional Analyses and Potential Explanations

So far, we have documented a variety of highly profitable option portfolio strategies. They are motivated by new option return predictabilities by underlying stock characteristics and firm fundamentals. The previous results are based on portfolio sorts. In this section, we conduct Fama-MacBeth (1973) cross-sectional regressions to confirm the previous results and verify their robustness to controlling for known determinants of option returns in the literature. We also test several possible explanations for our results and find their explanatory power to be quite limited.

4.1. Fama-MacBeth regressions

In each month, we regress the cross-section of returns over the next month to selling delta-hedged equity

[17] This is according to the CBOE margin manual (http://www.cboe.com/LearnCenter/pdf/margin2-00.pdf) which has been used in related studies on option margin cost (e.g., Bali and Murray (2013) and Hitzemann, Hofmann, Urig-Homburg, and Wagner (2018)).

calls on the stock characteristics used as sorting variables in previous results, as all as additional control variables motivated by previous studies. The control variables include (1) VOL_deviation (the log difference between the realized stock volatility and Black-Scholes implied volatility for at-the-money options) following Goyal and Saretto (2009); (2) stock idiosyncratic volatility (IVOL) to control for the effect identified by Cao and Han (2013); (3) the Amihud measure of stock illiquidity and option bid-ask spread to control for the effect identified by Christoffersen et al. (2018); (3) other firm characteristics including size (Ln(ME)), book-to-market ratio (Ln(BM)), momentum ($RET_{(-12,-2)}$)), and short-term reversal ($RET_{(-1,0)}$)); and (4) various option Greeks such as delta, vega, theta, gamma, and the square of gamma.

[Insert Table 6 about here]

Table 6 shows that the coefficient estimates of ten stock characteristics are all significant at the 1% level. For example, in the "VOL_deviation" column, we report the coefficient estimates after controlling for the difference between realized stock volatility and implied volatility. The coefficient estimates of the ten stock characteristics barely change in their magnitude and statistical significance. Other control variables like IVOL reduce the magnitude of the coefficient estimates, but do not affect the sign and statistical significance of the relation between the ten stock characteristics and next month return to delta-neutral call writing. Therefore, our option return predictability results are distinct from known determinants of (delta-hedged) option returns.

4.2. Variance risk premium

This subsection examines whether our results can be explained by the stock variance risk premium. Delta-hedged options are sensitive to underlying asset volatility. Investors generally dislike the randomness of future variance and, in equilibrium, demand a premium for accepting variance risk. Previous studies (e.g., Bakshi and Kapadia (2003); Bakshi, Kapadia, and Madan (2003)) have used delta-hedged options to examine variance risk premium. Individual stock variance risk premium have been empirically estimated (e.g., Carr and Wu (2008); Han and Zhou (2015)), and are theoretically related to the expected delta-hedged option returns under a stochastic volatility model (e.g., Bakshi and Kapadia (2003)). Stock variance risk premium depends importantly on various stock characteristics (Han and Zhou (2015)). Therefore, stock variance risk premium could be the underlying channel for the option return predictability we have documented if the stock characteristics are correlated with stock variance

risk premium.

In the left two columns of Table 7 Panel A, we regress next month return to delta-neutral call writing on one of the stock characteristics as well as monthly individual stock variance risk premium (VRP). VRP is measured as the difference between the expected stock return variance under the risk-neutral measure and under the empirical probability. Following Jiang and Tian (2005), and 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 a month and the empirical counterpart is proxied by realized return variance computed from intradaily stock returns over all trading days of a month (see Cao and Han (2013) Appendix A for details).

Table 7 Panel A shows that individual stock variance risk premium has a significantly positive coefficient in all regressions, suggesting higher returns to selling delta-hedged calls on stocks with large VRP. After controlling for VRP, the coefficients for all ten stock characteristics remain significant at the 1% level with the same signs as those in Table 6 Column 1 (Without Controls). The magnitudes of the coefficients shrink on average by about 20%. Therefore, the significant relationships between delta-hedged option returns and various stock characteristics do not merely reflect cross-sectional variation of stock variance risk premium.

[Insert Table 7 about here]

4.3. Uncertainty about stock volatility

In this subsection, we test a potential explanation of our results based on investors' uncertainties about future stock volatilities, the most important input in option valuation. Such uncertainties create a "model risk." Figlewski and Green (1999) show that the pricing and hedging errors due to inaccurate volatility forecasts create sizable risk exposure for option writers. Risk-averse option sellers respond by using a higher option implied volatility. Thus, when there is increased uncertainty about the underlying stock volatility, option sellers charge a higher option premium, leading to a higher return to selling delta-neutral options. This could explain our findings if uncertainty in stock volatility is correlated with the stock characteristics we use to predict the delta-hedged option return.

To test this potential explanation, we control for a measure (VOL-of-VOL) of uncertainty in stock volatility, computed as the standard deviation of percent change in the daily realized volatility over the previous month. We obtain estimates of daily volatility for each stock in each month by applying

from the EGARCH (1,1) model to a rolling window of past 12-month daily stock returns.[18] The results are reported in the middle two columns of Table 7 Panel A.

The coefficient of VOL-of-VOL is significantly positive. It is consistent with Figlewski and Green (1999) and supports the argument that option writers charge a higher option premium when facing greater uncertainty in the underlying stock volatility. More importantly, after we control for uncertainty in stock volatility, the coefficients for these ten stock characteristics are virtually the same as the corresponding coefficients reported in the first column of Table 6 (without controlling for uncertainty in stock volatility) and all are significant at the 1% level. Therefore, the predictive power of stock characteristics for delta-hedged option returns is independent of and unexplained by the effect of uncertainty in stock volatility.

4.4. Jump risk and higher moments of stock return

The delta-hedged option is immune to small changes in the price of the underlying stock. However, the delta-hedged option could be exposed to a stock jump risk since a large price movement would render the linear approximation in the construction of delta-hedging ineffective. As argued by Figlewski and Green (1999), option dealers may charge a premium for the jump risk when they write options. Broadie, Chernov, and Johannes (2009) show that incorporating a jump risk premium can help explain empirical patterns in index option returns. In this subsection, we examine whether our results could be explained by the correlations between stock jump risk and the stock characteristics that predict the cross-section of delta-hedged option return.

Following Bakshi and Kapadia (2003) as well as Bakshi et al. (2003), we proxy the underlying stock return jump risk by an ex-ante measure of the stock return risk-neutral skewness and kurtosis inferred model-free from equity options (see Cao and Han (2013) Appendix B for details). The right three columns of Table 7 Panel A show that estimates of the risk-neutral skewness and kurtosis are positively and significantly related to returns to selling delta-neutral calls. This is consistent with the prediction of Figlewski and Green (1999), as well as the findings in Bali and Murray (2013). More importantly, the presence of stock return jump risk proxies does not change the sign and statistical significance of the coefficient for these ten stock characteristics. Compared to the baseline regression results reported in the first column of Table 6 (Without Controls), the estimated coefficients for the stock

[18] We require at least 200 daily returns in each EGARCH estimation. The maximum number of iterations is 500 and over 97% of EGARCH regressions in our sample successfully converged. We obtain similar results when we define VOL-of-VOL as the standard deviation of volatility level scaled by the average volatility level in the same month or when we calculate the daily volatility level using the intraday stock returns (sampled at 10-minute or 5-minute interval).

characteristics become 35% lower on average after controlling for jump risk. Therefore, while jump risk plays an important role, it cannot fully explain our findings. After controlling for proxies of jump risk, the ten stock characteristics we examine still have significant predictive power for the cross-section of delta-hedged option returns.

In unreported tables, we have verified that our results continue to hold when we further control for higher order terms of stock return volatility, skewness, and kurtosis. Thus, the predictability of firm characteristics for the delta-hedged option return is not due to non-linear dependence of expected delta-hedged option return on the underlying stock.

4.5. Information asymmetry

This subsection explores the potential role of information asymmetry in explaining our results. Previous studies provide evidence of informed trading in the option market (e.g., Pan and Poteshman (2006)). The left two columns of Table 7 Panel B report the results of Fama-Macbeth cross-sectional regressions that control for probability of information-based trading using the PIN measure of Easley, Hvidkjaer, and O'hara (2002). The coefficient of PIN is significantly positive, suggesting that option market makers charger a higher premium when there is higher probability of informed trading. However, after controlling for the cross-sectional difference of firm-level information asymmetry with the PIN measure, the coefficients of the ten stock characteristics remain significant, and their magnitudes are reduced on average only by 5%. Therefore, the option return predictabilities we document are largely independent of and unexplained by the effect information asymmetry.

4.6. Option demand pressure and gambling preference

The impact of demand-pressure on the option price has been documented under the demand-based option pricing framework (e.g., Bollen and Whaley (2004), Garleanu, Pedersen, and Poteshman (2009), Muravyev (2016)). Option market makers charge a higher premium for options facing higher end users demand pressure, leading to a higher return to delta-neural call writing in these cases. To the extent that there are correlations between the firm characteristics we study and option demand pressure, we examine whether the option return predictability of ten firm characteristics still exists after controlling for option demand pressure.

Cross-sectionally, we measure option demand pressure by the total market value of all options (open interest times option price) on a given stock, scaled by the market value of underlying stock. The middle two columns of Panel B Table 7 report the Fama-Macbeth regression results after controlling for

option demand pressure. Consistent with demand-based option pricing framework, the coefficient of demand pressure is significantly positive. In the presence of option demand proxy, the coefficients for the ten stock characteristics are reduced by about 10% in magnitude, but they remain significant both economically and statistically. [19]

One source of demand pressure for call options is investor gambling preference, especially in the cases of stocks with lottery characteristics, leading to overvaluation of call options (e.g., Byun and Kim (2006)). In the right two columns of Panel B Table 7, we control for a measure of lottery characteristics of stocks, MAX(5), which is the average of the five highest daily stock returns within the last month (see Bali, Cakici, and Whitelaw (2011)). The coefficient of MAX(5) is significantly positive in all regressions, suggesting a higher return to selling delta-hedged calls on stocks with lottery characteristics. This is consistent with the result in Byun and Kim (2006) based on raw option returns. More importantly, after controlling for MAX(5), the ten stock characteristics are still significantly related to delta-hedged option returns with the same sign as in the first column of Table 6, but the magnitudes of the coefficients are reduced on average by about 30%. Therefore, similar to variance risk premium and jump risk, gambling preference plays an important role to partly explain our results.

To summarize, results in Section 4.2-4.6 indicate that it is more profitable to sell delta-hedged calls on stocks with high variance risk premium, high uncertainty in stock volatility, large jump risk, and high information asymmetry, as well as stocks with lottery characteristics, and when option demand pressure is large. These findings are interesting on their own and some are new to the literature. The effects of volatility uncertainty and information asymmetry are largely independent of our results. The other effects contribute to partly explain the option predictability by the underlying stock characteristics we have documented, but the explanatory power is modest when each effect is considered individually (the coefficients of stock characteristics are reduced by about 10% to 35%). In an unreported regression that simultaneously take into consideration all of the effects above, the coefficients of the ten stock characteristics are reduced by up to 70% in magnitude, but they all remain statistically significant.

4.7. Biased expectations and earnings announcements

Thus far, we have explored several alternative explanations of our option return predictability results that are based on risk (variance risk, jump risk), uncertainty, market friction (e.g., capacity of option

[19] We also control for an alternative proxy for demand pressure, and the ten stock characteristics continue to be significantly related to future delta-hedged option returns. Following Muravyev (2016), we estimate the option order imbalance using intra-day trades from Options Price Reporting Authority, and then scale it by the total number of trades or by the total dollar trading volume. This alternative proxy is available for only part of our sample period.

market makers to supply options to meet end users demand). The only behavioral explanation we have considered is based on gambling preference of investors. In this subsection, we examine another type of behavioral explanation based broadly on biased expectations.

Specifically, we study the role of earnings announcements on the option return predictabilities we have documented. Engelberg, McLean, and Pontiff (2018) find that stock return anomalies are six times higher on earnings announcement days. They interpret this result as evidence that anomaly returns are due to stock mispricing that are at least partially corrected upon the arrival of news such as the earning announcements. Similar argument suggests that if the option return predictabilities we have documented mainly reflect option mispricing caused by biased investor expectations, then they should be stronger around earning announcements.

We conduct two tests for the hypothesis above using portfolio sorts. First, we implement each option trading strategy sorted by one of the ten stock characteristics separately on two subsamples and then compare the average return of each strategy across the two subsamples. In each month, one subsample contains options where the underlying stocks have earnings announcements during that month, and all other options (i.e., those without earnings announcements in the given month) belong to the second subsample. Columns (1)-(3) in Appendix Table A6 report the equal-weighted (10-1) spread of monthly return to delta-neutral call writing for the two subsamples as well as the full sample. It turns out that all ten option portfolio strategies deliver significantly positive returns for both subsamples. However, without exception, the profits of option portfolio strategies are higher when implemented on stocks without earnings announcements. The difference in returns of our option portfolio strategies across the two subsamples is 0.88% per month on average. Columns (4)-(6) of Appendix Table A6 report similar results when we repeat the test above using daily rebalanced and compounded return of the delta-neutral call writing as described in Section 3.3.1.

In the second test, we focus on the subsample of stocks with earnings announcements during the holding period and compare the return of each daily-rebalanced option portfolio strategy over two subperiods in each month: the three-day event window around the earnings announcement date versus the remaining trading days of the month. Columns (7)-(8) of Appendix Table A6 show that most of our option portfolio strategies do not have significantly positive returns around earnings announcements. Most of the option strategy profits during the earnings-announcement month are earned outside the three-day earning-announcement window. These results confirm again that our option return predictability results are much stronger when there are no earnings announcements, contrary to the hypothesis above,

and also opposite to the patterns in stock anomalies. Thus, we conclude that our option return predictability results are not caused by biased investor expectations.

5. Factor Model for Option Returns

The cross-sectional tests in Section 4 indicate that the option return predictabilities by various stock characteristics and firm fundamentals we uncover are distinct from known patterns in the literature. Although there are hundreds of different anomalies in the stock market, many of them can be explained by a small number of common risk factors (e.g., Hou, Xue, and Zhang (2015), Fama and French (2016)). Could this be the case for options market as well? In this section, we use time-series regressions to examine the ability of a comprehensive set of common risk factors to explain the profits of our option portfolio strategies.

5.1. Common risk factor models from stock market

We first examine the alpha of our option portfolio strategies under a comprehensive set of common risk factors in the stock market, including Fama and French (2015)'s five factors, the momentum factor (Carhart (1997)), the stock liquidity risk factor (Pastor and Stambaugh (2003)), and two systematic mispricing factors of Stambaugh and Yuan (2017). Other risk factors include the common idiosyncratic volatility factor (Herskovic et al. (2016)), broker-dealer leverage shock factor (Adrian et al. (2014)), intermediary capital risk factor (He et al. (2017)), betting-against-beta factor (Frazzini and Petersen (2014)), and tail risk factor (Kelly and Jiang (2014)).[20]

We also control for several volatility factors including the zero-beta straddle return of the S&P 500 Index option (Coval and Shumway (2001)), the change in the Chicago Board Options Exchange Market Volatility Index (ΔVIX, Ang et al. (2006)), and the value-weighted average of zero-beta straddle returns on individual stocks belonging to the S&P 500 Index (Cao and Han (2013)). We regress the time series of equal-weighted monthly returns of our option portfolio strategies on the risk factors and examine whether the intercept terms are significantly different from zero. Table 8 shows that after controlling for the exposures to stock market common risk factors as well as volatility risk factors, the risk-adjusted average returns of our option portfolio strategies remain highly significant and are similar in magnitudes as the raw returns. Thus, our option strategies generate significant profits that are virtually unexplained by the stock market risk factors and the volatility risk factors. The same results obtain when we use stock-value-weighted or option-value-weighted return (see Appendix Table A7).

[20] We thank the authors for making these risk factors available to us.

[Insert Table 8 about here]

5.2. Common risk factor models from option market

In this subsection, we study the ability of several low-dimensional factor models to explain our results using new factors constructed from options data. We first consider the Level, Slope, and Value factors proposed by Karakaya (2013). These factors are designed to capture the cross-sectional variation in expected returns on option portfolios formed on moneyness, maturity and option "value" (where value is measured as the spread between historical stock return volatility and the Black-Scholes option implied volatility). Therefore, they are constructed using all the call options, not just short-term approximately at-the-money call options that our empirical analyses focus on. Specifically, the Level factor is the average return on selling at the money option portfolios; the Slope factor is the average return on buying long maturity option portfolios and selling short maturity ones; and the Value factor is the average return on buying high value option portfolios and selling low value ones. As shown in Model (1) of Table 9, the alpha of each option strategy becomes smaller than those in Table 8. Therefore, the three-factor model of Karakaya (2013) outperforms stock market factor models in explaining the profitability of our option portfolio strategies. Nevertheless, all alphas in Model (1) of Table 9 are still highly significant, both statistically and economically. The average raw return of the ten option portfolio strategies is 2.37% per month. After adjusting for the three-factor model of Karakaya (2013), the average alpha becomes 2.03% per month.

We take a step further and propose two new factors which are motivated by the findings of Cao and Han (2013) and Christoffersen et al. (2018), respectively. One factor is an option IVOL factor and the other is an option illiquidity factor. The factor realizations in each month are obtained as the high-minus low spread returns of equal-weighted option portfolios of delta-neutral covered calls sorted on the idiosyncratic volatility or the Amihud illiquidity measure of the underlying stock, just like the construction of our option portfolios strategies (except they sort on other stock characteristics).

Table 9 Model (2) shows that six out of ten portfolio strategies no longer have significant abnormal returns after adjusting for the option IVOL factor in a one-factor model. The alpha of the other four strategies is reduced by 62% with even bigger reduction in the t-statistics. The average absolute value of the alpha across the ten strategies under this one-factor model is 0.74%, already much lower than the 2.03% average alpha under the three-factor model of Karakaya (2013). Therefore, the single

option IVOL factor outperforms by a wide margin the three-factor model of Karakaya (2013) in explaining the profitability of our option strategies.

Table 9 Model (3) indicates that the option illiquidity factor also outperforms Karakaya (2013) three-factor model, but it is inferior to the option IVOL factor. After adjusting for the option illiquidity factor, only two out of ten portfolio strategies no longer have significant alpha, and the average absolute value of the alpha is 1.22%, higher than that under the option IVOL factor.

Model (4) suggests that our two-factor model consisting of option IVOL and illiquidity factor can fully explain the profits of our option portfolio strategies. The alphas are no longer significant statistically or economically, except for the strategy based on stock price sort, which is also the only strategy that loses significance after transaction costs (Table 5). The average absolute alpha is 0.37% under our two-factor model. Moreover, as shown in Model (5), adding the Karakaya (2013) three-factors does not improve the explanatory power of our two-factor model. [21] Appendix Table A8 reports similar results using value-weighted returns.

[Insert Table 9 about here]

6. Conclusions

This paper documents novel and robust evidence on predictabilities in delta-hedged option returns by various underlying stock characteristics. Expected returns of writing delta-hedged calls are negatively correlated with current stock price, firm profit margin and profitability, but positively correlated with firm cash holding, cash flow variance, new shares issuance, total external financing, distress risk, and dispersion of analyst forecasts. We examine several potential economic channels underlying our option return predictability results. Stock variance risk premium, jump risk, option demand pressure and investor gambling preference all play important roles that together explain about two-third half of the effects we document. On the other hand, our results are largely independent of the effects of volatility uncertainty and information asymmetry. Moreover, we find no evidence that biased investor expectations cause the option return predictability we document.

Based on these option return predictabilities, we construct ten tradable option portfolio strategies that generate stable profits over time and across a wide range of market conditions. The Sharpe ratios of

[21] Similarly, adding an option market factor and a volatility mispricing factor motivated by Goyal and Saretto (2009) to our two-factor model does not improve the explanatory power. The option market factor is equal-weighted average return of writing delta-neutral calls on individual stocks. The volatility mispricing factor is constructed from portfolios of delta-neutral call writing sorted by the difference between option implied-volatility and historical stock volatility. These two factors are close to the Level factor and the Value factor of Karakaya (2013).

our option portfolio strategies range from 0.97 to 1.47 at monthly frequency, or from 3.36 to 5.09 when annualized, substantially higher than stock-based strategies. After accounting for realistic option-transaction costs and margin requirements for writing options, our portfolio strategies still yield both statistically and economically significant profits.

The option portfolio strategies deliver significantly positive average returns with approximately the same magnitudes after controlling for a comprehensive set of common risk factors from the stock market. In contrast, when we regress the returns of our option portfolio strategies on a two-factor model from the options market, the alphas are no longer significant statistically or economically. One option factor, motivated by Christoffersen et al. (2018), captures the illiquidity premium in options market. The other is an idiosyncratic volatility factor motivated by Cao and Han (2013), and it captures the premium required by constrained financial intermediaries to meet demand pressure for options that are difficult to hedge.

It is beyond the scope of this study to answer definitely whether our findings represent option mispricing or rational compensation for some risk factors. Kozak, Nagel, and Santosh (2018) show that tests of reduced-form factor models cannot shed light on questions regarding the "rationality" of stochastic discount factors. However, we can draw several important conclusions. One, given our portfolio strategies involve only public traded securities, their high Sharpe ratios challenge the existing asset pricing models. The Hansen–Jagannathan bound suggests that in order to explain our option findings, the stochastic discount factors need to be much more volatile than implied by stock market anomalies, regardless of the sources of variations in the state prices. Two, under existing option pricing models based on the no-arbitrage framework such as the classical Black-Scholes model, mispricing of the underlying stock does not affect delta-hedged option returns. To examine the possibility that our findings manifest systematic patterns of mispricing in equity options, researchers need to develop equilibrium option pricing models. A better understanding of how mispricing in stocks affects demand for options, combined with the demand-based option pricing framework (e.g., Garleanu et al. (2009)), may yield useful insights. Another promising direction is to examine the cross-sectional differences in limits to arbitrage in the relative valuation of equity options and the underlying stocks (e.g., how they may depend on stock characteristics). We leave these and other interesting topics to future work.

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Appendix: Variable Definitions

Delta-Hedged Option Return Measures	
Returns to delta-neutral call writing till monthend	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 to compute the buy-and-hold return.
Returns to delta-neutral call writing till maturity	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 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 Characteristics	
CFV	Cash flow variance, as in Haugen and Baker (1996), computed as the variance of the monthly ratio of cash flow to market value of equity over the last 60 months. Cash flow is net income plus depreciation and amortization, all scaled by market value of equity.
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_1Y	1-year new issues, as in Pontiff and Woodgate (2008), measured as the change in shares outstanding from 11 months ago.
ISSUE_5Y	5-year new issues, as in Daniel and Titman (2006), measured as five-year real change in number of shares outstanding.
PM	Profit margin, as in Soliman (2008), calculated as EBIT scaled by Revenues.
Ln(PRICE)	The log of stock price at the end of last month, as in Blume and Husic (1972).
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.
TEF	Total external financing, as in Bradshaw, Richardson, and Sloan (2006), measured as (Net Share Issuance + Net Debt Issuance - Cash Dividends) scaled by Total Assets).
ZS	Z-Score, as in Dichev (1998), measured as (1.2×(Working Capital/Assets) + 1.4×(Retained Earnings/Assets) + 3.3×(EBIT/Assets)+0.6×(Market Value of Equity/Book Value of Total Liabilities) + (Revenues/Assets)). Higher values of ZS indicate lower probability of bankruptcy.

VOL_deviation	The log difference between the realized volatility and the Black-Scholes implied volatility for at-the-money options at the end of last month, as in Goyal and Saretto (2009). The realized volatility is the annualized standard deviation of stock returns estimated from daily data over the previous month.
IVOL	Annualized idiosyncratic return volatility, as in Ang, Hodrick, Xing, and Zhang (2006).
Ln(Amihud)	The natural logarithm of illiquidity, calculated as the average of the daily Amihud (2002) illiquidity measure over the previous month.
Ln(ME)	The natural logarithm of the market value of the firm's equity.
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.
$RET_{(-12,-2)}$	The cumulative return on the stock over the 11 months ending at the beginning of the previous month.
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.
Other Control Variables	
VRP	Volatility risk premium, defined as the difference between a model free estimate of the risk-neutral expected variance implied from stock options at the end of last month and the realized variance estimated from intradaily stock returns over last month.
VOL-of-VOL	The standard deviation of the percent change in daily realized stock volatility over the previous month. Each month for each stock, the daily realized volatility is estimated from the EGARCH (1,1) model using a rolling window of daily returns over the past 12-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.
Stock PIN	Probability of informed trading in Easley, Hvidkjaer, and O'hara (2002).
Stock MAX(5)	The average of five highest daily returns of underlying stock in the previous month.
Option demand pressure	The log difference between the total market value of all options and the market value of underlying stocks at the end of last 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.

Figure 1. Distribution of option returns.

Figure 1A plots the histogram for the pooled distribution of monthly buy-and-hold return to delta-neutral call writing. Figure 1B plots the histogram for the pooled distribution of monthly buy-and-hold raw return of call options. Delta-neutral call writing strategy is as follows: for each stock, we sell one contract of call option and delta hedge it by a long position of Δ shares of the underlying stock, where Δ is the Black-Scholes call option delta. The sample period is from January 1996 to April 2016 and the total number of observations is 186,220.

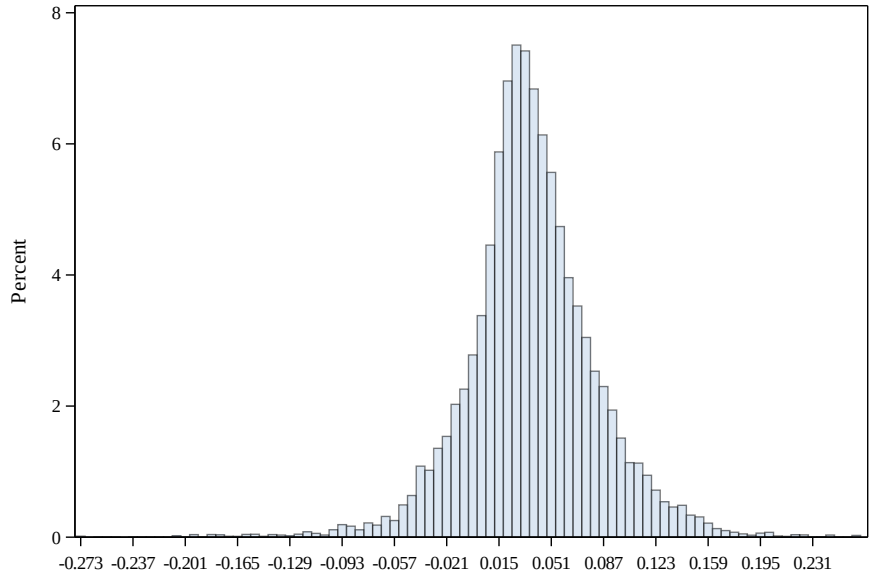


Figure 1A: Monthly buy-and-hold return to delta-neutral call writing

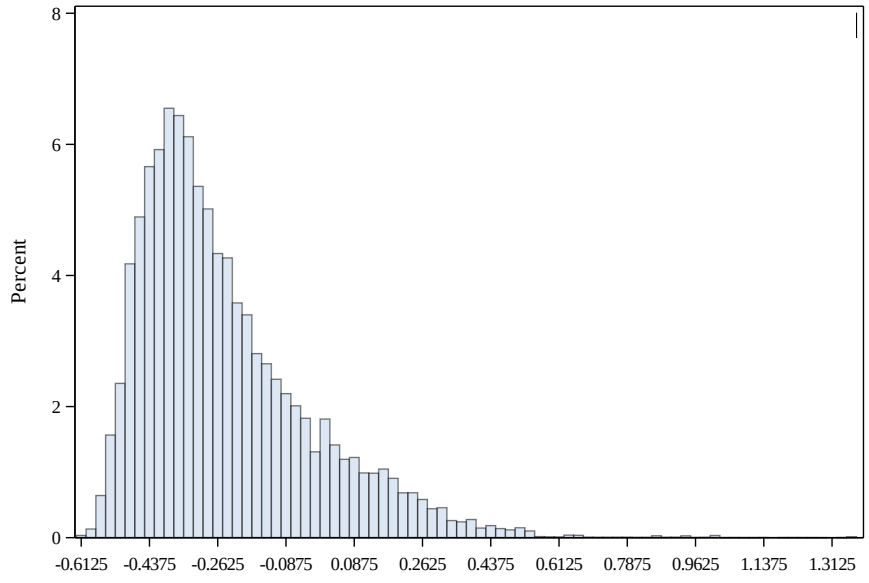
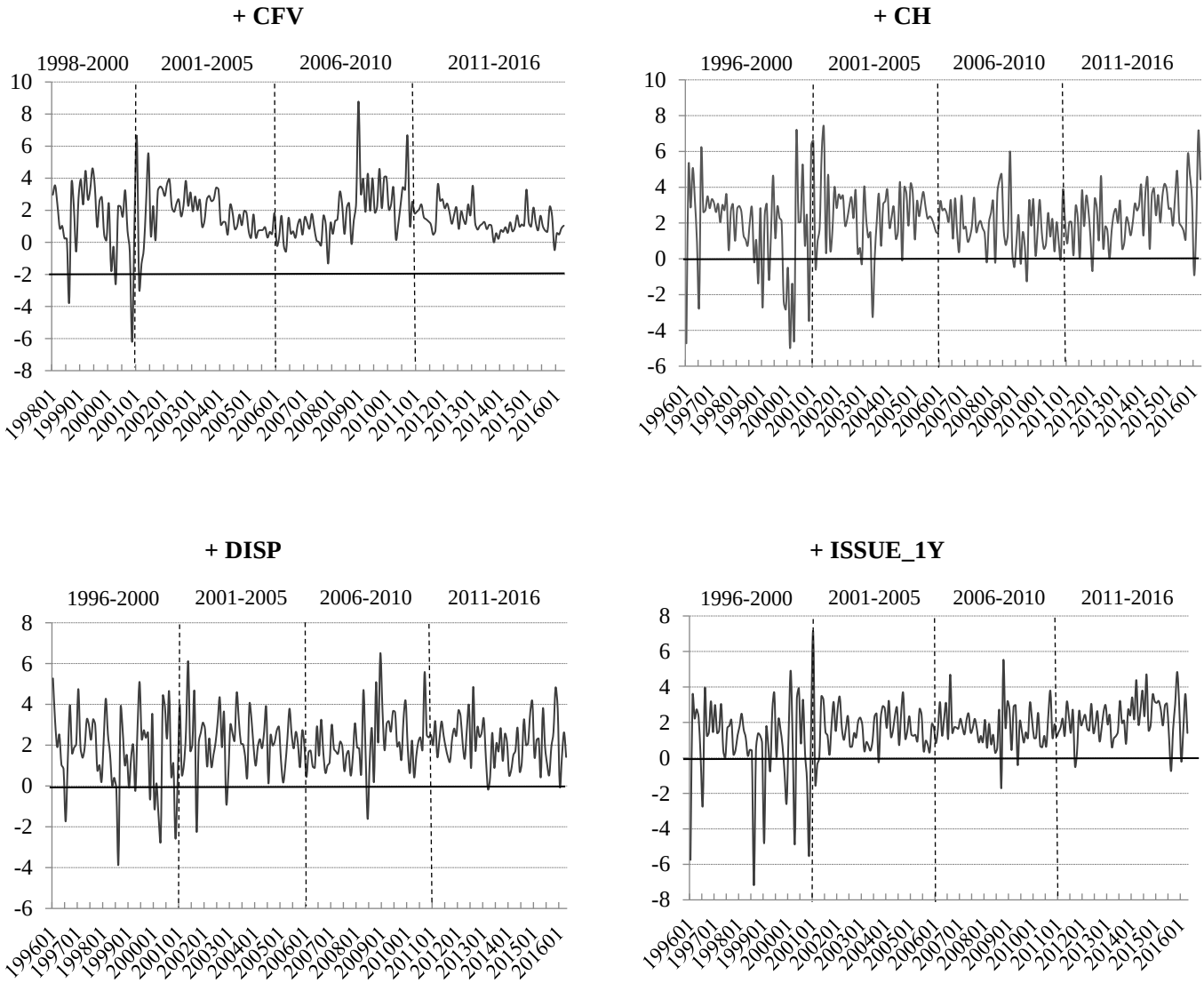


Figure 1B: Monthly buy-and-hold raw returns of call options

Figure 2. 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 April 2016.



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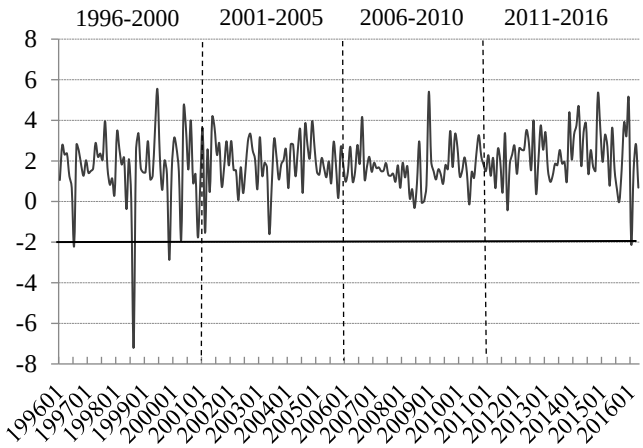

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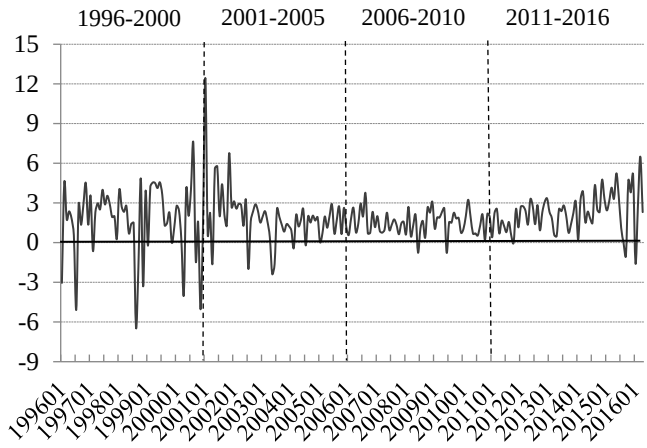
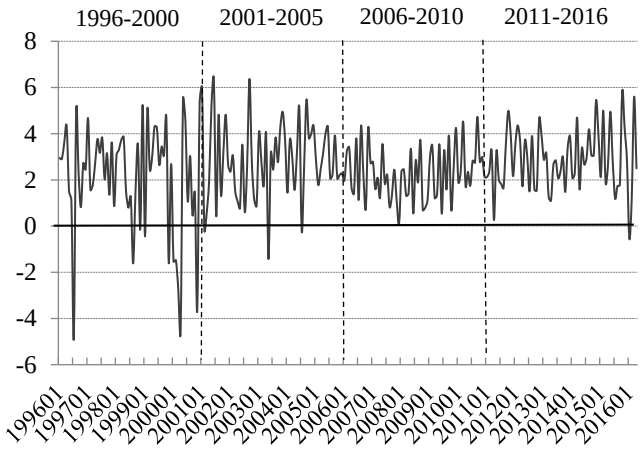
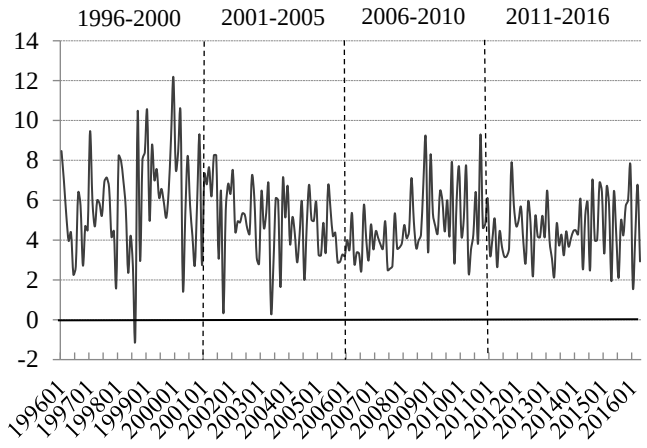


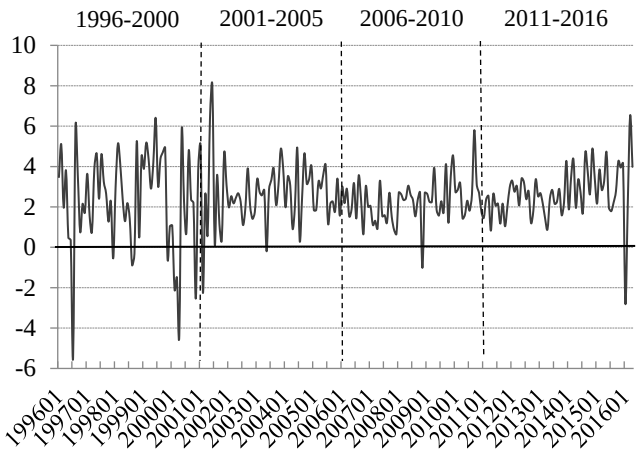
– PM



– Ln(PRICE)



– PROFIT



– ZS

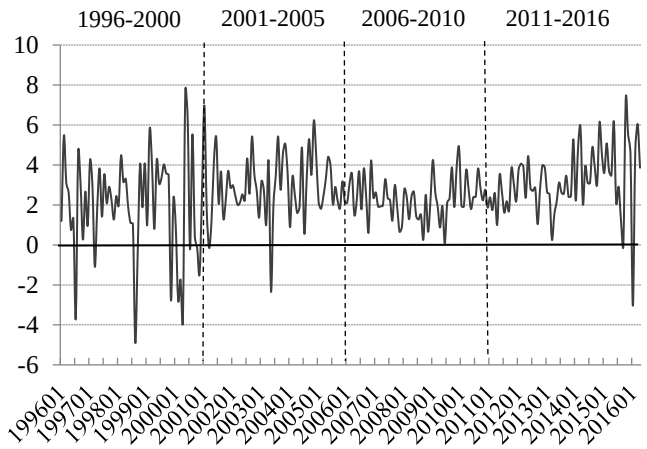


Table 1: Summary Statistics

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 April 2016. Panel A reports the pooled summary of returns to delta-neutral call writing strategy and option characteristics. 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. 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. Panel B reports the time-series average of cross-sectional statistics of equity characteristics. All of these variables are winsorized each month at the 0.5% level. CFV is cash flow variance as in Haugen and Baker (1996). 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_1Y represents 1-year new issues as in Pontiff and Woodgate (2008). ISSUE_5Y represents 5-year new issues as in Daniel and Titman (2006). PM is profit margin as in Soliman (2008). Ln(PRICE) is the log of the underlying stock price at the end of last month. PROFIT is the profitability as in Fama and French (2006). TEF is total external finance. ZS is Z-score as in Dichev (1998). IVOL is the annualized idiosyncratic volatility computed as in Ang, Hodrick, Xing, and Zhang (2006). VOL_deviation is the log difference between the realized volatility and the Black-Scholes implied volatility for at-the-money options at the end of last month, as in Goyal and Saretto (2009). The realized volatility is the annualized standard deviation of stock returns estimated from daily data over the previous month. 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.

Panel A: Pooled Summary of Returns to Delta-Neutral Call Writing Strategy and Option Characteristics (186,220 observations)

Variables		Mean	Standard deviation	10th percentile	Lower quartile	Median	Upper quartile	90th percentile
Buy & hold until month-end	(%)	3.50	5.65	-1.45	1.28	3.32	5.84	9.12
Buy & hold until maturity	(%)	5.87	11.20	-4.04	1.50	5.87	10.94	17.08
Daily rebalanced & compounded until month-end	(%)	1.53	5.53	-2.93	-0.19	1.54	3.59	6.45
Moneyness = S/K	(%)	100.24	4.32	95.20	97.61	100.00	102.57	105.44
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	(%)	20.34	16.88	5.66	9.11	15.29	26.01	41.51

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

Variable		Obs	Mean	Standard deviation	10th percentile	Lower quartile	Median	Upper quartile	90th percentile
CFV		165,510	0.24	1.01	0.01	0.02	0.05	0.13	0.36
CH		166,734	0.23	0.23	0.01	0.04	0.14	0.35	0.60
DISP	(%)	179,502	23.73	175.85	0.85	1.59	3.41	8.96	23.77
ISSUE_1Y		180,757	0.04	0.12	-0.04	-0.01	0.01	0.05	0.16
ISSUE_5Y		145,381	0.21	0.38	-0.13	-0.02	0.12	0.34	0.66
PM		176,754	-0.60	6.21	-0.16	0.04	0.11	0.19	0.30
Ln(PRICE)		186,220	3.35	0.70	2.38	2.87	3.39	3.84	5.13
PROFIT		173,302	0.05	0.47	-0.20	0.03	0.12	0.19	0.28
TEF		146,256	0.04	0.18	-0.10	-0.04	0.00	0.06	0.25
ZS		161,489	1.46	2.18	-0.36	0.84	1.72	2.58	3.41
VOL_deviation		186,211	-0.09	0.30	-0.46	-0.28	-0.10	0.09	0.27
IVOL		186,209	0.39	0.22	0.17	0.24	0.34	0.48	0.67
Ln(Amihud)		186,211	-6.89	1.64	-9.04	-8.04	-6.87	-5.72	-4.76
Ln(ME)		167,564	7.63	1.47	5.86	6.57	7.47	8.58	9.66
Ln(BM)		167,264	-1.10	0.81	-2.13	-1.58	-1.03	-0.54	-0.13
$RET_{(-1,0)}$	(%)	186,042	1.76	13.17	-13.00	-5.83	1.06	8.38	16.98
$RET_{(-12,-2)}$	(%)	183,398	26.95	65.89	-30.90	-10.49	13.57	44.91	93.82

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

The table presents the cross-sectional Pearson correlations of variables used in the cross-sectional regressions. These equity characteristics are described in Table 1 and are winsorized each month at the 0.5% level. We compute the cross-sectional correlations each month and report the time-series average of these correlations. The sample period is from January 1996 to April 2016.

	CH	DISP	ISSUE_ 1Y	ISSUE_ 5Y	PM	Ln (PRICE)	PROFIT	TEF	ZS	*VOL_ deviation*	*IVOL*	*Ln (Amihud)*	*Ln (ME)*
CFV	-0.016	0.047	0.049	0.057	-0.029	-0.097	-0.080	0.062	-0.078	0.005	0.093	0.061	-0.067
CH		0.067	0.152	0.202	-0.298	-0.204	-0.277	0.317	-0.380	-0.034	0.310	0.225	-0.283
DISP			0.062	0.094	-0.038	-0.188	-0.120	0.076	-0.134	0.000	0.131	0.133	-0.137
ISSUE_1Y				0.514	-0.121	-0.128	-0.203	0.262	-0.261	0.023	0.205	0.117	-0.172
ISSUE_5Y					-0.195	-0.246	-0.284	0.371	-0.395	-0.002	0.253	0.182	-0.217
PM						0.148	0.294	-0.297	0.377	0.047	-0.146	-0.144	0.139
Ln(PRICE)							0.265	-0.201	0.301	0.057	-0.409	-0.670	0.265
PROFIT								-0.326	0.545	0.028	-0.221	-0.220	0.239
TEF									-0.415	-0.006	0.276	0.223	-0.239
ZS										0.054	-0.239	-0.225	0.220
VOL_deviation											0.540	-0.033	0.048
IVOL												0.380	-0.430
Ln(Amihud)													-0.910

Table 3: 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 April 2016. 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
CFV												
EW	2.55	2.69	2.92	3.02	3.29	3.53	3.79	4.01	4.23	4.18	1.63***	1.58***
	(21.73)	(21.28)	(23.86)	(24.28)	(23.90)	(23.06)	(22.44)	(23.26)	(22.59)	(19.96)	(11.74)	(14.93)
Stock-VW	1.90	2.01	2.05	2.23	2.29	2.47	2.59	2.64	2.71	2.76	0.87***	0.75***
	(16.26)	(17.74)	(17.20)	(20.78)	(15.89)	(16.83)	(16.22)	(15.27)	(15.73)	(13.07)	(5.92)	(7.04)
Option-VW	2.15	2.23	2.50	2.51	2.80	3.11	3.55	3.54	3.68	3.65	1.51***	1.53***
	(12.54)	(17.04)	(18.44)	(16.56)	(17.40)	(17.44)	(14.87)	(14.96)	(15.52)	(12.35)	(6.36)	(8.56)
CH												
EW	3.03	2.91	2.96	3.13	3.26	3.54	3.62	3.79	4.05	5.14	2.11***	1.63***
	(21.10)	(24.82)	(21.63)	(22.53)	(23.35)	(25.02)	(23.00)	(23.78)	(24.53)	(30.89)	(15.88)	(13.99)
Stock-VW	2.28	2.00	2.06	2.11	2.07	2.31	2.39	2.48	2.63	2.75	0.48**	0.41**
	(17.08)	(19.27)	(18.46)	(18.78)	(17.05)	(17.39)	(15.98)	(12.18)	(15.12)	(11.43)	(2.02)	(2.51)
Option-VW	2.59	2.62	2.57	2.58	2.89	2.92	2.86	2.91	3.01	4.02	1.43***	0.41**
	(16.35)	(19.89)	(16.23)	(17.23)	(21.16)	(16.61)	(15.89)	(13.81)	(13.01)	(14.29)	(4.92)	(2.51)
DISP												
EW	2.62	2.59	2.78	2.90	3.14	3.35	3.68	3.97	4.30	4.66	2.03***	1.87***
	(21.83)	(22.94)	(23.80)	(22.40)	(23.85)	(24.58)	(26.22)	(25.28)	(28.09)	(26.87)	(19.81)	(21.95)
Stock-VW	1.87	1.98	1.98	2.08	2.18	2.30	2.42	2.59	2.92	3.38	1.51***	1.15***
	(16.39)	(18.63)	(19.07)	(18.06)	(16.74)	(17.03)	(16.66)	(16.04)	(18.78)	(18.94)	(10.94)	(10.24)
Option-VW	2.04	2.18	2.29	2.41	2.48	2.79	2.99	3.25	3.82	4.42	2.38***	1.15***
	(11.20)	(20.28)	(20.31)	(18.55)	(16.01)	(14.67)	(16.24)	(14.72)	(18.99)	(16.36)	(10.25)	(10.24)

ISSUE_1Y												
EW	2.76	2.70	2.95	3.28	3.47	3.58	3.69	3.75	3.91	4.37	1.60***	1.41***
	(23.33)	(23.32)	(23.54)	(24.01)	(23.91)	(23.83)	(24.23)	(24.47)	(26.47)	(29.30)	(14.84)	(16.83)
Stock-VW	2.15	1.91	2.03	2.13	2.27	2.33	2.35	2.51	2.41	2.72	0.56***	0.54***
	(18.88)	(20.07)	(18.47)	(17.63)	(19.08)	(15.31)	(16.73)	(17.36)	(14.84)	(17.19)	(4.86)	(5.64)
Option-VW	2.49	2.03	2.52	2.68	2.93	3.09	3.08	3.08	3.26	3.62	1.13***	0.54***
	(21.43)	(13.31)	(17.32)	(18.26)	(18.05)	(19.27)	(16.72)	(14.24)	(16.34)	(12.23)	(3.92)	(5.64)
ISSUE_5Y												
EW	2.53	2.55	2.74	2.95	3.08	3.30	3.49	3.60	3.94	4.39	1.86***	1.63***
	(24.10)	(25.29)	(23.78)	(23.04)	(21.84)	(22.42)	(24.76)	(24.76)	(27.92)	(29.93)	(19.92)	(23.11)
Stock-VW	2.00	1.97	2.02	2.00	2.11	2.35	2.15	2.41	2.45	2.73	0.73***	0.56***
	(18.99)	(17.58)	(20.15)	(13.98)	(16.90)	(15.91)	(14.10)	(18.03)	(15.67)	(18.75)	(7.98)	(6.62)
Option-VW	2.33	2.24	2.33	2.53	2.72	2.80	2.70	3.07	3.25	4.00	1.67***	1.32***
	(19.75)	(17.74)	(15.92)	(15.29)	(17.32)	(15.30)	(15.33)	(16.99)	(15.41)	(17.90)	(8.19)	(8.21)
TEF												
EW	2.91	2.83	2.89	3.10	3.17	3.50	3.53	3.58	3.72	4.78	1.87***	1.38***
	(27.55)	(23.75)	(21.97)	(22.85)	(22.76)	(24.13)	(24.79)	(24.43)	(23.06)	(27.06)	(14.63)	(14.17)
Stock-VW	2.03	2.09	2.05	2.15	2.07	2.30	2.23	2.46	2.69	3.32	1.28***	0.85***
	(18.66)	(20.04)	(15.63)	(19.41)	(14.34)	(17.27)	(15.05)	(14.16)	(16.86)	(19.03)	(8.88)	(7.51)
Option-VW	2.48	2.35	2.58	2.82	2.60	3.05	2.77	3.25	3.31	4.34	1.85***	1.40***
	(19.73)	(19.77)	(16.86)	(18.75)	(14.59)	(15.87)	(13.84)	(14.42)	(15.50)	(15.40)	(7.76)	(7.36)
–PM												
EW	2.90	2.92	2.92	3.02	3.00	3.08	3.24	3.52	4.18	5.42	2.53***	1.89***
	(21.62)	(20.95)	(22.84)	(22.89)	(23.84)	(22.72)	(26.94)	(25.53)	(24.62)	(31.25)	(22.11)	(20.17)
Stock-VW	1.98	1.97	2.06	2.20	2.13	2.23	2.29	2.39	2.98	3.90	1.92***	1.27***
	(14.34)	(15.37)	(19.80)	(18.78)	(18.15)	(18.91)	(21.10)	(17.54)	(18.76)	(18.21)	(11.98)	(10.73)
Option-VW	2.46	2.38	2.67	2.52	2.43	2.61	2.63	2.95	3.77	5.18	2.72***	1.99***
	(14.54)	(14.01)	(17.90)	(18.06)	(18.26)	(15.29)	(20.55)	(16.26)	(17.64)	(16.96)	(10.60)	(10.68)
–Ln(PRICE)												
EW	1.79	2.14	2.33	2.65	2.79	3.18	3.70	4.23	5.08	6.80	5.01***	3.97***
	(13.88)	(19.34)	(20.89)	(22.14)	(22.88)	(24.20)	(24.82)	(27.43)	(27.45)	(35.00)	(33.23)	(31.60)
Stock-VW	1.59	1.85	2.06	2.38	2.48	2.78	3.17	3.68	4.68	6.26	4.67***	3.53***
	(13.78)	(16.91)	(20.37)	(19.80)	(19.97)	(18.68)	(23.99)	(22.84)	(24.52)	(29.27)	(25.17)	(23.32)
Option-VW	1.60	2.08	2.39	2.67	2.86	3.22	3.85	4.42	5.55	7.45	5.85***	4.61***
	(10.34)	(16.27)	(16.77)	(17.67)	(17.32)	(18.58)	(20.95)	(18.85)	(26.73)	(25.37)	(20.18)	(21.14)

–PROFIT												
EW	2.90	2.82	2.78	2.96	2.94	3.16	3.33	3.66	4.17	5.38	2.48***	1.91***
	(23.37)	(22.02)	(22.21)	(22.47)	(23.42)	(22.57)	(22.88)	(27.39)	(25.29)	(31.00)	(21.67)	(19.97)
Stock-VW	1.96	2.02	1.99	2.10	2.06	2.23	2.40	2.55	2.94	3.70	1.73***	1.23***
	(15.86)	(18.85)	(17.81)	(18.30)	(19.58)	(17.67)	(13.73)	(18.56)	(17.48)	(18.87)	(10.96)	(10.48)
Option-VW	2.29	2.39	2.31	2.59	2.54	2.60	2.98	3.09	3.68	4.92	2.63***	2.01***
	(16.02)	(19.01)	(16.66)	(17.51)	(16.67)	(18.41)	(12.44)	(16.34)	(16.65)	(16.65)	(10.37)	(10.44)
–ZS												
EW	3.07	3.02	3.01	3.05	3.17	3.34	3.35	3.39	4.01	5.67	2.60***	1.79***
	(22.93)	(22.57)	(24.04)	(23.67)	(23.48)	(23.58)	(23.42)	(24.62)	(25.80)	(32.10)	(20.11)	(17.81)
Stock-VW	2.20	2.02	1.91	2.08	2.11	2.27	2.33	2.28	2.68	4.05	1.85***	0.92***
	(17.71)	(13.39)	(15.39)	(17.82)	(18.43)	(19.13)	(19.09)	(19.75)	(17.76)	(20.18)	(10.73)	(7.96)
Option-VW	2.42	2.36	2.17	2.47	2.78	2.73	2.89	2.82	3.54	5.54	3.12***	2.03***
	(15.73)	(13.80)	(15.14)	(17.19)	(19.23)	(16.19)	(14.84)	(15.77)	(13.73)	(22.01)	(11.82)	(10.16)
–VOL_deviation												
EW	3.22	2.97	3.13	3.11	3.16	3.36	3.44	3.58	3.92	4.81	1.59***	1.27***
	(23.62)	(19.90)	(22.50)	(23.01)	(22.40)	(24.50)	(25.31)	(24.98)	(28.08)	(31.83)	(12.42)	(11.26)
Stock-VW	2.26	2.19	2.07	2.09	2.14	2.22	2.21	2.20	2.43	2.73	0.47***	0.32***
	(15.69)	(15.63)	(15.26)	(16.82)	(17.69)	(17.68)	(20.09)	(15.53)	(20.38)	(19.53)	(3.67)	(3.10)
Option-VW	2.96	2.59	2.58	2.48	2.74	2.94	2.71	2.69	3.14	4.16	1.20***	0.91***
	(13.95)	(13.25)	(16.15)	(15.08)	(16.76)	(16.01)	(16.45)	(12.68)	(20.40)	(19.68)	(5.90)	(5.14)
IVOL												
EW	1.90	2.24	2.58	2.92	3.18	3.47	3.75	4.21	4.64	5.78	3.88***	3.14***
	(20.71)	(22.14)	(23.98)	(22.97)	(23.25)	(24.93)	(24.14)	(25.53)	(26.07)	(30.22)	(28.24)	(26.45)
Stock-VW	1.66	1.90	2.01	2.32	2.52	2.68	3.00	3.30	3.57	4.63	2.97***	2.25***
	(16.34)	(18.65)	(17.02)	(17.72)	(18.44)	(16.53)	(18.45)	(18.76)	(17.32)	(20.97)	(17.64)	(15.13)
Option-VW	1.72	1.83	2.02	2.40	2.80	2.87	3.45	3.88	4.46	5.39	3.67***	2.25***
	(18.27)	(13.03)	(13.67)	(18.24)	(18.52)	(16.04)	(17.25)	(18.45)	(17.72)	(18.06)	(14.05)	(15.13)
Ln(Amihud)												
EW	1.97	2.32	2.53	2.84	3.12	3.40	3.72	4.23	4.79	5.76	3.79***	3.13***
	(15.89)	(18.38)	(19.98)	(22.06)	(24.60)	(24.65)	(24.94)	(28.22)	(29.56)	(32.97)	(30.85)	(30.05)
Stock-VW	1.87	2.21	2.43	2.69	2.96	3.16	3.46	3.88	4.37	5.24	3.38***	2.75***
	(16.28)	(19.32)	(20.23)	(21.96)	(23.87)	(24.60)	(24.29)	(27.16)	(29.28)	(30.33)	(29.11)	(27.95)
Option-VW	2.00	2.74	2.90	3.12	3.70	4.15	4.38	5.12	5.70	6.73	4.73***	3.96***
	(14.08)	(16.92)	(17.25)	(17.31)	(20.24)	(20.85)	(20.31)	(23.94)	(20.46)	(25.98)	(19.21)	(19.46)

Table 4: 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 April 2016.

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
CFV	1.63***	-6.18	0.18	0.76	1.48	2.42	3.46	8.78	1.59	-0.05	4.83	1.03
CH	2.11***	-5.00	0.00	1.10	2.16	3.26	4.12	7.28	1.92	-0.58	1.99	1.10
DISP	2.03***	-3.79	0.44	1.21	2.04	2.83	3.81	6.50	1.48	-0.33	1.62	1.37
ISSUE_1Y	1.60***	-7.18	0.20	0.92	1.66	2.53	3.20	7.10	1.65	-1.61	7.14	0.97
ISSUE_5Y	1.86***	-7.19	0.49	1.26	1.79	2.68	3.52	5.53	1.42	-1.25	7.16	1.31
TEF	1.87***	-6.42	0.15	1.00	1.94	2.74	4.00	12.45	1.92	-0.05	6.10	0.97
–PM	2.53***	-4.88	0.75	1.53	2.66	3.68	4.63	6.37	1.72	-0.89	2.57	1.72
–Ln(PRICE)	5.01***	-0.92	2.72	3.61	4.77	6.26	7.67	12.18	1.98	0.44	0.56	2.53
–PROFIT	2.48***	-5.48	0.79	1.72	2.41	3.39	4.54	8.00	1.69	-0.75	3. 47	1.47
–ZS	2.60***	-4.89	0.74	1.83	2.57	3.70	4.67	7.70	1.84	-0.68	2.40	1.42

Panel B: Sub-Period Analysis

	Equal-Weighted (10-1) Return Spread											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	1996–2005	2006–2016	January	Feb-Dec	Sentiment Low	Sentiment High	Positive Mkt Ret	Negative Mkt Ret	NBER Expansion	NBER Recession	Broker-dealer Leverage Low	Broker-dealer Leverage High
# of Months	120	124	21	223	122	122	151	93	218	26	120	123
CFV	1.68***	1.59***	2.09***	1.58***	2.04***	1.18***	1.90***	1.21***	1.56***	2.13***	1.78***	1.46***
	(7.40)	(9.20)	(4.41)	(10.08)	(12.00)	(6.21)	(10.93)	(5.34)	(11.19)	(5.10)	(10.09)	(6.94)
CH	2.04***	2.18***	1.45***	2.17***	1.96***	2.19***	2.23***	1.91***	2.09***	2.25***	1.80***	2.39***
	(8.80)	(16.03)	(3.06)	(15.07)	(11.64)	(11.17)	(10.07)	(12.34)	(14.74)	(5.59)	(8.50)	(16.47)
DISP	1.93***	2.13***	2.15***	2.02***	2.24***	1.81***	2.35***	1.51***	1.99***	2.42***	2.07***	2.00***
	(11.71)	(17.56)	(6.10)	(19.32)	(16.71)	(12.57)	(22.32)	(9.80)	(19.12)	(6.57)	(14.74)	(13.21)
ISSUE_1Y	1.25***	1.95***	1.49***	1.61***	1.73***	1.44***	1.87***	1.17***	1.61***	1.53***	1.73***	1.48***
	(7.39)	(18.39)	(2.90)	(13.97)	(11.01)	(9.45)	(13.65)	(5.52)	(13.69)	(6.08)	(11.42)	(9.78)
ISSUE_5Y	1.76***	1.95***	1.93***	1.85***	2.02***	1.70***	2.11***	1.45***	1.89***	1.61***	2.01***	1.72***
	(12.43)	(16.26)	(6.88)	(17.47)	(15.56)	(14.35)	(21.49)	(8.94)	(19.28)	(5.66)	(16.88)	(12.17)
TEF	1.83***	1.90***	1.78**	1.87***	1.89***	1.77***	2.12***	1.45***	1.86***	1.95***	1.84***	1.88***
	(8.24)	(14.59)	(2.68)	(13.07)	(12.40)	(8.96)	(13.04)	(7.35)	(13.10)	(5.66)	(11.09)	(9.69)
–PM	2.46***	2.58***	2.36***	2.54***	2.74***	2.30***	2.90***	1.92***	2.56***	2.27***	2.54***	2.51***
	(12.21)	(23.24)	(8.87)	(20.50)	(23.97)	(11.89)	(21.00)	(10.23)	(20.70)	(8.55)	(14.73)	(16.47)
–Ln(PRICE)	5.43***	4.60***	5.69***	4.96***	5.05***	4.97***	5.38***	4.41***	4.96***	5.43***	4.81***	4.98***
	(22.09)	(32.04)	(6.83)	(32.54)	(25.75)	(23.15)	(26.05)	(19.64)	(30.81)	(13.19)	(26.10)	(24.41)
–PROFIT	2.49***	2.47***	2.43***	2.49***	2.74***	2.20***	2.80***	1.96***	2.49***	2.42***	2.60***	2.35***
	(12.24)	(22.37)	(7.22)	(19.28)	(21.30)	(12.90)	(20.46)	(10.87)	(20.31)	(7.07)	(14.61)	(16.29)
–ZS	2.45***	2.75***	2.42***	2.62***	2.85***	2.31***	2.90***	2.11***	2.66***	2.07***	2.70***	2.49***
	(11.58)	(18.60)	(7.61)	(17.28)	(18.81)	(12.64)	(16.89)	(10.57)	(18.92)	(8.05)	(14.43)	(14.12)

Table 5: Impact of Option Transaction Costs on the Returns of Option Portfolio Strategies

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). The margin cost adjusted return is calculated using initial CBOE-based margin requirements and assume the options are transacted at the midpoint of the bid and ask quotes. All of the numbers in this table are expressed in percent. The sample period is from January 1996 to April 2016. 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						
	No Cost	Effective Bid-Ask Spread / Quoted Bid-Ask Spread					Margin cost adjusted	No Cost	Effective Bid-Ask Spread / Quoted Bid-Ask Spread					Margin cost adjusted
		10%	25%	50%	75%	100%			10%	25%	50%	75%	100%	
CFV	1.63***	1.48***	1.26***	0.96***	0.68***	0.33***	1.00***	1.58***	1.44***	1.24***	0.94***	0.65***	0.33***	0.95***
	(11.74)	(10.95)	(9.45)	(7.78)	(5.25)	(2.80)	(10.62)	(14.93)	(14.04)	(12.44)	(10.09)	(7.00)	(3.75)	(13.67)
CH	2.11***	1.96***	1.75***	1.40***	1.06***	0.74***	1.13***	1.63***	1.52***	1.36***	1.11***	0.86***	0.62***	0.88***
	(15.88)	(15.67)	(14.75)	(11.70)	(7.98)	(4.77)	(13.93)	(13.99)	(13.58)	(12.66)	(10.46)	(7.79)	(5.18)	(12.80)
DISP	2.03***	1.85***	1.59***	1.16***	0.75***	0.34***	1.17***	1.87***	1.71***	1.47***	1.07***	0.69***	0.32***	1.07***
	(19.81)	(18.49)	(16.10)	(11.56)	(7.01)	(2.96)	(18.82)	(21.95)	(20.59)	(17.94)	(12.64)	(7.43)	(3.04)	(20.91)
ISSUE_1Y	1.60***	1.48***	1.29***	0.98***	0.68***	0.39***	0.93***	1.41***	1.29***	1.12***	0.85***	0.58***	0.32***	0.83***
	(14.84)	(14.59)	(13.64)	(10.50)	(6.58)	(3.24)	(12.90)	(16.83)	(16.24)	(14.65)	(10.63)	(6.40)	(3.00)	(15.19)
ISSUE_5Y	1.86***	1.72***	1.52***	1.20***	0.88***	0.57***	1.13***	1.63***	1.50***	1.32***	1.02***	0.73***	0.45***	0.98***
	(19.92)	(19.07)	(17.17)	(12.89)	(8.50)	(4.83)	(19.01)	(23.11)	(21.70)	(19.05)	(13.94)	(9.02)	(4.91)	(22.23)
TEF	1.87***	1.70***	1.46***	1.07***	0.69***	0.32*	1.06***	1.38***	1.25***	1.07***	0.78***	0.49***	0.22*	0.77***
	(14.63)	(13.94)	(12.29)	(8.51)	(4.81)	(1.91)	(13.48)	(14.17)	(13.33)	(11.65)	(8.17)	(4.70)	(1.82)	(12.98)
–PM	2.53***	2.30***	1.95***	1.44***	0.95***	0.42***	1.47***	1.89***	1.71***	1.45***	1.04***	0.65***	0.23**	1.11***
	(22.11)	(20.62)	(17.43)	(12.80)	(7.13)	(2.96)	(20.29)	(20.17)	(18.94)	(16.56)	(11.98)	(6.75)	(2.35)	(18.90)
–Ln(PRICE)	4.96***	4.50***	3.73***	2.54***	1.39***	0.21	3.04***	3.99***	3.58***	3.01***	2.11***	1.23***	0.34**	2.41***
	(25.21)	(30.49)	(25.35)	(16.31)	(7.70)	(1.10)	(33.67)	(26.16)	(29.05)	(24.64)	(16.23)	(8.44)	(2.17)	(33.86)
–PROFIT	2.48***	2.26***	1.93***	1.39***	0.87***	0.36**	1.43***	1.91***	1.73***	1.45***	1.00***	0.55***	0.12	1.10***
	(21.67)	(20.29)	(17.56)	(12.07)	(6.80)	(2.50)	(18.92)	(19.97)	(18.85)	(16.44)	(11.10)	(5.61)	(1.10)	(18.43)
–ZS	2.60***	2.38***	2.06***	1.54***	1.03***	0.54***	1.50***	1.79***	1.64***	1.43***	1.08***	0.73***	0.40***	1.01***
	(20.11)	(19.45)	(17.58)	(12.68)	(7.49)	(3.36)	(18.90)	(17.81)	(17.45)	(16.22)	(12.38)	(7.68)	(3.63)	(15.42)

Table 6: Fama-MacBeth Regressions

This table reports the average coefficients from monthly Fama-MacBeth regressions with the return to delta-neutral covered call as the dependent variable. 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 the VOL_deviation (the log difference between the VOL and the Black-Scholes implied volatility for at-the-money options), idiosyncratic volatility (IVOL, the annualized stock return idiosyncratic volatility of last month defined in Ang, Hodrick, Xing and Zhang (2006)), Stock Ln(Amihud) (the Amihud (2002) illiquidity measure's logarithm), 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 last month), Ln(ME) and Ln(BM) are defined in Fama and French (1992). $RET_{(-1,0)}$ is the lagged one month return. $RET_{(-12,-2)}$ is the cumulative returns over months 2 to 12 prior to the current month. Vega, theta, delta, and gamma are Greeks of selected options. All independent variables are winsorized each month at the 0.5% level. The sample period is from January 1996 to April 2016. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

Dependent Variable		Control for				
	Without Controls	VOL_deviation	IVOL	Ln(Amihud), Option bid-ask spread	Ln(ME), Ln(BM), Ret $_{(-12,-2)}$, Ret $_{(-1,0)}$	Vega, Theta, Delta, Gamma, Gamma^2
CFV	0.005***	0.005***	0.002***	0.003***	0.002***	0.004***
	(4.73)	(4.83)	(3.00)	(3.64)	(3.07)	(4.32)
CH	0.028***	0.028***	0.016***	0.019***	0.017***	0.030***
	(17.61)	(17.95)	(9.46)	(11.97)	(11.15)	(21.47)
DISP	0.008***	0.008***	0.005***	0.005***	0.005***	0.007***
	(10.45)	(10.46)	(7.39)	(7.57)	(7.15)	(9.51)
ISSUE_1Y	0.033***	0.033***	0.013***	0.021***	0.018***	0.033***
	(12.01)	(12.60)	(5.68)	(9.34)	(8.02)	(13.40)
ISSUE_5Y	0.014***	0.014***	0.008***	0.010***	0.009***	0.013***
	(20.82)	(20.67)	(13.00)	(15.60)	(13.23)	(19.52)
TEF	0.032***	0.031***	0.017***	0.019***	0.016***	0.031***
	(18.42)	(18.35)	(9.98)	(11.14)	(9.10)	(18.72)
–PM	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(5.89)	(5.86)	(5.15)	(5.04)	(4.78)	(5.80)
–Ln(PRICE)	0.021***	0.020***	0.017***	0.019***	0.018***	0.048***
	(30.80)	(31.04)	(26.00)	(21.04)	(23.41)	(28.92)
–PROFIT	0.014***	0.013***	0.008***	0.008***	0.008***	0.012***
	(17.89)	(17.57)	(13.31)	(13.11)	(13.38)	(17.28)
–ZS	0.003***	0.003***	0.002***	0.002***	0.002***	0.003***
	(22.06)	(20.87)	(16.58)	(14.81)	(16.10)	(21.63)

Table 7: Potential Explanations

This table reports the results of several tests of potential explanations of our main findings based on Fama-MacBeth regressions with the return to delta-neutral covered call as the dependent variable. Each regression uses one and only one of the stock characteristics as the key regressor. The volatility risk premium (VRP) is defined as the difference between a model free estimate of the risk-neutral expected variance implied from stock options at the end of last month and the realized variance estimated from intradaily stock returns over last month. The uncertainty in stock volatility (VOL-of-VOL) is the standard deviation of the percent change in daily realized stock volatility over the previous month. Option-implied Skewness and Kurtosis are the risk-neutral skewness and kurtosis of stock returns inferred from a cross-section of out-of-the-money calls and puts as in Bakshi, Kapadia, and Madan (2003). Stock PIN is the probability of informed trading in Easley, Hvidkjaer, and O'hara (2002). Option demand pressureis the log difference between the total market value of all options and the market value of underlying stocks at the end of last month. Stock MAX(5) is the average of five highest daily returns of underlying stock in the previous month. All independent variables are winsorized each month at the 0.5% level. The sample period is from January 1996 to April 2016. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

Panel A: Controlling for Volatility Risk Premium, Uncertainty in Volatility, and Jump Risk

	Control for Volatility Risk Premium		Control for Uncertainty in Volatility		Control for Jump Risk		
	Stock Characteristics	VRP	**Stock Characteristics**	VOL-of-VOL	**Stock Characteristics**	Option-implied Skewness	Option-implied Kurtosis
CFV	0.004^{***}	0.102^{***}	0.005^{***}	0.012^{***}	0.002^{**}	0.003^{***}	0.091^{***}
	(4.40)	(11.11)	(4.65)	(10.55)	(2.21)	(8.84)	(8.82)
CH	0.019^{***}	0.087^{***}	0.028^{***}	0.011^{***}	0.017^{***}	0.003^{***}	0.101^{***}
	(11.16)	(9.88)	(16.57)	(8.91)	(9.11)	(8.61)	(8.23)
DISP	0.006^{***}	0.092^{***}	0.008^{***}	0.012^{***}	0.005^{***}	0.004^{***}	0.100^{***}
	(8.74)	(9.82)	(10.44)	(9.93)	(4.92)	(9.68)	(8.70)
ISSUE_1Y	0.023^{***}	0.090^{***}	0.032^{***}	0.013^{***}	0.016^{***}	0.004^{***}	0.108^{***}
	(10.78)	(9.56)	(11.95)	(11.34)	(6.20)	(9.53)	(8.67)
ISSUE_5Y	0.011^{***}	0.087^{***}	0.014^{***}	0.011^{***}	0.008^{***}	0.003^{***}	0.110^{***}
	(16.51)	(9.64)	(20.48)	(10.37)	(10.62)	(8.83)	(7.75)
TEF	0.022^{***}	0.088^{***}	0.031^{***}	0.012^{***}	0.019^{***}	0.003^{***}	0.105^{***}
	(13.35)	(9.77)	(17.33)	(10.37)	(9.24)	(9.18)	(8.03)
–PM	0.002^{***}	0.087^{***}	0.002^{***}	0.012^{***}	0.002^{***}	0.003^{***}	0.102^{***}
	(5.54)	(9.61)	(5.88)	(10.71)	(5.52)	(9.19)	(8.14)
–Ln(PRICE)	0.019^{***}	0.076^{***}	0.020^{***}	0.006^{***}	0.017^{***}	0.004^{***}	0.068^{***}
	(19.36)	(10.96)	(30.53)	(6.58)	(27.75)	(11.80)	(6.98)
–PROFIT	0.010^{***}	0.087^{***}	0.014^{***}	0.012^{***}	0.009^{***}	0.003^{***}	0.101^{***}
	(13.32)	(9.64)	(18.04)	(11.29)	(10.79)	(9.44)	(8.19)
–ZS	0.002^{***}	0.086^{***}	0.003^{***}	0.011^{***}	0.002^{***}	0.004^{***}	0.102^{***}
	(14.43)	(9.88)	(21.77)	(10.23)	(13.71)	(9.31)	(7.81)

Panel B: Controlling for Information Asymmetry, Option Demand Pressure, and Lottery Preference

	Control for Information Asymmetry		Control for Option Demand Pressure		Control for Lottery Characteristics	
	Stock Characteristics	Stock PIN	**Stock Characteristics**	Option demand pressure	**Stock Characteristics**	Stock MAX(5)
CFV	0.005***	0.025***	0.003***	0.004***	0.002***	0.499***
	(4.47)	(7.37)	(4.36)	(13.30)	(3.94)	(19.11)
CH	0.022***	0.023***	0.023***	0.003***	0.019***	0.408***
	(9.87)	(8.31)	(14.78)	(9.78)	(12.59)	(18.29)
DISP	0.009***	0.025***	0.007***	0.004***	0.005***	0.469***
	(8.39)	(8.07)	(9.32)	(13.57)	(8.06)	(20.06)
ISSUE_1Y	0.023***	0.027***	0.026***	0.004***	0.016***	0.485***
	(8.93)	(8.63)	(10.07)	(14.29)	(8.21)	(20.95)
ISSUE_5Y	0.012***	0.024***	0.011***	0.003***	0.009***	0.468***
	(14.35)	(7.94)	(17.94)	(14.17)	(15.69)	(19.63)
TEF	0.025***	0.025***	0.026***	0.003***	0.020***	0.443***
	(12.53)	(8.02)	(15.84)	(13.48)	(12.59)	(19.40)
–PM	0.003***	0.025***	0.002***	0.004***	0.002***	0.469***
	(4.13)	(7.88)	(5.64)	(13.03)	(5.39)	(19.68)
–Ln(PRICE)	0.020***	0.008***	0.020***	0.003***	0.018***	0.284***
	(24.54)	(3.14)	(30.07)	(13.36)	(25.74)	(14.78)
–PROFIT	0.011***	0.025***	0.012***	0.003***	0.009***	0.445***
	(13.07)	(7.87)	(16.69)	(13.08)	(15.48)	(19.84)
–ZS	0.003***	0.024***	0.003***	0.003***	0.002***	0.413***
	(12.23)	(7.66)	(20.47)	(11.99)	(19.33)	(18.05)

Table 8: Explanatory Power of Stock Market Risk Factors

This table reports the return spread and alphas based on various stock market common risk factors. 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. 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. We compute the equal-weighted spread return that is long in the tenth decile and short in the first decile. The Fama and French (2015) five-factor model includes MKTRF, SMB, HML, RMW, and CMA factors. UMD is the Carhart (1997) momentum factor. PS is the Pastor and Stambaugh (2003) liquidity factor. The Stambaugh and Yuan (2017) mispricing factor model includes MKTRF, SMB, MGMT, and PERF factors. Three volatility risk factors include 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). Other risk factors include Herskovic, Kelly, Lustig, and Van Nieuwerburgh (2016) innovation in the common idiosyncratic volatility factor (CIV), Adrian, Etula and Muir (2014) leverage shock factor (LEV), He, Kelly, and Manela (2017) intermediary capital risk factor (ICR), Frazzini and Petersen (2014) betting-against-beta factor (BAB), and Kelly and Jiang (2014) tail risk factor (TAIL). All of the numbers in this table are expressed in percent. The sample period is from January 1996 to April 2016. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

Equal-Weighted (10-1) Return Spread

		Alphas of Different Models						
		Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
Sorted on	Raw Return	FF5 Model	FF5 + UMD + PS	SY MISP Model	FF5 + 3 Volatility -factors + CIV	FF5 + LEV + ICR	FF5+ BAB + TAIL	All 17 Factors
CFV	1.63***	1.57***	1.60***	1.67***	1.62***	1.60***	1.68***	1.78***
	(11.74)	(12.10)	(12.99)	(12.13)	(9.53)	(10.91)	(9.68)	(9.22)
CH	2.11***	2.09***	2.08***	2.18***	1.99***	2.09***	1.87***	1.98***
	(15.88)	(15.27)	(15.49)	(16.79)	(11.82)	(15.70)	(10.38)	(10.63)
DISP	2.03***	1.96***	1.98***	1.96***	1.98***	2.00***	1.92***	2.00***
	(19.81)	(17.32)	(17.73)	(17.21)	(13.75)	(15.55)	(12.31)	(10.80)
ISSUE_1Y	1.60***	1.58***	1.59***	1.65***	1.43***	1.62***	1.38***	1.42***
	(14.84)	(11.88)	(12.00)	(13.13)	(8.41)	(11.94)	(8.45)	(7.31)
ISSUE_5Y	1.86***	1.82***	1.84***	1.83***	1.76***	1.80***	1.71***	1.69***
	(19.92)	(18.08)	(17.50)	(18.73)	(13.19)	(16.12)	(15.45)	(12.03)
TEF	1.87***	1.83***	1.84***	1.86***	1.78***	1.85***	1.73***	1.76***
	(14.63)	(12.62)	(11.97)	(12.31)	(9.19)	(12.38)	(9.06)	(7.83)
–PM	2.53***	2.48***	2.48***	2.51***	2.43***	2.47***	2.32***	2.39***
	(22.11)	(20.56)	(20.86)	(22.95)	(14.85)	(21.84)	(13.90)	(13.33)
–Ln(PRICE)	5.01***	4.89***	4.90***	4.79***	5.18***	4.68***	5.11***	4.99***
	(33.23)	(28.77)	(29.52)	(31.08)	(24.26)	(26.94)	(27.86)	(23.74)
–PROFIT	2.48***	2.45***	2.46***	2.50***	2.39***	2.44***	2.34***	2.36***
	(21.67)	(20.84)	(21.31)	(23.81)	(16.50)	(21.44)	(13.42)	(14.36)
–ZS	2.60***	2.57***	2.57***	2.63***	2.47***	2.58***	2.36***	2.47***
	(20.11)	(18.10)	(18.07)	(20.22)	(14.03)	(18.39)	(13.07)	(13.46)

Table 9: Explanatory Power of Option Market Risk Factors

This table reports the return spread and alphas based on various option market risk factors. 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. 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. We compute the equal-weighted spread return that is long in the tenth decile and short in the first decile. The Karakaya (2013) three-factor model includes Level, Slope, and Value factors. IVOL factor is the (10-1) equal-weighted return spread sorted on idiosyncratic volatility. Ln(Amihud) factor is the (10-1) equal-weighted return spread sorted on stock Amihud illiquidity measure. All of the numbers in this table are expressed in percent. The sample period is from January 1996 to April 2016. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

Equal-Weighted (10-1) Return Spread

		Alphas of Different Models				
		Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Sorted on	Raw Return	Karakaya 3-factor	IVOL	Ln(Amihud)	IVOL + Ln(Amihud)	IVOL + Ln(Amihud) + Karakaya 3-factor
CFV	1.63***	1.24***	-0.32	1.01***	-0.20	0.23
	(10.12)	(6.84)	(-1.39)	(2.70)	(-0.91)	(0.85)
CH	2.11***	1.77***	0.33	1.76***	0.61	0.40
	(14.57)	(5.69)	(0.89)	(4.03)	(1.48)	(0.87)
DISP	2.03***	1.77***	0.36	1.04***	0.06	0.20
	(21.19)	(10.11)	(1.51)	(3.13)	(0.22)	(0.73)
ISSUE_1Y	1.60***	1.37***	-0.16	1.30***	0.15	0.17
	(13.50)	(5.78)	(-0.52)	(3.24)	(0.43)	(0.54)
ISSUE_5Y	1.86***	1.43***	0.39	0.91***	0.06	0.22
	(19.77)	(7.41)	(1.61)	(3.24)	(0.22)	(0.86)
TEF	1.87***	1.35***	-0.33	0.58	-0.71*	0.48
	(14.09)	(5.88)	(-1.14)	(1.52)	(-1.88)	(1.45)
–PM	2.53***	2.21***	0.84***	1.45***	0.47	0.80**
	(22.11)	(13.33)	(2.67)	(3.80)	(1.52)	(2.31)
–Ln(PRICE)	5.01***	4.79***	3.35***	1.49***	0.91***	0.40
	(33.23)	(13.32)	(7.12)	(5.56)	(3.22)	(1.29)
–PROFIT	2.48***	2.21***	0.66**	1.19***	0.15	-0.44
	(21.42)	(12.41)	(2.31)	(3.24)	(0.53)	(-1.38)
–ZS	2.60***	2.15***	0.70**	1.50***	0.38	0.51*
	(19.39)	(9.72)	(2.06)	(4.48)	(1.15)	(1.71)
Avg |α|		2.03	0.74	1.22	0.37	0.39

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 April 2016.

Panel A: Time-Series Distribution (244 Monthly Obs)

Jan 1996– April 2016	Mean	Std	10-Pctl	Q1	Med	Q3	90-Pctl
Number of stocks in the sample each month	763	155	562	679	771	860	960
Stock % coverage of stock universe (EW)	10.56	2.45	7.48	9.24	10.54	12.13	13.64
Stock % coverage of stock universe (VW)	35.75	11.08	17.48	29.49	36.84	43.94	47.98
Stock % traded at NYSE/AMEX	52.21	4.32	46.25	49.33	52.64	55.33	57.47
Stock % included in S&P500 index	27.10	4.26	21.24	24.27	27.08	30.23	32.35
Stock % already included in previous month	49.76	7.55	39.94	44.96	50.51	55.00	58.68

Panel B: Time-Series Average of Cross-Sectional Distributions (186,220 Stock-Month Obs)

Jan 1996– April 2016	Mean	Std	10-Pctl	Q1	Med	Q3	90-Pctl
Firm size in million	7,238	18,097	116	745	1,848	5,490	15,883
Firm size CSRP percentile (%)	80	14	37	71	83	92	97
Firm book-to-market CSRP percentile (%)	33	23	1	13	28	48	69
Firm volatility CSRP percentile (%)	51	22	7	34	52	69	81
Institutional ownership (%)	69	21	10	58	72	83	92
Analyst coverage	11.54	7.30	1.00	5.89	10.00	15.94	21.97

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	4.36%	5.00%	Telecom	3.43%	2.83%
Consumer durables	2.21%	2.34%	Utilities	2.11%	3.13%
Manufacturing	9.22%	9.76%	Wholesale	11.63%	9.98%
Energy	5.06%	3.55%	Healthcare	12.52%	8.45%
Chemicals	2.29%	2.04%	Finance	9.40%	22.92%
Business Equipment	22.57%	15.31%	Others	15.20%	14.69%

Table A2: Return Spread to Daily Rebalanced and Compounded Delta-Neutral Call Writing Sorted on Stock 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 April 2016. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

	(10-1) Return Spread			(5-1) Return Spread		
	EW	Stock-VW	Option-VW	EW	Stock-VW	Option-VW
CFV	1.03***	0.39***	0.86***	1.00***	0.24**	0.84***
	(8.73)	(3.49)	(4.46)	(11.62)	(2.51)	(5.30)
CH	1.52***	0.70***	1.47***	1.07***	0.36**	0.75***
	(10.10)	(4.25)	(5.75)	(8.00)	(2.29)	(3.70)
DISP	1.24***	0.61***	1.33***	1.12***	0.46***	1.17***
	(12.08)	(4.43)	(6.58)	(13.46)	(4.17)	(7.09)
ISSUE_1Y	0.89***	0.15	0.84***	0.75***	0.21**	0.71***
	(6.75)	(1.59)	(3.57)	(6.46)	(2.36)	(4.25)
ISSUE_5Y	1.21***	0.34***	1.05***	1.03***	0.21***	0.78***
	(11.21)	(4.10)	(5.24)	(12.30)	(2.80)	(5.17)
TEF	1.13***	0.53***	1.11***	0.79***	0.27**	0.80***
	(7.94)	(2.98)	(4.21)	(7.68)	(2.23)	(4.22)
–PM	1.89***	1.11***	2.27***	1.22***	0.46***	1.38***
	(16.16)	(6.21)	(9.58)	(14.08)	(3.15)	(9.35)
–Ln(PRICE)	3.52***	2.72***	3.95***	2.59***	1.81***	2.94***
	(22.00)	(15.92)	(15.17)	(19.15)	(14.26)	(15.22)
–PROFIT	1.77***	0.89***	2.06***	1.24***	0.50***	1.27***
	(16.78)	(6.72)	(10.43)	(14.18)	(4.24)	(8.15)
–ZS	2.24***	1.26***	2.62***	1.45***	0.43***	1.57***
	(18.21)	(8.67)	(11.52)	(16.30)	(4.12)	(9.63)

Table A3: Return to Delta-Neutral Call Option Strategies Held until Maturity

Sorted on Stock 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 April 2016. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

	(10-1) Return Spread			(5-1) Return Spread		
	EW	Stock-VW	Option-VW	EW	Stock-VW	Option-VW
CFV	3.20***	1.62***	2.85***	3.07***	1.43***	3.07***
	(15.20)	(5.45)	(6.72)	(17.02)	(7.10)	(9.54)
CH	3.85***	0.81*	3.44***	3.05***	0.90***	2.12***
	(11.89)	(1.81)	(5.95)	(11.06)	(3.13)	(4.94)
DISP	4.01***	3.26***	4.91***	3.64***	2.41***	4.04***
	(21.32)	(12.44)	(12.20)	(22.76)	(12.46)	(13.00)
ISSUE_1Y	3.19***	1.26***	2.74***	2.73***	1.16***	2.56***
	(14.59)	(4.75)	(5.56)	(15.08)	(5.81)	(6.95)
ISSUE_5Y	3.59***	1.64***	4.02***	3.17***	1.25***	3.08***
	(18.20)	(8.44)	(9.53)	(18.67)	(8.99)	(10.66)
TEF	3.56***	2.91***	4.69***	2.59***	1.89***	3.36***
	(13.90)	(8.27)	(8.91)	(12.93)	(7.38)	(9.97)
–PM	4.82***	3.73***	5.45***	3.60***	2.57***	4.11***
	(18.05)	(11.11)	(11.54)	(17.65)	(10.83)	(12.09)
–Ln(PRICE)	10.05***	8.93***	11.28***	7.85***	6.59***	8.80***
	(28.47)	(22.12)	(20.32)	(28.97)	(22.13)	(21.16)
–PROFIT	4.82***	3.60***	5.93***	3.78***	2.61***	4.39***
	(19.33)	(10.76)	(12.22)	(17.20)	(12.45)	(12.23)
–ZS	5.10***	3.74***	6.85***	3.51***	2.11***	4.66***
	(17.79)	(10.24)	(12.94)	(15.96)	(10.32)	(14.88)

Table A4: Return of Delta-Neutral Put Option Strategies

Sorted on Stock 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 April 2016. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

	(10-1) Return Spread			(5-1) Return Spread		
	EW	Stock-VW	Option-VW	EW	Stock-VW	Option-VW
CFV	-1.34***	-0.73***	-1.35***	-1.27***	-0.62***	-1.26***
	(-12.83)	(-5.76)	(-7.32)	(-15.78)	(-6.57)	(-7.98)
CH	-1.65***	-0.34	-1.18***	-1.30***	-0.30**	-0.66***
	(-15.89)	(-1.61)	(-5.73)	(-13.98)	(-1.99)	(-4.10)
DISP	-1.60***	-1.26***	-1.81***	-1.48***	-0.97***	-1.62***
	(-19.63)	(-10.13)	(-10.59)	(-23.51)	(-9.96)	(-11.02)
ISSUE_1Y	-1.34***	-0.56***	-0.88***	-1.17***	-0.49***	-0.79***
	(-13.43)	(-4.99)	(-3.80)	(-15.65)	(-4.99)	(-4.64)
ISSUE_5Y	-1.40***	-0.58***	-1.24***	-1.26***	-0.46***	-1.09***
	(-16.19)	(-6.14)	(-6.84)	(-19.62)	(-5.32)	(-6.93)
TEF	-1.45***	-1.06***	-1.57***	-1.08***	-0.70***	-1.28***
	(-14.86)	(-8.16)	(-8.80)	(-13.31)	(-6.75)	(-9.31)
–PM	-1.98***	-1.61***	-2.15***	-1.48***	-1.09***	-1.63***
	(-20.93)	(-11.81)	(-9.96)	(-18.84)	(-10.98)	(-10.11)
–Ln(PRICE)	-3.89***	-3.65***	-4.39***	-3.08***	-2.75***	-3.48***
	(-42.02)	(-30.26)	(-20.96)	(-42.83)	(-27.57)	(-22.86)
–PROFIT	-1.88***	-1.47***	-1.96***	-1.49***	-1.09***	-1.63***
	(-20.73)	(-10.86)	(-9.51)	(-19.26)	(-10.77)	(-10.99)
–ZS	-1.96***	-1.46***	-1.93***	-1.35***	-0.75***	-1.41***
	(-18.41)	(-10.09)	(-8.27)	(-15.43)	(-7.43)	(-7.66)

Table A5: Average Return to Delta-Neutral Call Writing across Moneyness and Maturity

For each stock at the end of each month, we retain its call options within 3x3 moneyness and maturity groups. Three moneyness groups are out-of-the-money (OTM) for Δ in [0.2, 0.4], at-the-money (ATM) for Δ in [0.4, 0.6], and in-the-money (ITM) for Δ in [0.6, 0.8]. Three maturity groups are short-term for days to maturity in [30, 60], medium-term for days to maturity in [90, 180], and long-term for days to maturity in [180, 360]. For each call option, we sell one contract of 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 to compute the buy-and-hold return of each option which is further averaged within each moneyness-maturity group. 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 moneyness-maturity group, we compute the equal-weighted average return spread that is long in the tenth decile and short in the first decile of equity characteristics. All returns in this table are expressed in percent. The sample period is from January 1996 to April 2016. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

Sorted on	Equal-Weighted (10-1) Return Spread								
	Short-term: Days to maturity in [30, 60]			Medium-term: Days to maturity in [90, 180]			Long-term: Days to maturity in [180, 360]		
	OTM	ATM	ITM	OTM	ATM	ITM	OTM	ATM	ITM
CFV	1.21***	1.68***	1.26***	0.83***	0.86***	0.73***	0.62***	0.68***	0.61***
	(5.36)	(9.14)	(10.39)	(4.38)	(6.02)	(6.83)	(3.33)	(4.51)	(5.26)
CH	2.31***	2.19***	1.54***	1.41***	1.28***	1.01***	0.65***	0.86***	0.82***
	(10.16)	(12.49)	(13.52)	(7.85)	(8.76)	(9.70)	(2.97)	(5.76)	(7.17)
DISP	1.74***	2.12***	1.52***	1.14***	1.11***	0.85***	0.90***	0.93***	0.75***
	(9.45)	(18.09)	(19.71)	(8.12)	(10.29)	(11.08)	(5.09)	(7.30)	(7.80)
ISSUE_1Y	1.72***	1.74***	1.28***	1.12***	1.01***	0.78***	0.58***	0.85***	0.69***
	(8.79)	(11.89)	(14.80)	(7.06)	(8.41)	(9.20)	(3.23)	(6.12)	(6.73)
ISSUE_5Y	1.82***	1.98***	1.33***	1.29***	1.11***	0.83***	0.76***	0.86***	0.63***
	(10.04)	(16.75)	(16.25)	(9.29)	(10.04)	(10.30)	(5.25)	(7.56)	(6.78)
TEF	1.89***	1.99***	1.36***	1.21***	1.15***	0.88***	0.57**	0.87***	0.65***
	(7.50)	(11.79)	(12.41)	(6.36)	(7.91)	(9.08)	(2.40)	(5.87)	(5.62)
–PM	2.32***	2.60***	1.90***	1.38***	1.36***	1.10***	0.55**	0.92***	0.80***
	(10.68)	(17.17)	(21.14)	(8.40)	(11.29)	(12.73)	(2.40)	(6.11)	(7.24)
–Ln(PRICE)	4.27***	5.95***	3.91***	3.16***	2.93***	2.30***	2.08***	2.37***	1.93***
	(14.96)	(33.43)	(28.91)	(17.17)	(20.88)	(20.33)	(12.63)	(16.18)	(16.87)
–PROFIT	2.10***	2.64***	1.83***	1.34***	1.35***	1.07***	0.45**	0.91***	0.82***
	(10.03)	(16.77)	(19.55)	(9.11)	(10.50)	(11.17)	(2.10)	(6.45)	(7.31)
–ZS	2.27***	2.73***	1.97***	1.47***	1.50***	1.21***	0.35	1.08***	0.96***
	(8.59)	(15.92)	(18.86)	(8.67)	(10.94)	(12.79)	(1.03)	(7.18)	(8.10)

Table A6: Investor Attention and the Impact of Earnings Announcements

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. The equal-weighted 10-1 return spread are reported. The return spreads in Column (1)-(3) are the monthly rebalanced return of delta-neutral call writing. The return spread in Column (4)-(8) are the daily rebalanced and compounded return of the delta-neutral call writing. The 1st and 4th column report the average return spread of all stocks for the full sample. The 2nd and 5th column report the average return spread in the months without earnings announcements. The 3rd and 6th column report the average return spread in the months with earnings announcements. The 7th column reports the average return spread over the three-day event window [-1,1] in the months with earnings announcements. The 8th column reports the average return spread over the other days in the event months. The sample period is from January 1996 to April 2016. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

	EW (10-1) Return Spread to Delta-Neutral Call Writing			Daily Rebalanced and Compounded EW (10-1) Return Spread to Delta-Neutral Call Writing				
	All Stocks	Without Earnings Events	With Earnings Events	All Stocks	Without Earnings Events	With Earnings Events		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Full Month	Full Month	Full Month	Full Month	Full Month	Full Month	Over [-1 ,1] Event window	Over other days in a month
CFV	1.63***	1.69***	1.22***	1.03***	1.10***	0.10	0.02	0.11
	(11.74)	(12.71)	(4.34)	(8.73)	(8.33)	(0.42)	(0.14)	(0.51)
CH	2.11***	2.39***	1.30***	1.52***	1.76***	0.70***	0.22*	0.46**
	(15.88)	(16.16)	(5.46)	(10.10)	(10.35)	(3.58)	(1.78)	(2.59)
DISP	2.03***	2.13***	1.67***	1.24***	1.33***	0.65***	0.23**	0.43**
	(19.81)	(18.89)	(9.59)	(12.08)	(12.60)	(3.81)	(2.43)	(2.35)
ISSUE_1Y	1.60***	1.75***	0.93***	0.89***	1.01***	0.33**	-0.05	0.38**
	(14.84)	(13.37)	(5.38)	(6.75)	(6.70)	(1.99)	(-0.52)	(2.51)
ISSUE_5Y	1.86***	2.02***	1.29***	1.21***	1.37***	0.54***	0.23**	0.33**
	(19.92)	(17.47)	(7.14)	(11.21)	(11.28)	(3.28)	(2.19)	(2.09)
TEF	1.87***	2.16***	1.05***	1.13***	1.31***	0.28	-0.12	0.41*
	(14.63)	(15.78)	(5.21)	(7.94)	(9.29)	(1.17)	(-0.94)	(1.87)
–PM	2.53***	2.75***	1.87***	1.89***	2.17***	0.93***	0.20*	0.67***
	(22.11)	(22.16)	(10.66)	(16.16)	(16.45)	(5.56)	(1.91)	(3.31)
–Ln(PRICE)	5.01***	5.25***	4.21***	3.52***	3.82***	2.09***	0.50***	1.68***
	(33.23)	(32.39)	(17.28)	(22.00)	(20.29)	(10.51)	(4.22)	(8.45)
–PROFIT	2.48***	2.60***	1.81***	1.77***	1.93***	0.74***	-0.01	0.74***
	(21.67)	(21.03)	(9.74)	(16.78)	(16.00)	(3.74)	(-0.06)	(3.68)
–ZS	2.60***	2.93***	1.52***	2.24***	2.47***	1.27***	0.28***	1.02***
	(20.11)	(21.38)	(6.56)	(18.21)	(18.62)	(7.27)	(2.68)	(6.95)

Table A7: Adjusting for Stock Market Risk Factors (Value-Weighted Return)

This table reports the return spread and alphas based on various stock market common risk factors. Panel A reports stock-value-weighted return and Panel B reports option-value-weighted return. 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. 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. We compute the spread return that is long in the tenth decile and short in the first decile. The Fama and French (2015) five-factor model includes MKTRF, SMB, HML, RMW, and CMA factors. UMD is the Carhart (1997) momentum factor. PS is the Pastor and Stambaugh (2003) liquidity factor. The Stambaugh and Yuan (2017) mispricing factor model includes MKTRF, SMB, MGMT, and PERF factors. Three volatility risk factors include 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). Other risk factors include Herskovic, Kelly, Lustig, and Van Nieuwerburgh (2016) innovation in the common idiosyncratic volatility factor (CIV), Adrian, Etula and Muir (2014) leverage shock factor (LEV), He, Kelly, and Manela (2017) intermediary capital risk factor (ICR), Frazzini and Petersen (2014) betting-against-beta factor (BAB), and Kelly and Jiang (2014) tail risk factor (TAIL). All of the numbers in this table are expressed in percent. The sample period is from January 1996 to April 2016. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

Panel A: Stock-Value-Weighted (10-1) Return Spread

		Alphas of Different Models						
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sorted on	Raw Return	FF5 Model	FF5 + UMD + PS	SY MISP Model	FF5 + 3 Volatility -factors + CIV	FF5 + LEV + ICR	FF5+ BAB + TAIL	All 17 Factors
CFV	0.87***	0.87***	0.89***	0.93***	0.76***	0.92***	1.03***	0.95***
	(5.92)	(6.38)	(6.58)	(6.57)	(4.36)	(5.38)	(6.24)	(4.02)
CH	0.48**	0.54**	0.53**	0.62**	0.22	0.83***	0.22	0.55*
	(2.02)	(2.07)	(2.03)	(2.59)	(0.71)	(3.70)	(0.63)	(1.83)
DISP	1.51***	1.39***	1.43***	1.46***	1.38***	1.43***	1.37***	1.43***
	(10.94)	(9.49)	(9.61)	(9.95)	(6.97)	(8.32)	(7.16)	(5.52)
ISSUE_1Y	0.56***	0.51***	0.53***	0.61***	0.31*	0.60***	0.39**	0.40**
	(4.86)	(3.83)	(4.22)	(5.57)	(1.75)	(4.21)	(2.04)	(2.07)
ISSUE_5Y	0.73***	0.67***	0.70***	0.75***	0.53***	0.77***	0.63***	0.65***
	(7.98)	(6.68)	(6.81)	(8.23)	(3.82)	(6.77)	(5.13)	(4.65)
TEF	1.28***	1.26***	1.27***	1.33***	1.10***	1.28***	1.15***	1.15***
	(8.88)	(9.81)	(9.80)	(9.39)	(5.76)	(9.09)	(7.33)	(5.51)
–PM	1.92***	1.90***	1.91***	1.95***	1.88***	1.78***	1.73***	1.77***
	(11.98)	(12.11)	(12.06)	(13.32)	(8.70)	(10.75)	(9.49)	(8.63)
–Ln(PRICE)	4.67***	4.52***	4.55***	4.44***	4.89***	4.36***	4.82***	4.84***
	(25.17)	(21.55)	(21.71)	(22.72)	(17.25)	(20.07)	(21.05)	(16.54)
–PROFIT	1.73***	1.77***	1.80***	1.83***	1.66***	1.76***	1.63***	1.67***
	(10.96)	(11.82)	(12.37)	(13.11)	(8.55)	(11.48)	(8.88)	(7.71)
–ZS	1.85***	1.78***	1.76***	1.77***	1.61***	1.71***	1.56***	1.44***
	(10.73)	(9.07)	(8.87)	(9.66)	(6.05)	(9.17)	(6.00)	(5.21)

Panel B: Returns of Option-Value-Weighted (10-1) Return Spread

		Alphas of Different Models						
		Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
Sorted on	Raw Return	FF5 Model	FF5 + UMD + PS	SY MISP Model	FF5 + 3 Volatility -factors + CIV	FF5 + LEV + ICR	FF5+ BAB + TAIL	All 17 Factors
CFV	1.51***	1.48***	1.55***	1.54***	1.56***	1.55***	1.64***	1.76***
	(6.36)	(6.81)	(7.11)	(6.49)	(4.97)	(5.52)	(6.65)	(4.53)
CH	1.43***	1.49***	1.46***	1.72***	1.38***	1.67***	1.05***	1.61***
	(4.92)	(4.73)	(4.73)	(5.89)	(3.79)	(5.14)	(2.65)	(3.64)
DISP	2.38***	2.42***	2.49***	2.39***	2.47***	2.42***	2.56***	2.57***
	(10.25)	(10.21)	(10.59)	(9.10)	(7.05)	(8.31)	(8.07)	(6.03)
ISSUE_1Y	1.13***	1.12***	1.21***	1.42***	0.82**	1.19***	0.63	0.85**
	(3.92)	(3.36)	(3.97)	(5.45)	(2.06)	(3.45)	(1.38)	(2.08)
ISSUE_5Y	1.67***	1.73***	1.79***	1.84***	1.60***	1.83***	1.74***	1.73***
	(8.19)	(6.76)	(6.94)	(7.19)	(4.78)	(5.70)	(5.23)	(3.99)
TEF	1.85***	1.94***	2.01***	2.21***	1.55***	2.14***	1.98***	2.07***
	(7.76)	(6.23)	(6.44)	(7.01)	(3.58)	(5.43)	(4.71)	(3.57)
–PM	2.72***	2.76***	2.77***	2.85***	2.51***	2.80***	2.64***	2.62***
	(10.60)	(9.80)	(9.55)	(10.74)	(7.19)	(8.82)	(7.78)	(6.54)
–Ln(PRICE)	5.85***	5.72***	5.78***	5.56***	6.06***	5.57***	6.11***	6.06***
	(20.18)	(16.60)	(17.37)	(16.12)	(13.54)	(13.15)	(15.10)	(11.16)
–PROFIT	2.63***	2.67***	2.72***	2.88***	2.43***	2.75***	2.64***	2.65***
	(10.37)	(8.86)	(8.72)	(9.72)	(5.22)	(8.16)	(6.62)	(4.57)
–ZS	3.12***	3.15***	3.15***	3.16***	2.95***	3.14***	2.86***	2.85***
	(11.82)	(9.81)	(9.58)	(9.94)	(6.17)	(9.40)	(6.80)	(5.11)

Table A8: Option Market Risk Factors (Value-Weighted Return)

This table reports the return spread and alphas based on various option market common risk factors. Panel A reports stock-value-weighted return and Panel B reports option-value-weighted return. 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. 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. We compute the spread return that is long in the tenth decile and short in the first decile. The Karakaya (2013) three-factor model includes Level, Slope, and Value factors. IVOL factor is the (10-1) stock-value-weighted (option-value-weighted) return spread sorted on idiosyncratic volatility in Panel A (Panel B). Ln(Amihud) factor is the (10-1) stock-value-weighted (option-value-weighted) return spread sorted on stock Amihud illiquidity measure in Panel A (Panel B). All of the numbers in this table are expressed in percent. The sample period is from January 1996 to April 2016. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

Panel A: Stock-Value-Weighted (10-1) Return Spread

		Alphas of Different Models				
		Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Sorted on	Raw Return	Karakaya 3-factor	IVOL	Ln(Amihud)	IVOL + Ln(Amihud)	IVOL + Ln(Amihud) + Karakaya 3-factor
CFV	0.87***	0.89***	-0.32	1.01***	-0.20	0.28
	(5.22)	(3.13)	(-1.39)	(2.70)	(-0.91)	(0.77)
CH	0.48*	-0.05	0.33	1.76***	0.61	-0.18
	(1.90)	(-0.10)	(0.89)	(4.03)	(1.48)	(-0.31)
DISP	1.51***	1.30***	0.36	1.04***	0.06	0.34
	(10.52)	(5.51)	(1.51)	(3.13)	(0.22)	(1.02)
ISSUE_1Y	0.56***	0.38	-0.16	1.30***	0.15	-0.27
	(4.77)	(1.47)	(-0.52)	(3.24)	(0.43)	(-0.78)
ISSUE_5Y	0.73***	0.40***	0.39	0.91***	0.06	0.33
	(8.04)	(3.08)	(1.61)	(3.24)	(0.22)	(1.44)
TEF	1.28***	0.70***	-0.33	0.58	-0.71*	-0.16
	(8.46)	(2.88)	(-1.14)	(1.52)	(-1.88)	(-0.39)
–PM	1.92***	1.45***	0.84***	1.45***	0.47	0.30
	(11.37)	(6.76)	(2.67)	(3.80)	(1.52)	(0.83)
–Ln(PRICE)	4.67***	4.46***	3.35***	1.49***	0.91***	1.43***
	(22.88)	(11.43)	(7.12)	(5.56)	(3.22)	(4.36)
–PROFIT	1.73***	1.58***	0.66**	1.19***	0.15	0.84**
	(10.34)	(7.70)	(2.31)	(3.24)	(0.53)	(2.01)
–ZS	1.85***	1.22***	0.70**	1.50***	0.38	0.24
	(10.35)	(3.78)	(2.06)	(4.48)	(1.15)	(0.65)
Avg |α|		1.24	0.74	1.22	0.37	0.43

Panel B: Option-Value-Weighted (10-1) Return Spread

		Alphas of Different Models				
		Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Sorted on	Raw Return	Karakaya 3-factor	IVOL	Ln(Amihud)	IVOL + Ln(Amihud)	IVOL + Ln(Amihud) + Karakaya 3-factor
CFV	1.51***	1.54***	0.52	0.95**	0.12	0.48
	(6.36)	(3.65)	(1.40)	(2.34)	(0.33)	(1.15)
CH	1.43***	0.63	0.54	1.90***	1.07**	0.25
	(4.92)	(0.83)	(1.23)	(3.94)	(2.30)	(0.38)
DISP	2.38***	2.09***	1.13***	2.14***	1.02***	0.91**
	(10.25)	(4.49)	(3.63)	(5.01)	(2.63)	(2.37)
ISSUE_1Y	1.13***	0.47	-0.07	1.38***	0.28	0.06
	(3.92)	(0.87)	(-0.22)	(3.23)	(0.65)	(0.15)
ISSUE_5Y	1.67***	1.19**	0.54*	1.86***	0.82*	0.61
	(8.19)	(2.28)	(1.76)	(5.01)	(1.95)	(1.20)
TEF	1.85***	0.53	0.59	1.61***	0.47	-0.25
	(7.76)	(0.85)	(1.57)	(4.16)	(0.87)	(-0.41)
–PM	2.72***	2.19***	1.69***	1.75***	0.87*	0.61
	(10.60)	(4.35)	(3.63)	(4.55)	(1.85)	(1.22)
–Ln(PRICE)	5.85***	5.63***	4.27***	3.57***	2.23***	2.34***
	(20.18)	(9.14)	(7.46)	(7.23)	(4.51)	(3.75)
–PROFIT	2.63***	2.49***	1.39***	1.80***	0.71	0.99
	(10.37)	(4.42)	(2.74)	(3.63)	(1.05)	(1.42)
–ZS	3.12***	2.41***	1.98***	1.65***	0.68	0.48
	(11.82)	(3.88)	(4.19)	(2.85)	(1.05)	(0.63)
Avg |α|		1.92	1.27	1.86	0.83	0.70